2010-10-22

Measuring Airport Efficiency with Fixed Asset Utilization to Minimize Airport Delays

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Recommended Citation

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UNIVERSITY OF MIAMI

MEASURING AIRPORT EFFICIENCY WITH FIXED ASSET UTILIZATION TO MINIMIZE AIRPORT DELAYS

By

Scott D. Widener

A DISSERTATION

Submitted to the Faculty
of the University of Miami
in partial fulfillment of the requirements for
the degree of Doctor of Philosophy

Coral Gables, Florida

December 2010

UNIVERSITY OF MIAMI

A dissertation submitted in partial fulfillment of
the requirements for the degree of
Doctor of Philosophy

MEASURING AIRPORT EFFICIENCY WITH FIXED ASSET UTILIZATION TO MINIMIZE AIRPORT DELAYS

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WIDENER, SCOTT D. (Ph.D., Industrial Engineering)
Measuring Airport Efficiency with Fixed Asset Utilization to Minimize Airport Delays (December 2010)

Abstract of a dissertation at the University of Miami.

Dissertation supervised by Professor Murat Erkoc.
No. of pages in text. (344)

Deregulation of the airlines in the United States spawned a free-for-all system which led to a variety of agents within the aviation system all seeking to optimize their own piece of the aviation system, and the net result was that the aviation system itself was not optimized in aggregate, frequently resulting in delays. Research on the efficiency of the system has likewise focused on the individual agents, primarily focusing on the municipalities in an economic context, and largely ignoring the consumer. This paper develops the case for a systemic efficiency measurement which incorporates the interests of the airlines and the consumers with those of the airport operating municipalities in three different Data Envelopment Analysis (DEA) models: traditional Charnes-Cooper-Rhodes and Banker-Charnes-Cooper models, and a Directional Output Distance Function model, devised and interpreted using quality management principles. These models were combined to allow the resulting efficiencies of the operating configurations of the given airport to predict the efficiency of the associated airport. Based upon regression models, these efficiency measurements can be used as a diagnostic for improving the efficiency of the entire United States airspace, on a systemic basis, at the individual airport configuration level. An

example analysis using this diagnostic is derived in the course of the development and description of the diagnostic and two additional case studies are presented.

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Chapter 1: Introduction and Literature Review

Sections 1-5

1. Introduction

The commercial aviation infrastructure in the United States has hit a wall in its own operation as a result of its growth and development over the previous one hundred years, as it evolved from a government run enterprise to speed the effectiveness of mail delivery into a heavily used means of transportation that is managed by distributed agents all independently optimizing their component of the system to survive in what has become a largely commoditized service characterized by sprawling hub-and-spoke networks which can create regional oligopolistic strength for the network operators.

The result of these optimizations have hit passengers and cargoes with huge delays, if not outright system meltdowns, and the responses by the airports over the last decade have been focused on increasing capacity by adding more runways at extreme financial cost to local municipalities as well as users through fees such as facility and usage fees added to ticket prices, while squeezing out whatever capacity could be gleaned from the existing infrastructure. In response to the increases in airport capacity and changing demand from consumers, the airlines have switched their aircraft fleets from larger aircraft with larger seating and cargo capacity to smaller and more fuel-efficient aircraft with smaller seating and cargo capacities flown on a more frequent basis. The additional flexibility induced by the more frequent flights fulfills consumer demand, but at the same time, has been shown to not be robust for the consumer against routine system disruption when considering reasonable system disturbances, such as weather and mechanical failure.

Existing studies both within the academic literature, as well as those related to the associated policies, have placed the focus on individual agents within the system: typically airlines or airports. These agents are then studied over a particular characteristic or measurement of relative efficiency, such as a return on investment or the duration or number of delays wherein each of these agents is treated independently and is assessed as a single unit; with a summary of these differences is made on the basis of the proposed model. This study differs from these other studies in that it uses quality management principles related to the inherent variation exhibited within the individual airports and the system itself, as well as the actual operations themselves.

By analyzing airports, not in their aggregate throughputs or delay characteristics, but in how these throughputs and delays are generated, recognizing the inherent, and predictable variances, such as sleet in Minneapolis or New York City, or severe thunderstorms in Chicago or Dallas, causing delays to ripple through the entire national airspace, a better measurement of actual efficiencies, can be made. This is particularly interesting, because in aggregate, if the system is not disturbed, such as a quiet autumn day in mid-October, the existing infrastructure holds up to the daily traffic load reasonably well. However, as seasonal patterns change, including wind directions and precipitation, as well as airline flight scheduling, the airport operational patterns likewise change.

Therefore, this dissertation will comprehensively dissect the pieces of this problem for the OPSNET 45 airports, the 45 largest airports in the United States as determined by operations count, by analyzing these changes in efficiencies over longer periods of time to analyze the impacts of internalizing day-to-day variances as a part of a larger data set. In quality management circles, the two terms applied are “common causes of variation”, sometimes referred to as “normal causes of variation”, which are different than “special causes of variation”. A “common cause” of variation is one inherent to the system, while a “special cause” lies outside the system. Further depth on these differences can be found in Deming (2000), but one of the key points is that of the duration of the study, which aims to internalize all variance as being common cause.

As an example of the difference between “common cause” and “special cause” variation, one could question whether hurricanes are “common cause” meteorological events in the weather patterns of Florida, or if they are “special causes”. A case can be made for both, as they are rare events, albeit significant ones; however, they do occur every few years, unlike in Nevada. Therefore, by looking over a long enough timeframe, all of these seemingly “special cause” events in a short-term, such as: runway maintenance and resurfacing, ice storms or other weather issues, union labor strikes, crashes or other non-standard operations, natural disasters, congestion and security breaches, amongst other events, can be viewed as a part of the common cause variation ascribed to the system.

The primary advantage of aggregating all of these events into common variation is that this allows for a single direction to be pursued for improvement of the system, in lieu of improvement of the individual entity or component of the system. Likewise, this breaks the mould of thinking in “special cause” terms, such as how to prevent a specific incident and instead focuses on the improvement of the entire national airspace, as it is an interwoven system by its very operation, which allows delays in one portion of the system to cascade throughout the entire system.

In terms more applicable to the research itself, recent efforts, both in the regulatory and academic realms have focused on congestion out of the New York City and Northeast United States airspace as being a critical driver of huge crippling delays rippling through the national airspace. This is a “special cause approach”, and the analogous “common cause approach” is not to look at specific dates or airports where congestion is bad, but instead to look holistically and see both how the entire national airspace is faring with this congestion, as the delays may only be acute in the grand scheme of annual operations, such as a busy week in the summer, but also to see if the solution lies outside of the problematic area. This is an interesting and different approach, because by only focusing on a known problematic airport, such as New York’s JFK, it is assumed that the cause is there, when in fact JFK may only be the realization of the problem, as a symptom for diagnosis; or pinpointing a very specific problem. However, rippling delays, known as knock-on delays, coming out of JFK should be routinely hitting other airports as well, such as Dallas-Fort Worth (DFW), Denver (DEN) and Los Angeles (LAX), all of which would be picked up as common cause sources of delayed operations at those airports and could be witnessed in a holistic model. Likewise, these may not be problems at all, because if flights are delayed coming out of JFK, but can make up time and land early at the destination, the service was delivered as desired by consumers, albeit not as expected by the consumer or predicted by the existing measurement system.

This dissertation reviews previous analyses and solutions of similar problems, and proposes a new method to address and model the resulting delay problem by using the operating configurations, the way the airport uses its runways to process flights, to predict and diagnose the efficiency of the airports. This is done using an emphasis in Lean Principles and other quality management theory based upon the aforementioned aggregation of variance, applied on the actual operating assets utilized at the airport instead of treating the airport as a static collection of assets that exist in a big open area, which has been a commonly used approach.

This holistic variance approach and interpretation of the data is then elevated into a more traditional operations research approach by using two widely accepted traditional Data Envelopment Analysis (DEA) models, the Charnes-Cooper-Rhodes and Banker-Charnes-Cooper models, as well as the Directional Output Distance Function model, efficiency measurements for both the airports themselves, and the operational configurations which comprise their function are made, and by weighting the configurations by operations, it was found that nearly 70 percent of the total variance, metric-dependent, could be accounted for in a single variable direct measurement of configuration efficiency to predict the total airport efficiency despite only accounting for primary configurations.

Predicated upon these total airport predictions, a diagnostic measurement is developed to be used to identify problematic airport configurations to reduce the number and impact of delays on the national airspace by using a Pareto Effect basis, as the common cause variances dictate an approach to reduce the largest source of delays, not simply identifying the problematic airports. By making this distinction, and merging the two sets of information, an actionable plan, either operation- or capital-based depending upon the context, can be made to shore up the inefficiency and help to make the entire system more robust as delays are less wont to propagate. In the course of this development and discussion, an analysis is developed to provide a sample based upon an assumed policy of delivering “the most delay reduction for the buck”, to maintain the interests of those making the payments which become the investments, as well as with the interests of the consumers and users of the aviation system. This study isolated four configurations to be studied in depth further: one at Chicago-Midway (MDW), one at Fort Lauderdale (FLL) and two at New York-LaGuardia (LGA) using data from 2008.

An extension was made on this study which is the first case study, and it extends the diagnostic example to address poor performance at New York’s JFK. This example shows how the existing information coming from the proposed mathematical programs, as well as the breakdown of information within the diagnostic yields a surprising amount of detail about the airport, even prior to doing a deeper analysis of the configurations in question. Furthermore, this provides the basis for a deeper discussion, which is not covered within this document, on the argument between capacity, demand and pricing as it relates to aviation policy.

The second case study removes itself from the 2008 analysis, and focuses on a different set of policy assumptions, and shows how by shifting to a policy of sustained scheduling, in that inclement weather and reduced visibility will not degrade performance, in lieu of the assumptions used in the development of the diagnostic, which were focused on total delay elimination. This case study, based at Hartsfield–Jackson Atlanta International Airport (ATL) draws upon data from 2006 and shows how non-capacity airport investment can be used to boost efficiency. Using a series of iterations of different data sets run through the developed mathematical models, it is shown that not only did ATL boost its own efficiencies within its operating configurations by slashing delays, but also moved the efficient frontier for all of the airports studied in the process.

The remainder of this chapter focuses on the description of aviation and aviation research. Section 2 contains the contextual setting of the problem to provide some history and background of how the system has reached its modern form and Section 3 contains an aviation efficiency literature review based upon this context. Section 4 further refines the context of the problem with recent data and analysis, which is incorporated into a case for a new model in Section 5.

Beyond this chapter, there are five other chapters, each of which is broken up into at least two sections, but with continued sequential numbering, to allow easy reference back to concepts between chapters. There are 23 numbered sections spanning across six chapters. Chapter 2 provides a description and development of the models used and Chapter 3 contains applications of these models and statistical analyses of the models to provide a sound base for further development. Chapter 4 contains the discussion and development of the diagnostic based upon these models. Chapter 5 contains the two case studies, and Chapter 6 provides a brief conclusion.

2. Contextual Setting

Historical Context

Humankind's interest in flight goes back thousands of years, probably long before documented myths and literature of ancient Greece brought stories of Daedalus and Icarus crafting wings to fly like the birds; however, it would be several thousand years before flight itself could begin to take the shape described in the myth, and even longer before it was considered to be a safe venture, which did not end with a fatal gravitational plummet as Icarus experienced.

By the middle of the 1700s, people were making trips up and down in the air by hot air balloon, which eventually evolved into controlled lateral flight with the advent of the airship. By the outbreak of The First World War, aircraft as we would recognize them today were in their formative years. However, it was not until after The Great War that commercial aviation began in earnest.

In the United States, the early pioneer of aviation was the United States Post Office Department (renamed the United States Postal Service in 1971), who laid down much of the infrastructure that still exists today. At the same time, the United States Army and Navy were both beginning to explore the concepts of air supremacy in the military theatre and in battle planning. However, it was the Post Office and civilian operation, such as the quest for endurance and speed by famous pilots such as Charles Lindbergh and Amelia Earhart, as well as traveling airshows and barnstorming tours, which really drove the development of aircraft and aviation and spread it to the masses.

Throughout the 1920s and 1930s, the United States Postal Service was experimenting with new and better ways to haul the mail, particularly for long, cross-continental routes which had previously taken a week or more by train. Systems were set up, similar to the long-obsolete Pony Express, wherein bags of mail were flown across the country by one pilot reaching an airport and passing the bags off to another pilot to continue on across the country through the skies. This was an expensive system to maintain, and the United States Congress sought a cheaper way to move the mail, so through a series of legislative actions in the 1920s and 1930s, air mail, as it was known, was outsourced to private companies, who aggregated routes in different regions of the country, and then flew the mail for the Post Office under contract. Several of these companies still exist today, and despite some rocky times, both economically and politically, are still widely known, such as American Airlines and United Airlines, as well as now defunct operations such as Eastern Airlines and Transcontinental and Western Air (TWA).

Because of the way the contracts were structured, a point which became a political firestorm in Congress, known as the Air Mail Scandal of 1934, it was profitable for these companies to haul other cargo, as well passengers. These airlines expanded their reach, within the bounds of the Civil Aeronautics Act of 1938 and under the oversight of the Civil Aeronautics Board (CAB). Despite the regulation of routes and fares, through technological improvements and Congressional subsides to ensure the mail was hauled, made it such that air travel to a variety of destinations was possible for a large portion of the population.

The Second World War brought about enormous advancements in aircraft and component design, including the development of the jet engine, and by the end of the war, the airframe designs of the heavy bombers were converted for commercial civilian use. Many of the aircraft designs of the post-war years were based upon these bomber airframes, and others, such as the DC-3, were kept in their pre-hostility civilian forms and further developed. However, in the United States, the CAB still controlled all routes and pricing and its influence would drive the development of commercial aviation in the post-war decades.

In 1978 the largest shakeup to civilian commercial aviation hit with the passage of the Airline Deregulation Act of 1978, commonly referred to simply as

“Deregulation”. This act removed the regulatory structure and system of the CAB and allowed the airlines to operate as independent businesses, determining their own route structures and pricing. Under a deregulated system, each airline would have to alter its operation, because there was no longer an artificial economy in place which subsidized smaller/less demanded destinations at the expense of larger/more demanded destinations. This also meant that there was open competition for air service by the nation’s cities.

Responses to Deregulation

In the absence of the CAB dictating how many flights needed to go into each airport, the behaviors of the airlines were predictable, as they sought to maximize their profits. The problem the airlines had was that there was no definitive model on how to do this, as the market had not existed in a free and open form months or years prior.

To some extent, the major airlines at the time were already entrenched regionally, due to the formation of the airlines in the mail-hauling days. For example, TWA was largely based in the Midwest and western parts of the country, Eastern was located along the Atlantic coast, American in the south, and United was Midwest-based out of Chicago. However, the elimination of the fixed price flights put the onus on the airlines to streamline their operations to ensure their own profitability. This led to a change in the business model of a point-to-point basis which dominated the system during Regulation, which then evolved to a hub-and-spoke basis that is more commonly seen today; although it should be noted that Pels et al (2000) argue that this hub-and-spoke system may not be an optimal solution.

This development also had a predictable result for small markets, as these small destinations were worried about both access to the air transportation system and monopolization of markets, and the associated distortions in pricing which would likely occur. Many of these fears were later determined to be unfounded by the United States General Accounting Office (GAO), and are readily realized today simply by shopping for a flight on an internet-based search: inflation adjusted prices to 1978 are significantly lower on many routes, frequently less than the cost of fuel for the passenger to drive the trip in their own vehicle, and a passenger can access almost all but the most remote rural areas of the United States.

However, in 1978, these conclusions were not forgone, and the airlines needed to ensure smooth operation so as to keep their passengers and aircraft in the air, generating revenue as an efficient and reliable service. At the same time, the airlines also wanted to operate in large metropolitan areas so as to have a large local base upon which to draw passengers, both outbound, and those attracted to the area for business and tourist reasons.

This set up a “chicken and egg” quandary for the municipalities, because in the United States, according to the Air Commerce Act of 1926, control of the airports was turned over to the local municipalities. This created a problem because under Regulation, the municipalities, via the CAB, knew what air traffic volumes would be, and any sway in the system was political; under an open market, these certainties were removed, as supply was no longer constrained and could shift, as noted in historical studies of the period by Graham (1999), which were then used to draw conclusions for a similar situation in Norway.

Therefore, questions had to be asked about economic growth in the area being related to ease of access, or would area growth drive further access? Similar questions had to be asked about demand for leisure tourism, business tourism, handling of cargo, etc, all of which contribute to the lifeblood of any municipality, as detailed by Brueckner (2003).

This then led to a series of difficult questions about the level of air service needed, and desired, because the municipality would have to attract the airlines as a destination, while at the same time selling the voting public within the municipality, who would likely have to pay for a significant part of any project, on any necessary high-value construction projects deemed necessary.

For a sense of scale to the size of these expenditures in question, in 2003 Houston’s George Bush Intercontinental Airport (IAH) added a fifth runway, RWY 8L/26R, for $300 million, which excludes the costs of the associated taxiways for access, as a part of a $2.9 billion expansion project, with another runway planned to start construction in 2014 at nearly another $300 million price tag as a part of another $2.5 billion expansion project, which includes a new $760 million parking garage. Two more complicated expansions took place in 2006, Hartsfield-Jackson Atlanta International Airport (ATL) opened its fifth runway, RWY 10/28, at a project cost of $1.28 billion which entailed building the runway over an Interstate highway, as reported by Yee (2006), and Lambert-Saint Louis International Airport (STL) opened its fourth runway, RWY 11/29, at a project cost of $1.1 billion, which entailed relocating an entire neighborhood in a nearby community, as noted by the Associated Press (2006).

These sorts of projects are gargantuan in cost; and, it should also be noted that these costs are only monetary, and do not include the other factors that voters consider such as increased traffic and more noise. This begs the question of how one can justify financing and borrowing to fund air-side projects that routinely cost over a billion dollars.

3. Aviation Efficiency Literature Review

Recognizing that a billion dollars in 2009 dollars was worth about $300 million when Deregulation hit in 1978, according to inflation calculations by the United States Bureau of Labor Statistics, this still meant that at the time, huge amounts of money were required for expansion projects. Therefore, a good way was needed to justify the expenditure of that magnitude beyond simple and boisterous political claims of economic and job growth, as well as other immeasurable issues such as prestige, none of which could be readily substantiated.

Traditional business models for project valuation from fields such as finance failed, because it was difficult to determine values, in aggregate, or at the margin, for landing one additional flight or transporting one additional cargo container or passenger. This rendered widely known business models such as Cost-Benefit Analysis and other payback and opportunity cost-based models useless, because the values of these cargos and passengers, and their associated revenue streams, were largely unknown and unknowable. This put any results of these sorts of traditional analyses at the mercy of the assumptions of these values and therefore limited the value of any conclusions drawn from them.

Financially, this was a difficult sell because of the assumptions involved, but backing into an answer operationally, wasn't much easier. Airport capacity models vary widely because of factor differences between various facilities, including weather, and are subject to heavy correlation with airline operations. These models are further complicated because a model which dictates a certain throughput can be readily subject to error by a change in operation by the airport or by a change in the arriving and departing fleets sent by the airlines. Likewise, manufacturing-based throughput modeling had trouble bridging across into the delivery of service, because of the aforementioned variability of the fleets, coupled with the systemic aviation realities of things like fairness of runway usage, as it is possible to boost throughput if the heavy aircraft all circle in the skies while the small and large aircraft land first, but this is not reasonable in the aviation context.

A different sort of solution arrived in 1978, as an extension of Data Envelopment Analysis, commonly referred to as the acronym DEA, and two seminal papers emerged in the following six years.

Data Envelopment Analysis and Its Application in Aviation

Productive efficiency studies have long been used to determine optimal production points and usages of inputs, but there was no general and theoretically sound way to conduct the analyses. Existing methods were heavily biased towards inputs under study, typically labor, and were largely based upon industry-specific efficiency indices. Farrell (1957, 1962) proposed a new framework, based upon a study of agricultural output, of comparing inputs and outputs to generate a more theoretically sound method for determining efficiency based upon defined terms for efficiency at both the firm and industry level, and then viewing these ratios graphically along the produced efficient frontier. This work was followed it up by addressing the issue of scaling of inputs and outputs to get a better understanding of the entities under study in a given industry.

Charnes, Cooper and Rhodes (1978) advanced these ideas, which became widely known as DEA, as a way to merge the economic concepts of efficiency with the engineering concepts of efficiency, by using linear and nonlinear programming models to supply a means to understand relative efficiency and advance the groundwork laid by Farrell in the previous two decades. The concept of relative efficiency was novel, because other methods, such as Cost-Benefit Analysis, were predicated upon an absolute efficiency, in that there was a meaningful zero point. DEA was not concerned with this because there were unknown and unknowable factors in play. The original 1978 paper references these explicitly in an educational context, citing, for example, the value of a child being able to correctly solve arithmetic problems or tread water; both valuable skills, but difficult to price as there is no direct market to dictate those values.

By working with these relative efficiencies, a production possibility frontier could be established, and based upon that frontier, a meaningful quantification of managerial efficiency, benchmarked against the best performers, could be made, despite the lack of pricing for the outputs. The mechanics of this will be further addressed in the Section 8, which details the models, and the method is frequently referred to as an acronym stemming from the authors' names: CCR.

Six years later, Banker, Charnes and Cooper (1984) revised the CCR method proposed in 1978, with a new method which became known as BCC. The primary fault addressed in the BCC paper was that the CCR efficiency ratio was predicated upon constant returns to scale, whereas real-world problems in economics have been shown to exhibit both increasing and decreasing returns to scale, as noted by Farrell leading to his subsequent paper in 1962. By tweaking the mathematical programs, BCC was able to account for the non-constant returns to scale, by creating a new managerial efficiency ratio, but perhaps more importantly, by taking a ratio of the CCR efficiency and the BCC efficiency for a given firm under study, a scale efficiency measurement could be developed.

These two seminal papers, supplemented by the comprehensive literature review of Cook and Seiford (2009) on more recent modeling developments, all based upon the work of Farrell, set up a foundation for efficiency studies in aviation, because both the CCR and BCC methods were based on existing data and were ideal for evaluating past performance and future planning, versus on-going control. This directly addressed the quandary the municipalities faced in 1978 under Deregulation: with the future no longer predictable, are the municipalities getting an adequate return on investment from the existing airport infrastructure? If not, this could be the basis for funding one of the high value projects, or juggling operations within the existing infrastructure to gain additional throughput from the existing assets.

Accordingly, the theory presented in these two significant papers was applied to a variety of aviation topics, and Table 1 presents a summary of a selection of papers from recent literature in the English language, from 1997 to the present, to show how these CCR and BCC concepts were applied in academic literature to answer this very question.

Authors	**Year**	**Methods**	**Area of Study**
Gillen and Lall	1997	BCC and Tobit Model	21 United States Airports
Parker	1999	Malmquist	32 United Kingdom Airports
Sarkis	2000	BCC and CCR	43 United States Airports
Pels et al	2001	BCC, CCR and Stochastic Frontier Analysis	34 European Airports
Fernandes and Pacheco	2002	BCC and CCR	16 Brazilian Airports
Bazargan and Vasigh	2003	CCR	45 United States Airports
Pels et al	2003	BCC, CCR and Stochastic Frontier Analysis	33 European Airports
Sarkis and Talluri	2004	CCR and Cross Efficiency Modeling	43 United States Airports
Yoshida	2004	Endogenous Weight Method	43 Japanese Airports
Yoshida and Fujimoto	2004	BCC and CCR	43 Japanese Airports
Yu	2004	CCR and Directional Output Distance	14 Taiwanese Airports

Lin and Hong	2006	BCC, CCR and Free Disposal Hull	20 Global Airports
Barros and Dieke	2007	BCC, CCR and Cross Efficiency Modeling	31 Italian Airports
Fung et al	2008	Malmquist	25 Chinese Airports
Pathomsiri et al	2008	Directional Output Distance	56 United States Airports

Table 1: A Summary of Recent Aviation Efficiency Literature

These papers shown in Table 1 analyzed a variety of operations across the world as shown, but there are some distinct differences between the United States and the rest of the world which should be noted here, to minimize any undue conclusions drawn from these papers.

As noted, the United States Congress transferred ownership of the majority of airports to the municipalities; however, this regional public ownership model is not universal around the world. In some cases governments retain tighter control of the airports in lieu of letting the surrounding communities decide how to structure their airport within the existing laws governing aviation, yet the other extreme also exists, wherein major airports are owned by private companies. One of the most famous cases would be London-Heathrow, along with five other major British airports, being owned by BAA Limited, which is a subsidiary of Grupo Ferrovial, a publically traded, Madrid-based company, which specializes in operating and maintaining transportation infrastructure.

At the same time, there are other operational differences, such as staffing of gates, allowable hours of operation, distribution of runway access rights, gate access and ownership differences, etc. There are literature bodies on each of these topics, some of which will be noted later, but for purposes of this literature review, the points are merely noted to show that it is dangerous to read into the literature and draw direct conclusions without understanding the differences and nuances amongst the systems under study.

What is interesting about the papers presented in the table is that each followed a very similar pattern of outputs for efficiency analysis, as shown in Table 2.

Authors	Year	Passenger Counts	Cargo Counts	Movement Counts	Revenue Outputs	Other Outputs
Gillen and Lall	1997	X	X	X		
Parker	1999	X	X			X
Sarkis	2000	X	X	X	X	
Pels et al	2001	X		X		
Fernandes and Pacheco	2002	X				
Bazargan and Vasigh	2003	X		X	X	X
Pels et al	2003	X		X		
Sarkis and Talluri	2004	X	X	X	X	
Yoshida	2004	X	X	X		
Yoshida and Fujimoto	2004	X	X	X		
Yu	2004	X		X		X
Lin and Hong	2006	X	X	X		
Barros and Dieke	2007	X	X	X	X	
Fung et al	2008	X	X	X		
Pathomsiri et al	2008	X	X	X		X

Table 2: Outputs of the Efficiency Studies

The inputs used in conjunction with these outputs were aimed to the topic of the paper and were likewise similar, but in different forms. For example, many of the papers focused on runways as an input, but handled them in differing fashions, including counts, the summed lengths of runways and total area of runways. Likewise, human labor was frequently used as an input, but was handled in terms of counts of manpower, but also as a monetary cost;

furthermore, this breaks down within different countries because of how staffing is conducted. Therefore, while similar, the patterns are not as pronounced.

Combining the information in the two tables shows that the literature has addressed the quandary faced by the municipalities facing deregulation, as the models are very much focused on economic objectives of interest to a municipality: people coming in and out of the airport to spend money and create jobs, cargo passing through the airport to generate jobs, but the question which remains is how effective this work was in building and maintaining that system.

4. Shaping and Refining the Context

Literature has shown a solid handling of the efficiency issue at the municipality/ownership-level, but it should also be noted that this is tied very tightly to the operations of the operating airlines, especially any hubbed airlines. This remains an interesting area of study for countries with emerging and growing aviation infrastructure, but the problem is that the focus in the United States has shifted away from efficiency being defined at the municipal-level and to a level defined by a paradox: the entire system and the individual flight.

The paradox has manifested itself, one could argue bitterly, in the United States as there has been a large passenger backlash against the airlines, frequently on an individual airline basis. This backlash appears to have reached its zenith sometime in 2008 as major social media, including newspapers, magazines and television, began covering the delay issues, but the kettle of troubles had been boiling for quite some time. The constant press and publicity over the issue, coupled with well documented individual delay of an American Airlines flight in Austin, Texas and Jet Blue's Valentine's Day Crisis of 2007 at JFK eventually pulled United States President George W. Bush into the fray to look at longer term solutions, including caps on the number of flights at the airports in the New York airspace, as noted by Conkey (2007).

However, the airlines are not necessarily at fault, because the operation of the airlines, individually and collectively, is highly correlated with the operation of the airports. Therefore, if one airport is not operating at peak performance, the effects ripple through the entire nation with cascading delays and cancellations, as individual aircraft cannot navigate through their entire flight route for the day. The New York airspace is widely known to be a major culprit for these types of problems, with Conkey (2007) citing as many as 75 percent of all delays in the entire United States system and deeper academic studies on the issue were conducted by Mukherjee (2005) specifically at New York's LaGuardia Airport (LGA), yet the FAA has largely been hamstrung to date to do anything significant about it.

As cancellations and delays ripple through the system, passengers later in the day are left scrambling to find flights to reach their connections and destinations because the system has impacted their flight, which is the one of interest. Exacerbating this problem is that rock-bottom pricing has encouraged more and more people to fly, coupled with higher costs causing the airlines to limit capacity, means there are fewer empty seats to rebook displaced passengers. For the individual passenger, the delays can be far longer than expected, further heightening the angst in, and with, the system.

The reason this paradox exists is because of the way the system has been managed in the past, which has largely been at the discretion of the municipalities under some overarching guidance from the Federal Aviation Administration (FAA), partially driven by the pursuit of funds from the FAA, while at the same time, letting the airlines conduct business largely as they saw fit, so long as safety standards were met. What this created was a series of different management groups optimizing themselves as components of the system instead of optimizing the entire air-travel system; a classic fault of Western management as described by W. Edwards Deming. This fault is explicitly called out and detailed in his System of Profound Knowledge in his book *The New Economics for Industry, Government, Education*, Deming (2000), and the aviation system yielded the predictable result of the inefficient system and the associated realized delays.

The Operational Environmental Basis of a New Proposal

Delay numbers and rates from 2008 and 2009 have shown declines from the 2007 and early 2008 numbers, as shown for the OPSNET 45 airports, the 45 largest airports in the United States by traffic volume, in Figure 1.

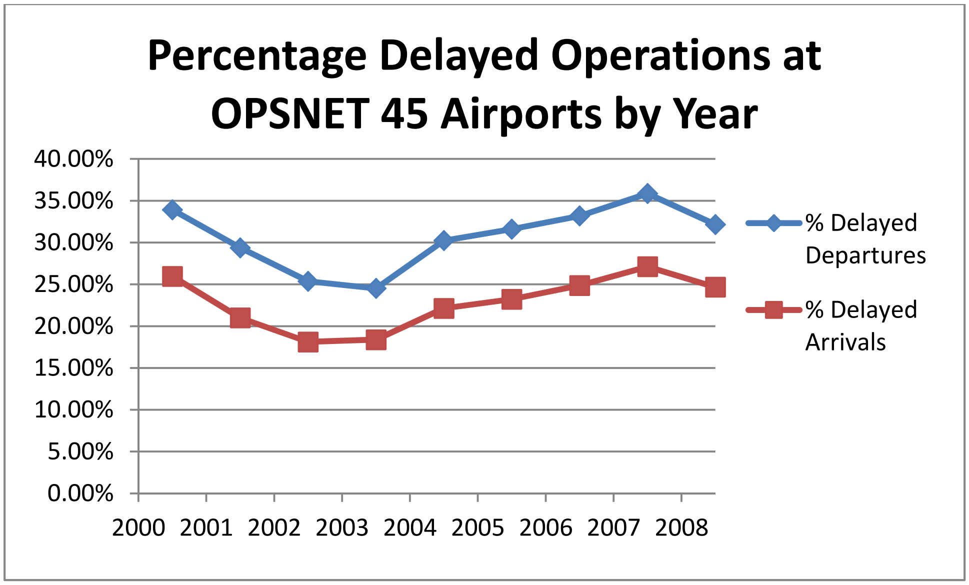


Figure 1: Percentage of Delayed Operations at the OPSNET 45 Airports by Year

The reasons for these declines are likely due to capacity and route cutting at the major airlines due to the deep global economic recession which began in December 2007, as can be seen in Figure 2.

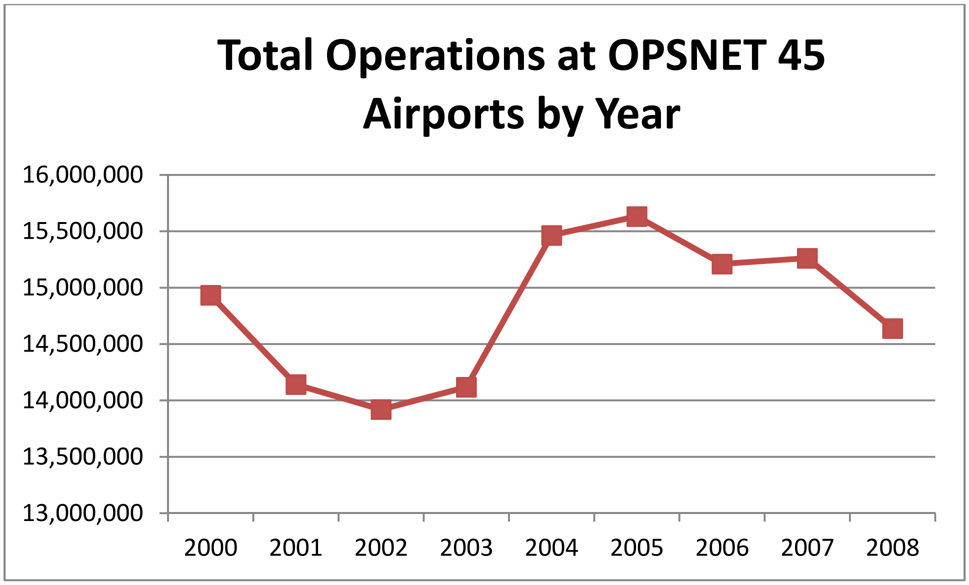


Figure 2: Total Operations Count at the OPSNET 45 Airports by Year

This is likely the case because there is less activity to interrupt, as the delay rate does not scale linearly, as spare runway capacity can be used to prevent delays or to “catch up”, whereas excess flight volumes can quickly flood the system. Therefore, one should not assume that once demand increases coming out of the severe economic recession which has gripped the United States from late 2007 through the period shown in the figure, that the delay problems will not reappear as capacity comes back online, a demand and capacity estimation and handling problem which has been considered by Zelinski and Romer (2007).

Given the backlash sparked by the delays, one has to question what constitutes “efficient operation” of an airport. As noted in the previous section, the literature has defined this to be in a context describing the economic welfare of the municipalities: primarily the ability to get many flights, many passengers and a lot of cargo to generate revenue for the surrounding area. While noble in intent, this does nothing to address the backlash stemming from the delays that these individual optimizations have created.

What is missing from these models is the voice of the individual consumer of the services provided by both the airport and the airlines. Note that there are strong correlations between the airlines and the airports, because the airport has some control over whether or not the airline can operate, such as by having adequate gate space and the capability to handle more flights, but the airline also schedules flights in and out of the airport at attractive times and prices to entice the consumer while working within its own capacity constraints, such as its number of gates and fleet structures. If these value propositions do not match to the point of a sale, the consumer either drops the travel consideration totally, searches for another means of travel, or seeks out another airport and airline in regions served by multiple facilities such as: MIA/FLL, DFW/DAL, or ORD/MDW; note that all relevant airport codes can be found in Appendix 1.

This switch to another airfield, and perhaps another airline, does not benefit the municipality's investment in the airfield, and quite possibly not the airline in question. Therefore, the consumer must be included in the value chain to determine what constitutes efficiency in the airport system.

Identifying and Understanding the Consumer and His Requirements

The first thing that needs to be done to address this efficiency is to understand who the consumers are, because the obvious, and erroneous, assumption is that the consumers are all passengers. While passengers make up a significant part of the consumer group, there are also other entities that use the airline/airport system that must be accounted for, such as mail for the United States Postal Service, air cargo, passenger luggage and overnight packages. These non-passenger items are consumer based because law firms need hard copy documents delivered quickly, electronics makers need lean inventories of chips and other small components under obsolescence pressure reliably moved to manufacturing lines and fresh produce and seafood needs to be moved quickly to avoid spoilage and companies are willing to pay for the speed of air transportation of these items accordingly.

The relationship between all of these items is not only the need and ability to cover vast distances quickly, but the ability to do so reliably. The passenger backlash witnessed in 2007 and 2008 was not about the aircraft not traveling fast enough; it was about the aircraft not getting the customers to where they wanted to be at the time they paid to be there. To some extent this is a reflection of the existing consumer-based economy, but the airlines are in a mature industry which operates in a largely commoditized environment. In this environment, with the associated pricing mechanisms, there is little that separates travel on Airline A from Airline B on a given route beyond perks like frequent flier programs. Therefore, the schedule, and more importantly, the reliability of that schedule, becomes one of the defining metrics for long-term airline survival.

With the understanding that the airlines are in a mature industry, and the understanding that the driving issue is not access to destinations, but instead the reliability to reach those destinations, it can be seen that the existing efficiency models from the scientific literature do not match with the requirements of consumers as expressed by the news and social media, because the scientific literature is focused on the efficiency of generating throughput volume, not the efficiency of generating reliable throughput. With this distinction made, a new theory can be developed.

The Predictable Airline Response

The airline is the “middle-man” in the system, because the airline schedule is what draws the consumer into the airport and is also the provider of service for the consumer, yet all of this occurs within the sphere of influence of the airports. Therefore, if a flight cannot depart because of an airport issue, such as congestion, it is typically the airline that is blamed by the customer, and if there is congestion, the airlines are blamed by the airports for scheduling too many flights. This sets up an ugly scenario for the airlines because they are perpetually “the bad guy” and have to face two different stakeholder groups dictating the airline actions, each having a different agenda.

The key to understanding the dominance in this relationship is that ultimately everything boils down to the paying customer, because they have the money being sought. The airlines, which are for-profit businesses, need to capture that as revenue, and the municipality needs the airport to be used to generate revenues such as landing fees, so the airlines focus on the customers, and working with the airports and FAA as needed, in the interest of working towards as large a profit as possible for themselves.

The existing consumer-based economy has driven consumers in the United States to expect first-class service at coach-class prices. Because of this mindset, products and services in the United States economy have been required to be adapted for consumers, ranging from the fast food restaurant Burger King touting “Have It Your Way” in their marketing campaigns to Dell building custom computers for customers on demand while Amazon.com sells millions of products under one banner, which can be purchased with the click of a mouse, and Amazon then has these selected products delivered to the customer's door under a variety of different shipping options.

Likewise in air travel, consumers base their flying decisions on when they want to fly, where they want to go, how they want to get there and what they are willing to pay for this service; this is both intuitive, and utilized by airlines in their operations research groups, noted by Ross and Swain (2007) in an effort to gain an advantage in the marketplace. Increasingly, consumers have become quite picky, as the commodity nature of the service has forced prices for the airlines to below cost in many cases, as leisure traveler fares are subsidized by higher fare business travelers. These low fares bring in more travelers, and with more travelers comes more demand to fly at different times; however, the marginal cost to transport one additional passenger is very low, if there is an unsold seat, given the associated high fixed costs of flight operation. Therefore, these leisure travelers were a significant means to boost profit as indicated by the large literature body in the field of airline revenue management.

To fulfill this demand, airlines began offering the same routes more frequently to capture more of these customers coming in from the margin. Furthermore, this gave the airlines even more pricing power on the business travelers, because the business travelers generally have less elasticity in their travel plans than those traveling for leisure and are willing to purchase accordingly.

Since the change in customer demand was not drastic, the economics of using the existing fleets to fulfill the increased flight schedule did not make sense. Literally, if nearly full wide-bodied aircraft leaving every four hours were replaced by hourly flights on many routes, and without a huge uptick in demand, it would mean that a large aircraft would only be flying at something on the order of a quarter or third of its possible passenger load. Not surprisingly, since larger aircraft are more expensive to operate and maintain than smaller aircraft, the airlines turned to smaller aircraft for cost containment.

The smaller aircraft chosen are widely known as “regional jets”, and typically seat sixty to one hundred passengers depending on the size of the aircraft and the interior configuration. The other advantage these aircraft have is that, much like compact cars compared to buses, they are significantly more fuel efficient than the larger jet fleets, even some of the newer and smaller jets such as the Boeing 737-series and the Airbus A319-series.

Simple Lean Theory would dictate that more flights on smaller aircraft would be a natural extension to add value in the value chain, as a flight is really nothing more than a batch of consumers being processed in the delivery of a transportation service, meaning that moving towards a batch size of one is both reasonable and expected. Therefore, this is a natural conclusion to any potential change in marginal demand to better serve the consumer by adding value to the value chain, but it must also be remembered that while the trend was already underway, oil prices spiked to levels in 2007 that had not been seen since the 1970s. Analysis of any airline’s financial statements typically reveals that fuel and labor are typically the two highest operating expenses, and with most airlines being under unionized labor contracts, minimizing fuel burn is one of the easiest ways to cut operational costs. This emphasis on minimizing fuel burn put further pressure on the airlines to retire older, larger aircraft, and replace them with smaller, less capital intensive, significantly more fuel efficient, regional jets.

This exact scenario was realized, as the regional jets were far cheaper to own and operate, and allowed for a larger schedule to be flown, while fulfilling other "soft" objectives such as less pollution due to less fuel burn and noise reduction relative to the aircraft being replaced.

A Perfect Storm Brews at the Airports

The structure of the consumer demand, coupled with aging fleets being retired and replaced by the regional jets set up a perfect storm for the airports, because while passenger volumes have increased in the United States, as shown in the table in Appendix 1 from the United States Department of Transportation's Bureau of Transportation Statistics (BTS), the rate of flight increases has far exceeded the passenger growth, despite little growth in capacity at the airports.

What is known, and is clearly shown in Figure 1 and Figure 2, is that the airlines and airports did not handle the increased schedules well, as the delay data shows. Both news media and academia have blamed a large part of the delay problem on the usage of regional jets, by both airlines and individuals, because of a limited amount of runway capacity.

Runway usage and capacity has been studied by economists for over forty years, as a significant body of research appeared in the late 1960s and carried on throughout the 1970s to study pricing models for landing fees to ensure proper allocation of the limited resource. Examples of this research, which was conducted worldwide, include: Borins (1978), Carlin and Park (1969), Carlin and Park (1970), Levine (1969), Little and McLeod (1972), Littlechild and Owen (1973) and Littlechild and Thompson (1977). However, most of this research has been trapped in the realm of theory, as the existing fee structure in the United States is still based upon the landing weight of the aircraft, on an increasing basis. This sets up a problem of valuing the runway itself, because the usage time, the metric of interest, of the runway for a regional jet or a wide-body is reasonably similar as shown by the K-Means clustering of runway occupancy times by Barbas et al (2007).

Barbas et al show that there is a predictable slight increase in usage time to slow down larger and heavier airframes, noting that these occupancy times range from about 30 to 80 seconds depending upon aircraft type, but all aircraft usage time distributions were heavily skewed to usage times on the order of 40 to 60 seconds, with the heavies (Airbus A330, Boeing 747, etc) running an extra ten or fifteen seconds as their weights increase.

Therefore, the fee structure is not indicative of usage, nor proportional, given the vast disparity, as much as eight times difference, in the weights of the aircraft. This fee system further encourages usage of the smaller aircraft more frequently.

The fee issue becomes sticky, because it is effectively a tax, and there are questions about how to levy the tax as well as who actually pays the tax. Brueckner (2002) studied this in detail to determine how much the fee would alter fleeting decisions, and notes that the impact is largely predicated upon the self-interest of maintaining one's own operations versus maintaining systemic harmony, and therefore may do nothing but create additional cost. In this vein, former American Airlines CEO Robert Crandall has advocated a flat fee at a high price to encourage larger aircraft by diluting the fee across the number of passengers on the flight to allow the market pricing of the flights to dictate aircraft size per McCartney (2007).

Other proposals include different versions of these fee structures, including a reversed scale, wherein the fee drops as the number of seats in the aircraft rises, but to date, nothing has been done as there is not even agreement amongst the players as to who can set these policies in the United States, however, Castelli and Ranieri (2007) show how similar European proposals function.

Non-economic approaches to resolve this problem have also been made, focusing directly on the sources of delays in an effort to impact regulatory policy. While FAA attempts to correct the problem have been on policy, including the cap on flights in the New York airspace, the debate rages on, although Hansen (2002) used a delay-based approach to identify “problem child” flights which induced excessive delays on other flights, and the majority of these “problem children" were the regional jets operating on frequent routes, which he proposed using policy to eliminate.

Therefore, there has been an effort made to address the runway crowding problem, and resulting delays, on both policy and non-policy bases without free market economics, but no decision seems imminent, so the existing gridlocked system appears to remain in place.

5. Creating a Case for a New Paradigm for Efficiency Analysis

It appears the gridlock that exists between passengers, airlines and airports on how to reduce delays will remain in place because the existing forces are likely to remain entrenched: consumers are largely unwilling to pay higher fares, consumers value flexibility, airlines need to service consumers to make their profit and the airports are subject to the results of the airline-consumer interaction, so long as that airline-consumer relationship is sustainable. This creates a problem for many of the airports, because with the number and duration of delays having reached peak levels, only to fall likely due to the recession hitting both leisure and business travel, there is no solid solution as it appears that the airlines will keep operating the regional jets on the more active schedule.

The obvious solution for increased demand on the known limited resource is increased runway capacity if there is any measure of capacity constraint.

Given the financial strains that many municipalities are under, the money cannot be readily raised locally to fund improvements, and passengers have rebelled against increases in fares, such as the response to the now common checked baggage fees, so obvious sources for funding of expansions are not readily available. Furthermore, any approval to add capacity carries two problems: first, capacity comes in step-function blocks, so a huge investment may be required for a large block of capacity that may not be efficiently utilized; and second, the addition of runway capacity does not happen quickly, as it literally requires years of environmental studies, approvals and permitting before construction can even begin. To get around these problems, airports have routinely turned to operational solutions to squeeze every last drop of productive capacity from the existing fixed assets at the airport: the runways, taxiways, aprons, etc.

When considering the operations literature available on airport operations, it should be noted that there is a gigantic body of literature available, and that there is a significant crossover of literature bodies. For example, airport operations and airline operations are tightly intertwined, as are airspace sector design and congestion problems with airport operations, as are weather forecasting methods and airport and airline operational responses, or scores of other niches within the overarching body of airport operations. As such, it is not the intent to gloss over enormous areas of the literature, but to focus explicitly on relevant areas to the problem of running a more efficient airport. That said, given the implicit tight correlation between airport operations and airline operations, especially hubbed airlines, a few notes should be made regarding what is studied within the airline literature.

The airline research literature body is vast and spans a variety of operations problems because as noted, the focus of an airline is selling a schedule and fulfilling that schedule with some of the most technologically advanced machinery on the planet. The logistics of actually executing these tasks are staggering. Ignoring the applications on the “business side” of the business, such as the marketing aspects of mining through frequent flier program databases to learn more about passengers and revenue management on seat sales, both of which are heavy areas of research, the actual “operations side” of the business is full of literature related to things such as: route scheduling, recovery from interrupted operations, crew scheduling, maintenance operation scheduling, fleeting, routing, gate management, weather forecasting, business forecasting for things like fuel price hedging, ground scheduling and ground operations studies for between flight activities such as baggage handling, fueling, cleaning and catering. The entire industry is literally a melting pot of activity for operations research activity, and many of these areas touch and interact with portions of the airport operation; therefore, these contact points should always be kept in mind when considering the operation of the airport itself as they do not exist in discrete bubbles isolated from each other.

Beyond the airlines, there is likewise a large body of research on the airport itself, as the airport is not simply a big open area with some long straight roads which are used by aircraft to access the all important runways. The airport is actually a very complicated operation, much like a large interstate highway interchange in a large city, which merges large traffic flows traveling in different directions at different speeds, except that the airport is not local to the ground it occupies. Beyond the ground upon which the airport is sited, the airport actually encompasses the airspace for many miles in any direction, as the management of all of this traffic requires a significant amount of space to slow down aircraft traveling at hundreds of miles per hour for arrival while allowing departing aircraft the ability to clear other traffic to get up to those speeds at cruising altitudes to then be taken over by regional air traffic control centers to keep them on track to their destinations.

This air-to-ground interaction has spawned an interesting field of research which integrates much of the ground operation literature with the open skies literature. As an example, on the departure side, Atkins and Walton (2002) looked at balancing runway usage at Dallas-Fort Worth International (DFW) by looking into the departure fixes to see if there was a geographic-based way to boost runway throughput by ensuring a heterogeneous mix of individual aircraft to departure fixes, to ensure a particular fix was not backed up. By clearing out the fixes, this would ensure there would be no downstream constraint, and the runways could operate with only wake vortex constraints versus having to worry about spacing and timing requirements to, and from, the departure fixes.

Shifting from the departure side to the arrival side, two examples of the air-to-ground interaction are presented. The first, from Simmons et al (2000) is similar to the departure fix paper, but addressed reconfiguring the arrival fixes at

Boston-Logan (BOS) for better throughput of arrivals in the winter. Because of the way the runways at BOS are laid out, in the winter, when the winds shift and come from the north, the arrival runways change over to RWY 27 and RWY 33L, which caused two perpendicular streams of aircraft to require landing clearance into BOS. By combining these two streams into a single stream at an arrival fix, and then splitting the stream, the arrival throughput could be boosted by as much as six aircraft per hour, which is a significant increase.

Another air-based arrival plan was proposed by Haraldsdottir et al (2007) which uses the constraint of an aircraft's stall speed to the advantage of the controller in TRACON by using a series of arced flight paths on arrival in lieu of the piecewise linear approaches currently used. The idea is that aircraft cannot be made to go slower on approach, lest they risk a stall, so by flying wide arcs with the same endpoints as the linear approach, an effectively slower approach speed is maintained with respect to the airport, as more lateral airspace is used, and more aircraft can be packed into the linear airspace to speed arrivals through the arrival procedures.

While the examples of the air-to-ground interaction research are interesting, these solutions tend to suffer from a variety of technical and administrative/policy problems and are difficult to implement because they require advanced navigational equipment and changes to existing procedures, which the FAA has been historically reluctant to change. Likewise, the constant specter of NextGen, the new multi-billion dollar navigational and communication system slated for full implementation in 2025, has caused stakeholders such as airports, airlines and the FAA to be wary of altering any new or upgraded technical equipment, as new systems will be needed to come online with the NextGen system. However, these studies do give some insight as to how to better use existing infrastructure under the Global Positioning System (GPS)-based NextGen, but many of these studies are a little ahead of their time for practical implementation purposes. Therefore, the airports themselves need to look at what they can control, which tends to be related more to their own ground.

One of the biggest areas of research at the airport level in recent years has been in arrival and departure management, known as AMAN and DMAN. Atkins and Walton (2002) addressed the issue in terms of routes in the air to better manage flights for departure, but a significant amount of work has been done addressing the ground-based issues as well. Typically, the constraints to both arrival and departure are wake vortex related.

A wake vortex is a turbulent patch of air from a combination of engine wash and wingtip vortices. This rapid displacement of air from the high-speed passing of the large aircraft frame, especially the wings, creates this turbulent space, which makes it difficult for trailing aircraft to maintain control, similar to how a car can be rocked around on a highway by a large passing truck; but the critical difference is that the car can still steer, as the tires grip the road, whereas the aircraft loses control as the laminar airflow over the control surfaces is compromised. These separations are defined by the FAA and are done to ensure that this turbulent air either passes or calms, such that trailing aircraft can maintain steady airflow over the control surfaces.

Note that other constraints exist in AMAN and DMAN planning, such as Miles-in-Trail (MIT) and Minutes-in-Trail (MINIT) restrictions for aircraft once airborne. These restrictions are most common into heavily controlled airspaces, such as New York, to help smooth arrival demand. But, there are also airport-specific issues, with the dominant one being the need to account for aircraft crossing active runways, which is a common situation for airports which have multiple runways.

Recognizing that an operation, a departure or arrival, occurs at most major airports almost every minute, and more frequently at large airports operating multiple runways, there is a large number of flights to juggle at any instant in time. Therefore, any effort to optimize the system to maximize the usage of the runways will be both mind-boggling to a stressed and overloaded controller trying to juggle all of these flights, and will likely be obsolete within a few minutes as the mix of aircraft awaiting arrival and departure enter the queues for assignment while being further constrained by rules of fairness in runway access.

Researchers recognized this problem and recognized that modern computation was the solution to it, but the IT infrastructure was not in place to handle these grandiose plans. Gosling (1993) introduced the idea of airport surface traffic automation and blocked out some of the parameters and cost structures to actually track aircraft on the ground. A similar concept was brought up by Bohme (1994), and the ideas were advanced by Feron et al (1997) and thoroughly developed into what could be described as a blueprint for a DMAN system. Included in the Feron research were provisions for dealing with aircraft on final approach, the departure schedule, orientation and position of aircraft, parameters of taxiways and the integration of aircraft size and spacing, such that the system could be lifted from the paper and actually be used, versus being a theory.

Development by Feron of the MIT white paper became the focus of several dissertations of MIT PhD students, as the details of the blueprint needed, and were able, to be filled in. One of the important details was recognizing the link between the coupling of arrivals and departures, especially in systems which used parallel runways. This issue was addressed by Anagnostakis et al (2000), which was one of the first to look into the three operations a runway can conduct: arrival, departure and crossing.

As technology and IT infrastructure developed and could supply both the necessary data and solve the resulting optimizations in a timely fashion, a number of other holes in the original Feron blueprint could be addressed. Atkin et al (2007) looked into taxiway geometry as a way to predict taxi-out times at London-Heathrow (LHR) while Balakrishna et al (2007) did a similar analysis in predicting taxi-out times at DTW and DCA in the United States. At the same time, Kaufhold et al (2007) developed a concurrent integer linear program to assign aircraft to runways, while also incorporating ground holds. Likewise, Bohme et al (2007) addressed the issue of incorporating holes into the arrival stream to further boost departure rates.

A lot of the other research has been airport specific, such as the models developed by Anagnostakis to plan crossings, but these models were for BOS, the taxi-out models were specific to LHR, DTW and DCA, and so on. This has led to a fractured research body wherein very elegant, but impractical, solutions are developed, or a solution for a very specific problem at a specific location is developed. Horner (2007) noted this development in an interview with Institute for Operations Research and the Management Sciences (INFORMS) president Cynthia Barnhardt who referred to the ability and desire to optimize a number of individual airline schedules, but not the entire aviation system.

The systemic concept is not a new development, as previously noted with Deming (2000) in his work with systemic theory, which also manifested itself within the integration of components within the development of Feron's DMAN system. Hartman (2001) pointed this out with respect to the operation of the entire airport, stating that the dynamics of large international airports are likely suboptimal because of a lack of integration between air-side and land-side operations.

However, other holistic theories have been developed, largely based upon existing management templates in an effort to branch out further. Schmidberger et al (2009) developed a balanced scorecard for ground handling at three European hub airports and were able to generate meaningful comparisons between the three. Likewise, Fernandes and Pacheco (2007) expanded the scope to a strategic level and proposed balanced scorecard use at the seven major international airports in Brazil and demonstrated a case study of results.

Chapter 2: Model and Efficiency Analysis

Sections 6-8

6. A New Model for Efficiency Analysis

By failing to incorporate the consumer as a stakeholder in the efficiency models and optimizing the components of the commercial aviation system in lieu of the system itself, a systemic failure was likely, especially in the eyes of the consumer as the industry evolved. However, the lack of convergence of the two literature bodies, efficiency analysis and operations research of the airport itself, when coupled with the operating economics driving behaviors in the system, yield an opportunity to create a new way to define and analyze the efficiency of the system. The key to developing a new paradigm is to break down the components of the literature bodies and the behaviors to understand what the critical components are, and to systemically incorporate these components into a new measurement.

Determining the Components of the New Model

Obviously, one of the largest problems has been the lack of incorporation of the consumer, and the biggest problem the consumer has is the issue of delays in the system. Therefore, any new analytical system has to incorporate the reduction of delays into the framework, yet the existing literature bodies do not address the delays directly. The operations research literature body tends to focus more on boosting throughput of the existing systems, which can indirectly reduce delays, noting that there are papers across the breadth of the scale which do look at delay reduction directly, such as in fleet routing, the swapping of aircraft on a route can eliminate a delay by shifting schedule slack, but this again gets back into the previously noted airport-airline correlation area. An example of this can be seen in the method of route augmentation and exchanges proposed by Arguello et al (1997) and their associated extensive review of literature body in the research area.

Likewise, the efficiency models largely do not touch the issue, as a deeper dive into the outputs shown in Table 2 to analyze the output on delayed flights shows very little in the way of incorporation of the delays into the efficiency models, as shown in Table 3. Note these delays are listed as "timely movements", because the treatment within the models varies and the "timely movement" is a more generic and less leading term.

Authors	Year	Movement Counts	Timely Movement Outputs
Gillen and Lall	1997	X	
Parker	1999		
Sarkis	2000	X	
Pels et al	2001	X	
Fernandes and Pacheco	2002		
Bazargan and Vasigh	2003	X	X
Pels et al	2003	X	
Sarkis and Talluri	2004	X	
Yoshida	2004	X	
Yoshida and Fujimoto	2004	X	
Yu	2004	X	
Lin and Hong	2006	X	
Barros and Dieke	2007	X	
Fung et al	2008	X	
Pathomsiri et al	2008	X	X

Table 3: Timeliness in the Outputs of the Literature Models

Table 3 shows that only two of the referenced efficiency papers deal with delays, so further development is needed in this regard. Gillen and Lall (1997) referenced this problem by stating that delays and cancellations were a part of any existing aviation system and should be integrated into models as inputs. This thinking implies that they can be treated as “costs” of operating the schedule. Bazargan and Vasigh (2003) incorporated this idea into their model by using the on-time flights as an output, but Pathomsiri et al (2008) went in a different direction, bypassing traditional BCC and CCR DEA methods and using a Directional Output Distance Method, so as to incorporate a “penalty function” against airports with large numbers of delays.

These two methods directly address the delays in the efficiency model, shifting the issue in how to define what should go into each of the models. Returning to the output table, Table 2, both Bazargan and Vasigh (2003) and Pathomsiri et al (2008) use passenger counts as an output, but the economic analysis has showed that the airlines have found more cost efficient ways to utilize their networks with the more frequent operation of the smaller and more fuel efficient regional jets, thus exploiting the value of the passenger count, and to a lesser extent, other aircraft contents such as cargo.

Looking at this in more detail, the problem at the airport appears to be the number of flights, which have increased disproportionately to the number of passengers, indicating that there are fewer passengers per flight. This would seem to be a problem, but the technological development of the regional jet has made the cost curve of flight operations shift such that the passenger count is less important than it was in the past. As a result, airlines are choosing to fly more frequently, and since the airlines are for-profit, these flights must be taken to be maximizing the airlines' profit, otherwise they would not be flown. Taken to the extreme, this presents an interesting problem for both the airport and literature, because airlines would fly the aircraft empty if it were profitable.

Therefore, the airport, regardless of what is onboard the aircraft, must still allow the aircraft to land and depart from its facilities as the only constrained facilities in the United States are the four slot-controlled facilities (ORD, LGA, JFK, DCA), while all others operate under the open skies policies that allow airlines to schedule at will.

This means the outputs for cargo and passengers are actually not airport-specific, they are highly correlated to the fleet and schedule structures of the airlines. As such, any model of efficiency should return to the underlying concern, the delays, or ability to process the aircraft placing demand on the runways, which remain the resource to be protected, not the contents of the aircraft on those runways.

This focus on processing aircraft also sets up and interesting look on how to approach the inputs of the model, because the driving issue is processing aircraft so as to protect the runway as the constrained resource. Since passengers are largely irrelevant, as they, much like boxes in cargo containers, are simply contents of the aircraft which need to be processed and are independent of the airport, many of the inputs likewise can be peeled away from the models both from a theory side and from a correlation side. As an example, if passengers are no longer a consideration, the handling of their baggage becomes moot; furthermore, the handling of baggage is an airline function, meaning the airport-airline correlation also appears again.

However, this is a useful point for modeling purposes because it allows for further cutting of the inputs and outputs of the model. Keeping in mind that the airlines must operate at a profit, the schedules the airlines make must take into account the ability for the airlines to process their own aircraft. Since airlines lease or own their own gates outright, this means the airlines must schedule predicated upon the ability to use their own gates and ground turning functions, such as catering, cleaning, baggage handling and fueling, meaning all of these functions, and their associated input streams, can be lumped into a group of “airline considerations”.

These considerations enter into that vague correlation area, but by removing this block of potential input candidates, the problem becomes much clearer: the efficiency of the airport is predicated upon the operation of the airside, as all of those considerations were part of groundside activity. Therefore, only airside activities and results need to be considered.

Since airports are largely fixed assets in nature, a point which will be addressed later, the inputs to this model reveal themselves when simply looking at the airside. The airside is dominated by the runways, which is obvious, leaving the taxiways and aprons as the only other ground-based options for model inclusion. However, taxiways and their usage are heavily driven by which runways are being used, so there will be heavy correlation with the runway, rendering the taxiways redundant. Note that this line of reasoning also encompasses the terminal airspace, as the routes in and out of an airport are tightly tied to the runways, and are typically perfectly aligned with the runway, but on a known slope, known as a glide path. As such, terminal airspace is correlated with the runway as well as the taxiways.

Likewise, the apron, the big “parking lot area” where the gates and buildings are located, is largely driven by the management of the gates, which is a previously noted airline function. This means the runways are the only significant input, although this point will be further developed and refined, as this conclusion in its existing state would argue for a capacity-based model.

Returning to the outputs, with the focus on the airside, the outputs clearly present themselves. Remembering that the problem being faced is the number of aircraft, and whether those aircraft are moving in a timely fashion, a question can spell out the necessary outputs for study: what do runways do? This elementary question actually sheds significant insight into the problem, because runways exist to allow aircraft to build and drop speed to depart and land, respectively. Since the problem is the number of aircraft departing and landing, counts of these activities become valuable, yet the consumer must be integrated into this mix, and the consumer cares about late departures and arrivals. This yields four outputs from the airside.

Building a New Model

Analysis of any of the papers referenced in Table 1 yields a surprisingly simple way to measure efficiency, a ratio of inputs to outputs. All of the models in those papers boil down to a ratio that can be generically described as:

$$Efficiency = \frac{Outputs}{Inputs}$$

With this in mind, given the model has been refined to account for different input and output streams, and as stated thus far, incorporating the airside measurements, using the Bazargan and Vasigh (2003) method of counting the timely operations in lieu of the delayed operations, yields the following, shown non-weighted for proof of concept:

$$Efficiency = \frac{Total\ Departures + Total\ Arrivals + Timely\ Departures + Timely\ Arrivals}{Number\ of\ Runways\ Available}$$

On an actual DEA basis, this expression will not hold, because of the need for similarity of units, as well as the need to create flexibility in tradeoffs between inputs and outputs, similar to pricing the inputs and outputs. Therefore, the weighted version, with weighting terms W, of this expression becomes:

$$Efficiency = \frac{W_{TotDeps}TotDeps + W_{TotArrs}TotArrs + W_{OTDeps}OTDeps + W_{OTArrs}OTArrs}{W_{Runways}Number\ of\ Runways\ Available}$$

Where, Deps, Arrs, Tot, and OT are abbreviations for departures, arrivals, total, and on-time respectively. This appears to be similar to a capacity model, but is predicated upon existing data, as the aircraft would actually have to be counted to get the output values in the numerator, meaning this is actually a post-hoc value. However, as previously noted, this assumes that the runway term is fixed, and in fact, at many airports it is not; therefore, the model is incomplete.

The Airport Versus the Operating Configuration

Airports when viewed from above are huge open spaces of land which are filled with long straight strips of pavement which serve as runways and other long strips which serve as taxiways, however, the alignment of these strips of pavement actually produces very interesting changes in how the airport operates. The reason for this is because fixed wing aircraft require their wings to generate lift for flight, and that lift is created by using the wing to split an oncoming air stream to create a vacuum over the top surface of the wing. Since nature abhors a vacuum, the air underneath the wing "pushes up" to fill the pressure void, thereby pushing on the bottom surface of the wing, creating the lift.

To create this pressure differential, speed is needed to generate the necessary airflow over the wing. Since the generation of lift is about pressure differences, the key is not about the speed itself, but the volume of air relative to the wing surface. This creates a tradeoff, in that speed can introduce more volume, but the problem is that the creation of speed requires more space on the ground to roll, meaning a longer runway is needed for a given aircraft.

To counter this problem, aircraft typically depart and arrive into a headwind. The reason for this is that without moving, air is already being forced over the wing just by being aimed into the wind. This means that an aircraft can reach its threshold speed, the speed at which it lifts off the ground, at a lower ground speed. This means that less runway is required, so there is an additional factor of safety, and there is a reduction in noise directed across the ground from the engines.

The key point from this explanation is that prevailing winds dictate which direction arrivals and departures take place, so the orientation of the runways dictates which ones are heading into the wind and can be used. This selection of which runways to use, and how to use them, is known as the “operating configuration of the airport”. Throughout this paper, the “operating configuration of the airport” will be referred to simply as “the configuration”.

Configurations at many airports, especially newer airports are typically similar to the layout of the airport itself. As an example, a satellite image of ATL from Google Maps is shown in Figure 3.

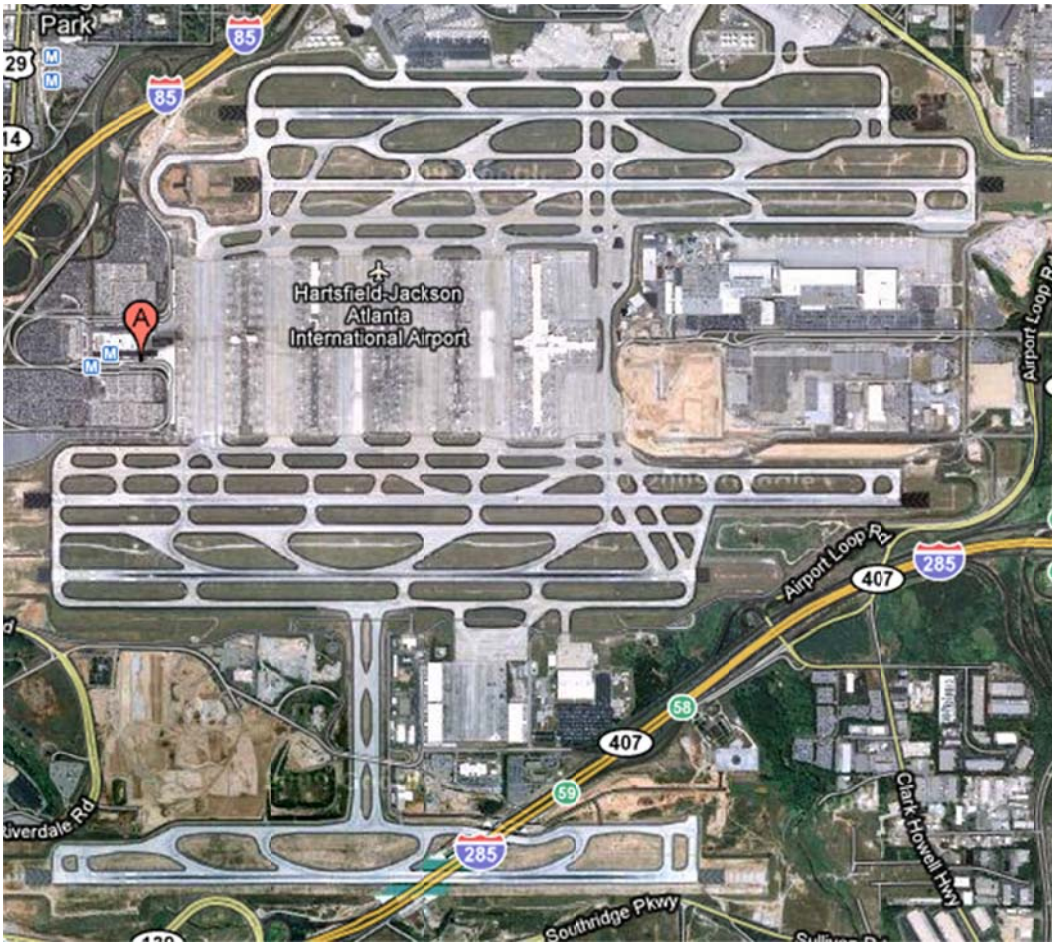


Figure 3: Satellite View of ATL

It can clearly be seen in Figure 3 that all five runways are oriented in an east-west configuration, so at ATL, the layout of the airport likely is the same as the configuration.

However, this is not the case, as can be seen at other large airports such as MSP, as shown in Figure 4.

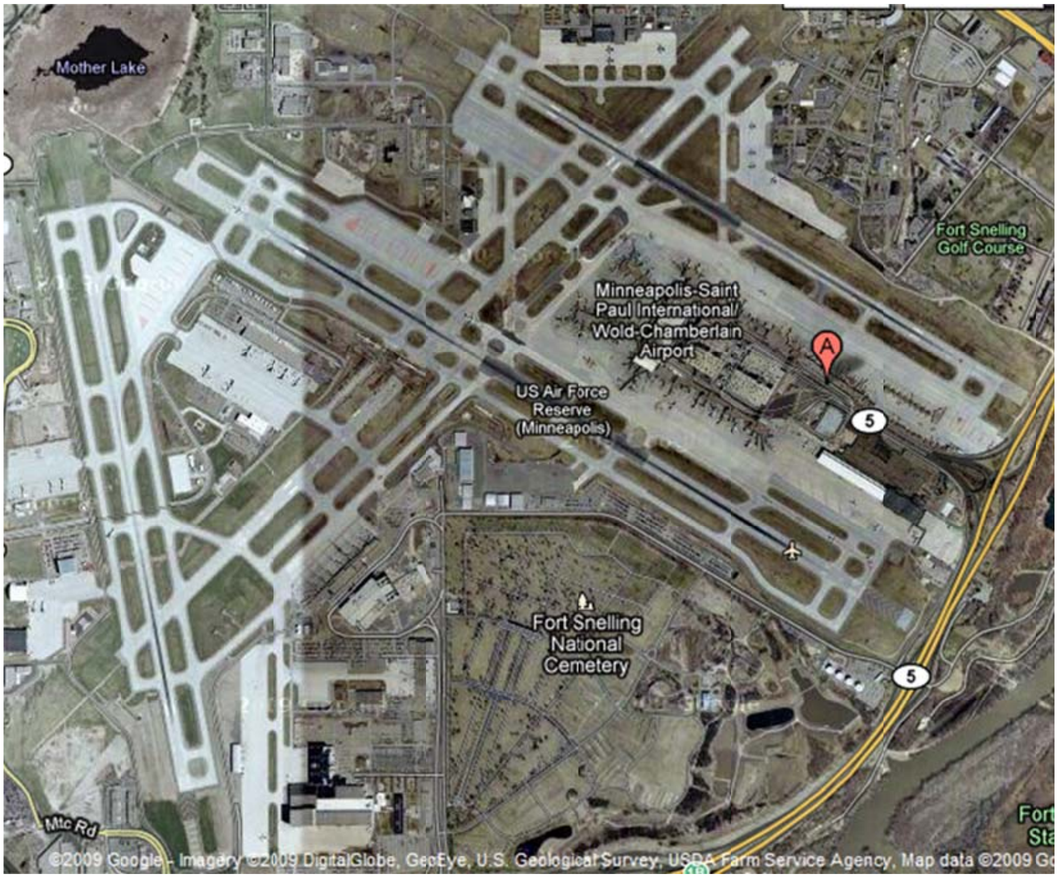


Figure 4: Satellite View of MSP

Figure 4 shows four different runways at MSP, running primarily along a northwest to southeast layout, but with a crossing runway which runs perpendicular to that direction. Therefore, using all four runways at one time would be very difficult, because of all of the crossing involved; as such, it does not occur in practice. However, the effect becomes even more pronounced at an older airport, such as BOS, shown in Figure 5.

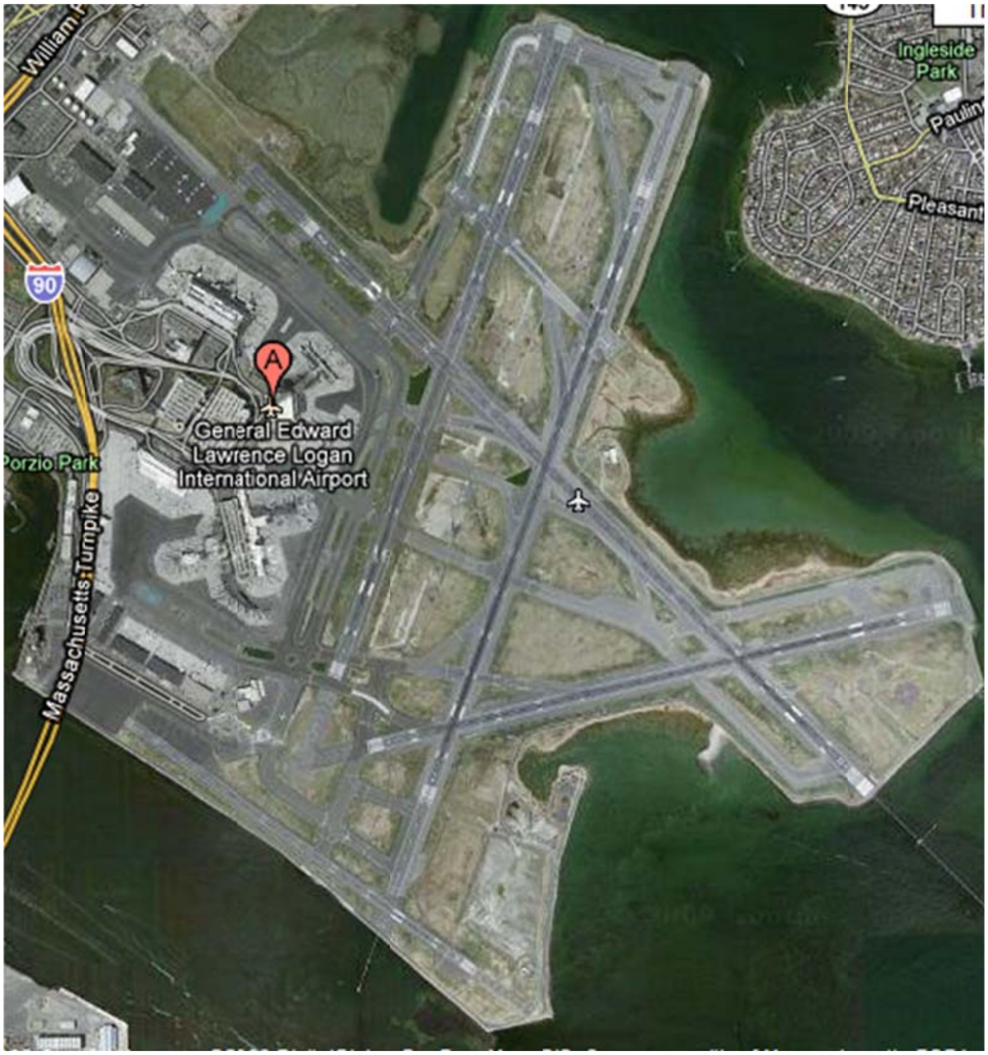


Figure 5: Satellite View of BOS

Figure 5 shows that BOS has six runways laid out such that all points of the compass are covered, as there is no dominant direction, and in practice, at most three can be readily used at any one time given the amount of crossing which would be involved.

Therefore, the inputs in the denominator of the efficiency calculation cannot be assumed, it must be adapted to the runways in use, and tied to the aircraft these runways handle. As such, two additional dimensions must be added to the inputs: how long the runways are in use, as the usage shifts predicated upon weather and other factors, and a modifier, like a price, to convert the two dissimilar terms into a standard unit. The revised expression is first shown without the modifier for concept, followed by the weighted version with weight terms, W, and using the previous nomenclature:.

$$Efficiency = \frac{Total\ Departures + Total\ Arrivals + Timely\ Departures + Timely\ Arrivals}{Usage\ Time + Number\ of\ Runways\ Used}$$

$$Efficiency = \frac{W_{TotDeps}TotDeps + W_{TotArrs}TotArrs + W_{OTDeps}OTDeps + W_{OTArrs}OTArrs}{W_{Time}Usage\ Time + W_{Runways}Number\ of\ Runways\ Used}$$

However, even this formulation is not correct, because while the count of the runways in use is relevant, there are differences in how these runways are used. This indicates an additional layer of complexity is needed in the model.

Analysis of Runway Usage

The previous analysis of the runways showed that the number of runways in use is a significant factor in the efficiency calculation because the number of runways in use changes based upon the orientation of the wind. As such, a time weighting variable was assigned to the number of runways in use, because that number might change between configurations. For the airports shown in the three figures, Figure 3, Figure 4 and Figure 5, these configuration numbers could range from anywhere between two and five runways in operation, despite the fact that the geography of the airports as shown dictate that the fewest number of runways available is four, at MSP.

However, the other open question this leaves is how the runways are actually used, which creates yet another question as to what “the correct number” is for the number of runways in use in the denominator of the efficiency ratio. Simply watching different airports process aircraft operations throughout the day shows there are three different ways to use a runway: dedicated to arrivals, dedicated to departures and processing both arrivals and departures, which is known as “mixed mode” or “mixed operation”.

There are a variety of different reasons for using one method over the other, such as lumpy demand cycles, which are common with hubbed airline banking wherein there is significantly more demand for arrivals than departures, which is then followed by a period of more departures than arrivals in the hub-and-spoke system; but there are also airports which operate in dedicated or mixed modes all the time. Using the three airports referenced in Figure 3, Figure 4 and Figure 5, a dominant configuration of these three airports, by total operation counts from 2008, are shown on their respective FAA Airport Diagrams in corresponding order. Note that the configuration name and numerical values will be explained in more detail in Section 7.

Note that in these diagrams, the colors and arrows indicate both the direction of flow and the usage. As a visual guide, the arrows are like the wings of an aircraft, and are used to show the average location on the runway wherein there is a change in the relationship between on the ground and in flight, pointing in the direction of travel. Therefore, a yellow runway has the arrow at the beginning of the runway, indicating it is used for arrivals, using the runway length to slow down on the ground, while the green runway has the arrow at the end of the runway indicating it is used for departures, indicating the length of the runway is used to speed up to reach the threshold speed to become airborne. The exception to this is the red runway which has the arrow in the middle, to indicate that it is used for both arrivals and departures, meaning that average position is somewhere in the middle.

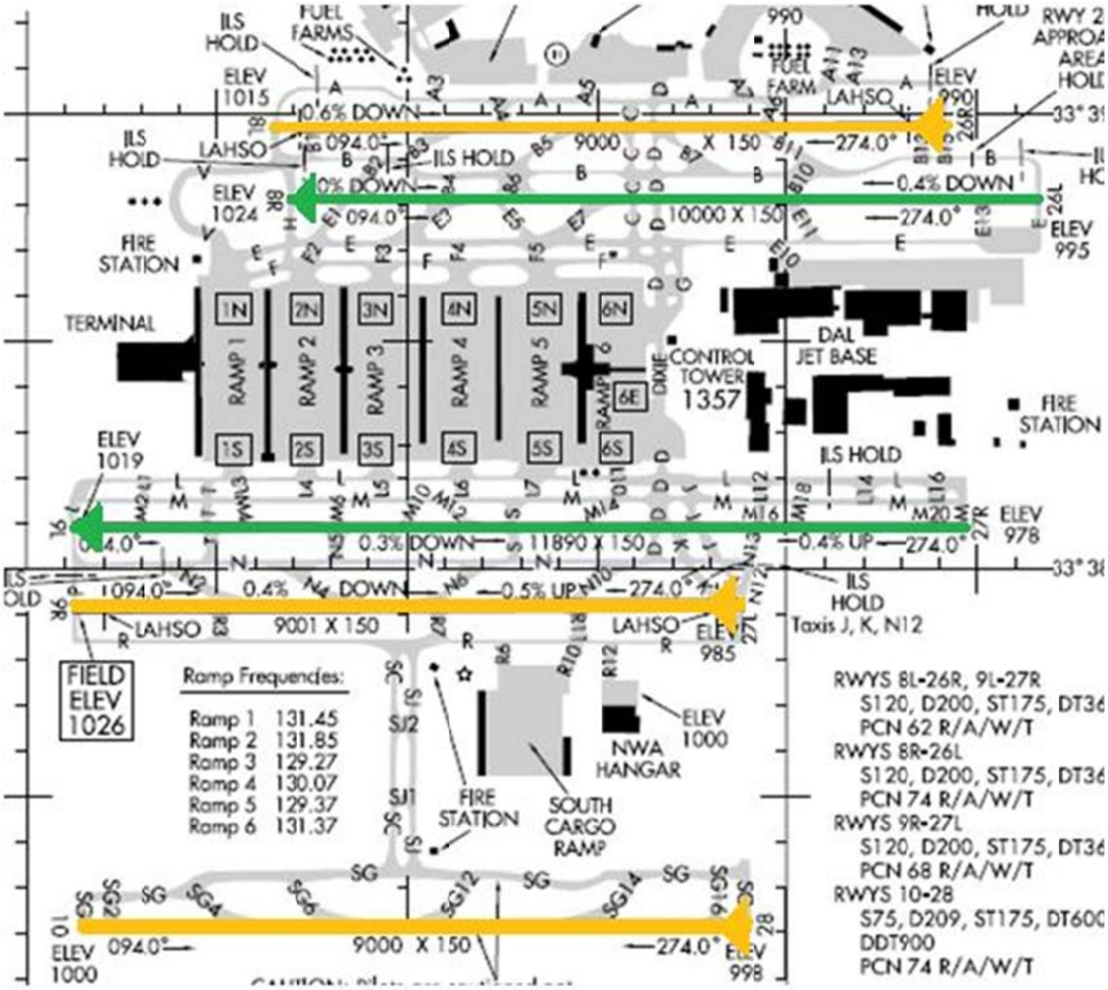


Figure 6: ATL 26R, 27L, 28 | 26L, 27R (52.2 Percent of Total Operations)

Figure 6 shows ATL uses a westbound configuration over half of the time, and it is fully in a dedicated mode of operation, with three runways for arrivals and two runways for departures.

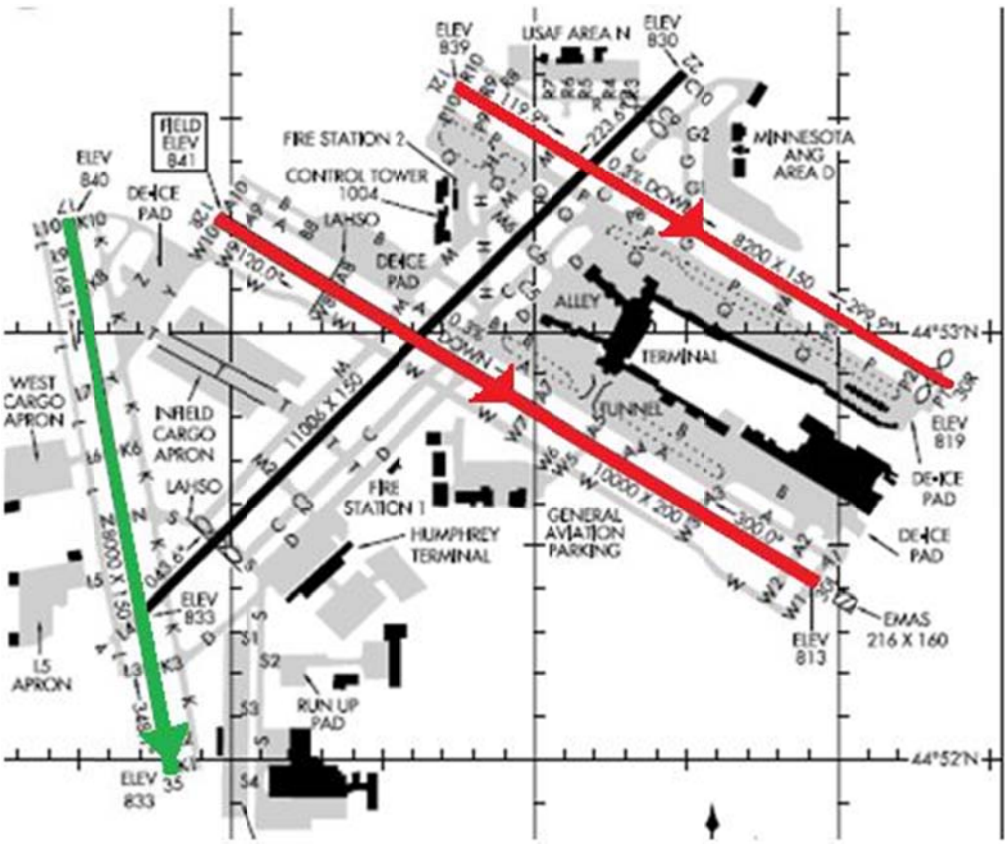


Figure 7: MSP 12L, 12R | 12L, 12R, 17 (39.4 Percent of Total Operations)

Figure 7 shows MSP uses a southeast-bound configuration about two-fifths of the time, but unlike ATL, it incorporates mixed mode operations, with two runways operating in mixed mode and the other active runway dedicated to departures.

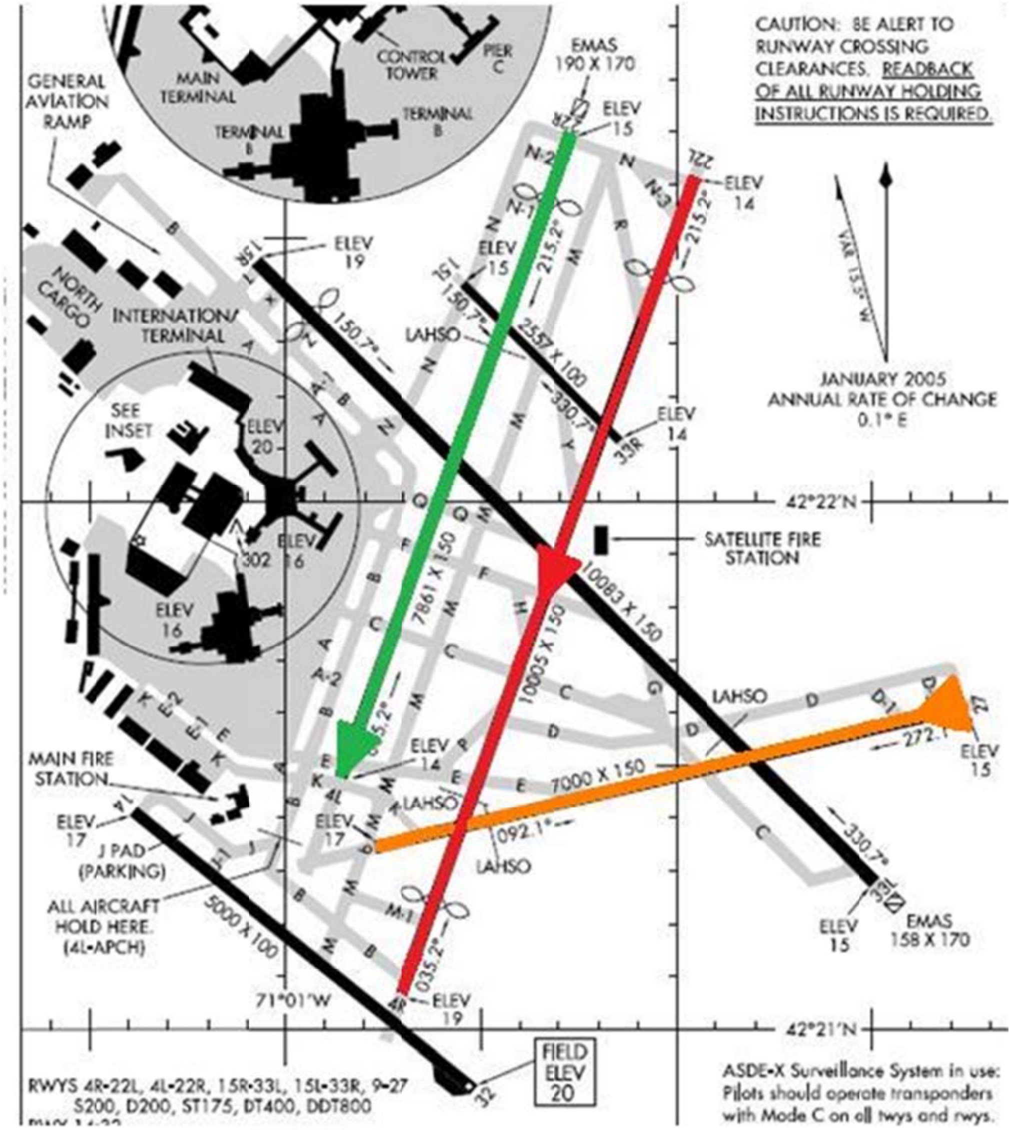


Figure 8: BOS 22L, 27 | 22L, 22R (14.3 Percent of Total Operations)

Figure 8 shows one of the many configurations BOS uses, and the configuration shown represents about a seventh of the time, and it uses one runway of each type: one dedicated for arrivals, one dedicated for departures and a runway in mixed mode operation.

These three figures represent just a small fraction of the possible number of potential ways to operate a given airport, but are actual configurations in use, which follow Lean principles such as the minimization of interaction between lines, meaning an effort to minimize crossing, which is important for both safety purposes to prevent incursions, as well as to minimize taxiing, which incurs additional transportation and thus more fuel burn for the affected aircraft.

It should be noted that mixed mode is much more common throughout Europe, where the airports are nowhere near as large and expansive as they are in the United States, indicating that there may be a case for mixed mode operation being more efficient than dedicated runway usage. Either way, these differences in operations of the existing runways offer an interesting insight into the airport efficiency question, because it moves the research analysis away from a pure capacity question, effectively a “return on capacity”, to include the question of the management of that capacity to determine if there are significant operational differences as well.

By including the three different uses of runways, as runway counts, the generic efficiency ratio again needs to be updated. Again, the model is shown without the necessary weight modifiers for concept:

$$Efficiency = \frac{Total\ Departures + Total\ Arrivals + Timely\ Departures + Timely\ Arrivals}{Usage\ Time + Departure\ Runways + Arrival\ Runways + Mixed\ Runways}$$

And with the weighting terms, W, a configuration efficiency metric is formed:

$$Efficiency = \frac{W_{TotDeps}TotDeps + W_{TotArrs}TotArrs + W_{OTDeps}OTDeps + W_{OTArrs}OTArrs}{W_{Time}Usage\ Time + W_{DepRWY}Dep\ RWY + W_{ArrRWY}Arr\ RWY + W_{MixRWY}Mix\ RWY}$$

Where, RWY and Mix stand for runways and mixed mode respectively.

7. Sources of Data and Model Refinement

With the efficiency ratio in hand which describes the operational efficiency of the airside, the next step is to ensure that the data is available, or find a way to get it. Fortunately, as referenced in the Literature Review, the period from the late-1990s through the mid-2000s brought about a significant amount of growth in the information technology infrastructure in aviation. In this timeframe, new technology was brought online for things like “ground surveillance”, a term used by Gosling (1993), which allowed aircraft to be electronically tracked while taxiing before departure or after arrival, giving huge insights into where aircraft were, and therefore, where delays were occurring. This data was then coupled with flight data and fed to a variety of databases maintained by the Federal Aviation Administration (FAA) for both ground-based and airborne traffic analysis.

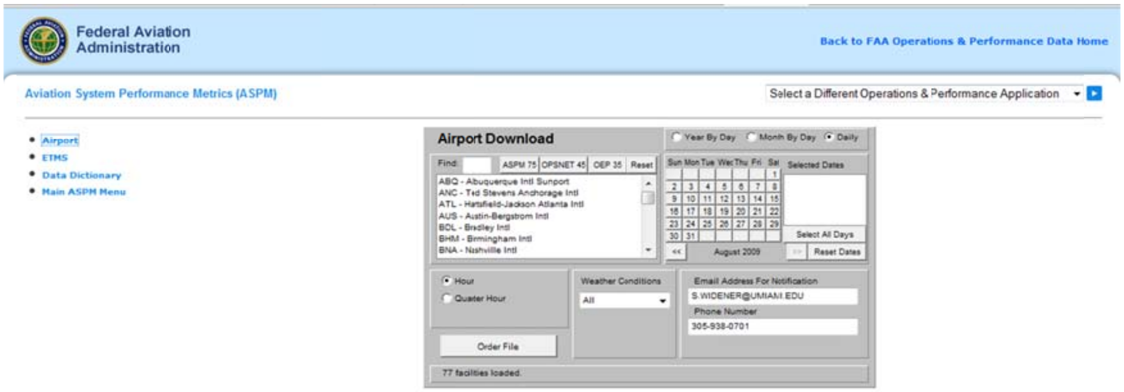
Selection and Acquisition of the Data

To get the necessary information for the efficiency ratio, the Aviation System Performance Metrics (ASPM) database was referenced, and the summary description of the database from the ASPM's own system overview is excerpted below:

> The Aviation System Performance Metrics (ASPM) online access system provides detailed information on individual flight performance for the ASPM Carriers (currently 29), and airport efficiency data for 77 U.S. airports. It is a source of preliminary next-day data on system performance, as well as rich detail for retrospective trend analysis and targeted studies. The database is compiled piece by piece beginning with basic flight plan and message data for flights captured by the Enhanced Traffic Management System (ETMS), enhanced with next-day OOOI data for a key set of airlines, updated with published schedule data, and further updated and enhanced with BTS Aviation System Quality and Performance (ASQP) records which include OOOI data, final schedule data, and carrier-reported delay causes for the largest U.S. carriers. ASPM includes records for the vast majority of commercial flights for the ASPM airports, and for ASPM carriers regardless of airport, providing a robust picture of air traffic activity for these airports and air carriers.
>
> ASPM records fall into two groupings: Efficiency Counts and Metrics Counts. ASPM Efficiency Counts include the full set of ASPM records, including those that are missing one or more pieces of key data. In contrast, ASPM Metrics counts only include complete records and records for which accurate estimates are possible for the few pieces of missing data. Metrics counts exclude most General Aviation and Military flights, as well as records for international flights that only include data associated with the arrival or departure to/from the U.S. airport. ASPM Metrics Counts are a subset of ASPM Efficiency counts. The purpose of these two groupings is to allow for a more complete traffic count (Efficiency Counts) while ensuring that only records with fully specified flight information are used.
>
> The components of today's ASPM have been developed and extensively examined over many years by stakeholders, including FAA internal organizations and many of the major airlines and aviation research groups. Each step of the ASPM process has been debated, tested, and tuned. At each point, our goal has been to implement decision rules that result in the most complete and valid representation of air traffic possible given the quality and quantity of data available.

The description of the database shows that there are two sets of data available, a set of metrics, which are based upon efficiency count data, and the efficiency count data themselves. The data of interest is the efficiency count data, which can be broken down, by airport, into quarter hour blocks, rendering a reasonable degree of resolution in studying the changes in the configuration of the airport through time, as significant change in weather, or other flight operating conditions, rarely occur within a fifteen minute block of time.

To study these configurations and the resulting efficiency counts, within the database is a download section, which allows for the vast amount of data to be sent electronically to the user authorized by the FAA, instead of generating individual daily or hourly reports. A screen shot of this interface is shown in Figure 9.



○ Year By Day ○ Month By Day ● Daily

● Hour
○ Quarter Hour

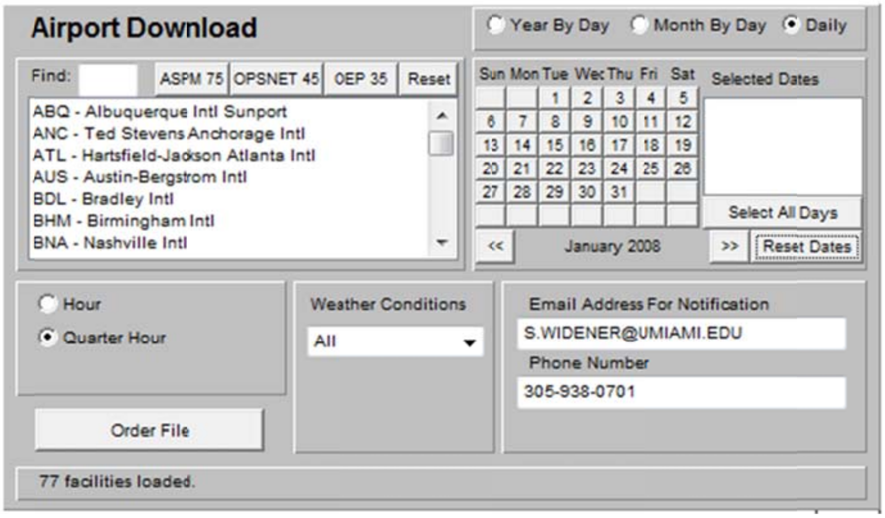
Weather Conditions: All

Email Address For Notification: S.WIDENER@UMIAMI.EDU

Phone Number: 305-938-0701

Figure 9: The ASPM Download Interface

Figure 10 shows a cropped and zoomed version of the Figure 9 screenshot to concentrate on the grey download box for further discussion.



Airport Download

○ Year By Day ○ Month By Day ● Daily

ABQ - Albuquerque Intl Sunport
ANC - Ted Stevens Anchorage Intl
ATL - Hartsfield-Jackson Atlanta Intl
AUS - Austin-Bergstrom Intl
BDL - Bradley Intl
BHM - Birmingham Intl
BNA - Nashville Intl

January 2008

○ Hour
● Quarter Hour

Weather Conditions: All

Email Address For Notification: S.WIDENER@UMIAMI.EDU

Phone Number: 305-938-0701

77 facilities loaded.

Figure 10: A Larger View of the Download Box

The grey download box shown in Figure 10 shows a variety of options for information which can be requested from the ASPM database, according to how the user needs the data displayed. In the case of studying configurations to understand the delay and usage problem, a significant amount of data was needed to see where changes in the system occurred, and as a result, the quarter hour option was needed for every airport on every day for the period under study. This means a huge avalanche of data is required to address the problem, so a few notes on how the data was scoped are in order.

The largest assumption made was that of which set of airports to use. Within the download box, there is a field with a scroll bar, and within that field is the list of all 77 airports within the ASPM. The option to use all 77 airports is perfectly valid as it would yield a large and overarching dataset encompassing most of the airfields in the United States, but this choice creates two problems that require a bit of insight on the problem to understand.

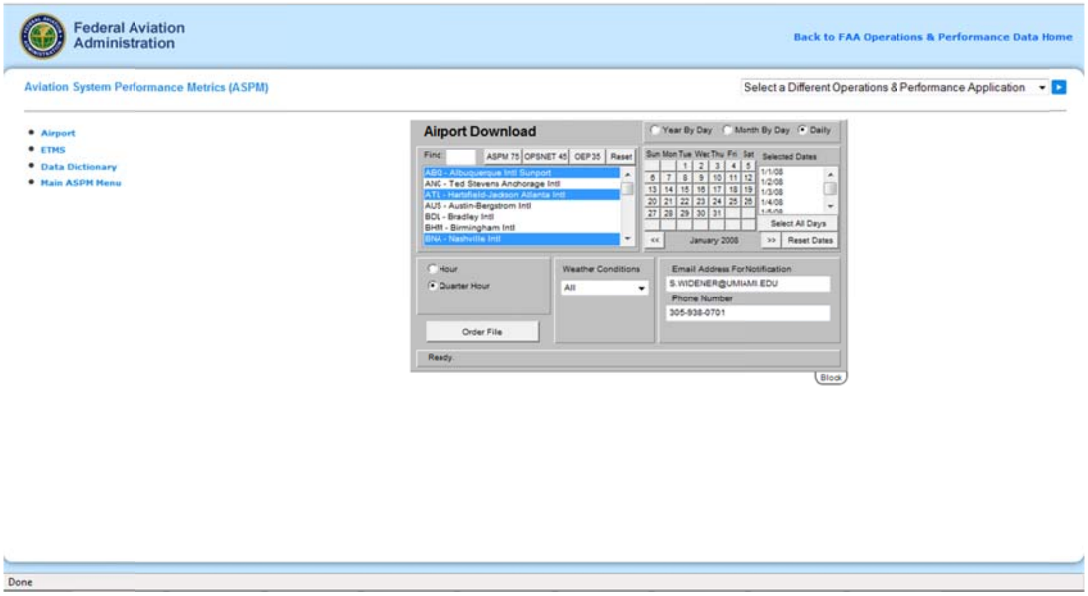
The first problem is that of how realistic it would be to compare huge international airports with hundreds of operations per hour, such as ATL and ORD to smaller airports like Dallas-Love Field (DAL) and Long Island Macarthur (ISP) given their significantly different flight loads, both in quantity and types of aircraft processed, as well as their operations. This discrepancy is further heightened by the lack of data available in the early years, as the ground surveillance systems were introduced, meaning that direct year-over-year comparisons cannot be reliably made.

Second, is the sheer quantity of data involved coupled with the understanding as to how the variables of interest change. The configurations themselves move very little, as significant changes in the configurations typically require new construction, and a new runway for a given airport is a once in a decade sort of event, and it is worth noting that there was a significant period of runway expansion during the George W. Bush presidency, so many of the larger airports did see changes in their configurations through time. Likewise, weather patterns operate on an annual cycle, so multiple years of data would be needed to see the impact of seasonal weather on the airport operations over time.

In both cases, years of data are needed, but the data is also needed in quarter-hour blocks to get the necessary resolution to see how the individual configurations operated. This set up an ugly situation, wherein each airport generated 96 data points per day, with 365 or 366 days per year (leap year dependant), and multiple years of data were needed. Therefore, a reasonable way was needed to handle, and process, this sheer quantity of data. At the top of the airport box in Figure 10, there are four buttons, labeled, “ASPM 75”, “OPSNET 45”, “OEP 35” and “Reset”, and each of these helped to further scope and refine how to solve this dilemma. Note that the “Reset” button does exactly what its name implies, in that it resets the selection within the box, but the other three buttons select a subset of the available airports, which are detailed in Appendix 2.

The ASPM button selects all of the airports to prevent the necessary clicking within the Java interface, but the other two allow for a significantly reduced subset of data, and are predicated upon historical sets of data which were used by the FAA to study the airports. The OEP 35 airports comprise roughly 70 percent of the entire passenger volume in the United States according to the FAA, and as such, are frequently the first facilities which see any new improvements in infrastructure, such as the ability to track aircraft on the ground. This means that these airports should have the most reliable data as far back as possible. However, the OPSNET 45 airports comprise all of the OEP 35 airports plus ten other major airports, and allows for a full comparison to any queries into OPSNET, the Operations Network, maintained by the FAA. Given that handling an extra ten airports is not a huge undertaking, it was decided that the OPSNET 45 was a better selection than the OEP 35 as it encompassed more facilities, which were still similar in size and operation to the OEP 35 airports to maintain a reasonably homogeneous airport set, while also ensuring complete compatibility with OPSNET if needed.

All that was needed was to gather all of this information for the OPSNET 45, by year, for analysis, and the download box was set up accordingly, as shown in Figure 11.



○ Year By Day ○ Month By Day ● Daily

ABQ - Albuquerque Intl Sunport
ANC - Ted Stevens Anchorage Intl
ATL - Hartsfield-Jackson Atlanta Intl
AUS - Austin-Bergstrom Intl
BDL - Bradley Intl
BHM - Birmingham Intl
BNA - Nashville Intl

Selected Dates: 1/1/08, 1/2/08, 1/3/08, 1/4/08

○ Hour ● Quarter Hour

Weather Conditions: All

Email Address For Notification: S.WIDENER@UMIAMI.EDU

Phone Number: 305-938-0701

Ready.

Figure 11: The Prepared Download Box

A file was ordered for each year as far back as the ASPM data ran in full year blocks. At the time of the analysis, this meant 2000-2008, inclusive. Upon receipt, the database would process the requests and send a link to the resulting zip files by e-mail, within fifteen to thirty minutes. The zip files for the annual OPSNET 45 data were huge given readily available desktop hardware, about 1.1 gigabytes each, and these compressed database files were converted into Microsoft Access databases for easier handling.

Processing the Data for Use-Numerator

Upon conversion to the Access format the data could be readily navigated and queried to yield information useful in extracting out the numbers of flights and the configuration of the airport processing those flights. This information, along with a host of other information was readily available in the database, as indicated in the ASPM Data Dictionary, shown in Appendix 3 and a listing of who reports into the databases in Appendix 4.

Looking through the field definitions in Appendix 3, it can readily be seen that for the terms required for the efficiency computation, multiple columns of numbers were going to be needed. For purposes of this discussion, note that each of the rows in Appendix 3 is labeled, corresponding to a column number within the database, and that columns one through five supply the location, date and time information necessary to track the data.

The numerator of the efficiency computation is focused around exactly what the database was designed to do: count aircraft. Therefore, what is needed are the columns that give the counts of these aircraft. As a reminder, the terms sought are: Total Departures, Total Arrivals, Timely Departures, and Timely Arrivals. However, the database does not readily supply these values, because there are different ways to count different aircraft, depending upon the definitions used to classify a given aircraft. These classifications are primarily centered around the concept of assigning a delay cause, and as a result, many of the columns contained in the databases are full of the associated data to allow research accordingly. However, what is needed for the purposes of determining the efficiency of the configurations is not where, how or why the aircraft were delayed, but simply if they were processed; therefore, what is needed is a holistic count. Furthermore, this holistic count needs to be based upon the FAA operational definition of a delayed flight, which is any flight that is fifteen minutes late or more for departure or arrival.

Using this FAA definition the four needed columns of data are the columns labeled: DLAOFFC15, DLAARRC15, OTSCHOFFC and OTSCHARRC; and these are column numbers 25, 28, 35 and 39, respectively. Each of these acronyms specifies a count, as denoted by the “C”, but also the delay, denoted by “DLA”, or the on-time-schedule, denoted by “OTS”, and coupled with the database notation in Appendix 3, is self-explanatory. However, at this stage a few questions should be addressed to understand what is covered in the data and what is not.

The information gleaned from these four columns is strictly for the ability to process aircraft in a timely fashion given the operation of the airport. Note that this is a binary condition, because the aircraft is either counted as being “on-time”, or not. This is dictated per the noted FAA definition of a delay, and that fifteen minute window is based upon the Official Airline Guide, which is the OAG denoted in Appendix 3. The OAG is simply a compiled schedule for all airline operations, so each airline sends its route times and schedules and the actual times of departures are arrivals are compared to these schedules. With this binary count in place, several questions arise about the usefulness of the data.

First, the data says nothing about the time in delay for any given delayed aircraft. Therefore, any delayed aircraft is given a count of one, regardless of if it is sixteen minutes late or four hours late. From the consumer standpoint, this would appear to be a hole in the data, however, the focus of the study is systemic, in that the individual delay is not of interest relative to the aggregated delay in the system, which is minimized by minimizing the number of delayed flights. Furthermore, this is complicated by the fact that delays simply will happen in the course of system operation, an assumption noted by Pathomsiri (2007) as “null jointness”, but more commonly dubbed “Murphy’s Law”, in reference to the associated systemic entropy. However, this distinction does lead to a critical second point in understanding the data and resulting outputs.

The delay counts are based upon the OAG, and those schedules are built by analysts at the individual airlines, weeks and months before the actual delays are incurred. Therefore, the OAG schedule is largely independent of any chaos that occurs on a given day in the aviation system beyond constraints built into the routing, fleeting and scheduling algorithms that generated the schedule, and even further removed from any individual flight. Therefore, it is known that delays will propagate in the data. This means that if a flight arrives two hours late because of a delayed departure upstream, despite the arrival airport having no cause in the delay, it will be “charged” with a delay. Likewise, there may well be a departure delay “charged” if another flight on the same aircraft, or within the same fleet, fails to hit its OAG window. This is not a guarantee per the sort of response generated from a system like that described by Arguello et al (1997), but it is a distinct possibility, and this very well could occur again downstream at the next airport on the route.

If no departure delay is incurred, it is because the airline was able to absorb the delay by juggling the fleet, ground-turn efficiency or because of a cancellation. This is an important point because cancellations are not in the data; as a cancelled flight never departs or arrives to be counted. This would appear to be a significant hole in the data, but the proportion of cancelled flights is small relative to those flown, and literature such as Arguello et al (1997) shows that airlines are inclined to cancel as few flights as possible to maintain their route structures. The reason for this is primarily economic, as all affected passengers and cargo must be rerouted, which can be an expensive proposition, but cancellations also break up fleet routings and introduce more variation into maintenance schedules which are stringently regulated by the FAA.

Returning to the issue of the propagation of delay counts, and ignoring the cancelation issue, the propagation actually turns out to be a positive accounting for the consumer, because the delay counts are what the consumer actually experiences. Remembering that the consumer is buying a schedule, his demands are to be where he wants to be when he wants to be there, and the source of the delay is largely irrelevant to his interests. Since the consumer actually experiences the propagation, this is actually not a “double counting” type of problem, as consumers are interested in if they are going to get where they want to go when they want to be there. Therefore, if a third of the flights are late from somewhere else upstream, to the consumer, it is not his problem, because he is the one stuck waiting.

Processing the Data for Use-Denominator

While the numerator of the efficiency calculation required in-depth analysis to determine the proper columns to fulfill the data requirements, and deeper analysis to understand what was, and was not, covered within the scope of the data, the denominator is much more straightforward, once the nomenclature of the database is understood.

The denominator of the efficiency calculation is based upon two factors, time and usage of runways, and by finding how the runways operate, the time can be derived because of the nature of a relational database.

As noted in Section 6, the configuration is primarily dictated by wind direction, and within the ASPM database, the meteorological data can be found in columns 69 through 74, with the active configuration given in column 75. One of the assumptions made throughout the course of the research that those operating the airport know what they are doing in choosing a configuration, which renders the information in all but column 75 irrelevant, as the choice of configuration in column 75 is predicated upon a reasonable interpretation of the meteorological data from columns 69 through 74. With this assumption in place, the configuration, which is given as (Arrival Runways | Departure Runways) can be used to isolate how many runways were used for arrival, departure and mixed mode operations for the given conditions.

To make these determinations, it is helpful to understand how runways are labeled.

Runways are named by their two digit compass headings, or more simply, taking the compass heading, and dropping the last zero. For example, heading due south would be compass heading 180, so a runway operating in that direction would be RWY 18, and if the runway was used in the other direction, its heading would be 180 degrees in the opposite direction, meaning that RWY 18 would also be the same strip of pavement as RWY 36; as compass heading 360 (or 000) is due north. Likewise, these numbers are rounded, so a runway being used with a heading of 092 would simply be treated as 090, and would therefore be RWY 09.

However, at many major airports there are parallel runways, such as those shown at MSP in Figure 7, so other modifiers are needed to ensure pilots use the proper runway. The most common means to do this is to split the runways by their visual position. Using Figure 7, if an aircraft were on final approach into MSP on a southwest-bound heading, coming in from the upper left corner of the figure image, as shown in the figure, it would need to use RWY 12, but the problem is that the figure shows that all both active runways for arrivals are oriented for this direction approach. This is resolved by using a position modifier, such as Left and Right, although in a few cases, such as occurs at DFW and BNA, a Center modifier does appear for triplet runways. Therefore, the controller would send the aircraft to RWY 12R, which would be the runway in the middle of the figure, because on approach from the upper left corner of the picture, RWY 12R would be the runway on the right side in the cockpit view.

This problem gets a little more complicated when there are more runways and more traffic, and there are various means to solve this, such as Figure 6, which details five runways at ATL all oriented east-west. At ATL, this has been solved by giving the north runways the designation 08/26 left and right, “middle runways” the designation 09/27 left and right, and the furthest south runway 10/28, as those numbers all approximate east-west headings and avoid a complex mish-mash of alphanumeric characters to name the runways.

With the brief introduction into runway designations, the contents of the 75th column become much more understandable, because the alphanumeric codes listed therein are actually meaningful names, much like a road name.

The configurations are listed as an ordered pair, separated by a vertical line, |, herein referred to as a “pipe”. The runways on the left side of the pipe are the arrival runways and the runways on the right side of the pipe are the departure runways. Mixed mode runways can be found by taking the intersection of the two sets, as mixed operation requires both departures and arrivals from the same runway.

By counting the number of elements in each set, arrival runways, departure runways and the intersection of the two sets, the values for the three runway terms in the denominator of the efficiency expression can be inserted as follows:

$$Arrival\ Runways = Arrival\ Count - Intersecton\ Count$$

$$Departure\ Runways = Departure\ Count - Intersecton\ Count$$

$$Mixed\ Runways = Intersecton\ Count$$

As an example of this, returning to the configuration shown in Figure 7, is listed as: MSP 12L, 12R | 12L, 12R, 17. This breaks down as follows:

Arrival Count = 2, RWY 12L and RWY 12R
Departure Count = 3, RWY 12L, RWY 12R and RWY 17
Intersection Count = 2, RWY 12L and RWY 12R

Therefore, the denominator runway count for computation of the efficiency expression would be: 0, 1, 2, which implies three active runways: one for designated departure and two in mixed mode.

Switching gears to the other denominator component, the time component is simply a count of the number of rows in the database which a given configuration occurs, which is the usage frequency. Since the database is relational through time, the first five columns describe the location and time, and referring to Appendix 3, it can be seen in column five that each row is a quarter hour block. Since there is only a single configuration in column 75, it is taken that the entire quarter hour operates in this configuration. This raises a question about the degree of error in this measurement, but insight into airport operation renders this insignificant.

Airport configurations are a lot like steering large ocean-going oil tankers in that they are hard to turn. The ideal situation would be to never shift the configuration, because the shift requires a lot of integration of both airborne and land-based traffic flows. Furthermore, configuration changes are rarely small, as a ten- or twenty-degree shift in wind is unlikely to change the configurations, which are reasonably robust over roughly a 120-degree arc of wind angle. This means that a shift in configuration is on the order of a 90-degree turn, which opens up many more opportunities for runway incursions, two aircraft occupying the same active runway, as the flows from the old configuration finish flowing as the transition is made to the new configuration. Therefore, these changeovers require several minutes and may take a half-hour or more to execute, as aircraft on arrival routes working through their fixes cannot be easily rerouted with the existing navigation systems.

Given the relatively slow pace of weather changes and the time required to change configuration, what happens in practice is that configurations occur in large blocks of time. In places like ATL, wherein the winds are reasonably constant, the active configuration may not change for days, beyond the occasional removal of a runway for a few minutes for routine maintenance, such as a friction test or debris removal.

However, in other places, such as BOS, environmental regulations require a changes to ensure that no one group has to bear excess airport noise, so this sort of requirement is built into the system, which could be problematic; but at the same time, a place like MIA sees a constant shift, as the winds are impacted by the ocean currents which flow predictably through the day. Even in these cases, the configurations stay in place for hours at a time, and even if the configuration only held for two and a half hours, or ten quarter hours, which would correspond to ten rows in the database, this shifting period would only account for a possible ten percent error, and even less than that, as an even split of the fifteen minute block would still be halfway correct for the information provided.

Given that these quick turns are the exception rather than the norm, and there is little that can be done about it with the given reporting systems, the error induced is taken to be reasonable.

Preparing the Data for Analysis

With the data sources identified, and the means to convert that data into the useful information detailed, the only remaining task before modeling it was to ensure the data was appropriately filtered and cleaned.

The data, on an “as-is” basis from the FAA is actually reasonably reliable, because the FAA cleans the data and fills in any missing information as noted in the section labeled Selection and Acquisition of the Data. Therefore, the data is taken to be reliable, and given the more than four thousand data points per day, and errors would quickly wash through the system, removing any undue fears about erroneous data.

However, the data itself is also quite expansive, which leads to a problem of finding meaningful information amongst the piles and piles of information. Given that the bulk of the efficiency expression is count data, the source of the problem comes from the number of configurations.

The configurations, as noted, come from column 75 in the databases, but by querying the databases, any unique configuration at a given facility is returned as being viable, when in fact this is not the case. The reason for this, as noted in the previous section, is that a configuration is frequently altered in the course of use to address issues such as maintenance and required testing, so while the configuration may remain largely in place, it does change for a short duration. Likewise, other changes may occur, such as closing the airport or altering the airport's configuration for specific operating conditions, such as using only a single runway for a few late night operations. To address this problem, a means was needed to determine what the significant configurations were, so as to focus analysis on these significant few versus the trivial many.

According to FAA Order 7210.3V , effective as of 14 February 2008, Section 7 on the Airport Arrival Rate (AAR) specifies that AAR statistics must be calculated for any Airport Primary Runway Configuration, and this Primary Configuration is identified as any configuration which handles three percent or more of the total annual operations.

The FAA Order greatly simplified this problem, because the annual operations counts were already available within the existing data, simply by summing these numbers, meaning that the individual configuration numbers could be summed within the configuration and divided by this total value and compared against the three percent standard. With modern database technology, this was not an issue, and the following figures show results for the three airports used in Figure 6, Figure 7 and Figure 8 in graphical form to illustrate the point further, and show where the information contained in the captions was derived, and is shown in corresponding order.

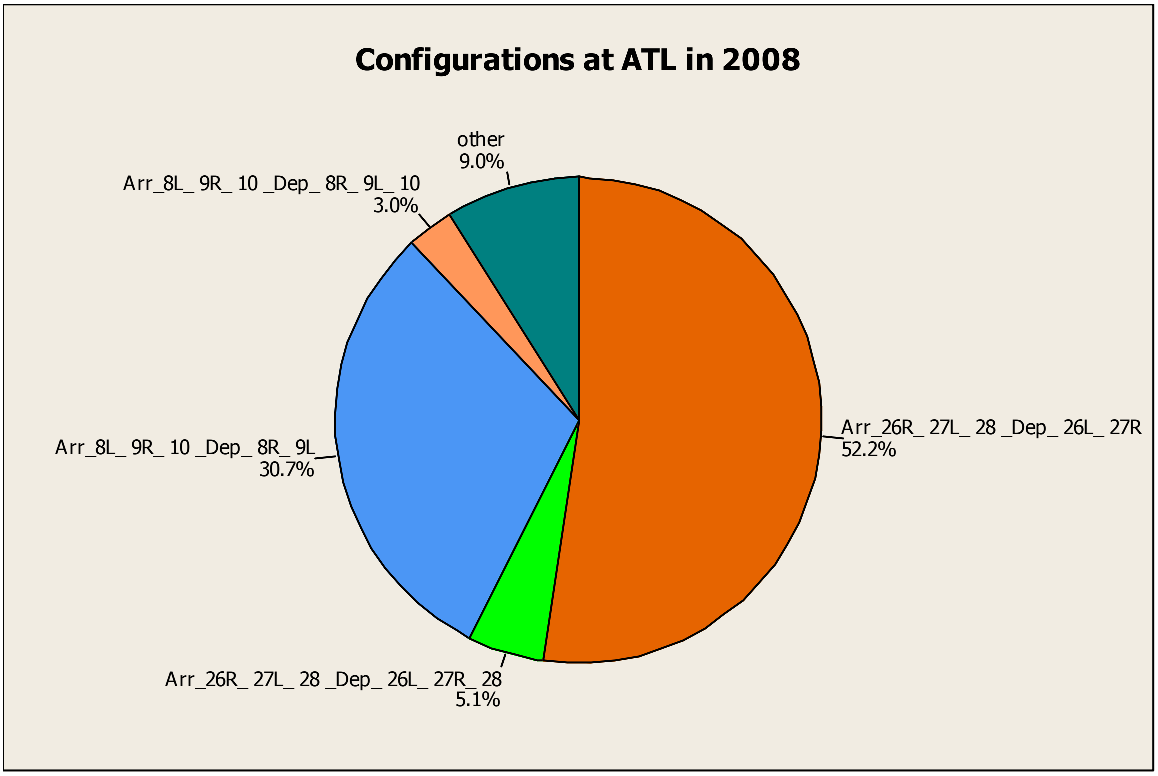


Figure 12: Primary Configuration Identification at ATL in 2008

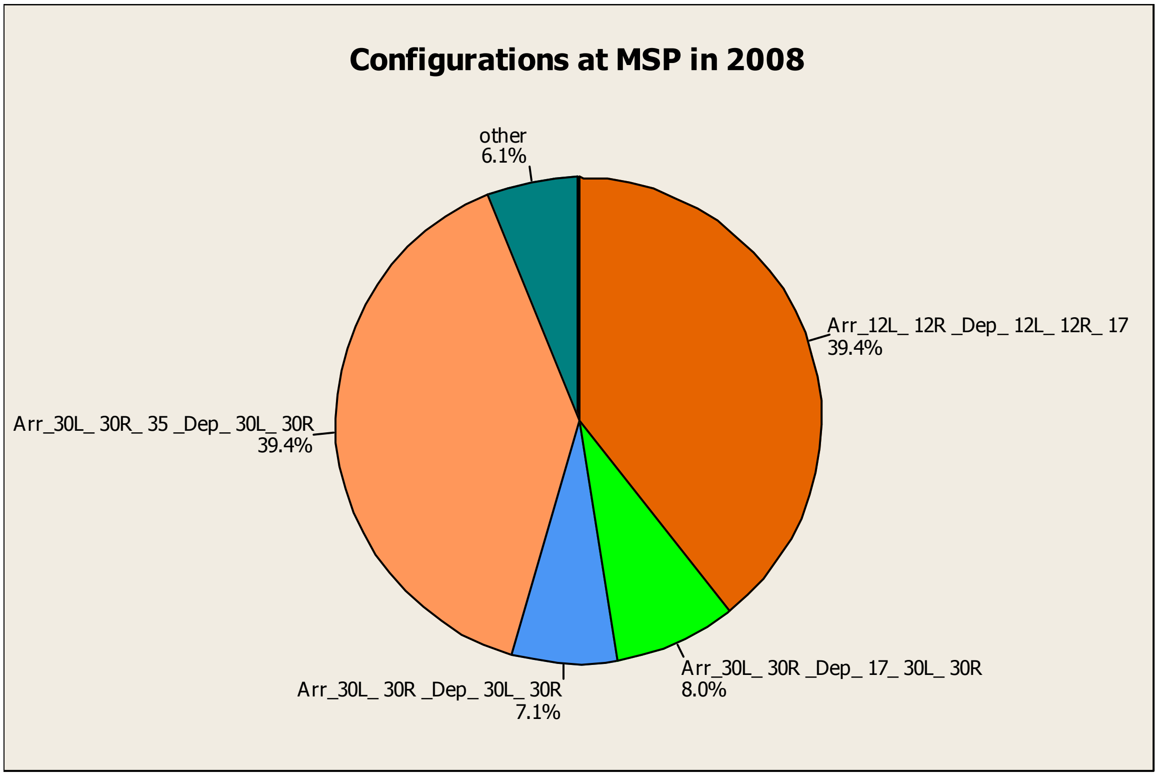


Figure 13: Primary Configuration Identification at MSP in 2008

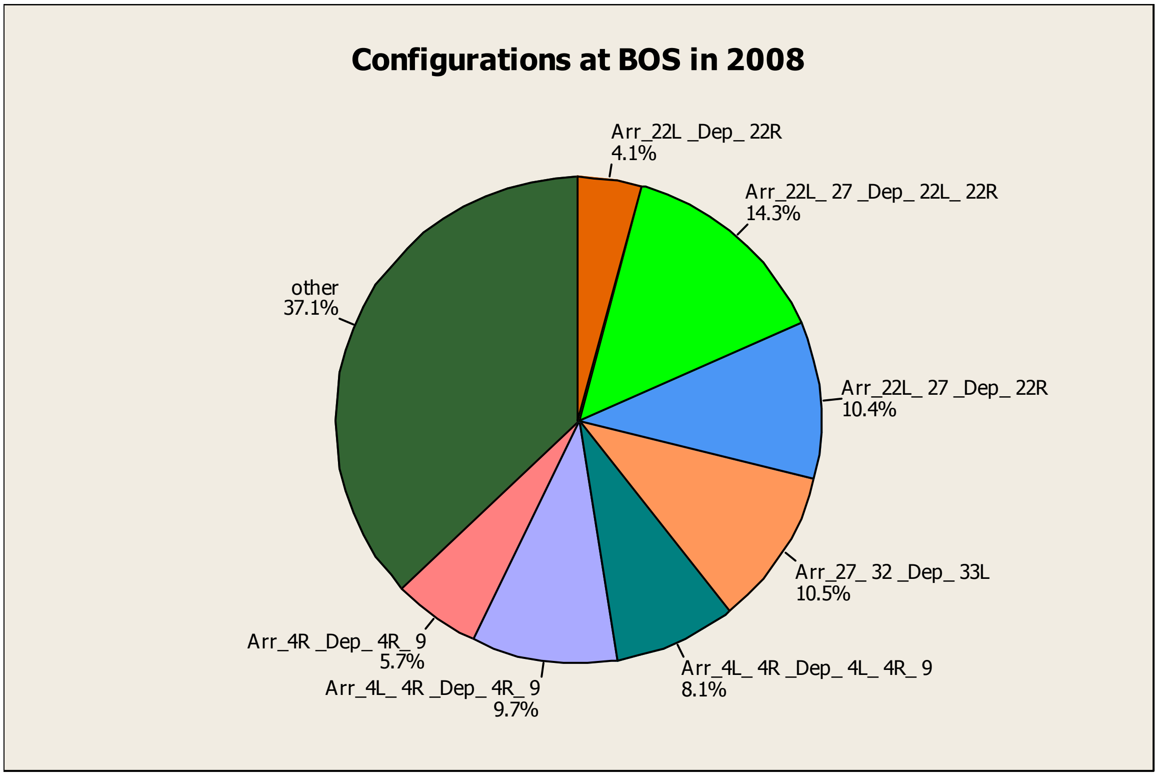
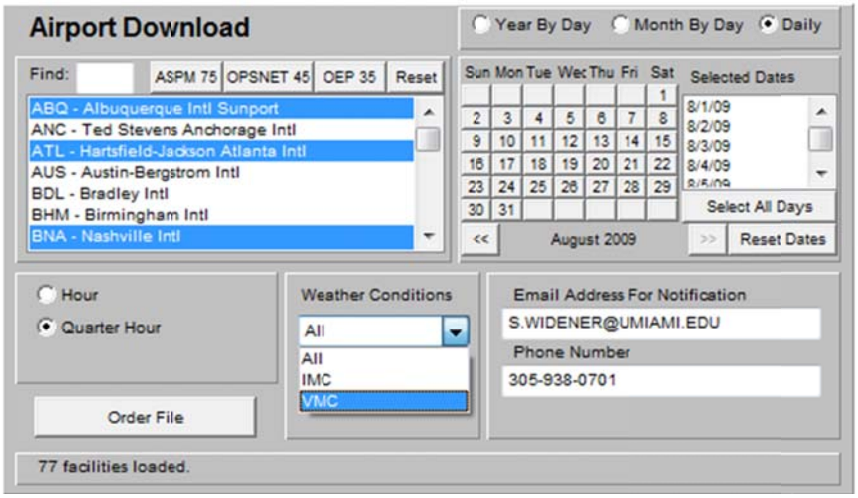


Figure 14: Primary Configuration Identification at BOS in 2008

The three configuration identification figures show two interesting points, which are indicative across all of the OPSNET 45 airports. First, is that there are a few major configurations which define daily operation at the airport as noted, with four to eight primary configurations common, but IAD having twelve. The second interesting note is that the proportion of operations which occur outside of primary configurations is significant, denoted by the “Other” slice in each of the figures, and noting that at BOS, it is the dominant slice. Note that the contents of the “Other” slice are the trivial many and all of the configurations lumped into these slices carried less than three percent of the operations for the year, per the FAA definition of a primary configuration; however, this does not mean that these non-primary configurations are necessarily insignificant, as Figure 14 shows, they accounted for over a third of the operations at BOS. Therefore, this means that at BOS, there are at least thirteen different configurations lumped into this slice.

Further complicating this issue is visibility, which is can be tied to wind patterns, but not necessarily, and visibility has a tremendous effect on aviation. In aviation, visual conditions are vitally important because of the speeds involved and the drastic consequences of errors, so two states of visibility are denoted, Visual Flight Rules and Instrument Flight Rules, typically abbreviated as VFR and IFR. Sometimes VFR and IFR referred to as Visual and Instrument Meteorological Conditions, VMC and IMC respectively, depending upon the literature context, both are correct. Different airspaces require different flight rules, but in general, especially near airports, the primary drivers are visibility, which are largely determined by precipitation, cloud ceilings and other obscuring conditions such as fog or smoke.

Ideally, aircraft operate under VFR, wherein the pilot is responsible for seeing and avoiding obstacles, but this is not always possible, meaning that instrument flying can be required. The big difference between flying VFR and IFR from the airport perspective is that most airports must increase spacing between flights to account for the lack of pilots being able to see. This spacing allows for fewer aircraft in the airspace, lowering the probabilities of any sort of interaction, but this comes at the expense of runway utilization, because if aircraft cannot depart or arrive in succession, this will bias the apparent efficiency of the runway as throughput ought to be reduced accordingly. This is not a new concept, and in Figure 10 there is even a pull-down menu to account for these differences, as shown in Figure 15.



○ Year By Day ○ Month By Day ● Daily

ABQ - Albuquerque Intl Sunport
ANC - Ted Stevens Anchorage Intl
ATL - Hartsfield-Jackson Atlanta Intl
AUS - Austin-Bergstrom Intl
BDL - Bradley Intl
BHM - Birmingham Intl
BNA - Nashville Intl

Selected Dates: 8/1/09, 8/2/09, 8/3/09, 8/4/09

○ Hour
● Quarter Hour

Weather Conditions: All

Email Address For Notification: S.WIDENER@UMIAMI.EDU

Phone Number: 305-938-0701

77 facilities loaded.

Figure 15: The Download Box Showing Weather Condition Options

Figure 15 shows that the data can be blocked for VFR or IFR conditions, but returning to the premise of the research, both are needed, because all airports are subject to these conditions, and a traveler does not have a readily available and reliable way to know if they will be flying on a day under VFR or IFR conditions. This creates an interesting problem, because IFR conditions are not unique to given wind and weather conditions, so there needs to be a way to account for these differences within the configurations.

To counter this problem all assumptions about operations were removed, and the number of primary configurations was doubled, so that every configuration had a VFR component and an IFR component. Graphically, this would look like taking every pie slice in Figure 12, Figure 13 and Figure 14, and splitting them. The issue was the degree to which the slices were split, because without combing through the data, there was no way to know if the splits would be 40-60 or 90-10 or some other ratio, as it would vary by configuration. This also caused a deeper problem, because it would be possible that a VFR configuration would be considered a primary configuration, but the associated IFR configuration would not; therefore, this was a secondary filter on the data, in that the configurations were first sorted by the three percent definition, and anything which passed that filter was then assumed to have both a VFR and an IFR component.

The reasoning for this is that the configurations are based upon runway layouts, and the runway layouts are done by mapping winds to determine where the prevailing winds are. This is a historical study, and when aggregated the statistics yield a likely picture of what should occur in the long-term, but do not guarantee anything on a given day. Likewise, cloud cover or precipitation are subject to the same laws of random statistics, in that the conditions on a given day a month away are largely unknown and unknowable, much less how these conditions will nest with the prevailing winds on those days, so the VFR-IFR issue was left as an independent variable by simply doubling the number of configurations to account for both cases. Note that this also changes the appearance of the pie charts shown in Figure 16, Figure 17 and Figure 18, as the revised charts are shown to give a sense as to how the primary configurations split with the VFR-IFR differences taken into account, denoted as V and I after a pair of dashes.

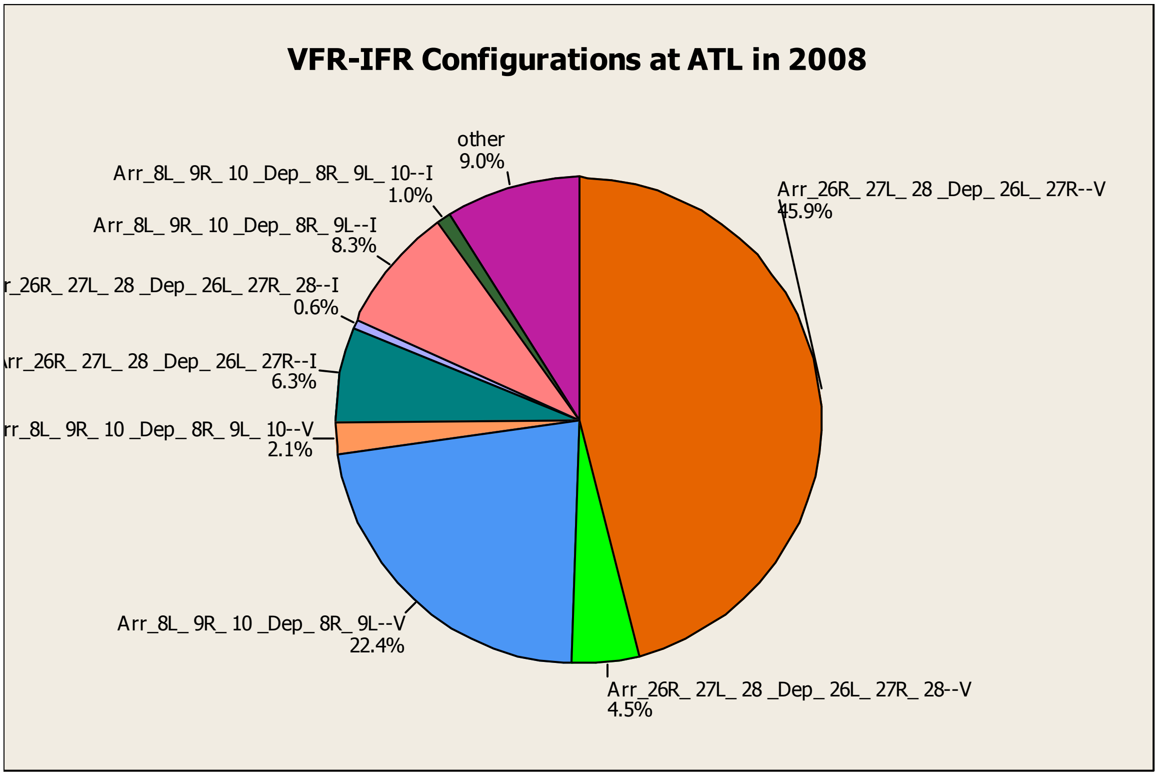


Figure 16: Primary Configurations at ATL in 2008 Revised for VFR-IFR Distinction

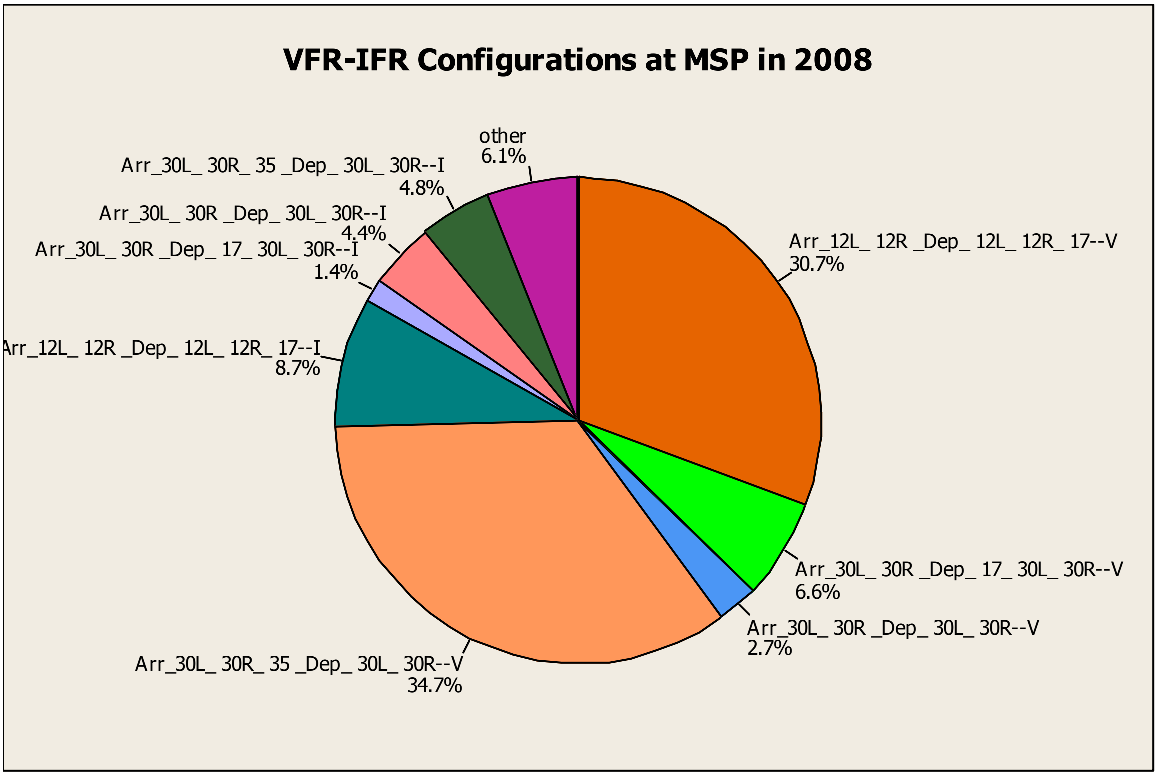


Figure 17: Primary Configurations at MSP in 2008 Revised for VFR-IFR Distinction

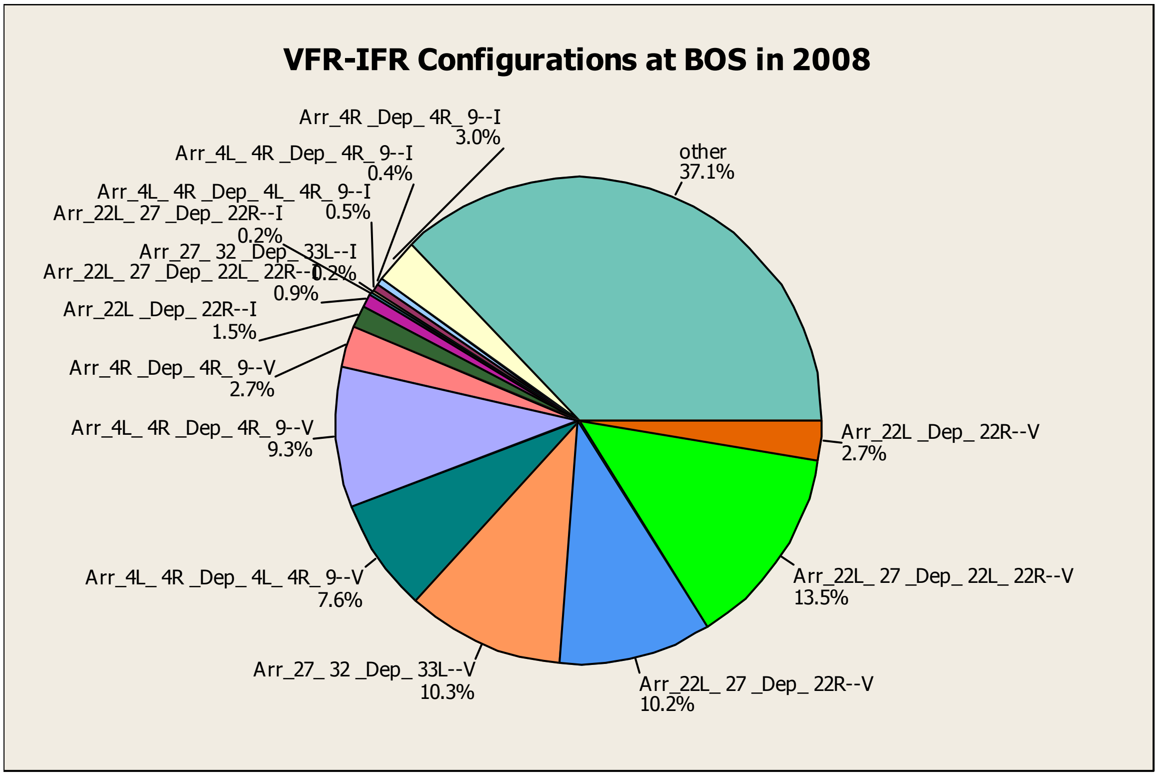


Figure 18: Primary Configurations at BOS in 2008 Revised for VFR-IFR Distinction

The revised figures, shown in the three revised configuration figures continue to show a Pareto Principle with a significant few and a trivial many, however, these three figures also show that the double filtration was necessary, as a disproportionate number of the IFR configurations would otherwise be lost. With these configurations all known and in place, the actual analysis can begin.

A Note on Data Availability for Analysis

While the OPSNET 45 airports were chosen for analysis, with data reaching back as far as the ASPM database allows, because of the nature of the start-up of the ground surveillance programs, not all airports have configuration data available for all years under study. The flight count data is available, as it has been tracked for decades, so the aggregate numbers are readily available, meaning that the numerator of the efficiency expression is complete, but without the configuration, the denominator is incomplete for any calculation that is not about the airport in aggregate. Table 4 lists the members of the OPSNET 45 and which have missing data.

Airport	Number of Missing Years	Missing Years
ABQ	2	2001 2000
ATL	0	None
BNA	3	2002 2001 2000
BOS	0	None
BWI	1	2000
CLE	0	None
CLT	1	2000
CVG	0	None
DCA	1	2000
DEN	1	2000
DFW	0	None
DTW	0	None
EWR	0	None
FLL	2	2001 2000
HOU	3	2002 2001 2000
IAD	0	None
IAH	0	None
IND	2	2001 2000
JFK	0	None
LAS	1	2000
LAX	0	None

LGA	0	None
MCI	2	2001 2000
MCO	1	2000
MDW	0	None
MEM	0	None
MIA	1	2000
MSP	0	None
MSY	2	2001 2000
OAK	3	2002 2001 2000
ORD	0	None
PBI	3	2002 2001 2000
PDX	2	2001 2000
PHL	0	None
PHX	0	None
PIT	1	2000
RDU	3	2002 2001 2000
SAN	2	2001 2000
SEA	0	None
SFO	0	None
SJC	3	2002 2001 2000
SLC	1	2000
STL	0	None
TEB	3	2002 2001 2000
TPA	1	2000

Table 4: Missing Configuration Data in the OPSNET 45 Airports

Table 4 shows that at most, three of the nine available years for any given airport are missing, but the majority of the large international hub airports are missing at most one year. Therefore, the disparity is noted, but is unlikely to cause any undue effects in the analysis.

8. Mathematical Framework of the Models for Efficiency Assessment

Based upon the work of the previous sections detailing the measurements and values required to make a relevant assessment of airside efficiency, all of the information can finally be brought together for analysis to actually determine what those efficiencies are, drawing upon the models and insights presented in the Aviation Efficiency Literature Review in Section 3.

The problem faced in the assessment of those efficiencies is not the computation, as the values going into all of the variable slots in the efficiency computation are positive integers, but that the comparison amongst the efficiency statistics is rather nebulous.

A quick look at the numbers being inserted into the expression show that there will be numbers on the order of thousands or tens of thousands, for the four variables in the numerator, yet in the denominator, the time variable will be in the hundreds or thousands but the runway values will be small single digits. As written, this ratio will be large, but ultimately meaningless, and it is further clouded by the fact that not all inputs and outputs are equal in value. As an example on the input side, adding another runway is enormously expensive, with project costs noted to be measured in hundreds of millions to billions of dollars, but the cost to add an extra hour of time in a given configuration are comparatively small so long as no major safety violations occur. Therefore, how does one account for these differences in input costs? Likewise, what is the value of an extra aircraft arriving or departing, and the value of it doing so timely? These questions need to be addressed, because these cost and benefit tradeoffs are ultimately determine what is, and is not, efficient.

The following three models will detail different ways to make these assessments.

The CCR Model

As noted in the Aviation Efficiency Literature Review, much of the ground work for this sort of analysis with these unknown and unknowable costs was laid down by Farrell in 1957 and 1962. The ideas put forth were then converted into the CCR form in 1978 and the BCC form in 1984, which converted the efficiency concept into a format which was compatible with linear programming solvers, allowing for multiple iterations of the program to yield comparisons amongst all of the entities, and standardizing some of the nomenclature.

One of the advancements of the CCR model was that it standardized the efficiency ratio between zero and one in lieu of leaving an arbitrary efficiency ratio for each entity under study. These entities, dubbed Decision Making Units, DMUs, by Charnes et al (1978) could then be studied on a standardized basis for further clarity.

Returning to the definition of efficiency presented in Section 6, the basic form of the efficiency expression is defined mathematically as:

$$Efficiency = \frac{\sum Total\ Outputs}{\sum Total\ Inputs}$$

However, as shown, the values of the inputs and the outputs are likely not equivalent, so these must be weighted accordingly. Refining the expression to account for this change:

$$Efficiency = \frac{\sum Weighted\ Outputs}{\sum Weighted\ Inputs}$$

According to Charnes et al (1978) this would then be reduced to the following:

$$\max \frac{\sum_{k=1}^{s} u_k y_{kp}}{\sum_{j=1}^{m} v_j x_{ip}}$$

$$Subject\ to: \frac{\sum_{k=1}^{s} u_k y_{ki}}{\sum_{j=1}^{m} v_j x_{ji}} \leq 1\ for\ all\ i$$

$$Subject\ to: u_k \geq 0\ and\ v_j \geq 0\ for\ all\ k\ and\ j$$

Where: k = 1 to s, index of all outputs
j = 1 to m, index of all inputs
i = 1 to n, index of all DMUs
p = DMU under consideration
x_{ji} = amount of input j used by DMU-i
y_{ki} = amount of output k produced by DMU-i
u_k = weight of output k
v_j = weight of input j

The model itself boils down to a series of iterations of "pricing constraints" within the weights, and within those constraints, the objective is to maximize the objective function. The objective function requires maximization to push out to the frontier, coupled with the associated non-negativity constraints, to ensure that the program does not set everything to zero, thereby showing efficiency for all DMUs by showing that there are no differences in weights, or prices, u_k and v_j.

The constraints themselves are all standardized such that the unknown, and unknowable, wieights become standardized by ensuring the ratios do not exceed one. Within the model, the decision variables in this program are u_k and v_j, because the quantities of the x_{ji} and y_{ki} usage and output are known. Returning to the context of the airside efficiency proposed, the y_{ki} represent aircraft counts while the x_{ij} represent runway and time counts. Therefore, these weights are similar to the "prices" of these inputs and outputs, giving the answer to the value of a runway or an additional flight, by iterating across all of the other airports, which are the DMUs, to determine a relative value, all within the a standardized zero to one basis.

The problem with this formatting of the problem is that it is fractional, which a linear solver cannot process, so the format needs to be converted to a linear format. Using the same variables and indices, the linear format becomes:

$$\max \sum_{k=1}^{s} u_k y_{kp} = \theta_p$$

$$Subject\ to{:} \sum_{j=1}^{m} v_j y_{jp} = 1$$

$$Subject\ to{:} \sum_{k=1}^{s} u_k y_{ki} - \sum_{j=1}^{m} v_j x_{ji} \leq 0\ for\ all\ i$$

$$Subject\ to{:}\ u_k \geq 0\ and\ v_j \geq 0\ for\ all\ k\ and\ j$$

This program is run n times, so that each DMU, or individual p, generates a θ-value.

Within the literature, however, a different trend holds. Given that the problem is linearized to maximize the outputs for a given set of inputs, a dual situation could be used to minimize the inverse of the outputs. This does not change much in the way of computation, but what is more widely done within the literature is to focus instead on the inputs, to determine what the minimum set of inputs is required to yield the respective given outputs.

In this case, the idea would be to minimize the inputs for a given block out outputs, but what is frequently done is to instead work through the dual of this problem, and maximize the inverse of those inputs. Historically in literature, this is widely done as it limits the number of decision variables which must be iterated as each of the u and v variables are condensed into dual variables, frequently characterized as U and λ. This slashes the number of variables down and aids in computation, although this is less of an issue with the advances in computing hardware over the last decade, barring a huge number of variables or DMUs, but follows precedent.

The resulting maximization of the inverse of the inputs in the CCR program becomes:

$$\max U$$

$$Subject\ to\colon \sum_{j=1}^{n} \lambda_j x_{ij} \leq U_k x_{ij}\ for\ all\ i = 1\ to\ m$$

$$Subject\ to: \sum_{j=1}^{n} \lambda_j y_{rj} \geq y_{rk}\ for\ all\ r = 1\ to\ s$$

$$Subject\ to: \lambda \geq 0\ for\ all\ j$$

Where: λ_j = is the weight vector for DMU_j to produce the associated value of DMU_k

U_k = is the optimal value of U for DMU_k
i = the index for the inputs, 1 to m
r = the index for the outputs, 1 to s
j = the index of DMUs, 1 to j

This formulation is likewise run n-times to account for each DMU.

All that is required beyond this is a way to read in the data tables to allow for the computation of the decision variables within the solver environment and the resulting U-values can be inverted to give the efficiency of the DMU.

Further discussion of the efficiency values and their usage will follow in Section 9.

The BCC Model

As noted in the Aviation Efficiency Literature Review, the BCC model was a refinement that was published six years after the original CCR model, and was a refinement to the model which allowed for variable returns to scale. The CCR model only allowed for constant returns to scale, but in practice, many applications have variable returns to scale. Therefore, the model needed a way to account for the “bowing” of the efficient frontier as a piecewise curve, instead of a constant sloping line; as noted in Banker (1984).

Computationally, this was a quick and simple addition. The CCR model was used as the basis for the model, and the only change made was to add a convexity constraint to the model, which forced all of the λ_j terms to sum to one. Therefore, the BCC model is as shown:

$$\max U$$

$$Subject\ to: \sum_{j=1}^{n} \lambda_j x_{ij} \leq U_k x_{ij}\ for\ all\ i = 1\ to\ m$$

$$Subject\ to: \sum_{j=1}^{n} \lambda_j y_{rj} \geq y_{rk}\ for\ all\ r = 1\ to\ s$$

$$Subject\ to: \lambda \geq 0\ for\ all\ j$$

$$Subject\ to: \sum_{j=1}^{n} \lambda_j = 1$$

Where: λ_j = is the weight vector for DMU_j to produce the associated value of DMU_k

U_k = is the optimal value of U for DMU_k
i = the index for the inputs, 1 to m
r = the index for the outputs, 1 to s
j = the index of DMUs, 1 to j

Like the CCR model, this model is run n-times and requires the necessary reading of data tables for computation within the solver environment. Also like the CCR model, the resulting U-values are inverted to give the efficiency measurement.

Directional Output Distance Function

The BCC and CCR models provide a known and reasonably comprehensive way to study the airside efficiency, as they are widely used, especially within this area of the aviation literature, and therefore readily interpreted by anyone familiar with DEA. However, both models are constrained in that there is an implicit assumption that all outputs are good, and should be maximized, and that all inputs are to be minimized. In practice, this was shown to not be true by Chung et al (1997).

Gillen and Lall (1997) first addressed the topic of non-favorable outputs in the aviation context and believed that non-favorable outputs were inevitable, and could be treated as inputs, in that they were to be minimized to produce the positive outputs. However, Chung et al (1997) addressed the problem of the lack of explicit and implicit ability to price the bad outputs, such as pollution, or in the case of an airport, noise or a delay, to attempt to use a productivity index, such as the Tornqvist or Fisher Indices to assess efficiency. Since this could not be readily computed or estimated in a reliable way, a different means was required.

Drawing upon literature related to the Directional Output Distance Function from the field of production economics, a new index was developed to separate the good and bad outputs. Swedish paper plants, were used to supply the proof, as paper is a desired output, but in making paper, two forms of oxygen pollution and suspended solids in the water used for production were identified as waste streams. Therefore, to make the operation more efficient, the waste streams could be reduced, or the amount of paper produced could be increased for the same volume of waste streams.

This idea was taken by Pathomsiri (2007) and adopted for aviation analysis, and the linearized model is shown:

$$\max \beta_k$$

$$Subject\ to: \sum_{k \varepsilon K} \lambda_k y_{km} \geq (1+\beta_k) y_{km} \ \ for\ all\ m = 1\ to\ M$$

$$Subject\ to: \sum_{k \varepsilon K} \lambda_k b_{kj} = (1-\beta_k) b_{kj} \ \ for\ all\ j = 1\ to\ J$$

$$Subject\ to: \sum_{k \varepsilon K} \lambda_k x_{kn} \leq x_{kn} \ \ for\ all\ n = 1\ to\ N$$

$$Subject\ to: \lambda_k \geq 0\ for\ all\ k = 1\ to\ K$$

Where: β_k = efficiency score for DMU k
λ_k = is an intensity vector to allow for DMUs to be mixed to create a hypothetically efficient DMU
y_m = value of desirable output m
b_j = value of undesirable output j
x_n = value of input n
m = the index for the desirable outputs, 1 to M
j = the index for the undesirable outputs, 1 to J
n = the index for the inputs, 1 to N
k = the index of DMUs, 1 to K

This model is run k times to generate a β_k for each DMU, wherein β_k is a modifier, or penalty vector, which shows the location of a DMU relative to the efficient frontier. Note that unlike CCR and BCC, which carry values of one on the efficient frontier, β_k carries a value of zero, as it indicates no penalty which would drive the DMU away from the efficient frontier.

The model as shown is also predicated upon six assumptions detailed in both Chung et al (1997) and Pathomsiri (2007) but summarized here for completeness.

Assumption 1: No Free Lunch—this assumption assures that for any input the minimum output will be zero, and is further constrained such that the application of no input results in no output produced.

Assumption 2: Convexity—all inputs and outputs are finite.

Assumption 3: Free Disposability of Desirable Outputs—all desirable outputs are readily accepted, and there is no additional cost or limit resulting from the outputs which impacts other outputs being produced.

Assumption 4: Free Disposability of Inputs—similar to the desirable outputs, inputs are readily accepted, and there is no additional cost or limit to other inputs or the application of further inputs.

Assumption 5: Weak Disposability of Undesirable Outputs—unlike the desirable outputs and inputs, undesirable outputs can only be reduced by a corresponding reduction in the desirable outputs, implying that there is a cost of disposal.

Assumption 6: Null Jointness—at any time there are desirable outputs produced, undesirable outputs will also be produced, except at the point of zero, in which case no desirable or undesirable outputs are produced.

Chapter 3: Applications and Analyses

Sections 9-11

9. Methods and Applications

The previous sections dealt with the formation of the efficiency expression and then the ways to theoretically craft a framework to make the determination. This section takes the other side of that determination and looks into the practical application of how to actually bring the models to fruition and set up a corresponding path towards a meaningful conclusion.

Detailing the Research Hypothesis

The premise of the research, as noted in the Introduction, is to use the configurations to predict the performance of the airport, because the components of the system predict the performance of the entire system, which is a tenet of both Lean and Six Sigma thinking. Incorporating those improvement method ideas into the airport efficiency context, to boost the throughput of a process, one of the ways to do this, absent capital investment, is to reduce the waste such that more good product is produced. Given that capital investment in the aviation context is frequently enormous and difficult to acquire, as previously noted, this line of thinking is of value. The problem is executing it, because unlike a traditional process being analyzed for improvement, there are not multiple steps each supplying its own yield for analysis. Upon further reflection, this is actually not true, but requires an abstraction of the concept.

Visualizing a factory, the throughput of the factory is predicated upon the efficiency of the individual portions of the production, frequently incorporated into a Rolled Throughput Yield (RTY). In a traditional Western context, this would lead to the idea that the RTY is simply the multiplication of the yields at each step, and given how factories are typically engineered and laid out, one could almost literally walk down the assembly line to build the map to generate this RTY number.

This line of thinking leads to a roadblock in the aviation context, because this linear situation does not present itself. While there is still only one flow of direction in a typical airport configuration, as soon as that flow direction changes, it is like a new factory needs to be modeled. But, abstracting a little further and leaving the Western paradigm actually reveals something quite interesting.

Using a Japanese paradigm, wherein the factory is pull-based instead of push-based, meaning that the factory does not necessarily align itself to produce thousands of the same product efficiently; instead it is designed to produce one product efficiently, and it is the one product which is needed at the time. This is an interesting twist, because under the Japanese paradigm, the factory does not know what the next unit will be.

Returning to the Western example, the Western system is geared to produce thousands of Product A, which are then shipped out into the supply chain. If another product is needed, another production line is created, which then creates thousands of Product B to ship into the supply chain. The Japanese system is that Product A has a route through the factory and Product B has a route through the factory, and the factory does not operate until a consumer buys Product A, at which point a replacement Product A is produced; with the same production trigger for Product B.

By taking the Japanese pull-based approach, and replacing Product A and Product B with two configurations at the same airport, a similar situation is created: individual flights under certain operating conditions, such as wind direction, demand runway usage, necessitating Configuration A or Configuration B; just as the consumer in the factory example demands either Product A or Product B, based upon their own needs and desires. Therefore, if the efficiencies of these configurations are viewed over a longer time horizon, patterns should emerge which show not only demand, but also the efficiency of the airport itself, just as the efficiency of the factory could be generated based upon how many times Products A and B had to be produced.

By aggregating the data over annual time periods to account for seasonality in both weather patterns and travel patterns, it is believed that the efficiency of the configurations can predict the efficiency of the entire airport. Furthermore, by understanding what these component efficiencies are, it is believed that improvements to the airports to eliminate the delays can be identified by looking within the efficiency numbers to find areas for improvement by looking at the configurations with poor efficiency, thereby creating a diagnostic tool.

Hypothesis Model and Theory

As previously noted, the existing literature bodies focus on the airport as an economic entity to the municipality or as a geographic entity that operates as a single configuration. Since this is known to be false by observation, an efficiency metric was created to assess the efficiency of the individual configurations utilizing only airside factors to minimize interference from airline operational decisions. The question then shifts to how this can be done to incorporate the configurations into the whole of the airport.

Returning to the Japanese factory concept, the efficiency of the factory is based upon how efficient the production of each product was, and then scaled accordingly. As an example, assuming the two products are similar in material usage, processing, cost, etc, if the factory was very good at producing Product A, but produced very few, while being mediocre at producing Product B, and producing many, the factory would be viewed as middling, based upon its total output. However, if the demands were reversed, the factory total output would be viewed in a positive light. Therefore, the efficiencies should be weighted.

The difference in the aviation context is that there are not two products, as a Tuesday night departure operation is no different than a Sunday morning arrival operation, as both operations must happen safely and without incident. Therefore, there is no differentiation between products, but merely the configurations, the routes through the factory in the analogy, on how to process these aircraft. Mathematically, this can be summarized by operation weighted averages of the individual configuration efficiencies:

$$\text{Total Airport Efficiency} = WA_1 * Eff_1 + WA_2 * Eff_2 + \ldots + WA_n * Eff_n$$

Where: WA_x = the operation weighted average of configuration x
Eff_x = the efficiency of configuration x

Therefore, to determine if this is valid, efficiency values are needed for both the airport in aggregate and of the associated configurations.

Information Requirements

To determine the validity of the hypothesis, two sets of data are needed for each airport, but it must be remembered that the existing problem as noted by both Deming on a theory basis and within the literature as previously noted, is derived from optimization of the components of the system versus a systemic approach. Therefore, what is needed is a systemic comparison of the airports and the configurations to determine both what is happening at the individual DMU level, but also what is possible within the system.

The DEA and Direction Output Distance models provide this sort of discernment for differential diagnosis as all three are designed to take vast pools of data, and by using slightly different, but related, objective functions, pass through a series of constraints to identify the top performing DMUs within the data pools and base the efficiency of the others upon the top performers. The line connecting the top performers is known as the efficiency frontier, and the distance from this frontier is the graphical depiction of the efficiency score in two dimensions.

What is unknown is which model best characterizes these efficiencies, therefore, six total models are required. The first set of models are CCR, BCC and Direction Output Distance models for the total airport case, which incorporates 45 DMUs, which are the OPSNET 45 airports. These three models will be a similar representation of the models from the existing literature, and the efficiency expression has to be altered because the total airport is based upon the geographical layout of the airport, not the usage of the airport. Therefore the generic efficiency expression for the CCR and BCC models, ignoring the individual cost variables u and v, is:

$$Efficiency \\ = \frac{Total\ Departures + Total\ Arrivals + Timely\ Departures + Timely\ Arrivals}{Usage\ Time + Runways\ Available}$$

Note that the usage time is fixed, because the entire airport is being evaluated over the entire year, so the time value, or number of quarter hour blocks, is a constant, which is the same for each airport, either 35040 or 35136 depending upon the year, with the difference of 96 time units due to leap year.

Another problem which needed to be addressed was that of how to count the runways available for use over the course of the year. This seemingly simple task is complicated by the fact that airports have evolved as the usage has changed, and now that the majority of the traffic at large airports is by jet aircraft, the runways must be able to accommodate this traffic. Within the configurations, this problem is easily solved, as the short runways are rarely used, or if they are used, it is sparingly and even then, only for the aircraft which can use them; therefore, are these runways really a part of the usable airport infrastructure?

The solution to this question was determined by operationally defining a runway for this count to be at least 5500 feet, and this cutoff value was chosen by trying to bracket down the shortest possible runway a jet aircraft could reasonably use. Three candidate airports known for short runways shined light on this situation. The lone runway used for jet traffic at John Wayne-Orange County (SNA) , RWY 1L/19R, is 5701 feet long, but has aircraft size restrictions. Likewise, at MDW, the shortest runway which sees routine use in the configurations is RWY 4L/22R, which is 5507 feet. However, a Wikipedia blurb, excerpted below, on the River Visual Approach into DCA, another airport with aircraft size restrictions, sheds further light onto the lower bound:

> The River Visual approach
>
> The River Visual approach was instituted due to safety and noise abatement concerns, and is the preferred approach route.[citation needed] The approach (which is for runway 19), which follows the course of the Potomac River, is only possible with a ceiling of at least 3,500 feet and visibility of 3 miles or more. There are lights on the Key Bridge, Theodore Roosevelt Bridge, Arlington Memorial Bridge, and the George Mason Memorial Bridge to aid pilots following the river. Aircraft using the approach can be observed from various parks on the river's west bank. Passengers seated on the left side of an airplane that is landing can easily see the Capitol, the Washington Monument, the Jefferson Memorial, the World War II Memorial, the National Mall, and the White House. Passengers seated on the right side can see CIA headquarters, Arlington National Cemetery, the Pentagon, and the United States Air Force Memorial.

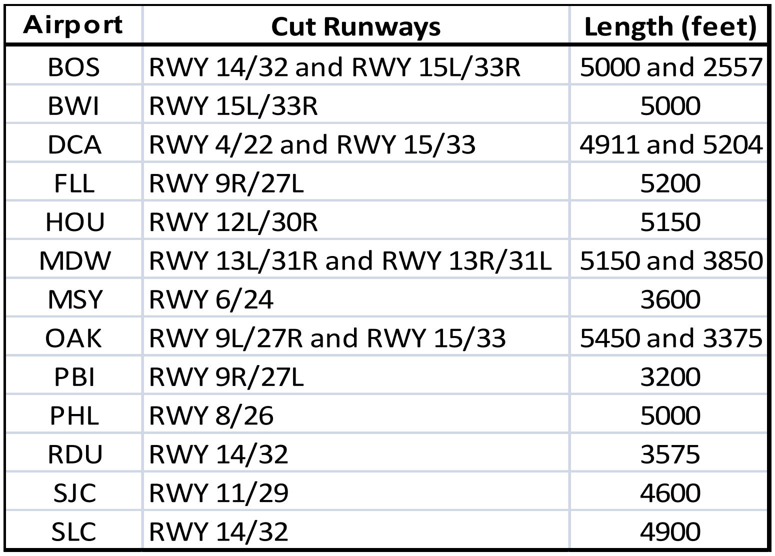
> When visibility and ceiling are below the minimums for the River Visual and southerly winds restrict northbound runway operations, aircraft fly an offset localizer or GPS approach to Runway 19, again involving a final turn moments before touchdown, or they fly a VOR or GPS approach to either of the shorter Runways 15 and 22, which are marginally usable by air carrier jets.

http://en.wikipedia.org/wiki/Ronald_Reagan_Washington_National_Airport
Accessed 7 December 2009

The term “marginally usable” does not provide for a sense of readily available usage on a sustained basis, and consulting an airport diagram of DCA, shows that RWY 15/33 is only 5204 feet long and RWY 4/22 is even shorter, at 4911 feet.

Using DCA RWY 15/33 as a lower bound, it was decided that any runway had to be over 5204 feet to be defined as an available runway for computation, but upon further investigation into SNA and the aircraft restrictions imposed on departing Boeing 757 aircraft, a common fleet for many airlines, the minimum was raised to 5500 to ensure full usability.

Using this cutoff length to operationally define the runway counts, the following airports in the OPSNET 45 set used as the DMU base had their total runway counts reduced:



Airport	Cut Runways	Length (feet)
BOS	RWY 14/32 and RWY 15L/33R	5000 and 2557
BWI	RWY 15L/33R	5000
DCA	RWY 4/22 and RWY 15/33	4911 and 5204
FLL	RWY 9R/27L	5200
HOU	RWY 12L/30R	5150
MDW	RWY 13L/31R and RWY 13R/31L	5150 and 3850
MSY	RWY 6/24	3600
OAK	RWY 9L/27R and RWY 15/33	5450 and 3375
PBI	RWY 9R/27L	3200
PHL	RWY 8/26	5000
RDU	RWY 14/32	3575
SJC	RWY 11/29	4600
SLC	RWY 14/32	4900

Table 5: Airports Runways Removed from Total Runway Counts

Table 5 shows that the increase of the extra 300 feet in minimum length would only impact a single runway, RWY 9L/27R at OAK, and further research into operations at OAK showed that OAK has a large amount of general aviation, and the configuration of the airfield is such that general aviation uses the north end of the field, and commercial aviation occurs on the south side, using only RWY 11/29. A portion of the airport diagram for OAK is shown in Figure 19, with RWY 9L/27R highlighted in red to better show this split.

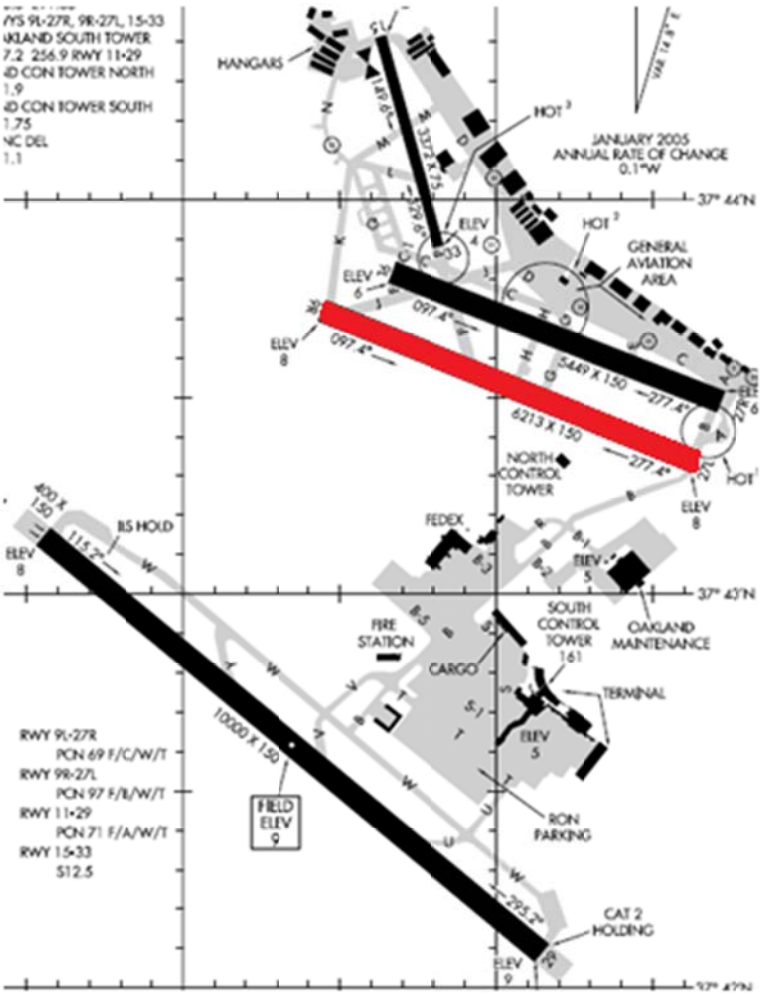


Figure 19: The Position of RWY 9L/27R at OAK

Given that the only impacted runway of the 300-foot increase from all of the OPSNET 45 airports is a runway largely dedicated to general aviation, further bolstered by the fact that it only has one taxiway connected into the commercial terminal complex, at the end of RWY 9R, visible on the right side of Figure 19, this assumption is taken to be reasonable.

The efficiency expression for the Directional Output Distance model is similar, but since the model can account for the differences between good and bad outputs, a more direct expression is used, which removes the total departure and arrival count and substitutes in the counts of delayed departures and arrivals. Since the two sets, on-time and delayed, sum to the total number of operations, and the model can account for the differences and weight accordingly, the expression can be summarized in a generic form without weights as:

$$Efficiency = \frac{Delay\ Departures + Delay\ Arrivals + Timely\ Departures + Timely\ Arrivals}{Usage\ Time + Runways\ Available}$$

The second set of three models which needs to be run is for the configurations, and as was for the total airport case, the models are CCR, BCC and Directional Output Distance. However, the denominator of the efficiency expression is much simpler. For the CCR and BCC models, the generic efficiency expression, shown without weights, is:

$$Efficiency = \frac{Total\ Departures + Total\ Arrivals + Timely\ Departures + Timely\ Arrivals}{Usage\ Time + Departure\ Runways + Arrival\ Runways + Mixed\ Runways}$$

Unlike the total airport case, the usage times will vary by how long the configuration was in use over the course of the year, and the runways can be counted, as the configuration yields exactly what was used, versus attempting to determine what the available pool is.

Likewise, the Directional Output Distance model has a similar structure, with the same numerator change as noted in the total airport case, as shown in a generic form without weights:

$$Efficiency = \frac{Delay\ Departures + Delay\ Arrivals + Timely\ Departures + Timely\ Arrivals}{Usage\ Time + Runways\ Available}$$

Note that in the configuration case the number of DMUs varies by year, but is on the order of 200 to 500 DMUs, increasing through time. This is a function of additional airports acquiring ground surveillance technologies per Table 4, but also because of airport expansions that added runways that occurred during this nine-year period which added to the operational complexity of the associated airport.

For both the total airport and configuration cases, the numbers of runways were altered each year as appropriate, but within the configuration case, recognizing that there will be error in the total airport case as the additional runway is treated as if it came online 1 January of the year in question, but this assumption made the modeling easier. This problem did not exist in the configuration data, because as the runways were integrated, new configurations were created, so any time dependency is picked up by the usage time in the denominator, meaning if a new runway came online late in the year, the usage time for the associated new configuration would be small.

Given that there are nine years of data available, with six models per year, a total of 54 models need to be run to generate the necessary data for comparison. As a result of this data, the resulting efficiencies from the configurations can be weighted by number of operations to predict the efficiency of the total airport.

Remembering that the data was taken by year to account for seasonality in both weather and travel patterns, this means six models are needed per year so the comparisons can be made by year. The reason for this is that at any given time, a comparison should be able to be made to know where the best performers are, but it does not make sense to characterize or reference to a state no longer in existence. As an example, if two configurations were on the efficient frontier, but one was from 2002 while the other was from 2008, this does not give an adequate explanation of what was running well in 2002 or poorly in 2008, as the data is confounded in itself. Therefore, to better track historical events, the data is split into meaningful year blocks, and the blocks are then recombined to tell the historical story, by searching for specific entities within those blocks.

At this stage, an important note should be made about the efficiency values themselves being used in this prediction. The values resulting from the three models are not absolute, in that there is no meaningful zero point, because in reality there is no meaningful zero. In a more traditional Lean or Six Sigma approach, a delay could be treated as a variable for reduction in either time or as a count, but there is no zero, as noted by the Direct Output Distance Function assumptions of weak disposability; or as most travelers are acutely aware: delays will happen.

Therefore, the intent is to set the top instead of the bottom. Since zero delays are not possible, meaning a perfect flight schedule, the resulting yield can also not be one hundred percent. However, by setting the efficiencies to be based upon best-in-class performance, which is the benchmark created by the efficient frontier, a meaningful scale is established within the efficiency values themselves because the "perfect" value is unknown and unknowable. Therefore, by building up a body of data for post-hoc observation, these unknown and unknowable efficiencies of benchmark DMUs can be identified. In other words, 83 percent efficient means little when the comparison point is unknown and unknowable, but 83 percent against the best realized is more telling, and for interpretation purposes, an efficiency of 83 percent does not mean 17 percent of flights are delayed, it means the gap to the best performer is 17 percent. Since all of the numbers are scaled in this way, meaningful comparisons can be made and are based on a systemic view with the values calculated in this manner.

Resulting Values from the Models

While extensive work has been done on detailing what the structure and the means are to yield efficiency values, there has been little discussion about the efficiency values themselves.

The resulting output of the DEA models is an inverse value called U, which must be inverted to become an efficiency number, which ranges from zero to one, indicating zero to a one hundred percent efficient, meaning a higher score is better. However, the interpretation of this is important, especially as it pertains to the differences between the two models.

The resulting efficiency value directly from the model is known as a “technical efficiency” and this is a measurement of how effectively the existing inputs are used; as such, it is frequently referred to as a measurement of “managerial efficiency”. However, both the CCR and BCC method generate technical efficiencies, using different constraints, so it is worth exploring the difference.

The efficiency from CCR is a measurement based upon constant returns to scale, meaning that for every marginal unit of input, a known amount of marginal output should be returned; frequently abbreviated in literature as CRS. This assumption of the return is relaxed in the BCC model, meaning that the marginal output return on a marginal unit of input can be more or less than the CRS case, which is known as variable returns to scale. Within literature this property is abbreviated VRS when used in a generic term, or if the situation is known, increasing returns to scale (IRS) or decreasing returns to scale (DRS) depending upon the slope of the piecewise linear frontier.

A graphical example will help to show how the values are derived, and point out an important relationship between the two. A simple two-dimensional input-output plot is shown in Figure 20.

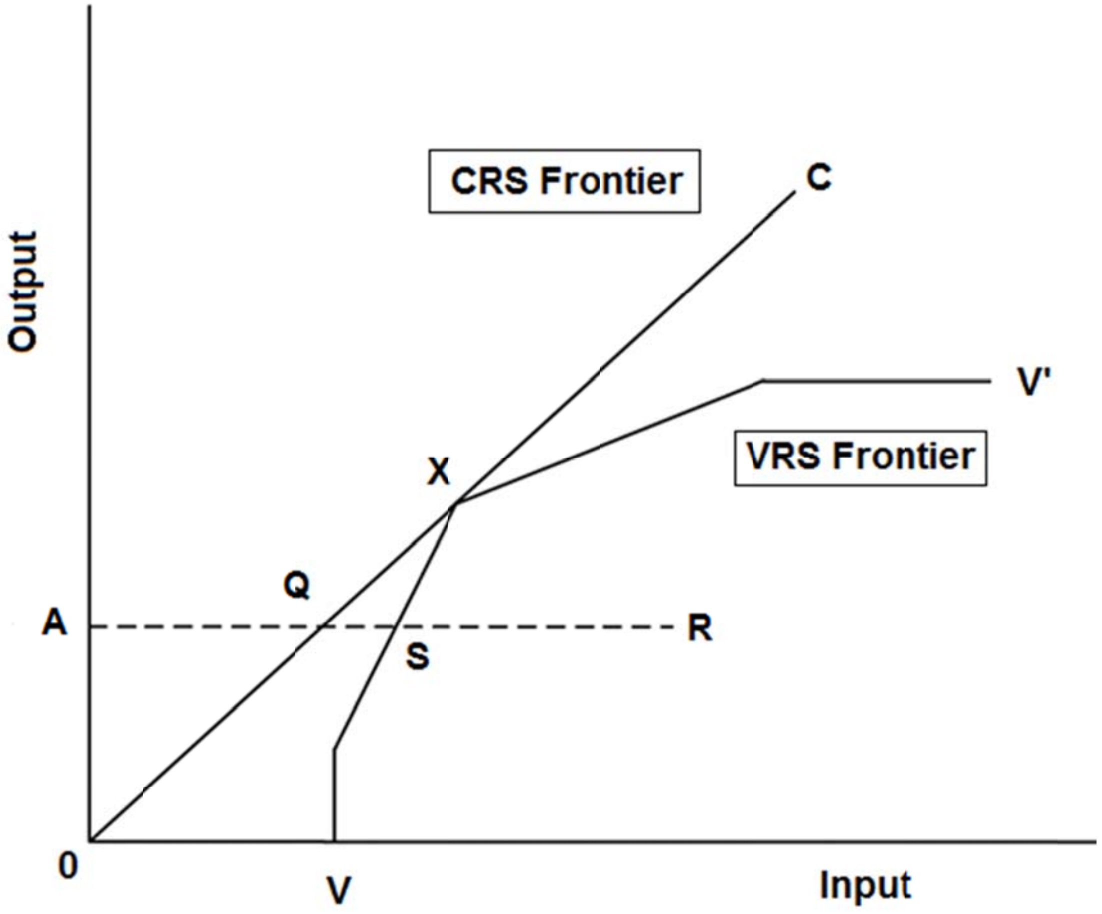


Figure 20: A Simple Input-Output Plot

Figure 20 shows a simple plot with arbitrary CRS and VRS efficient frontiers drawn in, where the CRS frontier runs from zero to C and the VRS frontier is piecewise linear from V to V'. It should also be noted by the axes that the ideal direction for a given DMU is towards the upper left corner: maximization of outputs while minimizing inputs. Note that this direction is sometimes referred to as “the northwest corner” in literature.

In the figure, a DMU is plotted by the amount of input it uses and the output it produces, and this point is denoted as R. The DMU is trying to achieve efficiency towards the upper left corner, but it is well away from the corner, and it does not sit on either of the two frontiers, so it is known that this DMU is not efficient.

As noted, CCR efficiency is based upon the CRS Frontier and the BCC efficiency is based upon the VRS frontier, so the resulting efficiency scores are ratios of linear distances from the plotted DMU point to the output axis and the efficient frontiers. Therefore:

$$CCR\ Technical\ Efficiency = \frac{AQ}{AR}$$

$$BCC\ Technical\ Efficiency = \frac{AS}{AR}$$

In each case, the denominator is the distance of the plotted point of the DMU, but the numerators change based upon where the frontier exists; and it will always be the case that if the frontiers are not shared, the VRS will be further away from the upper left corner of the figure because of the condition in the BCC program enforcing the convexity of the frontier.

The interesting point about the VRS frontier is that it is piecewise linear, in that it bends along a path of DMUs closest to the upper left corner, coming from the origin, while the CRS frontier is a line from the origin to the DMU closest to the upper left corner, noting that multiple DMUs may align along this line.

Because of this relationship, the distance AS will always be greater than or equal to the distance AQ. As such, the technical efficiency derived from the BCC model will always be greater than or equal to the technical efficiency from the CCR model. In practice, this is a useful piece of information, because the results should not be the same. Banker et al (1984) recognized this and created an additional ratio called the scale efficiency, to address this difference to show how these two numbers related to each other.

$$Scale\ Efficiency = \frac{CCR\ Technical\ Efficiency}{BCC\ Technical\ Efficiency}$$

Since the CCR value will always be less than or equal to the BCC value, this ratio also runs from zero to one, where one is defined as 100 percent scale efficient. On Figure 20, this perfectly scale efficient point is shown where the two frontiers share a point, at X.

Whereas the technical efficiency is viewed as the ability to manage the system in converting the inputs to outputs, the scale efficiency itself is a comparison of the size of system, asking whether the input quantity is suitable for the level of output produced.

The Directional Output Distance Model takes a different approach, as it weighs the good and bad outputs and imposes a “penalty vector” to account for how much of the bad output is produced relative to the efficient DMUs. A drawing of the Direction Output Distance Model is shown in Figure 21.

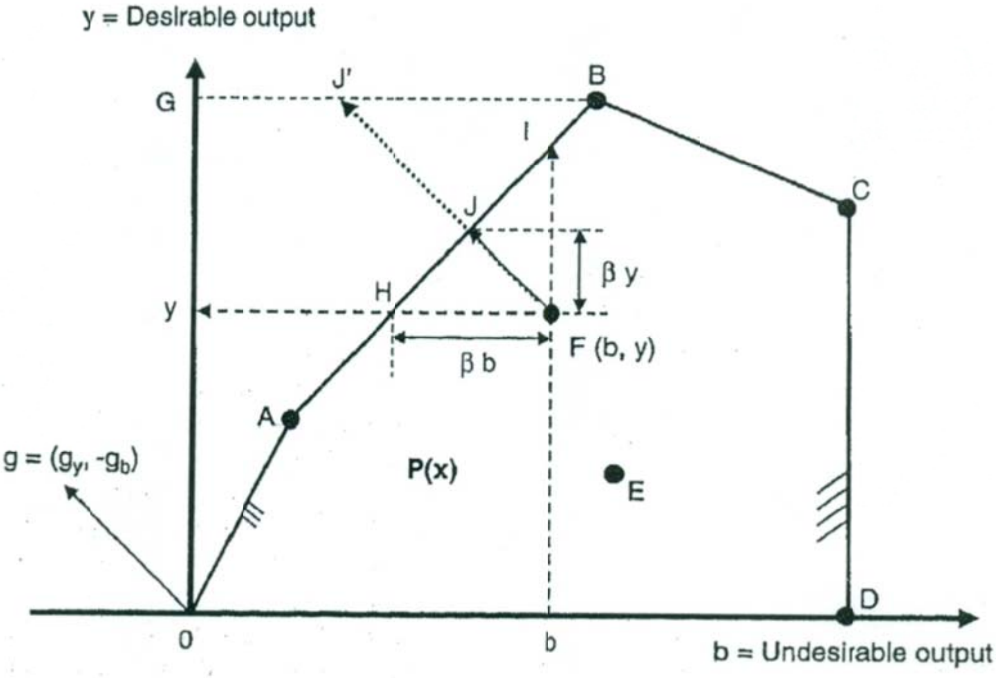


Figure 21: Directional Output Distance Model Plot

Figure 21 shows a piecewise linear frontier with the DMU plotted at point F by its desirable and undesirable outputs, unlike the CCR and BCC case, wherein the plotting was done by inputs and outputs for DMUs sharing equal inputs.

The distinction here, which is also referenced in the coding of the model itself, is the influence of the β-term, shown by arrows coming up out of F and to the left of F. The reason for this is the same as the efficiency definitions from CCR and BCC, in that the desired direction is the upper left corner, “the northwest corner”, of the graph, along the Y-axis. However, in this case, instead of inputs being minimized, it is the undesirable outputs being minimized; in the context of this study, this means the number of delayed flights.

Because of the β_k constraint terms in the program, the efficiencies for a point, such as DMU F, are juggled as decision variables to find the appropriate vector, FJ, to reach the efficient frontier. The components of this vector are the relative strengths of the linear distances to reach the frontier on the given axis, y and b, respectively. This raises a question as to the direction of FJ, but by leaving the constraints of the program in terms of y and b, the exact direction can be determined by the program, versus forcing a choice; at the extremes, (-b, 0) to minimize undesirable outputs to reach back to the frontier, and (0, y) to boost desirable outputs to reach the frontier. This selection is indicated in the second quadrant by vector g, which shows the output magnitude of that choice; note that in Figure 21 this choice is left in a generic form, with the component directions defined by b and y. Also note that the move to the second quadrant is not for convenience, but because the X-value, b, needs to be negative to reach back to the frontier, by eliminating undesirable outputs.

The resulting decision variable β indicates the “strength” of this move, as it is the modifier for the distance in the constraints of the linear program. As such, it is of note that β, the readily visible as the distance modifier shown in Figure 21, is also an efficiency measurement. However, β works in the opposite fashion of the efficiencies generated by the CCR and BCC models, as an efficient β is zero. Using Figure 21, it can be seen that if $\beta=0$, the distances βb and βy would also be zero, indicating that DMU F would therefore be on the efficient frontier.

How to Use the Efficiency Statistics

The previous section detailed the generation of the efficiency statistics, meaning the next logical issue is to determine how to use them.

Before any framework for analysis is constructed, it is useful to summarize the directions of the efficiency statistics. CCR and BCC both generate a technical efficiency, and those values range from zero to one, with a value of one indicating "best performance" efficiency, which also means that the DMU sits on the efficient frontier. These two efficiencies can then be divided, CCR divided by BCC, and the resulting ratio is known as a scale efficiency. The scale efficiency also ranges from zero to one with a value of one indicating "best performance", and a value of one indicates that the DMU sits on both the CCR and BCC efficient frontiers. The other statistic, β_k, comes from the Directional Output Distance Model, and it also runs from zero to one, but in the reverse order, as zero is deemed "best performance", and the associated DMU would sit on the efficient frontier.

With these definitions reinforced, the question becomes what to do with them, as the numbers themselves are meaningless without interpretation. As previously noted, the numbers are already benchmarked systemically, so one of the first items to note from all model runs is which DMUs are efficient, meaning efficiency values of one or zero, as noted in the previous paragraph. Any patterns within the DMUs, especially through time, could yield some insight into how the overall aviation system is performing and where consistent benchmark DMUs are located.

Continuing with the analysis of the numbers themselves, the dispersion of the efficiency values is of interest, because it gives some insight as to how the system is structured. As an example, if the airports are widely scattered, it is an indication that there is no simple solution, as there are airports in all strata. Another case which could be witnessed is many airports clustered around the frontiers, but not quite on them, indicating that the system is running well, and continuing to squeeze efficiency could move airports towards the frontier, all the while developing new technology to boost the entire frontier. Yet another case would be a large outlier or two, which could be dragging down the system; a case proposed by many, as the northeast, particularly the New York area, is frequently blamed for delays in the entire aviation system.

While analyzing the numbers themselves with a traditional statistical sort of analysis, looking at centrality and spread, other analyses specific to these efficiency scores are also warranted. One of the key questions is that of the scale efficiency, in that the degree of difference in the CRS-VRS is unknown; or in more common terms, how much does the VRS frontier “bow” in comparison to the straight CRS frontier? This will help interpret if the municipalities have scaled their operations accordingly.

Another interesting question to further frame the predictability of the airport in aggregate, which stems from the question about the differences in the frontiers, is how correlated the measurements are. By understanding these sorts of relationships, further questions can be asked of the data to yield more beneficial conclusions, but also by understanding the data, the ability of the resulting efficiency metrics can be used to establish a diagnostic, to identify inefficient operations within the entire system; not just the individual airport in isolation.

Generating the Efficiency Values

With the theory, hypothesis, models and analysis structure in place, all that was needed was a way to generate the necessary data. Literature has repeatedly suggested a linear programming approach, a point which was reflected in Section 8, as it allows for a reasonably quick solution, in a proven format; therefore, a linear programming environment was needed to generate the data.

The AMPL programming language was chosen to convert the models into a solvable format because it is a widely used language, is taught at the University of Miami, and as such, has readily available licenses for solving of the larger configuration models, which had several hundred DMUs and would dwarf the typical freeware or student version of a typical software package.

The models and the associated data were converted into AMPL, and the resulting tables and constraints were fed into ILOG CPLEX, a software package which is a simplex solver, for solution to generate the U- and β-values which were then converted into the efficiency scores.

The runs were conducted on two different machines. The first ran only the 45 DMU total airport cases, and this machine running an Intel Core 2 Duo processor running at 2.20 GHz was able to solve each of the programs in about twenty seconds. The larger models, for the configurations, sported as many as 466 DMUs and were run on networked AMPL licenses, and required anywhere between a minute and five minutes to process, dependent upon the number of DMUs, although most of the models were completed in roughly two minutes.

In both cases, the models were fully tractable on readily available existing desktop hardware.

10. General Results of the Efficiency Models

The previous section detailed the setup for the experiment to show the hypothesized relationship between the efficiency of the operating configurations of the airport and the overall efficiency of the airport, in an effort to "diagnose" where the weaknesses in the entire aviation system lie. Included in this description were several general tests to begin to frame an understanding of the resulting model data. Based upon how that information fits together, a better understanding of what the efficiency values mean can describe what a diagnostic metric would look like, and then how it could be used. This section will present these preliminary results, while the following section will draw conclusions based upon these results and set up a series of deeper questions as a part of the proposal for future work.

Given that there are 27 models that need to be summarized, nine years for each of the three models, three appendices house the relevant output data.

Appendix 5 contains all of the data from the Directional Output Distance Model, Appendix 6 contains all of the data from the BCC Model, and Appendix 7 contains all of the data from the CCR Model.

Each of the appendices shows nine figures, in reverse chronological order, with the 45 DMU airports listed in alphabetical order, showing the resulting efficiency values coming from the specific model for the specific year. Within these figures, several patterns emerge, and many of these patterns emerge which hold across the figures, which means over time. To summarize the entire data sets of the models, each of the models will be analyzed in an aggregated format which shows the distribution of the data from each DMU, in the order of the appendix listing.

Results of the Total Airport Directional Output Distance Model

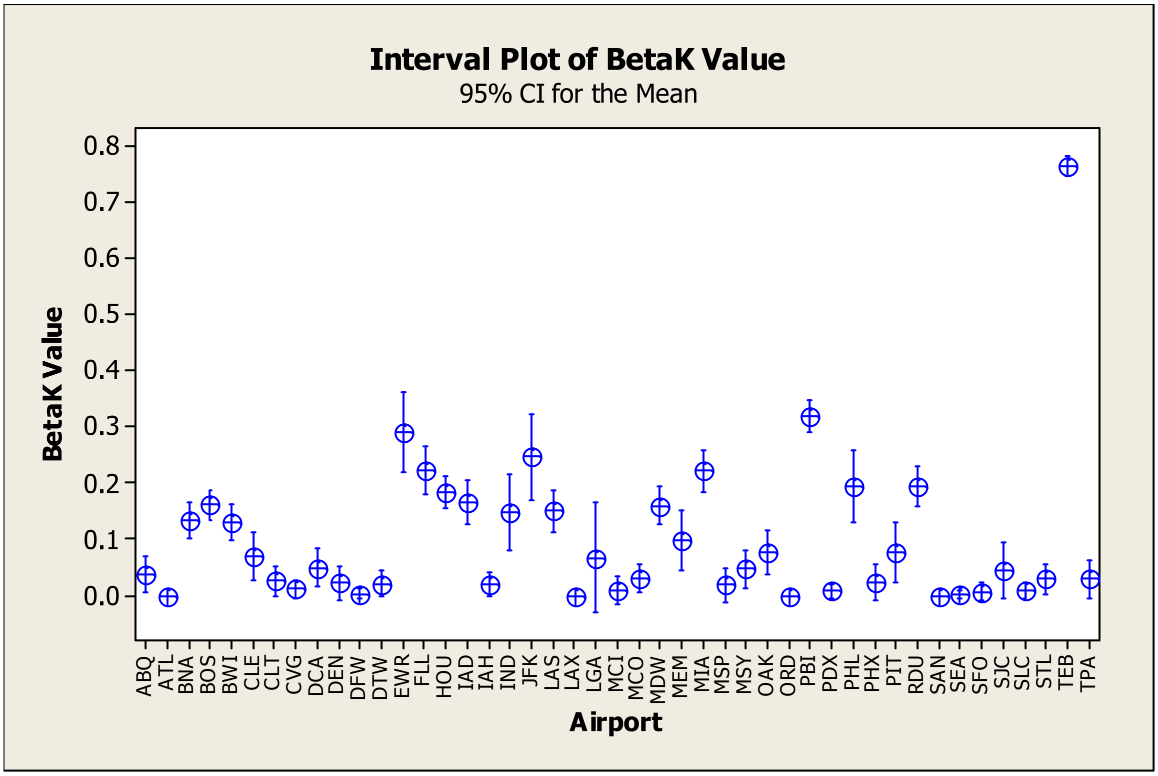


Figure 22: Combined Data for the Directional Output Distance Model

Figure 22 shows the combined data from the Directional Output Distance Model, and one of the most noticeable features of the figure is the outlier in the upper right corner. This outlier is for TEB, which is a unique DMU amongst the 45, as it is the only one which does not have commercial service. Instead, TEB, located in Teterboro, New Jersey, just northwest of New York City, is a reliever airport which sees heavy volumes of general aviation traffic, including a large number of business jets. Therefore, the airport is impacted by the congestion known to plague the three major New York airports: EWR, LGA and JFK. Also of note is that the distribution of this outlier is tight, in that the interval is comprised of six years of data, which results in very little in the way of dispersion, so TEB is likely not a unique outlier, but instead an ongoing part of the New York Airspace problem; although at this stage it is not known if this is a problem or a symptom of a problem, but TEB clearly stands out for some reason.

The other item of note in Figure 22 is the number of airports which approach the frontier value of zero. In some cases, such as ATL and SAN, they sit on the frontier at all times, as there is no dispersion, but others are very close and sometimes reach the frontier. However, there also appears to be another set that are not close, and remembering that the data is in alphabetical order, which is meaningless for this statistical analysis, it almost appears as if there is a “wave” in the middle of the figure. Remembering that the “good” values of β are zero, there is an odd pattern, but is meaningless beyond the fact that these intervals are uniformally not approaching the frontier. Returning to the literature supplied by news media and other social sources, the candidates are not surprising, as BOS and BWI start the wave on the left side, as both are part of the known problematic airspace in the Northeast, but the second part of the wave is full of problematic facilities including all three major New York facilities, IAD and PHL, which largely encapsulates the entire Northeast Corridor, running all the way from Washington DC to Boston, with the lone reasonably well performing airport in the region at DCA.

The other area of concern which appears in Figure 22 is South Florida, as all three airports, FLL, MIA and PBI all fared quite poorly, on par with their New York counterparts.

Beyond the geographical conclusions, the other item of note is that the distributions of β scores for each DMU are reasonably tight, indicating consistency year over year, with each distribution having six to nine years of data to create the individual distribution per DMU, and further information on the data counts per year, for all models can be found in Table 4.

Results of the Total Airport BCC Model

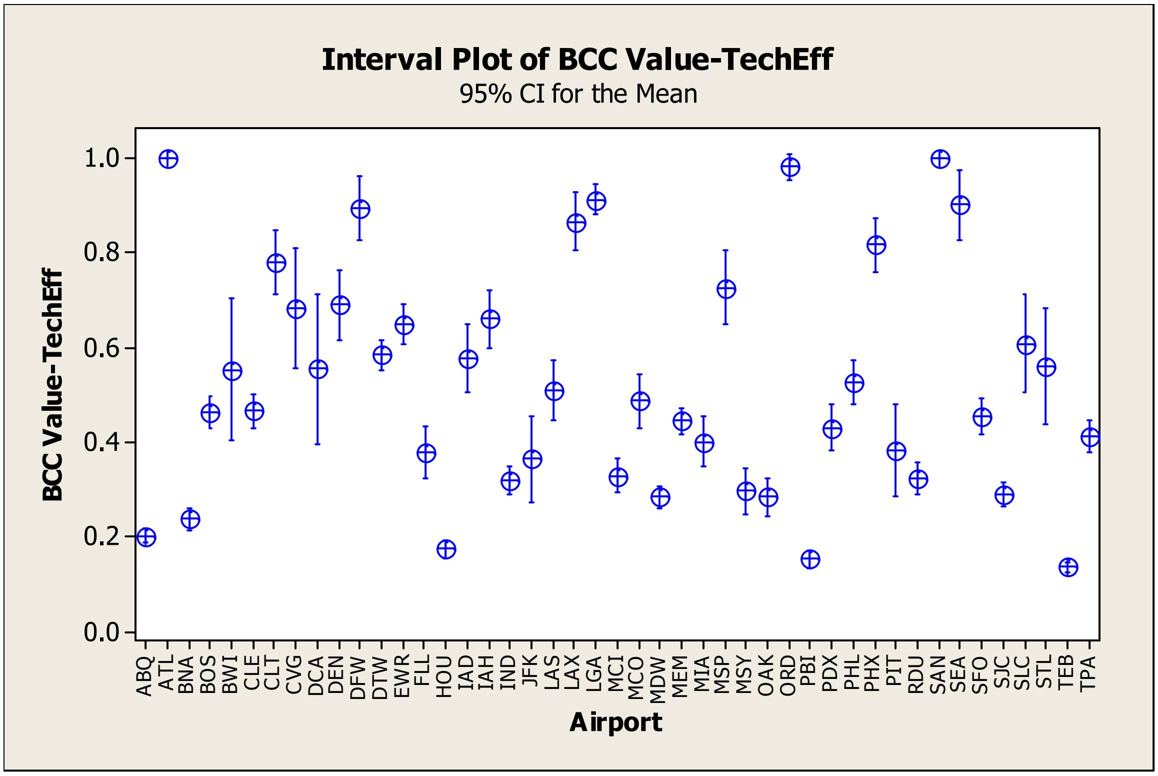


Figure 23: Combined Data for the BCC Model

Figure 23 shows a very different picture from Figure 22 because there is much more even spreading of the data, and there are also two well defined groups at the extremes within the data. While the Figure 22 showed several DMUs approaching the frontier, and sitting on it at different times, the BCC data shows only two on the frontier, ATL and SAN, with ORD being on the frontier about half the time, and just barely off in the other half. Beyond those three, nothing appears to even be close, although this is a function of the display of the intervals, as over the course of the nine years of data, SEA and LAX each made it to the frontier once, and DFW made it twice.

This airport list actually makes for a compelling list, because of the three which routinely sat on the frontier, they exhibit the extremes of the efficiency expression, two with the numerator the other with the denominator. ATL and ORD are the two busiest airports in the world by traffic volume, as noted by the Airports Council International, so the numerator becomes biased as huge flight volumes appear. However, SAN goes the other route, in that it does not have huge flight volumes, but it also only has one runway, RWY 9/27, so what volume it does have, which tends to get in and out on time, is produced on a very limited input stream. Merging these two, it is therefore no surprise that DFW flirts with the list, because DFW also moves huge volumes of aircraft, the third most in the world, but it also has seven runways, so the denominator becomes large enough to not land it consistently on the frontier. Therefore, this collection does make sense.

The other group which appears is at the bottom of the figure, as there appears to be almost a straight line lower bound, comprised of ABQ, BNA, HOU, PBI and TEB. A quick analysis of these airports shows that by OPSNET 45 standards, these are quite small. Two of the metropolitan areas are not that large by the OPSNET 45 standard, Albuquerque, New Mexico and Nashville, Tennessee, and the other three airports are secondary options in their larger markets, as TEB is a reliever for the New York City majors, PBI is an alternative to MIA and FLL at the northern edge of the South Florida megapolis, and HOU, commonly known as “Hobby” or “Houston-Hobby” is the old airport for the Houston, Texas metro. HOU is primarily serviced by Southwest, similar to the operation of Love Field in Dallas, but otherwise has very limited service, as the bulk of the flights in and out of Houston are through IAH.

Beyond these two nearly linear bounds, the rest are reasonably scattered across the continuum, and the distributions are not as tight as they were for the β measurements shown on Figure 22, with DCA and BWI exhibiting relatively large variance compared to the others on the figure. Also of note are the variances of CVG and STL, which appear to be a little large, but it is also known that both airports added a new runway in the period studied, so this is merely noted at this time for completeness.

Therefore, this measurement operates in a different fashion, and gives a different picture of the efficiency, as it influenced more by volumes and inputs than the Directional Output Distance Model, which matched up well with consumer experience.

Results of the Total Airport CCR Model

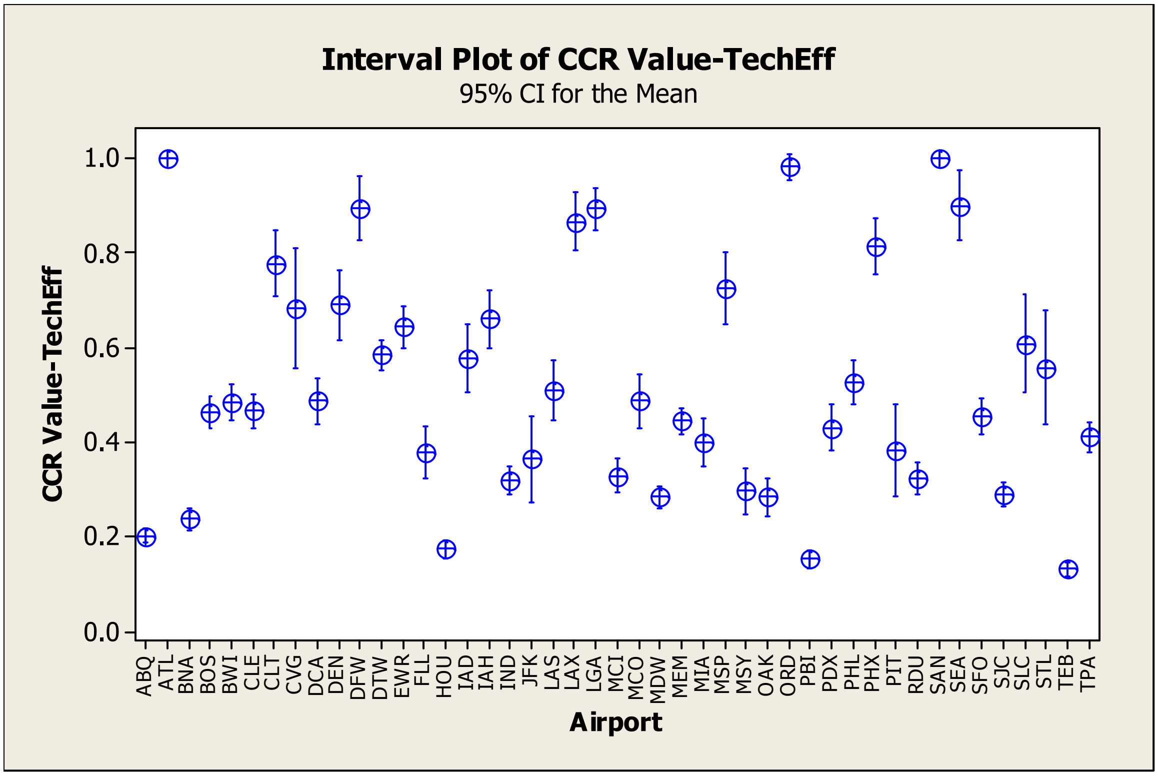


Figure 24: Combined Data for the CCR Model

Figure 24 shows a similar picture to Figure 23, which is not surprising given that the efficiency expression is almost identical, and the difference between the models being the convexity constraint. Therefore, it is expected that the figures would appear similar, noting that the apparent linear bound at the bottom, comprised of the same five airports, is still in place, albeit less distinct as some of the other airports are a little closer to this apparent line.

Likewise, the frontier is still dominated by ATL, ORD and SAN, with flirtations by DFW as noted in the BCC case, and also with LAX and SEA each appearing on the frontier once in the period studied. The reasoning for this remains the same as the efficiency expression is the same, and will not be repeated here.

Also of note again is the reasonably tight distributions scattered throughout the continuum. Again the variances of CVG and STL, which appear to be a little large, but it is also known that both airports added a new runway in the period studied, so this is merely noted for completeness.

Results of Total Airport Scale Efficiency Analysis

As noted, the scale efficiency is a ratio of the technical efficiencies of the BCC and CCR models, and the scale efficiency gives a sense of how the results of the operation are impacted by the quantity of the inputs used. In literature, the scale efficiency can be a source of consternation because it is frequently indicative of something less positive. Cullianne et al (2006) notes that in container port operation scale efficiency is highly correlated with congestion, because of a lack of space to operate implying an efficient use of said space, which is a fear coming from the CCR and BCC models, as it is known that the airspace in the northeastern United States is constrained.

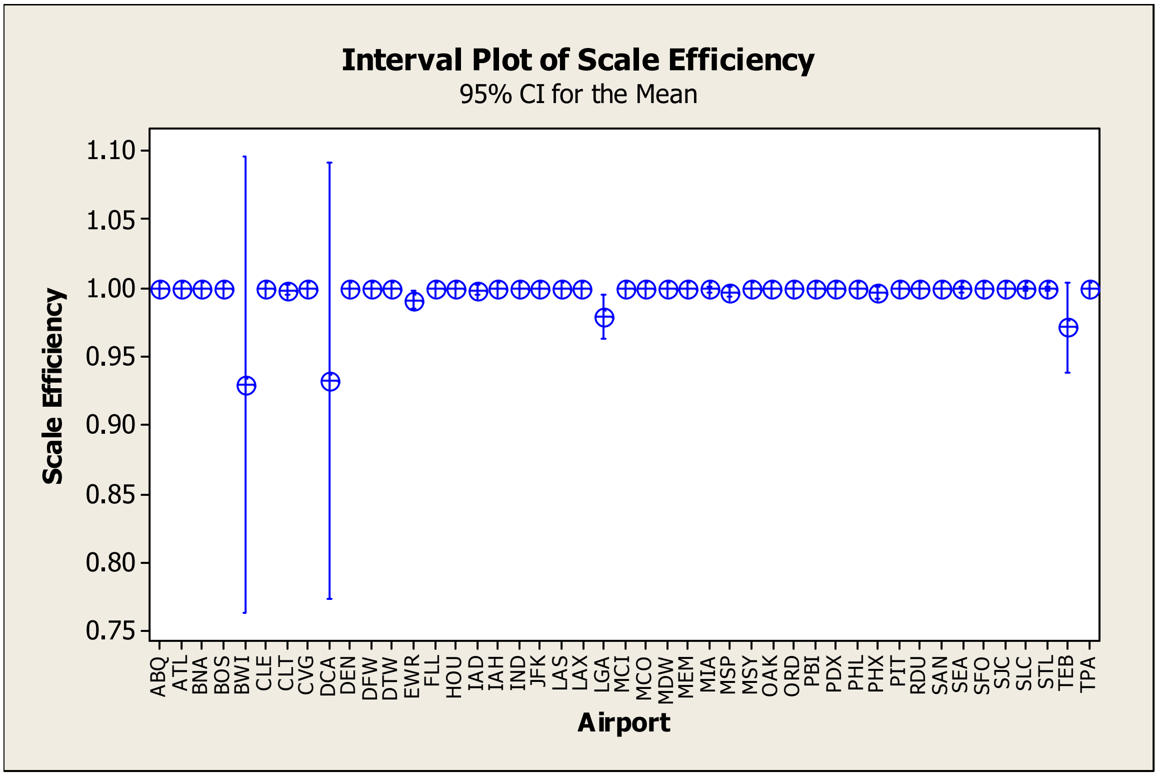


Figure 25: Combined Data for the Derived Scale Efficiencies

Figure 25 shows the resulting scale efficiencies of the airports under study, and from it, two points need to be addressed. The first is that the scale on the Y-axis is significantly smaller than in any of the other three summary analyses. This means that the values shown here are actually quite small on a relative basis; however, this also leads to the second point.

The other notable observation from the graph is that almost all of the DMUs are aligned in a perfectly straight line across Figure 25 at a value of one. This is a perplexing result, given the few numbers of DMUs which were located on the efficient frontier in the CCR and BCC models, and because it is so close to unity across all DMUs.

The belief is that the amount of bending, or bowing, in the frontier is minimal relative to the constant-returns-to-scale case, therefore, the results are similar. This appears reasonable given that not all of the DMU airports are sitting on the line with a scale efficiency of one, which would be more indicative of an error, and instead may be an indication that the governing municipalities have correctly sized the airports relative to demand; or the converse, that airlines have elected to use all of the available capacity to use more regional jet traffic to better serve consumer demand.

However, what may be more interesting is which airports are not located on this scale efficient frontier. While the differences are small, as noted with the short range of values on the Y-axis, the airports which clearly do not sit on the frontier are: BWI, DCA, EWR, LGA and TEB. Likewise, MSP and PHX are just barely off.

Starting the analysis with MSP and PHX, a quick survey through the data shows that the values which were not on the efficient frontier were located just off by tenths of percents, and between the two, the most recent was in 2005; otherwise, these two airports have also been scale efficient. The more interesting group is the other five.

While MSP and PHX do not share any obvious ties, BWI, DCA, EWR, LGA and TEB all operate in the congested northeastern air corridor, which would seem to indicate this is not a coincidence, and has been referenced in literature for shipping containers as noted. This raises questions as to why JFK, PHL and BOS were also not included in the group, but looking through the data, these three did not appear.

The three New York area facilities had scale efficiencies of less than one for every year up to and including 2005, indicating that this was not an isolated incident, although it will not be further addressed at this time. However, DCA and BWI are likely data errors, caused by huge outlier values in 2003 alone.

Deeper analysis into the data feeding these two outliers shows that the large intervals at DCA and BWI come from a known error in the data, which caused the 2003 values to vastly inflate. The cause of the data blip is unknown, but the impact of this error is, as the expected value of time in 2003 should have been 35040 quarter-hour units, but for some reason in the ASPM databases, in 2003, both DCA and BWI reported only 34944 quarter-hour units. This single day gap, the 96 missing quarter-hour units, created havoc within the models, throwing off the efficiency values as the scale efficiencies for all 45 airports are so tight, that this single day in a single year stands out so drastically graphically. As such, the scale efficiency appears to be a poor metric to differentiate facility efficiencies.

Correlation in the Total Airport Measurements

While the individual measurements revealed some interesting information the similarity of the CCR and BCC measurements, coupled with the resulting lack of differentiation amongst the scale measurements, leads to a question about how tightly correlated the three models are, and if there is any meaningful difference between them.

To address this issue, the airport data was fed into Minitab to generate Pearson Correlation Coefficients to determine if this was the case. The output is shown below.

Correlations: BetaK Value, BCC Value-TechEff, CCR Value-TechEff

```
                       BetaK Value  BCC Value-TechEf
BCC Value-TechEf            -0.477
                             0.000

CCR Value-TechEf            -0.489             0.986
                             0.000             0.000


Cell Contents: Pearson correlation
               P-Value
```

The correlation data backs up what was witnessed by analyzing the individual variables, in that the correlation between the CCR and BCC outputs is almost perfect, at 0.986, which also helps to explain the high values of scale efficiency as the two outputs track almost perfectly. But, also of note, is that all three correlations are statistically significant. Given the nature of the efficiency expressions, this is not surprising, as each model was to be a different interpretation of the system.

General Primary Configuration Results

The preceding analyses investigated the efficiency values for the airport taken as a whole, but the research hypothesis is about being able to predict this value by using the underlying operating configurations. To this point, only half of the models which were run through ILOG CPLEX have been used, and this section looks at incorporating the models of the configurations to actually predict the results given by the airport models.

This section will not be structured like the previous sections, which looked into the efficiency values themselves, due to the large number of DMUs, ranging from 144 in 2000 to 466 in 2008, and the variability of the DMUs. The reason for the increase in the number of DMUs is largely an effect of more airports implementing ground surveillance technology, as well as new runways coming online, which gave some airports new options in how to process flights, and all studied airports better information to make better decisions on how to process flights. Because of these options, new efficient configurations were put into place, meaning the ability to historically follow a configuration would not be guaranteed, and it is known that several major maintenance operations occurred during this time, such as runway resurfacing at IAH, which removed other runways from service, further altering the stability of the configurations through time.

Cursory analysis of the runway efficiency values was done graphically, as a visual inspection of the nearly 2800 data points from the nine years appeared to be similarly distributed as the total airport efficiencies were. For completeness, the four efficiencies were plotted as histograms to show the frequencies of where the efficiency values were, to get a sense of the dispersion within the values. These histograms are shown as Figure 26 to Figure 29.

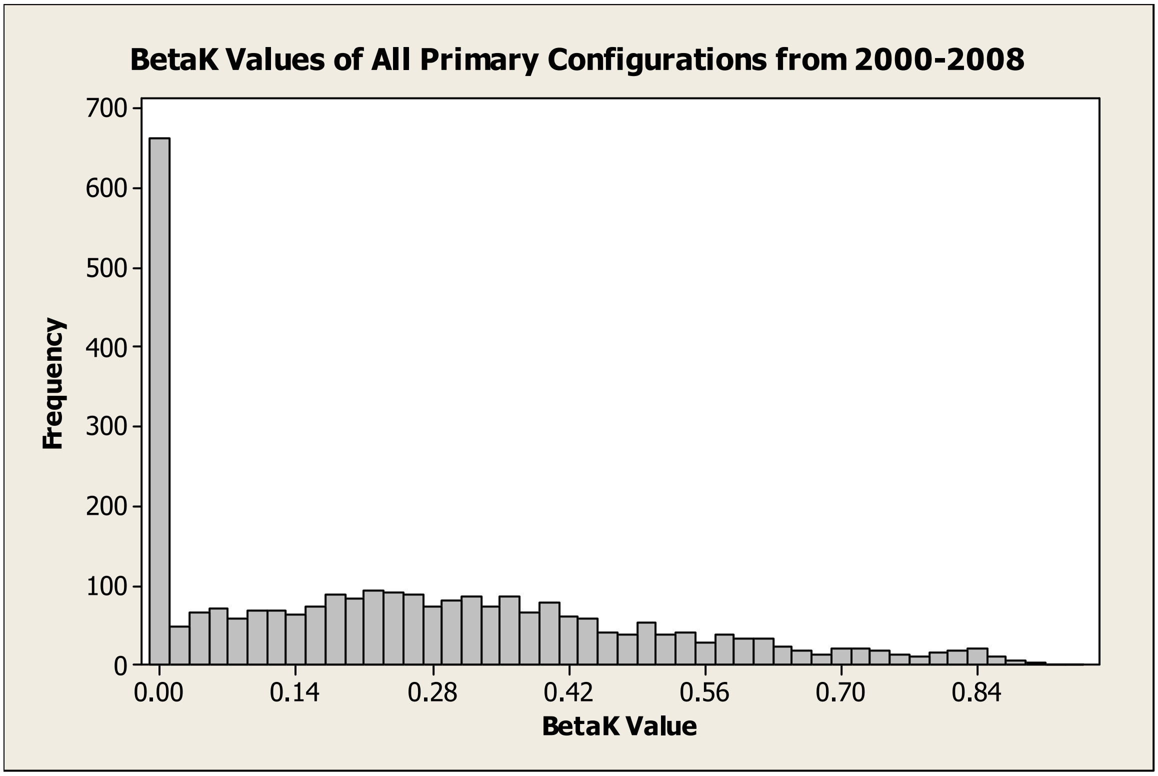


Figure 26: BetaK Values of All Primary Configurations from 2000-2008

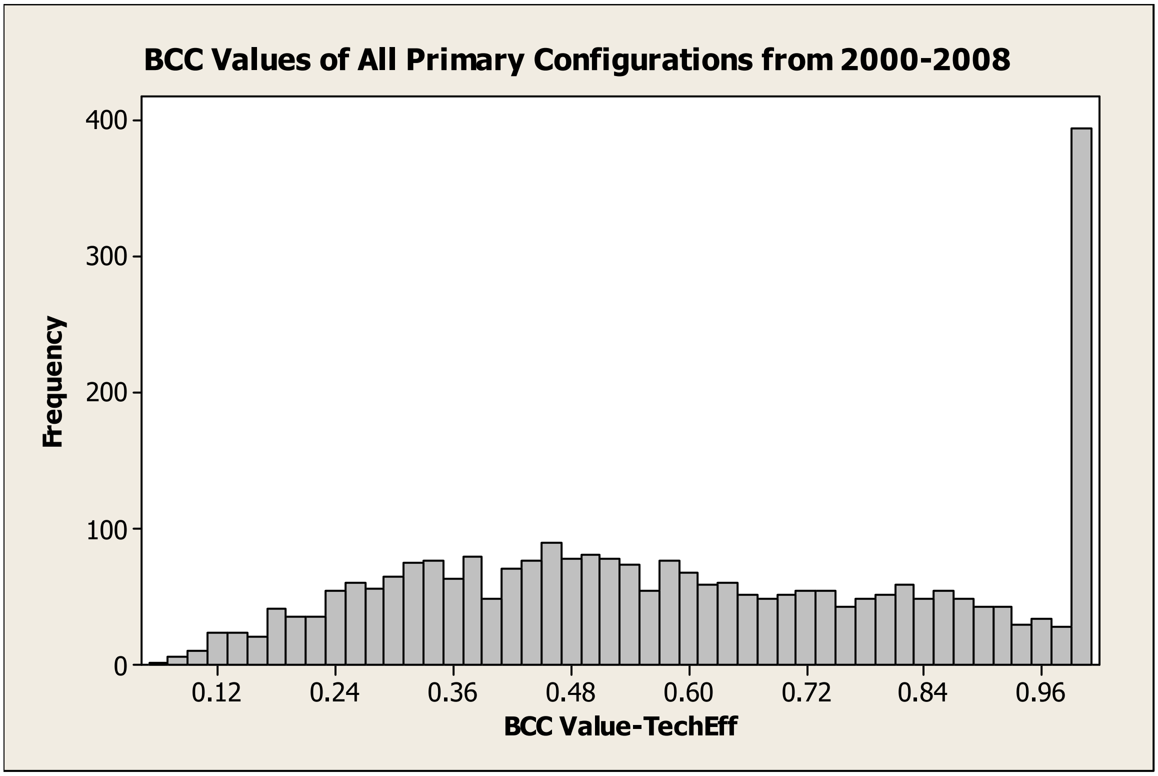


Figure 27: BCC Values of All Primary Configurations from 2000-2008

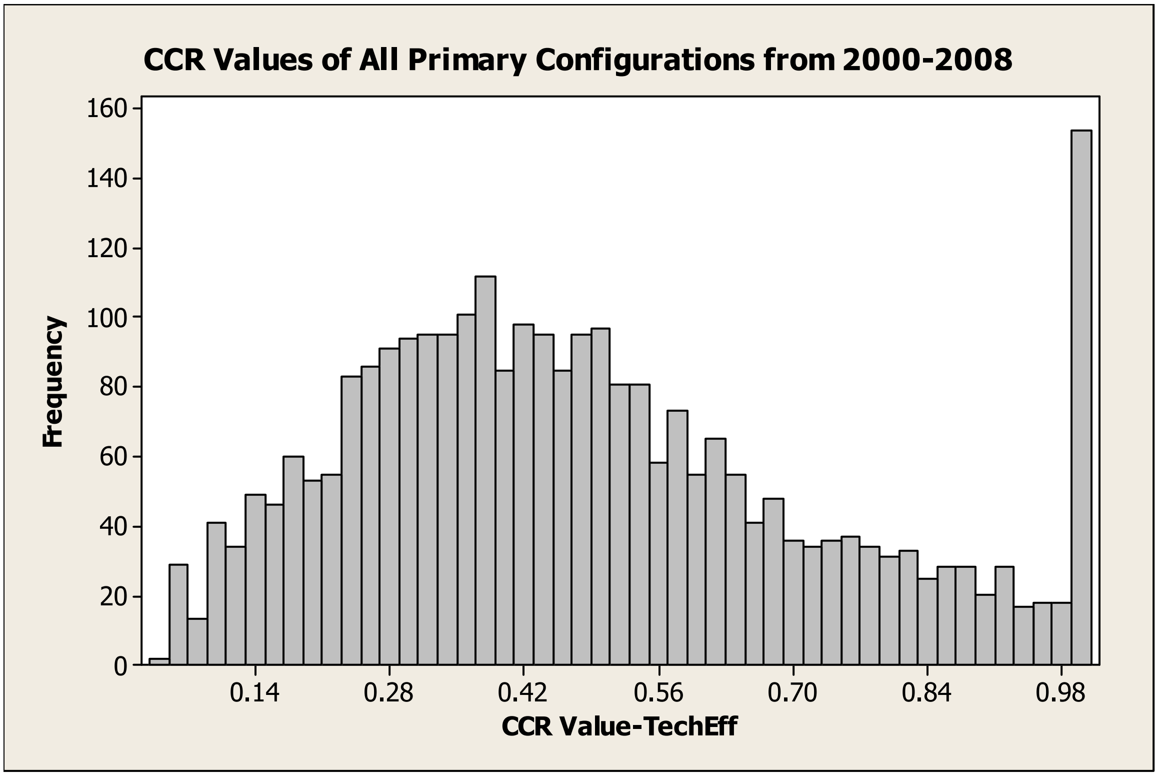


Figure 28: CCR Values of All Primary Configurations from 2000-2008

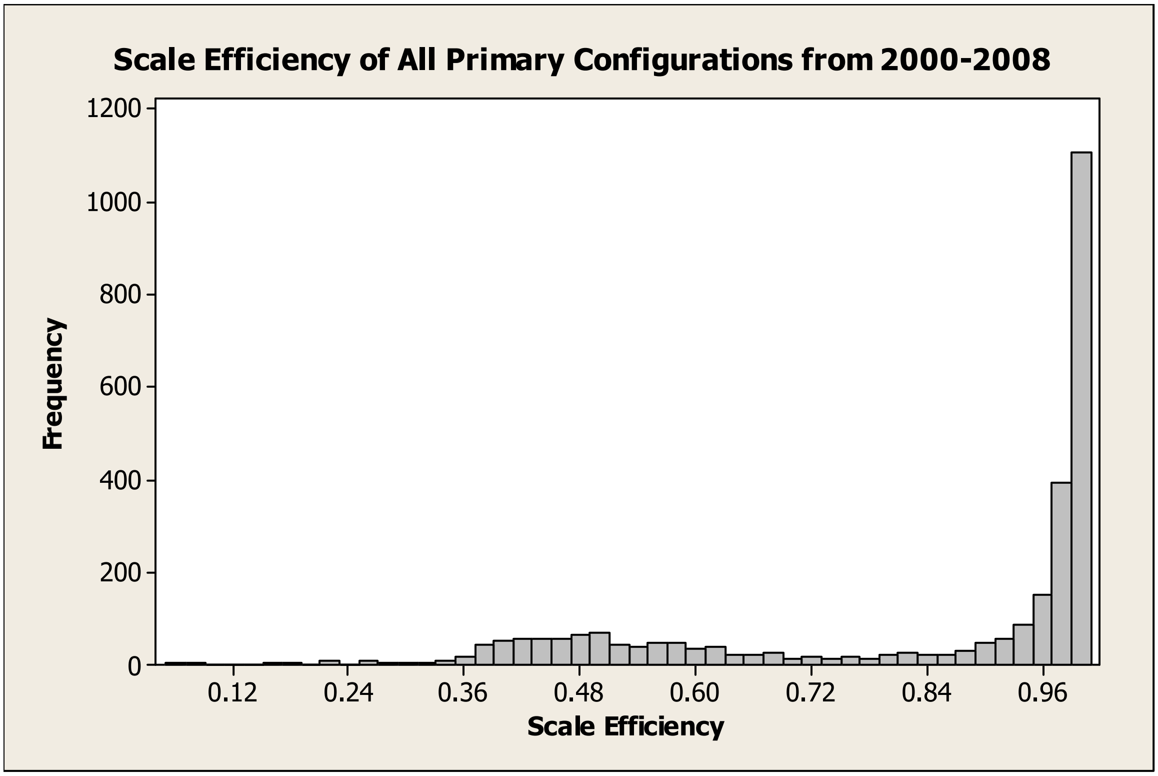


Figure 29: Scale Efficiency Frequencies for the Primary Configurations 2000-2008

The four figures show a reasonable distribution of the efficiency values, indicating that there are differences between the various configurations, noting that the VFR and IFR configurations are merged in these four graphics. However, the other item of note is the different shapes of the Figure 27 and Figure 28, the BCC and CCR figures respectively, which indicates that there is more bowing of the efficient frontier for the configurations than for the airports themselves. This led to a set of scale efficiencies which offer a better opportunity for differentiation, shown in Figure 29, but it is worth noting that a huge majority of these configurations still show a very high scale efficiency, as the two rightmost bars account for a little more than half of the total configurations studied over the nine-year period.

Given the differences shown in the four figures, there is likely less correlation between the efficiency scores of the configurations, but in the interest of completeness, the correlations were checked to be sure.

Correlations: BetaK Value, BCC Value-TechEf, CCR Value-TechEf, Scale Efficiency

```
                       BetaK Value  BCC Value-TechEf  CCR Value-TechEf
BCC Value-TechEf            -0.309
                             0.000

CCR Value-TechEf            -0.454             0.746
                             0.000             0.000

Scale Efficiency            -0.248            -0.233             0.427
                             0.000             0.000             0.000


Cell Contents: Pearson correlation
               P-Value
```

As expected, the correlations were statistically significant, as the efficiency expressions were similar, but unlike the total airport case, the correlations were not as strong. That said, the correlation between the BCC and CCR values, as expected, was still quite strong at 0.746. However, correlation is not the same as causation, so a link is needed to peg the efficiency of the configurations to the efficiency of the entire airport.

As noted in Section 9 in the analysis of the Japanese factory, weighted sums of the configuration efficiencies could be used to show the efficiency of the factory, since defined operations are largely unknown in a true demand-pull system, as the operations are dictated by the purchase of a product. In the case of an airport, the paths through the airport are the configurations, and there is a single product, which is a safe operation, which is either a departure or arrival operation, but the underlying weighting remains the same. Therefore, the configuration outputs, the number of departure and arrival operations, need to be used as weights to generate an efficiency component for the total airport.

11. Statistically Modeling Total Airport Results

The previous section showed that the models were able to differentiate efficiencies at both the airport and configuration level, although there is a danger from a large amount of correlation within any potential predictors. Therefore, any statistical model "rolling up" the configurations into a total airport value needs to be mindful of this potential trap.

Preliminary Error Analysis

Given the known correlations, knowing about any other sources of error going into the modeling will be helpful in understanding the analyses.

Building these statistical models of the whole from the components would seem to be straightforward, but is subject to a significant problem, because only the primary configurations could be reasonably be tracked for efficiency generation purposes. This means that any operation occurring on a non-primary configuration would not be accounted for within the configuration data, but was captured in the aggregate airport data. This leads to a potentially large source of error, and Table 6 shows how large these errors are, as a percentage of operations, at all 45 airports.

Airport	Percent Operations in Non-Primary Configuration Operations By Year								
	2008	2007	2006	2005	2004	2003	2002	2001	2000
ABQ	7.5%	5.7%	2.6%	9.7%	9.2%	14.4%	65.1%	100.0%	100.0%
ATL	9.0%	11.9%	10.4%	0.1%	0.0%	0.3%	0.0%	0.6%	1.9%
BNA	28.7%	11.4%	14.5%	93.7%	0.6%	75.6%	100.0%	100.0%	100.0%
BOS	37.1%	23.6%	23.7%	13.9%	19.3%	11.6%	14.4%	18.1%	12.0%
BWI	16.2%	9.5%	6.4%	4.4%	3.2%	4.4%	14.1%	60.9%	100.0%
CLE	7.6%	9.8%	9.8%	4.9%	7.1%	5.6%	7.7%	3.3%	9.9%
CLT	11.1%	7.3%	0.6%	1.4%	0.9%	0.3%	0.9%	62.2%	100.0%
CVG	11.1%	10.5%	5.1%	3.0%	0.3%	0.0%	0.7%	0.2%	3.8%
DCA	2.9%	3.6%	1.4%	6.6%	1.3%	14.0%	10.7%	75.3%	100.0%
DEN	48.5%	23.4%	20.4%	1.4%	1.0%	6.1%	3.5%	68.7%	100.0%
DFW	14.5%	8.4%	4.9%	1.3%	0.0%	0.2%	0.0%	0.1%	8.0%
DTW	17.3%	23.0%	12.4%	0.9%	0.7%	0.7%	3.9%	0.6%	4.1%
EWR	5.5%	3.8%	4.7%	4.4%	9.0%	13.3%	4.8%	3.8%	4.7%
FLL	5.0%	3.7%	7.6%	2.3%	1.2%	0.2%	46.6%	100.0%	100.0%
HOU	20.3%	10.9%	17.1%	4.4%	1.9%	60.3%	100.0%	100.0%	100.0%
IAD	18.7%	12.3%	5.6%	3.9%	2.7%	8.3%	2.8%	1.9%	3.1%
IAH	13.4%	14.8%	12.0%	1.2%	1.5%	5.1%	1.1%	3.1%	10.1%
IND	11.4%	13.3%	12.0%	11.1%	8.5%	14.4%	68.8%	100.0%	100.0%
JFK	11.2%	13.7%	3.4%	4.0%	5.5%	8.6%	5.0%	4.9%	12.4%
LAS	9.6%	15.8%	15.0%	4.4%	2.9%	1.9%	1.3%	66.6%	100.0%
LAX	18.9%	5.0%	1.7%	3.8%	2.3%	2.6%	0.8%	0.4%	9.0%
LGA	7.7%	6.5%	7.1%	8.2%	4.7%	6.3%	7.0%	3.8%	16.1%
MCI	19.3%	12.7%	12.1%	15.1%	11.4%	17.0%	69.6%	100.0%	100.0%
MCO	23.5%	10.8%	4.0%	4.0%	0.9%	3.3%	2.6%	68.1%	100.0%
MDW	8.9%	6.2%	4.6%	2.8%	2.8%	1.9%	6.7%	21.6%	47.2%
MEM	13.7%	24.8%	20.5%	8.8%	7.6%	22.0%	31.0%	17.4%	10.5%
MIA	15.3%	13.9%	13.0%	9.6%	3.9%	3.9%	3.3%	66.9%	100.0%
MSP	6.1%	16.8%	23.1%	6.8%	4.0%	2.8%	3.2%	4.7%	6.7%
MSY	28.3%	3.4%	15.8%	9.6%	3.5%	0.9%	69.1%	100.0%	100.0%
OAK	3.7%	8.5%	7.4%	3.4%	2.7%	26.5%	100.0%	100.0%	100.0%
ORD	31.9%	26.3%	10.4%	6.4%	7.0%	5.8%	6.0%	7.8%	8.5%

PBI	4.0%	0.6%	8.2%	13.9%	4.9%	72.1%	100.0%	100.0%	100.0%
PDX	6.6%	2.2%	3.2%	4.0%	3.9%	4.3%	68.9%	100.0%	100.0%
PHL	20.6%	8.4%	8.8%	6.2%	8.7%	9.9%	6.4%	9.3%	4.5%
PHX	2.3%	1.0%	0.3%	0.6%	1.4%	1.5%	1.3%	4.8%	3.9%
PIT	19.3%	22.4%	10.4%	4.0%	1.5%	2.4%	1.2%	65.2%	100.0%
RDU	35.5%	3.5%	1.1%	0.8%	0.4%	63.8%	100.0%	100.0%	100.0%
SAN	5.3%	3.4%	5.3%	1.5%	1.9%	26.5%	26.7%	100.0%	100.0%
SEA	10.0%	4.8%	15.8%	0.9%	0.3%	0.5%	0.0%	0.0%	3.5%
SFO	6.9%	1.7%	6.7%	2.5%	1.0%	1.4%	0.7%	2.3%	3.1%
SJC	10.4%	2.5%	2.4%	3.5%	4.2%	57.6%	100.0%	100.0%	100.0%
SLC	2.4%	11.3%	0.8%	0.9%	0.0%	0.5%	1.5%	57.8%	100.0%
STL	12.3%	20.5%	32.6%	4.6%	0.1%	0.0%	0.0%	0.6%	1.9%
TEB	3.3%	6.5%	1.6%	4.5%	3.9%	69.6%	100.0%	100.0%	100.0%
TPA	5.6%	5.0%	18.0%	7.3%	4.2%	5.2%	2.0%	65.9%	100.0%

Table 6: Percent Operations in Non-Primary Configuration Operations By Year

Table 6 shows that the early data years are somewhat suspect, in that any cell with red text indicates that primary configuration were not even tracked, as the ground surveillance was not in place to support the data, as noted in Table 4. However, scanning through the table from right to left shows a pattern that as airports came online with the ground surveillance technology, the first year contributed an inordinately large number of operations assigned to non-primary configurations, shown as “Other” in the pie graphs shown in Figure 16, Figure 17 and Figure 18. This large error was due to the part of the year that was run before the full implementation of the ground surveillance program, and the percentages shown approximate when the surveillance data started. For example, at ABQ 65.1 percent of the data is listed as being in non-primary configurations in 2002, and the surveillance system was activated in August, accounting for roughly two thirds of the year which had passed before implementation. Likewise, at FLL in 2002, the percentage attributed to non-primary configurations was 46.6 percent, and the surveillance system was activated in June, so roughly half the year of operations had passed prior to implementation.

After that first year where the data was typically truncated, the data settled down in the table as the full year data took effect. This caused a drop by almost an order of magnitude in many cases, to a more stable few percent, although there was some significant jumping around at airports undergoing expansion or significant maintenance operations.

As an example of this jumping, RDU jumped from single digits to almost a third of total operations, but in summer 2008 RDU closed RWY 5R/23L was closed at night for repairs. Likewise, ORD opened RWY 9L/27R in November 2008 in the midst of a $6 billion airfield renovation and expansion plan, which will give the airfield a look similar to that of DFW, but with six parallel runways and two offset runways following an east-west orientation. Therefore, with the ongoing construction, which started in 2007, and new runways coming online, there is likely to be some hopping around amongst the configurations, but these can be reasonably explained on an individual basis.

Regression Modeling

With the understanding that there are potentially large errors in place at certain times at certain locations, which are inherent to the system and not necessarily statistical outliers when the time span of interest is considered, as runways do require resurfacing, lighting replacements and other maintenance over their lifetimes, the three efficiency outputs of the total airport models were tested against the operation count weighted efficiencies of the configurations to determine if there was even a predictor set that could be used for a reasonable prediction. The data was placed into the Best Subsets function in Minitab to draw upon the software's ability to calculate multiple predictors in a timely fashion. The results of these prediction set variables of the total airport case BetaK, BCC and CCR values are shown.

Best Subsets Regression: BetaK Value versus Summed W-Bet, Summed W-BCC, ...

```
Response is BetaK Value

                                          S
                                          u
                                          m S S
                                          m u u
                                          e m m
                                          d m m
                                            e e
                                          W d d
                                          -
                                          B W W
                                          e - -
                                          t B C
                       Mallows            a C C
Vars  R-Sq  R-Sq(adj)        Cp         S  K C R
   1  71.3       71.2      15.9  0.069946  X
   1  19.5       19.2     686.3   0.11709      X
   2  72.3       72.1       4.5  0.068771  X X
   2  71.9       71.7      10.1  0.069299  X   X
   3  72.5       72.3       4.0  0.068623  X X X
```

Best Subsets Regression: BCC Value-Te versus Summed W-Bet, Summed W-BCC, ...

```
Response is BCC Value-TechEff

                                         S
                                         u
                                         m S S
                                         m u u
```

```
                                            e m m
                                            d m m
                                              e e
                                            W d d
                                            -
                                            B W W
                                            e - -
                                            t B C
                          Mallows           a C C
Vars  R-Sq  R-Sq(adj)        Cp          S  K C R
   1  63.5       63.4      41.8  0.14929    X
   1  63.2       63.1      44.5  0.14980      X
   2  66.7       66.5       9.1  0.14284  X X
   2  65.6       65.4      20.4  0.14504    X X
   3  67.3       67.0       4.0  0.14163  X X X
```

Best Subsets Regression: CCR Value-Te versus Summed W-Bet, Summed W-BCC, ...

```
Response is CCR Value-TechEff

                                            S
                                            u
                                            m S S
                                            m u u
                                            e m m
                                            d m m
                                              e e
                                            W d d
                                            -
                                            B W W
                                            e - -
                                            t B C
                          Mallows           a C C
Vars  R-Sq  R-Sq(adj)        Cp          S  K C R
   1  65.6       65.5      49.9  0.14313    X
   1  65.5       65.4      51.2  0.14335      X
   2  69.2       69.0       9.9  0.13572  X X
   2  67.9       67.8      24.8  0.13846    X X
   3  69.9       69.6       4.0  0.13442  X X X
```

The same pattern emerged in each of the three searches for the best predictors, which is that the weighted sums of the operations efficiencies could predict the total airport value, but the question became to what degree this could be done.

All three models exhibited the same behavior, in that a single predictor variable could do a reasonable job in predicting the response, especially given the inability to account for flights operated in non-primary configurations.

However, the models were not universal, as problems existed within the diagnostic statistics shown, especially Mallows' Cp.

In all three models, the adjusted R-squared columns do not argue for inclusion of additional terms in the models, as the gains from doing so only range from one to six percent. This is very little in the way of variance explained relative to the simplicity of a single term model, which argues strongly for a single predictor. However, the Mallows' Cp scores give pause to this decision, as the values for the best models predicated upon adjusted R-squares also have amongst the highest Mallows' Cp values. In the Beta-K case, which predicts the β from the Directional Distance Output Model, this is not extreme, and probably not worth investigating, but in the BCC and CCR models, the differences are by an order of magnitude.

Looking into the formula to calculate the Mallows' Cp diagnostic helps to identify the source of consternation:

$$Cp = \frac{SSE_p}{MSE_m} - (n - 2p)$$

The issue is in the first term of the equation, as the sample size n is quite large at 360, and the number of predictors in any of the cases is small, rendering the 2p term at largest eight, meaning something in the first term is creating a value well in excess of 350 to generate the double digit Cp values. Since MSE_m is fixed, this means the SSE_p must be huge, as it is model specific.

Therefore, a preference for simple models is identified, but the error sums of squares require further investigation. Stepwise regression was done on each of the three total airport outputs to allow a dynamic insertion and removal of variables, to allow a better picture to emerge. The entry and exit alphas were intentionally placed at 0.10 as it is known that a single factor model may be workable, so any term on the perimeter flirting with entry is already known to not be a major player in the regression, as the intent of the analysis is to take a different approach to see if further clarity around the Cp value emerges. The stepwise regression output from Minitab is shown below, with notes inserted between the outputs for each model.

Stepwise Regression: BetaK Value versus Summed W-Bet, Summed W-BCC, ...

```
  Alpha-to-Enter: 0.1  Alpha-to-Remove: 0.1


Response is BetaK Value on 3 predictors, with N = 360


Step                   1        2
Constant        -0.01464  0.02320

Summed W-BetaK     0.930    0.892
T-Value            29.79    27.53
P-Value            0.000    0.000

Summed W-BCC              -0.056
T-Value                    -3.65
P-Value                    0.000

S                 0.0699   0.0688
R-Sq               71.26    72.29
R-Sq(adj)          71.18    72.14
Mallows Cp          15.9      4.5
PRESS            1.77809  1.73532
R-Sq(pred)         70.82    71.52
```

The stepwise regression for the Directional Output Distance model confirms the results of the best subsets analysis, as the predicted sums of squares (PRESS) is only 0.04 higher than the value from a model with an extra term; therefore, the large difference in Mallows' Cp is not of concern, as the slight inaccuracy in variance explanation is readily accepted for the trade off of a simple linear model.

Stepwise Regression: BCC Value-Te versus Summed W-Bet, Summed W-BCC, ...

```
  Alpha-to-Enter: 0.1  Alpha-to-Remove: 0.1


Response is BCC Value-TechEff on 3 predictors, with N = 360


Step                   1        2        3
Constant         0.08017  0.16186  0.14618

Summed W-BCC       0.786    0.727    0.516
T-Value            24.95    22.82     6.07
P-Value            0.000    0.000    0.000

Summed W-BetaK            -0.393   -0.313
T-Value                    -5.84    -4.29
P-Value                    0.000    0.000

Summed W-CCR                         0.248
T-Value                               2.67
P-Value                              0.008

S                  0.149    0.143    0.142
R-Sq               63.49    66.67    67.32
R-Sq(adj)          63.39    66.48    67.05
Mallows Cp          41.8      9.1      4.0
PRESS            8.07026  7.42350  7.33962
R-Sq(pred)         63.07    66.03    66.41
```

The PRESS values for the BCC model also exhibit differences, but not nearly as small as the previous case, which range near ten percent between the simplest and most complex models. However, the argument for a more complicated model is a better explanation of the variance. The differences in adjusted R-squares are small, which argues against the more complicated model, but the ten percent difference in PRESS might argue otherwise.

The other problem with a more complicated model is that the predictor terms are known to be correlated, at a statistically significant level. Furthermore, in the case of the CCR and BCC terms, this correlation is quite strong. Therefore, the question instead shifts to what is gained by adding a predictor to the equation that does not bring a distinctly unique modification to the regression?

For this degree of correlation, and the resulting differences in both the PRESS and adjusted R-squares, it is preferable to have simplicity and not have to worry about additional terms or underlying correlations.

Stepwise Regression: CCR Value-Te versus Summed W-Bet, Summed W-BCC, ...

```
  Alpha-to-Enter: 0.1  Alpha-to-Remove: 0.1


Response is CCR Value-TechEff on 3 predictors, with N = 360


Step                 1        2        3
Constant       0.07392  0.15923  0.14355

Summed W-BCC     0.790    0.728    0.517
T-Value          26.15    24.06     6.41
P-Value          0.000    0.000    0.000

Summed W-BetaK           -0.410   -0.331
T-Value                   -6.42    -4.77
P-Value                   0.000    0.000

Summed W-CCR                       0.248
T-Value                             2.82
P-Value                            0.005

S                0.143    0.136    0.134
R-Sq             65.64    69.19    69.87
R-Sq(adj)        65.55    69.02    69.61
Mallows Cp        49.9      9.9      4.0
PRESS          7.42035  6.71204  6.62139
R-Sq(pred)       65.24    68.56    68.98
```

The same pattern emerges in the CCR case as the BCC case, as the correlations between the variables are not enough to override the small gains in PRESS or adjusted R-squares relative to the simplicity of the model with a single term.

Each of the three single term models were then regressed to check for the statistical relevance of the assumptions underlying the regression, the regression equation itself, as well as the terms of the regression equation. Each model is handled individually.

Regression Analysis: BetaK Value versus Summed W-BetaK

```
The regression equation is
BetaK Value = - 0.0146 + 0.930 Summed W-BetaK


Predictor            Coef   SE Coef      T      P
Constant        -0.014641  0.005198  -2.82  0.005
Summed W-BetaK    0.92960   0.03120  29.79  0.000


S = 0.0699458   R-Sq = 71.3%   R-Sq(adj) = 71.2%

PRESS = 1.77809   R-Sq(pred) = 70.82%


Analysis of Variance

Source           DF      SS      MS       F      P
Regression        1  4.3423  4.3423  887.56  0.000
Residual Error  358  1.7515  0.0049
Total           359  6.0938


Unusual Observations

      Summed
Obs  W-BetaK  BetaK Value      Fit   SE Fit  Residual  St Resid
 13    0.193      0.36927  0.16467  0.00437   0.20459      2.93R
 22    0.286      0.00000  0.25167  0.00643  -0.25167     -3.61R
 27    0.073      0.27013  0.05327  0.00394   0.21686      3.11R
 32    0.404      0.33959  0.36083  0.00967  -0.02124     -0.31 X
 44    0.784      0.76769  0.71434  0.02113   0.05336      0.80 X
 58    0.391      0.35690  0.34928  0.00931   0.00763      0.11 X
 67    0.407      0.00000  0.36338  0.00975  -0.36338     -5.25RX
 89    0.711      0.73290  0.64596  0.01887   0.08695      1.29 X
109    0.337      0.00000  0.29874  0.00778  -0.29874     -4.30R
```

```
112    0.301      0.00000  0.26510  0.00681  -0.26510      -3.81R
134    0.812      0.75282  0.73984  0.02197   0.01298       0.20 X
148    0.193      0.35751  0.16521  0.00438   0.19230       2.75R
154    0.383      0.31974  0.34138  0.00907  -0.02165      -0.31 X
179    0.771      0.77502  0.70248  0.02074   0.07254       1.09 X
202    0.226      0.05479  0.19560  0.00501  -0.14081      -2.02R
214    0.237     -0.00000  0.20611  0.00525  -0.20611      -2.96R
224    0.751      0.77182  0.68339  0.02011   0.08843       1.32 X
247    0.252      0.00000  0.22003  0.00560  -0.22003      -3.16R
257    0.103      0.35001  0.08130  0.00371   0.26871       3.85R
262    0.108      0.23747  0.08541  0.00370   0.15205       2.18R
269    0.246      0.78187  0.21369  0.00544   0.56818       8.15R
325    0.171      0.00000  0.14390  0.00404  -0.14390      -2.06R
329    0.076      0.21246  0.05579  0.00391   0.15668       2.24R

R denotes an observation with a large standardized residual.
X denotes an observation whose X value gives it large leverage.
```

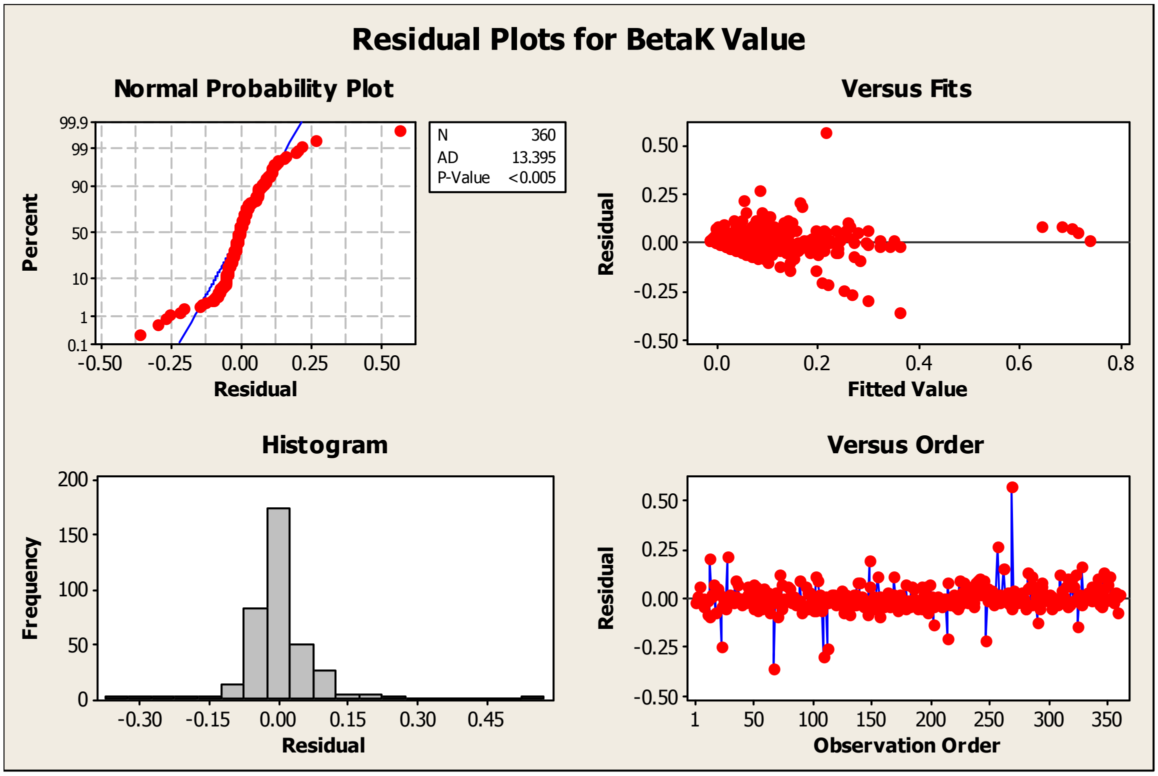


Figure 30: The Residual Plot from the BetaK Regression

Figure 30 shows an interesting residual pattern, as the normality plot has a bit of an "S" shape to it, but the bulk of the points lie along a line. Given that the Anderson-Darling test becomes increasingly sensitive as sample sizes grow, the low p-value is not that big of a concern, especially given the somewhat peaked bell-curve shown in the histogram. However, both the histogram and the fitted residuals show outliers, as well as the normal probability plot.

On the normal probability plot there are seven points which comprise the tails of “the S”, one at the top, which is a TEB (point 269) result, and six at the bottom, all of which are in the Northeastern airspace: one at PHL (point 214), one at JFK (point 109) and the other four at LGA (points 22, 67, 112 and 247), all of which have been highlighted yellow in the regression output; noting that only one has large leverage. Given that this is a known “hot spot” area in the United States airspace, these results are likely real, and not large outliers. Furthermore, these points comprise the top and bottom flares on the Versus Fits plot, giving it a “leftward-looking fish-shape”, while the rest is reasonably well distributed on both sides of the center line in a random fashion, albeit with the odd tail to the right which corresponds to the TEB points. Note that the data are arranged alphabetically, therefore the observation order plot does not hold.

The other area of interest is the large number of unaccounted for residuals with large leverage, and these points are all tied to TEB, which as previously noted is a unique case, because of its usage as a reliever airport and location in New Jersey. However, given the fact that there are 360 data points, several outliers are to be expected, and with standardized residuals over an absolute value of two being reported, the 23 reported points is not out of line with the roughly 18 or so that would be expected. Therefore, the assumptions of the regression are reasonably fulfilled, which allows for further analysis.

As expected, the regression is statistically significant, as are both terms given their extremely low p-values versus a reasonable comparison alpha, such as 0.05. Therefore, the β-value for a given airport can be predicted by the following equation:

BetaK Value = - 0.0146 + 0.930 Summed W-BetaK

Note that the term SummedW-BetaK is the weighted sum of the individual configuration β-values.

Moving to the prediction of the BCC model, using the same form:

Regression Analysis: BCC Value-TechEff versus Summed W-BCC

```
The regression equation is
BCC Value-TechEff = 0.0802 + 0.786 Summed W-BCC


Predictor        Coef  SE Coef      T      P
Constant      0.08017  0.02037   3.94  0.000
Summed W-BCC  0.78645  0.03152  24.95  0.000


S = 0.149292   R-Sq = 63.5%   R-Sq(adj) = 63.4%

PRESS = 8.07026   R-Sq(pred) = 63.07%


Analysis of Variance

Source           DF      SS      MS       F      P
Regression        1  13.874  13.874  622.48  0.000
Residual Error  358   7.979   0.022
Total           359  21.853


Unusual Observations

     Summed            BCC
Obs   W-BCC  Value-TechEff      Fit   SE Fit  Residual  St Resid
 10   0.363        0.74033  0.36546  0.01077   0.37487     2.52R
 25   0.683        0.24943  0.61702  0.00833  -0.36759    -2.47R
 31   0.605        0.90150  0.55607  0.00787   0.34543     2.32R
 76   0.692        0.93537  0.62425  0.00843   0.31112     2.09R
138   0.018        0.21215  0.09402  0.01986   0.11813     0.80 X
149   0.718        0.34405  0.64474  0.00875  -0.30069    -2.02R
```

```
155    0.918         0.46338  0.80205  0.01284  -0.33866       -2.28R
200    0.938         0.47100  0.81806  0.01335  -0.34707       -2.33R
230    0.383         0.99031  0.38137  0.01035   0.60894        4.09R
234    0.516         1.00000  0.48606  0.00826   0.51394        3.45R
245    0.920         0.44808  0.80398  0.01290  -0.35590       -2.39R
263    0.708         1.00000  0.63734  0.00863   0.36266        2.43R
269    0.038         0.12867  0.10975  0.01929   0.01892        0.13 X
288    0.896         0.45256  0.78452  0.01229  -0.33196       -2.23R
303    0.696         1.00000  0.62739  0.00847   0.37261        2.50R
311    0.159         0.52983  0.20494  0.01588   0.32489        2.19R
313    0.277         0.75771  0.29769  0.01278   0.46002        3.09R
316    0.157         0.55175  0.20378  0.01592   0.34796        2.34R
326    0.208         0.55969  0.24369  0.01455   0.31599        2.13R
334    0.184         0.55078  0.22513  0.01518   0.32565        2.19R

R denotes an observation with a large standardized residual.
X denotes an observation whose X value gives it large leverage.
```

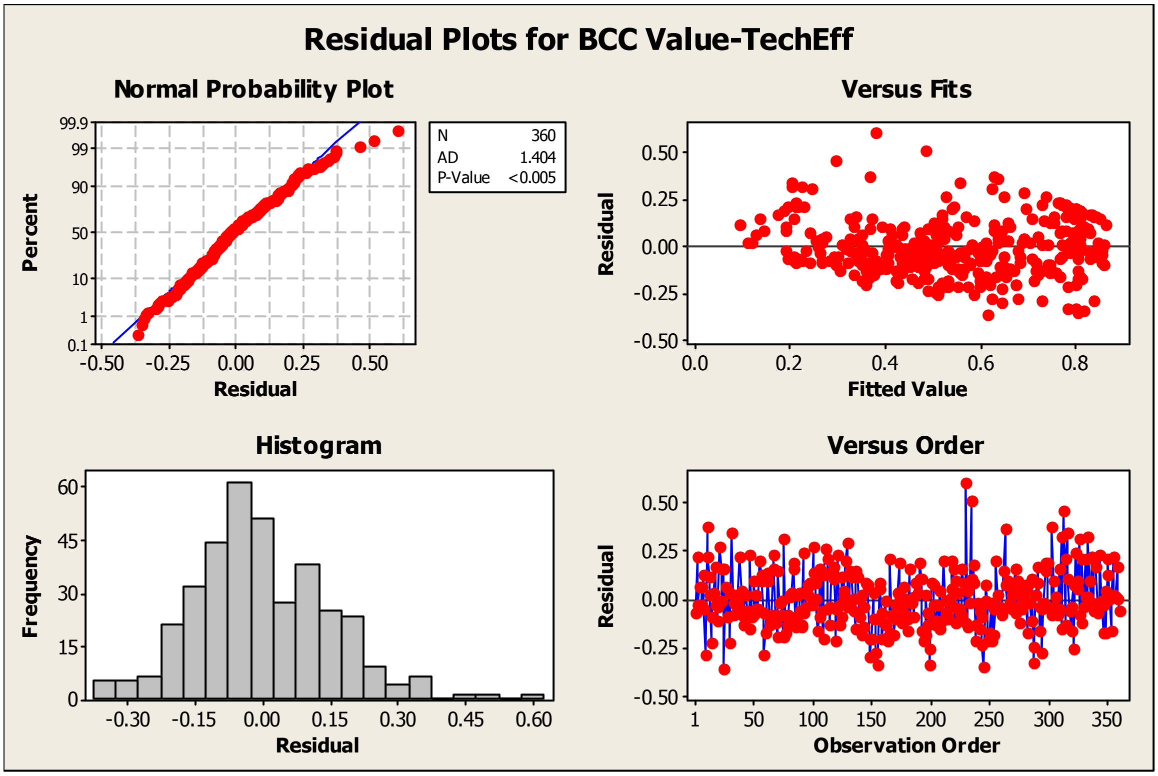


Figure 31: The Residual Plot from the BCC Regression

Figure 31 shows a much cleaner residual plot than was found in the previous analysis for the BetaK regression, although the same problem from the Anderson-Darling test appears, as a few points deviate from the line at the top of the normal probability plot. Investigating these five departures, again highlighted yellow in the Unusual Observations table, the pattern is not as pronounced, as the five points were: MDW (point 25), BWI (point 230), DCA (point 234), LAS (point 245) and CLT (point 313), all of which were highlighted in the residual table. Note that these five points were also the peaks in the Versus Fits table at the top, but otherwise, that plot has a nice random scattering, and the histogram is likewise somewhat bell shaped. Again, the Versus Order plot is rendered meaningless as the data is alphabetical, but the peaks do coincide with the five listed points.

The other two points of interest are the two points denoted as having high leverage, and one of these was at TEB and the other at BNA, further continuing the lack of a pattern, and allowing for the assumptions of the regression to be deemed fulfilled. This allows for further analysis.

Again, as expected, the regression is statistically significant, as are both terms given their extremely low p-values versus a reasonable comparison alpha, such as 0.05. Therefore, the BCC technical efficiency value for a given airport can be predicted by the following equation:

$$\text{BCC Value-TechEff} = 0.0802 + 0.786 \text{ Summed W-BCC}$$

Finally, the prediction of the CCR model, using the same form:

Regression Analysis: CCR Value-TechEff versus Summed W-CCR

```
The regression equation is
CCR Value-TechEff = 0.110 + 0.817 Summed W-CCR
```

```
Predictor        Coef  SE Coef      T      P
Constant      0.10960  0.01832   5.98  0.000
Summed W-CCR  0.81723  0.03132  26.09  0.000


S = 0.143350   R-Sq = 65.5%   R-Sq(adj) = 65.4%

PRESS = 7.43370   R-Sq(pred) = 65.17%


Analysis of Variance

Source           DF      SS      MS       F      P
Regression        1  13.989  13.989  680.76  0.000
Residual Error  358   7.357   0.021
Total           359  21.346


Unusual Observations

     Summed            CCR
Obs   W-CCR  Value-TechEff      Fit   SE Fit  Residual  St Resid
 10   0.363        0.74033  0.40600  0.00925   0.33433      2.34R
 22   0.483        0.94169  0.50425  0.00772   0.43744      3.06R
 31   0.605        0.90150  0.60372  0.00788   0.29778      2.08R
 67   0.534        0.94994  0.54637  0.00756   0.40357      2.82R
 84   0.528        0.91137  0.54118  0.00756   0.37019      2.59R
112   0.608        0.99728  0.60654  0.00791   0.39075      2.73R
129   0.549        0.97899  0.55833  0.00757   0.42066      2.94R
157   0.448        0.81835  0.47537  0.00801   0.34298      2.40R
200   0.796        0.47100  0.75975  0.01117  -0.28875     -2.02R
202   0.471        0.86849  0.49484  0.00780   0.37365      2.61R
245   0.882        0.44808  0.83051  0.01329  -0.38243     -2.68R
247   0.457        0.83016  0.48325  0.00792   0.34690      2.42R
263   0.644        1.00000  0.63559  0.00831   0.36441      2.55R
288   0.847        0.45256  0.80154  0.01240  -0.34898     -2.44R
290   0.489        0.87438  0.50909  0.00768   0.36529      2.55R
303   0.638        1.00000  0.63089  0.00824   0.36911      2.58R
311   0.156        0.52983  0.23691  0.01402   0.29292      2.05R
313   0.274        0.75771  0.33338  0.01109   0.42432      2.97R
316   0.156        0.55175  0.23706  0.01402   0.31468      2.21R
325   0.489        0.88559  0.50955  0.00768   0.37604      2.63R
334   0.182        0.55078  0.25834  0.01334   0.29243      2.05R
351   0.395        0.87195  0.43234  0.00870   0.43961      3.07R

R denotes an observation with a large standardized residual.
```

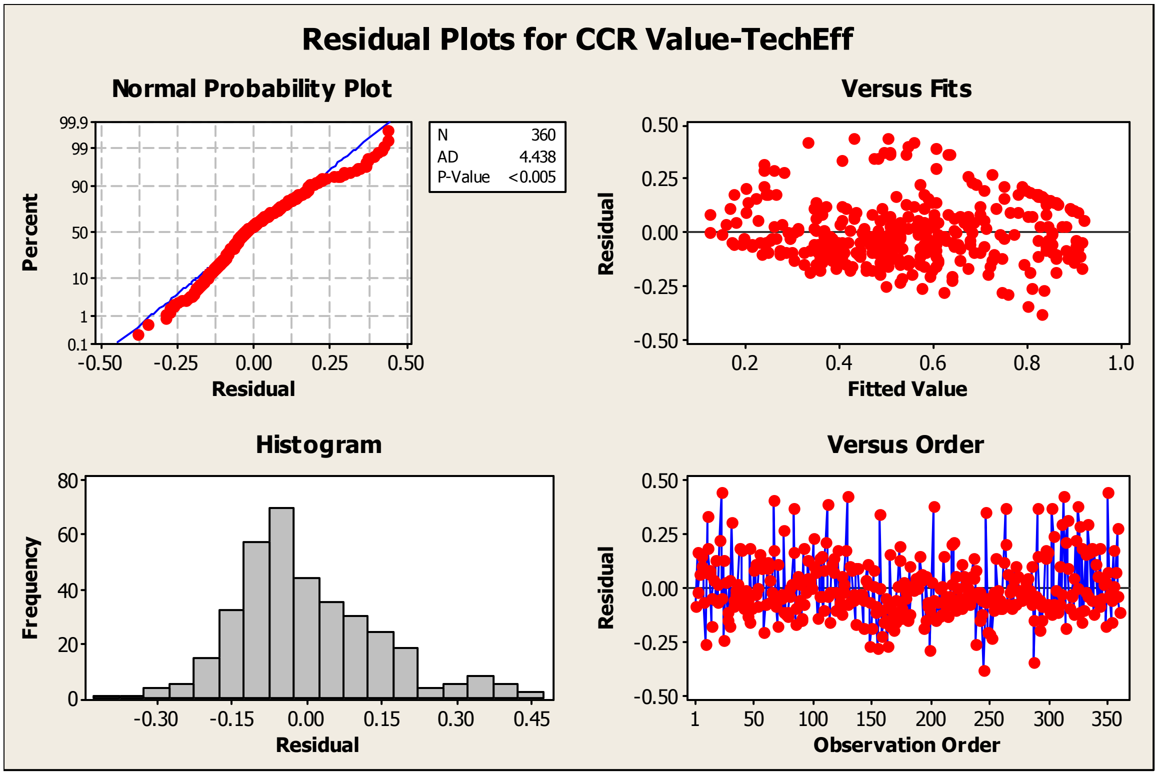


Figure 32: The Residual Plot from the CCR Regression

Figure 32 shows the cleanest residual plot of the three regressions, and the only area of concern, again related to the Anderson-Darling test showing a low p-value, is the slight bow at the top end of the Normal Probability Plot. This is reflected in the histogram a lump in the right tail, but overall, is probably fine. The Versus Fits plot shows an even and random distribution, and there are no points with excess leverage, nor are there an excessive number of large residual points. As previously noted, the Versus Order plot is rendered meaningless as the data is arranged in alphabetical order.

Again, as expected, the regression is statistically significant, as are both terms given their extremely low p-values versus a reasonable comparison alpha, such as 0.05. Therefore, the CCR technical efficiency value for a given airport can be predicted by the following equation:

$$\text{CCR Value-TechEff} = 0.110 + 0.817 \text{ Summed W-CCR}$$

These three equations can now be used to form a diagnostic for airport efficiency improvement.

Chapter 4: Diagnostic Development

Sections 12-19

12. Background for an Airport Diagnostic

Given the holistic approach of the three models coupled with the ability to tie the results of the programs to airport performance, there are an enormous number of possibilities to consider for improving the performance and efficiency of the nation’s largest airports. Obvious candidates would include working on the worst performing airports, or the worst configurations, or even boosting performance from baseline levels on the configurations which see the highest operations counts, as these are the configurations which likely ensure the cleanest day-to-day operation. Cases can be made for all of these approaches, as well as scores of other approaches, as there is no single “right answer” for how to approach the problem because there is no set valuation for the benefits; for example, is it better to reduce delays on a daily basis or is it better to ensure that there are no complete system meltdowns, such as the JetBlue Valentine’s Day Crisis of 2007? This determination is a political question that cannot readily be solved or answered by science, and as such, it makes the focus of what a diagnostic should identify difficult, because of the broad spectrum of possibilities.

Likewise the answer is not an all encompassing “yes” or “everything” or “all delays”, because it is known is that there is one driving constraint, which is that the funding which can be allocated to improvement projects, either operational or capital-based, is not only finite, but also a fraction of the billions upon billions of dollars required to “fix” everything. Furthermore, these billions of dollars ignore all of the political and environmental costs such as moving airports or runways, or determining who would have to bear the additional non-monetary costs, such as additional noise. Therefore, a method, whatever it may be, is needed to ensure a sound and holistic method is used to ensure that local optimality, one of the sources of the existing systemic problems, does not reign in the decision process.

Existing Systems to Fund Candidates

The current system for airport improvement, via the FAA, which typically supplies a large amount of the funding for improvements in the national aviation system entails what is known as a Benefit-Cost Analysis (BCA), which is an iterative system of negotiations to create a value proposition for project funding. This system, described in detail in the Airport Cooperative Research Program (ACRP) Synthesis 13, works by having airport managements build cases for a desired improvement, and then determining a range for potential outcomes based upon the breakdown of the underlying assumptions, both positive and negative. This proposal is then iterated back and forth between the airport and the FAA, until a “consensus on reality” is reached between the two sides, and the BCA is then reviewed to determine if it is in the FAA’s interest to fund the project. If the project is not approved, it is removed from consideration, and if the project is approved, it enters a pool awaiting funding.

This system covers a broad spectrum of improvements ranging from the seemingly mundane, like lighting replacements, all the way to extravagant and glamorous projects, like building entirely new airports. The results are public record, viewable on the FAA's government website, as the funding is from the United States Congress, and therefore derived from the United States income taxpayer. Therefore, it is in the best interest of the taxpaying public to ensure that the money is adequately appropriated, and therein lies the problem: the BCA process is local and is fueled by a local entity pushing to get an airport improvement.

The existing FAA structure is such that it has little power, and has no ability to issue debt, meaning that any move by the FAA has to be approved and funded by Congress on a year-over-year basis. This is a slow process, and Congress has a long history of engaging in other locally optimal projects, frequently referred to as "earmarks" or "pork barrel spending" in the common lexicon. Therefore, the BCA process is not backed by a systemic Congressional approval process, and there are plenty of opportunities for personal and regional interference in the process, coupled with the fact that benefits and costs are negotiated by two sides, versus driven by hard data, to show that a new taxiway or lengthened runway has value.

Diagnostic Objective Based Upon Assumptions and Constraints

Given that the BCA process is highly flawed in its ability to take a systemic view, both in the nature of how the process operates, as well as how the valuations are made. As noted in the Aviation Literature Review, the marginal values of capacity and delays are largely unknown and unknowable, but can only be estimated. This opens up serious questions about the validity of the assumptions in financial models, as well as their results, and includes models such as the BCA.

The three models presented in this document work around this problem by working with relative costs, since absolute numbers are not available, meaning that the only issue is orienting the application of the analyses according to the desired outcomes. As previously noted, this is a political question versus a scientific question, but given the finite nature of Congressional funding, it is likely fair to assume that taxpayers would like to see their funds allocated to the FAA by Congress be used wisely, versus wasted on locally optimal projects which do not bolster the entire system, and are most likely not in the individual taxpayer's district. Likewise, this assumption holds for those who pay the associated fees and taxes on airline operations, such as the security and facility fees charged on the purchase of airline tickets.

With this assumption in place, and recognizing that air travel is interconnected, in that a delay in New York can very easily impact flights in San Francisco, the case for a holistic diagnostic to improve the entire airspace operation yielding the best "bang for the buck" should be the focus of the diagnostic, given that funding is limited.

Restrictions of the Diagnostic

In the interest of completeness, it should be noted that any diagnostic for airport operations and investment will not fix the system, nor is it designed to do so. A diagnostic is a flag to indicate what could be wrong, and provide an indication of where a solution might lie; in either case, further in-depth analysis will be required, and given that no model is perfect, there are also likely to be “false flags” in the usage of the diagnostic. In the following development and analysis, these issues should be kept in mind, and will be noted as appropriate in the discussion.

13. Existing Diagnostic Shortcomings

One of the first questions which arises in the creation of a diagnostic is why the existing diagnostics, or the newly developed relationships and regressions, cannot be used to discern where the problems in the system lie. These issues will be addressed first by looking at the problems at the total airport level, and then at the configuration level.

Problems Using the Total Airport

Section 10 identified many of the problems at the total airport level, showing that there is an inherent bias in the CCR and BCC models against smaller facilities, which does not exist in the resulting Beta-K values from the Directional Output

Distance Function results. This indicates a difference between these models such that the pairing of BCC and CCR are focused more towards throughput per runway, while the Beta-K values side more towards delay minimization. In and of itself, this is not problematic, but requires that all three models are used for analysis; although, given the lack of differentiation in scale efficiencies, shown in aggregate in Figure 25 and coupled with the associated analysis, and coupled with the correlation analysis, one could argue that the BCC model is redundant at the total airport level and does not add to the analysis.

The resulting problem of either this two or three model analysis is not the conclusions about which airports are inefficient at producing timely flights, but that the resulting information is neither unique or helpful. This is a rather scathing criticism, but it is already widely accepted that the Northeast is the problem, and a figure, such as Figure 22, only serves to confirm what is already known; albeit in a new and unique way. Furthermore, the resulting conclusions of identifying benchmark airports, and those which are far from that frontier don't provide much insight on what to do next to move from the diagnostic step into an improvement step.

This lack of direction is further amplified by the problem in creating a solution to an efficiency problem that is both feasible and realistic. As the noted size bias points out, one of the ways to move ABQ towards the efficiency frontier is to add a hundred thousand flights per year to "justify" the three runways which see the most usage, more than doubling the throughput at the airport. Likewise, PIT has a significantly smaller flight load than it did a decade ago, so one of the quickest ways to boost efficiencies would be to tear up a runway.

In both cases, the manipulations work within the structure of the mathematics, but are not realistic, and one could argue are outright ridiculous. Furthermore, these mathematical mechanics also work the other way, in that an airport with large flight volumes and a large number of delays needs more capacity, so an airport like JFK should add a runway, despite not having any land to do so, or it should cut flights, which is market infeasible; although perhaps possible at the regulatory level.

As such, workable and feasible solutions are more likely to emerge in the configurations.

Problems Using the Configurations

The configurations present many more problems than the total airport analyses, but they do so in a variety of different ways because of the differences in usage emerge, coupled with the sheer number of DMUs allowing for oddities to break through.

Unlike the total airport case, it is known that BCC and CCR exhibit different values in the configuration case because of the differences in scale efficiencies shown in Figure 29. While it was noted that the mode of this distribution was still scale efficient, and nearly half of the configurations were in this scale efficient tail in the two right-most bars in the figure, this means that roughly half were not, indicative of a difference in BCC and CCR values; offering a third perspective on how to evaluate configurations.

Given that the three models maximize their efficient values at different values, CCR and BCC at one and the Beta-K values at zero, efficient DMUs should show an inverse relationship between these models: when CCR and BCC efficiencies are high, the corresponding Beta-K from the Directional Output Distance Function should be low. However, in practice, this does not necessarily occur, and these differences, when coupled with the underlying assumptions of the models, give some insight into the performance of the configurations as the diagnostic, as well as the large number of “false flags” that this method creates.

With this in mind, the following subsections sort through the configuration data using parameters other than the expected CCR or BCC high and the DODF low, to show these departures from the expected pattern.

BCC High and DODF High

In this case, configurations are checked which have high BCC efficiency scores, the more forgiving of the two traditional DEA assessments because of the variable returns to scale, in lieu of the stricter standard of constant returns to scale of CCR, while being paired with a high DODF efficiency score. In practical terms, because the traditional DEA efficiencies sit on the efficient frontier at a value of one, but the DODF efficiencies sit on the efficient frontier at a value of zero, this would indicate that delays are not being adequately internalized in the

BCC model, because the throughput of the configuration is such that the delay isn't hurting the outputs in the model, but in the DODF model, is boosting the delay penalty to drive the configuration away from the efficient frontier.

To make this comparison, the data was sorted by the highest BCC values, and then a secondary filter was put in place to sort by the highest DODF values, and a stark pattern emerged, the results of which are shown in Table 7.

DODF Value	BCC Value	CCR Value	Scale Efficiency	Configuration	LOCID
0.7199	1.0000	0.3866	0.3866	JFK--Arr_22L _Dep_ 22R_ 31L--I	JFK
0.7000	1.0000	0.3409	0.3409	JFK--Arr_13L _Dep_ 13R--I	JFK
0.6958	1.0000	0.4161	0.4161	LGA--Arr_31 _Dep_ 4--I	LGA
0.6296	1.0000	0.2163	0.2163	ABQ--Arr_21 _Dep_ 21--I	ABQ
0.6010	1.0000	0.3754	0.3754	JFK--Arr_31R _Dep_ 31L--I	JFK
0.5264	1.0000	0.1763	0.1763	MDW--Arr_31C _Dep_ 22L--I	MDW
0.4127	1.0000	0.5327	0.5327	JFK--Arr_22L _Dep_ 22R_ 31L--V	JFK
0.3685	1.0000	0.5580	0.5580	LGA--Arr_22 _Dep_ 13--V	LGA
0.3392	1.0000	0.2591	0.2591	MDW--Arr_4R _Dep_ 31C--I	MDW
0.3275	1.0000	0.5731	0.5731	LGA--Arr_22 _Dep_ 31--V	LGA
0.3216	1.0000	0.4520	0.4520	DCA--Arr_1 _Dep_ 1--I	DCA
0.2811	1.0000	0.5039	0.5039	JFK--Arr_4R _Dep_ 4L_ 31L--V	JFK
0.2750	1.0000	0.4985	0.4985	LGA--Arr_4 _Dep_ 13--V	LGA

Table 7: Configurations with High BCC and DODF Scores

Table 7 shows the stark pattern of a column of efficient ones in the BCC column, coupled with very large DODF numbers. However, what is also of interest is in the final column, LOCID, which is the ASPM code for Location ID, which is the airport code. Of the thirteen rows in the table, nine of them are in the known problematic Northeast, specifically in the worst part of it, in New York City. This is indicative of delays not adequately being accounted for, and merges neatly with a known hotspot for delays. However, the four remaining configurations require study as well.

The Albuquerque International Sunport (ABQ) configuration is the primary crosswind configuration and carries very little annual traffic, and for the part under Instrument Flight Rules (IFR) conditions, as noted by the "—I" in Table 8, there were only 101 total operations for all of 2008, indicating this is statistical noise as much as anything, as the associated VFR configuration is what pulled the configuration into the model with the larger throughput to generate the flight load necessary to meet the definition of a primary configuration. Given this tiny flight load, which amounts to only an hour of operation at many of the other OPSNET 45 airports, this is deemed moot.

The DCA configuration carried significantly more traffic, and was northbound, meaning departures were entering the Northeast airspace under IFR conditions, indicating that this may be tied to the Northeast/New York airspace problem, coupled with the fact that DCA, like JFK and LGA is a slot controlled airport. This means that airlines own rights to depart and arrive, and jockey for their rights accordingly, resulting in huge delays; therefore, this likely fits the description as well.

The two remaining configurations are both at Chicago Midway International Airport (MDW) and both involve a dedicated departure runway and dedicated arrival runway crossing each other. This sets up a logistical problem as the departure and arrival streams must be managed to ensure there are no collisions, coupled with the fact that MDW has a very small footprint given that it sits in the heart of an urban area in Chicago. Therefore, the delays to move aircraft on the ground, and then stagger them in and out result in huge delay numbers, meaning this is also a case where the delays were not adequately internalized.

However, the other item of interest in Table 8 is that the resulting CCR values were all very low, so the more restrictive CCR model was able to catch these discrepancies.

CCR High and DODF High

This case is similar to the previous case, except that it was found that the gross examples with the BCC model were picked off by the CCR model as being inefficient. Therefore, this case is a search to see if the two constant returns to scale models ever clash. A similar sort was done, yet nothing as stark revealed itself, as at the efficient frontier, the two models largely agreed with each other. However, scrolling through the data looking for discrepancies yielded instances wherein large flight volumes were moved, but were heavily delayed. The first ten notable discrepancies from this sort are shown in Table 8.

DODF Value	BCC Value	CCR Value	Scale Efficiency	Configuration	LOCID
0.1760	0.9143	0.9143	1.0000	ATL--Arr_8L_9R_10 _Dep_8R_9L_10--I	ATL
0.1751	0.8826	0.8811	0.9983	ATL--Arr_26R_27L_28 _Dep_26L_27R--I	ATL
0.1924	0.8829	0.8785	0.9950	CLT--Arr_36C_36R _Dep_36C_36R--V	CLT
0.3600	0.8707	0.8614	0.9893	CLT--Arr_36C_36R _Dep_36C_36R--I	CLT
0.5333	0.8534	0.7520	0.8811	JFK--Arr_31L_31R _Dep_31L--I	JFK
0.4152	0.7349	0.7349	1.0000	DEN--Arr_34R_35L_35R _Dep_8_25_34L_34R--I	DEN
0.5581	0.7433	0.7068	0.9510	JFK--Arr_22L_22R _Dep_22R--V	JFK
0.3909	0.6708	0.6698	0.9985	ORD--Arr_4R_9R_10 _Dep_4L_9R_32L--I	ORD
0.4437	0.6665	0.6655	0.9985	DFW--Arr_35C_35R_36L _Dep_31L_35L_36R--I	DFW

Table 8: Configurations with High CCR and DODF Scores

Table 8 shows significantly lower values, including nothing on the frontier in the CCR model, but the ATL configurations did appear, as did IFR configurations from JFK and ORD, both known to be very weather sensitive airports. In the ORD case, this is currently being addressed as ORD is being converted to a layout more resembling an east-west version of the DFW design, but in the case of JFK, there are very high DODF values. It is also of note that the two Charlotte Douglas International Airport (CLT) configurations which appeared were the same, meaning the configuration produces a lot of delays under both VFR and IFR conditions, although this data is from 2008, and a new third parallel runway, RWY 18R/36L, was opened 6 January 2010, which should help to alleviate the problem.

While discrepancies between the inverse relationship of the DODF and CCR models can be found, they are tougher to find, meaning that in a pinch, one could substitute for the other, but the differences in that inverse relationship could help to eliminate bias in the CCR model, by finding configurations where sheer throughput is dominating the efficiency expressions, masking the underlying delays.

Low DODF and Low Traditional DEA

Given that CCR is the more restrictive of the two traditional DEA models, it follows that if BCC is low, CCR will be low, although the converse does not hold true, which is how scale inefficiency occurs. However, many airports and runway configurations are scale efficient, which is likely due to the economics underlying expansion and improvement of airports, as projects which cost hundreds of millions of dollars require a very sound reason to be undertaken; so demand must be present to use the improvements.

In this case what is being sought is the case of a low DODF score, which is indicative of few delays, coupled with a low traditional DEA score, which is indicative of low throughput. This creates a sense of a “false positive”, in that the DODF score indicates a configuration which does not generate delays, but the resulting low traditional DEA number indicates this is achieved by using an excess of inputs that does not justify the inputs used. In a sense, this is a bad situation if it is based upon recent investment, but is more likely to occur with configurations being used under low pressure situations, such as late at night, where there is limited red-eye or international traffic, or at airports where major hubbed carriers have largely pulled out, so the existing infrastructure remains without the hub flight demand has declined; such as Lambert-St. Louis

International Airport (STL) losing TWA/American Airlines and Pittsburgh International Airport (PIT) losing US Airways.

In both cases, removing runways from operation to boost the efficiency score is merely massaging the numbers, and as such, is not realistic, so it is important to be able to separate these indicators, as they are not indicative of exemplary performance; recognizing that many of them exist. Table 9 lists a series of configurations fitting this profile, sorted by increasing DODF value and then by CCR value, as it is more restrictive than BCC as noted.

DODF Value	BCC Value	CCR Value	Scale Efficiency	Configuration	LOCID
0.0000	0.0725	0.0595	0.8212	LAS--Arr_19L_19R_25L _Dep_19L_19R_25R--I	LAS
0.0000	0.1106	0.1069	0.9667	DTW--Arr_3R_4L_4R _Dep_3L_4R--I	DTW
0.0000	0.1376	0.1226	0.8915	ABQ--Arr_26_30 _Dep_21_26_30--I	ABQ
0.0000	0.1794	0.1793	0.9994	SJC--Arr_29_30L_30R _Dep_29_30L_30R--I	SJC
0.0000	0.1893	0.1848	0.9759	SJC--Arr_29_30R _Dep_29_30R--I	SJC
0.0000	0.2102	0.1841	0.8756	PHL--Arr_26_27R _Dep_27L--I	PHL
0.0000	0.2389	0.2378	0.9956	CLE--Arr_6L_10 _Dep_6L_6R--V	CLE
0.0000	0.2493	0.2301	0.9229	CLE--Arr_6L_10 _Dep_6R--V	CLE
0.0000	0.2670	0.2653	0.9937	SEA--Arr_16C_16L _Dep_16C_16L--I	SEA
0.0000	0.3025	0.2999	0.9911	SFO--Arr_28L_28R _Dep_1L_1R--I	SFO
0.0000	0.3289	0.3275	0.9959	IAD--Arr_1C_1R _Dep_1R_30--V	IAD
0.0000	0.3340	0.3159	0.9457	DEN--Arr_7_16L_16R _Dep_8_17L_17R--I	DEN
0.0000	0.3833	0.3155	0.8231	PIT--Arr_28R_32 _Dep_28C_28R--I	PIT
0.0000	0.3941	0.3927	0.9965	MCI--Arr_1L_1R _Dep_1L_1R--V	MCI
0.0000	0.4187	0.4167	0.9952	PDX--Arr_28L_28R _Dep_28L_28R--I	PDX
0.0000	0.4327	0.4306	0.9953	CLE--Arr_24L_24R _Dep_24L_24R--V	CLE
0.0000	0.4554	0.4551	0.9995	MEM--Arr_27_36L_36R _Dep_36C_36L_36R--V	MEM

Table 9: Configurations with Low DODF Scores and Low Traditional DEA Scores

Table 9 shows that this effect ranges over quite a large swath of CCR values, and the table was arbitrarily cut at a CCR value of 0.5000 for convenience, as at some point, the 0.000 DODF value coupled with the higher CCR value is indicative of good performance. However, as shown in Figure 7, the largest number of DODF values are at zero, so a second table showing results just off the efficient DODF frontier further bolsters this case, and is shown in Table 10.

DODF Value	BCC Value	CCR Value	Scale Efficiency	Configuration	LOCID
0.0028	0.3441	0.3440	0.9996	ABQ--Arr_3_8 _Dep_8--V	ABQ
0.0125	0.4875	0.4852	0.9952	MEM--Arr_36L_36R _Dep_36L_36R--V	MEM
0.0125	0.3343	0.3339	0.9988	MEM--Arr_9_36L_36R _Dep_36C_36L_36R--V	MEM
0.0262	0.3878	0.1537	0.3965	HOU--Arr_4 _Dep_12R--V	HOU
0.0386	0.3142	0.3074	0.9785	OAK--Arr_27L_27R_29 _Dep_27L_27R_29--I	OAK
0.0412	0.3189	0.3084	0.9672	IND--Arr_5L_5R _Dep_5L_5R--V	IND
0.0448	0.3829	0.3754	0.9803	SEA--Arr_16L_16R _Dep_16C_16L--V	SEA
0.0465	0.3035	0.2778	0.9155	MSY--Arr_1_10 _Dep_1--V	MSY

Table 10: Table 9 Supplement with Non-Zero DODF Values

By combining the information in both Table 9 and Table 10, it can be seen that there may be a bias towards smaller volume airports, given that ABQ, HOU, MCI and others appear, in some cases multiple times, while large volume airports, such as ATL, DFW, ORD and LAX do not. This likely speaks to the bias of the nature of the step functions of capacity addition, as airports which use configurations with two runways require throughputs rivaling configurations frequently used at busier locations such as EWR, LGA and JFK which also frequently use two runway configurations to yield similar efficiencies based upon volume. These relative volumes simply will not occur at Cleveland Hopkins International Airport (CLE) or Louis Armstrong New Orleans International Airport

(MSY). Therefore, care must be taken to ensure that apples-to-apples comparisons are being made.

14. Creating a New Airport Operations Diagnostic

Section 13 brought to light a number of potential pitfalls in creating a diagnostic outright from the resulting mathematical programming results, but by carefully tailoring the usage to create a series of tests to find good candidates for funding. Remember, the intent of any diagnostic is to flag areas of interest for deeper study, and in this case, with over 400 potential configurations requiring study, there needs to be a way to whittle this number down to a more manageable field.

The diagnostic proposed here works on two fronts, both the airport level itself, as well as the configuration level. The work on these two fronts is in parallel, but it is at the merger of the information wherein the information becomes powerful. A color coded flowchart of the diagnostic is shown in Figure 33.

Figure 33: A Schematic of the Diagnostic

Figure 33 shows what appears to be a very complicated process, but the color codes show that it is really only four clusters of activity. The yellow and red boxes show a parallel track of information extraction which are based upon

Sections 10 through 13, and the information coming out of the yellow boxes with red text is then weighted to yield another blocking variable, and all of this information is then merged with the airport information in the orange boxes with green text to sort out the best candidates by policy. Each of the colored blocks will be addressed in its own section.

15. Creating a New Airport Operations Diagnostic—Total Airport Candidates

This section deals with the red boxes with the yellow text in Figure 33, and the bulk of the information generated in this block of boxes is covered in Sections 10, 11 and 13. The purpose of identifying the airport, given that its lack of information is a restriction, is that the airport is what is ultimately measured by the consumer, and it is also the collection of the underlying configurations. In the context shown in Figure 33, this is then related to picking out the poor performing facilities, to see if these results filter, and are also recognized by the configurations. In theory, this should occur, as poor performing airports should have poor predicted outcomes from the regression equations, therefore, the configuration data should merge reasonably well with the total airport data; however, the airport provides the check on the configuration output resulting from Figure 33, not the other way around. Stated differently, it is a check to see if the Xs in the regressions are matching up with the realized Ys in practice.

Of the three red highlighted boxes coming out of the split for information generation in Figure 33, the left and center box have already been well covered, and the results of these boxes are shown in Table 11 and Table 12.

Airport	High Beta-K Appearance
FLL	9
TEB	9
EWR	8
JFK	8
PBI	8
MIA	7
PHL	7
HOU	6
IND	6
BOS	5
IAD	5
LAS	5
RDU	5
BNA	2
BWI	2
LGA	2
MDW	2
OAK	2
CLE	1
MEM	1
PIT	1
SJC	1

Table 11: Filtered Total Airport Data to Find High Beta-K Candidates

Table 11 shows two columns, and the airport selections in those two columns were somewhat arbitrary, because this is a policy question. Specifically, what constitutes a poor performer? This is not operationally defined, and goes back to what the policy direction is, so for simplicity, using Figure 22, it can be seen that there is a gap at around 0.15, as the “good performers” don’t have ranges which go that high on any regular basis, and the poor performers do not go below. This is also substantiated by the fact that for the nine years of data, 2000 through 2008, the third quartile of data is bounded at 0.158. Therefore, a count was done of any airport with a Beta-K value of 0.158 or higher, and that number is recorded in the right column. As the table shows, there are several airports which routinely produce high Beta-K values.

Airport	Low CCR Appearance
ABQ	9
BNA	9
HOU	9
OAK	9
PBI	9
SJC	9
TEB	9
MDW	8
IND	6
JFK	5
RDU	5
FLL	4
MSY	4
MCI	3
PIT	3
MIA	1

Table 12: Filtered Total Airport Data to Find Low CCR Candidates

Table 12 is similar, except that with CCR and BCC the values are maximized at high values, so the search is for low values. The associated general data plots, Figure 23 and Figure 24, show that there is a gap around 0.4 to separate the “poor performers”, but using the same third quartile metric to try and highlight the routine performers at this level showed a value of 0.333, and the associated counts are shown.

Given the scale efficiency arguments previously made in Section 13, and the fact that BCC candidates were the same, no additional BCC data is shown.

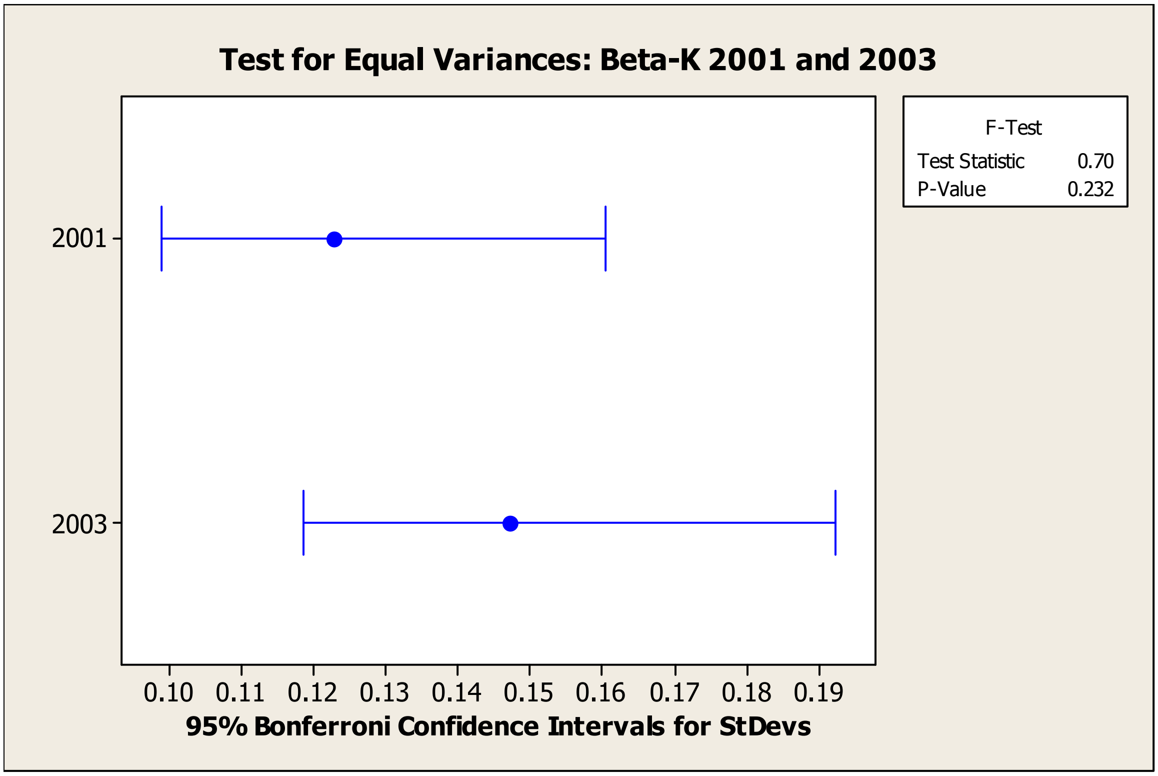
High Variance DMUs

The issue not addressed to this point is that of the variances shown within Figures 21, 22 and 23 for the total airport case, as the commentary to date has been about the individual measurements themselves, and their relationship to the other measurements. However, the spread of the data is also indicative of operations at an airport, as the year-over-year changes should not be that drastic, barring a significant event, such as the opening of a runway. Even then, flight loads tend to be reasonably stable, as airlines are capital intensive businesses, so the numerators of the efficiency expressions should remain reasonably stable, as it is prohibitively expensive for airlines to race in and out of markets. As an example, when American Airlines bought TWA in 2001, it began ramping down the hub operation in Saint Louis, as American has its two largest hubs bracketing Saint Louis, at Chicago-O’Hare and Dallas-Fort Worth; and that hub has been winding down for years. A similar situation exists in Pittsburgh with the departure of US Airways from a runway pricing dispute in 2003.

As a result, the variances of the DMUs could also be a potential flag if there are large changes which are not readily explained.

The problem with this analysis is that it merges the yearly data from the individual program iterations, but in practice, this may not be possible given the amount of “variability” existing in the datasets. In layman’s terms, the amount of variance sloshing around through the program in 2002 might be vastly different than in 2007, rendering direct comparisons suspect.

To check this, variances were generated using the yearly data, yielding nine variances for each model; one corresponding to each year. The extremes of these variances, the largest and smallest, were then tested for equivalence, because if the largest and smallest were equivalent, then any of the intervening variances would also be equivalent. The graphical outputs are shown with the corresponding Minitab session output.



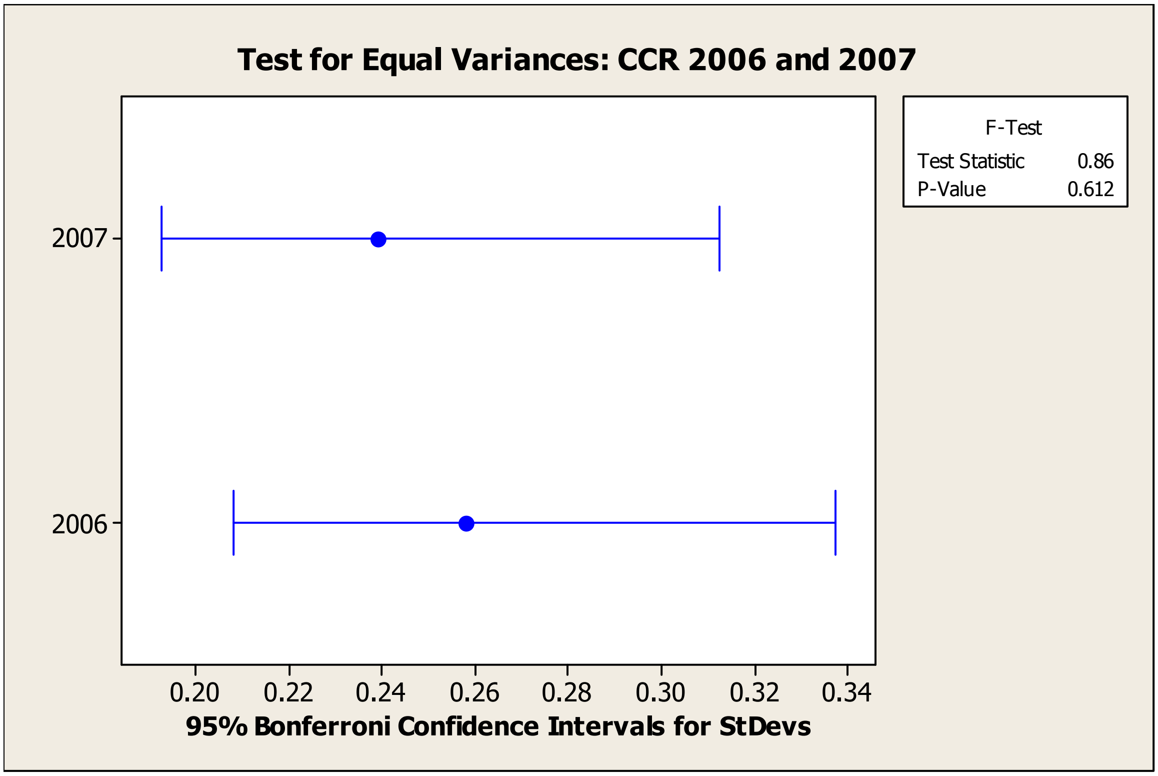
Test for Equal Variances

```
95% Bonferroni confidence intervals for standard deviations

Sample   N     Lower     StDev     Upper
     1  45  0.098848  0.122565  0.160381
     2  45  0.118558  0.147004  0.192361


F-Test (Normal Distribution)
Test statistic = 0.70, p-value = 0.232
```

Figure 34: Year-Over-Year Variance Equivalence for Beta-Ks



Test for Equal Variances

```
95% Bonferroni confidence intervals for standard deviations

Sample   N     Lower     StDev     Upper
     1  45  0.192578  0.238783  0.312457
     2  45  0.207978  0.257878  0.337443


F-Test (Normal Distribution)
Test statistic = 0.86, p-value = 0.612
```

Figure 35: Year-Over-Year Variance Equivalence for CCR

Figure 34 and 34 both show very large p-values and the corresponding graphics show distinct overlapping of the confidence intervals, so year-over-year comparisons can be made on a variance basis. It should also be noted that BCC variances were not checked, again due to the lack of differentiation, as well as the known data error in 2003 at BWI and DCA which inflated the largest variance in the group of nine.

Given that the variances can be used as a flag, because of the year-over-year stability, the variances were calculated across the years for each of the airports, and this information is summarized in Figure 36 and Figure 37.

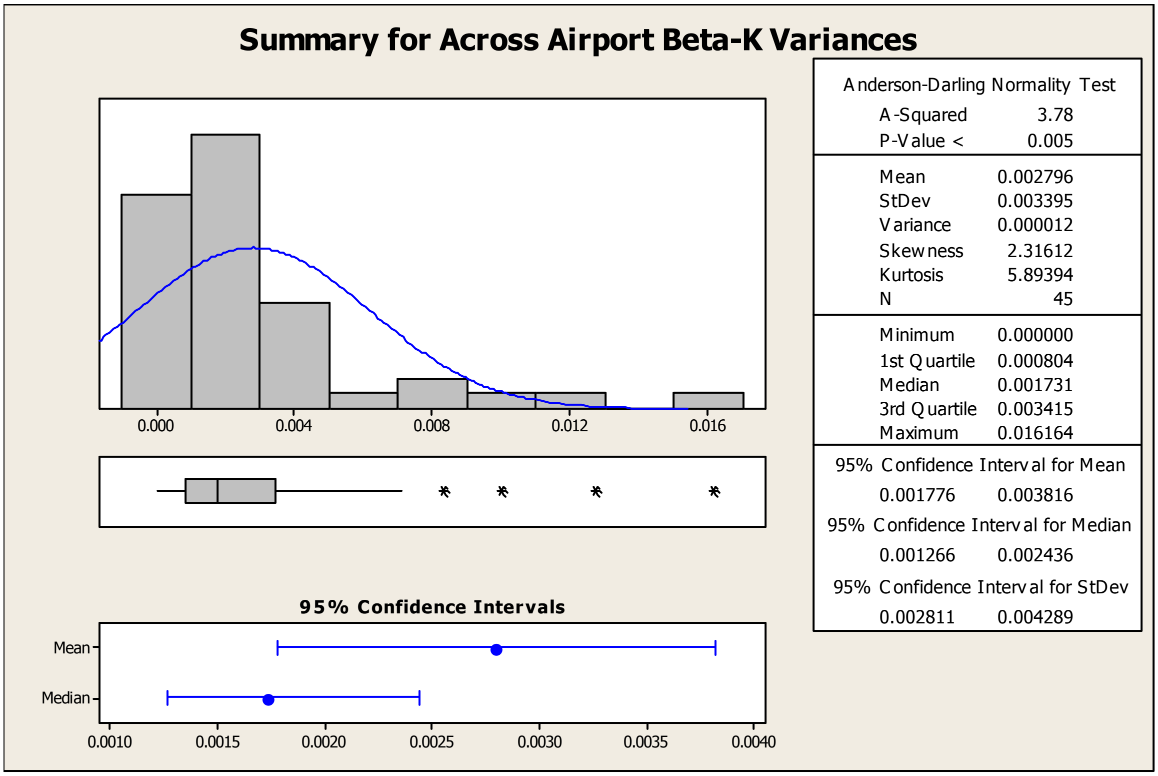


Figure 36: Graphical Summary of Across Airport Beta-K Variances

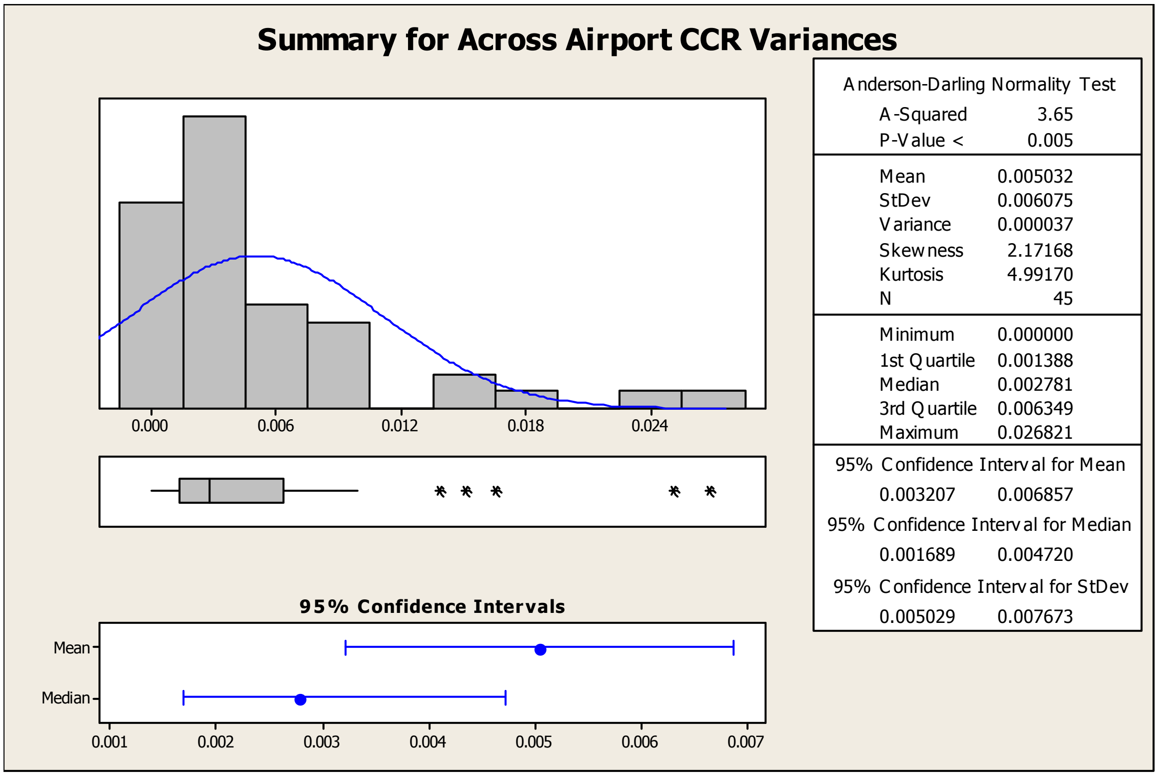


Figure 37: Graphical Summary of Across Airport CCR Variances

Both Figure 36 and Figure 37 show the same Pareto effect pattern, with most of the DMU variances clustered together to the left, and a few outliers to the right. Since variances are absolute, in this case there is no differences between the models, as larger variances indicate more variability. Therefore, in both cases, it is the right tails which are of interest.

Given that the box plots respectively show four and five outlier points, which corresponds to the very flat areas of both histograms, these points are highlighted in Table 13 for further consideration.

High Beta-K Variance	High CCR Variance
EWR	CVG
JFK	JFK
LGA	PIT
PBI	SLC
	STL

Table 13: Summary of High Variance Airports

Filtering of the Total Airport Results

This section has generated four groupings of flagged airports, which are summarized in Table 14 in an odd, alphabetical fashion, to show continuity of the flags across the rows.

Airport	High Beta-K Appearance	Low CCR Appearance	High Beta-K Variance	High CCR Variance
ABQ		9		
ATL				
BNA	2	9		
BOS	5			
BWI	2			
CLE	1			
CLT				
CVG				🟥
DCA				
DEN				
DFW				
DTW				
EWR	8		🟥	
FLL	9	4		
HOU	6	9		
IAD	5			

IAH				
IND	6	6		
JFK	8	5	🟥	🟥
LAS	5			
LAX				
LGA	2		🟥	
MCI		3		
MCO				
MDW	2	8		
MEM	1			
MIA	7	1		
MSP				
MSY		4		
OAK	2	9		
ORD				
PBI	8	9	🟥	
PDX				
PHL	7			
PHX				
PIT	1	3		🟥
RDU	5	5		
SAN				
SEA				
SFO				
SJC	1	9		
SLC				🟥
STL				🟥
TEB	9	9		
TPA				

Table 14: Flag Summary of the Four Total Airport Predictors

Table 14 shows an extensive list of airports, but many of these airports show no problems in practice. As such, Table 15 condenses this table to remove all airports which did not trip a flag to create a more manageable list.

Airport	High Beta-K Appearance	Low CCR Appearance	High Beta-K Variance	High CCR Variance
ABQ		9		
BNA	2	9		
BOS	5			
BWI	2			
CLE	1			
CVG				🟥
EWR	8		🟥	
FLL	9	4		
HOU	6	9		
IAD	5			
IND	6	6		
JFK	8	5	🟥	🟥
LAS	5			
LGA	2		🟥	
MCI		3		
MDW	2	8		
MEM	1			
MIA	7	1		
MSY		4		
OAK	2	9		
PBI	8	9	🟥	
PHL	7			
PIT	1	3		🟥
RDU	5	5		
SJC	1	9		
SLC				🟥
STL				🟥
TEB	9	9		

Table 15: Condensed Total Airport Flag List

Table 15 is still quite large, with 28 of the 45 airports in the OPSNET 45 still appearing. As such, there is little in the way of discrimination to be able to identify truly problematic airports versus getting lost in the proverbial “trivial many". Therefore, further filtration is required on a case-by-case basis, to understand what is behind the numbers.

Expected Values in the Quartiles

Since the first two columns of Table 15 were generated by using the third quartile cuts to isolate the large values, versus a more arbitrary random cut where it looked like a hole could be found in one of the underlying figures from Section 10, coupled with the fact that all the variances analyses did not yield any truly outstanding values, it would be expected that if all of the airports were similar, that all ought to have an equal representation in that quartile. This means that all things being equal, we should see each airport in that quartile a couple of times over the nine periods studied.

However, it is also known that there are true differences in performance, as the TEB points indicate, as it is a consistently poor performer, so the ones and twos are really background noise that are expected; CLE is a good example, as it has one blip on the Beta-K side, but is otherwise clear on Table 15. As such, any value less than two can be reasonably eliminated in the first two columns. A revised copy of Table 15 is shown as Table 16, removing these small values, and any associated airports, such as CLE, which no longer belong on the list.

Airport	High Beta-K Appearance	Low CCR Appearance	High Beta-K Variance	High CCR Variance
ABQ		🟥 9		
BNA	🟥	🟥 9		
BOS	🟥 5			
CVG				🟥

EWR	8		🟥	
FLL	9	4		
HOU	6	9		
IAD	5			
IND	6	6		
JFK	8	5	🟥	🟥
LAS	5			
LGA	🟥		🟥	
MCI		3		
MDW	🟥	8		
MIA	7	🟥		
MSY		4		
OAK	🟥	9		
PBI	8	9	🟥	
PHL	7			
PIT	🟥	3		🟥
RDU	5	5		
SJC	🟥	9		
SLC				🟥
STL				🟥
TEB	9	9		

Table 16: The Total Airport Flag List Filtered for Expected Quartiles

Note that in Table 16 several airports have red in the first two columns without numbers. This is done to indicate that the flag was tripped, but was likely statistical noise, as noted with the expectation of two appearances in a quartile in nine trials, but the airport was not removed due to other flags being tripped.

The Small Airport Bias

Table 15 has a large number of entries for the small airports which formed a line along the bottom of Figure 23 and Figure 24, and as expected, showed up in

Table 16 as well. Since this is a known bias of the models, as these airports experience the same step-function capacity of having a runway as larger airports, but do not have as much demand on that capacity to "justify" its cost, the CCR model has picked these airports off. Therefore, the small airports have been highlighted in yellow to show that this may not be a function of the operation of the airport, but of the model bias. Likewise, the 2008 operation volume data is included for comparison, which is integrated into the rightmost column of Table 17.

Airport	**High Beta-K Appearance**	**Low CCR Appearance**	**High Beta-K Variance**	**High CCR Variance**	**2008 Flight Load**
ABQ		9			99101
BNA	🟥	9			150360
BOS	5				337060
CVG				🟥	276981
EWR	8		🟥		413478
FLL	9	4			225773
HOU	6	9			124850
IAD	5				329263
IND	6	6			168847
JFK	8	5	🟥	🟥	415653
LAS	5				415772
LGA	🟥		🟥		372243
MCI		3			168235
MDW	🟥	8			213443
MIA	7	🟥			288651
MSY		4			99834
OAK	🟥	9			174586
PBI	8	9	🟥		85880
PHL	7				459819
PIT	🟥	3		🟥	143935
RDU	5	5			165589
SJC	🟥	9			135325

SLC				🟥	316852
STL				🟥	232916
TEB	9	9			51920

Table 17: The Total Airport Flag List Highlighted for Small Airports

Table 17 shows a vast disparity in the operations volumes, as several airports were only generating tens of thousands of operations, while others were generating hundreds of thousands. Therefore, any bias on size, which is evident from Figure 23 and Figure 24, could certainly be at work. Furthermore, the likelihood of impacting flights in the national airspace is more likely to occur at the larger facilities, as there are more opportunities. Therefore, a case can be made to remove these smaller airports due to the bias, but any underperformance may be glossed over, if in fact there is a problem. Given that the list is now 25 of the 45 airports, it is still large, but is workable.

Discrepancies in Variances

The previous table analyses have focused on the two leftmost columns of the table, but the variances tell a different story, because they look into the slower changes through time. As noted in Section 3 and Section 4, airline operation is highly correlated with the airport efficiency, as the airline schedules and operates the flights being measured, therefore, it is important to have an accounting for what impact the flight load has on the efficiency. As noted, this tends to be slow, given the large capital costs and asset juggling across airline networks required to change service levels.

The examples given in the description of the variance metric were the pullouts of American Airlines, via the TWA acquisition, from the STL hub and US Airways from the PIT hub, and both of these flight load reductions were enormous. In both cases the hubbed airline was by far the dominant operator at the airport, and in both cases, accounted for almost a thousand operations per day (500 flights). By slashing these numbers down to their existing levels, which are on the order of 50-75, and likely heading even lower, a gigantic chunk of the of the flight load has been removed. In the case of PIT, as shown in Table 16, it has largely not been replaced, while at STL, Southwest has moved in and become the dominant operator, which has somewhat bolstered the flight load and efficiency numbers as American continues to wind down operations.

However, it should be noted that large carriers exiting an airport hub do not necessarily cause this problem, because of replacement. MDW was a hub for both Midway Airlines and ATA, but upon the bankruptcy of each of those carriers, other carriers have stepped in immediately to get the gates and the access of a Chicago hub; most recently Southwest taking over for ATA, beating out AirTran Airways in an open market bid. Likewise, ATA’s other hub at IND has bounced around through various airlines, as no one has solidified a hold for longer than a year or two, but someone has always come in to make IND a focus city or small hub.

The other interesting case for the airline replacement is the pairing of MCI and Milwaukee’s General Mitchell International Airport (MKE), which sits just outside the OPSNET 45, but is included in the next step up, the ASPM 77, whose membership is shown in Appendix 2. Milwaukee and Kansas City are both large cities which have been largely attractive to airlines, but like Indianapolis, have been unable to hold profitable hubs. Furthermore, in the case of MKE, it provides an alternative hub to the Chicago-metro, much as PBI does for South Florida and SJC does for the California Bay Area. However, history is littered with airlines who have tried to make it in both cities since Deregulation.

In the case of MCI, Branniff and TWA were large anchors in the 1970s, but due to bankruptcy and a political dispute over design of the new airport, respectively. Eastern Airlines also hubbed there and went bankrupt. With the demise of the legacy carriers, the market proved to be attractive to discount airlines which led to later entry by Southwest Airlines, Midwest Express (later renamed Midwest Airlines), Frontier Airlines, as well as Vanguard Airlines, yet only Frontier and Southwest survive. Likewise, MKE has been gutted by bankruptcy, as Midwest Airlines was folded into Frontier Airlines as a part of Republic Airways, although discounter AirTran Airways has recently established a hub at MKE, further boosting its flight loads.

Since airline failure, or retreat is not indicative of wholesale changes through time, but happens to be the case for PIT and STL, the question is what else is driving the outliers in the variances which are noted in Table 16.

Two points jump out from the data in analyzing both the variance of the Beta-Ks and the CCR output. First, the large Beta-K values for PBI and JFK were both attributed to a single point which sat on the efficient frontier, in 2000 and 2006, respectively. In both cases, this value of zero is highly unusual, as the average of the other Beta-Ks are 0.285 and 0.278 respectively; so these are huge outliers as Figure 22 shows, since the effective range, barring the huge TEB outlier, is roughly 0.4.

The other major point in the variance analyses was the geographic tie, as the rules of the airspace have been changed over the last decade; however, no specific value stood out as starkly as the PBI and JFK points, which indicated a distinct one-time event. Ignoring the already accounted for activity at PIT and STL, the only tie between the remaining variance flagged airports, which were all CCR flagged, is that they are all hubs for Delta: SLC, CVG and JFK, but all exhibited similarly non-distinct patterns. Therefore, this may be a change in the operation of the hubbed airline, and it may or may not be relevant.

Total Airport Filtration Conclusion

Unfortunately Table 16 could not be narrowed down further, although on a non-scientific basis, a case can be made that the list is smaller, because there are some “heavy hitters” in that group, including the bulk of the airports in the known problematic area of the Northeast, as well as the South Florida area identified in Section 10.

16. Creating a New Airport Operations Diagnostic—Configuration Candidates

This section deals with the yellow highlighted boxes with the red text in Figure 33, and the purpose of identifying the configuration candidates is that this level corresponds to where investment action can be taken; either with capital improvements or operational redesigns. Section 13 provided solid insight as to what occurs within the data for the primary configurations, therefore, the intent of this section is to expand these special cases in the context of the entire body of data per the requirements shown in Figure 33.

Configuration Candidate Identification Process Overview

Figure 33 shows a generic breakdown of how to approach this sort of problem by using the three yellow highlighted boxes, which are the means to identify candidate configurations for improvement, but all configurations flagged by these three operations are candidates.

Working from right to left, the “Low BCC and High Beta-K” box is indicative of what would be expected in a poor performing configuration. Given the analysis in Section 13, this indicates to low throughput that is not timely, which is the “worst of the worst” situation, and by sorting the configuration data, these configurations can be readily identified to create a “sample space” of candidates. Likewise, this sample is generated using BCC, which is the more “forgiving” of the two models, so if a configuration performs poorly in BCC, by definition, it will perform poorly in CCR; although, as noted previously, the converse is not true, which is the basis of determinations of scale efficiencies.

This sample space is then modified as noted in Section 13 by the two left-most yellow highlighted boxes in Figure 33, which are “High BCC and High Beta-K” and “Low CCR and Low Beta-K”. As a reminder, the high BCC and high Beta-K scores were indicative of configurations which had high throughput volumes dominating delays in the models, causing the configurations to appear to be BCC efficient while also generating a large number of delays, although this relationship did not hold nearly as well with the CCR and Beta-K values; this is especially notable given that the sample space is established using the BCC model. Likewise, the low CCR and low Beta-K scores were found to be indicative of smaller airports and smaller configurations not producing huge volumes on their existing infrastructure, meaning that the models were, in effect, penalizing for not using the step-function nature of the capacity additions; as such, these hits are treated as “false positives”.

Identifying Configuration Candidates

The data used in the study spanned nine years, from 2000 through 2008, and in that time, within the OPSNET 45 airports, thirteen runways were built at twelve different airports, and entered service at different times, altering existing configurations, and at the same time other existing runways were being moved in and out of service for other expansion projects as well as ongoing maintenance. As such, year-over-year comparison is difficult, coupled with the lack of available information at all of the OPSNET 45 airports until 2003. However, as further evidence of the changes in configurations through time, in 2003 there were 148 primary configurations identified in the data, leading to 296 DMUs in the associated mathematical programs used to process the information for the diagnostic, as each primary configuration was split into its visual (VFR) and instrument (IFR) flight rule components to look for differences within the primary configuration.

These 148 primary configurations ballooned to 233 primary configurations for 466 DMUs in 2008, only five years later. Therefore, there was a lot of activity both in creating new capacity, but also integrating and adapting that capacity as well as juggling the existing capacity in an effort to better process aircraft. As such, it is difficult to make year-over-year comparisons as many configurations were added, and in the process some were removed, or expanded.

Circumventing this problem is actually not that difficult, because while airports are slow to evolve, since runways are largely fixed, and airline schedules change at a pace measured in months or quarters, configurations can literally change with the wind. Therefore, the proposed solution for the airport case, which may not be applicable if this method is applied to other systems, is to use the 2008 configuration data, as that is the best representation available of the existing state. Comparing existing configurations to configurations no longer in use does not make sense, therefore, this approach and assumption is deemed reasonable, as the intent is not to focus on past performance, but to use the existing state performance as the basis for decisions on future improvement, which can be supplemented with the older configuration data if needed, and available.

Following the procedure of the overview indicates that the 2008 data needs to be sorted by decreasing Beta-K values (i.e. highest to lowest) and then sorted at the secondary level by increasing BCC values (i.e. lowest to highest) to ensure that the “worst of the worst” configurations bubble to the top for improvement. Due to the limitations of space within the text body, this resulting sort of all 466 DMUs can be found in Appendix 8.

With the sample space identified, the two refinements to find the hidden, or lurking configurations. Appendix 9 highlights these additions to Appendix 8, noting that the search for high levels of BCC and Beta-K, indicating delays being dominated by throughput volume yielded the same results as shown in Table 7, but in an effort to expand this to include results which were close to the frontier, the range was expanded. The reason for this is that the pattern of interest is delay domination by throughput volume, so the concern is that if the BCC value is not on the frontier, lower throughputs on an existing set of assets which are dominated would wash through, despite being of interest.

In practice, this could happen wherein an airport is unable to efficiently use its resources relative to another similarly configured airport. The most common example of this would be related to arrival runway spacing, wherein a pair of runways being used for arrivals would have to be staggered in usage if there were not a mile of separation between the runways, the distance at which the runways are allowed to operate independently under IFR conditions with the Instrument Landing System (ILS). As the runways get closer and closer together, more and more staggering is required in the arrival streams, so if an airport had two runways which were close together, such as at SFO or EWR, those two runways might not be able to generate the same volume of throughput as airports where the runways have much more space, such as IAD or MCO, which have significantly more space between the centerlines of their parallel runways.

To counter this problem, the list in Table 7 was expanded from the BCC frontier all the way down to a value of 0.8000, which was arbitrarily chosen based upon what could still be construed as “pretty good” from the configuration efficiency histogram in Figure 27. This value is likely too low, and was chosen as such, because by including more of these dominated cases, a conservative list is generated; or in other words, this allows for more candidates.

However, for one of these additional “high BCC” points to be included, it also had to have a corresponding high Beta-K, and the same method was used to set the cut-off point on Beta-K, using Figure 25, and that value was set at greater than 0.2000. Again, this value was probably too low, but to be conservative, it is better to be inclusive.

By using these two cut-offs, an additional eleven candidates were added to the pool of thirteen which was found at the BCC frontier. In Appendix 9, these are denoted by bold red text.

The second group that needed to be identified were the configuration which had low BCC and low Beta-K values, as these are configurations that need to be removed from consideration, as this is the case of existing infrastructure dwarfing the existing flight load. A conservative assessment in this case works the other way, as it is best to not unduly pull candidates. Based upon Table 10, the values were set at a BCC value lower than 0.5000 and a Beta-K less than 0.0500. This filtration yielded 25 DMUs, most of which were at the smaller airports as expected, such as ABQ and SJC, but a few larger ones, such as DTW, were able to slide in a configuration here and there. These configurations were highlighted in red in Appendix 9, so as to stand out, and be cut in filtration along with those which sit on the efficient frontier.

The filtration dictated in Figure 33 is simply a matter of removing the efficient configurations which sit on both the BCC and DODF frontier, as well as the small airport configurations which have been caught in the mix, to get a smaller and more easily handled sample space. However, the resulting cut is not that large, as shown in Appendix 10, nor is it intended to be, because the idea is to pass as many reasonable candidates as possible into the following steps for weighting. The idea behind this is to allow the policy, whatever that may be, to drive the sorting and resulting selection of the configurations, versus having an arbitrary filter destroy the options before the policy even gets a chance to work on the options.

17. Creating a New Airport Operations Diagnostic—Weighting and Sorting

This section deals with the two green highlighted boxes with the orange text in Figure 33, and the purpose of these boxes is to tie the configuration candidates back to the regression equations developed in Section 11, which are predicated upon weighting the configuration components to yield the total airport value.

The table in Appendix 11 was merged with the input data files for the programs to match up the configurations to the actual operations counts using a series of cross-file conversions within Excel to yield a simple VLOOKUP within a single file, which was then inserted as an additional column in the data table. The airport throughput was performed similarly, creating a second column in the data table, and these two numbers were divided to give the percentage of operations that each DMU carried at the given airport, which provided a third column.

With these three new columns, the data was ready to be sorted for application to the overall research question about which configurations to fund, but the policy question appears yet again. Specifically, the question becomes how should the sort be done?

As previously noted, this is not a scientific question, it is a value-for-invested-money question which looks into how those who pay associated aviation fees, as well as those who pay federal income tax which the FAA disperses, feel about how their money should be allocated, if at all. Multiple scenarios exist, with the two obvious and extreme cases being cutting daily delays and "harden" the system against catastrophic meltdown, which would be executed by different sorts.

In the case of the daily delays, the data sort would be aimed at large throughput airports, and focused on the configurations which carry the largest volumes at those airports, ensuring that the configurations which carry the most traffic sit on the efficient frontier; or perhaps even taking efficient configurations and moving them "to the northwest", per Figure 20 for the CCR and BCC case and Figure 21 for the DODF case, to create a new frontier.

This is a rational plan, because the theory that an airport will not create delays is unrealistic, as by their very nature operating, delays will occur from common causes of variation like airborne and ground traffic, slower than expected ground turns for a variety of reasons, mechanical problems, etc. Furthermore, there are delays in the data, as have been noted, that are not the fault of the airport itself. In the industry, these are known as "knock-on" delays, which are derived from aircraft arriving very late, which cannot possibly hope to turn on the ground in time for a timely departure on the next leg of the aircraft's route. This is phenomenon of "rippling delays", how delays at JFK impact flights at DEN, because the aircraft cannot get to where they are going to continue on the route for the day. Therefore, a brutally efficient configuration which can allow extremely speedy arrivals and departures to minimize knocking-on could be of interest on a systemic basis for the national airspace.

The other side of this coin is catastrophic meltdowns, wherein an airport is subject to conditions it rarely handles, and the flight loads swamp the available operational plan. Typically, this is weather related, but not necessarily a special cause, as the New York airports routinely, on an annualized basis, melt down during winter storms, creating massive havoc in the national airspace, despite the fact that snow, ice and sleet routinely occur in the Northeast, just not on a daily basis.

The most recently famous of these meltdowns, mentioned here to create context, is the Valentine's Day 2007 Crisis, which crippled JFK, and as a result, it's only hubbed passenger airline, JetBlue. Scouring through the data for 13 and 14 February 2007 shows that the typical runways, the 13/31 pair, were not in use, but the far less efficient 4/22 pair was. This already had JFK at a disadvantage, but coupled with the blowing ice and snow causing IFR conditions, one could also make the argument that instead of the FAA should harden these configurations to ensure these situations do not occur. In statistical terms, this is cutting the variance by "pulling in the bad tail" of the distribution, and the data sort would be geared to look, likely, at IFR configurations with horrendously large Beta-K values (indicating a lot of delays); and probably again at large airports, because of ABQ collapses, there just aren't that many flights compared to losing DFW or DTW.

These scenarios can be mixed and matched, but for purposes of this document, it is assumed that all scenarios are created equal so long as the “biggest bang for the buck” is delivered. The reason for this, which is not unrealistic, is that by attacking the airport configuration with the largest throughput that is poorly performing, leverage in the investment is maximized, as more flights have the opportunity to be impacted by the improved configuration. Keeping in mind that all three models were run holistically, the worst performer is the worst performer systemically, not just the worst performer at that airport, meaning this configuration is one of the major cogs to start unplugging the system.

Running a nested sort for largest total operations, then by configuration weight (“Percent Ops”) and then largest Beta-K, yields the following top-30 results shown in Table 18.

BetaK Value	BCC Value TechEff	CCR Value TechEff	Configuration	Total Operations	Airport Operations	Percent Ops
0.03521	0.96401	0.86164	PHL--Arr_26_ 27R_ 35 _Dep_ 27L_ 35--V	286814	459819	0.62375
0.04605	0.76982	0.73552	DFW--Arr_13R_ 17C_ 17L_ 18R _Dep_ 13L_ 17R_ 18L--V	254897	644199	0.39568
0.00468	0.93579	0.89163	LAS--Arr_19R_ 25L _Dep_ 19L_ 25R—V	238830	415772	0.57443
0.00000	0.73006	0.73006	IAH--Arr_26L_ 26R_ 27 _Dep_ 15L_ 15R--V	216071	557317	0.38770
0.00000	1.00000	0.99604	CLT--Arr_18R_ 23 _Dep_ 18L_ 18R—V	213536	496390	0.43018
0.00000	0.78074	0.74389	SFO--Arr_28L_ 28R _Dep_ 1L_ 1R—V	194497	361208	0.53846
0.00000	0.72908	0.69467	MIA--Arr_8L_ 9 _Dep_ 8R_ 12—V	188154	288651	0.65184
0.00000	0.90671	0.90670	ORD--Arr_22R_ 27L_ 28 _Dep_ 22L_ 32L_ 32R--V	171519	863020	0.19874
0.19323	0.89414	0.71333	FLL--Arr_9L_ 9R _Dep_ 9L_ 9R—V	155773	225773	0.68995
0.00000	0.92004	0.80311	SLC--Arr_34L_ 34R_ 35 _Dep_ 34L_ 34R_ 35--V	153843	316852	0.48554
0.00000	0.94935	0.94924	ORD--Arr_4R_ 9R_ 10 _Dep_ 4L_ 9R_ 32L--V	152555	863020	0.17677
0.00000	0.64542	0.58834	CVG--Arr_18C_ 18L_ 18R _Dep_ 18C_ 18L_ 27--V	147963	276981	0.53420
0.00000	0.76617	0.73164	LAX--Arr_24R_ 25L _Dep_ 24L_ 25R—V	127109	588143	0.21612
0.00000	0.75881	0.74566	SLC--Arr_16L_ 16R_ 17 _Dep_ 16L_ 16R_ 17--V	125444	316852	0.39591
0.22586	0.59946	0.59860	DFW--Arr_31R_ 35C_ 35R_ 36L _Dep_ 31L_ 35L_ 36R--V	121162	644199	0.18808
0.08663	0.67473	0.51403	OAK--Arr_27L_ 27R_ 29 _Dep_ 27L_ 27R_ 29--V	120043	174586	0.68759
0.10346	0.55418	0.50972	DTW--Arr_21L_ 22R _Dep_ 21R_ 22L--V	113787	452450	0.25149
0.00819	0.55453	0.41833	SJC--Arr_29_ 30L_ 30R _Dep_ 29_ 30L_ 30R--V	95590	135325	0.70637
0.13650	0.58847	0.58540	TPA--Arr_18L_ 18R _Dep_ 18L_ 18R—V	92789	200831	0.46203
0.00000	0.57056	0.56826	TPA--Arr_36L_ 36R _Dep_ 36L_ 36R—V	89300	200831	0.44465
0.06219	0.99750	0.84667	DCA--Arr_19 _Dep_ 19—V	88836	271959	0.32665
0.00000	0.62084	0.61553	PDX--Arr_28L_ 28R _Dep_ 28L_ 28R—V	88165	215794	0.40856
0.32747	**1.00000**	**0.57314**	**LGA--Arr_22 _Dep_ 31—V**	**84178**	**372243**	**0.22614**
0.00000	1.00000	0.56054	LGA--Arr_31 _Dep_ 4—V	82666	372243	0.22208
0.15194	0.78859	0.69890	MDW--Arr_31C _Dep_ 31C—V	81069	213443	0.37982
0.36854	**1.00000**	**0.55800**	**LGA--Arr_22 _Dep_ 13—V**	**80385**	**372243**	**0.21595**
0.09605	0.50495	0.49529	IND--Arr_23L_ 23R _Dep_ 23L_ 23R—V	79871	168847	0.47304
0.00000	0.86267	0.86119	ATL--Arr_8L_ 9R_ 10 _Dep_ 8R_ 9L—I	79773	961520	0.08297
0.00000	0.64771	0.61059	IAH--Arr_26L_ 26R _Dep_ 15L_ 15R—V	78016	557317	0.13998
0.01775	0.65020	0.65012	DEN--Arr_16L_ 16R_ 17R _Dep_ 8_ 17L_ 17R_ 25--V	74444	617913	0.12048

Table 18: Top 30 Results on the Assumed Policy Sort

Table 18 was derived from the sorting of the information in Appendix 11, with the scale efficiency column removed for ease of presentation; therefore, there are another nearly 400 DMUs which have been sorted and are available to be passed into the policy decision in the next section, wherein this sort will be merged with known hotspots, as it can be seen here, that many of these configurations are performing quite well, such as the third row from the bottom in Table 18, which shows a dedicated five runway configuration, three for arrivals and two for departures under IFR conditions, which handles about 8.3 percent of traffic at ATL, and has a Beta-K on the frontier. Based upon the assumed policy, this is not a good candidate; however, the red bolded LGA configuration two rows above it with the huge Beta-K might be. These are considerations for the next section.

18. Creating a New Airport Operations Diagnostic—Selections Based Upon Policy

Similar to Section 17, this section incorporates the regressions into the candidate selections to affect systemic performance. However, Section 17 supplied the bridging link to do so, whereas Section 18, which deals with the orange highlighted boxes with green text, is the final merger of these information streams, and incorporates the decisions based upon selection criteria and air transportation policy.

To understand the importance of this section, it is helpful to abstract Figure 33, and consider what is happening at a high level. The red highlighted boxes identify the poorest performing airports, by systematically analyzing the high-level performance of the airports to find those with “poor values of Y” in the regression models. However, the yellow highlighted boxes go the other direction, and find the Xs in all regression models which need to be moved to have a practical impact on the national aviation system. This is supplemented in the green boxes by finding those Xs in the regression which have large leverage, and the intent here in the orange boxes is to close that loop, by putting together the “leveraged Xs” with the “poor Ys” to boost performance, by making the necessary improvements to the underlying configurations.

The activity within these orange boxes is nothing more than a pair of filtrations to build a solid, systemically impacting, candidate list to then allow a better selection of potential projects to be made. The first filtration is simply a check to see if the data sort, coupled with the airport selection and the policy, yield any viable improvement candidates.

To illustrate the point, Table 17 provides the list of airports of interest for improvement, but if Table 18, the list of leveraged configurations, was full of configurations at very efficient airports like ATL and DFW, it is a sign of a potential error, or that the existing operations and policy don’t merge well, and another allocation should be used. This discrepancy leads to the flowchart endpoint of choosing based upon policy, because if things are working well, and there are no errors in the selection of the Xs or Ys, and the Xs still don't match up to the Ys within the regression, then policy should dictate the decision, as there is no underlying science to dictate what the choice should be.

As an example, if the policy were to harden the system against meltdowns, a reasonable execution of policy might be to choose a configuration which is agreed upon as a "known vulnerability" in the system. It needs to be remembered that the mathematical programs are based upon existing data, in that they are post-hoc analyses, so things had to happen for the data to be generated. Therefore, unrealized, but potential instances, are not covered by this process, but may be of value.

In this meltdown example, using this existing data, one way this could easily occur is if a configuration which could melt down, or did melt down, was a "one-off", in that it was only used a few times and did not generate enough throughput to be considered a primary configuration. This would violate an assumption of the model, and therefore, would not be included in the analysis. These are the sorts of issues picked off by this first decision.

The second decision is the point at which candidate listings are built, because it is an iterative approach to merging the Ys to the Xs. By cycling through the two lists, a match can be made to then be used to create a better sense of potential impacts.

Using the assumed policy which created Table 18 and merging with the airport candidate list in Table 17 yields Table 19, which has a new column inserted at the right side of the table to flag configurations operating at the airports of interest.

BetaK Value	BCC Value TechEff	CCR Value TechEff	Configuration	Total Operations	Airport Operations	Percent Ops	LOCID	Airport of Interest?
0.03521	0.96401	0.86164	PHL--Arr_26_ 27R_ 35 _Dep_ 27L_ 35--V	286814	459819	0.62375	PHL	PHL
0.04605	0.76982	0.73552	DFW--Arr_13R_ 17C_ 17L_ 18R _Dep_ 13L_ 17R_ 18L--V	254897	644199	0.39568	DFW	
0.00468	0.93579	0.89163	LAS--Arr_19R_ 25L _Dep_ 19L_ 25R--V	238830	415772	0.57443	LAS	LAS
0.00000	0.73006	0.73006	IAH--Arr_26L_ 26R_ 27 _Dep_ 15L_ 15R--V	216071	557317	0.38770	IAH	
0.00000	1.00000	0.99604	CLT--Arr_18R_ 23 _Dep_ 18L_ 18R--V	213536	496390	0.43018	CLT	
0.00000	0.78074	0.74389	SFO--Arr_28L_ 28R _Dep_ 1L_ 1R--V	194497	361208	0.53846	SFO	
0.00000	0.72908	0.69467	MIA--Arr_8L_ 9 _Dep_ 8R_ 12--V	188154	288651	0.65184	MIA	MIA
0.00000	0.90671	0.90670	ORD--Arr_22R_ 27L_ 28 _Dep_ 22L_ 32L_ 32R--V	171519	863020	0.19874	ORD	
0.19323	0.89414	0.71333	FLL--Arr_9L_ 9R _Dep_ 9L_ 9R--V	155773	225773	0.68995	FLL	FLL
0.00000	0.92004	0.80311	SLC--Arr_34L_ 34R_ 35 _Dep_ 34L_ 34R_ 35--V	153843	316852	0.48554	SLC	SLC
0.00000	0.94935	0.94924	ORD--Arr_4R_ 9R_ 10 _Dep_ 4L_ 9R_ 32L--V	152555	863020	0.17677	ORD	
0.00000	0.64542	0.58834	CVG--Arr_18C_ 18L_ 18R _Dep_ 18C_ 18L_ 27--V	147963	276981	0.53420	CVG	CVG
0.00000	0.76617	0.73164	LAX--Arr_24R_ 25L _Dep_ 24L_ 25R--V	127109	588143	0.21612	LAX	
0.00000	0.75881	0.74566	SLC--Arr_16L_ 16R_ 17 _Dep_ 16L_ 16R_ 17--V	125444	316852	0.39591	SLC	SLC
0.22586	0.59946	0.59860	DFW--Arr_31R_ 35C_ 35R_ 36L _Dep_ 31L_ 35L_ 36R--V	121162	644199	0.18808	DFW	
0.08663	0.67473	0.51403	OAK--Arr_27L_ 27R_ 29 _Dep_ 27L_ 27R_ 29--V	120043	174586	0.68759	OAK	OAK
0.10346	0.55418	0.50972	DTW--Arr_21L_ 22R _Dep_ 21R_ 22L--V	113787	452450	0.25149	DTW	
0.00819	0.55453	0.41833	SJC--Arr_29_ 30L_ 30R _Dep_ 29_ 30L_ 30R--V	95590	135325	0.70637	SJC	SJC
0.13650	0.58847	0.58540	TPA--Arr_18L_ 18R _Dep_ 18L_ 18R--V	92789	200831	0.46203	TPA	
0.00000	0.57056	0.56826	TPA--Arr_36L_ 36R _Dep_ 36L_ 36R--V	89300	200831	0.44465	TPA	
0.06219	0.99750	0.84667	DCA--Arr_19 _Dep_ 19--V	88836	271959	0.32665	DCA	
0.00000	0.62084	0.61553	PDX--Arr_28L_ 28R _Dep_ 28L_ 28R--V	88165	215794	0.40856	PDX	
0.32747	**1.00000**	**0.57314**	**LGA--Arr_22 _Dep_ 31--V**	**84178**	**372243**	**0.22614**	**LGA**	LGA
0.00000	1.00000	0.56054	LGA--Arr_31 _Dep_ 4--V	82666	372243	0.22208	LGA	LGA
0.15194	0.78859	0.69890	MDW--Arr_31C _Dep_ 31C--V	81069	213443	0.37982	MDW	MDW
0.36854	**1.00000**	**0.55800**	**LGA--Arr_22 _Dep_ 13--V**	**80385**	**372243**	**0.21595**	**LGA**	LGA

0.09605	0.50495	0.49529	IND--Arr_23L_ 23R _Dep_ 23L_ 23R--V	79871	168847	0.47304	IND	IND
0.00000	0.86267	0.86119	ATL--Arr_8L_ 9R_ 10 _Dep_ 8R_ 9L--I	79773	961520	0.08297	ATL	
0.00000	0.64771	0.61059	IAH--Arr_26L_ 26R _Dep_ 15L_ 15R--V	78016	557317	0.13998	IAH	
0.01775	0.65020	0.65012	DEN--Arr_16L_ 16R_ 17R _Dep_ 8_ 17L_ 17R_ 25--V	74444	617913	0.12048	DEN	

Table 19: The Top 30 Leveraged Configurations Flagged for Airports of Interest

Table 19 shows that several of these high-leverage configurations exist at the airports which have had routine poor performance, therefore, the list should be further filtered.

The obvious first step is to remove any configurations not at the airports of interest, but at the same time, any configurations which are at airports of interest that are efficient, such as the two SLC configurations which sit on the DODF efficient frontier should likewise be removed. The resulting, and much smaller, table is shown in Table 20, with the airport flags on the right side removed for easier presentation.

BetaK Value	BCC Value TechEff	CCR Value TechEff	Configuration	Total Operations	Airport Operations	Percent Ops
0.03521	0.96401	0.86164	PHL--Arr_26_ 27R_ 35 _Dep_ 27L_ 35—V	286814	459819	0.62375
0.00468	0.93579	0.89163	LAS--Arr_19R_ 25L _Dep_ 19L_ 25R—V	238830	415772	0.57443
0.19323	0.89414	0.71333	FLL--Arr_9L_ 9R _Dep_ 9L_ 9R—V	155773	225773	0.68995
0.08663	0.67473	0.51403	OAK--Arr_27L_ 27R_ 29 _Dep_ 27L_ 27R_ 29--V	120043	174586	0.68759
0.00819	0.55453	0.41833	SJC--Arr_29_ 30L_ 30R _Dep_ 29_ 30L_ 30R--V	95590	135325	0.70637
0.32747	**1.00000**	**0.57314**	**LGA--Arr_22 _Dep_ 31—V**	**84178**	**372243**	**0.22614**
0.15194	0.78859	0.69890	MDW--Arr_31C _Dep_ 31C—V	81069	213443	0.37982
0.36854	**1.00000**	**0.55800**	**LGA--Arr_22 _Dep_ 13—V**	**80385**	**372243**	**0.21595**
0.09605	0.50495	0.49529	IND--Arr_23L_ 23R _Dep_ 23L_ 23R—V	79871	168847	0.47304

Table 20: The Filtered Leveraged Configurations at Flagged Airports

Table 20 is quite manageable, with only nine configurations, which started off as 466 in the appendices and were gradually boiled down. Accordingly, selecting configurations from Table 20 for improvement based upon the assumed policy is also quite easy, as several of the configurations are reasonably efficient, sitting just off the frontier, such as the second row at LAS, which has a Beta-K of 0.004, and handles over half of the traffic at an extremely busy international airport.

The four which really jump out are those with the double digit Beta-K values: FLL in the third row, and towards the bottom, the two LGA configurations in bolded red text, a modification made in Section 16, indicative of a configuration hiding delays under supposedly efficient throughput, as well as the MDW configuration sandwiched between them.

19. Model Assessment

Figure 33 and the subsequent analysis in Sections 15-19 of that model created a diagnostic to identify leveraged improvement points to target for the airports in the national airspace, but there should also be an assessment of the accuracy and suitability of the new model.

Model Accuracy

Recognizing that the model draws upon past data and tries to predict the future in a socio-government context creates many problems with validating the model; however, some insight can be gleaned through some exploratory analysis, as the aviation complex in the country has evolved since the end of the data capture on 31 December 2008.

This listing of four good candidates actually meshes very well with reality, as this 2008 data stacks up well with the existing problems in the national airspace. The New York airspace remains a hot area for both consumer complaint, as well as study, as academic literature is rife with papers operating in this sector of the airspace, especially focused on operations at LGA and JFK.

Likewise, there has been an ongoing battle between those touting runway lengthening at FLL and Broward County residents, as the airport direly needs the south parallel runway to be fully capable of handling commercial jet traffic, which it currently cannot. The result is that commercial jet traffic is relegated to the north runway, while other smaller traffic, such as propeller driven aircraft, are serviced on the south runway; as the results in Table 20 indicate. However, this is not a new development, and this request is based upon years of data. This eastbound configuration was in use for the entire duration of the study, as the most heavily used configuration at FLL, with this same sort of poor performance, as shown in Table 21, for both the VFR and IFR conditions.

Configuration	**BetaK Value by Year**						
	2002	2003	2004	2005	2006	2007	2008
FLL--Arr_9L_ 9R _Dep_ 9L_ 9R--V	0.1723	0.1747	0.1893	0.1782	0.0301	0.0970	0.1932
FLL--Arr_9L_ 9R _Dep_ 9L_ 9R--I	0.3637	0.4132	0.3991	0.4713	0.2141	0.2496	0.3734

Table 21: FLL Eastbound Configuration Results Over the Period Studied

Table 21 shows that the airport needs improvement, and the additional capacity gained by being able to use the south runway for jet traffic would certainly help the situation, however, local residents are worried about the additional noise which would be created. This has been an ongoing battle, and as such, much like the New York airspace, is evidence that the model, was able to identify a known hotspot.

The other configuration identified was at Chicago's Midway Airport, which is the smaller of the two major airports in the area, and is an interesting case because of the significant land constraint imposed by the airport literally sitting on a square mile of land in the middle of an urban area on the south side of Chicago. This compressed footprint creates a significant about of trouble in moving aircraft around, as the runways need to be oriented to work along the diagonals of the square, requiring a lot of crossing and little space to maneuver, unlike the large sprawling airports with parallel runways such as DFW and ATL, which can easily create departure and arrival queues on the ground to allow airborne traffic the right of way. MDW cannot do this, as it doesn't have space, so it effectively "blocks up" just by operating.

While this isn't as much of a hot spot relative to the Northeast, the Chicago airspace has been a source of large delays, in part because the orientation of runways at ORD, coupled with the huge volume of air traffic in the airspace, which also encompasses airports in Rockford, which is striving to become a reliever for ORD and MDW commercial traffic, catering to low-cost carriers, like Allegiant, as well as cargo airlines. Furthermore, Milwaukee is a large facility in its own right, as a member of the ASPM 77, sitting just outside the OPSNET 45.

Therefore, the accuracy of the model appears good given the context, and this is based upon an arbitrary cut of the top thirty based upon a sort geared towards configuration volume. An expansion of Table 18 and 19 to fifty configurations would have added three more excellent candidates, each of which had a Beta-K over 0.35 and carried over 57000 operations. Two of these configurations were at JFK, and the other at EWR, both of which are in the New York metropolitan area, indicating that the needed resolution in the model is present.

Model Faults

While the model is accurate and suitable, it does suffer from a couple of significant faults, both of which can be derived from the suitability analysis, but can be overcome by aviation expertise.

The first is that the sorting of the data, which is driven by the policy being applied, is critical. Erroneous policy creates havoc with the diagnostic process because it will not allow the proper linkage of getting the leveraged configurations to properly boost the performance via the known regression relationships to maximize consumer benefit via delay reduction.

The other fault, which is not explicit, is the fact that interactions lurk in the model. The reason for this lurking is because of a tradeoff of information versus inclusion, and is most easily explained by addressing the two obvious cases where it exists: the flight rules and the relationship between airports.

The flight rules create a lurking interaction because the models, as described here, treat the same runways as different entities under different flight rules. This was intentionally done, because there can be, and frequently are, differences in the operation of runways under visual and instrument conditions, and being able to differentiate them in the context of the model is quite meaningful. This is especially true because depending upon how the gap between the two configurations works, useful information about the direction of a solution to a problem can be generated.

Using Table 21 as an example, the VFR configuration is a poor performer, and the IFR configuration is even worse. Typically, it is expected that the IFR configuration should be worse, because the restrictions imposed by IFR flight typically indicate greater spacing between aircraft, meaning fewer operations can be packed into the same amount of time; thereby lowering throughput. Therefore, at FLL, the problem is not between the VFR and IFR operation of the eastbound configuration, the problem is the configuration itself; hence, the call to lengthen the south runway to be suitable for processing commercial jet traffic, which would add useful capacity.

However, there are other patterns possible. For example, a good IFR score and poor VFR score is probably indicative of a small configuration, wherein delays aren’t the issue, but a lot of available runway versus what is churned out; while a poor IFR score coupled with a good VFR score could be indicative of a need to update navigational equipment to allow for better arrival procedures under IFR conditions, or a design problem, wherein runways are too close together.

The tradeoff to gain this sort of information is that the interaction which defines the runways themselves, is lost. This is further amplified by any sorting of the data which focuses on throughput counts, as IFR configurations will almost always be pushed to the bottom, as VFR conditions typically dominate the United States since operational ceilings are usually high enough and there are more hours without precipitation. However, by merging the flight rules, this additional informational granularity would be lost.

Therefore, it requires a skilled analyst to know about these issues and find them. Likewise, this may also argue that the existing BCA process should be retained and used in conjunction with the overarching systemic analysis, because local expertise is required to diagnose the underlying causes of these sorts or problems, which may or may not be systemic.

The other lurking interaction is that of the between airport interactions. This is most acute and known in the Northeast, because it is known that the airports are all clustered together, meaning that the arrival and departure corridors have to account for each other. Therefore, improving the efficiency at one of the airports may actually not matter, as the bottleneck could very well be the traffic in the air, not the operational design of taxiing patterns or other airport or ground-based initiatives which are capped by the other airports even operating.

While this is especially known to be the case in the New York metropolitan area, perhaps expressing itself in the OPSNET 45 data shown here via LGA, JFK, EWR and TEB, this ignores other airports in the area, such as Westchester Count Airport (HPN, frequently called “White Plains”) and Long Island MacArthur Airport (ISP, frequently called “Islip”).

Other crowded metropolitan areas are likely to have similar interactions hidden in the data, such as the aforementioned Chicago airspace. Los Angeles has a similar issue, although the largest airport is LAX, but there are also significant operations from Ontario International Airport (ONT), Bob Hope Airport (BUR, frequently called “Burbank”), John Wayne Airport (SNA, frequently called “Orange County”), Long Beach Airport (LGB) and Palm Springs International Airport (PSP). The San Francisco Bay Area, with its three OPSNET 45 facilities, SFO, OAK and SJU likewise have similar airspace congestion, and deeper analysis in all of these cases is required to see if a configuration improvement will be rendered moot by something beyond the direct airport control.

Chapter 5: Case Studies

Sections 20-21

20. Case Study—Extending the Policy Example at JFK

This section presents a case study at JFK derived from the policy assumptions used in the previous sections about maximizing the “bang for the buck” in proposed improvements.

A note was made in the model assessment in Section 19 about Table 19, which only showed the first thirty entries in the sorted data, stating that if the table were expanded to the first fifty results, three additional configurations of interest would appear. These configurations were all in the New York metro, and two were at JFK. Table 22 shows the first of these two configurations, and the associated IFR configuration which is paired with it, to minimize any lurking interaction.

BetaK Value	BCC Value TechEff	CCR Value TechEff	Configuration	Total Operations	Airport Operations	Percent Ops
0.41274	**1.0000**	**0.5327**	**JFK--Arr_22L _Dep_22R_31L--V**	57548	415653	0.1385
0.71986	**1.0000**	**0.3866**	**JFK--Arr_22L _Dep_22R_31L--I**	1500	415653	0.0036

Table 22: JFK Configuration Data

Table 22 shows that this configuration, and the two DMUs that encompass it, account for about 14.2 percent of all operations at JFK, or roughly one in seven flights for all of 2008 at JFK. Likewise, 59048 combined operations on the configuration were more than the entire flight load processed at Teterboro (TEB), on all configurations, in the entire year. For a sense of scale, TEB is the smallest of the OPSNET 45, and only handled 51920 operations in 2008.

Two other items stand out in Table 22. The first is that the text is red and bolded, indicative of an operation deemed to be efficient, but hiding large number of delays, which is indicated in the sizable Beta-K values, and the fact that the IFR configuration saw very little use, meaning this is primarily a VFR configuration. Looking at a drawing of the configuration, shown in Figure 38, shows why.

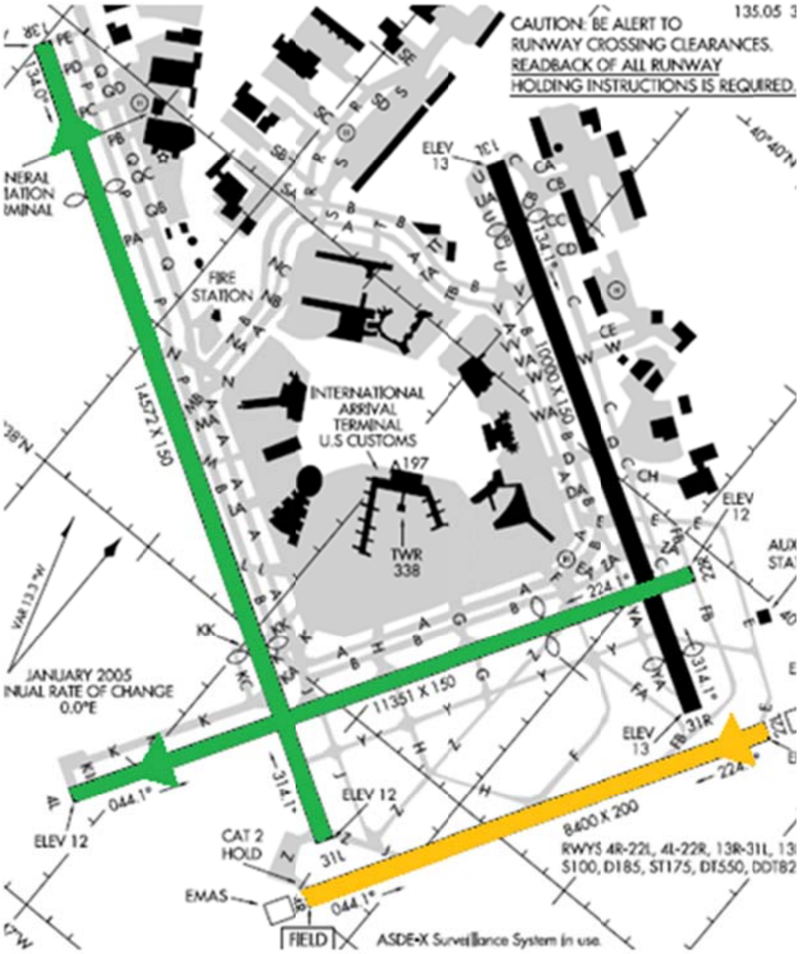


Figure 38: JFK 22L | 22R, 31L

Figure 38 shows a configuration which uses two runways dedicated to departure and one dedicated to arrivals, but the problem is that all runways have to interact with at least one other runway to generate an operation. This point is not inherently obvious from the figure, as the figure shows all of the runway colored, but the thresholds on both departure runways are displaced, making the actual ground rolls along the pavement significantly shorter than shown. However, for RWY 22R, the departure schedule must account for crossings from the parallel arrival runway, RWY 22L, lest the taxi back to the terminal for the arrivals stretch several miles as the aircraft head all the way back east to use the taxiways near RWY 31R. This is similar, in principle, to how an end-around taxiway could operate, and could be a basis for both operational and capital improvement if further research warranted, however, this also incurs a large fuel burn, and would take quite awhile on the ground to execute. There are two important points to remember with taxiing: first, that jet engines are extremely inefficient on the ground, as they are precision machines designed to operate at cruising altitudes at cruising speeds, not in stop-and-start traffic; and second, that taxiing speed limits are typically 35 miles per hour, so going several miles will take a long time, even if the aircraft isn't forced to stop and queue.

At the same time, the jet wash from departures on RWY 31L must also be taken into account, despite the displaced threshold, as RWY 22R has a perpendicular crossing orientation to the very long RWY 31L, which will further impact departure scheduling.

Deeper analysis into the JFK primary configurations as a whole shows that many of the configurations are very inefficient, as shown in Table 23.

Configuration	BetaK Value	BCC Value TechEff	CCR Value TechEff
JFK--Arr_13L _Dep_ 13R--V	0.4080	0.8225	0.3631
JFK--Arr_13L_ 22L _Dep_ 13R--V	0.3516	0.5186	0.4833
JFK--Arr_22L _Dep_ 22R--V	0.5496	0.7345	0.3453
JFK--Arr_22L _Dep_ 22R_ 31L--V	0.4127	1.0000	0.5327
JFK--Arr_22L_ 22R _Dep_ 22R--V	0.5581	0.7433	0.7068
JFK--Arr_22L_ 22R _Dep_ 22R_ 31L--V	0.6040	0.4510	0.4473
JFK--Arr_31L_ 31R _Dep_ 31L--V	0.0000	1.0000	1.0000
JFK--Arr_31R _Dep_ 31L--V	0.3933	0.7316	0.3574

JFK--Arr_4R _Dep_ 4L--V	0.4003	0.9553	0.3910
JFK--Arr_4R _Dep_ 4L_ 31L--V	0.2811	1.0000	0.5039
JFK--Arr_13L_ 22L _Dep_ 13R--I	0.6540	0.3180	0.2943
JFK--Arr_22L _Dep_ 22R--I	0.7166	0.7755	0.3646
JFK--Arr_22L _Dep_ 22R_ 31L--I	0.7199	1.0000	0.3866
JFK--Arr_22L_ 22R _Dep_ 22R--I	0.7844	0.6764	0.6288
JFK--Arr_22L_ 22R _Dep_ 22R_ 31L--I	0.4991	0.1516	0.1412
JFK--Arr_31L_ 31R _Dep_ 31L--I	0.5333	0.8534	0.7520
JFK--Arr_31R _Dep_ 31L--I	0.6010	1.0000	0.3754
JFK--Arr_4R _Dep_ 4L--I	0.7545	0.7235	0.3349
JFK--Arr_4R _Dep_ 4L_ 31L--I	0.7534	0.8440	0.3923

Table 23: Efficiencies of the Primary Configurations at JFK for 2008

The results in Table 23 show one very good configuration, arriving on 31L and 31R, while departing on 31L, indicating a dedicated arrival runway and a mixed operation runway, which sits on the efficient frontier in all three models. While this configuration positively contributes to the overall operations of the airport on an aggregate basis, the less than perfect performance for this airport is attributed to quite a few configurations that yield values significantly below one, such as the ones listed 2nd, 6th, 12th, and 16th in Table 23.

From a systemic diagnosis standpoint, there are anecdotal indications that JFK does not have enough capacity to reliably handle its current flight load on a routine and sustained basis, as the Beta-K values for all but one configuration are high, meaning the existing capacity is already stretched to the absolute limit and delays are almost guaranteed, unless a consumer gets lucky and happens to fly on a day when the efficient configuration is being used. However, using the DEA-based diagnostic, it can be seen that there are efficient configurations which sit on the efficiency frontier at JFK for handling the daily flight loads, but not for all the configurations, and not all configurations are scale efficient. This is in stark contrast to a benchmark airport, such as ATL which has best in class performance as an entire airport and within most of its configurations.

This benchmark comparison raises a serious question about the amount of effective capacity at JFK versus what has been allocated as slots, but a simple geographic analysis raises further questions. JFK is bounded by water on significant parts of three sides, and by major road expressways wherever there is no water. Therefore, a sustainability question for these flight loads should be raised, because it is likely this lack of capacity relative to demand is causing the excessive lack of timely operations, which shrinks the numerator in the objective function, leading to the observed low efficiencies, indicating a lack of performance.

21. Case Study—A Historical Look at Shifting the Efficient Frontier Using Non-Capacity Investment at ATL

One of the primary areas of research in the area of aviation project approval is to incorporate the value of non-capacity projects, because they are difficult to value, in that they do not, in theory, add any more ability to process aircraft. In the BCA process, there are workarounds for these, creating economic justifications for longer runways allowing larger aircraft, and the associated larger cargo and passenger loads, and the like, but in some cases, these projects are extremely hard to value. Safety is sometimes used as a basis for valuation, but beyond that, how should a benefit-cost analysis value an upgraded lighting system or a new taxiway?

In 2006, ATL was still the busiest airport in the world by traffic movements, and had recently added the new southern runway, RWY 10/28, but was also widely recognized as an airport, much like ORD, the second busiest airport in the world, that was heavily impacted by weather. When things were going well, both airports could turn enormous flight loads, but once the winds shifted, the delays shot through the roof.

At ATL, the primary problems was the orientation of the airport itself, as shown in Figure 3 and Figure 6, the airport typically operates in a westbound configuration, but when the weather turns, and the configuration shown in Figure 6 has to turn and operate eastbound, the runway crossing delays on the north runway pair became crippling. This resulted in huge delays, and the corresponding terrible delays creating huge inefficiencies as shown in Table 24.

BetaK Value	BCC Value-TechEff	CCR Value-TechEff	Scale Efficiency	Configuration
0.0000	1.0000	1.0000	1.0000	ATL--Arr_26R_ 27L _Dep_ 26L_ 27R--V
0.0000	1.0000	1.0000	1.0000	ATL--Arr_26R_ 27L_ 28 _Dep_ 26L_ 27R--V
0.0000	0.9763	0.9763	1.0000	ATL--Arr_26R_ 27L_ 28 _Dep_ 26L_ 27R_ 28--V
0.2028	0.9217	0.9206	0.9988	ATL--Arr_26R_ 27L_ 28 _Dep_ 26R_ 27R--V
0.0000	1.0000	1.0000	1.0000	ATL--Arr_8L_ 9R _Dep_ 8R_ 9L--V
0.0000	1.0000	1.0000	1.0000	ATL--Arr_8L_ 9R_ 10 _Dep_ 8L_ 9L--V
0.0519	0.9758	0.9752	0.9994	ATL--Arr_8L_ 9R_ 10 _Dep_ 8R_ 9L--V
0.0000	1.0000	1.0000	1.0000	ATL--Arr_8L_ 9R_ 10 _Dep_ 8R_ 9L_ 10--V
0.1221	0.9618	0.9604	0.9985	ATL--Arr_8L_ 9R_ 10 _Dep_ 8R_9L--V

0.3436	0.9289	0.9153	0.9854	ATL--Arr_26R_ 27L _Dep_ 26L_ 27R--I
0.3912	0.8157	0.8135	0.9974	ATL--Arr_26R_ 27L_ 28 _Dep_ 26L_ 27R--I
0.2902	0.9325	0.9292	0.9965	ATL--Arr_26R_ 27L_ 28 _Dep_ 26L_ 27R_ 28--I
0.5555	0.6332	0.6274	0.9908	ATL--Arr_26R_ 27L_ 28 _Dep_ 26R_ 27R--I
0.0000	0.8951	0.8828	0.9863	ATL--Arr_8L_ 9R _Dep_ 8R_ 9L--I
0.6382	0.6711	0.6671	0.9940	ATL--Arr_8L_ 9R_ 10 _Dep_ 8L_ 9L--I
0.3589	0.8654	0.8642	0.9986	ATL--Arr_8L_ 9R_ 10 _Dep_ 8R_ 9L--I
0.4639	0.7185	0.7163	0.9969	ATL--Arr_8L_ 9R_ 10 _Dep_ 8R_ 9L_ 10--I
0.0000	1.0000	1.0000	1.0000	ATL--Arr_8L_ 9R_ 10 _Dep_ 8R_9L--I

Table 24: ATL Configuration Performance in 2006

One of the interesting points to note about Table 24 is that while it shows several large Beta-K values, the majority of the BCC and CCR values remained fairly high, and as such, ATL sat on the efficient frontier in all three models. However, because of the huge flight loads of the busiest airport in the world, any disruption in bad weather carried huge ripples through the national airspace from both direct delays, as well as knock-on delays.

To counter this problem, a way was needed to alleviate the runway crossing constraint that was crippling the north parallel runway pair. The solution came from Germany, as Frankfurt am Main Airport (FRA), the busiest airport in Germany, used what is called an “end-around taxiway” to allow independent runway operations, by eliminating the need to cross paths. ATL embraced this idea, and built one on the north pair, as shown in Figures 38-40 with images from Google Maps.

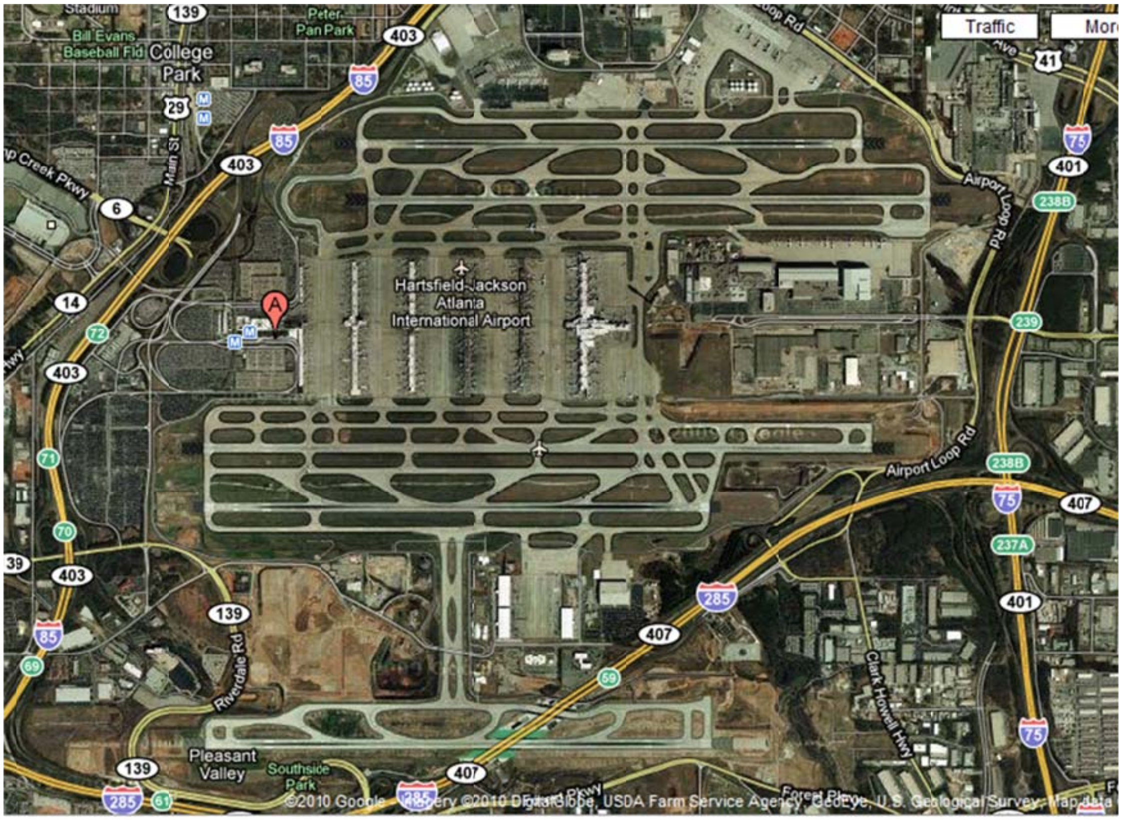


Figure 39: A Satellite View of ATL

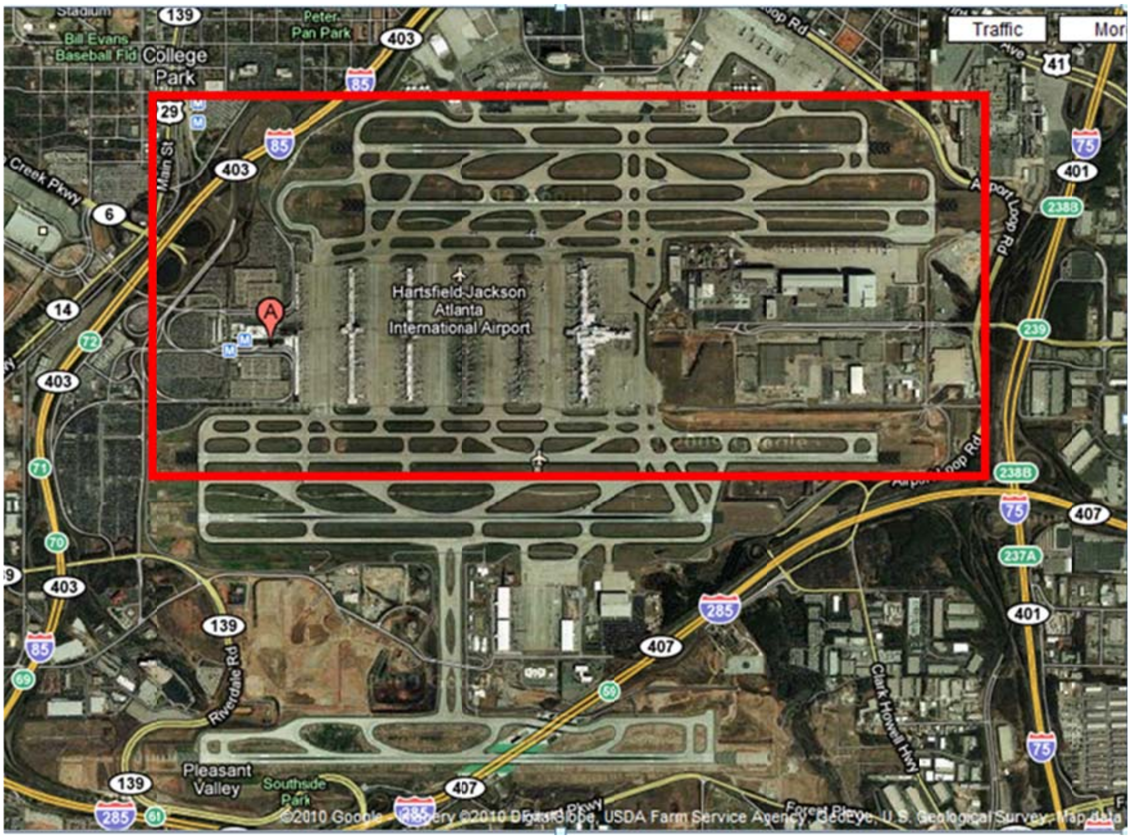


Figure 40: The Area of Interest at ATL

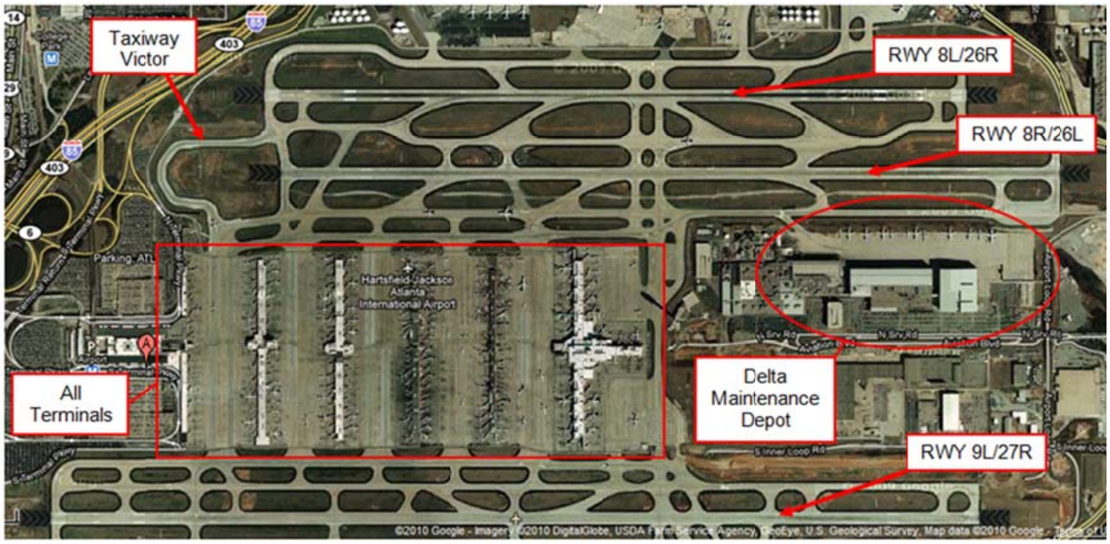


Figure 41: Location of Taxiway Victor Relative to Other Important Landmarks

Figure 41 shows the semicircular Taxiway Victor, the ATL end-around taxiway is located on the west side of the airport, and by bending back behind, and below, given the elevation drop, operations on RWY 8L/26R no longer impact operations on RWY 8R/26L en route to the terminal.

Through a stroke of complete luck for research purposes, the Google Maps satellite images happened to catch ATL on a day with an eastbound configuration, typical of poor weather, as the traditional west to east winds that characterize a good portion of the weather pattern of the United States, shift on the back side of a storm. Therefore, in lieu of an explanation, a series of pictures can be used to explain the operation of the new taxiway, and how it improved operations. The portion of the eastbound configuration for Figure 41 is shown in Figure 42.

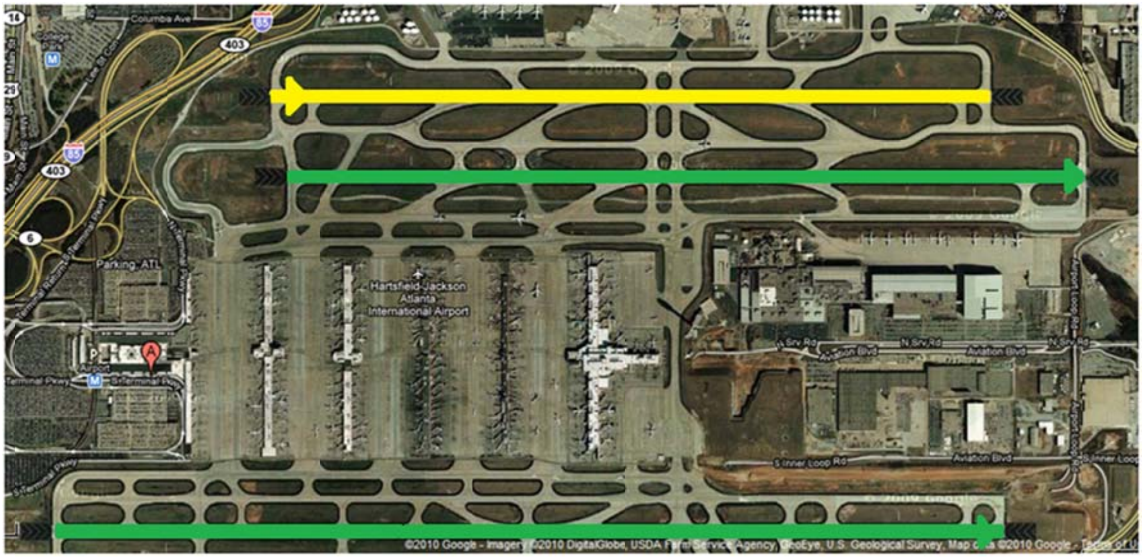


Figure 42: The Eastbound Diagram for Figure 41

Prior to Taxiway Victor, an arrival had to first clear the arrival runway, RWY 8L. Figure 43 shows there are three exit opportunities at the end of the runway: the high-speed taxiway (the slanted one), or either of the two slow-speed taxiways. All three are shown, highlighted in yellow, but are usually chosen at the pilot's discretion, unless the ground controller instructs him otherwise. Likewise, if a pilot had a slow enough approach and a light enough aircraft that it could stop in a shorter distance, other midfield options to exit the runway can be seen. As will be shown in a future figure, in Figure 43, there is a regional jet using one of these exits.

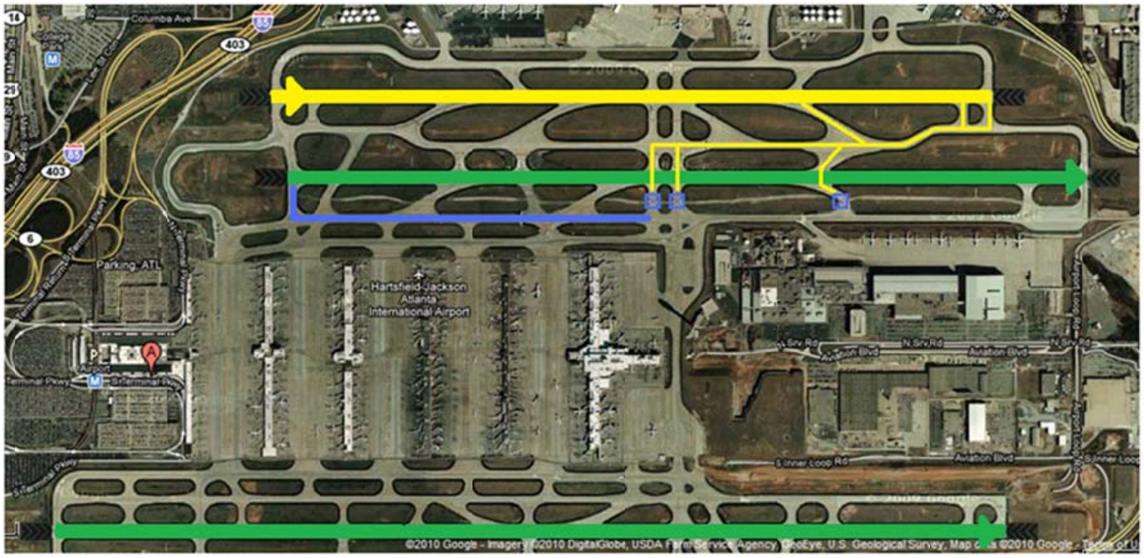


Figure 43: RWY 8L Exit Paths and RWY 8R Crossing Points

Continuing with the analysis of Figure 43, the routing back to the terminals is governed by three crossing points denoted as by the small blue boxes with Xs inside. Which routing is taken to which crossing will vary by instruction from the ground controller. However, the key point here is that the departure queue, shown as a blue line, must also be crossed. Therefore, there are two forces at work which must be balanced: not clogging the departures queue, so the queue doesn't grow and choke off the ability for arrivals to cross (note: arrivals always have priority, so this can build inefficiency quickly), while also getting arrivals through, to minimize the number of crossings, yet still working with the limited taxiway space in crossing the departure queue; denoted by the blue line. This balancing act is what created the delay problem.

After the construction of Taxiway Victor, a new arrival traffic ground pattern was implemented, which largely bypassed all of the problems associated with the length of the departure queue, and the crossing of RWY 8R, except for aircraft with wingspans longer than 171 feet, which cannot traverse Taxiway Victor; however, these heavy aircraft are not frequent, and the departure and ground controller will typically have something on the order of fifteen minutes to plan for a crossing similar to Figure 43 for these larger aircraft, like an Airbus A330 with its 197-foot wingspan or Boeing 777, which has a wingspans of 200 or 212 feet, depending upon the aircraft series. Also, many Boeing 767 aircraft do not use Taxiway Victor per airline policy, as the wingspan clearance on 400ER series aircraft is only eight inches. However, most flights can use Taxiway Victor, and the new taxiing pattern is shown in Figure 44.

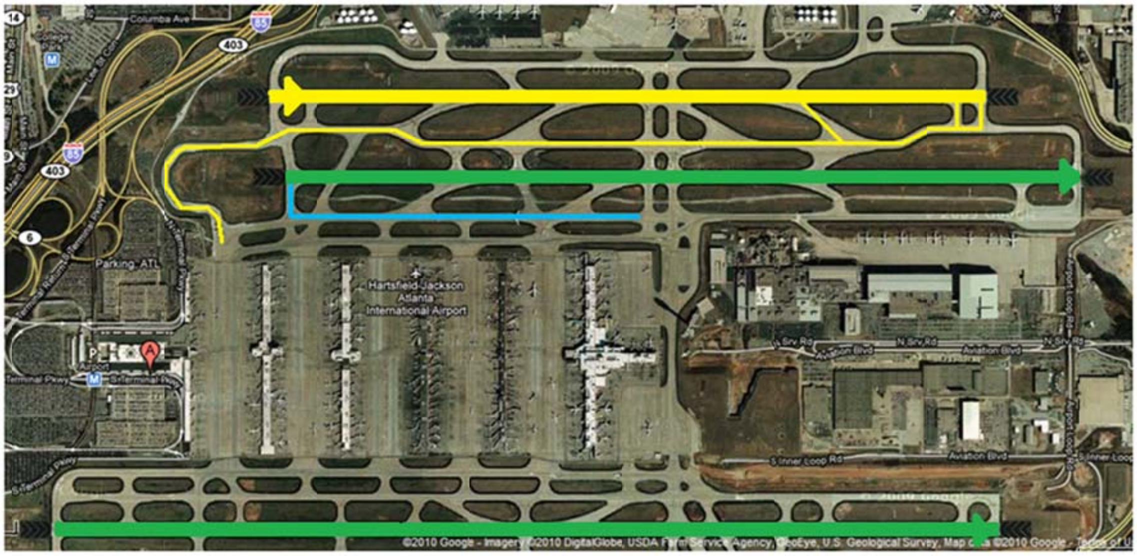


Figure 44: The New Eastbound Taxi Pattern for Arrivals

As previously noted, Google Maps captured the eastbound operation, and a zoomed in view of Taxiway Victor in use is shown in Figure 45. Note the westbound direction of the aircraft heading for the departure runway, as well as the aircraft on Taxiway Victor, and the two aircraft at midfield (located in the upper right corner of the image), taxiing towards Taxiway Victor.

Figure 45: A Satellite Image of Eastbound Operation at ATL

With the understanding, and the photographic evidence, of how the new taxiway operated, the question then shifted to whether the new taxiway was able to reduce delays, and therefore boost the efficiency ratings.

To make this determination, the date of opening was used as a cut-off value, 26 April 2007, and all of the associated configurations were split before and after, and a direct comparison was made in the 2007 data. The results of this comparison were stark. Note that the taxiway was built to handle inclement weather and the associated delays, so the eastbound IFR is highlighted to indicate where the major impact should be. This information is shown in Table 25.

	Configurations	Pre-Victor Efficiency	Post-Victor Efficiency	Victor Efficiency Gain
CCR	ATL--Arr_26R_ 27L_ 28 _Dep_ 26L_ 27R--V	0.1749	1.0000	**0.8251**
	ATL--Arr_26R_ 27L_ 28 _Dep_ 26L_ 27R_ 28--V	1.0000	1.0000	**0.0000**
	ATL--Arr_8L_ 9R_ 10 _Dep_ 8R_ 9L--V	1.0000	0.2436	**-0.7564**
	ATL--Arr_26R_ 27L_ 28 _Dep_ 26L_ 27R--I	0.1226	0.1867	**0.0641**
	ATL--Arr_26R_ 27L_ 28 _Dep_ 26L_ 27R_ 28--I	0.2062	0.2162	**0.0100**
	ATL--Arr_8L_ 9R_ 10 _Dep_ 8R_ 9L--I	0.1609	0.8811	**0.7203**
BCC	ATL--Arr_26R_ 27L_ 28 _Dep_ 26L_ 27R--V	0.9309	1.0000	**0.0691**
	ATL--Arr_26R_ 27L_ 28 _Dep_ 26L_ 27R_ 28--V	1.0000	1.0000	**0.0000**
	ATL--Arr_8L_ 9R_ 10 _Dep_ 8R_ 9L--V	0.9955	1.0000	**0.0045**
	ATL--Arr_26R_ 27L_ 28 _Dep_ 26L_ 27R--I	0.9063	0.9456	**0.0394**
	ATL--Arr_26R_ 27L_ 28 _Dep_ 26L_ 27R_ 28--I	1.0000	0.9809	**-0.0191**
	ATL--Arr_8L_ 9R_ 10 _Dep_ 8R_ 9L--I	0.8372	0.9325	**0.0954**
DODF	ATL--Arr_26R_ 27L_ 28 _Dep_ 26L_ 27R--V	0.0000	0.0000	**0.0000**
	ATL--Arr_26R_ 27L_ 28 _Dep_ 26L_ 27R_ 28--V	0.0000	0.0000	**0.0000**
	ATL--Arr_8L_ 9R_ 10 _Dep_ 8R_ 9L--V	0.0000	0.0000	**0.0000**
	ATL--Arr_26R_ 27L_ 28 _Dep_ 26L_ 27R--I	0.3279	0.3886	**-0.0607**
	ATL--Arr_26R_ 27L_ 28 _Dep_ 26L_ 27R_ 28--I	0.0000	0.0000	**0.0000**
	ATL--Arr_8L_ 9R_ 10 _Dep_ 8R_ 9L--I	0.2231	0.0000	**0.2231**

Table 25: Before and After Taxiway Victor Comparison of ATL Configurations

Table 25 shows vast improvements in the dominant IFR configuration, and small gains in most others, with one notable exception in the CCR block that did not appear in any of the other two blocks, which both showed the configuration sitting on the efficient frontier.

Given that a well placed taxiway was able to drastically slash delays and boost the efficiency values of the configurations, it was decided that a check should be made to see what happened to the total airport score, as ATL sat on the efficient frontier in all three models, in all years, as noted in Section 10. A similar analysis, was run at the total airport level, again splitting the data on 26 April 2007, to see what happened to the total airport efficiency values. The results of this test are shown in Table 26.

Airport	CCR Value-Original	CCR-Split Data	Frontier Shift?	BCC Value-Original	BCC-Split Data	Frontier Shift?	BetaK Value-Original	BetaK Value-Split Data	Frontier Shift?
ABQ	0.2262	0.2349	0.0087	0.2262	0.2349	0.0087	0.0199	0.0199	0.0000
ATL-Pre-Victor	1.0000	1.0000		1.0000	1.0000		0.0000	0.0000	
ATL-Post-Victor		1.0000			1.0000			0.0000	
BNA	0.2552	0.2668	0.0116	0.2552	0.2668	0.0116	0.1378	0.1378	0.0000
BOS	0.4279	0.4575	0.0296	0.4279	0.4575	0.0296	0.1636	0.1636	0.0000
BWI	0.5060	0.5296	0.0235	0.5060	0.5296	0.0235	0.0945	0.0945	0.0000
CLE	0.4554	0.4729	0.0175	0.4554	0.4729	0.0175	0.0916	0.0916	0.0000
CLT	0.8138	0.9736	0.1598	0.8138	0.9736	0.1598	0.0715	0.0000	-0.0715
CVG	0.4941	0.5307	0.0365	0.4941	0.5307	0.0365	0.0000	0.0000	0.0000
DCA	0.5079	0.5525	0.0446	0.5079	0.5525	0.0446	0.0812	0.0812	0.0000
DEN	0.7434	0.7947	0.0514	0.7434	0.7947	0.0514	0.0193	0.0211	0.0018
DFW	0.7869	0.7970	0.0101	0.7869	0.8413	0.0544	0.0339	0.0348	0.0009
DTW	0.5282	0.5646	0.0365	0.5282	0.5646	0.0365	0.0802	0.0875	0.0073
EWR	0.6987	0.8120	0.1134	0.6987	0.8120	0.1134	0.3569	0.3569	0.0000
FLL	0.4342	0.4708	0.0366	0.4342	0.4708	0.0366	0.1643	0.1643	0.0000
HOU	0.1887	0.2047	0.0160	0.1887	0.2047	0.0160	0.1549	0.1549	0.0000
IAD	0.6021	0.6884	0.0863	0.6021	0.6884	0.0863	0.1530	0.1530	0.0000
IAH	0.7188	0.8347	0.1159	0.7188	0.8347	0.1159	0.0000	0.0000	0.0000
IND	0.3410	0.3541	0.0131	0.3410	0.3541	0.0131	0.0000	0.0000	0.0000
JFK	0.5357	0.6494	0.1138	0.5357	0.6494	0.1138	0.2718	0.2503	-0.0215
LAS	0.5976	0.7119	0.1143	0.5976	0.7119	0.1143	0.0601	0.0713	0.0112
LAX	0.9566	1.0000	0.0435	0.9566	1.0000	0.0435	0.0000	0.0000	0.0000
LGA	0.9499	1.0000	0.0501	0.9499	1.0000	0.0501	0.0000	0.0000	0.0000
MCI	0.3803	0.3948	0.0146	0.3803	0.3948	0.0146	0.0714	0.0714	0.0000
MCO	0.5376	0.5620	0.0244	0.5376	0.5620	0.0244	0.0225	0.0225	0.0000
MDW	0.2759	0.3252	0.0493	0.2759	0.3252	0.0493	0.1066	0.1188	0.0123
MEM	0.4738	0.5372	0.0634	0.4738	0.5372	0.0634	0.0418	0.0703	0.0285
MIA	0.4375	0.4831	0.0456	0.4375	0.4831	0.0456	0.1967	0.1967	0.0000
MSP	0.5961	0.6753	0.0792	0.5961	0.6753	0.0792	0.1219	0.1219	0.0000

MSY	0.2673	0.2743	0.0070	0.2673	0.2743	0.0070	0.0000	0.0000	0.0000
OAK	0.3261	0.3409	0.0148	0.3261	0.3409	0.0148	0.0079	0.0079	0.0000
ORD	0.9354	1.0000	0.0646	0.9354	1.0000	0.0646	0.0000	0.0000	0.0000
PBI	0.1718	0.1898	0.0179	0.1718	0.1898	0.0179	0.2843	0.2843	0.0000
PDX	0.4935	0.5124	0.0189	0.4935	0.5124	0.0189	0.0000	0.0000	0.0000
PHL	0.5948	0.7236	0.1288	0.5948	0.7236	0.1288	0.1817	0.1711	-0.0106
PHX	0.8706	0.9963	0.1257	0.8706	0.9963	0.1257	0.0000	0.0000	0.0000
PIT	0.2870	0.3001	0.0130	0.2870	0.3001	0.0130	0.1434	0.1434	0.0000
RDU	0.3593	0.3757	0.0164	0.3593	0.3757	0.0164	0.1823	0.1823	0.0000
SAN	1.0000	1.0000	0.0000	1.0000	1.0000	0.0000	0.0000	0.0000	0.0000
SEA	0.9114	0.9466	0.0353	0.9114	0.9466	0.0353	0.0000	0.0000	0.0000
SFO	0.5027	0.5500	0.0473	0.5027	0.5500	0.0473	0.0000	0.0000	0.0000
SJC	0.3155	0.3276	0.0121	0.3155	0.3276	0.0121	0.0000	0.0000	0.0000
SLC	0.6597	0.7121	0.0524	0.6597	0.7121	0.0524	0.0000	0.0000	0.0000
STL	0.3789	0.3961	0.0172	0.3789	0.3961	0.0172	0.0664	0.0664	0.0000
TEB	0.1517	0.1597	0.0080	0.1517	0.1597	0.0080	0.7329	0.7329	0.0000
TPA	0.4517	0.4691	0.0173	0.4517	0.4691	0.0173	0.0000	0.0000	0.0000

Table 26: Impact of Taxiway Victor on Total Airport Models

Table 26 shows that the addition of Taxiway Victor made ATL even more efficient, and as such, slid the efficient frontier in the CCR and BCC models, as indicated by many non-zero values in the third column of each block, which show the difference between the models. Likewise, the new taxiway may have bumped the efficient frontier a bit in the DODF model, as some of the larger airports jostled around a bit, but not much; therefore, this may just be statistical noise given the large number of zeroed out cells.

Chapter 6: Conclusions

Sections 22-23

22. Conclusions

The three predictive equations for airport efficiency allow for three different views on how to address the issue of airport efficiency in a systemic way, which incorporates all stakeholders, and causes the airports to internalize delays, which had long been treated as an externality to the airport, borne by the airlines and consumers. Based upon these three predictive regression equations, coupled with the holistic nature of the data envelopment analysis models, a systemic assessment of the entire aviation system can be made to identify not just poor performing parts of the entire national airspace, but those most likely to impact others.

Based upon these assessments, which are based upon the relative measurement derived from the efficient frontier, improvements can be made to targeted airports. However, conducting the second set of analyses at the configuration level allows specific areas of the airport to be targeted for improvement based upon actual usage. This provides a more targeted approach, and by splitting each configuration into visual and instrument flight rules operations, a better sense of what the underlying problems are in a given configuration can be shown. This data provides a sense of direction as to how to go about addressing the performance of the configuration, from both a capital and operational perspective.

Based upon this theory, a diagnostic was developed to merge these two sets of analyses, while internalizing the inherent biases of each of the three models within each of the analyses. Beta-K values from the Directional Output Distance Function best represent the interest of the consumer, as they were shown to best model the existing situation, showing the trouble in the Northeast, but the other two, BCC and CCR, provide a backdrop to confirm more macro-scale trends, as these models, in this application, are based on flight volumes instead of specific delays, as well as providing a bridge back to the existing literature bodies.

By working systematically in the execution of the diagnostic, these biases were leveraged to find the airports with the most trouble, and to find the configurations with the most leverage to be able to move these airports to higher levels of performance. By using this leverage based approach, this ensures that maximum value is delivered to those paying for the improvements; typically the federal income taxpayer, traveler, and local residents, while still working within the constraints beyond the known financial ones, including noise and traffic.

These benefits can then be realized by the consumer, especially passengers, as cargo doesn’t care how it gets from Point A to Point B, because the consumer is focused on the performability of the airport to turn flights based upon the schedule, not the intricacies or profitability of the operation of the airport itself. Understanding the efficiencies of the configurations of the airport helps the consumer because the configurations are not chosen by the consumer, but by nature and policy; the consumer is merely subject to them on the day of flight. Therefore, there is an impetus for the entire airport and airspace to have a robust set of primary configurations that should lead to enhanced probabilities that the consumer requirements of schedule fulfillment will be maintained.

The developed diagnostic was found to be reflective of the existing conditions of the national airspace, although not perfect, in that it was still subject to poor policy decisions at the legal and managerial levels, and due to the granularity of the modeling, could miss more macro-trends at individual facilities, without proper guidance.

23. Future Work

The work presented herein establishes a diagnostic which flags poor performance for deeper analysis at the configuration level, and two faults were identified within the system. Each of these faults presents an opportunity for expansion of the work, first in the study of various policies, both within the model mechanics and in the resulting output. These are important considerations as these tie to national transportation policy and law, and directly impact the quality of any recommendation that can come from the diagnostic. Because of this integration, a symbiotic relationship can be formed between the policy side as well as the operations research side, suggesting further study both qualitatively and quantitatively, as better information can lead to better policy, and better policy can lead to better information.

The second fault focused on interactions which exist within the model structure that cause a lack of independence between the airport and configuration DMUs in terms of the correlation of the associated regression equations. Within the mathematical models, these interactions were not problematic, as they were treated as a part of the variance within the model, as it was an inherent characteristic of the system. However, in trying to extract an individual DMU from the system, this could create significant difficulty in realizing the expected gains from improvements if other configurations or airports are tied to the one under study.

Academic literature has addressed shared airspaces in the past, but has never done so on a configuration basis, asking questions such as what happens at LGA if a northwest bound configuration is in effect at JFK? These studies could provide an interesting way to break the existing paradigm of configuration usage and control, given the evolution of flight technology that has rendered prevailing winds less significant of a factor than they were when many of these airports were first constructed. The hope is that by breaking this paradigm, new configuration interactions can be generated to minimize any interactions and allow for independence of operation, versus assuming that this is the case.

It should also be noted that the existing diagnostic process is robust against any changes which will be brought about by NextGen, as the system starts to come online in 2018, as is currently slated, noting that this date may change as the system continues to be developed. However, while the process is robust, this is probably not true for the underlying data feeding the process; therefore, similar to work which was done on computers for the Y2K problem, this process will need to be "future-proofed" to ensure that it is still relevant and able to work within the new airspace rules which will come into effect with NextGen.

References

Anagnostakis, Ioannis, et al. "A Conceptual Design of a Departure Planner Decision Aid." *3rd USA/Europe Air Traffic Management R&D Seminar from Napoli, Italy 2000.*

Associated Press. "New $1 Billion Runway Opens This Week, But It's Not Needed Anymore." *USA Today* 10 April 2006. Online Edition.

Atkin, Jason A. D., et al. "Hybrid Metaheuristics to Aid Runway Scheduling at London Heathrow Airport." Transportation Science 41.1 (2007): 90-106.

Atkins, Stephen and Walton, Deborah. "Prediction and Control of Departure Runway Balancing at Dallas/Fort Worth Airport." *Proceedings of the American Control Conference 2002*.

Balakrishna, Poornima, Rajesh Ganesan, and Lance Sherry. "Airport Taxi-Out Prediction using Approximate Dynamic Programming Intelligence-Based Paradigm." Transportation Research Record 2052 (2008): 54-61.

Banker, R. D., A. Charnes, and W. W. Cooper. "Some Models for Estimating Technical and Scale Inefficiencies in Data Envelopment Analysis." Management Science 30.9 (1984): 1078-92.

Barbas, Carlos, et al. "Development of an Algorithm to Model the Landing Operations Based on Statistical Analysis of Actual Data Survey (ProESTOP)." *Eurocontrol 7th Conference Procedings from Barcelona 2007.*

Barros, Carlos Pestana, and Peter U. C. Dieke. "Measuring the Economic Efficiency of Airports: A Simar-Wilson Methodology Analysis." Transportation Research Part E-Logistics and Transportation Review 44.6 (2008): 1039-51.

---. "Performance Evaluation of Italian Airports: A Data Envelopment Analysis." Journal of Air Transport Management 13.4 (2007): 184-91.

Bazargan, M., and B. Vasigh. "Size Versus Efficiency: A Case Study of US Commercial Airports." Journal of Air Transport Management 9.3 (2003): 187-93.

Bohme, Dieter. "Improved Airport Surface Traffic Management by Planning--Problems, Concepts and a Solution-TARMAC." *Advanced Technologies for Air Traffic Flow Management : Proceedings of an International Seminar Organized by Deutsche Forschungsanstalt für Luft- und Raumfahrt (DLR),* *Bonn, Germany, April 1994.* Eds. H. Winter and H.-G. Nüsser. New York: Springer-Verlag, 1994. 191-224.

---. "Coordinated Arrival Departure Management.")." *Eurocontrol 7th Conference Procedings from Barcelona 2007.*

Borins, Sandford F.. “Pricing and Investment in a Transportation Network: The Case of Toronto Airport.” The Canadian Journal of Economics 11.4 (1978): 680-700.

Brueckner, J. K. "Airline Traffic and Urban Economic Development." Urban Studies 40.8 (2003): 1455-69.

---. "Airport Congestion when Carriers have Market Power." American Economic Review 92.5 (2002): 1357-75.

Castelli, Lorenzo and Ranieri, Andrea. "Air Navigation Service Charges in Europe." *Eurocontrol 7th Conference Procedings from Barcelona 2007.*

Carlin, Alan and R. E. Park. “Marginal Cost Pricing of Airport Runway Capacity.” The American Economic Review 60.3 (1970): 310-319.

Carlin, Alan and Rolla Edward Park. “The Efficient Use of Airport Runway Capacity in a Time of Scarcity.” The RAND Corporation, RM-5817-PA, 1969.

Charnes, A., W. W. Cooper, and E. Rhodes. "Measuring Efficiency of Decision-Making Units." European Journal of Operational Research 2.6 (1978): 429-44.

Chung, Y.H., et al. “Productivity and Undesirable Outputs: A Directional Distance Function Approach*.”* Journal of Environmental Management 51.3 (1997): 229-40.

Conkey, Christopher. “Bush Seeks to Reduce Air-Travel Delays Strategy Would Cap Number of Flights At Kennedy Airport.” *Wall Street Journal* 18 December 2007: D2.

Cook, W. and L. Seiford. “Data Envelopment Analysis (DEA) -Thirty Years On.” European Journal of Operational Research 192 (2009): 1-17.

Cullinane, K., et al. "The Technical Efficiency of Container Ports: Comparing Data Envelopment Analysis and Stochastic Frontier Analysis." Transportation Research Part A-Policy and Practice 40.4 (2006): 354-74.

Deming, W. Edwards. *The New Economics for Industry, Government, Education*. Second Edition. Cambridge, MA: The MIT Press, 2000.

Farrell, M. J., and M. Fieldhouse. "Estimating Efficient Production-Functions Under Increasing Returns to Scale." Journal of the Royal Statistical Society Series A-General 125.2 (1962): 252-67.

Farrell, M. J. "The Measurement of Productive Efficiency." Journal of the Royal Statistical Society Series A-General 120.3 (1957): 253-90.

Fernandes, E., and R. R. Pacheco. "Efficient use of Airport Capacity." Transportation Research Part A-Policy and Practice 36.3 (2002): 225-38.

Fernandes, Elton, and Ricardo Rodrigues Pacheco. "Airport Management: A Strategic Approach." Transportation 34.1 (2007): 129-42.

Feron, Eric, et al. "The Departure Planner: A Conceptual Discussion." White Paper. Massachusetts Institute of Technology, International Center for Air Transportation. December 1997. http://dspace.mit.edu/handle/1721.1/34944

Fung, Michael Ka Yiu, et al. "Productivity Changes in Chinese Airports 1995-2004." Transportation Research Part E-Logistics and Transportation Review 44.3 (2008): 521-42.

Gillen, D., and A. Lall. "Developing Measures of Airport Productivity and Performance: An Application of Data Envelopment Analysis." Transportation Research Part E-Logistics and Transportation Review 33.4 (1997): 261-73.

Gosling, Geoffrey D.. "Development of a Framework for Assessing the Benefits of Airport Surface Traffic Automation." IEEE Transactions on Control Systems Technology 1.3 (1993): 155-67.

Graham, Brian. "Airport-Specific Traffic Forecasts: A Critical Perspective." Journal of Transport Geography 7 (1999): 285-89.

Haraldsdottir, Aslaug, et al. "Arrival Management With Required Navigation Performance and 3D Paths." *Eurocontrol 7th Conference Procedings from Barcelona 2007.*

Hartmann, Henning. "CARE Action "Innovation" Final Report of Preliminary Study Total Airport Management". German Aerospace Center, Institute of Flight Guidance. November 2001. http://www.eurocontrol.int/care-innov/gallery/content/public/docs/studies2001/tam_finalreportr1.1.pdf

Hansen, Mark. "Micro-Level Analysis of Airport Delay Externalities Using Deterministic Queuing Models." Journal of Air Transport Management 8.2 (2002): 73-87.

Horner, Peter. "Doing Good with Good O.R.." *ORMS Today* December 2007: 44-49.

Kaufhold, Rainer, et al. "A Pre-Tactical Generalised Air Traffic Flow Management Problem." *Eurocontrol 7th Conference Procedings from Barcelona 2007.*

Levine, Michael E.. “Landing Fees and the Airport Congestion Problem.” Journal of Law and Economics 12.1 (1969): 79-108.

Lin, L. C., and C. H. Hong. "Operational Performance Evaluation of International Major Airports: An Application of Data Envelopment Analysis." Journal of Air Transport Management 12.6 (2006): 342-51.

Little, I. M. D. and K. M. McLeod. “The New Pricing Policy of the British Airports Authority.” Journal of Transport Economics and Policy 6.2 (1972): 101-115.

Littlechild, S. C. and G. Owen. “A Simple Expression for the Shapely Value in a Special Case.” Management Science 20.3 Theory Series (1973): 370-372.

Littlechild, S. C. and G. F. Thompson. “Aircraft Landing Fees: A Game Theory Approach.” The Bell Journal of Economics 8.1 (1977): 186-204.

Martin, J. C., and C. Roman. "A Benchmarking Analysis of Spanish Commercial Airports. A Comparison between SMOP and DEA Ranking Methods." Networks & Spatial Economics 6.2 (2006): 111-34.

McCartney, Scott. “Frequent Flying: Small Jets, More Trips Worsen Airport Delays; FAA Likes Bigger Craft But Passengers, Airlines Prefer Busy Schedules.” *Wall Street Journal* 13 August 2007: A1.

Mukherjee, Avijit, et al. "Modeling Delays and Cancellation Probabilities to Support Strategic Simulations." Proceedings of the 2005 Air Traffic Management Research and Development Seminar, Baltimore, MD.

Parker, D. "The Performance of BAA before and After Privatisation - A DEA Study." Journal of Transport Economics and Policy 33 (1999): 133-45.

Pathomsiri, Somchai, et al. "Impact of Undesirable Outputs on the Productivity of US Airports." Transportation Research Part E-Logistics and Transportation Review 44.2 (2008): 235-59.

Pathomsiri, Somchai. "Assessment of Airport Productivity - Nonparametric Directional Output Distance Function Approach and its Robustness." Transportation Research Record.2007 (2007): 28-36.

Pels, E., P. Nijkamp, and P. Rietveld. "Inefficiencies and Scale Economies of European Airport Operations." Transportation Research Part E-Logistics and Transportation Review 39.5 (2003): 341-61.

---. "A Note on the Optimality of Airline Networks." Economics Letters 69.3 (2000): 429-34.

Ross, Alex and Alison Swain. “Fighting Flight Delays.” ORMS Today 34.2 (2007): 22-29.

Sarkis, J., and S. Talluri. "Performance Based Clustering for Benchmarking of US Airports." Transportation Research Part A-Policy and Practice 38.5 (2004): 329-46.

Sarkis, J. "An Analysis of the Operational Efficiency of Major Airports in the United States." Journal of Operations Management 18.3 (2000): 335-51.

Schmidberger, Stephan, et al. "Ground Handling Services at European Hub Airports: Development of a Performance Measurement System for Benchmarking." International Journal of Production Economics 117.1 (2009): 104-16.

Simmons, Brian, et al. "Simulation Analysis of Dual CRDA Arrival Streams to Runways 27 and 33L at Boston Logan International Airport." MITRE Corporation, November 2000.

Yee, Daniel. "New Runway at Atlanta Hub Could Reduce Air Delays Throughout US." Associated Press article, 19 May 2006. Accessed through: http://archives.californiaaviation.org/airport/msg37478.html

Yoshida, Y., and H. Fujimoto. "Japanese-Airport Benchmarking with the DEA and Endogenous-Weight TFP Methods: Testing the Criticism of Overinvestment in Japanese Regional Airports." Transportation Research Part E-Logistics and Transportation Review 40.6 (2004): 533-46.

Yoshida, Y. "Endogenous-Weight TFP Measurement: Methodology and its Application to Japanese-Airport Benchmarking." Transportation Research Part E-Logistics and Transportation Review 40.2 (2004): 151-82.

Yu, M. M. "Measuring Physical Efficiency of Domestic Airports in Taiwan with Undesirable Outputs and Environmental Factors." Journal of Air Transport Management 10.5 (2004): 295-303.

Zelinski, Shannon and Romer, Tom. "Estimating Capacity Requirements for Air Transportation System Design." *Eurocontrol 7th Conference Procedings from Barcelona 2007.*

Appendix 1: Passengers Boarded at the Top 50 U.S. Airports

Table 1-41: Passengers Boarded at the Top 50 U.S. Airports[a]
(Ranked By Passenger Enplanements in 2008)

Airport	Code	1998		2007		2008		Percent change 1998-2008	Percent change 2007-2008
		Rank	Total Enplaned Passengers	Rank	Total Enplaned Passengers	Rank	Total Enplaned Passengers		
Atlanta, GA (Hartsfield-Jackson Atlanta International)	ATL	1	34,950,624	1	42,703,925	1	43,238,440	23.7	1.3
Chicago, IL (Chicago O'Hare International)	ORD	2	33,001,514	2	34,213,375	2	31,351,227	-5.0	-8.4
Dallas, TX (Dallas/Fort Worth International)	DFW	3	28,288,866	3	28,183,932	3	26,830,947	-5.2	-4.8
Denver, CO (Denver International)	DEN	5	16,928,800	5	23,731,431	4	23,919,713	41.3	0.8
Los Angeles, CA (Los Angeles International)	LAX	4	22,873,919	4	23,795,604	5	22,439,873	-1.9	-5.7
Las Vegas, NV (McCarran International)	LAS	11	14,033,044	6	21,490,456	6	19,887,290	41.7	-7.5
Houston, TX (George Bush Intercontinental)	IAH	13	13,784,260	8	20,091,915	7	19,239,836	39.6	-4.2
Phoenix, AZ (Phoenix Sky Harbor International)	PHX	8	15,045,207	7	20,563,619	8	19,209,392	27.7	-6.6
Charlotte, NC (Charlotte Douglas International)	CLT	20	10,242,126	14	16,506,672	9	17,185,243	67.8	4.1
New York, NY (John F. Kennedy International)	JFK	21	10,076,141	11	16,758,684	10	16,955,540	68.3	1.2
Detroit, MI (Detroit Metropolitan Wayne County)	DTW	7	15,113,361	9	17,278,955	11	16,749,472	10.8	-3.1
Minneapolis, MN (Minneapolis-St. Paul International/Wold-Chamberlain)	MSP	12	13,908,618	10	16,895,507	12	16,302,227	17.2	-3.5
Orlando, FL (Orlando International)	MCO	16	11,931,179	13	16,590,473	13	16,112,383	35.0	-2.9
Newark, NJ (Newark Liberty International)	EWR	9	14,563,610	12	16,613,652	14	16,105,083	10.6	-3.1
San Francisco, CA (San Francisco International)	SFO	6	16,684,337	17	14,848,757	15	15,727,533	-5.7	5.9
Philadelphia, PA (Philadelphia International)	PHL	19	10,286,199	15	15,314,929	16	15,257,081	48.3	-0.4
Seattle, WA (Seattle-Tacoma International)	SEA	15	12,242,768	16	14,912,461	17	15,206,521	24.2	2.0
Miami, FL (Miami International)	MIA	14	13,265,268	18	13,478,811	18	13,577,782	2.4	0.7
Boston, MA (General Edward Lawrence Logan International)	BOS	17	10,703,631	19	12,485,079	19	11,588,988	8.3	-7.2
New York, NY (LaGuardia)	LGA	18	10,356,421	20	12,107,802	20	11,159,038	7.7	-7.8
Fort Lauderdale, FL (Fort Lauderdale-Hollywood International)	FLL	32	5,479,331	22	10,501,414	21	10,370,421	89.3	-1.2
Baltimore, MD (Baltimore/Washington International Thurgood Marshall)	BWI	28	6,842,133	24	10,293,320	22	10,078,747	47.3	-2.1

Washington, DC (Dulles International)	IAD	33	5,380,822	23	10,392,788	23	9,917,944	84.3	-4.6
Salt Lake City, UT (Salt Lake City International)	SLC	22	9,096,235	21	10,560,244	24	9,887,540	8.7	-6.4
San Diego, CA (San Diego International)	SAN	27	6,996,325	28	9,046,701	25	8,931,211	27.7	-1.3
Tampa, FL (Tampa International)	TPA	29	6,276,284	26	9,126,330	26	8,689,410	38.4	-4.8
Washington, DC (Ronald Reagan Washington National)	DCA	26	7,067,065	29	8,934,441	27	8,599,934	21.7	-3.7
Chicago, IL (Chicago Midway)	MDW	36	5,031,271	25	9,127,993	28	8,012,938	59.3	-12.2
Honolulu, HI (Honolulu International)	HNL	24	8,604,618	27	9,090,457	29	7,785,515	-9.5	-14.4
Portland, OR (Portland International)	PDX	30	6,208,415	31	7,129,505	30	6,942,236	11.8	-2.6
St. Louis, MO (Lambert-St Louis International)	STL	10	14,211,362	32	7,086,758	31	6,626,545	-53.4	-6.5
Cincinnati, OH (Cincinnati/Northern Kentucky International)	CVG	25	7,782,586	30	7,727,495	32	6,480,292	-16.7	-16.1
Oakland, CA (Oakland International)	OAK	38	4,410,001	33	7,065,844	33	5,482,324	24.3	-22.4
Memphis, TN (Memphis International)	MEM	41	4,075,300	36	5,545,451	34	5,375,733	31.9	-3.1
Kansas City, MO (Kansas City International)	MCI	34	5,280,221	34	5,816,563	35	5,346,702	1.3	-8.1
Cleveland, OH (Cleveland-Hopkins International)	CLE	31	5,714,330	35	5,554,813	36	5,277,778	-7.6	-5.0
Sacramento, CA (Sacramento International)	SMF	45	3,494,596	37	5,315,066	37	4,891,967	40.0	-8.0
Raleigh, NC (Raleigh-Durham International)	RDU	48	3,289,286	41	4,940,504	38	4,741,753	44.2	-4.0
San Jose, CA (Norman Y. Mineta San Jose International)	SJC	37	4,994,765	38	5,183,513	39	4,698,523	-5.9	-9.4
Nashville, TN (Nashville International)	BNA	42	3,776,545	42	4,866,911	40	4,615,999	22.2	-5.2
San Juan, PR (Luis Munoz Marin International)	SJU	35	5,178,870	39	5,051,731	41	4,546,996	-12.2	-10.0
Santa Ana, CA (John Wayne-Orange County)	SNA	43	3,633,053	40	4,945,927	42	4,462,999	22.8	-9.8
Pittsburgh, PA (Pittsburgh International)	PIT	23	8,968,613	43	4,856,561	43	4,264,809	-52.4	-12.2
Austin, TX (Austin-Bergstrom International)	AUS	51	3,028,297	45	4,173,476	44	4,255,238	40.5	2.0
Houston, TX (William P. Hobby)	HOU	40	4,223,014	44	4,236,254	45	4,224,294	0.0	-0.3
Dallas, TX (Love Field)	DAL	46	3,362,850	47	3,982,958	46	4,030,509	19.9	1.2
Indianapolis, IN (Indianapolis International)	IND	44	3,499,207	46	4,078,891	47	4,025,647	15.0	-1.3
New Orleans, LA (Louis Armstrong International)	MSY	39	4,356,208	51	3,763,067	48	3,976,840	-8.7	5.7
San Antonio, TX (San Antonio International)	SAT	47	3,307,842	49	3,821,638	49	3,949,819	19.4	3.4
Milwaukee, WI (General Mitchell Field)	MKE	57	2,599,939	52	3,733,749	50	3,824,181	47.1	2.4
Total top 50[b]	**NA**	**NA**	**495,081,931**	**NA**	**594,674,583**	**NA**	**572,358,453**	15.6	-3.8
All airports	**NA**	**NA**	**639,052,581**	**NA**	**726,428,614**	**NA**	**697,365,141**	9.1	-4.0

KEY: NA = not applicable.

[a] Rank order by total enplaned passengers on large certificated U.S. air carriers (Majors, Nationals, Large Regionals, and Medium Regionals), scheduled and nonscheduled operations, at all airports served within the 50 states, the District of Columbia, and other U.S. areas designated by the Federal Aviation Administration.

[b] The total for the top 50 airports will not sum from the individual airports because some top 50 airports in 2008 were not in the top 50 in the earlier years.

NOTE

Large certificated air carriers hold Certificates of Public Convenience and Necessity issued by the U.S. Department of Transportation authorizing the performance of air transportation. Large certificated air carriers operate at least one aircraft with seating capacity of more than 60 seats or a maximum payload capacity of more than 18,000 pounds. Data for commuter, small-certificated and foreign-flag air carriers are not included.

SOURCE

U.S. Department of Transportation, Bureau of Transportation Statistics, *Office of Airline Information*, *T-3 Data*, available at http://www.transtats.bts.gov/Databases.asp?Subject_ID=2&Subject_Desc=Freight%20%25Transport&Mode_ID2=0 as of May 05, 2009.

Appendix 2: The ASPM 77-OPSNET 45-OEP 35 Content Comparisons

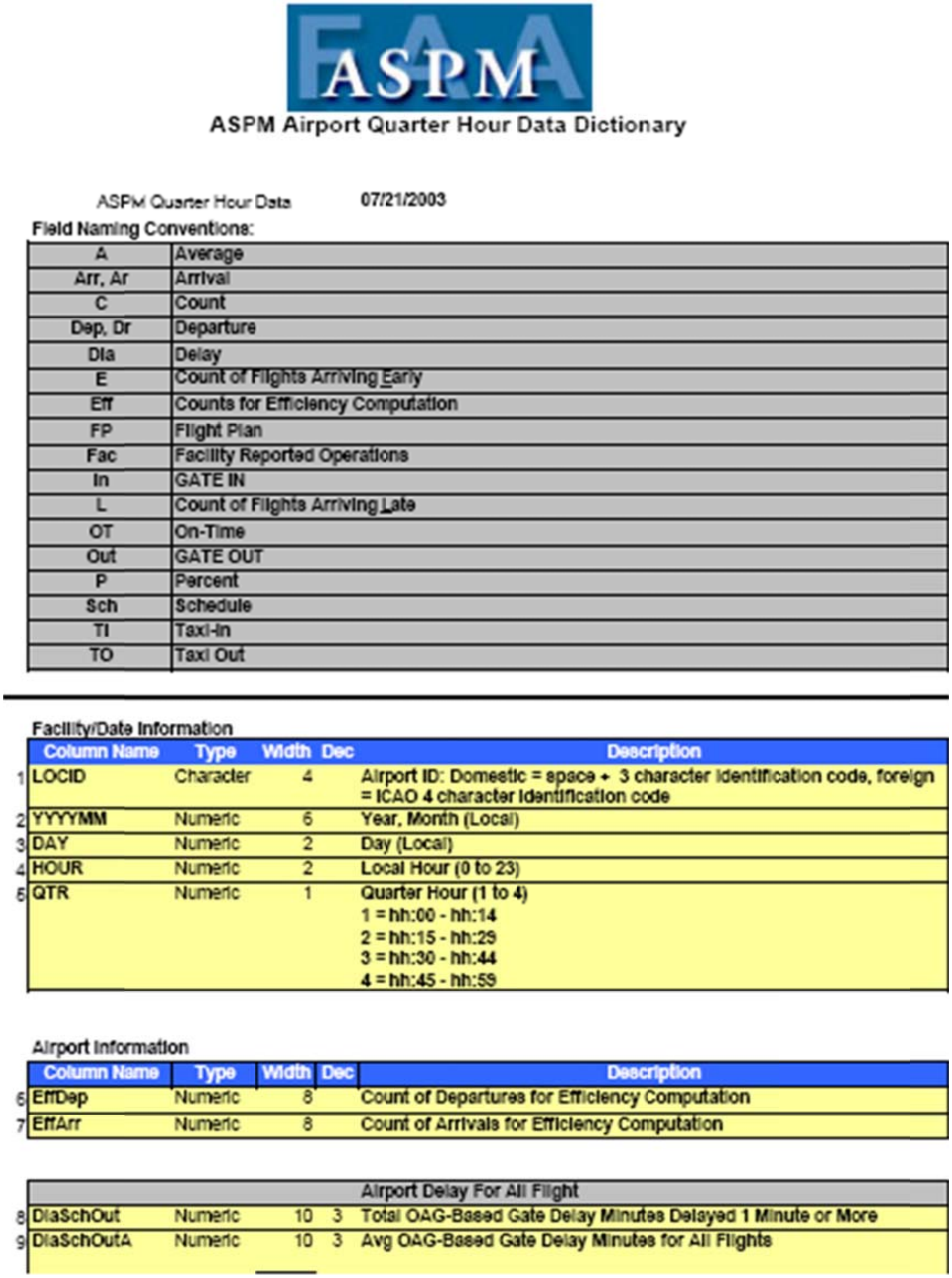
ASPM 77	OPSNET 45	OEP 35	Airport Name
ABQ	ABQ		Albuquerque Intl Sunport
ANC			Ted Stevens Anchorage Intl
ATL	ATL	ATL	Hartsfield-Jackson Atlanta Intl
AUS			Austin-Bergstrom Intl
BDL			Bradley Intl
BHM			Birmingham Intl
BNA	BNA		Nashville Intl
BOS	BOS	BOS	Boston Logan Intl
BUF			Buffalo Niagara Intl
BUR			Bob Hope (Burbank/Glendale/Pasadena)
BWI	BWI	BWI	Baltimore/Washington Intl
CLE	CLE	CLE	Cleveland Hopkins Intl
CLT	CLT	CLT	Charlotte Douglas Intl
CVG	CVG	CVG	Cincinnati/Northern Kentucky Intl
DAL			Dallas Love Field
DAY			Dayton Intl
DCA	DCA	DCA	Ronald Reagan Washington National
DEN	DEN	DEN	Denver Intl
DFW	DFW	DFW	Dallas/Fort Worth Intl
DTW	DTW	DTW	Detroit Metropolitan Wayne County
EWR	EWR	EWR	Newark Liberty Intl
FLL	FLL	FLL	Fort Lauderdale/Hollywood Intl
GYY			Gary Chicago Intl
HNL		HNL	Honolulu Intl
HOU	HOU		Houston Hobby
HPN			Westchester County
IAD	IAD	IAD	Washington Dulles Intl
IAH	IAH	IAH	George Bush Houston Intercontinental
IND	IND		Indianapolis Intl
ISP			Long Island Mac Arthur
JAX			Jacksonville Intl
JFK	JFK	JFK	New York John F. Kennedy Intl
LAS	LAS	LAS	Las Vegas McCarran Intl
LAX	LAX	LAX	Los Angeles Intl
LGA	LGA	LGA	New York LaGuardia
LGB			Long Beach

MCI	MCI		Kansas City Intl
MCO	MCO	MCO	Orlando Intl
MDW	MDW	MDW	Chicago Midway
MEM	MEM	MEM	Memphis Intl
MHT			Manchester
MIA	MIA	MIA	Miami Intl
MKE			Milwaukee Gnl Mitchell International
MSP	MSP	MSP	Minneapolis/St. Paul Intl
MSY	MSY		Louis Armstrong New Orleans Intl
OAK	OAK		Oakland Intl
OGG			Kahului
OMA			Omaha Eppley Airfield
ONT			Ontario Intl
ORD	ORD	ORD	Chicago O’Hare Intl
OXR			Oxnard
PBI	PBI		Palm Beach Intl
PDX	PDX	PDX	Portland Intl
PHL	PHL	PHL	Philadelphia Intl
PHX	PHX	PHX	Phoenix Sky Harbor Intl
PIT	PIT	PIT	Pittsburgh Intl
PSP			Palm Springs International
PVD			Providence Francis Green State
RDU	RDU		Raleigh/Durham Intl
RFD			Greater Rockford
RSW			Southwest Florida Intl
SAN	SAN	SAN	San Diego Intl
SAT			San Antonio Intl
SDF			Louisville Intl
SEA	SEA	SEA	Seattle/Tacoma Intl
SFO	SFO	SFO	San Francisco Intl
SJC	SJC		Norman Mineta San Jose Intl
SJU			San Juan Luis Munoz Intl
SLC	SLC	SLC	Salt Lake City Intl
SMF			Sacramento International Airport
SNA			John Wayne Airport-Orange County
STL	STL	STL	Lambert Saint Louis Intl
SWF			Stewart Intl
TEB	TEB		Teterboro
TPA	TPA	TPA	Tampa Intl
TUS			Tucson Intl
VNY			Van Nuys

Appendix 3: The Data Tracked in ASPM

Original .pdf located at: http://aspm.faa.gov/aspm/Dict_AirportQtr.pdf

These are the pasted in screen shots of the individual pages.



ASPM Airport Quarter Hour Data Dictionary

ASPM Quarter Hour Data 07/21/2003

Field Naming Conventions:

A	Average
Arr, Ar	Arrival
C	Count
Dep, Dr	Departure
Dla	Delay
E	Count of Flights Arriving Early
Eff	Counts for Efficiency Computation
FP	Flight Plan
Fac	Facility Reported Operations
In	GATE IN
L	Count of Flights Arriving Late
OT	On-Time
Out	GATE OUT
P	Percent
Sch	Schedule
TI	Taxi-In
TO	Taxi Out

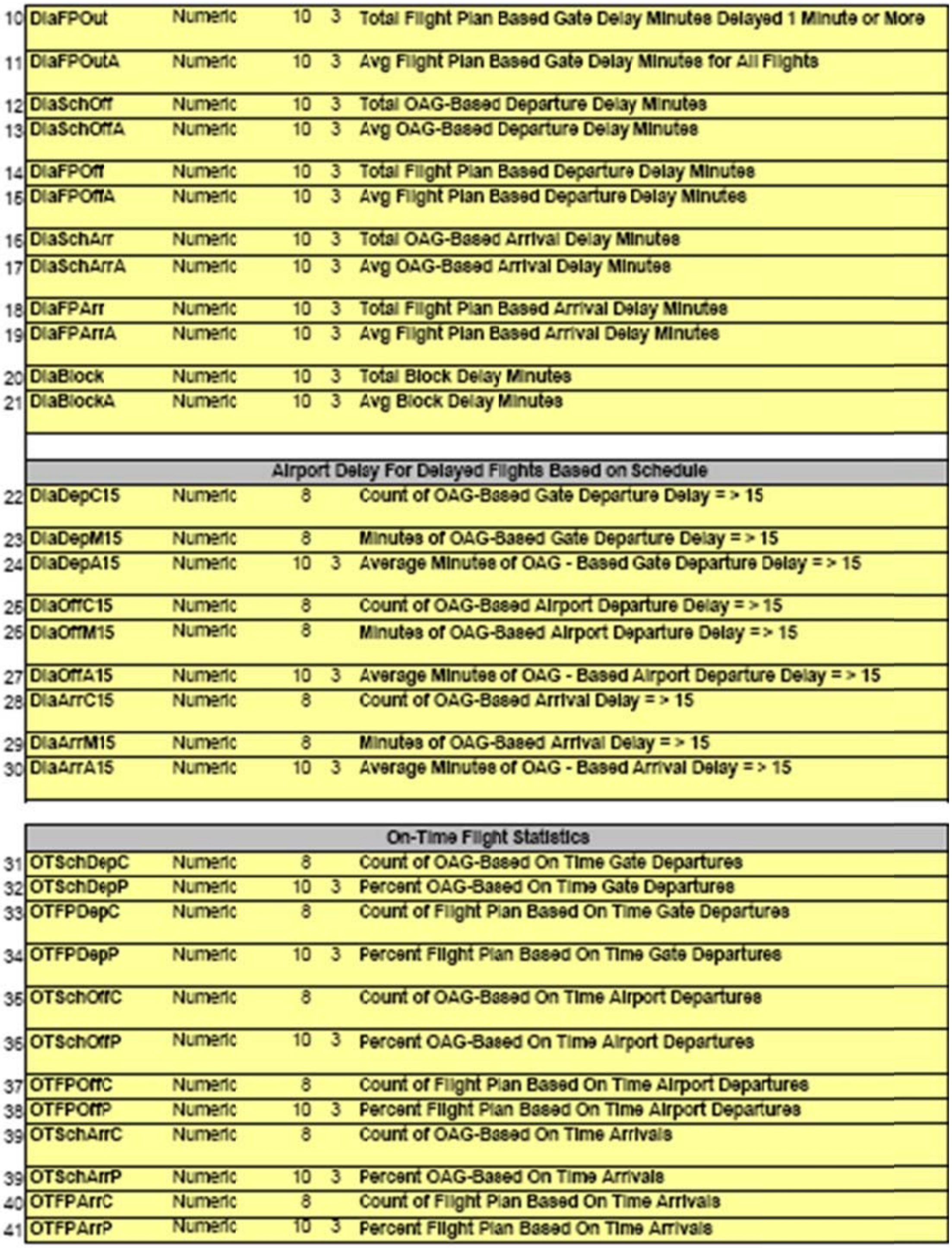
Facility/Date Information

Column Name	Type	Width	Dec	Description
1 LOCID	Character	4		Airport ID: Domestic = space + 3 character identification code, foreign = ICAO 4 character identification code
2 YYYYMM	Numeric	6		Year, Month (Local)
3 DAY	Numeric	2		Day (Local)
4 HOUR	Numeric	2		Local Hour (0 to 23)
5 QTR	Numeric	1		Quarter Hour (1 to 4) 1 = hh:00 - hh:14 2 = hh:15 - hh:29 3 = hh:30 - hh:44 4 = hh:45 - hh:59

Airport Information

Column Name	Type	Width	Dec	Description
6 EffDep	Numeric	8		Count of Departures for Efficiency Computation
7 EffArr	Numeric	8		Count of Arrivals for Efficiency Computation

				Airport Delay For All Flight
8 DlaSchOut	Numeric	10	3	Total OAG-Based Gate Delay Minutes Delayed 1 Minute or More
9 DlaSchOutA	Numeric	10	3	Avg OAG-Based Gate Delay Minutes for All Flights



10	DiaFPOut	Numeric	10	3	Total Flight Plan Based Gate Delay Minutes Delayed 1 Minute or More
11	DiaFPOutA	Numeric	10	3	Avg Flight Plan Based Gate Delay Minutes for All Flights
12	DiaSchOff	Numeric	10	3	Total OAG-Based Departure Delay Minutes
13	DiaSchOffA	Numeric	10	3	Avg OAG-Based Departure Delay Minutes
14	DiaFPOff	Numeric	10	3	Total Flight Plan Based Departure Delay Minutes
15	DiaFPOffA	Numeric	10	3	Avg Flight Plan Based Departure Delay Minutes
16	DiaSchArr	Numeric	10	3	Total OAG-Based Arrival Delay Minutes
17	DiaSchArrA	Numeric	10	3	Avg OAG-Based Arrival Delay Minutes
18	DiaFPArr	Numeric	10	3	Total Flight Plan Based Arrival Delay Minutes
19	DiaFPArrA	Numeric	10	3	Avg Flight Plan Based Arrival Delay Minutes
20	DiaBlock	Numeric	10	3	Total Block Delay Minutes
21	DiaBlockA	Numeric	10	3	Avg Block Delay Minutes
	Airport Delay For Delayed Flights Based on Schedule				
22	DiaDepC15	Numeric	8		Count of OAG-Based Gate Departure Delay = > 15
23	DiaDepM15	Numeric	8		Minutes of OAG-Based Gate Departure Delay = > 15
24	DiaDepA15	Numeric	10	3	Average Minutes of OAG - Based Gate Departure Delay = > 15
25	DiaOffC15	Numeric	8		Count of OAG-Based Airport Departure Delay = > 15
26	DiaOffM15	Numeric	8		Minutes of OAG-Based Airport Departure Delay = > 15
27	DiaOffA15	Numeric	10	3	Average Minutes of OAG - Based Airport Departure Delay = > 15
28	DiaArrC15	Numeric	8		Count of OAG-Based Arrival Delay = > 15
29	DiaArrM15	Numeric	8		Minutes of OAG-Based Arrival Delay = > 15
30	DiaArrA15	Numeric	10	3	Average Minutes of OAG - Based Arrival Delay = > 15
	On-Time Flight Statistics				
31	OTSchDepC	Numeric	8		Count of OAG-Based On Time Gate Departures
32	OTSchDepP	Numeric	10	3	Percent OAG-Based On Time Gate Departures
33	OTFPDepC	Numeric	8		Count of Flight Plan Based On Time Gate Departures
34	OTFPDepP	Numeric	10	3	Percent Flight Plan Based On Time Gate Departures
35	OTSchOffC	Numeric	8		Count of OAG-Based On Time Airport Departures
36	OTSchOffP	Numeric	10	3	Percent OAG-Based On Time Airport Departures
37	OTFPOffC	Numeric	8		Count of Flight Plan Based On Time Airport Departures
38	OTFPOffP	Numeric	10	3	Percent Flight Plan Based On Time Airport Departures
39	OTSchArrC	Numeric	8		Count of OAG-Based On Time Arrivals
39	OTSchArrP	Numeric	10	3	Percent OAG-Based On Time Arrivals
40	OTFPArrC	Numeric	8		Count of Flight Plan Based On Time Arrivals
41	OTFPArrP	Numeric	10	3	Percent Flight Plan Based On Time Arrivals

EDCT Information

	Column Name	Type	Width	Dec	Description
	EDCT Delay				
43	DlaEDCTDep	Numeric	10	3	EDCT Hold Minutes Departing this airport
44	DlaEDCTArr	Numeric	10	3	EDCT Hold Minutes at Other Airports Arriving this Airport
45	DlaEDCTDC	Numeric	8		Count of EDCT Holds Departing this Airport
46	DlaEDCTArC	Numeric	8		Count of EDCT Holds at Other Airports Arriving this Airport
47	DlaEDCTDrE	Numeric	8		Count of EDCT Holds Departing this Airport Early
48	DlaEDCTDrL	Numeric	8		Count of EDCT Holds Departing this Airport Late
49	DlaEDCTArE	Numeric	8		Count of EDCT Holds at Other Airports Arriving this Airport Early
50	DlaEDCTArL	Numeric	8		Count of EDCT Holds at Other Airports Arriving this Airport Late

Taxi-Out Information

	Column Name	Type	Width	Dec	Description
51	ActTO	Numeric	10	3	Total Taxi Out Minutes
	Taxi-Out Delay				
52	DlaTOC	Numeric	8		Count of Total Taxi Out Delays
53	DlaTO	Numeric	10	3	Total Taxi Out Delay Minutes
54	DlaTOA	Numeric	10	3	Avg Taxi Out Delay Minutes

Enroute Information

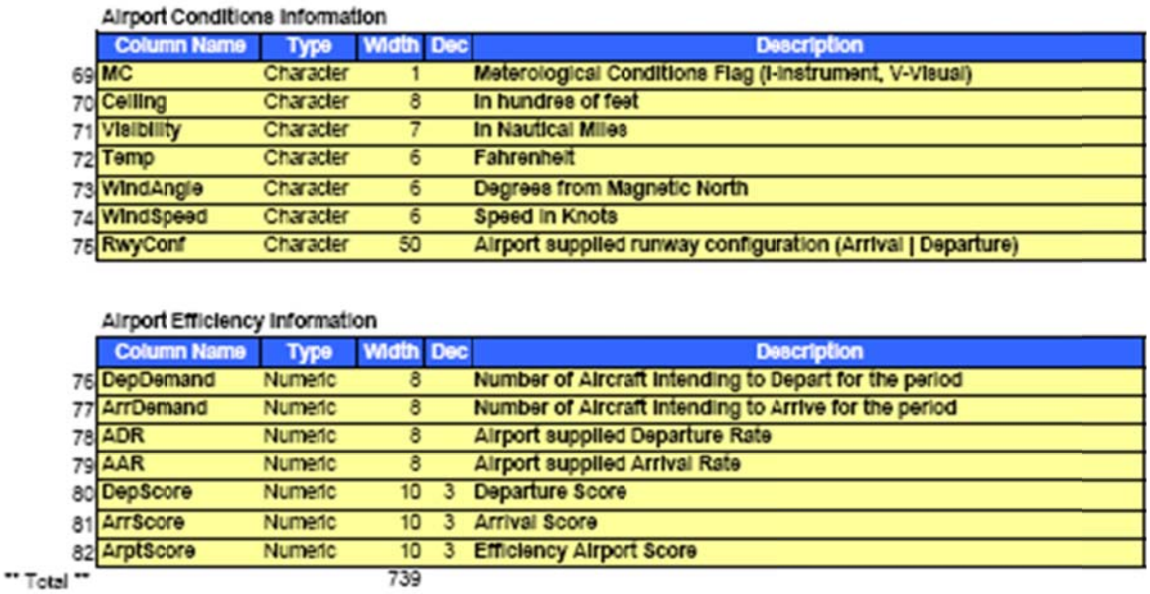
	Column Name	Type	Width	Dec	Description
	Airborne Delay				
55	DlaAirC	Numeric	8		Count of Total Airborne Delays
56	DlaAir	Numeric	10	3	Total Airborne Delay Minutes
57	DlaAirA	Numeric	10	3	Average Airborne Delay Minutes

Taxi-In Information

	Column Name	Type	Width	Dec	Description
57	ActTI	Numeric	10	3	Total Taxi In Minutes
	Taxi-In Delay				
58	DlaTIC	Numeric	8		Count of Total Taxi In Delays
59	DlaTI	Numeric	10	3	Total Taxi In Delay Minutes
60	DlaTIA	Numeric	10	3	Avg Taxi In Delay Minutes

Airport Information

	Column Name	Type	Width	Dec	Description
61	MetricDep	Numeric	8		Count of ASPM Departures
62	MetricArr	Numeric	8		Count of ASPM Arrivals
63	SchDep	Numeric	8		Count of Scheduled Departures
64	SchArr	Numeric	8		Count of Scheduled Arrivals
65	ETMSDep	Numeric	8		Count of ETMS Departures
66	ETMSArr	Numeric	8		Count of ETMS Arrivals
67	FacDep	Numeric	8		Count of Facility Reported Departures ("-1" indicates missing)
68	FacArr	Numeric	8		Count of Facility Reported Arrivals ("-1" indicates missing)



Airport Conditions Information

	Column Name	Type	Width	Dec	Description
69	MC	Character	1		Meterological Conditions Flag (I-Instrument, V-Visual)
70	Ceiling	Character	8		In hundres of feet
71	Visibility	Character	7		In Nautical Miles
72	Temp	Character	6		Fahrenheit
73	WindAngle	Character	6		Degrees from Magnetic North
74	WindSpeed	Character	6		Speed in Knots
75	RwyConf	Character	50		Airport supplied runway configuration (Arrival | Departure)

Airport Efficiency Information

	Column Name	Type	Width	Dec	Description
76	DepDemand	Numeric	8		Number of Aircraft Intending to Depart for the period
77	ArrDemand	Numeric	8		Number of Aircraft Intending to Arrive for the period
78	ADR	Numeric	8		Airport supplied Departure Rate
79	AAR	Numeric	8		Airport supplied Arrival Rate
80	DepScore	Numeric	10	3	Departure Score
81	ArrScore	Numeric	10	3	Arrival Score
82	ArptScore	Numeric	10	3	Efficiency Airport Score
** Total **			739		

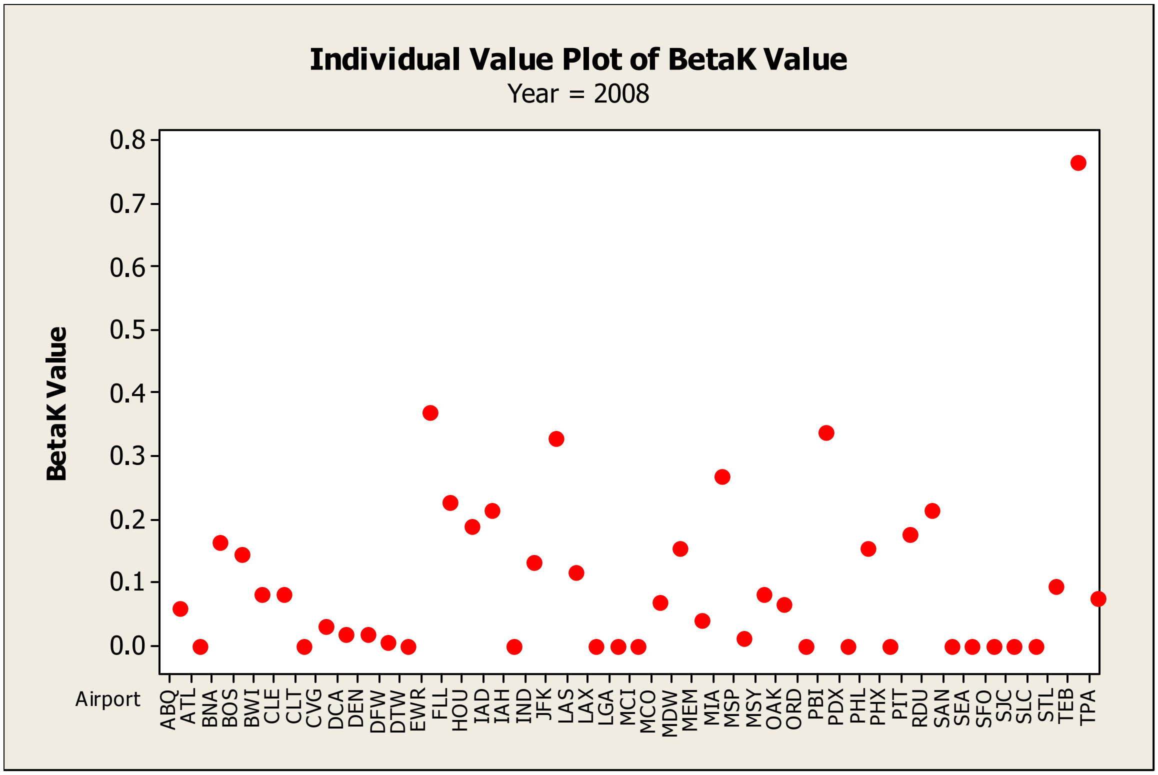
Appendix 4: The Carriers Tracked in ASPM

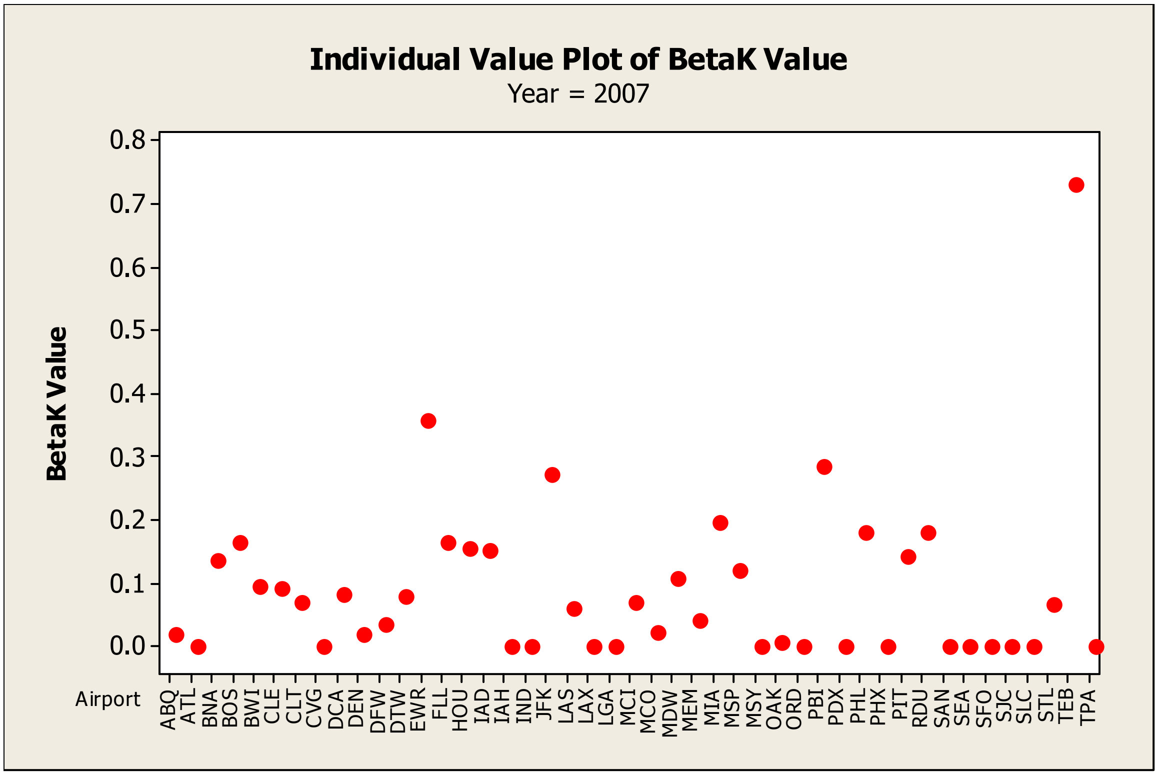
The ASPM Carriers are the carriers that are specifically tracked in ASPM.

1. Air Canada (ACA)
2. Airtran Airways TRS*
3. Alaska Airlines (ASA)*
4. Aloha Airlines (AAH)*
5. American Airlines (AAL)*
6. American Eagle (EGF)*
7. America West (AWE)*
8. ATA Airlines (AMT)*
9. Atlantic Coast (BLR)*
10. Atlantic Southeast Airlines (ASQ)*
11. Atlantic Southeast Airlines (CAA)*
12. Comair (COM)*
13. Continental Airlines (COA)*
14. Delta Air Lines (DAL)*
15. ExpressJet Airlines (BTA)*
16. FedEx (FDX)
17. Frontier Airlines FFT*
18. Hawaiian Airlines HAL*
19. Independence Air IDE*
20. Jetblue Airways JBU*
21. Mesa Airlines (ASH)*
22. Northwest Airlines NWA*
23. Pinnacle Airlines (FLG)
24. Skywest Airlines SKW*
25. Southwest Airlines SWA*
26. TWA (TWA)*
27. United Airlines (UAL)*
28. United Parcel Service (UPS)
29. US Airways (USA)*

Note: Although some of these carriers may no longer be in operation, ASPM has tracked operations for them since January 2000.

Appendix 5: The Directional Output Distance Model Data

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BetaK Value
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0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
Airport
ABQ
ATL
BNA
BOS
BWI
CLE
CLT
CVG
DCA
DEN
DFW
DTW
EWR
FLL
HOU
IAD
IAH
IND
JFK
LAS
LAX
LGA
MCI
MCO
MDW
MEM
MIA
MSP
MSY
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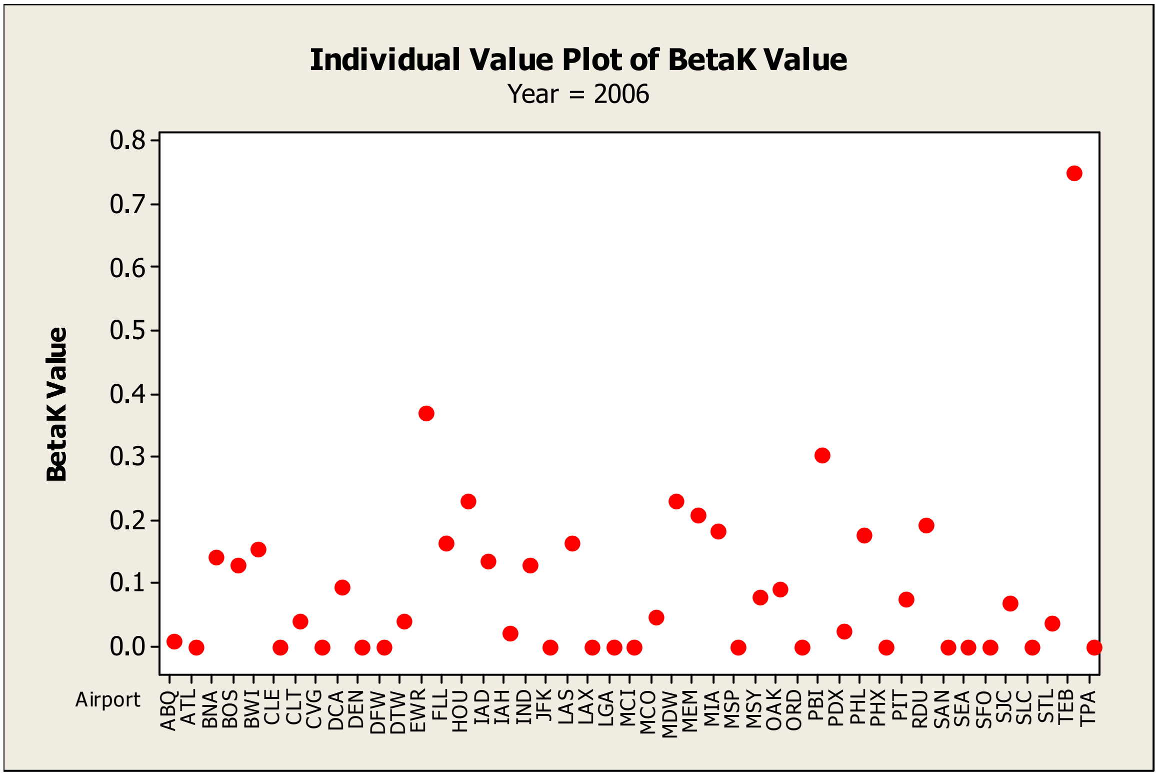
RDU
SAN
SEA
SFO
SJC
SLC
STL
TEB
TPA


Individual Value Plot of BetaK Value
Year = 2006
BetaK Value
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
Airport
ABQ
ATL
BNA
BOS
BWI
CLE
CLT
CVG
DCA
DEN
DFW
DTW
EWR
FLL
HOU
IAD
IAH
IND
JFK
LAS
LAX
LGA
MCI
MCO
MDW
MEM
MIA
MSP
MSY
OAK
ORD
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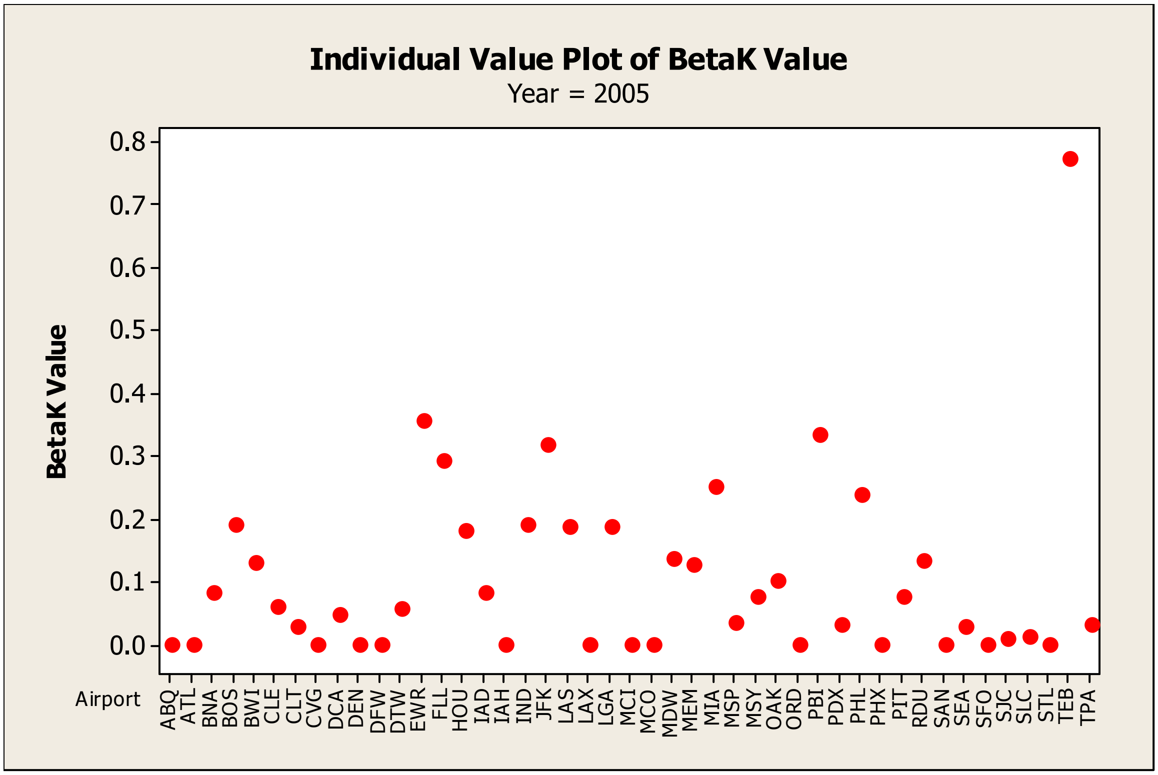
SEA
SFO
SJC
SLC
STL
TEB
TPA


Individual Value Plot of BetaK Value
Year = 2005
BetaK Value
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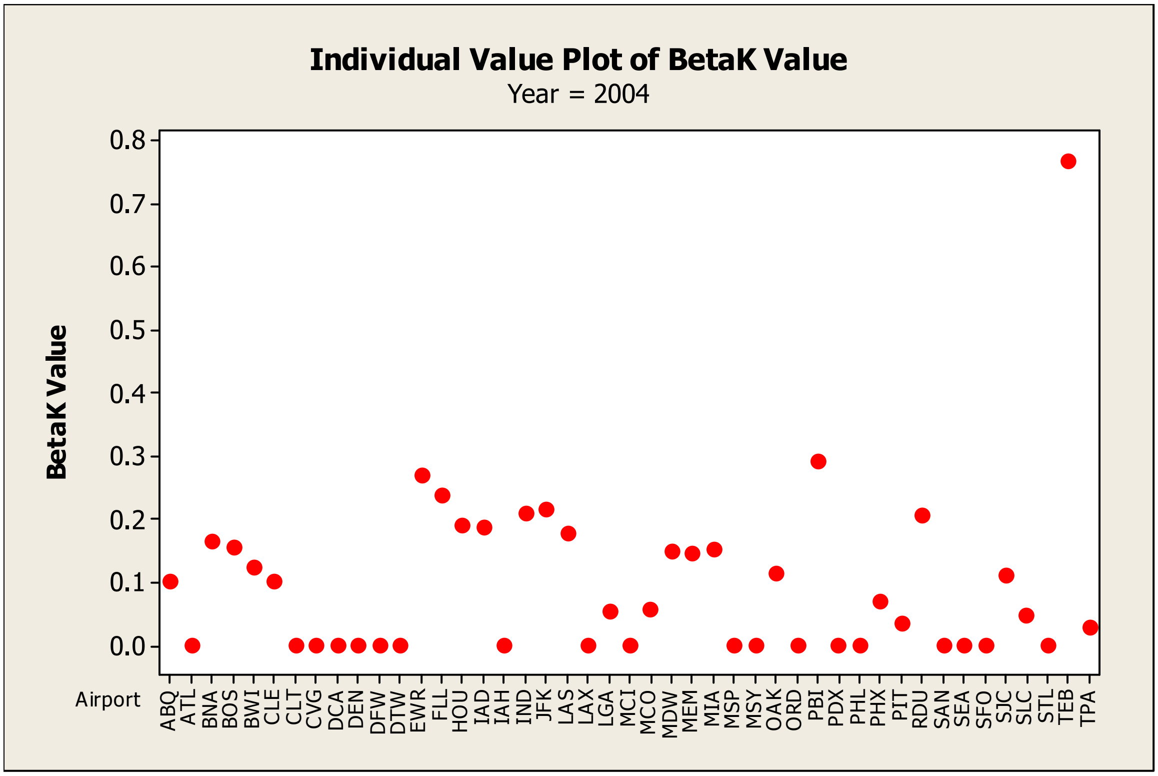
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
Airport
ABQ
ATL
BNA
BOS
BWI
CLE
CLT
CVG
DCA
DEN
DFW
DTW
EWR
FLL
HOU
IAD
IAH
IND
JFK
LAS
LAX
LGA
MCI
MCO
MDW
MEM
MIA
MSP
MSY
OAK
ORD
PBI
PDX
PHL
PHX
PIT
RDU
SAN
SEA
SFO
SJC
SLC
STL
TEB
TPA


Individual Value Plot of BetaK Value
Year = 2004
BetaK Value
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
Airport
ABQ
ATL
BNA
BOS
BWI
CLE
CLT
CVG
DCA
DEN
DFW
DTW
EWR
FLL
HOU
IAD
IAH
IND
JFK
LAS
LAX
LGA
MCI
MCO
MDW
MEM
MIA
MSP
MSY
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STL
TEB
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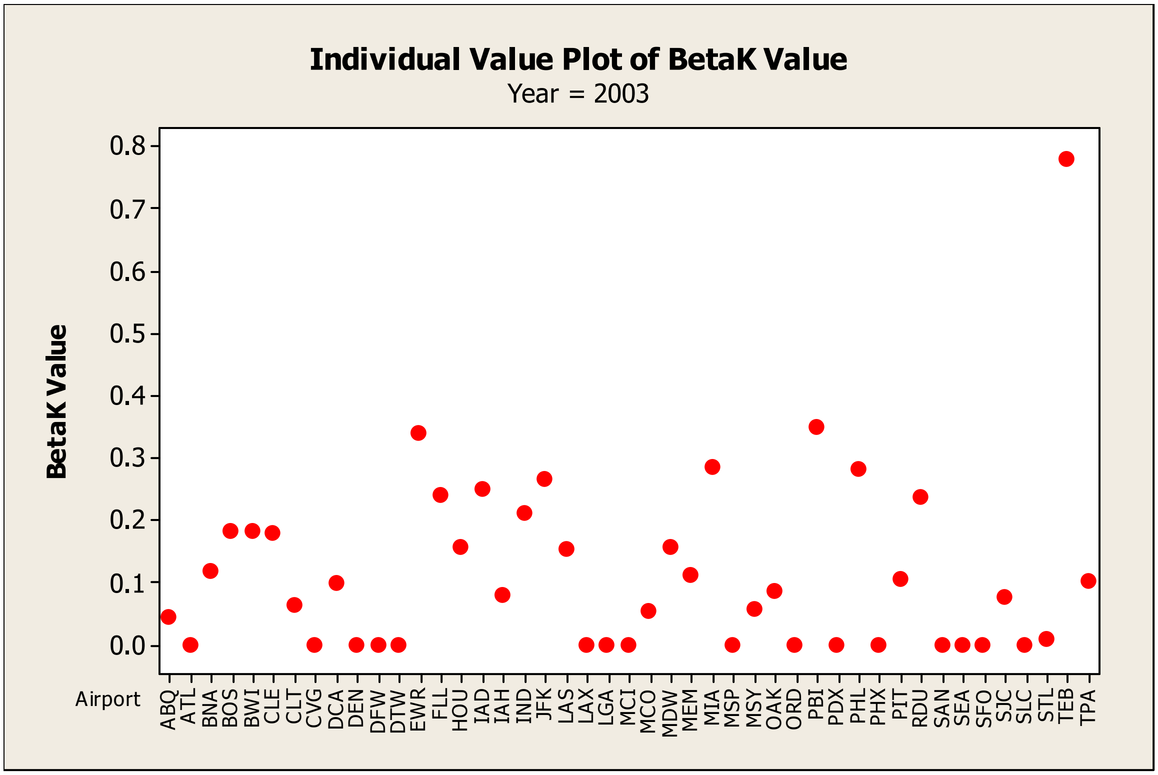
Individual Value Plot of BetaK Value
Year = 2003
BetaK Value
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
Airport
ABQ
ATL
BNA
BOS
BWI
CLE
CLT
CVG
DCA
DEN
DFW
DTW
EWR
FLL
HOU
IAD
IAH
IND
JFK
LAS
LAX
LGA
MCI
MCO
MDW
MEM
MIA
MSP
MSY
OAK
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RDU
SAN
SEA
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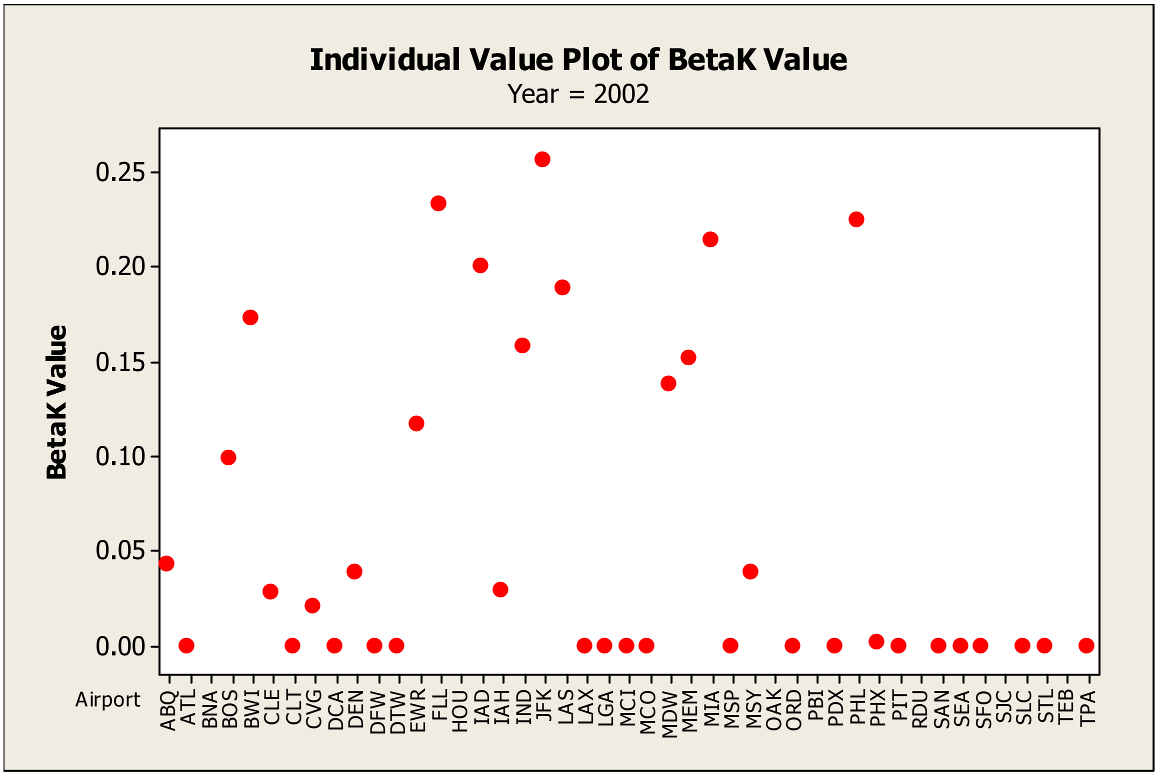
SJC
SLC
STL
TEB
TPA


Individual Value Plot of BetaK Value
Year = 2002
BetaK Value
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0.20
0.15
0.10
0.05
0.00
Airport
ABQ
ATL
BNA
BOS
BWI
CLE
CLT
CVG
DCA
DEN
DFW
DTW
EWR
FLL
HOU
IAD
IAH
IND
JFK
LAS
LAX
LGA
MCI
MCO
MDW
MEM
MIA
MSP
MSY
OAK
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PBI
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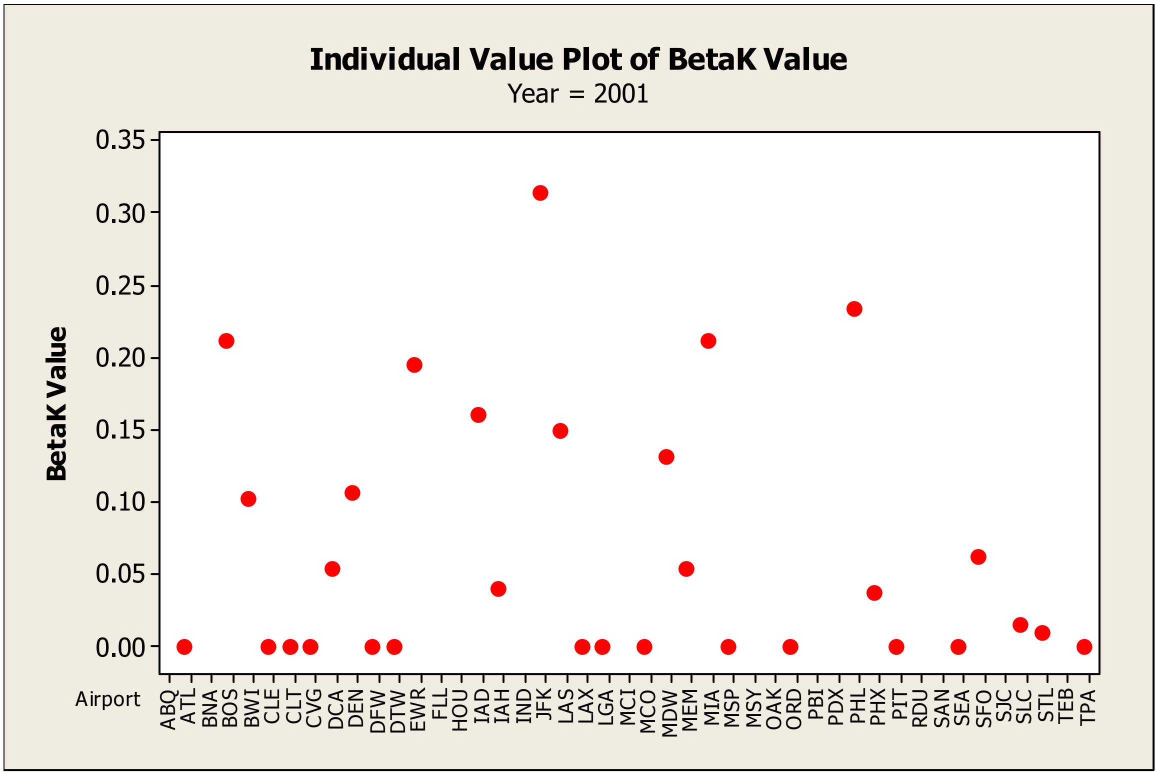
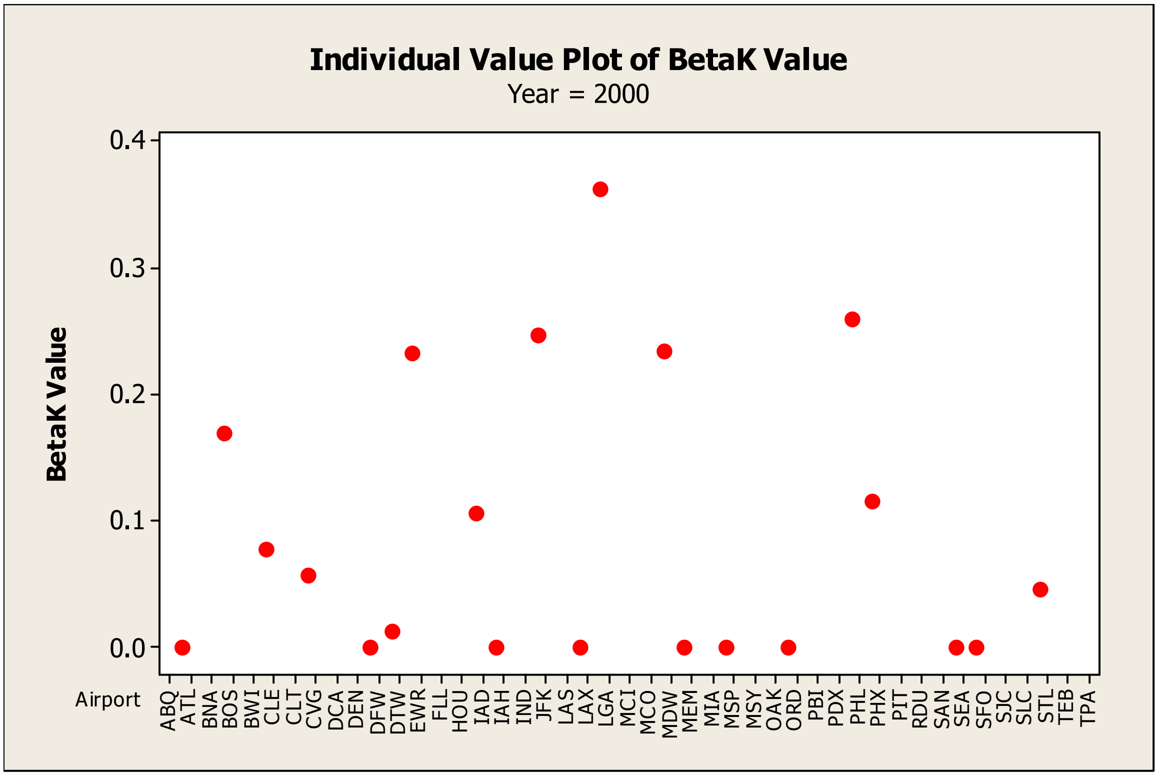
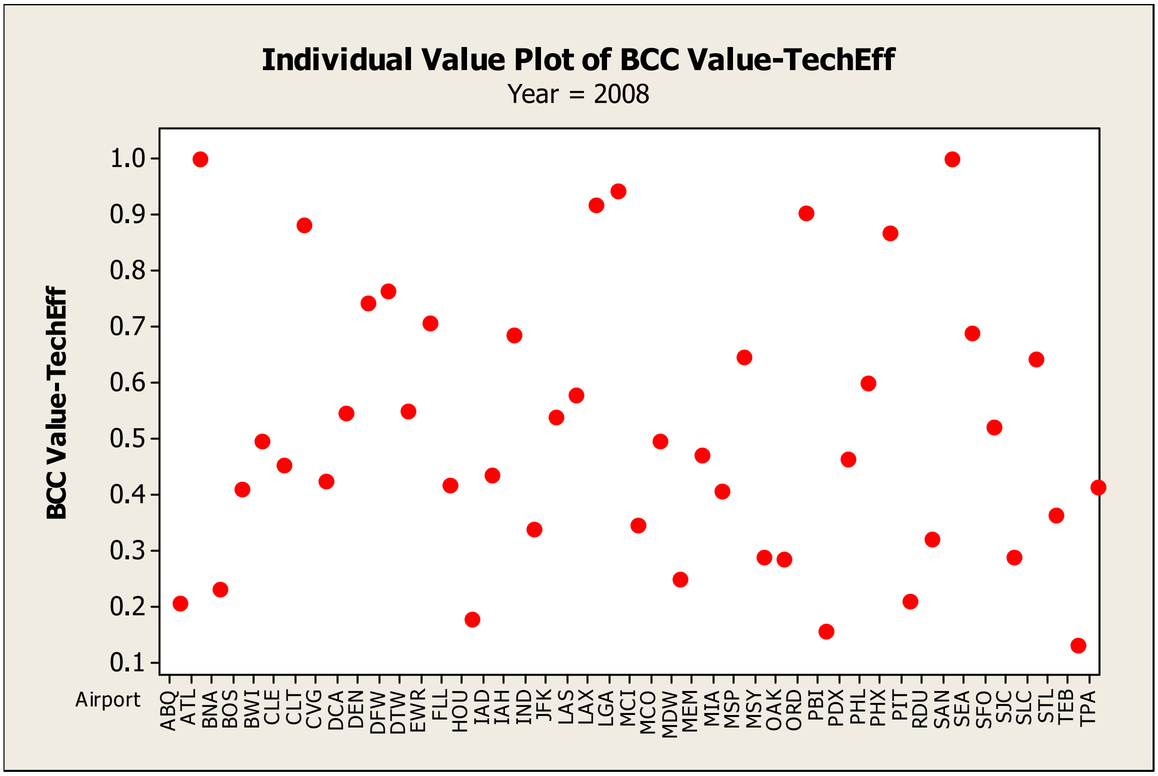
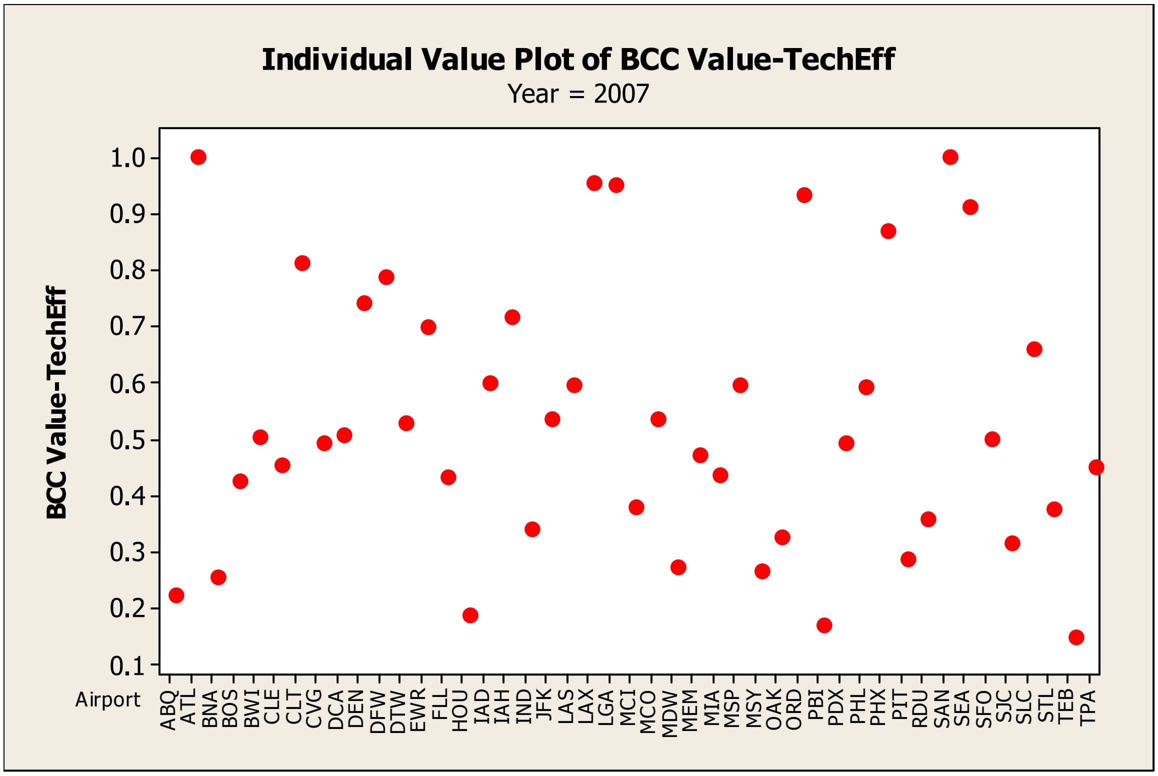
PHX
PIT
RDU
SAN
SEA
SFO
SJC
SLC
STL
TEB
TPA

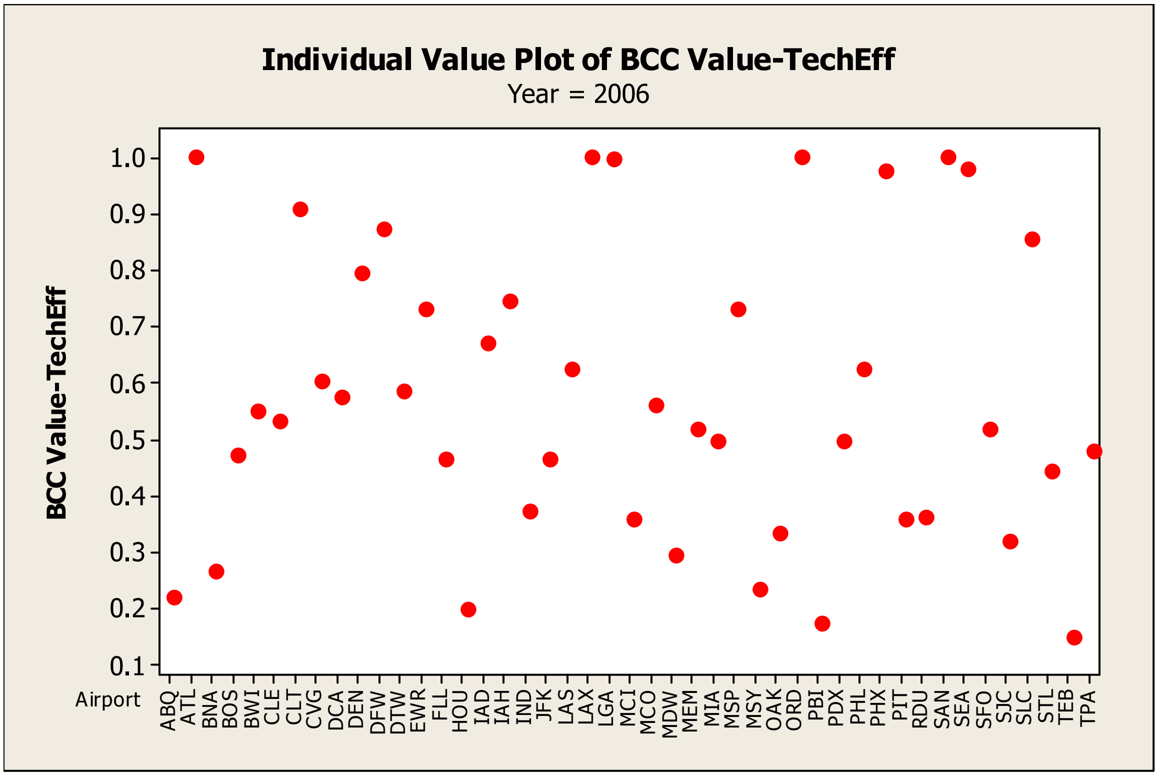

Individual Value Plot of BetaK Value
Year = 2001
BetaK Value
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
Airport
ABQ ATL BNA BOS BWI CLE CLT CVG DCA DEN DFW DTW EWR FLL HOU IAD IAH IND JFK LAS LAX LGA MCI MCO MDW MEM MIA MSP MSY OAK ORD PBI PDX PHL PHX PIT RDU SAN SEA SFO SJC SLC STL TEB TPA


Individual Value Plot of BetaK Value
Year = 2000
BetaK Value
0.4
0.3
0.2
0.1
0.0
Airport
ABQ ATL BNA BOS BWI CLE CLT CVG DCA DEN DFW DTW EWR FLL HOU IAD IAH IND JFK LAS LAX LGA MCI MCO MDW MEM MIA MSP MSY OAK ORD PBI PDX PHL PHX PIT RDU SAN SEA SFO SJC SLC STL TEB TPA

Appendix 6: The BCC Model Data






Individual Value Plot of BCC Value-TechEff
Year = 2006
BCC Value-TechEff
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
Airport
ABQ
ATL
BNA
BOS
BWI
CLE
CLT
CVG
DCA
DEN
DFW
DTW
EWR
FLL
HOU
IAD
IAH
IND
JFK
LAS
LAX
LGA
MCI
MCO
MDW
MEM
MIA
MSP
MSY
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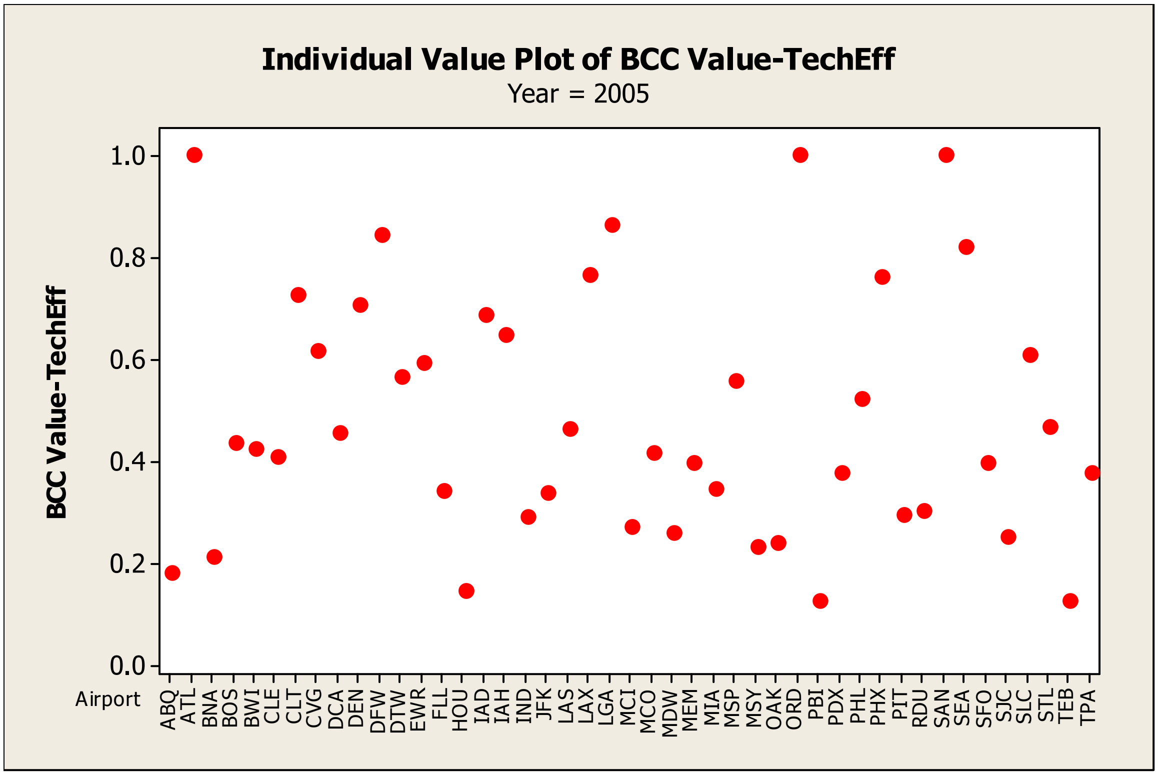
RDU
SAN
SEA
SFO
SJC
SLC
STL
TEB
TPA


Individual Value Plot of BCC Value-TechEff
Year = 2005
BCC Value-TechEff
1.0
0.8
0.6
0.4
0.2
0.0
Airport
ABQ
ATL
BNA
BOS
BWI
CLE
CLT
CVG
DCA
DEN
DFW
DTW
EWR
FLL
HOU
IAD
IAH
IND
JFK
LAS
LAX
LGA
MCI
MCO
MDW
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MIA
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MSY
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STL
TEB
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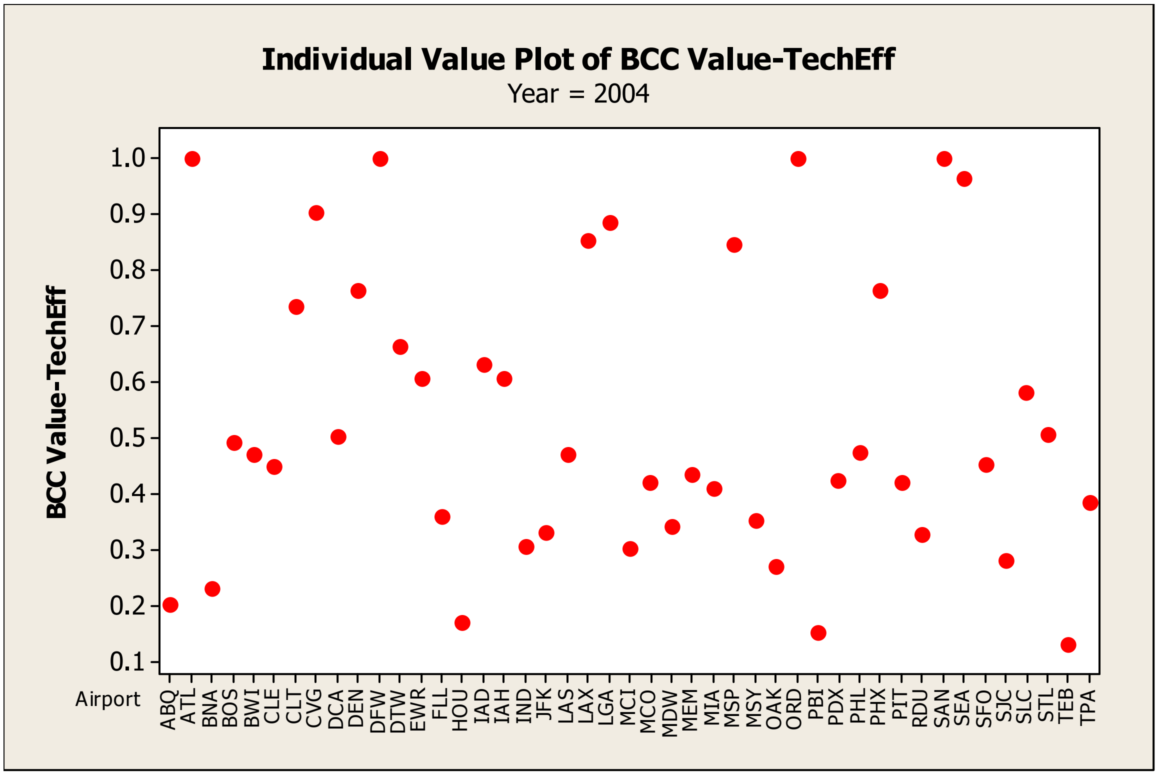
Individual Value Plot of BCC Value-TechEff
Year = 2004
BCC Value-TechEff
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
Airport
ABQ
ATL
BNA
BOS
BWI
CLE
CLT
CVG
DCA
DEN
DFW
DTW
EWR
FLL
HOU
IAD
IAH
IND
JFK
LAS
LAX
LGA
MCI
MCO
MDW
MEM
MIA
MSP
MSY
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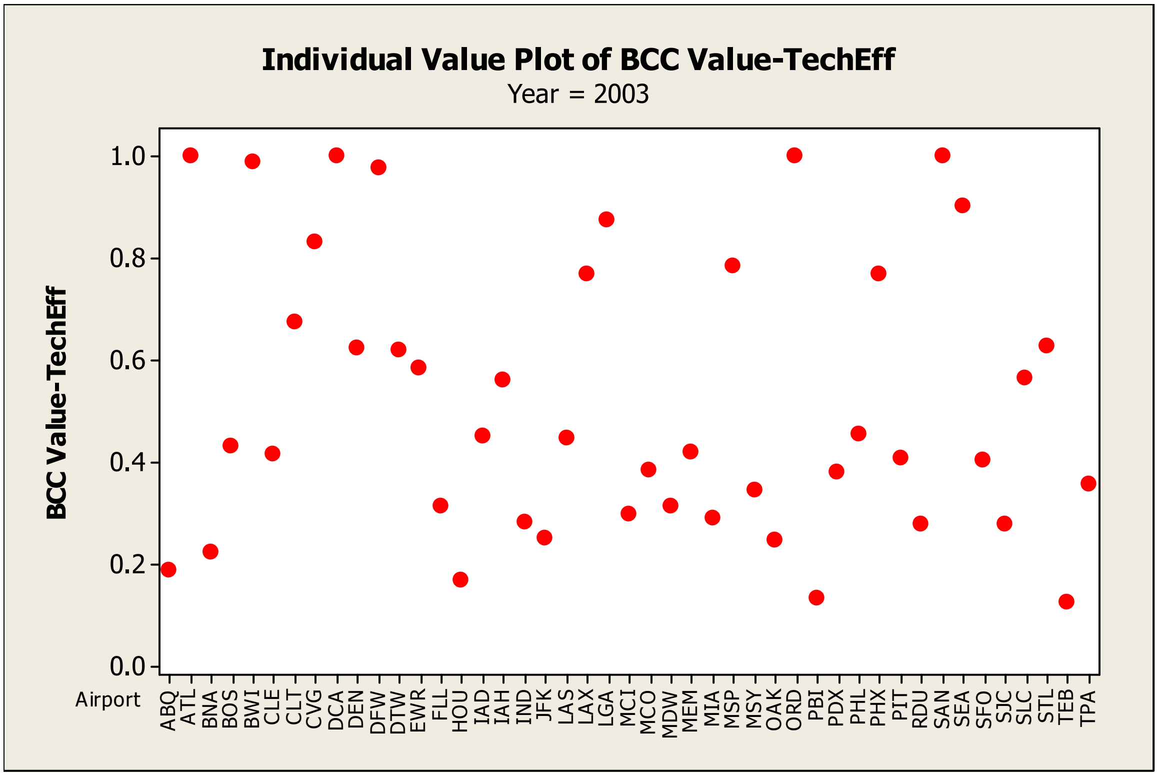
TPA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Year = 2003
BCC Value-TechEff
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0.6
0.4
0.2
0.0
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ABQ
ATL
BNA
BOS
BWI
CLE
CLT
CVG
DCA
DEN
DFW
DTW
EWR
FLL
HOU
IAD
IAH
IND
JFK
LAS
LAX
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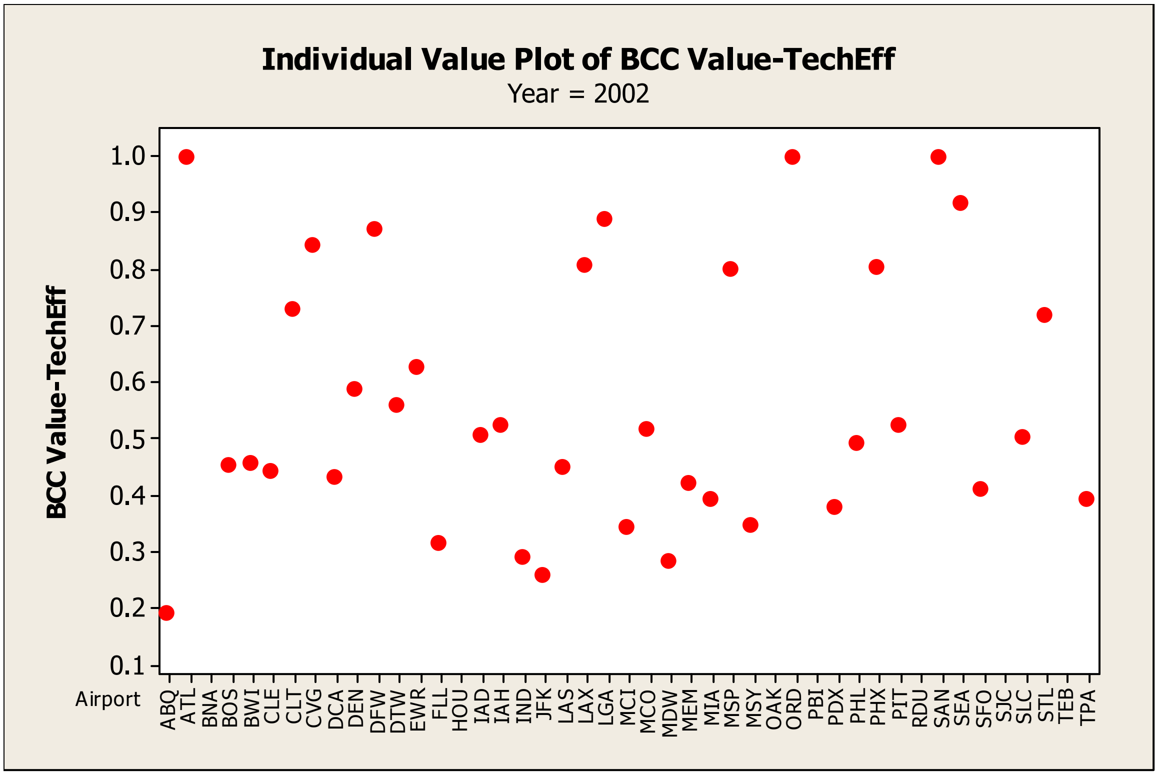
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Year = 2002
BCC Value-TechEff
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0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
Airport
ABQ
ATL
BNA
BOS
BWI
CLE
CLT
CVG
DCA
DEN
DFW
DTW
EWR
FLL
HOU
IAD
IAH
IND
JFK
LAS
LAX
LGA
MCI
MCO
MDW
MEM
MIA
MSP
MSY
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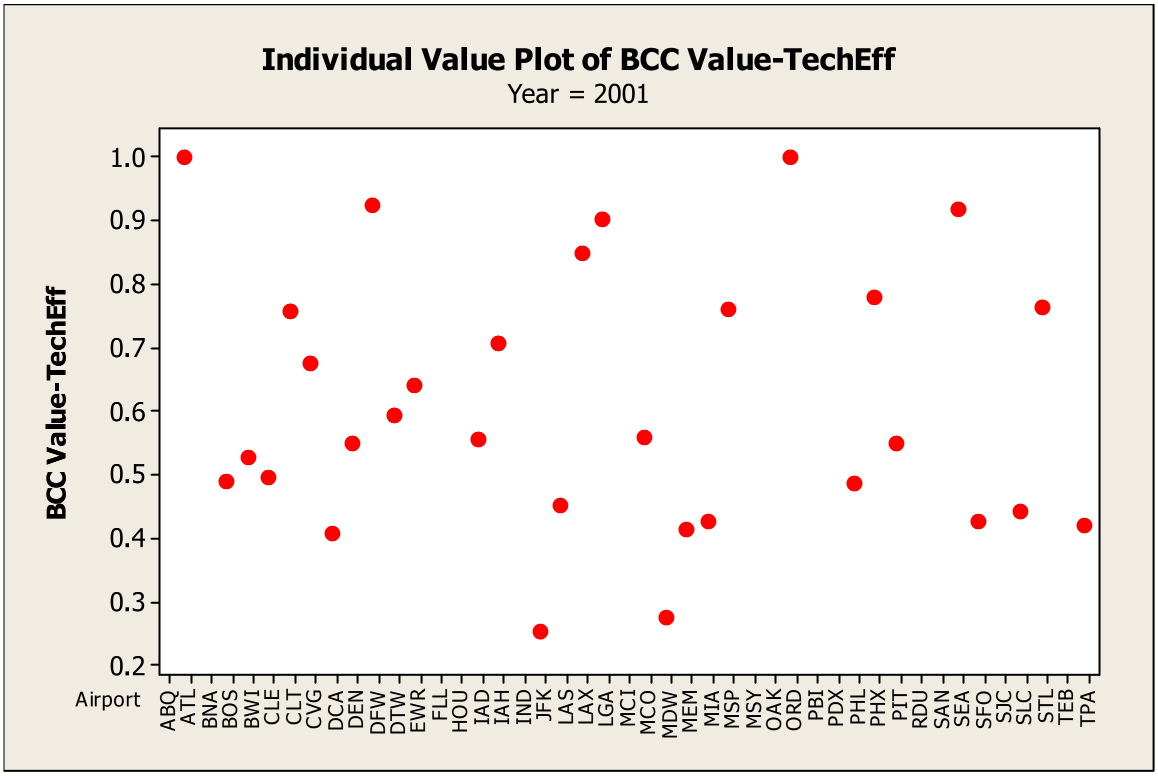
TEB
TPA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Year = 2001
BCC Value-TechEff
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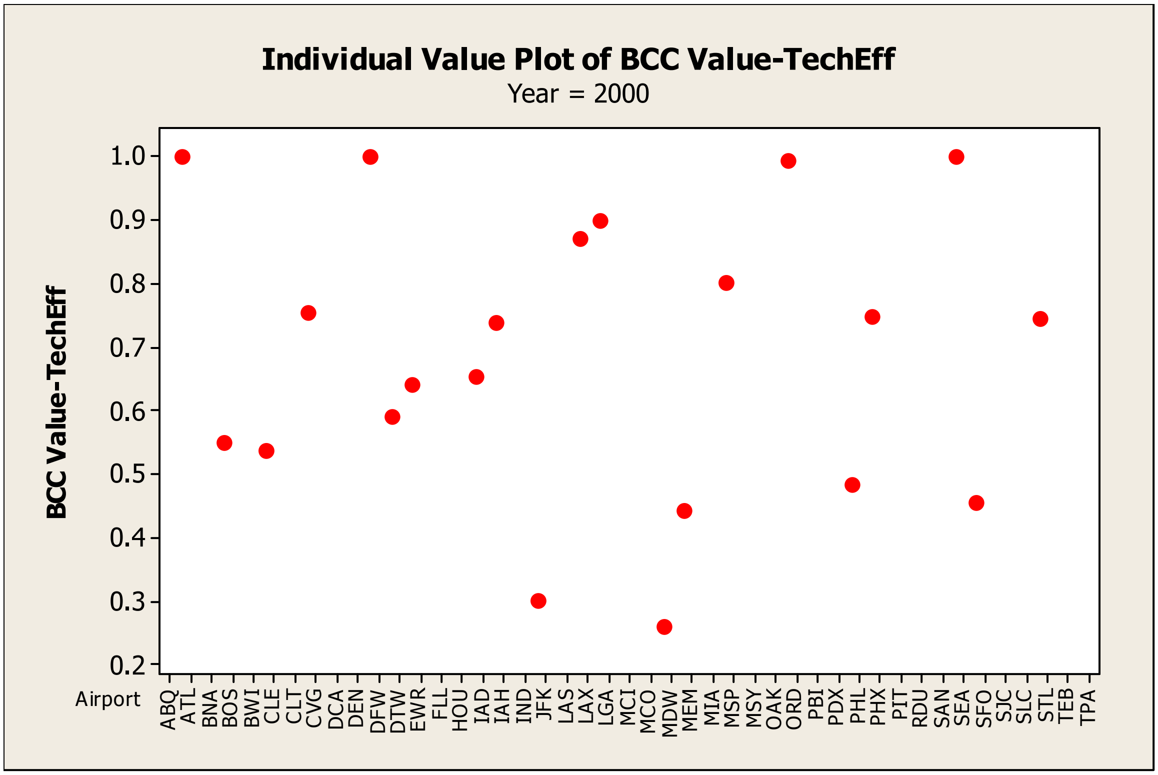
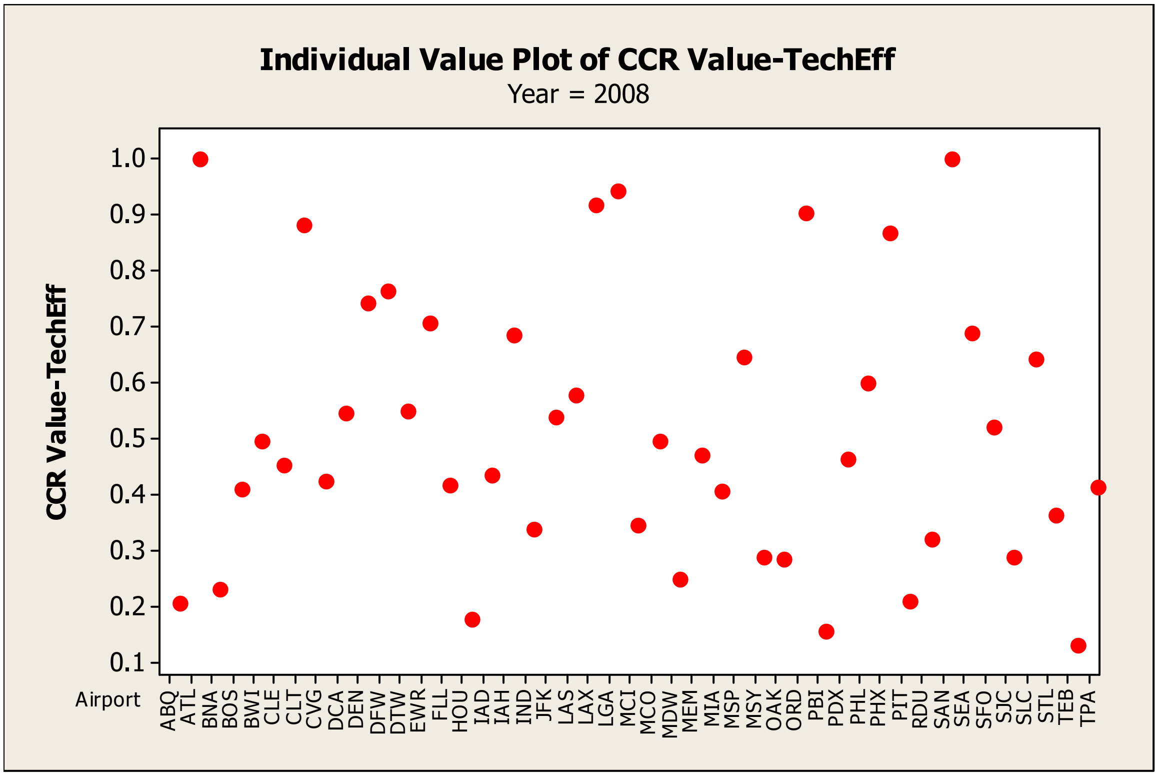
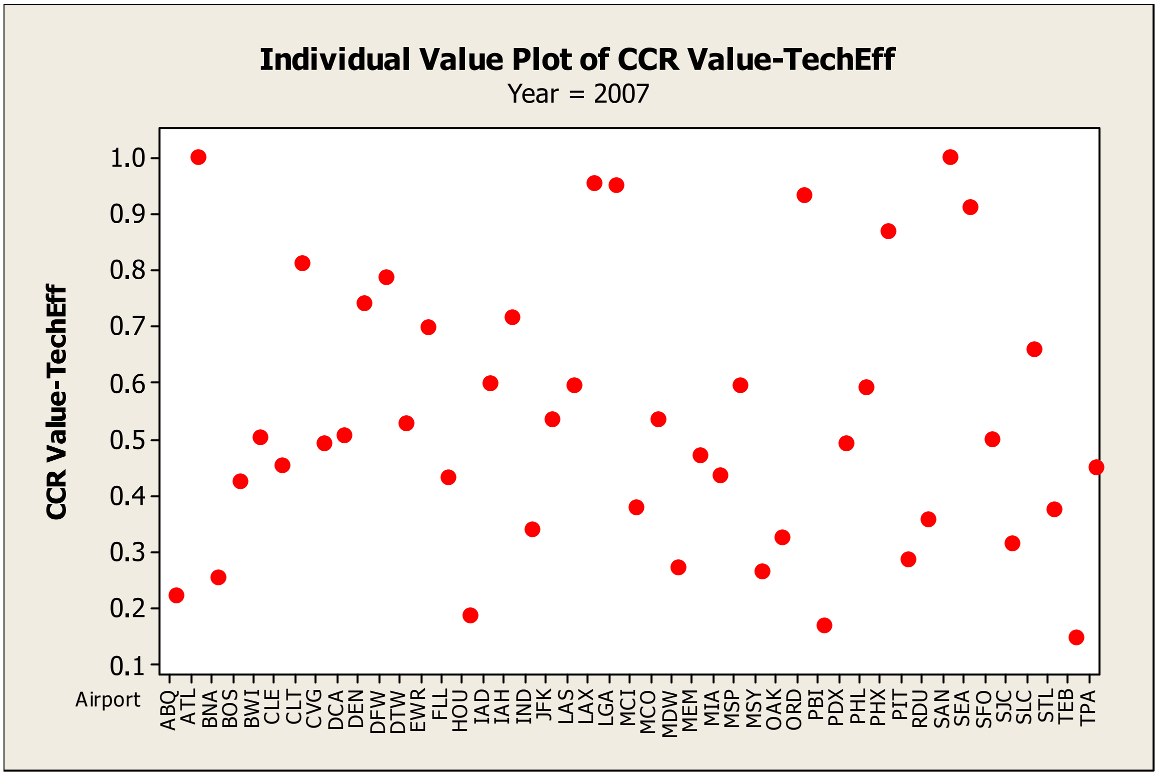
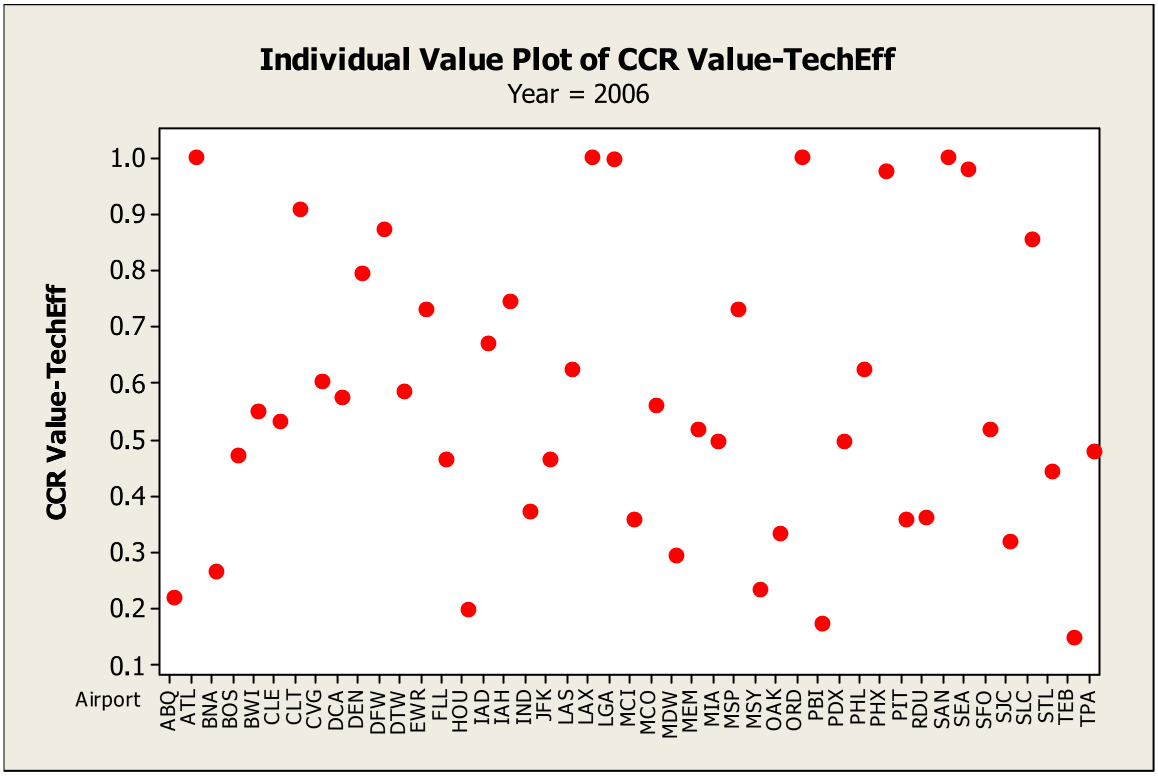
0.8
0.7
0.6
0.5
0.4
0.3
0.2
Airport
ABQ
ATL
BNA
BOS
BWI
CLE
CLT
CVG
DCA
DEN
DFW
DTW
EWR
FLL
HOU
IAD
IAH
IND
JFK
LAS
LAX
LGA
MCI
MCO
MDW
MEM
MIA
MSP
MSY
OAK
ORD
PBI
PDX
PHL
PHX
PIT
RDU
SAN
SEA
SFO
SJC
SLC
STL
TEB
TPA


Individual Value Plot of BCC Value-TechEff
Year = 2000
BCC Value-TechEff
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
Airport
ABQ
ATL
BNA
BOS
BWI
CLE
CLT
CVG
DCA
DEN
DFW
DTW
EWR
FLL
HOU
IAD
IAH
IND
JFK
LAS
LAX
LGA
MCI
MCO
MDW
MEM
MIA
MSP
MSY
OAK
ORD
PBI
PDX
PHL
PHX
PIT
RDU
SAN
SEA
SFO
SJC
SLC
STL
TEB
TPA

Appendix 7: The CCR Model Data






Individual Value Plot of CCR Value-TechEff
Year = 2006
CCR Value-TechEff
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0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
Airport
ABQ
ATL
BNA
BOS
BWI
CLE
CLT
CVG
DCA
DEN
DFW
DTW
EWR
FLL
HOU
IAD
IAH
IND
JFK
LAS
LAX
LGA
MCI
MCO
MDW
MEM
MIA
MSP
MSY
OAK
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PHX
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RDU
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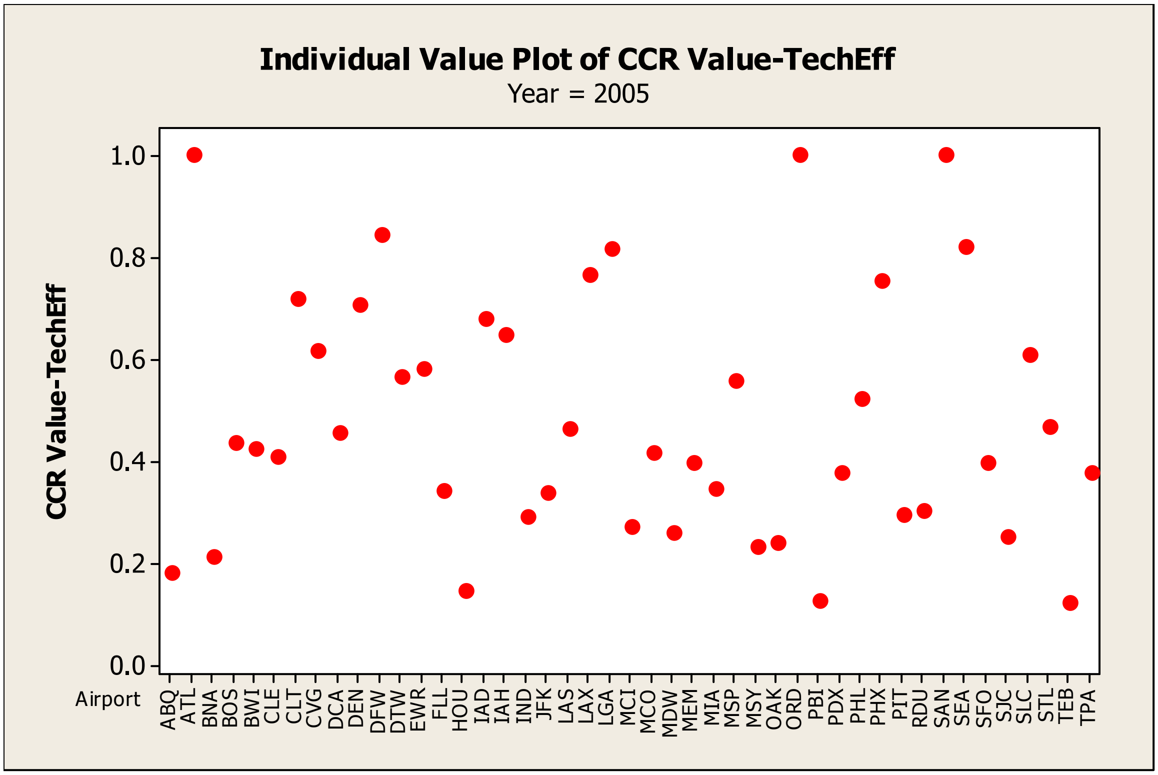
SFO
SJC
SLC
STL
TEB
TPA


Individual Value Plot of CCR Value-TechEff
Year = 2005
CCR Value-TechEff
1.0
0.8
0.6
0.4
0.2
0.0
Airport
ABQ
ATL
BNA
BOS
BWI
CLE
CLT
CVG
DCA
DEN
DFW
DTW
EWR
FLL
HOU
IAD
IAH
IND
JFK
LAS
LAX
LGA
MCI
MCO
MDW
MEM
MIA
MSP
MSY
OAK
ORD
PBI
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PHX
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SAN
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SFO
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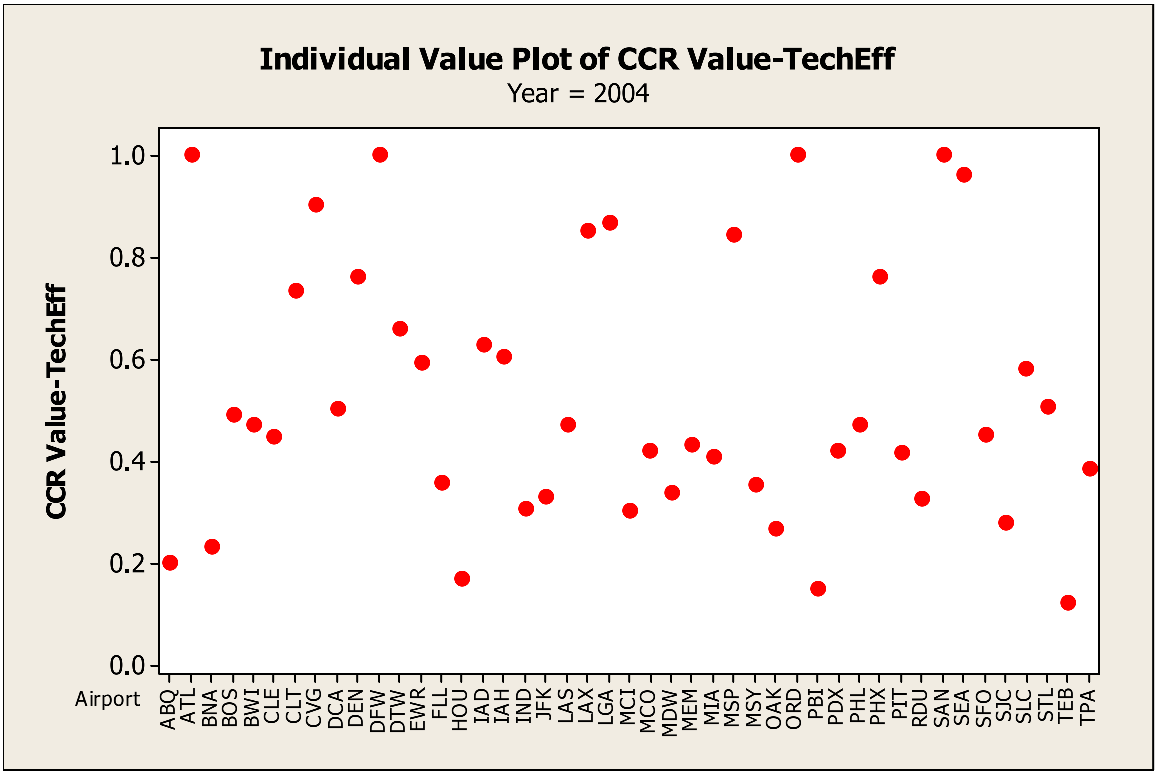
STL
TEB
TPA


Individual Value Plot of CCR Value-TechEff
Year = 2004
CCR Value-TechEff
1.0
0.8
0.6
0.4
0.2
0.0
Airport
ABQ
ATL
BNA
BOS
BWI
CLE
CLT
CVG
DCA
DEN
DFW
DTW
EWR
FLL
HOU
IAD
IAH
IND
JFK
LAS
LAX
LGA
MCI
MCO
MDW
MEM
MIA
MSP
MSY
OAK
ORD
PBI
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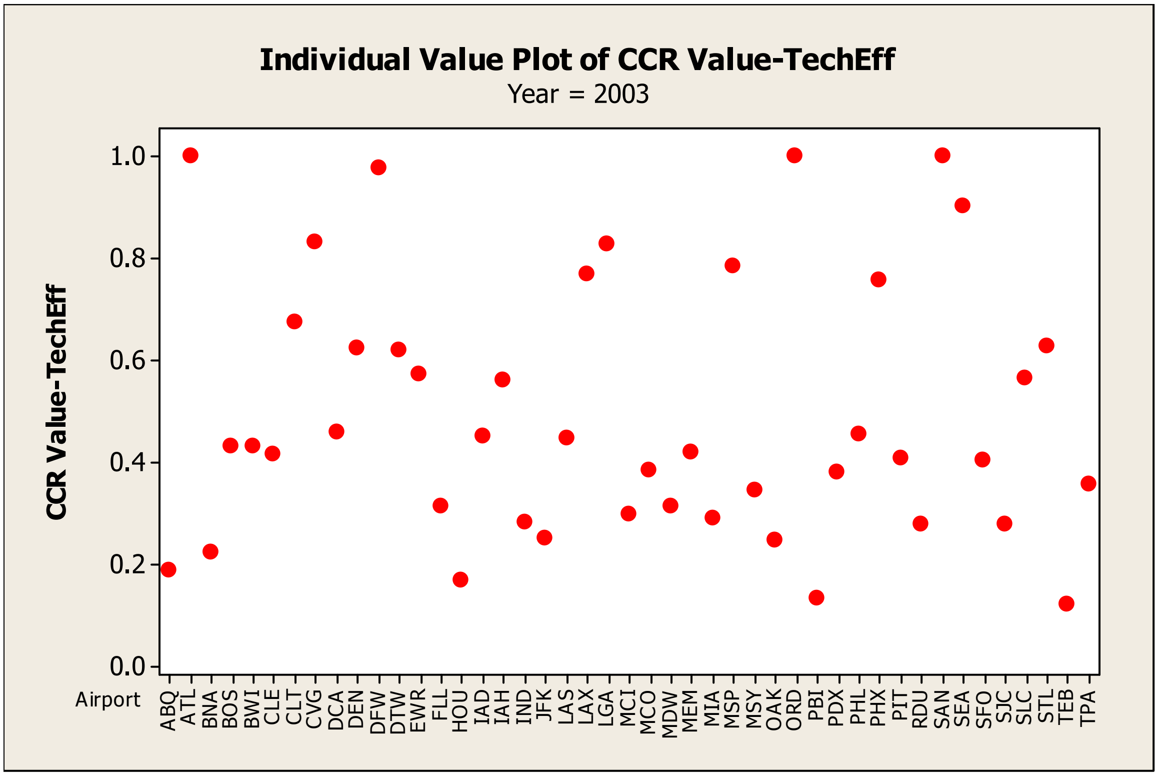
PHX
PIT
RDU
SAN
SEA
SFO
SJC
SLC
STL
TEB
TPA


Individual Value Plot of CCR Value-TechEff
Year = 2003
CCR Value-TechEff
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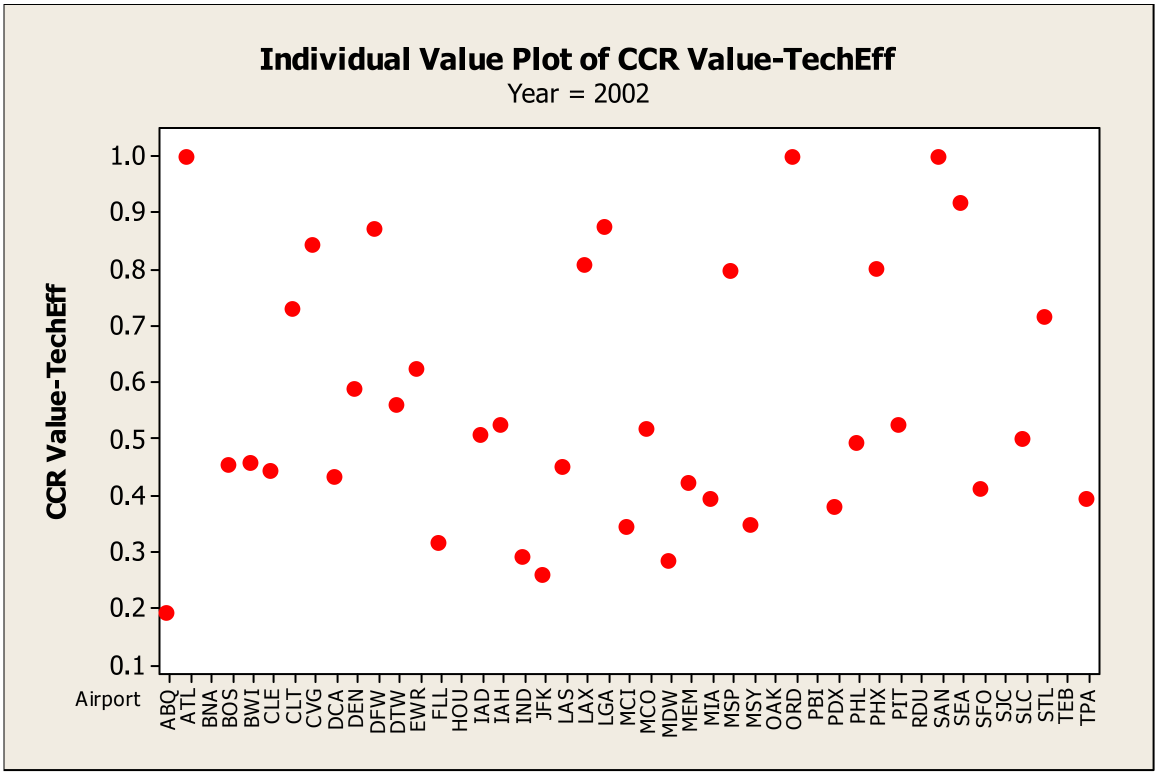
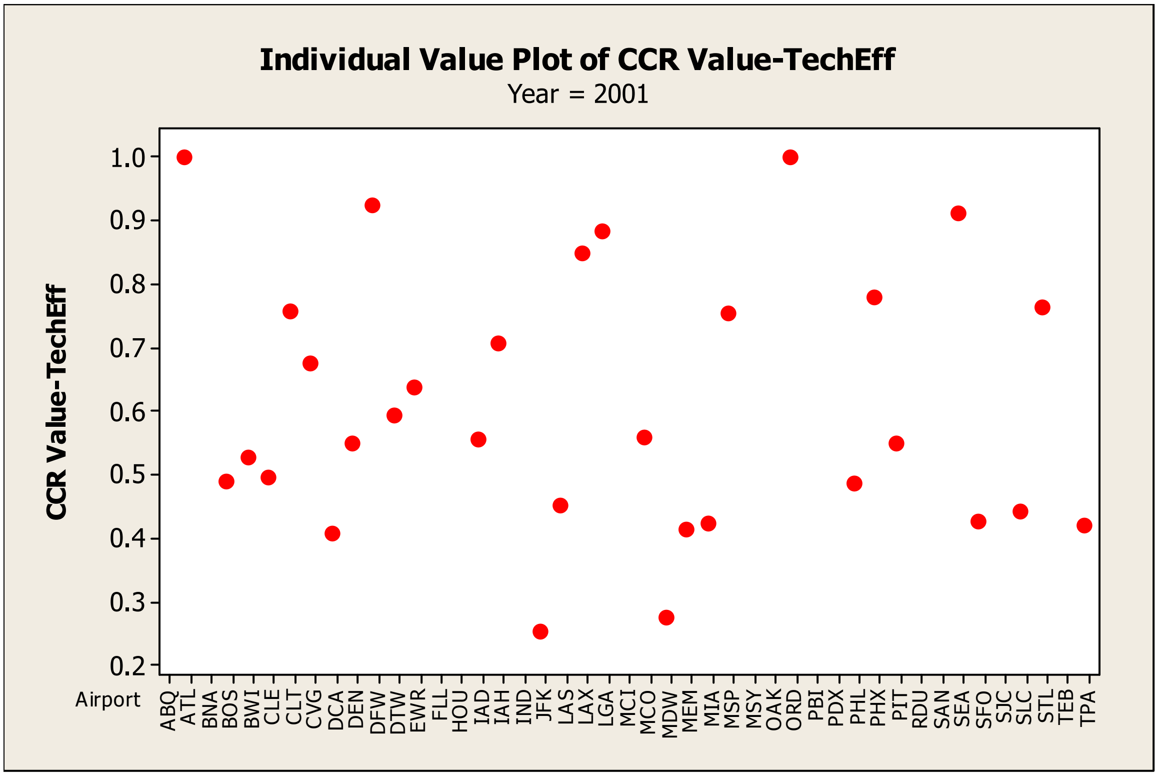
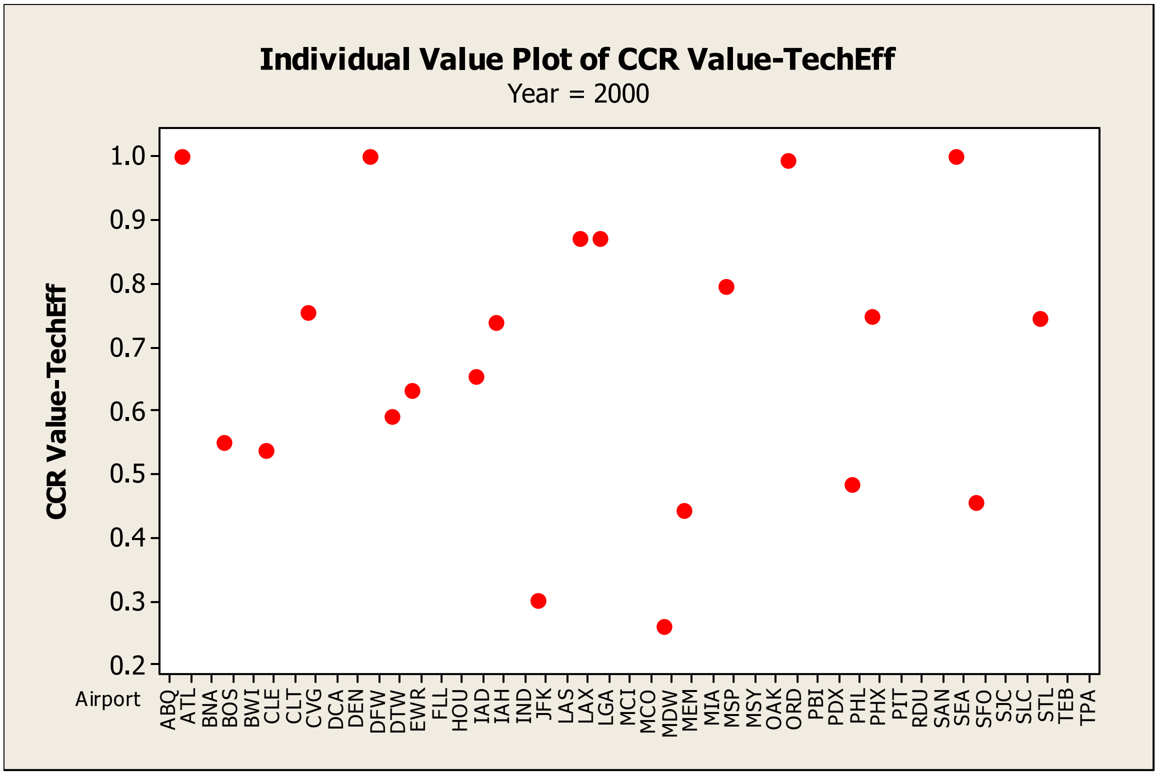
0.8
0.6
0.4
0.2
0.0
Airport
ABQ
ATL
BNA
BOS
BWI
CLE
CLT
CVG
DCA
DEN
DFW
DTW
EWR
FLL
HOU
IAD
IAH
IND
JFK
LAS
LAX
LGA
MCI
MCO
MDW
MEM
MIA
MSP
MSY
OAK
ORD
PBI
PDX
PHL
PHX
PIT
RDU
SAN
SEA
SFO
SJC
SLC
STL
TEB
TPA


Individual Value Plot of CCR Value-TechEff
Year = 2002
CCR Value-TechEff
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
Airport
ABQ ATL BNA BOS BWI CLE CLT CVG DCA DEN DFW DTW EWR FLL HOU IAD IAH IND JFK LAS LAX LGA MCI MCO MDW MEM MIA MSP MSY OAK ORD PBI PDX PHL PHX PIT RDU SAN SEA SFO SJC SLC STL TEB TPA


Individual Value Plot of CCR Value-TechEff
Year = 2001
CCR Value-TechEff
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
Airport
ABQ ATL BNA BOS BWI CLE CLT CVG DCA DEN DFW DTW EWR FLL HOU IAD IAH IND JFK LAS LAX LGA MCI MCO MDW MEM MIA MSP MSY OAK ORD PBI PDX PHL PHX PIT RDU SAN SEA SFO SJC SLC STL TEB TPA


Individual Value Plot of CCR Value-TechEff
Year = 2000
CCR Value-TechEff
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
Airport
ABQ
ATL
BNA
BOS
BWI
CLE
CLT
CVG
DCA
DEN
DFW
DTW
EWR
FLL
HOU
IAD
IAH
IND
JFK
LAS
LAX
LGA
MCI
MCO
MDW
MEM
MIA
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TPA

Appendix 8: The Sorted Configuration Candidate Data

BetaK Value	BCC Value-TechEff	CCR Value-TechEff	Scale Efficiency	Configuration	LOCID	Visibility
0.84117	0.24015	0.10625	0.44242	TEB--Arr_24 _Dep_ 24--V	TEB	V
0.83847	0.10395	0.05178	0.49811	TEB--Arr_6 _Dep_ 1--I	TEB	I
0.83414	0.36445	0.35919	0.98559	SFO--Arr_19L_ 19R _Dep_ 10L_ 10R--I	SFO	I
0.83369	0.22639	0.10125	0.44723	TEB--Arr_1 _Dep_ 1--V	TEB	V
0.83305	0.21933	0.09148	0.41710	TEB--Arr_1 _Dep_ 1--I	TEB	I
0.83044	0.09824	0.04892	0.49797	TEB--Arr_19 _Dep_ 24--I	TEB	I
0.82101	0.18446	0.07725	0.41879	TEB--Arr_19 _Dep_ 19--I	TEB	I
0.80855	0.23882	0.10693	0.44773	TEB--Arr_19 _Dep_ 19--V	TEB	V
0.80320	0.11668	0.08006	0.68611	TEB--Arr_6 _Dep_ 1--V	TEB	V
0.79724	0.13226	0.13217	0.99928	TEB--Arr_19 _Dep_ 24--V	TEB	V
0.78922	0.27612	0.10860	0.39332	TEB--Arr_24 _Dep_ 24--I	TEB	I
0.78442	0.67641	0.62877	0.92957	JFK--Arr_22L_ 22R _Dep_ 22R--I	JFK	I
0.77819	0.78128	0.38701	0.49535	LGA--Arr_4 _Dep_ 13--I	LGA	I
0.76141	0.45161	0.40982	0.90745	PHX--Arr_25L_ 26 _Dep_ 25R--I	PHX	I
0.75447	0.72348	0.33490	0.46289	JFK--Arr_4R _Dep_ 4L--I	JFK	I
0.75338	0.84405	0.39226	0.46473	JFK--Arr_4R _Dep_ 4L_ 31L--I	JFK	I
0.74612	0.20238	0.20238	1.00000	DEN--Arr_26_ 35L_ 35R _Dep_ 25_ 34L_ 34R--I	DEN	I
0.74424	0.60487	0.60239	0.99590	IAH--Arr_26L_ 26R_ 27 _Dep_ 33L_ 33R--I	IAH	I
0.73366	0.75130	0.37430	0.49820	EWR--Arr_4R _Dep_ 4L--I	EWR	I
0.73255	0.60145	0.59785	0.99403	ORD--Arr_27L_ 28 _Dep_ 22L_ 32L_ 32R--V	ORD	V
0.72962	0.83397	0.39018	0.46786	PHL--Arr_9R _Dep_ 8_ 9L--I	PHL	I
0.72069	0.83601	0.39808	0.47616	LGA--Arr_22 _Dep_ 13--I	LGA	I
0.71986	1.00000	0.38660	0.38660	JFK--Arr_22L _Dep_ 22R_ 31L--I	JFK	I
0.71659	0.77546	0.36456	0.47012	JFK--Arr_22L _Dep_ 22R--I	JFK	I
0.69999	1.00000	0.34092	0.34092	JFK--Arr_13L _Dep_ 13R--I	JFK	I
0.69973	0.81066	0.39854	0.49162	EWR--Arr_22L _Dep_ 22R--I	EWR	I
0.69849	0.06715	0.06293	0.93703	CLE--Arr_6L_ 10 _Dep_ 6L_ 6R--I	CLE	I
0.69577	1.00000	0.41611	0.41611	LGA--Arr_31 _Dep_ 4--I	LGA	I
0.69553	0.44476	0.38683	0.86975	PHX--Arr_7R_ 8 _Dep_ 7L--I	PHX	I
0.66217	0.33509	0.32789	0.97851	LAS--Arr_19R_ 25L _Dep_ 19L_ 25R--I	LAS	I
0.66198	0.18116	0.17056	0.94149	HOU--Arr_12L_ 12R _Dep_ 12R--I	HOU	I
0.66175	0.23796	0.23234	0.97639	IAD--Arr_1L_ 1R _Dep_ 1R_ 30--I	IAD	I
0.65615	0.40587	0.39735	0.97901	SFO--Arr_19L_ 19R _Dep_ 10L_ 10R--V	SFO	V
0.65405	0.31799	0.29428	0.92542	JFK--Arr_13L_ 22L _Dep_ 13R--I	JFK	I

0.64793	0.25194	0.24684	0.97974	PHL--Arr_9R_ 35 _Dep_ 8_ 9L_ 35--I	PHL	I
0.64703	0.34051	0.33433	0.98186	PHL--Arr_9R_ 17 _Dep_ 8_ 9L_ 17--I	PHL	I
0.64189	0.10326	0.10229	0.99058	PBI--Arr_9L_ 9R_ 13 _Dep_ 9L_ 9R_ 13--I	PBI	I
0.64156	0.74208	0.29384	0.39596	LGA--Arr_31 _Dep_ 31--I	LGA	I
0.63857	0.42248	0.41855	0.99070	STL--Arr_30L_ 30R _Dep_ 30L_ 30R--I	STL	I
0.62965	1.00000	0.21631	0.21631	ABQ--Arr_21 _Dep_ 21--I	ABQ	I
0.62494	0.74754	0.20859	0.27904	MSY--Arr_1 _Dep_ 1--I	MSY	I
0.62241	0.44771	0.19188	0.42858	HOU--Arr_12R _Dep_ 12R--I	HOU	I
0.62184	0.26629	0.18672	0.70118	ABQ--Arr_3_ 8 _Dep_ 8--I	ABQ	I
0.62161	0.37185	0.34077	0.91641	LAS--Arr_1L_ 25R _Dep_ 1R--I	LAS	I
0.61618	0.51156	0.51059	0.99810	DEN--Arr_34R_ 35L_ 35R _Dep_ 25_ 34L_ 34R--I	DEN	I
0.60556	0.37030	0.35334	0.95422	IAD--Arr_19L_ 19R _Dep_ 30--I	IAD	I
0.60403	0.12985	0.12756	0.98236	PBI--Arr_9L_ 9R _Dep_ 9L_ 9R--I	PBI	I
0.60401	0.45099	0.44726	0.99172	JFK--Arr_22L_ 22R _Dep_ 22R_ 31L--V	JFK	V
0.60102	1.00000	0.37537	0.37537	JFK--Arr_31R _Dep_ 31L--I	JFK	I
0.59580	0.23080	0.23034	0.99801	BNA--Arr_2C_ 2L_ 2R _Dep_ 2C_ 2L_ 2R--I	BNA	I
0.59213	0.22541	0.21953	0.97392	PHL--Arr_26_ 27R_ 35 _Dep_ 27L_ 35--I	PHL	I
0.58481	0.79386	0.35019	0.44113	LGA--Arr_22 _Dep_ 31--I	LGA	I
0.58237	0.63412	0.51715	0.81553	BOS--Arr_27_ 32 _Dep_ 33L--I	BOS	I
0.57998	0.31607	0.28324	0.89614	EWR--Arr_11_ 22L _Dep_ 22R--I	EWR	I
0.57961	0.35519	0.35460	0.99834	DEN--Arr_34R_ 35L_ 35R _Dep_ 8_ 34L_ 34R--I	DEN	I
0.57753	0.31386	0.31249	0.99564	OAK--Arr_9L_ 9R_ 11 _Dep_ 9L_ 9R_ 11--I	OAK	I
0.57249	0.43080	0.39480	0.91642	DTW--Arr_21L_ 22R _Dep_ 21R--I	DTW	I
0.56793	0.77859	0.34484	0.44291	MDW--Arr_4R _Dep_ 4R--I	MDW	I
0.56031	0.25819	0.25669	0.99419	ORD--Arr_14R_ 22R_ 27L _Dep_ 22L_ 28--I	ORD	I
0.55812	0.74328	0.70683	0.95096	JFK--Arr_22L_ 22R _Dep_ 22R--V	JFK	V
0.55790	0.31175	0.11957	0.38353	PIT--Arr_28L _Dep_ 28C--I	PIT	I
0.54960	0.73454	0.34532	0.47011	JFK--Arr_22L _Dep_ 22R--V	JFK	V
0.53606	0.18614	0.18187	0.97708	IND--Arr_IN_ ONE _Dep_ ONE_ OUT--I	IND	I
0.53413	0.32799	0.32102	0.97873	BOS--Arr_22L_ 27 _Dep_ 22L_ 22R--I	BOS	I
0.53406	0.49203	0.48886	0.99356	IAH--Arr_8L_ 8R _Dep_ 9_ 15L_ 15R--I	IAH	I
0.53348	0.26865	0.26700	0.99388	RDU--Arr_23L_ 23R _Dep_ 23L_ 23R--I	RDU	I
0.53334	0.54310	0.54204	0.99805	MEM--Arr_18L_ 18R _Dep_ 18L_ 18R--I	MEM	I
0.53329	0.85344	0.75196	0.88110	JFK--Arr_31L_ 31R _Dep_ 31L--I	JFK	I
0.53283	0.68511	0.29737	0.43405	PHL--Arr_9R _Dep_ 8_ 9L--V	PHL	V
0.53229	0.31641	0.31261	0.98798	IAH--Arr_8L_ 8R _Dep_ 15L_ 15R--I	IAH	I

0.53114	0.10741	0.10112	0.94139	HOU--Arr_12L_ 12R _Dep_ 22--I	HOU	I
0.52967	0.21211	0.20767	0.97904	PBI--Arr_27L_ 27R_ 31 _Dep_ 27L_ 27R_ 31--I	PBI	I
0.52837	0.41031	0.27749	0.67629	MDW--Arr_22L_ 31C _Dep_ 22L--I	MDW	I
0.52808	0.49132	0.22573	0.45944	CLE--Arr_6L _Dep_ 6R--I	CLE	I
0.52637	1.00000	0.17628	0.17628	MDW--Arr_31C _Dep_ 22L--I	MDW	I
0.52483	0.17220	0.17217	0.99980	PBI--Arr_27L_ 27R_ 31 _Dep_ 27L_ 27R_ 31--V	PBI	V
0.52459	0.33297	0.31651	0.95057	IAD--Arr_1L_ 1R _Dep_ 30--I	IAD	I
0.51534	0.46793	0.46598	0.99583	FLL--Arr_27L_ 27R _Dep_ 27L_ 27R--I	FLL	I
0.51217	0.27054	0.26755	0.98893	MIA--Arr_8L_ 9 _Dep_ 8R_ 12--I	MIA	I
0.51195	0.73461	0.30303	0.41250	BOS--Arr_22L _Dep_ 22R--I	BOS	I
0.50984	0.16496	0.16086	0.97515	ABQ--Arr_3_ 8 _Dep_ 3_ 8--I	ABQ	I
0.50886	0.54287	0.53737	0.98987	SFO--Arr_28L_ 28R _Dep_ 28L_ 28R--I	SFO	I
0.50505	0.29816	0.29771	0.99849	OAK--Arr_9L_ 9R_ 11 _Dep_ 9L_ 9R_ 11--V	OAK	V
0.50417	0.21084	0.20350	0.96521	IAD--Arr_19L_ 19R _Dep_ 19L_ 30--I	IAD	I
0.50021	0.28470	0.28352	0.99584	CVG--Arr_36C_ 36L_ 36R _Dep_ 27_ 36C_ 36R--I	CVG	I
0.49905	0.15165	0.14120	0.93108	JFK--Arr_22L_ 22R _Dep_ 22R_ 31L--I	JFK	I
0.49892	0.60005	0.59589	0.99306	MEM--Arr_36L_ 36R _Dep_ 36L_ 36R--I	MEM	I
0.49234	0.57290	0.24834	0.43347	IAD--Arr_1L _Dep_ 1R_ 30--I	IAD	I
0.49170	0.33846	0.32301	0.95433	IAD--Arr_19L_ 19R _Dep_ 30--V	IAD	V
0.49070	0.29146	0.29089	0.99803	IND--Arr_5L_ 5R _Dep_ 5L_ 5R--I	IND	I
0.48967	0.15244	0.14882	0.97624	PBI--Arr_27L_ 27R _Dep_ 27L_ 27R--I	PBI	I
0.48871	0.48812	0.18718	0.38346	BWI--Arr_33L _Dep_ 28--I	BWI	I
0.48608	0.14032	0.13957	0.99466	PIT--Arr_28L_ 28R _Dep_ 28C_ 28R--I	PIT	I
0.48351	0.53634	0.23671	0.44135	CLE--Arr_24R _Dep_ 24L--I	CLE	I
0.47986	0.09732	0.09677	0.99431	DEN--Arr_16L_ 16R_ 17R _Dep_ 8_ 17L_ 17R--I	DEN	I
0.47871	0.38688	0.36736	0.94956	IAD--Arr_19C_ 19L _Dep_ 30--I	IAD	I
0.47792	0.15394	0.14853	0.96484	CLE--Arr_24L_ 24R _Dep_ 24L_ 24R--I	CLE	I
0.47759	0.28255	0.28137	0.99580	TPA--Arr_18L_ 18R _Dep_ 18L_ 18R--I	TPA	I
0.47466	0.13030	0.12853	0.98640	PIT--Arr_10L_ 10R _Dep_ 10C_ 14--I	PIT	I
0.46941	0.23580	0.23106	0.97991	STL--Arr_11_ 12R _Dep_ 12L_ 12R--I	STL	I
0.46624	0.29063	0.28977	0.99704	MCI--Arr_1L_ 1R _Dep_ 1L_ 1R--I	MCI	I
0.46541	0.51656	0.51145	0.99010	PHL--Arr_9R_ 17 _Dep_ 8_ 9L_ 17--V	PHL	V
0.46452	0.43547	0.43111	0.98998	DTW--Arr_3R_ 4L _Dep_ 3L_ 4R--I	DTW	I
0.46339	0.61768	0.61628	0.99772	MEM--Arr_18L_ 18R _Dep_ 18C_ 18L_ 18R--I	MEM	I
0.45961	0.26652	0.26113	0.97978	MIA--Arr_26R_ 30 _Dep_ 26L_ 27--I	MIA	I
0.45886	0.24716	0.24660	0.99776	BNA--Arr_20C_ 20L_ 20R _Dep_ 20C_ 20L_ 20R--I	BNA	I

0.45842	0.31213	0.30983	0.99263	MEM--Arr_9_ 36L_ 36R _Dep_ 36C_ 36L_ 36R--I	MEM	I
0.45077	0.47831	0.17002	0.35545	PIT--Arr_10R _Dep_ 10C_ 14--I	PIT	I
0.44603	0.28759	0.28572	0.99352	RDU--Arr_5L_ 5R _Dep_ 5L_ 5R--I	RDU	I
0.44365	0.66654	0.66551	0.99845	DFW--Arr_35C_ 35R_ 36L _Dep_ 31L_ 35L_ 36R--I	DFW	I
0.44145	0.39804	0.39760	0.99890	LAS--Arr_19L_ 19R_ 25L _Dep_ 19L_ 19R_ 25R--V	LAS	V
0.44082	0.28353	0.28209	0.99491	RDU--Arr_23L_ 23R _Dep_ 23L_ 23R--V	RDU	V
0.43927	0.39413	0.39291	0.99691	FLL--Arr_27L_ 27R _Dep_ 27L_ 27R--V	FLL	V
0.43825	0.75000	0.33841	0.45122	LGA--Arr_31 _Dep_ 31--V	LGA	V
0.43808	0.07452	0.07318	0.98199	DEN--Arr_16L_ 16R_ 17R _Dep_ 8_ 17L_ 17R_ 25--I	DEN	I
0.43436	0.14893	0.14571	0.97839	BWI--Arr_10_ 15L _Dep_ 15L_ 15R--I	BWI	I
0.43416	0.54059	0.23713	0.43866	HOU--Arr_22 _Dep_ 22--V	HOU	V
0.42973	0.21056	0.20414	0.96952	IAD--Arr_1C_ 1R _Dep_ 1R_ 30--I	IAD	I
0.42471	0.64597	0.64386	0.99673	MEM--Arr_36L_ 36R _Dep_ 36C_ 36L_ 36R--I	MEM	I
0.42284	0.50020	0.49783	0.99527	CVG--Arr_36C_ 36L_ 36R _Dep_ 36C_ 36R--I	CVG	I
0.41518	0.73487	0.73487	1.00000	DEN--Arr_34R_ 35L_ 35R _Dep_ 8_ 25_ 34L_ 34R--I	DEN	I
0.41498	0.31576	0.28395	0.89926	BWI--Arr_33L_ 33R _Dep_ 28--I	BWI	I
0.41274	1.00000	0.53275	0.53275	JFK--Arr_22L _Dep_ 22R_ 31L--V	JFK	V
0.41265	0.80065	0.31723	0.39622	IND--Arr_32 _Dep_ 32--I	IND	I
0.41245	0.20327	0.19796	0.97387	STL--Arr_11_ 12L _Dep_ 12L_ 12R--I	STL	I
0.40831	0.60869	0.25405	0.41736	BNA--Arr_20R _Dep_ 20R--I	BNA	I
0.40803	0.82250	0.36307	0.44142	JFK--Arr_13L _Dep_ 13R--V	JFK	V
0.40679	0.60025	0.59933	0.99846	ORD--Arr_4R_ 9R_ 10 _Dep_ 4L_ 9R_ 32L_ 32R--I	ORD	I
0.40678	0.64368	0.63132	0.98080	BOS--Arr_4L_ 4R _Dep_ 4L_ 4R_ 9--I	BOS	I
0.40336	0.28486	0.28408	0.99728	IND--Arr_23L_ 23R _Dep_ 23L_ 23R--I	IND	I
0.40321	0.26185	0.20151	0.76955	PBI--Arr_9L_ 9R_ 13 _Dep_ 9L_ 9R_ 13--V	PBI	V
0.40243	0.20254	0.19751	0.97515	IAD--Arr_19C_ 19L _Dep_ 19L_ 30--I	IAD	I
0.40027	0.95531	0.39098	0.40927	JFK--Arr_4R _Dep_ 4L--V	JFK	V
0.40018	0.56732	0.56228	0.99112	MEM--Arr_27_ 36L_ 36R _Dep_ 36L_ 36R--I	MEM	I
0.39776	0.12468	0.12432	0.99713	PBI--Arr_27L_ 27R _Dep_ 27L_ 27R--V	PBI	V
0.39711	0.41092	0.38010	0.92499	MCO--Arr_17L_ 18R _Dep_ 17R_ 18R--I	MCO	I
0.39557	0.57590	0.33494	0.58158	CLE--Arr_24R _Dep_ 24L_ 24R--I	CLE	I
0.39335	0.73161	0.35738	0.48848	JFK--Arr_31R _Dep_ 31L--V	JFK	V
0.39094	0.67084	0.66984	0.99851	ORD--Arr_4R_ 9R_ 10 _Dep_ 4L_ 9R_ 32L--I	ORD	I
0.39080	0.37351	0.16266	0.43548	HOU--Arr_22 _Dep_ 22--I	HOU	I
0.39060	0.23496	0.23431	0.99723	STL--Arr_30L_ 30R _Dep_ 29_ 30L--I	STL	I
0.37958	0.29901	0.29693	0.99304	RDU--Arr_23L_ 23R_ 32 _Dep_ 23L_ 23R--I	RDU	I

0.37834	0.30490	0.30366	0.99593	MCI--Arr_19L_ 19R _Dep_ 19L_ 19R--I	MCI	I
0.37821	0.29173	0.28961	0.99273	MCO--Arr_35R_ 36R _Dep_ 35L_ 36L--I	MCO	I
0.37762	0.58053	0.22434	0.38644	CLE--Arr_24L _Dep_ 24R--I	CLE	I
0.37487	0.58971	0.23114	0.39195	BWI--Arr_10 _Dep_ 15R--I	BWI	I
0.37364	0.35822	0.35710	0.99688	MEM--Arr_18L_ 18R_ 27 _Dep_ 18C_ 18L_ 18R--I	MEM	I
0.37342	0.37329	0.37239	0.99757	FLL--Arr_9L_ 9R _Dep_ 9L_ 9R--I	FLL	I
0.37254	0.38721	0.35546	0.91801	LAS--Arr_1L_ 25R _Dep_ 1R--V	LAS	V
0.36984	0.13871	0.13242	0.95462	STL--Arr_11_ 12L _Dep_ 12R--I	STL	I
0.36854	1.00000	0.55800	0.55800	LGA--Arr_22 _Dep_ 13--V	LGA	V
0.36804	0.63175	0.56914	0.90089	EWR--Arr_11_ 22L _Dep_ 22R--V	EWR	V
0.36648	0.24207	0.23909	0.98769	SJC--Arr_11_ 12L_ 12R _Dep_ 11_ 12L_ 12R--I	SJC	I
0.36342	0.37192	0.35574	0.95649	IAD--Arr_1C_ 1R _Dep_ 30--I	IAD	I
0.36145	0.56023	0.55675	0.99378	CVG--Arr_18C_ 18L_ 18R _Dep_ 18C_ 18L--I	CVG	I
0.36064	0.29650	0.28931	0.97575	MIA--Arr_26R_ 30 _Dep_ 26L_ 27--V	MIA	V
0.36041	0.12558	0.11607	0.92429	PBI--Arr_9L_ 9R _Dep_ 9L_ 9R--V	PBI	V
0.36000	0.87070	0.86135	0.98926	CLT--Arr_36C_ 36R _Dep_ 36C_ 36R--I	CLT	I
0.35996	0.55977	0.52861	0.94434	EWR--Arr_4R_ 11 _Dep_ 4L--V	EWR	V
0.35719	0.26135	0.25982	0.99415	RDU--Arr_5L_ 5R_ 32 _Dep_ 5L_ 5R--I	RDU	I
0.35712	0.76034	0.31534	0.41474	RDU--Arr_23R _Dep_ 23R--I	RDU	I
0.35694	0.44482	0.41651	0.93635	EWR--Arr_4R_ 11 _Dep_ 4L--I	EWR	I
0.35609	0.22840	0.19306	0.84529	HOU--Arr_12L_ 12R _Dep_ 12R--V	HOU	V
0.35326	0.55287	0.54680	0.98902	IAH--Arr_26L_ 26R _Dep_ 15L_ 15R--I	IAH	I
0.35295	0.58141	0.25827	0.44421	RDU--Arr_23R _Dep_ 23R--V	RDU	V
0.35212	0.67155	0.29745	0.44293	IND--Arr_32 _Dep_ 32--V	IND	V
0.35158	0.51857	0.48328	0.93195	JFK--Arr_13L_ 22L _Dep_ 13R--V	JFK	V
0.34682	0.27372	0.27173	0.99273	MCO--Arr_17L_ 18R _Dep_ 17R_ 18L--I	MCO	I
0.34620	0.19093	0.18793	0.98428	DTW--Arr_21R_ 22L_ 22R _Dep_ 21R_ 22L--I	DTW	I
0.34416	0.19899	0.19273	0.96855	PIT--Arr_28R_ 32 _Dep_ 28L_ 28R--I	PIT	I
0.34177	0.06138	0.05958	0.97070	ORD--Arr_27L_ 27R_ 28 _Dep_ 22L_ 32L--I	ORD	I
0.33949	0.24341	0.24334	0.99973	BNA--Arr_2C_ 2L_ 2R _Dep_ 2C_ 2L_ 2R--V	BNA	V
0.33921	1.00000	0.25909	0.25909	MDW--Arr_4R _Dep_ 31C--I	MDW	I
0.33810	0.09290	0.09221	0.99255	HOU--Arr_12L_ 12R _Dep_ 4_ 22--I	HOU	I
0.33783	0.43501	0.42603	0.97935	DTW--Arr_21L_ 22R _Dep_ 21R_ 22L--I	DTW	I
0.33680	0.32619	0.32374	0.99248	MCO--Arr_17L_ 18L _Dep_ 17R_ 18R--V	MCO	V
0.33442	0.36065	0.35925	0.99612	STL--Arr_12L_ 12R _Dep_ 12L_ 12R--I	STL	I
0.33404	0.51783	0.51738	0.99914	MEM--Arr_18L_ 18R _Dep_ 18C_ 18L_ 18R--V	MEM	V

0.33290	0.23803	0.23772	0.99872	SJC--Arr_11_ 12L_ 12R _Dep_ 11_ 12L_ 12R--V	SJC	V
0.32825	0.25844	0.25660	0.99290	IAD--Arr_19C_ 19L _Dep_ 19L_ 30--V	IAD	V
0.32747	1.00000	0.57314	0.57314	LGA--Arr_22 _Dep_ 31--V	LGA	V
0.32720	0.27035	0.26897	0.99487	RDU--Arr_5L_ 5R _Dep_ 5L_ 5R--V	RDU	V
0.32592	0.52264	0.20234	0.38716	MDW--Arr_31C _Dep_ 22L--V	MDW	V
0.32369	0.67619	0.28719	0.42471	BWI--Arr_10 _Dep_ 15L_ 15R--I	BWI	I
0.32265	0.44443	0.19964	0.44921	HOU--Arr_12R _Dep_ 12R--V	HOU	V
0.32163	1.00000	0.45202	0.45202	DCA--Arr_1 _Dep_ 1--I	DCA	I
0.32161	0.42912	0.23124	0.53888	BNA--Arr_20R _Dep_ 20C_ 20R--I	BNA	I
0.31944	0.54564	0.54424	0.99742	MEM--Arr_18L_ 18R _Dep_ 18L_ 18R--V	MEM	V
0.31904	0.53458	0.53320	0.99742	IAH--Arr_26L_ 26R_ 27 _Dep_ 33L_ 33R--V	IAH	V
0.31814	0.48748	0.42131	0.86426	SEA--Arr_16C_ 16L _Dep_ 16L--I	SEA	I
0.31749	0.56011	0.54458	0.97227	CLT--Arr_18C_ 23 _Dep_ 18C_ 18L--I	CLT	I
0.31411	0.55276	0.55237	0.99928	DFW--Arr_31R_ 35C_ 35R_ 36L _Dep_ 31L_ 35L_ 36R--I	DFW	I
0.31204	0.37325	0.16484	0.44162	ABQ--Arr_21 _Dep_ 21--V	ABQ	V
0.30995	0.42121	0.40383	0.95873	IAD--Arr_19C_ 19L _Dep_ 30--V	IAD	V
0.30825	0.23972	0.23952	0.99916	CVG--Arr_18C_ 18L_ 18R _Dep_ 18C_ 18L_ 27--I	CVG	I
0.30534	0.68712	0.68626	0.99875	MSP--Arr_30L_ 30R _Dep_ 30L_ 30R--I	MSP	I
0.30468	0.80743	0.36349	0.45018	DCA--Arr_19 _Dep_ 19--I	DCA	I
0.30458	0.24302	0.24102	0.99177	BWI--Arr_10_ 15L _Dep_ 15L_ 15R--V	BWI	V
0.30135	0.63931	0.28406	0.44432	RDU--Arr_5L _Dep_ 5L--I	RDU	I
0.30127	0.27620	0.27281	0.98772	SEA--Arr_16L_ 16R _Dep_ 16C_ 16L--I	SEA	I
0.29746	0.15376	0.15259	0.99241	HOU--Arr_12L_ 12R _Dep_ 4_ 22--V	HOU	V
0.29704	0.51227	0.50802	0.99172	PHL--Arr_9R_ 35 _Dep_ 8_ 9L_ 35--V	PHL	V
0.29366	0.31325	0.30999	0.98959	IAD--Arr_19L_ 19R _Dep_ 19L_ 30--V	IAD	V
0.29302	0.27727	0.26947	0.97185	BOS--Arr_4L_ 4R _Dep_ 4R_ 9--I	BOS	I
0.29157	0.32092	0.31720	0.98842	MCO--Arr_17L_ 18L _Dep_ 17R_ 18R--I	MCO	I
0.29119	0.93906	0.16420	0.17485	MSY--Arr_19 _Dep_ 28--I	MSY	I
0.29060	0.58481	0.26044	0.44534	BNA--Arr_20R _Dep_ 20R--V	BNA	V
0.28986	0.57633	0.33338	0.57846	CLE--Arr_24L _Dep_ 24L_ 24R--I	CLE	I
0.28891	0.31746	0.31742	0.99987	DEN--Arr_16L_ 16R_ 17R _Dep_ 8_ 17L_ 17R--V	DEN	V
0.28815	0.65749	0.53114	0.80783	IAD--Arr_12_ 19L_ 19R _Dep_ 19L--I	IAD	I
0.28799	0.37101	0.37098	0.99993	DEN--Arr_34R_ 35L_ 35R _Dep_ 8_ 34L_ 34R--V	DEN	V
0.28562	0.28727	0.28427	0.98956	RDU--Arr_23L_ 23R_ 32 _Dep_ 23L_ 23R--V	RDU	V
0.28244	0.87412	0.39310	0.44971	MDW--Arr_31C _Dep_ 31C--I	MDW	I
0.28111	1.00000	0.50392	0.50392	JFK--Arr_4R _Dep_ 4L_ 31L--V	JFK	V

0.28015	0.50923	0.49790	0.97774	DTW--Arr_21L_ 22L_ 22R _Dep_ 21R_ 22L--I	DTW	I
0.27661	0.75468	0.34339	0.45501	IAD--Arr_1L _Dep_ 1R_ 30--V	IAD	V
0.27496	1.00000	0.49851	0.49851	LGA--Arr_4 _Dep_ 13--V	LGA	V
0.27418	0.16076	0.15925	0.99066	SJC--Arr_29_ 30L _Dep_ 29_ 30L_ 30R--I	SJC	I
0.27183	0.51189	0.51093	0.99811	SLC--Arr_16L_ 16R_ 17 _Dep_ 16L_ 16R_ 17--I	SLC	I
0.27091	0.32321	0.12342	0.38187	HOU--Arr_4 _Dep_ 30L--V	HOU	V
0.26764	0.53296	0.12080	0.22666	MSY--Arr_1 _Dep_ 28--I	MSY	I
0.26560	0.48752	0.46182	0.94729	LAS--Arr_1L_ 25L _Dep_ 1R--V	LAS	V
0.26513	0.26273	0.25962	0.98814	STL--Arr_11_ 12R _Dep_ 12L_ 12R--V	STL	V
0.26241	0.42350	0.16020	0.37828	PIT--Arr_28L _Dep_ 28C--V	PIT	V
0.26015	0.33207	0.32974	0.99297	IAD--Arr_1L_ 1R _Dep_ 1R_ 30--V	IAD	V
0.25923	0.39364	0.37674	0.95708	MDW--Arr_22L_ 31C _Dep_ 22L--V	MDW	V
0.25769	0.61893	0.24254	0.39187	BWI--Arr_10 _Dep_ 15L_ 15R--V	BWI	V
0.25681	0.26142	0.26004	0.99472	PIT--Arr_28L_ 28R _Dep_ 28C_ 28R--V	PIT	V
0.25595	0.57591	0.26252	0.45585	RDU--Arr_5L _Dep_ 5L--V	RDU	V
0.25241	0.40586	0.37984	0.93590	IAD--Arr_1L_ 1R _Dep_ 30--V	IAD	V
0.25222	0.53156	0.53112	0.99916	SLC--Arr_34L_ 34R_ 35 _Dep_ 34L_ 34R_ 35--I	SLC	I
0.25168	0.65391	0.65283	0.99836	MSP--Arr_12L_ 12R _Dep_ 12L_ 12R_ 17--I	MSP	I
0.25116	0.43735	0.41011	0.93770	LAS--Arr_1L_ 1R _Dep_ 7L--V	LAS	V
0.25006	0.38272	0.17235	0.45033	HOU--Arr_4 _Dep_ 4--I	HOU	I
0.24969	0.24375	0.24360	0.99937	BNA--Arr_20C_ 20L_ 20R _Dep_ 20C_ 20L_ 20R--V	BNA	V
0.24961	0.59466	0.23662	0.39790	CLE--Arr_6L _Dep_ 6R--V	CLE	V
0.24920	0.25399	0.24863	0.97892	BWI--Arr_33L_ 33R _Dep_ 28_ 33R--I	BWI	I
0.24886	0.17517	0.16311	0.93114	BOS--Arr_22L_ 27 _Dep_ 22R--I	BOS	I
0.24845	0.25059	0.25037	0.99911	CVG--Arr_36C_ 36L_ 36R _Dep_ 27_ 36C_ 36R--V	CVG	V
0.24783	0.34239	0.33989	0.99272	TPA--Arr_36L_ 36R _Dep_ 36L_ 36R--I	TPA	I
0.24668	0.17450	0.16578	0.95004	ABQ--Arr_26_ 30 _Dep_ 26_ 30--V	ABQ	V
0.24553	0.48166	0.46434	0.96405	DTW--Arr_21L_ 22R _Dep_ 21R--V	DTW	V
0.24498	0.57279	0.56557	0.98740	CLT--Arr_18R_ 23 _Dep_ 18L_ 18R--I	CLT	I
0.24474	0.14751	0.13161	0.89217	CLE--Arr_6L_ 10 _Dep_ 6R--I	CLE	I
0.23827	0.30522	0.30483	0.99871	MEM--Arr_27_ 36L_ 36R _Dep_ 36C_ 36L_ 36R--I	MEM	I
0.23705	0.26314	0.25343	0.96311	BNA--Arr_20C_ 20R _Dep_ 20C_ 20R--I	BNA	I
0.23626	0.24206	0.23766	0.98181	STL--Arr_29_ 30R _Dep_ 29_ 30L--I	STL	I
0.23271	0.34465	0.34136	0.99044	MCO--Arr_17L_ 18R _Dep_ 17R_ 18R--V	MCO	V
0.22911	0.20234	0.20141	0.99536	IND--Arr_IN_ ONE _Dep_ ONE_ OUT--V	IND	V
0.22628	0.15374	0.15195	0.98834	PIT--Arr_28R_ 32 _Dep_ 28C_ 28R--V	PIT	V

0.22586	0.59946	0.59860	0.99857	DFW--Arr_31R_ 35C_ 35R_ 36L _Dep_ 31L_ 35L_ 36R--V	DFW	V
0.22298	0.62354	0.62304	0.99920	DFW--Arr_35C_ 35R_ 36L _Dep_ 31L_ 35L_ 36R--V	DFW	V
0.22236	0.20846	0.15695	0.75290	HOU--Arr_12L_ 12R _Dep_ 22--V	HOU	V
0.21684	0.54777	0.54581	0.99642	MSP--Arr_30L_ 30R _Dep_ 30L_ 30R--V	MSP	V
0.21528	0.73807	0.73480	0.99557	SFO--Arr_28L_ 28R _Dep_ 28L_ 28R--V	SFO	V
0.21522	0.49434	0.49430	0.99992	IAH--Arr_26L_ 26R_ 27 _Dep_ 15L_ 15R--I	IAH	I
0.21478	0.17392	0.17321	0.99590	PIT--Arr_28R_ 32 _Dep_ 28L_ 28R--V	PIT	V
0.21474	0.28925	0.28789	0.99528	RDU--Arr_5L_ 5R_ 32 _Dep_ 5L_ 5R--V	RDU	V
0.21430	0.57790	0.24586	0.42544	CLE--Arr_24R _Dep_ 24L--V	CLE	V
0.21314	0.27346	0.10678	0.39047	MSY--Arr_19 _Dep_ 28--V	MSY	V
0.21301	0.44331	0.44249	0.99815	BOS--Arr_22L_ 27 _Dep_ 22L_ 22R--V	BOS	V
0.21224	0.33861	0.33606	0.99245	MCO--Arr_35R_ 36L _Dep_ 35L_ 36R--V	MCO	V
0.21152	0.55401	0.25491	0.46012	BNA--Arr_2L _Dep_ 2L--V	BNA	V
0.20675	0.54923	0.54781	0.99740	CVG--Arr_36C_ 36L_ 36R _Dep_ 36C_ 36R--V	CVG	V
0.20637	0.43291	0.13994	0.32324	HOU--Arr_4 _Dep_ 30L--I	HOU	I
0.20551	0.43312	0.27405	0.63274	HOU--Arr_4 _Dep_ 4--V	HOU	V
0.20466	0.54066	0.20581	0.38067	MDW--Arr_4R _Dep_ 31C--V	MDW	V
0.20405	0.59599	0.59338	0.99563	MCO--Arr_17L_ 18R _Dep_ 17L_ 17R_ 18L_ 18R--V	MCO	V
0.20130	0.51346	0.51111	0.99543	CVG--Arr_18C_ 18L_ 18R _Dep_ 18C_ 18L--V	CVG	V
0.19676	0.22711	0.22637	0.99677	SJC--Arr_29_ 30L _Dep_ 29_ 30L_ 30R--V	SJC	V
0.19562	0.51949	0.51942	0.99986	DFW--Arr_13R_ 17C_ 17L_ 18R _Dep_ 13L_ 17R_ 18L--I	DFW	I
0.19327	0.50215	0.49831	0.99234	DTW--Arr_3R_ 4L _Dep_ 3L_ 4R--V	DTW	V
0.19323	0.89414	0.71333	0.79779	FLL--Arr_9L_ 9R _Dep_ 9L_ 9R--V	FLL	V
0.19244	0.88290	0.87846	0.99497	CLT--Arr_36C_ 36R _Dep_ 36C_ 36R--V	CLT	V
0.19192	0.64727	0.64159	0.99122	MEM--Arr_36L_ 36R _Dep_ 36C_ 36L_ 36R--V	MEM	V
0.19007	0.16814	0.16010	0.95218	PIT--Arr_10L_ 10R _Dep_ 10C_ 14--V	PIT	V
0.18864	0.22052	0.21059	0.95495	ABQ--Arr_3_ 8 _Dep_ 3_ 8--V	ABQ	V
0.18857	0.55960	0.15135	0.27045	HOU--Arr_4 _Dep_ 12R--I	HOU	I
0.18637	0.78398	0.39792	0.50756	MDW--Arr_22L _Dep_ 22L--V	MDW	V
0.18516	0.50779	0.46124	0.90833	BOS--Arr_27_ 32 _Dep_ 33L--V	BOS	V
0.18028	0.57624	0.54576	0.94711	SEA--Arr_16C_ 16L _Dep_ 16L--V	SEA	V
0.17932	0.61556	0.61091	0.99244	IAH--Arr_8L_ 8R _Dep_ 15L_ 15R--V	IAH	V
0.17916	0.91538	0.58993	0.64446	BOS--Arr_4R _Dep_ 4R_ 9--V	BOS	V
0.17599	0.91432	0.91432	1.00000	ATL--Arr_8L_ 9R_ 10 _Dep_ 8R_ 9L_ 10--I	ATL	I
0.17573	0.42024	0.37415	0.89032	PDX--Arr_10L_ 10R _Dep_ 10L_ 10R--I	PDX	I
0.17508	0.88262	0.88112	0.99831	ATL--Arr_26R_ 27L_ 28 _Dep_ 26L_ 27R--I	ATL	I

0.17491	0.48988	0.46868	0.95673	DTW--Arr_21L_ 22R _Dep_ 22L--I	DTW	I
0.17302	0.27334	0.27114	0.99194	STL--Arr_11_ 12L _Dep_ 12L_ 12R--V	STL	V
0.17192	0.15549	0.14724	0.94697	MSY--Arr_1_ 10 _Dep_ 1--I	MSY	I
0.16937	0.77085	0.51031	0.66201	MDW--Arr_4R _Dep_ 4R--V	MDW	V
0.16909	0.73161	0.72903	0.99648	MSP--Arr_30L_ 30R_ 35 _Dep_ 30L_ 30R--I	MSP	I
0.16856	0.17437	0.17183	0.98543	SEA--Arr_34C_ 34R _Dep_ 34C_ 34R--I	SEA	I
0.16855	0.58717	0.58279	0.99256	IAH--Arr_8L_ 8R _Dep_ 9_ 15L_ 15R--V	IAH	V
0.16805	0.59042	0.24399	0.41324	BWI--Arr_10 _Dep_ 15R--V	BWI	V
0.16487	0.64424	0.64418	0.99991	DEN--Arr_34R_ 35L_ 35R _Dep_ 25_ 34L_ 34R--V	DEN	V
0.16483	0.39524	0.15902	0.40235	PIT--Arr_10R _Dep_ 10C_ 14--V	PIT	V
0.16383	0.25570	0.25293	0.98915	STL--Arr_29_ 30R _Dep_ 29_ 30L--V	STL	V
0.16262	0.36009	0.32209	0.89448	BOS--Arr_22L_ 27 _Dep_ 22R--V	BOS	V
0.16219	0.43334	0.27293	0.62984	BNA--Arr_2L _Dep_ 2C_ 2L--V	BNA	V
0.16031	0.54946	0.39610	0.72090	SAN--Arr_27 _Dep_ 27--I	SAN	I
0.15809	0.66440	0.66426	0.99978	DFW--Arr_17C_ 17L_ 18R _Dep_ 13L_ 17R_ 18L--I	DFW	I
0.15746	0.41261	0.41177	0.99797	DFW--Arr_13R_ 17C_ 17L_ 18R _Dep_ 17R_ 18L--I	DFW	I
0.15484	0.45292	0.42398	0.93609	IAD--Arr_1C_ 1R _Dep_ 30--V	IAD	V
0.15362	0.16469	0.16450	0.99884	ABQ--Arr_26_ 30 _Dep_ 21_ 26_ 30--V	ABQ	V
0.15194	0.78859	0.69890	0.88627	MDW--Arr_31C _Dep_ 31C--V	MDW	V
0.15011	0.35915	0.34496	0.96051	STL--Arr_30L_ 30R _Dep_ 29_ 30L--V	STL	V
0.14919	0.49663	0.49400	0.99470	MCO--Arr_17L_ 17R_ 18L_ 18R _Dep_ 17L_ 17R_ 18L_ 18R--I	MCO	I
0.14879	0.37087	0.16503	0.44497	MSY--Arr_1 _Dep_ 1--V	MSY	V
0.14845	0.27560	0.27414	0.99470	BNA--Arr_20C_ 20R _Dep_ 20C_ 20R--V	BNA	V
0.14600	0.23400	0.23283	0.99499	BNA--Arr_2C_ 2L _Dep_ 2C_ 2L--V	BNA	V
0.14587	0.43695	0.43442	0.99422	STL--Arr_30L_ 30R _Dep_ 30L_ 30R--V	STL	V
0.14465	0.15517	0.14719	0.94860	MSY--Arr_10_ 19 _Dep_ 19--I	MSY	I
0.13650	0.58847	0.58540	0.99478	TPA--Arr_18L_ 18R _Dep_ 18L_ 18R--V	TPA	V
0.13247	0.30919	0.30523	0.98718	BNA--Arr_2C_ 2L _Dep_ 2C_ 2L--I	BNA	I
0.13165	0.32812	0.31511	0.96034	MSY--Arr_10_ 19 _Dep_ 19--V	MSY	V
0.13031	0.73839	0.73831	0.99988	DFW--Arr_17C_ 17L_ 18R _Dep_ 13L_ 17R_ 18L--V	DFW	V
0.12956	0.27689	0.10870	0.39258	MSY--Arr_1 _Dep_ 28--V	MSY	V
0.12674	0.52800	0.52795	0.99992	MCO--Arr_17L_ 17R_ 18L_ 18R _Dep_ 17L_ 17R_ 18L_ 18R--V	MCO	V
0.12338	0.61298	0.61206	0.99851	ORD--Arr_22R_ 27L_ 28 _Dep_ 22L_ 32L_ 32R--I	ORD	I
0.12139	0.67862	0.63389	0.93408	MCO--Arr_17L_ 18R _Dep_ 17L_ 17R_ 18L_ 18R--I	MCO	I
0.11739	0.37091	0.35550	0.95845	BWI--Arr_33L_ 33R _Dep_ 28_ 33R--V	BWI	V
0.10904	0.45390	0.43751	0.96391	PHL--Arr_26_ 27R _Dep_ 27L--V	PHL	V

0.10816	0.82650	0.82496	0.99814	ORD--Arr_22R_ 27L_ 28 _Dep_ 22L_ 32L--V	ORD	V
0.10772	0.39619	0.37826	0.95473	MCO--Arr_17L_ 18R _Dep_ 17R_ 18L--V	MCO	V
0.10390	0.45010	0.27577	0.61268	BNA--Arr_20R _Dep_ 20C_ 20R--V	BNA	V
0.10363	0.97839	0.37764	0.38598	BOS--Arr_22L _Dep_ 22R--V	BOS	V
0.10346	0.55418	0.50972	0.91977	DTW--Arr_21L_ 22R _Dep_ 21R_ 22L--V	DTW	V
0.09893	0.60289	0.58000	0.96203	LAS--Arr_7R_ 19R _Dep_ 7L--V	LAS	V
0.09605	0.50495	0.49529	0.98087	IND--Arr_23L_ 23R _Dep_ 23L_ 23R--V	IND	V
0.09589	0.62397	0.62368	0.99953	BOS--Arr_4L_ 4R _Dep_ 4L_ 4R_ 9--V	BOS	V
0.09516	0.95004	0.94510	0.99480	ORD--Arr_22R_ 27L_ 28 _Dep_ 22L_ 32L--I	ORD	I
0.09481	0.68526	0.41593	0.60696	CLE--Arr_24R _Dep_ 24L_ 24R--V	CLE	V
0.09466	0.63377	0.63364	0.99981	DFW--Arr_13R_ 17C_ 17L_ 18R _Dep_ 17R_ 18L--V	DFW	V
0.08663	0.67473	0.51403	0.76183	OAK--Arr_27L_ 27R_ 29 _Dep_ 27L_ 27R_ 29--V	OAK	V
0.08386	0.26942	0.25964	0.96368	STL--Arr_11_ 12L _Dep_ 12R--V	STL	V
0.08329	0.36727	0.34564	0.94111	MCO--Arr_35R_ 36R _Dep_ 35L_ 36L--V	MCO	V
0.08050	0.48592	0.48459	0.99725	BOS--Arr_4L_ 4R _Dep_ 4R_ 9--V	BOS	V
0.07864	0.70365	0.42841	0.60884	CLE--Arr_6L _Dep_ 6L_ 6R--V	CLE	V
0.07633	0.37619	0.17485	0.46479	ABQ--Arr_8 _Dep_ 8--V	ABQ	V
0.07495	0.71509	0.71197	0.99565	MSP--Arr_30L_ 30R _Dep_ 17_ 30L_ 30R--I	MSP	I
0.07297	0.35795	0.31508	0.88024	BWI--Arr_33L_ 33R _Dep_ 28--V	BWI	V
0.06608	0.24721	0.24568	0.99381	SJC--Arr_29_ 30R _Dep_ 29_ 30R--V	SJC	V
0.06419	0.84252	0.84216	0.99956	ORD--Arr_27L_ 27R_ 28 _Dep_ 22L_ 32L--V	ORD	V
0.06219	0.99750	0.84667	0.84879	DCA--Arr_19 _Dep_ 19--V	DCA	V
0.06166	0.98839	0.66704	0.67487	SEA--Arr_16C _Dep_ 16C_ 16L--I	SEA	I
0.06132	0.45836	0.45824	0.99972	MEM--Arr_18L_ 18R_ 27 _Dep_ 18C_ 18L_ 18R--V	MEM	V
0.05848	1.00000	0.66798	0.66798	SEA--Arr_16C _Dep_ 16C_ 16L--V	SEA	V
0.05771	0.49038	0.49016	0.99956	MCI--Arr_19L_ 19R _Dep_ 19L_ 19R--V	MCI	V
0.05605	0.71164	0.50080	0.70372	CLE--Arr_24L _Dep_ 24L_ 24R--V	CLE	V
0.05269	0.41250	0.40960	0.99299	MCO--Arr_35R_ 36L _Dep_ 35L_ 36R--I	MCO	I
0.04747	0.82914	0.47877	0.57743	BWI--Arr_33L _Dep_ 28--V	BWI	V
0.04645	0.30346	0.27783	0.91554	MSY--Arr_1_ 10 _Dep_ 1--V	MSY	V
0.04605	0.76982	0.73552	0.95545	DFW--Arr_13R_ 17C_ 17L_ 18R _Dep_ 13L_ 17R_ 18L--V	DFW	V
0.04480	0.38293	0.37537	0.98026	SEA--Arr_16L_ 16R _Dep_ 16C_ 16L--V	SEA	V
0.04168	0.91725	0.91699	0.99971	DEN--Arr_26_ 35L_ 35R _Dep_ 25_ 34L_ 34R--V	DEN	V
0.04118	0.31888	0.30842	0.96722	IND--Arr_5L_ 5R _Dep_ 5L_ 5R--V	IND	V
0.03856	0.31419	0.30744	0.97852	OAK--Arr_27L_ 27R_ 29 _Dep_ 27L_ 27R_ 29--I	OAK	I
0.03521	0.96401	0.86164	0.89380	PHL--Arr_26_ 27R_ 35 _Dep_ 27L_ 35--V	PHL	V

0.02811	0.54338	0.54054	0.99476	STL--Arr_12L_ 12R _Dep_ 12L_ 12R--V	STL	V
0.02788	0.56748	0.24540	0.43245	MDW--Arr_22L _Dep_ 22L--I	MDW	I
0.02624	0.38779	0.15374	0.39645	HOU--Arr_4 _Dep_ 12R--V	HOU	V
0.02395	0.78628	0.78617	0.99985	DEN--Arr_34R_ 35L_ 35R _Dep_ 8_ 25_ 34L_ 34R--V	DEN	V
0.02003	0.55700	0.55278	0.99241	LAX--Arr_24R_ 25L _Dep_ 24L_ 25R--I	LAX	I
0.01775	0.65020	0.65012	0.99987	DEN--Arr_16L_ 16R_ 17R _Dep_ 8_ 17L_ 17R_ 25--V	DEN	V
0.01254	0.33433	0.33394	0.99883	MEM--Arr_9_ 36L_ 36R _Dep_ 36C_ 36L_ 36R--V	MEM	V
0.01246	0.48748	0.48515	0.99523	MEM--Arr_36L_ 36R _Dep_ 36L_ 36R--V	MEM	V
0.00885	0.60307	0.26386	0.43752	CLE--Arr_24L _Dep_ 24R--V	CLE	V
0.00819	0.55453	0.41833	0.75439	SJC--Arr_29_ 30L_ 30R _Dep_ 29_ 30L_ 30R--V	SJC	V
0.00522	0.80593	0.54991	0.68233	IAD--Arr_12_ 19C_ 19L _Dep_ 19L--I	IAD	I
0.00468	0.93579	0.89163	0.95280	LAS--Arr_19R_ 25L _Dep_ 19L_ 25R--V	LAS	V
0.00282	0.34414	0.34400	0.99959	ABQ--Arr_3_ 8 _Dep_ 8--V	ABQ	V
0.00191	0.57169	0.56944	0.99606	PDX--Arr_10L_ 10R _Dep_ 10L_ 10R--V	PDX	V
0.00000	0.07245	0.05949	0.82117	LAS--Arr_19L_ 19R_ 25L _Dep_ 19L_ 19R_ 25R--I	LAS	I
0.00000	0.11059	0.10690	0.96670	DTW--Arr_3R_ 4L_ 4R _Dep_ 3L_ 4R--I	DTW	I
0.00000	0.13756	0.12263	0.89147	ABQ--Arr_26_ 30 _Dep_ 21_ 26_ 30--I	ABQ	I
0.00000	0.17941	0.17931	0.99944	SJC--Arr_29_ 30L_ 30R _Dep_ 29_ 30L_ 30R--I	SJC	I
0.00000	0.18933	0.18478	0.97594	SJC--Arr_29_ 30R _Dep_ 29_ 30R--I	SJC	I
0.00000	0.21025	0.18409	0.87558	PHL--Arr_26_ 27R _Dep_ 27L--I	PHL	I
0.00000	0.23888	0.23783	0.99558	CLE--Arr_6L_ 10 _Dep_ 6L_ 6R--V	CLE	V
0.00000	0.24932	0.23010	0.92290	CLE--Arr_6L_ 10 _Dep_ 6R--V	CLE	V
0.00000	0.26699	0.26530	0.99370	SEA--Arr_16C_ 16L _Dep_ 16C_ 16L--I	SEA	I
0.00000	0.30255	0.29987	0.99115	SFO--Arr_28L_ 28R _Dep_ 1L_ 1R--I	SFO	I
0.00000	0.32888	0.32753	0.99590	IAD--Arr_1C_ 1R _Dep_ 1R_ 30--V	IAD	V
0.00000	0.33403	0.31590	0.94572	DEN--Arr_7_ 16L_ 16R _Dep_ 8_ 17L_ 17R--I	DEN	I
0.00000	0.38330	0.31550	0.82311	PIT--Arr_28R_ 32 _Dep_ 28C_ 28R--I	PIT	I
0.00000	0.39408	0.39268	0.99647	MCI--Arr_1L_ 1R _Dep_ 1L_ 1R--V	MCI	V
0.00000	0.41867	0.41665	0.99519	PDX--Arr_28L_ 28R _Dep_ 28L_ 28R--I	PDX	I
0.00000	0.43268	0.43065	0.99531	CLE--Arr_24L_ 24R _Dep_ 24L_ 24R--V	CLE	V
0.00000	0.45536	0.45511	0.99946	MEM--Arr_27_ 36L_ 36R _Dep_ 36C_ 36L_ 36R--V	MEM	V
0.00000	0.52020	0.51948	0.99861	DTW--Arr_3R_ 4L_ 4R _Dep_ 3L_ 4R--V	DTW	V
0.00000	0.52681	0.29801	0.56569	CLE--Arr_6L _Dep_ 6L_ 6R--I	CLE	I
0.00000	0.54389	0.54248	0.99741	MEM--Arr_27_ 36L_ 36R _Dep_ 36L_ 36R--V	MEM	V
0.00000	0.55997	0.55741	0.99543	DTW--Arr_21L_ 22L_ 22R _Dep_ 21R_ 22L--V	DTW	V
0.00000	0.57056	0.56826	0.99596	TPA--Arr_36L_ 36R _Dep_ 36L_ 36R--V	TPA	V

0.00000	0.57237	0.53776	0.93953	MEM--Arr_18L_ 18R_ 27 _Dep_ 18L_ 18R--I	MEM	I
0.00000	0.58576	0.56467	0.96400	DTW--Arr_21L_ 22R _Dep_ 22L--V	DTW	V
0.00000	0.60264	0.60149	0.99808	MSP--Arr_30L_ 30R _Dep_ 17_ 30L_ 30R--V	MSP	V
0.00000	0.62084	0.61553	0.99144	PDX--Arr_28L_ 28R _Dep_ 28L_ 28R--V	PDX	V
0.00000	0.62692	0.34692	0.55337	BNA--Arr_2L _Dep_ 2C_ 2L--I	BNA	I
0.00000	0.64542	0.58834	0.91156	CVG--Arr_18C_ 18L_ 18R _Dep_ 18C_ 18L_ 27--V	CVG	V
0.00000	0.64771	0.61059	0.94268	IAH--Arr_26L_ 26R _Dep_ 15L_ 15R--V	IAH	V
0.00000	0.65349	0.65171	0.99728	LAX--Arr_24L_ 24R_ 25L_ 25R _Dep_ 24L_ 24R_ 25L_ 25R--I	LAX	I
0.00000	0.66763	0.65594	0.98250	CLT--Arr_18C_ 23 _Dep_ 18C_ 18L--V	CLT	V
0.00000	0.66834	0.59597	0.89171	SEA--Arr_16C_ 16L _Dep_ 16C_ 16L--V	SEA	V
0.00000	0.68109	0.65770	0.96565	SEA--Arr_34C_ 34R _Dep_ 34C_ 34R--V	SEA	V
0.00000	0.70735	0.32856	0.46449	SFO--Arr_28R _Dep_ 1L_ 1R--V	SFO	V
0.00000	0.72610	0.33228	0.45762	SFO--Arr_28R _Dep_ 1L_ 1R--I	SFO	I
0.00000	0.72908	0.69467	0.95280	MIA--Arr_8L_ 9 _Dep_ 8R_ 12--V	MIA	V
0.00000	0.73006	0.73006	1.00000	IAH--Arr_26L_ 26R_ 27 _Dep_ 15L_ 15R--V	IAH	V
0.00000	0.73020	0.72551	0.99358	MEM--Arr_18L_ 18R_ 27 _Dep_ 18L_ 18R--V	MEM	V
0.00000	0.75881	0.74566	0.98267	SLC--Arr_16L_ 16R_ 17 _Dep_ 16L_ 16R_ 17--V	SLC	V
0.00000	0.76617	0.73164	0.95493	LAX--Arr_24R_ 25L _Dep_ 24L_ 25R--V	LAX	V
0.00000	0.78074	0.74389	0.95280	SFO--Arr_28L_ 28R _Dep_ 1L_ 1R--V	SFO	V
0.00000	0.79879	0.37160	0.46521	IAD--Arr_1C _Dep_ 1R_ 30--V	IAD	V
0.00000	0.80295	0.31291	0.38970	IAD--Arr_1C _Dep_ 1R_ 30--I	IAD	I
0.00000	0.80522	0.77811	0.96633	IAD--Arr_12_ 19L_ 19R _Dep_ 19L--V	IAD	V
0.00000	0.81384	0.50684	0.62278	EWR--Arr_4R _Dep_ 4L--V	EWR	V
0.00000	0.82163	0.81858	0.99628	DTW--Arr_21R_ 22L_ 22R _Dep_ 21R_ 22L--V	DTW	V
0.00000	0.82364	0.82325	0.99953	ORD--Arr_14R_ 22R_ 27L _Dep_ 22L_ 28--V	ORD	V
0.00000	0.84763	0.84669	0.99889	LAX--Arr_24R_ 25L _Dep_ 24L_ 24R_ 25L_ 25R--I	LAX	I
0.00000	0.86267	0.86119	0.99828	ATL--Arr_8L_ 9R_ 10 _Dep_ 8R_ 9L--I	ATL	I
0.00000	0.87287	0.27258	0.31227	BNA--Arr_2L _Dep_ 2L--I	BNA	I
0.00000	0.88033	0.88021	0.99987	ORD--Arr_4R_ 9R_ 10 _Dep_ 4L_ 9R_ 32L_ 32R--V	ORD	V
0.00000	0.90671	0.90670	0.99999	ORD--Arr_22R_ 27L_ 28 _Dep_ 22L_ 32L_ 32R--V	ORD	V
0.00000	0.91085	0.90434	0.99285	ORD--Arr_22R_ 28 _Dep_ 22L_ 32L_ 32R--V	ORD	V
0.00000	0.91601	0.90968	0.99310	LAX--Arr_24R_ 25L _Dep_ 24R_ 25L--I	LAX	I
0.00000	0.92004	0.80311	0.87291	SLC--Arr_34L_ 34R_ 35 _Dep_ 34L_ 34R_ 35--V	SLC	V
0.00000	0.94222	0.91294	0.96893	IAD--Arr_12_ 19C_ 19L _Dep_ 19L--V	IAD	V
0.00000	0.94814	0.45831	0.48338	SEA--Arr_16C _Dep_ 16L--I	SEA	I
0.00000	0.94935	0.94924	0.99989	ORD--Arr_4R_ 9R_ 10 _Dep_ 4L_ 9R_ 32L--V	ORD	V

0.00000	0.97593	0.90724	0.92961	RDU--Arr_5L_ 5R_ 32 _Dep_--I	RDU	I
0.00000	0.98164	0.97775	0.99604	LAX--Arr_24R_ 25L _Dep_ 24R_ 25L--V	LAX	V
0.00000	0.99242	0.99205	0.99962	DEN--Arr_7_ 16L_ 16R _Dep_ 8_ 17L_ 17R--V	DEN	V
0.00000	0.99932	0.99862	0.99930	CLT--Arr_36L_ 36R _Dep_ 36L_ 36R--I	CLT	I
0.00000	1.00000	1.00000	1.00000	ATL--Arr_26R_ 27L_ 28 _Dep_ 26L_ 27R--V	ATL	V
0.00000	1.00000	1.00000	1.00000	ATL--Arr_26R_ 27L_ 28 _Dep_ 26L_ 27R_ 28--V	ATL	V
0.00000	1.00000	1.00000	1.00000	ATL--Arr_8L_ 9R_ 10 _Dep_ 8R_ 9L--V	ATL	V
0.00000	1.00000	1.00000	1.00000	ATL--Arr_8L_ 9R_ 10 _Dep_ 8R_ 9L_ 10--V	ATL	V
0.00000	1.00000	0.99604	0.99604	CLT--Arr_18R_ 23 _Dep_ 18L_ 18R--V	CLT	V
0.00000	1.00000	1.00000	1.00000	CLT--Arr_36L_ 36R _Dep_ 36L_ 36R--V	CLT	V
0.00000	1.00000	1.00000	1.00000	DCA--Arr_1 _Dep_ 1--V	DCA	V
0.00000	1.00000	1.00000	1.00000	DEN--Arr_16L_ 16R_ 26 _Dep_ 17L_ 17R_ 25--V	DEN	V
0.00000	1.00000	1.00000	1.00000	EWR--Arr_22L _Dep_ 22R--V	EWR	V
0.00000	1.00000	1.00000	1.00000	JFK--Arr_31L_ 31R _Dep_ 31L--V	JFK	V
0.00000	1.00000	1.00000	1.00000	LAX--Arr_24L_ 24R_ 25L_ 25R _Dep_ 24L_ 24R_ 25L_ 25R--V	LAX	V
0.00000	1.00000	1.00000	1.00000	LAX--Arr_24R_ 25L _Dep_ 24L_ 24R_ 25L_ 25R--V	LAX	V
0.00000	1.00000	0.56054	0.56054	LGA--Arr_31 _Dep_ 4--V	LGA	V
0.00000	1.00000	1.00000	1.00000	MSP--Arr_12L_ 12R _Dep_ 12L_ 12R_ 17--V	MSP	V
0.00000	1.00000	1.00000	1.00000	MSP--Arr_30L_ 30R_ 35 _Dep_ 30L_ 30R--V	MSP	V
0.00000	1.00000	1.00000	1.00000	PHX--Arr_25L_ 26 _Dep_ 25R--V	PHX	V
0.00000	1.00000	1.00000	1.00000	PHX--Arr_7R_ 8 _Dep_ 7L--V	PHX	V
0.00000	1.00000	1.00000	1.00000	RDU--Arr_23L_ 23R_ 32 _Dep_--V	RDU	V
0.00000	1.00000	1.00000	1.00000	RDU--Arr_5L_ 5R_ 32 _Dep_--V	RDU	V
0.00000	1.00000	1.00000	1.00000	SAN--Arr_27 _Dep_ 27--V	SAN	V
0.00000	1.00000	0.42846	0.42846	SEA--Arr_16C _Dep_ 16L--V	SEA	V
0.00000	1.00000	0.20618	0.20618	ABQ--Arr_26_ 30 _Dep_ 26_ 30--I	ABQ	I
0.00000	1.00000	0.21617	0.21617	ABQ--Arr_8 _Dep_ 8--I	ABQ	I
0.00000	1.00000	1.00000	1.00000	ATL--Arr_26R_ 27L_ 28 _Dep_ 26L_ 27R_ 28--I	ATL	I
0.00000	1.00000	0.68340	0.68340	BOS--Arr_4R _Dep_ 4R_ 9--I	BOS	I
0.00000	1.00000	1.00000	1.00000	DEN--Arr_16L_ 16R_ 26 _Dep_ 17L_ 17R_ 25--I	DEN	I
0.00000	1.00000	0.06226	0.06226	LAS--Arr_1L_ 1R _Dep_ 7L--I	LAS	I
0.00000	1.00000	0.06226	0.06226	LAS--Arr_1L_ 25L _Dep_ 1R--I	LAS	I
0.00000	1.00000	0.06226	0.06226	LAS--Arr_7R_ 19R _Dep_ 7L--I	LAS	I
0.00000	1.00000	1.00000	1.00000	ORD--Arr_22R_ 28 _Dep_ 22L_ 32L_ 32R--I	ORD	I
0.00000	1.00000	1.00000	1.00000	ORD--Arr_27L_ 28 _Dep_ 22L_ 32L_ 32R--I	ORD	I
0.00000	1.00000	1.00000	1.00000	RDU--Arr_23L_ 23R_ 32 _Dep_--I	RDU	I

Appendix 9: The Revised Sorted Configuration Candidate Data

BetaK Value	BCC Value-TechEff	CCR Value-TechEff	Scale Efficiency	Configuration	LOCID	Visibility
0.84117	0.24015	0.10625	0.44242	TEB--Arr_24 _Dep_ 24--V	TEB	V
0.83847	0.10395	0.05178	0.49811	TEB--Arr_6 _Dep_ 1--I	TEB	I
0.83414	0.36445	0.35919	0.98559	SFO--Arr_19L_ 19R _Dep_ 10L_ 10R--I	SFO	I
0.83369	0.22639	0.10125	0.44723	TEB--Arr_1 _Dep_ 1--V	TEB	V
0.83305	0.21933	0.09148	0.41710	TEB--Arr_1 _Dep_ 1--I	TEB	I
0.83044	0.09824	0.04892	0.49797	TEB--Arr_19 _Dep_ 24--I	TEB	I
0.82101	0.18446	0.07725	0.41879	TEB--Arr_19 _Dep_ 19--I	TEB	I
0.80855	0.23882	0.10693	0.44773	TEB--Arr_19 _Dep_ 19--V	TEB	V
0.80320	0.11668	0.08006	0.68611	TEB--Arr_6 _Dep_ 1--V	TEB	V
0.79724	0.13226	0.13217	0.99928	TEB--Arr_19 _Dep_ 24--V	TEB	V
0.78922	0.27612	0.10860	0.39332	TEB--Arr_24 _Dep_ 24--I	TEB	I
0.78442	0.67641	0.62877	0.92957	JFK--Arr_22L_ 22R _Dep_ 22R--I	JFK	I
0.77819	0.78128	0.38701	0.49535	LGA--Arr_4 _Dep_ 13--I	LGA	I
0.76141	0.45161	0.40982	0.90745	PHX--Arr_25L_ 26 _Dep_ 25R--I	PHX	I
0.75447	0.72348	0.33490	0.46289	JFK--Arr_4R _Dep_ 4L--I	JFK	I
0.75338	**0.84405**	**0.39226**	**0.46473**	**JFK--Arr_4R _Dep_ 4L_ 31L--I**	**JFK**	**I**
0.74612	0.20238	0.20238	1.00000	DEN--Arr_26_ 35L_ 35R _Dep_ 25_ 34L_ 34R--I	DEN	I
0.74424	0.60487	0.60239	0.99590	IAH--Arr_26L_ 26R_ 27 _Dep_ 33L_ 33R--I	IAH	I
0.73366	0.75130	0.37430	0.49820	EWR--Arr_4R _Dep_ 4L--I	EWR	I
0.73255	0.60145	0.59785	0.99403	ORD--Arr_27L_ 28 _Dep_ 22L_ 32L_ 32R--V	ORD	V
0.72962	**0.83397**	**0.39018**	**0.46786**	**PHL--Arr_9R _Dep_ 8_ 9L--I**	**PHL**	**I**
0.72069	**0.83601**	**0.39808**	**0.47616**	**LGA--Arr_22 _Dep_ 13--I**	**LGA**	**I**
0.71986	**1.00000**	**0.38660**	**0.38660**	**JFK--Arr_22L _Dep_ 22R_ 31L--I**	**JFK**	**I**
0.71659	0.77546	0.36456	0.47012	JFK--Arr_22L _Dep_ 22R--I	JFK	I
0.69999	**1.00000**	**0.34092**	**0.34092**	**JFK--Arr_13L _Dep_ 13R--I**	**JFK**	**I**
0.69973	**0.81066**	**0.39854**	**0.49162**	**EWR--Arr_22L _Dep_ 22R--I**	**EWR**	**I**
0.69849	0.06715	0.06293	0.93703	CLE--Arr_6L_ 10 _Dep_ 6L_ 6R--I	CLE	I

0.69577	**1.00000**	**0.41611**	**0.41611**	**LGA--Arr_31 _Dep_ 4--I**	**LGA**	**I**
0.69553	0.44476	0.38683	0.86975	PHX--Arr_7R_ 8 _Dep_ 7L--I	PHX	I
0.66217	0.33509	0.32789	0.97851	LAS--Arr_19R_ 25L _Dep_ 19L_ 25R--I	LAS	I
0.66198	0.18116	0.17056	0.94149	HOU--Arr_12L_ 12R _Dep_ 12R--I	HOU	I
0.66175	0.23796	0.23234	0.97639	IAD--Arr_1L_ 1R _Dep_ 1R_ 30--I	IAD	I
0.65615	0.40587	0.39735	0.97901	SFO--Arr_19L_ 19R _Dep_ 10L_ 10R--V	SFO	V
0.65405	0.31799	0.29428	0.92542	JFK--Arr_13L_ 22L _Dep_ 13R--I	JFK	I
0.64793	0.25194	0.24684	0.97974	PHL--Arr_9R_ 35 _Dep_ 8_ 9L_ 35--I	PHL	I
0.64703	0.34051	0.33433	0.98186	PHL--Arr_9R_ 17 _Dep_ 8_ 9L_ 17--I	PHL	I
0.64189	0.10326	0.10229	0.99058	PBI--Arr_9L_ 9R_ 13 _Dep_ 9L_ 9R_ 13--I	PBI	I
0.64156	0.74208	0.29384	0.39596	LGA--Arr_31 _Dep_ 31--I	LGA	I
0.63857	0.42248	0.41855	0.99070	STL--Arr_30L_ 30R _Dep_ 30L_ 30R--I	STL	I
0.62965	**1.00000**	**0.21631**	**0.21631**	**ABQ--Arr_21 _Dep_ 21--I**	**ABQ**	**I**
0.62494	0.74754	0.20859	0.27904	MSY--Arr_1 _Dep_ 1--I	MSY	I
0.62241	0.44771	0.19188	0.42858	HOU--Arr_12R _Dep_ 12R--I	HOU	I
0.62184	0.26629	0.18672	0.70118	ABQ--Arr_3_ 8 _Dep_ 8--I	ABQ	I
0.62161	0.37185	0.34077	0.91641	LAS--Arr_1L_ 25R _Dep_ 1R--I	LAS	I
0.61618	0.51156	0.51059	0.99810	DEN--Arr_34R_ 35L_ 35R _Dep_ 25_ 34L_ 34R--I	DEN	I
0.60556	0.37030	0.35334	0.95422	IAD--Arr_19L_ 19R _Dep_ 30--I	IAD	I
0.60403	0.12985	0.12756	0.98236	PBI--Arr_9L_ 9R _Dep_ 9L_ 9R--I	PBI	I
0.60401	0.45099	0.44726	0.99172	JFK--Arr_22L_ 22R _Dep_ 22R_ 31L--V	JFK	V
0.60102	**1.00000**	**0.37537**	**0.37537**	**JFK--Arr_31R _Dep_ 31L--I**	**JFK**	**I**
0.59580	0.23080	0.23034	0.99801	BNA--Arr_2C_ 2L_ 2R _Dep_ 2C_ 2L_ 2R--I	BNA	I
0.59213	0.22541	0.21953	0.97392	PHL--Arr_26_ 27R_ 35 _Dep_ 27L_ 35--I	PHL	I
0.58481	0.79386	0.35019	0.44113	LGA--Arr_22 _Dep_ 31--I	LGA	I
0.58237	0.63412	0.51715	0.81553	BOS--Arr_27_ 32 _Dep_ 33L--I	BOS	I
0.57998	0.31607	0.28324	0.89614	EWR--Arr_11_ 22L _Dep_ 22R--I	EWR	I
0.57961	0.35519	0.35460	0.99834	DEN--Arr_34R_ 35L_ 35R _Dep_ 8_ 34L_ 34R--I	DEN	I
0.57753	0.31386	0.31249	0.99564	OAK--Arr_9L_ 9R_ 11 _Dep_ 9L_ 9R_ 11--I	OAK	I

0.57249	0.43080	0.39480	0.91642	DTW--Arr_21L_ 22R _Dep_ 21R--I	DTW	I
0.56793	0.77859	0.34484	0.44291	MDW--Arr_4R _Dep_ 4R--I	MDW	I
0.56031	0.25819	0.25669	0.99419	ORD--Arr_14R_ 22R_ 27L _Dep_ 22L_ 28--I	ORD	I
0.55812	0.74328	0.70683	0.95096	JFK--Arr_22L_ 22R _Dep_ 22R--V	JFK	V
0.55790	0.31175	0.11957	0.38353	PIT--Arr_28L _Dep_ 28C--I	PIT	I
0.54960	0.73454	0.34532	0.47011	JFK--Arr_22L _Dep_ 22R--V	JFK	V
0.53606	0.18614	0.18187	0.97708	IND--Arr_IN_ ONE _Dep_ ONE_ OUT--I	IND	I
0.53413	0.32799	0.32102	0.97873	BOS--Arr_22L_ 27 _Dep_ 22L_ 22R--I	BOS	I
0.53406	0.49203	0.48886	0.99356	IAH--Arr_8L_ 8R _Dep_ 9_ 15L_ 15R--I	IAH	I
0.53348	0.26865	0.26700	0.99388	RDU--Arr_23L_ 23R _Dep_ 23L_ 23R--I	RDU	I
0.53334	0.54310	0.54204	0.99805	MEM--Arr_18L_ 18R _Dep_ 18L_ 18R--I	MEM	I
0.53329	**0.85344**	**0.75196**	**0.88110**	**JFK--Arr_31L_ 31R _Dep_ 31L--I**	**JFK**	**I**
0.53283	0.68511	0.29737	0.43405	PHL--Arr_9R _Dep_ 8_ 9L--V	PHL	V
0.53229	0.31641	0.31261	0.98798	IAH--Arr_8L_ 8R _Dep_ 15L_ 15R--I	IAH	I
0.53114	0.10741	0.10112	0.94139	HOU--Arr_12L_ 12R _Dep_ 22--I	HOU	I
0.52967	0.21211	0.20767	0.97904	PBI--Arr_27L_ 27R_ 31 _Dep_ 27L_ 27R_ 31--I	PBI	I
0.52837	0.41031	0.27749	0.67629	MDW--Arr_22L_ 31C _Dep_ 22L--I	MDW	I
0.52808	0.49132	0.22573	0.45944	CLE--Arr_6L _Dep_ 6R--I	CLE	I
0.52637	**1.00000**	**0.17628**	**0.17628**	**MDW--Arr_31C _Dep_ 22L--I**	**MDW**	**I**
0.52483	0.17220	0.17217	0.99980	PBI--Arr_27L_ 27R_ 31 _Dep_ 27L_ 27R_ 31--V	PBI	V
0.52459	0.33297	0.31651	0.95057	IAD--Arr_1L_ 1R _Dep_ 30--I	IAD	I
0.51534	0.46793	0.46598	0.99583	FLL--Arr_27L_ 27R _Dep_ 27L_ 27R--I	FLL	I
0.51217	0.27054	0.26755	0.98893	MIA--Arr_8L_ 9 _Dep_ 8R_ 12--I	MIA	I
0.51195	0.73461	0.30303	0.41250	BOS--Arr_22L _Dep_ 22R--I	BOS	I
0.50984	0.16496	0.16086	0.97515	ABQ--Arr_3_ 8 _Dep_ 3_ 8--I	ABQ	I
0.50886	0.54287	0.53737	0.98987	SFO--Arr_28L_ 28R _Dep_ 28L_ 28R--I	SFO	I
0.50505	0.29816	0.29771	0.99849	OAK--Arr_9L_ 9R_ 11 _Dep_ 9L_ 9R_ 11--V	OAK	V
0.50417	0.21084	0.20350	0.96521	IAD--Arr_19L_ 19R _Dep_ 19L_ 30--I	IAD	I
0.50021	0.28470	0.28352	0.99584	CVG--Arr_36C_ 36L_ 36R _Dep_ 27_ 36C_ 36R--I	CVG	I

0.49905	0.15165	0.14120	0.93108	JFK--Arr_22L_ 22R _Dep_ 22R_ 31L--I	JFK	I
0.49892	0.60005	0.59589	0.99306	MEM--Arr_36L_ 36R _Dep_ 36L_ 36R--I	MEM	I
0.49234	0.57290	0.24834	0.43347	IAD--Arr_1L _Dep_ 1R_ 30--I	IAD	I
0.49170	0.33846	0.32301	0.95433	IAD--Arr_19L_ 19R _Dep_ 30--V	IAD	V
0.49070	0.29146	0.29089	0.99803	IND--Arr_5L_ 5R _Dep_ 5L_ 5R--I	IND	I
0.48967	0.15244	0.14882	0.97624	PBI--Arr_27L_ 27R _Dep_ 27L_ 27R--I	PBI	I
0.48871	0.48812	0.18718	0.38346	BWI--Arr_33L _Dep_ 28--I	BWI	I
0.48608	0.14032	0.13957	0.99466	PIT--Arr_28L_ 28R _Dep_ 28C_ 28R--I	PIT	I
0.48351	0.53634	0.23671	0.44135	CLE--Arr_24R _Dep_ 24L--I	CLE	I
0.47986	0.09732	0.09677	0.99431	DEN--Arr_16L_ 16R_ 17R _Dep_ 8_ 17L_ 17R--I	DEN	I
0.47871	0.38688	0.36736	0.94956	IAD--Arr_19C_ 19L _Dep_ 30--I	IAD	I
0.47792	0.15394	0.14853	0.96484	CLE--Arr_24L_ 24R _Dep_ 24L_ 24R--I	CLE	I
0.47759	0.28255	0.28137	0.99580	TPA--Arr_18L_ 18R _Dep_ 18L_ 18R--I	TPA	I
0.47466	0.13030	0.12853	0.98640	PIT--Arr_10L_ 10R _Dep_ 10C_ 14--I	PIT	I
0.46941	0.23580	0.23106	0.97991	STL--Arr_11_ 12R _Dep_ 12L_ 12R--I	STL	I
0.46624	0.29063	0.28977	0.99704	MCI--Arr_1L_ 1R _Dep_ 1L_ 1R--I	MCI	I
0.46541	0.51656	0.51145	0.99010	PHL--Arr_9R_ 17 _Dep_ 8_ 9L_ 17--V	PHL	V
0.46452	0.43547	0.43111	0.98998	DTW--Arr_3R_ 4L _Dep_ 3L_ 4R--I	DTW	I
0.46339	0.61768	0.61628	0.99772	MEM--Arr_18L_ 18R _Dep_ 18C_ 18L_ 18R--I	MEM	I
0.45961	0.26652	0.26113	0.97978	MIA--Arr_26R_ 30 _Dep_ 26L_ 27--I	MIA	I
0.45886	0.24716	0.24660	0.99776	BNA--Arr_20C_ 20L_ 20R _Dep_ 20C_ 20L_ 20R--I	BNA	I
0.45842	0.31213	0.30983	0.99263	MEM--Arr_9_ 36L_ 36R _Dep_ 36C_ 36L_ 36R--I	MEM	I
0.45077	0.47831	0.17002	0.35545	PIT--Arr_10R _Dep_ 10C_ 14--I	PIT	I
0.44603	0.28759	0.28572	0.99352	RDU--Arr_5L_ 5R _Dep_ 5L_ 5R--I	RDU	I
0.44365	0.66654	0.66551	0.99845	DFW--Arr_35C_ 35R_ 36L _Dep_ 31L_ 35L_ 36R--I	DFW	I
0.44145	0.39804	0.39760	0.99890	LAS--Arr_19L_ 19R_ 25L _Dep_ 19L_ 19R_ 25R--V	LAS	V
0.44082	0.28353	0.28209	0.99491	RDU--Arr_23L_ 23R _Dep_ 23L_ 23R--V	RDU	V
0.43927	0.39413	0.39291	0.99691	FLL--Arr_27L_ 27R _Dep_ 27L_ 27R--V	FLL	V
0.43825	0.75000	0.33841	0.45122	LGA--Arr_31 _Dep_ 31--V	LGA	V

0.43808	0.07452	0.07318	0.98199	DEN--Arr_16L_ 16R_ 17R _Dep_ 8_ 17L_ 17R_ 25--I	DEN	I
0.43436	0.14893	0.14571	0.97839	BWI--Arr_10_ 15L _Dep_ 15L_ 15R--I	BWI	I
0.43416	0.54059	0.23713	0.43866	HOU--Arr_22 _Dep_ 22--V	HOU	V
0.42973	0.21056	0.20414	0.96952	IAD--Arr_1C_ 1R _Dep_ 1R_ 30--I	IAD	I
0.42471	0.64597	0.64386	0.99673	MEM--Arr_36L_ 36R _Dep_ 36C_ 36L_ 36R--I	MEM	I
0.42284	0.50020	0.49783	0.99527	CVG--Arr_36C_ 36L_ 36R _Dep_ 36C_ 36R--I	CVG	I
0.41518	0.73487	0.73487	1.00000	DEN--Arr_34R_ 35L_ 35R _Dep_ 8_ 25_ 34L_ 34R--I	DEN	I
0.41498	0.31576	0.28395	0.89926	BWI--Arr_33L_ 33R _Dep_ 28--I	BWI	I
0.41274	**1.00000**	**0.53275**	**0.53275**	**JFK--Arr_22L _Dep_ 22R_ 31L--V**	**JFK**	**V**
0.41265	**0.80065**	**0.31723**	**0.39622**	**IND--Arr_32 _Dep_ 32--I**	**IND**	**I**
0.41245	0.20327	0.19796	0.97387	STL--Arr_11_ 12L _Dep_ 12L_ 12R--I	STL	I
0.40831	0.60869	0.25405	0.41736	BNA--Arr_20R _Dep_ 20R--I	BNA	I
0.40803	**0.82250**	**0.36307**	**0.44142**	**JFK--Arr_13L _Dep_ 13R--V**	**JFK**	**V**
0.40679	0.60025	0.59933	0.99846	ORD--Arr_4R_ 9R_ 10 _Dep_ 4L_ 9R_ 32L_ 32R--I	ORD	I
0.40678	0.64368	0.63132	0.98080	BOS--Arr_4L_ 4R _Dep_ 4L_ 4R_ 9--I	BOS	I
0.40336	0.28486	0.28408	0.99728	IND--Arr_23L_ 23R _Dep_ 23L_ 23R--I	IND	I
0.40321	0.26185	0.20151	0.76955	PBI--Arr_9L_ 9R_ 13 _Dep_ 9L_ 9R_ 13--V	PBI	V
0.40243	0.20254	0.19751	0.97515	IAD--Arr_19C_ 19L _Dep_ 19L_ 30--I	IAD	I
0.40027	**0.95531**	**0.39098**	**0.40927**	**JFK--Arr_4R _Dep_ 4L--V**	**JFK**	**V**
0.40018	0.56732	0.56228	0.99112	MEM--Arr_27_ 36L_ 36R _Dep_ 36L_ 36R--I	MEM	I
0.39776	0.12468	0.12432	0.99713	PBI--Arr_27L_ 27R _Dep_ 27L_ 27R--V	PBI	V
0.39711	0.41092	0.38010	0.92499	MCO--Arr_17L_ 18R _Dep_ 17R_ 18R--I	MCO	I
0.39557	0.57590	0.33494	0.58158	CLE--Arr_24R _Dep_ 24L_ 24R--I	CLE	I
0.39335	0.73161	0.35738	0.48848	JFK--Arr_31R _Dep_ 31L--V	JFK	V
0.39094	0.67084	0.66984	0.99851	ORD--Arr_4R_ 9R_ 10 _Dep_ 4L_ 9R_ 32L--I	ORD	I
0.39080	0.37351	0.16266	0.43548	HOU--Arr_22 _Dep_ 22--I	HOU	I
0.39060	0.23496	0.23431	0.99723	STL--Arr_30L_ 30R _Dep_ 29_ 30L--I	STL	I
0.37958	0.29901	0.29693	0.99304	RDU--Arr_23L_ 23R_ 32 _Dep_ 23L_ 23R--I	RDU	I
0.37834	0.30490	0.30366	0.99593	MCI--Arr_19L_ 19R _Dep_ 19L_ 19R--I	MCI	I

0.37821	0.29173	0.28961	0.99273	MCO--Arr_35R_ 36R _Dep_ 35L_ 36L--I	MCO	I
0.37762	0.58053	0.22434	0.38644	CLE--Arr_24L _Dep_ 24R--I	CLE	I
0.37487	0.58971	0.23114	0.39195	BWI--Arr_10 _Dep_ 15R--I	BWI	I
0.37364	0.35822	0.35710	0.99688	MEM--Arr_18L_ 18R_ 27 _Dep_ 18C_ 18L_ 18R--I	MEM	I
0.37342	0.37329	0.37239	0.99757	FLL--Arr_9L_ 9R _Dep_ 9L_ 9R--I	FLL	I
0.37254	0.38721	0.35546	0.91801	LAS--Arr_1L_ 25R _Dep_ 1R--V	LAS	V
0.36984	0.13871	0.13242	0.95462	STL--Arr_11_ 12L _Dep_ 12R--I	STL	I
0.36854	**1.00000**	**0.55800**	**0.55800**	**LGA--Arr_22 _Dep_ 13--V**	**LGA**	**V**
0.36804	0.63175	0.56914	0.90089	EWR--Arr_11_ 22L _Dep_ 22R--V	EWR	V
0.36648	0.24207	0.23909	0.98769	SJC--Arr_11_ 12L_ 12R _Dep_ 11_ 12L_ 12R--I	SJC	I
0.36342	0.37192	0.35574	0.95649	IAD--Arr_1C_ 1R _Dep_ 30--I	IAD	I
0.36145	0.56023	0.55675	0.99378	CVG--Arr_18C_ 18L_ 18R _Dep_ 18C_ 18L--I	CVG	I
0.36064	0.29650	0.28931	0.97575	MIA--Arr_26R_ 30 _Dep_ 26L_ 27--V	MIA	V
0.36041	0.12558	0.11607	0.92429	PBI--Arr_9L_ 9R _Dep_ 9L_ 9R--V	PBI	V
0.36000	**0.87070**	**0.86135**	**0.98926**	**CLT--Arr_36C_ 36R _Dep_ 36C_ 36R--I**	**CLT**	**I**
0.35996	0.55977	0.52861	0.94434	EWR--Arr_4R_ 11 _Dep_ 4L--V	EWR	V
0.35719	0.26135	0.25982	0.99415	RDU--Arr_5L_ 5R_ 32 _Dep_ 5L_ 5R--I	RDU	I
0.35712	0.76034	0.31534	0.41474	RDU--Arr_23R _Dep_ 23R--I	RDU	I
0.35694	0.44482	0.41651	0.93635	EWR--Arr_4R_ 11 _Dep_ 4L--I	EWR	I
0.35609	0.22840	0.19306	0.84529	HOU--Arr_12L_ 12R _Dep_ 12R--V	HOU	V
0.35326	0.55287	0.54680	0.98902	IAH--Arr_26L_ 26R _Dep_ 15L_ 15R--I	IAH	I
0.35295	0.58141	0.25827	0.44421	RDU--Arr_23R _Dep_ 23R--V	RDU	V
0.35212	0.67155	0.29745	0.44293	IND--Arr_32 _Dep_ 32--V	IND	V
0.35158	0.51857	0.48328	0.93195	JFK--Arr_13L_ 22L _Dep_ 13R--V	JFK	V
0.34682	0.27372	0.27173	0.99273	MCO--Arr_17L_ 18R _Dep_ 17R_ 18L--I	MCO	I
0.34620	0.19093	0.18793	0.98428	DTW--Arr_21R_ 22L_ 22R _Dep_ 21R_ 22L--I	DTW	I
0.34416	0.19899	0.19273	0.96855	PIT--Arr_28R_ 32 _Dep_ 28L_ 28R--I	PIT	I
0.34177	0.06138	0.05958	0.97070	ORD--Arr_27L_ 27R_ 28 _Dep_ 22L_ 32L--I	ORD	I
0.33949	0.24341	0.24334	0.99973	BNA--Arr_2C_ 2L_ 2R _Dep_ 2C_ 2L_ 2R--V	BNA	V

0.33921	**1.00000**	**0.25909**	**0.25909**	**MDW--Arr_4R _Dep_ 31C--I**	**MDW**	**I**
0.33810	0.09290	0.09221	0.99255	HOU--Arr_12L_ 12R _Dep_ 4_ 22--I	HOU	I
0.33783	0.43501	0.42603	0.97935	DTW--Arr_21L_ 22R _Dep_ 21R_ 22L--I	DTW	I
0.33680	0.32619	0.32374	0.99248	MCO--Arr_17L_ 18L _Dep_ 17R_ 18R--V	MCO	V
0.33442	0.36065	0.35925	0.99612	STL--Arr_12L_ 12R _Dep_ 12L_ 12R--I	STL	I
0.33404	0.51783	0.51738	0.99914	MEM--Arr_18L_ 18R _Dep_ 18C_ 18L_ 18R--V	MEM	V
0.33290	0.23803	0.23772	0.99872	SJC--Arr_11_ 12L_ 12R _Dep_ 11_ 12L_ 12R--V	SJC	V
0.32825	0.25844	0.25660	0.99290	IAD--Arr_19C_ 19L _Dep_ 19L_ 30--V	IAD	V
0.32747	**1.00000**	**0.57314**	**0.57314**	**LGA--Arr_22 _Dep_ 31--V**	**LGA**	**V**
0.32720	0.27035	0.26897	0.99487	RDU--Arr_5L_ 5R _Dep_ 5L_ 5R--V	RDU	V
0.32592	0.52264	0.20234	0.38716	MDW--Arr_31C _Dep_ 22L--V	MDW	V
0.32369	0.67619	0.28719	0.42471	BWI--Arr_10 _Dep_ 15L_ 15R--I	BWI	I
0.32265	0.44443	0.19964	0.44921	HOU--Arr_12R _Dep_ 12R--V	HOU	V
0.32163	**1.00000**	**0.45202**	**0.45202**	**DCA--Arr_1 _Dep_ 1--I**	**DCA**	**I**
0.32161	0.42912	0.23124	0.53888	BNA--Arr_20R _Dep_ 20C_ 20R--I	BNA	I
0.31944	0.54564	0.54424	0.99742	MEM--Arr_18L_ 18R _Dep_ 18L_ 18R--V	MEM	V
0.31904	0.53458	0.53320	0.99742	IAH--Arr_26L_ 26R_ 27 _Dep_ 33L_ 33R--V	IAH	V
0.31814	0.48748	0.42131	0.86426	SEA--Arr_16C_ 16L _Dep_ 16L--I	SEA	I
0.31749	0.56011	0.54458	0.97227	CLT--Arr_18C_ 23 _Dep_ 18C_ 18L--I	CLT	I
0.31411	0.55276	0.55237	0.99928	DFW--Arr_31R_ 35C_ 35R_ 36L _Dep_ 31L_ 35L_ 36R--I	DFW	I
0.31204	0.37325	0.16484	0.44162	ABQ--Arr_21 _Dep_ 21--V	ABQ	V
0.30995	0.42121	0.40383	0.95873	IAD--Arr_19C_ 19L _Dep_ 30--V	IAD	V
0.30825	0.23972	0.23952	0.99916	CVG--Arr_18C_ 18L_ 18R _Dep_ 18C_ 18L_ 27--I	CVG	I
0.30534	0.68712	0.68626	0.99875	MSP--Arr_30L_ 30R _Dep_ 30L_ 30R--I	MSP	I
0.30468	**0.80743**	**0.36349**	**0.45018**	**DCA--Arr_19 _Dep_ 19--I**	**DCA**	**I**
0.30458	0.24302	0.24102	0.99177	BWI--Arr_10_ 15L _Dep_ 15L_ 15R--V	BWI	V
0.30135	0.63931	0.28406	0.44432	RDU--Arr_5L _Dep_ 5L--I	RDU	I
0.30127	0.27620	0.27281	0.98772	SEA--Arr_16L_ 16R _Dep_ 16C_ 16L--I	SEA	I
0.29746	0.15376	0.15259	0.99241	HOU--Arr_12L_ 12R _Dep_ 4_ 22--V	HOU	V

0.29704	0.51227	0.50802	0.99172	PHL--Arr_9R_ 35 _Dep_ 8_ 9L_ 35--V	PHL	V
0.29366	0.31325	0.30999	0.98959	IAD--Arr_19L_ 19R _Dep_ 19L_ 30--V	IAD	V
0.29302	0.27727	0.26947	0.97185	BOS--Arr_4L_ 4R _Dep_ 4R_ 9--I	BOS	I
0.29157	0.32092	0.31720	0.98842	MCO--Arr_17L_ 18L _Dep_ 17R_ 18R--I	MCO	I
0.29119	**0.93906**	**0.16420**	**0.17485**	**MSY--Arr_19 _Dep_ 28--I**	**MSY**	**I**
0.29060	0.58481	0.26044	0.44534	BNA--Arr_20R _Dep_ 20R--V	BNA	V
0.28986	0.57633	0.33338	0.57846	CLE--Arr_24L _Dep_ 24L_ 24R--I	CLE	I
0.28891	0.31746	0.31742	0.99987	DEN--Arr_16L_ 16R_ 17R _Dep_ 8_ 17L_ 17R--V	DEN	V
0.28815	0.65749	0.53114	0.80783	IAD--Arr_12_ 19L_ 19R _Dep_ 19L--I	IAD	I
0.28799	0.37101	0.37098	0.99993	DEN--Arr_34R_ 35L_ 35R _Dep_ 8_ 34L_ 34R--V	DEN	V
0.28562	0.28727	0.28427	0.98956	RDU--Arr_23L_ 23R_ 32 _Dep_ 23L_ 23R--V	RDU	V
0.28244	0.87412	0.39310	0.44971	MDW--Arr_31C _Dep_ 31C--I	MDW	I
0.28111	**1.00000**	**0.50392**	**0.50392**	**JFK--Arr_4R _Dep_ 4L_ 31L--V**	**JFK**	**V**
0.28015	0.50923	0.49790	0.97774	DTW--Arr_21L_ 22L_ 22R _Dep_ 21R_ 22L--I	DTW	I
0.27661	0.75468	0.34339	0.45501	IAD--Arr_1L _Dep_ 1R_ 30--V	IAD	V
0.27496	**1.00000**	**0.49851**	**0.49851**	**LGA--Arr_4 _Dep_ 13--V**	**LGA**	**V**
0.27418	0.16076	0.15925	0.99066	SJC--Arr_29_ 30L _Dep_ 29_ 30L_ 30R--I	SJC	I
0.27183	0.51189	0.51093	0.99811	SLC--Arr_16L_ 16R_ 17 _Dep_ 16L_ 16R_ 17--I	SLC	I
0.27091	0.32321	0.12342	0.38187	HOU--Arr_4 _Dep_ 30L--V	HOU	V
0.26764	0.53296	0.12080	0.22666	MSY--Arr_1 _Dep_ 28--I	MSY	I
0.26560	0.48752	0.46182	0.94729	LAS--Arr_1L_ 25L _Dep_ 1R--V	LAS	V
0.26513	0.26273	0.25962	0.98814	STL--Arr_11_ 12R _Dep_ 12L_ 12R--V	STL	V
0.26241	0.42350	0.16020	0.37828	PIT--Arr_28L _Dep_ 28C--V	PIT	V
0.26015	0.33207	0.32974	0.99297	IAD--Arr_1L_ 1R _Dep_ 1R_ 30--V	IAD	V
0.25923	0.39364	0.37674	0.95708	MDW--Arr_22L_ 31C _Dep_ 22L--V	MDW	V
0.25769	0.61893	0.24254	0.39187	BWI--Arr_10 _Dep_ 15L_ 15R--V	BWI	V
0.25681	0.26142	0.26004	0.99472	PIT--Arr_28L_ 28R _Dep_ 28C_ 28R--V	PIT	V
0.25595	0.57591	0.26252	0.45585	RDU--Arr_5L _Dep_ 5L--V	RDU	V
0.25241	0.40586	0.37984	0.93590	IAD--Arr_1L_ 1R _Dep_ 30--V	IAD	V

0.25222	0.53156	0.53112	0.99916	SLC--Arr_34L_ 34R_ 35 _Dep_ 34L_ 34R_ 35--I	SLC	I
0.25168	0.65391	0.65283	0.99836	MSP--Arr_12L_ 12R _Dep_ 12L_ 12R_ 17--I	MSP	I
0.25116	0.43735	0.41011	0.93770	LAS--Arr_1L_ 1R _Dep_ 7L--V	LAS	V
0.25006	0.38272	0.17235	0.45033	HOU--Arr_4 _Dep_ 4--I	HOU	I
0.24969	0.24375	0.24360	0.99937	BNA--Arr_20C_ 20L_ 20R _Dep_ 20C_ 20L_ 20R--V	BNA	V
0.24961	0.59466	0.23662	0.39790	CLE--Arr_6L _Dep_ 6R--V	CLE	V
0.24920	0.25399	0.24863	0.97892	BWI--Arr_33L_ 33R _Dep_ 28_ 33R--I	BWI	I
0.24886	0.17517	0.16311	0.93114	BOS--Arr_22L_ 27 _Dep_ 22R--I	BOS	I
0.24845	0.25059	0.25037	0.99911	CVG--Arr_36C_ 36L_ 36R _Dep_ 27_ 36C_ 36R--V	CVG	V
0.24783	0.34239	0.33989	0.99272	TPA--Arr_36L_ 36R _Dep_ 36L_ 36R--I	TPA	I
0.24668	0.17450	0.16578	0.95004	ABQ--Arr_26_ 30 _Dep_ 26_ 30--V	ABQ	V
0.24553	0.48166	0.46434	0.96405	DTW--Arr_21L_ 22R _Dep_ 21R--V	DTW	V
0.24498	0.57279	0.56557	0.98740	CLT--Arr_18R_ 23 _Dep_ 18L_ 18R--I	CLT	I
0.24474	0.14751	0.13161	0.89217	CLE--Arr_6L_ 10 _Dep_ 6R--I	CLE	I
0.23827	0.30522	0.30483	0.99871	MEM--Arr_27_ 36L_ 36R _Dep_ 36C_ 36L_ 36R--I	MEM	I
0.23705	0.26314	0.25343	0.96311	BNA--Arr_20C_ 20R _Dep_ 20C_ 20R--I	BNA	I
0.23626	0.24206	0.23766	0.98181	STL--Arr_29_ 30R _Dep_ 29_ 30L--I	STL	I
0.23271	0.34465	0.34136	0.99044	MCO--Arr_17L_ 18R _Dep_ 17R_ 18R--V	MCO	V
0.22911	0.20234	0.20141	0.99536	IND--Arr_IN_ ONE _Dep_ ONE_ OUT--V	IND	V
0.22628	0.15374	0.15195	0.98834	PIT--Arr_28R_ 32 _Dep_ 28C_ 28R--V	PIT	V
0.22586	0.59946	0.59860	0.99857	DFW--Arr_31R_ 35C_ 35R_ 36L _Dep_ 31L_ 35L_ 36R--V	DFW	V
0.22298	0.62354	0.62304	0.99920	DFW--Arr_35C_ 35R_ 36L _Dep_ 31L_ 35L_ 36R--V	DFW	V
0.22236	0.20846	0.15695	0.75290	HOU--Arr_12L_ 12R _Dep_ 22--V	HOU	V
0.21684	0.54777	0.54581	0.99642	MSP--Arr_30L_ 30R _Dep_ 30L_ 30R--V	MSP	V
0.21528	0.73807	0.73480	0.99557	SFO--Arr_28L_ 28R _Dep_ 28L_ 28R--V	SFO	V
0.21522	0.49434	0.49430	0.99992	IAH--Arr_26L_ 26R_ 27 _Dep_ 15L_ 15R--I	IAH	I
0.21478	0.17392	0.17321	0.99590	PIT--Arr_28R_ 32 _Dep_ 28L_ 28R--V	PIT	V
0.21474	0.28925	0.28789	0.99528	RDU--Arr_5L_ 5R_ 32 _Dep_ 5L_ 5R--V	RDU	V
0.21430	0.57790	0.24586	0.42544	CLE--Arr_24R _Dep_ 24L--V	CLE	V

0.21314	0.27346	0.10678	0.39047	MSY--Arr_19 _Dep_ 28--V	MSY	V
0.21301	0.44331	0.44249	0.99815	BOS--Arr_22L_ 27 _Dep_ 22L_ 22R--V	BOS	V
0.21224	0.33861	0.33606	0.99245	MCO--Arr_35R_ 36L _Dep_ 35L_ 36R--V	MCO	V
0.21152	0.55401	0.25491	0.46012	BNA--Arr_2L _Dep_ 2L--V	BNA	V
0.20675	0.54923	0.54781	0.99740	CVG--Arr_36C_ 36L_ 36R _Dep_ 36C_ 36R--V	CVG	V
0.20637	0.43291	0.13994	0.32324	HOU--Arr_4 _Dep_ 30L--I	HOU	I
0.20551	0.43312	0.27405	0.63274	HOU--Arr_4 _Dep_ 4--V	HOU	V
0.20466	0.54066	0.20581	0.38067	MDW--Arr_4R _Dep_ 31C--V	MDW	V
0.20405	0.59599	0.59338	0.99563	MCO--Arr_17L_ 18R _Dep_ 17L_ 17R_ 18L_ 18R--V	MCO	V
0.20130	0.51346	0.51111	0.99543	CVG--Arr_18C_ 18L_ 18R _Dep_ 18C_ 18L--V	CVG	V
0.19676	0.22711	0.22637	0.99677	SJC--Arr_29_ 30L _Dep_ 29_ 30L_ 30R--V	SJC	V
0.19562	0.51949	0.51942	0.99986	DFW--Arr_13R_ 17C_ 17L_ 18R _Dep_ 13L_ 17R_ 18L--I	DFW	I
0.19327	0.50215	0.49831	0.99234	DTW--Arr_3R_ 4L _Dep_ 3L_ 4R--V	DTW	V
0.19323	0.89414	0.71333	0.79779	FLL--Arr_9L_ 9R _Dep_ 9L_ 9R--V	FLL	V
0.19244	0.88290	0.87846	0.99497	CLT--Arr_36C_ 36R _Dep_ 36C_ 36R--V	CLT	V
0.19192	0.64727	0.64159	0.99122	MEM--Arr_36L_ 36R _Dep_ 36C_ 36L_ 36R--V	MEM	V
0.19007	0.16814	0.16010	0.95218	PIT--Arr_10L_ 10R _Dep_ 10C_ 14--V	PIT	V
0.18864	0.22052	0.21059	0.95495	ABQ--Arr_3_ 8 _Dep_ 3_ 8--V	ABQ	V
0.18857	0.55960	0.15135	0.27045	HOU--Arr_4 _Dep_ 12R--I	HOU	I
0.18637	0.78398	0.39792	0.50756	MDW--Arr_22L _Dep_ 22L--V	MDW	V
0.18516	0.50779	0.46124	0.90833	BOS--Arr_27_ 32 _Dep_ 33L--V	BOS	V
0.18028	0.57624	0.54576	0.94711	SEA--Arr_16C_ 16L _Dep_ 16L--V	SEA	V
0.17932	0.61556	0.61091	0.99244	IAH--Arr_8L_ 8R _Dep_ 15L_ 15R--V	IAH	V
0.17916	0.91538	0.58993	0.64446	BOS--Arr_4R _Dep_ 4R_ 9--V	BOS	V
0.17599	0.91432	0.91432	1.00000	ATL--Arr_8L_ 9R_ 10 _Dep_ 8R_ 9L_ 10--I	ATL	I
0.17573	0.42024	0.37415	0.89032	PDX--Arr_10L_ 10R _Dep_ 10L_ 10R--I	PDX	I
0.17508	0.88262	0.88112	0.99831	ATL--Arr_26R_ 27L_ 28 _Dep_ 26L_ 27R--I	ATL	I
0.17491	0.48988	0.46868	0.95673	DTW--Arr_21L_ 22R _Dep_ 22L--I	DTW	I
0.17302	0.27334	0.27114	0.99194	STL--Arr_11_ 12L _Dep_ 12L_ 12R--V	STL	V

0.17192	0.15549	0.14724	0.94697	MSY--Arr_1_ 10 _Dep_ 1--I	MSY	I
0.16937	0.77085	0.51031	0.66201	MDW--Arr_4R _Dep_ 4R--V	MDW	V
0.16909	0.73161	0.72903	0.99648	MSP--Arr_30L_ 30R_ 35 _Dep_ 30L_ 30R--I	MSP	I
0.16856	0.17437	0.17183	0.98543	SEA--Arr_34C_ 34R _Dep_ 34C_ 34R--I	SEA	I
0.16855	0.58717	0.58279	0.99256	IAH--Arr_8L_ 8R _Dep_ 9_ 15L_ 15R--V	IAH	V
0.16805	0.59042	0.24399	0.41324	BWI--Arr_10 _Dep_ 15R--V	BWI	V
0.16487	0.64424	0.64418	0.99991	DEN--Arr_34R_ 35L_ 35R _Dep_ 25_ 34L_ 34R--V	DEN	V
0.16483	0.39524	0.15902	0.40235	PIT--Arr_10R _Dep_ 10C_ 14--V	PIT	V
0.16383	0.25570	0.25293	0.98915	STL--Arr_29_ 30R _Dep_ 29_ 30L--V	STL	V
0.16262	0.36009	0.32209	0.89448	BOS--Arr_22L_ 27 _Dep_ 22R--V	BOS	V
0.16219	0.43334	0.27293	0.62984	BNA--Arr_2L _Dep_ 2C_ 2L--V	BNA	V
0.16031	0.54946	0.39610	0.72090	SAN--Arr_27 _Dep_ 27--I	SAN	I
0.15809	0.66440	0.66426	0.99978	DFW--Arr_17C_ 17L_ 18R _Dep_ 13L_ 17R_ 18L--I	DFW	I
0.15746	0.41261	0.41177	0.99797	DFW--Arr_13R_ 17C_ 17L_ 18R _Dep_ 17R_ 18L--I	DFW	I
0.15484	0.45292	0.42398	0.93609	IAD--Arr_1C_ 1R _Dep_ 30--V	IAD	V
0.15362	0.16469	0.16450	0.99884	ABQ--Arr_26_ 30 _Dep_ 21_ 26_ 30--V	ABQ	V
0.15194	0.78859	0.69890	0.88627	MDW--Arr_31C _Dep_ 31C--V	MDW	V
0.15011	0.35915	0.34496	0.96051	STL--Arr_30L_ 30R _Dep_ 29_ 30L--V	STL	V
0.14919	0.49663	0.49400	0.99470	MCO--Arr_17L_ 17R_ 18L_ 18R _Dep_ 17L_ 17R_ 18L_ 18R--I	MCO	I
0.14879	0.37087	0.16503	0.44497	MSY--Arr_1 _Dep_ 1--V	MSY	V
0.14845	0.27560	0.27414	0.99470	BNA--Arr_20C_ 20R _Dep_ 20C_ 20R--V	BNA	V
0.14600	0.23400	0.23283	0.99499	BNA--Arr_2C_ 2L _Dep_ 2C_ 2L--V	BNA	V
0.14587	0.43695	0.43442	0.99422	STL--Arr_30L_ 30R _Dep_ 30L_ 30R--V	STL	V
0.14465	0.15517	0.14719	0.94860	MSY--Arr_10_ 19 _Dep_ 19--I	MSY	I
0.13650	0.58847	0.58540	0.99478	TPA--Arr_18L_ 18R _Dep_ 18L_ 18R--V	TPA	V
0.13247	0.30919	0.30523	0.98718	BNA--Arr_2C_ 2L _Dep_ 2C_ 2L--I	BNA	I
0.13165	0.32812	0.31511	0.96034	MSY--Arr_10_ 19 _Dep_ 19--V	MSY	V
0.13031	0.73839	0.73831	0.99988	DFW--Arr_17C_ 17L_ 18R _Dep_ 13L_ 17R_ 18L--V	DFW	V
0.12956	0.27689	0.10870	0.39258	MSY--Arr_1 _Dep_ 28--V	MSY	V

0.12674	0.52800	0.52795	0.99992	MCO--Arr_17L_ 17R_ 18L_ 18R _Dep_ 17L_ 17R_ 18L_ 18R--V	MCO	V
0.12338	0.61298	0.61206	0.99851	ORD--Arr_22R_ 27L_ 28 _Dep_ 22L_ 32L_ 32R--I	ORD	I
0.12139	0.67862	0.63389	0.93408	MCO--Arr_17L_ 18R _Dep_ 17L_ 17R_ 18L_ 18R--I	MCO	I
0.11739	0.37091	0.35550	0.95845	BWI--Arr_33L_ 33R _Dep_ 28_ 33R--V	BWI	V
0.10904	0.45390	0.43751	0.96391	PHL--Arr_26_ 27R _Dep_ 27L--V	PHL	V
0.10816	0.82650	0.82496	0.99814	ORD--Arr_22R_ 27L_ 28 _Dep_ 22L_ 32L--V	ORD	V
0.10772	0.39619	0.37826	0.95473	MCO--Arr_17L_ 18R _Dep_ 17R_ 18L--V	MCO	V
0.10390	0.45010	0.27577	0.61268	BNA--Arr_20R _Dep_ 20C_ 20R--V	BNA	V
0.10363	0.97839	0.37764	0.38598	BOS--Arr_22L _Dep_ 22R--V	BOS	V
0.10346	0.55418	0.50972	0.91977	DTW--Arr_21L_ 22R _Dep_ 21R_ 22L--V	DTW	V
0.09893	0.60289	0.58000	0.96203	LAS--Arr_7R_ 19R _Dep_ 7L--V	LAS	V
0.09605	0.50495	0.49529	0.98087	IND--Arr_23L_ 23R _Dep_ 23L_ 23R--V	IND	V
0.09589	0.62397	0.62368	0.99953	BOS--Arr_4L_ 4R _Dep_ 4L_ 4R_ 9--V	BOS	V
0.09516	0.95004	0.94510	0.99480	ORD--Arr_22R_ 27L_ 28 _Dep_ 22L_ 32L--I	ORD	I
0.09481	0.68526	0.41593	0.60696	CLE--Arr_24R _Dep_ 24L_ 24R--V	CLE	V
0.09466	0.63377	0.63364	0.99981	DFW--Arr_13R_ 17C_ 17L_ 18R _Dep_ 17R_ 18L--V	DFW	V
0.08663	0.67473	0.51403	0.76183	OAK--Arr_27L_ 27R_ 29 _Dep_ 27L_ 27R_ 29--V	OAK	V
0.08386	0.26942	0.25964	0.96368	STL--Arr_11_ 12L _Dep_ 12R--V	STL	V
0.08329	0.36727	0.34564	0.94111	MCO--Arr_35R_ 36R _Dep_ 35L_ 36L--V	MCO	V
0.08050	0.48592	0.48459	0.99725	BOS--Arr_4L_ 4R _Dep_ 4R_ 9--V	BOS	V
0.07864	0.70365	0.42841	0.60884	CLE--Arr_6L _Dep_ 6L_ 6R--V	CLE	V
0.07633	0.37619	0.17485	0.46479	ABQ--Arr_8 _Dep_ 8--V	ABQ	V
0.07495	0.71509	0.71197	0.99565	MSP--Arr_30L_ 30R _Dep_ 17_ 30L_ 30R--I	MSP	I
0.07297	0.35795	0.31508	0.88024	BWI--Arr_33L_ 33R _Dep_ 28--V	BWI	V
0.06608	0.24721	0.24568	0.99381	SJC--Arr_29_ 30R _Dep_ 29_ 30R--V	SJC	V
0.06419	0.84252	0.84216	0.99956	ORD--Arr_27L_ 27R_ 28 _Dep_ 22L_ 32L--V	ORD	V
0.06219	0.99750	0.84667	0.84879	DCA--Arr_19 _Dep_ 19--V	DCA	V
0.06166	0.98839	0.66704	0.67487	SEA--Arr_16C _Dep_ 16C_ 16L--I	SEA	I
0.06132	0.45836	0.45824	0.99972	MEM--Arr_18L_ 18R_ 27 _Dep_ 18C_ 18L_ 18R--V	MEM	V

0.05848	1.00000	0.66798	0.66798	SEA--Arr_16C _Dep_ 16C_ 16L--V	SEA	V
0.05771	0.49038	0.49016	0.99956	MCI--Arr_19L_ 19R _Dep_ 19L_ 19R--V	MCI	V
0.05605	0.71164	0.50080	0.70372	CLE--Arr_24L _Dep_ 24L_ 24R--V	CLE	V
0.05269	0.41250	0.40960	0.99299	MCO--Arr_35R_ 36L _Dep_ 35L_ 36R--I	MCO	I
0.04747	0.82914	0.47877	0.57743	BWI--Arr_33L _Dep_ 28--V	BWI	V
0.04645	0.30346	0.27783	0.91554	MSY--Arr_1_ 10 _Dep_ 1--V	MSY	V
0.04605	0.76982	0.73552	0.95545	DFW--Arr_13R_ 17C_ 17L_ 18R _Dep_ 13L_ 17R_ 18L--V	DFW	V
0.04480	0.38293	0.37537	0.98026	SEA--Arr_16L_ 16R _Dep_ 16C_ 16L--V	SEA	V
0.04168	0.91725	0.91699	0.99971	DEN--Arr_26_ 35L_ 35R _Dep_ 25_ 34L_ 34R--V	DEN	V
0.04118	0.31888	0.30842	0.96722	IND--Arr_5L_ 5R _Dep_ 5L_ 5R--V	IND	V
0.03856	0.31419	0.30744	0.97852	OAK--Arr_27L_ 27R_ 29 _Dep_ 27L_ 27R_ 29--I	OAK	I
0.03521	0.96401	0.86164	0.89380	PHL--Arr_26_ 27R_ 35 _Dep_ 27L_ 35--V	PHL	V
0.02811	0.54338	0.54054	0.99476	STL--Arr_12L_ 12R _Dep_ 12L_ 12R--V	STL	V
0.02788	0.56748	0.24540	0.43245	MDW--Arr_22L _Dep_ 22L--I	MDW	I
0.02624	0.38779	0.15374	0.39645	HOU--Arr_4 _Dep_ 12R--V	HOU	V
0.02395	0.78628	0.78617	0.99985	DEN--Arr_34R_ 35L_ 35R _Dep_ 8_ 25_ 34L_ 34R--V	DEN	V
0.02003	0.55700	0.55278	0.99241	LAX--Arr_24R_ 25L _Dep_ 24L_ 25R--I	LAX	I
0.01775	0.65020	0.65012	0.99987	DEN--Arr_16L_ 16R_ 17R _Dep_ 8_ 17L_ 17R_ 25--V	DEN	V
0.01254	0.33433	0.33394	0.99883	MEM--Arr_9_ 36L_ 36R _Dep_ 36C_ 36L_ 36R--V	MEM	V
0.01246	0.48748	0.48515	0.99523	MEM--Arr_36L_ 36R _Dep_ 36L_ 36R--V	MEM	V
0.00885	0.60307	0.26386	0.43752	CLE--Arr_24L _Dep_ 24R--V	CLE	V
0.00819	0.55453	0.41833	0.75439	SJC--Arr_29_ 30L_ 30R _Dep_ 29_ 30L_ 30R--V	SJC	V
0.00522	0.80593	0.54991	0.68233	IAD--Arr_12_ 19C_ 19L _Dep_ 19L--I	IAD	I
0.00468	0.93579	0.89163	0.95280	LAS--Arr_19R_ 25L _Dep_ 19L_ 25R--V	LAS	V
0.00282	0.34414	0.34400	0.99959	ABQ--Arr_3_ 8 _Dep_ 8--V	ABQ	V
0.00191	0.57169	0.56944	0.99606	PDX--Arr_10L_ 10R _Dep_ 10L_ 10R--V	PDX	V
0.00000	0.07245	0.05949	0.82117	LAS--Arr_19L_ 19R_ 25L _Dep_ 19L_ 19R_ 25R--I	LAS	I
0.00000	0.11059	0.10690	0.96670	DTW--Arr_3R_ 4L_ 4R _Dep_ 3L_ 4R--I	DTW	I
0.00000	0.13756	0.12263	0.89147	ABQ--Arr_26_ 30 _Dep_ 21_ 26_ 30--I	ABQ	I

0.00000	0.17941	0.17931	0.99944	SJC--Arr_29_ 30L_ 30R _Dep_ 29_ 30L_ 30R--I	SJC	I
0.00000	0.18933	0.18478	0.97594	SJC--Arr_29_ 30R _Dep_ 29_ 30R--I	SJC	I
0.00000	0.21025	0.18409	0.87558	PHL--Arr_26_ 27R _Dep_ 27L--I	PHL	I
0.00000	0.23888	0.23783	0.99558	CLE--Arr_6L_ 10 _Dep_ 6L_ 6R--V	CLE	V
0.00000	0.24932	0.23010	0.92290	CLE--Arr_6L_ 10 _Dep_ 6R--V	CLE	V
0.00000	0.26699	0.26530	0.99370	SEA--Arr_16C_ 16L _Dep_ 16C_ 16L--I	SEA	I
0.00000	0.30255	0.29987	0.99115	SFO--Arr_28L_ 28R _Dep_ 1L_ 1R--I	SFO	I
0.00000	0.32888	0.32753	0.99590	IAD--Arr_1C_ 1R _Dep_ 1R_ 30--V	IAD	V
0.00000	0.33403	0.31590	0.94572	DEN--Arr_7_ 16L_ 16R _Dep_ 8_ 17L_ 17R--I	DEN	I
0.00000	0.38330	0.31550	0.82311	PIT--Arr_28R_ 32 _Dep_ 28C_ 28R--I	PIT	I
0.00000	0.39408	0.39268	0.99647	MCI--Arr_1L_ 1R _Dep_ 1L_ 1R--V	MCI	V
0.00000	0.41867	0.41665	0.99519	PDX--Arr_28L_ 28R _Dep_ 28L_ 28R--I	PDX	I
0.00000	0.43268	0.43065	0.99531	CLE--Arr_24L_ 24R _Dep_ 24L_ 24R--V	CLE	V
0.00000	0.45536	0.45511	0.99946	MEM--Arr_27_ 36L_ 36R _Dep_ 36C_ 36L_ 36R--V	MEM	V
0.00000	0.52020	0.51948	0.99861	DTW--Arr_3R_ 4L_ 4R _Dep_ 3L_ 4R--V	DTW	V
0.00000	0.52681	0.29801	0.56569	CLE--Arr_6L _Dep_ 6L_ 6R--I	CLE	I
0.00000	0.54389	0.54248	0.99741	MEM--Arr_27_ 36L_ 36R _Dep_ 36L_ 36R--V	MEM	V
0.00000	0.55997	0.55741	0.99543	DTW--Arr_21L_ 22L_ 22R _Dep_ 21R_ 22L--V	DTW	V
0.00000	0.57056	0.56826	0.99596	TPA--Arr_36L_ 36R _Dep_ 36L_ 36R--V	TPA	V
0.00000	0.57237	0.53776	0.93953	MEM--Arr_18L_ 18R_ 27 _Dep_ 18L_ 18R--I	MEM	I
0.00000	0.58576	0.56467	0.96400	DTW--Arr_21L_ 22R _Dep_ 22L--V	DTW	V
0.00000	0.60264	0.60149	0.99808	MSP--Arr_30L_ 30R _Dep_ 17_ 30L_ 30R--V	MSP	V
0.00000	0.62084	0.61553	0.99144	PDX--Arr_28L_ 28R _Dep_ 28L_ 28R--V	PDX	V
0.00000	0.62692	0.34692	0.55337	BNA--Arr_2L _Dep_ 2C_ 2L--I	BNA	I
0.00000	0.64542	0.58834	0.91156	CVG--Arr_18C_ 18L_ 18R _Dep_ 18C_ 18L_ 27--V	CVG	V
0.00000	0.64771	0.61059	0.94268	IAH--Arr_26L_ 26R _Dep_ 15L_ 15R--V	IAH	V
0.00000	0.65349	0.65171	0.99728	LAX--Arr_24L_ 24R_ 25L_ 25R _Dep_ 24L_ 24R_ 25L_ 25R--I	LAX	I
0.00000	0.66763	0.65594	0.98250	CLT--Arr_18C_ 23 _Dep_ 18C_ 18L--V	CLT	V
0.00000	0.66834	0.59597	0.89171	SEA--Arr_16C_ 16L _Dep_ 16C_ 16L--V	SEA	V

0.00000	0.68109	0.65770	0.96565	SEA--Arr_34C_ 34R _Dep_ 34C_ 34R--V	SEA	V
0.00000	0.70735	0.32856	0.46449	SFO--Arr_28R _Dep_ 1L_ 1R--V	SFO	V
0.00000	0.72610	0.33228	0.45762	SFO--Arr_28R _Dep_ 1L_ 1R--I	SFO	I
0.00000	0.72908	0.69467	0.95280	MIA--Arr_8L_ 9 _Dep_ 8R_ 12--V	MIA	V
0.00000	0.73006	0.73006	1.00000	IAH--Arr_26L_ 26R_ 27 _Dep_ 15L_ 15R--V	IAH	V
0.00000	0.73020	0.72551	0.99358	MEM--Arr_18L_ 18R_ 27 _Dep_ 18L_ 18R--V	MEM	V
0.00000	0.75881	0.74566	0.98267	SLC--Arr_16L_ 16R_ 17 _Dep_ 16L_ 16R_ 17--V	SLC	V
0.00000	0.76617	0.73164	0.95493	LAX--Arr_24R_ 25L _Dep_ 24L_ 25R--V	LAX	V
0.00000	0.78074	0.74389	0.95280	SFO--Arr_28L_ 28R _Dep_ 1L_ 1R--V	SFO	V
0.00000	0.79879	0.37160	0.46521	IAD--Arr_1C _Dep_ 1R_ 30--V	IAD	V
0.00000	0.80295	0.31291	0.38970	IAD--Arr_1C _Dep_ 1R_ 30--I	IAD	I
0.00000	0.80522	0.77811	0.96633	IAD--Arr_12_ 19L_ 19R _Dep_ 19L--V	IAD	V
0.00000	0.81384	0.50684	0.62278	EWR--Arr_4R _Dep_ 4L--V	EWR	V
0.00000	0.82163	0.81858	0.99628	DTW--Arr_21R_ 22L_ 22R _Dep_ 21R_ 22L--V	DTW	V
0.00000	0.82364	0.82325	0.99953	ORD--Arr_14R_ 22R_ 27L _Dep_ 22L_ 28--V	ORD	V
0.00000	0.84763	0.84669	0.99889	LAX--Arr_24R_ 25L _Dep_ 24L_ 24R_ 25L_ 25R--I	LAX	I
0.00000	0.86267	0.86119	0.99828	ATL--Arr_8L_ 9R_ 10 _Dep_ 8R_ 9L--I	ATL	I
0.00000	0.87287	0.27258	0.31227	BNA--Arr_2L _Dep_ 2L--I	BNA	I
0.00000	0.88033	0.88021	0.99987	ORD--Arr_4R_ 9R_ 10 _Dep_ 4L_ 9R_ 32L_ 32R--V	ORD	V
0.00000	0.90671	0.90670	0.99999	ORD--Arr_22R_ 27L_ 28 _Dep_ 22L_ 32L_ 32R--V	ORD	V
0.00000	0.91085	0.90434	0.99285	ORD--Arr_22R_ 28 _Dep_ 22L_ 32L_ 32R--V	ORD	V
0.00000	0.91601	0.90968	0.99310	LAX--Arr_24R_ 25L _Dep_ 24R_ 25L--I	LAX	I
0.00000	0.92004	0.80311	0.87291	SLC--Arr_34L_ 34R_ 35 _Dep_ 34L_ 34R_ 35--V	SLC	V
0.00000	0.94222	0.91294	0.96893	IAD--Arr_12_ 19C_ 19L _Dep_ 19L--V	IAD	V
0.00000	0.94814	0.45831	0.48338	SEA--Arr_16C _Dep_ 16L--I	SEA	I
0.00000	0.94935	0.94924	0.99989	ORD--Arr_4R_ 9R_ 10 _Dep_ 4L_ 9R_ 32L--V	ORD	V
0.00000	0.97593	0.90724	0.92961	RDU--Arr_5L_ 5R_ 32 _Dep_--I	RDU	I
0.00000	0.98164	0.97775	0.99604	LAX--Arr_24R_ 25L _Dep_ 24R_ 25L--V	LAX	V
0.00000	0.99242	0.99205	0.99962	DEN--Arr_7_ 16L_ 16R _Dep_ 8_ 17L_ 17R--V	DEN	V

0.00000	0.99932	0.99862	0.99930	CLT--Arr_36L_ 36R _Dep_ 36L_ 36R--I	CLT	I
0.00000	1.00000	1.00000	1.00000	ATL--Arr_26R_ 27L_ 28 _Dep_ 26L_ 27R--V	ATL	V
0.00000	1.00000	1.00000	1.00000	ATL--Arr_26R_ 27L_ 28 _Dep_ 26L_ 27R_ 28--V	ATL	V
0.00000	1.00000	1.00000	1.00000	ATL--Arr_8L_ 9R_ 10 _Dep_ 8R_ 9L--V	ATL	V
0.00000	1.00000	1.00000	1.00000	ATL--Arr_8L_ 9R_ 10 _Dep_ 8R_ 9L_ 10--V	ATL	V
0.00000	1.00000	1.00000	1.00000	CLT--Arr_36L_ 36R _Dep_ 36L_ 36R--V	CLT	V
0.00000	1.00000	1.00000	1.00000	DCA--Arr_1 _Dep_ 1--V	DCA	V
0.00000	1.00000	1.00000	1.00000	DEN--Arr_16L_ 16R_ 26 _Dep_ 17L_ 17R_ 25--V	DEN	V
0.00000	1.00000	1.00000	1.00000	EWR--Arr_22L _Dep_ 22R--V	EWR	V
0.00000	1.00000	1.00000	1.00000	JFK--Arr_31L_ 31R _Dep_ 31L--V	JFK	V
0.00000	1.00000	1.00000	1.00000	LAX--Arr_24L_ 24R_ 25L_ 25R _Dep_ 24L_ 24R_ 25L_ 25R--V	LAX	V
0.00000	1.00000	1.00000	1.00000	LAX--Arr_24R_ 25L _Dep_ 24L_ 24R_ 25L_ 25R--V	LAX	V
0.00000	1.00000	1.00000	1.00000	MSP--Arr_12L_ 12R _Dep_ 12L_ 12R_ 17--V	MSP	V
0.00000	1.00000	1.00000	1.00000	MSP--Arr_30L_ 30R_ 35 _Dep_ 30L_ 30R--V	MSP	V
0.00000	1.00000	1.00000	1.00000	PHX--Arr_25L_ 26 _Dep_ 25R--V	PHX	V
0.00000	1.00000	1.00000	1.00000	PHX--Arr_7R_ 8 _Dep_ 7L--V	PHX	V
0.00000	1.00000	1.00000	1.00000	RDU--Arr_23L_ 23R_ 32 _Dep_--V	RDU	V
0.00000	1.00000	1.00000	1.00000	RDU--Arr_5L_ 5R_ 32 _Dep_--V	RDU	V
0.00000	1.00000	1.00000	1.00000	SAN--Arr_27 _Dep_ 27--V	SAN	V
0.00000	1.00000	1.00000	1.00000	ATL--Arr_26R_ 27L_ 28 _Dep_ 26L_ 27R_ 28--I	ATL	I
0.00000	1.00000	1.00000	1.00000	DEN--Arr_16L_ 16R_ 26 _Dep_ 17L_ 17R_ 25--I	DEN	I
0.00000	1.00000	1.00000	1.00000	ORD--Arr_22R_ 28 _Dep_ 22L_ 32L_ 32R--I	ORD	I
0.00000	1.00000	1.00000	1.00000	ORD--Arr_27L_ 28 _Dep_ 22L_ 32L_ 32R--I	ORD	I
0.00000	1.00000	1.00000	1.00000	RDU--Arr_23L_ 23R_ 32 _Dep_--I	RDU	I
0.00000	1.00000	0.99604	0.99604	CLT--Arr_18R_ 23 _Dep_ 18L_ 18R--V	CLT	V
0.00000	1.00000	0.68340	0.68340	BOS--Arr_4R _Dep_ 4R_ 9--I	BOS	I
0.00000	1.00000	0.56054	0.56054	LGA--Arr_31 _Dep_ 4--V	LGA	V
0.00000	1.00000	0.42846	0.42846	SEA--Arr_16C _Dep_ 16L--V	SEA	V
0.00000	1.00000	0.21617	0.21617	ABQ--Arr_8 _Dep_ 8--I	ABQ	I

0.00000	1.00000	0.20618	0.20618	ABQ--Arr_26_ 30 _Dep_ 26_ 30--I	ABQ	I
0.00000	1.00000	0.06226	0.06226	LAS--Arr_1L_ 1R _Dep_ 7L--I	LAS	I
0.00000	1.00000	0.06226	0.06226	LAS--Arr_1L_ 25L _Dep_ 1R--I	LAS	I
0.00000	1.00000	0.06226	0.06226	LAS--Arr_7R_ 19R _Dep_ 7L--I	LAS	I

Appendix 10: The Cut Configuration Candidate Data

BetaK Value	BCC Value-TechEff	CCR Value-TechEff	Scale Efficiency	Configuration	LOCID	Visibility
0.84117	0.24015	0.10625	0.44242	TEB--Arr_24 _Dep_ 24--V	TEB	V
0.83847	0.10395	0.05178	0.49811	TEB--Arr_6 _Dep_ 1--I	TEB	I
0.83414	0.36445	0.35919	0.98559	SFO--Arr_19L_ 19R _Dep_ 10L_ 10R--I	SFO	I
0.83369	0.22639	0.10125	0.44723	TEB--Arr_1 _Dep_ 1--V	TEB	V
0.83305	0.21933	0.09148	0.41710	TEB--Arr_1 _Dep_ 1--I	TEB	I
0.83044	0.09824	0.04892	0.49797	TEB--Arr_19 _Dep_ 24--I	TEB	I
0.82101	0.18446	0.07725	0.41879	TEB--Arr_19 _Dep_ 19--I	TEB	I
0.80855	0.23882	0.10693	0.44773	TEB--Arr_19 _Dep_ 19--V	TEB	V
0.80320	0.11668	0.08006	0.68611	TEB--Arr_6 _Dep_ 1--V	TEB	V
0.79724	0.13226	0.13217	0.99928	TEB--Arr_19 _Dep_ 24--V	TEB	V
0.78922	0.27612	0.10860	0.39332	TEB--Arr_24 _Dep_ 24--I	TEB	I
0.78442	0.67641	0.62877	0.92957	JFK--Arr_22L_ 22R _Dep_ 22R--I	JFK	I
0.77819	0.78128	0.38701	0.49535	LGA--Arr_4 _Dep_ 13--I	LGA	I
0.76141	0.45161	0.40982	0.90745	PHX--Arr_25L_ 26 _Dep_ 25R--I	PHX	I
0.75447	0.72348	0.33490	0.46289	JFK--Arr_4R _Dep_ 4L--I	JFK	I
0.75338	**0.84405**	**0.39226**	**0.46473**	**JFK--Arr_4R _Dep_ 4L_ 31L--I**	**JFK**	**I**
0.74612	0.20238	0.20238	1.00000	DEN--Arr_26_ 35L_ 35R _Dep_ 25_ 34L_ 34R--I	DEN	I
0.74424	0.60487	0.60239	0.99590	IAH--Arr_26L_ 26R_ 27 _Dep_ 33L_ 33R--I	IAH	I
0.73366	0.75130	0.37430	0.49820	EWR--Arr_4R _Dep_ 4L--I	EWR	I
0.73255	0.60145	0.59785	0.99403	ORD--Arr_27L_ 28 _Dep_ 22L_ 32L_ 32R--V	ORD	V
0.72962	**0.83397**	**0.39018**	**0.46786**	**PHL--Arr_9R _Dep_ 8_ 9L--I**	**PHL**	**I**
0.72069	**0.83601**	**0.39808**	**0.47616**	**LGA--Arr_22 _Dep_ 13--I**	**LGA**	**I**
0.71986	**1.00000**	**0.38660**	**0.38660**	**JFK--Arr_22L _Dep_ 22R_ 31L--I**	**JFK**	**I**
0.71659	0.77546	0.36456	0.47012	JFK--Arr_22L _Dep_ 22R--I	JFK	I
0.69999	**1.00000**	**0.34092**	**0.34092**	**JFK--Arr_13L _Dep_ 13R--I**	**JFK**	**I**
0.69973	**0.81066**	**0.39854**	**0.49162**	**EWR--Arr_22L _Dep_ 22R--I**	**EWR**	**I**
0.69849	0.06715	0.06293	0.93703	CLE--Arr_6L_ 10 _Dep_ 6L_ 6R--I	CLE	I

0.69577	**1.00000**	**0.41611**	**0.41611**	**LGA--Arr_31 _Dep_ 4--I**	**LGA**	**I**
0.69553	0.44476	0.38683	0.86975	PHX--Arr_7R_ 8 _Dep_ 7L--I	PHX	I
0.66217	0.33509	0.32789	0.97851	LAS--Arr_19R_ 25L _Dep_ 19L_ 25R--I	LAS	I
0.66198	0.18116	0.17056	0.94149	HOU--Arr_12L_ 12R _Dep_ 12R--I	HOU	I
0.66175	0.23796	0.23234	0.97639	IAD--Arr_1L_ 1R _Dep_ 1R_ 30--I	IAD	I
0.65615	0.40587	0.39735	0.97901	SFO--Arr_19L_ 19R _Dep_ 10L_ 10R--V	SFO	V
0.65405	0.31799	0.29428	0.92542	JFK--Arr_13L_ 22L _Dep_ 13R--I	JFK	I
0.64793	0.25194	0.24684	0.97974	PHL--Arr_9R_ 35 _Dep_ 8_ 9L_ 35--I	PHL	I
0.64703	0.34051	0.33433	0.98186	PHL--Arr_9R_ 17 _Dep_ 8_ 9L_ 17--I	PHL	I
0.64189	0.10326	0.10229	0.99058	PBI--Arr_9L_ 9R_ 13 _Dep_ 9L_ 9R_ 13--I	PBI	I
0.64156	0.74208	0.29384	0.39596	LGA--Arr_31 _Dep_ 31--I	LGA	I
0.63857	0.42248	0.41855	0.99070	STL--Arr_30L_ 30R _Dep_ 30L_ 30R--I	STL	I
0.62965	**1.00000**	**0.21631**	**0.21631**	**ABQ--Arr_21 _Dep_ 21--I**	**ABQ**	**I**
0.62494	0.74754	0.20859	0.27904	MSY--Arr_1 _Dep_ 1--I	MSY	I
0.62241	0.44771	0.19188	0.42858	HOU--Arr_12R _Dep_ 12R--I	HOU	I
0.62184	0.26629	0.18672	0.70118	ABQ--Arr_3_ 8 _Dep_ 8--I	ABQ	I
0.62161	0.37185	0.34077	0.91641	LAS--Arr_1L_ 25R _Dep_ 1R--I	LAS	I
0.61618	0.51156	0.51059	0.99810	DEN--Arr_34R_ 35L_ 35R _Dep_ 25_ 34L_ 34R--I	DEN	I
0.60556	0.37030	0.35334	0.95422	IAD--Arr_19L_ 19R _Dep_ 30--I	IAD	I
0.60403	0.12985	0.12756	0.98236	PBI--Arr_9L_ 9R _Dep_ 9L_ 9R--I	PBI	I
0.60401	0.45099	0.44726	0.99172	JFK--Arr_22L_ 22R _Dep_ 22R_ 31L--V	JFK	V
0.60102	**1.00000**	**0.37537**	**0.37537**	**JFK--Arr_31R _Dep_ 31L--I**	**JFK**	**I**
0.59580	0.23080	0.23034	0.99801	BNA--Arr_2C_ 2L_ 2R _Dep_ 2C_ 2L_ 2R--I	BNA	I
0.59213	0.22541	0.21953	0.97392	PHL--Arr_26_ 27R_ 35 _Dep_ 27L_ 35--I	PHL	I
0.58481	0.79386	0.35019	0.44113	LGA--Arr_22 _Dep_ 31--I	LGA	I
0.58237	0.63412	0.51715	0.81553	BOS--Arr_27_ 32 _Dep_ 33L--I	BOS	I
0.57998	0.31607	0.28324	0.89614	EWR--Arr_11_ 22L _Dep_ 22R--I	EWR	I
0.57961	0.35519	0.35460	0.99834	DEN--Arr_34R_ 35L_ 35R _Dep_ 8_ 34L_ 34R--I	DEN	I
0.57753	0.31386	0.31249	0.99564	OAK--Arr_9L_ 9R_ 11 _Dep_ 9L_ 9R_ 11--I	OAK	I

0.57249	0.43080	0.39480	0.91642	DTW--Arr_21L_ 22R _Dep_ 21R--I	DTW	I
0.56793	0.77859	0.34484	0.44291	MDW--Arr_4R _Dep_ 4R--I	MDW	I
0.56031	0.25819	0.25669	0.99419	ORD--Arr_14R_ 22R_ 27L _Dep_ 22L_ 28--I	ORD	I
0.55812	0.74328	0.70683	0.95096	JFK--Arr_22L_ 22R _Dep_ 22R--V	JFK	V
0.55790	0.31175	0.11957	0.38353	PIT--Arr_28L _Dep_ 28C--I	PIT	I
0.54960	0.73454	0.34532	0.47011	JFK--Arr_22L _Dep_ 22R--V	JFK	V
0.53606	0.18614	0.18187	0.97708	IND--Arr_IN_ ONE _Dep_ ONE_ OUT--I	IND	I
0.53413	0.32799	0.32102	0.97873	BOS--Arr_22L_ 27 _Dep_ 22L_ 22R--I	BOS	I
0.53406	0.49203	0.48886	0.99356	IAH--Arr_8L_ 8R _Dep_ 9_ 15L_ 15R--I	IAH	I
0.53348	0.26865	0.26700	0.99388	RDU--Arr_23L_ 23R _Dep_ 23L_ 23R--I	RDU	I
0.53334	0.54310	0.54204	0.99805	MEM--Arr_18L_ 18R _Dep_ 18L_ 18R--I	MEM	I
0.53329	**0.85344**	**0.75196**	**0.88110**	**JFK--Arr_31L_ 31R _Dep_ 31L--I**	**JFK**	**I**
0.53283	0.68511	0.29737	0.43405	PHL--Arr_9R _Dep_ 8_ 9L--V	PHL	V
0.53229	0.31641	0.31261	0.98798	IAH--Arr_8L_ 8R _Dep_ 15L_ 15R--I	IAH	I
0.53114	0.10741	0.10112	0.94139	HOU--Arr_12L_ 12R _Dep_ 22--I	HOU	I
0.52967	0.21211	0.20767	0.97904	PBI--Arr_27L_ 27R_ 31 _Dep_ 27L_ 27R_ 31--I	PBI	I
0.52837	0.41031	0.27749	0.67629	MDW--Arr_22L_ 31C _Dep_ 22L--I	MDW	I
0.52808	0.49132	0.22573	0.45944	CLE--Arr_6L _Dep_ 6R--I	CLE	I
0.52637	**1.00000**	**0.17628**	**0.17628**	**MDW--Arr_31C _Dep_ 22L--I**	**MDW**	**I**
0.52483	0.17220	0.17217	0.99980	PBI--Arr_27L_ 27R_ 31 _Dep_ 27L_ 27R_ 31--V	PBI	V
0.52459	0.33297	0.31651	0.95057	IAD--Arr_1L_ 1R _Dep_ 30--I	IAD	I
0.51534	0.46793	0.46598	0.99583	FLL--Arr_27L_ 27R _Dep_ 27L_ 27R--I	FLL	I
0.51217	0.27054	0.26755	0.98893	MIA--Arr_8L_ 9 _Dep_ 8R_ 12--I	MIA	I
0.51195	0.73461	0.30303	0.41250	BOS--Arr_22L _Dep_ 22R--I	BOS	I
0.50984	0.16496	0.16086	0.97515	ABQ--Arr_3_ 8 _Dep_ 3_ 8--I	ABQ	I
0.50886	0.54287	0.53737	0.98987	SFO--Arr_28L_ 28R _Dep_ 28L_ 28R--I	SFO	I
0.50505	0.29816	0.29771	0.99849	OAK--Arr_9L_ 9R_ 11 _Dep_ 9L_ 9R_ 11--V	OAK	V
0.50417	0.21084	0.20350	0.96521	IAD--Arr_19L_ 19R _Dep_ 19L_ 30--I	IAD	I
0.50021	0.28470	0.28352	0.99584	CVG--Arr_36C_ 36L_ 36R _Dep_ 27_ 36C_ 36R--I	CVG	I

0.49905	0.15165	0.14120	0.93108	JFK--Arr_22L_ 22R _Dep_ 22R_ 31L--I	JFK	I
0.49892	0.60005	0.59589	0.99306	MEM--Arr_36L_ 36R _Dep_ 36L_ 36R--I	MEM	I
0.49234	0.57290	0.24834	0.43347	IAD--Arr_1L _Dep_ 1R_ 30--I	IAD	I
0.49170	0.33846	0.32301	0.95433	IAD--Arr_19L_ 19R _Dep_ 30--V	IAD	V
0.49070	0.29146	0.29089	0.99803	IND--Arr_5L_ 5R _Dep_ 5L_ 5R--I	IND	I
0.48967	0.15244	0.14882	0.97624	PBI--Arr_27L_ 27R _Dep_ 27L_ 27R--I	PBI	I
0.48871	0.48812	0.18718	0.38346	BWI--Arr_33L _Dep_ 28--I	BWI	I
0.48608	0.14032	0.13957	0.99466	PIT--Arr_28L_ 28R _Dep_ 28C_ 28R--I	PIT	I
0.48351	0.53634	0.23671	0.44135	CLE--Arr_24R _Dep_ 24L--I	CLE	I
0.47986	0.09732	0.09677	0.99431	DEN--Arr_16L_ 16R_ 17R _Dep_ 8_ 17L_ 17R--I	DEN	I
0.47871	0.38688	0.36736	0.94956	IAD--Arr_19C_ 19L _Dep_ 30--I	IAD	I
0.47792	0.15394	0.14853	0.96484	CLE--Arr_24L_ 24R _Dep_ 24L_ 24R--I	CLE	I
0.47759	0.28255	0.28137	0.99580	TPA--Arr_18L_ 18R _Dep_ 18L_ 18R--I	TPA	I
0.47466	0.13030	0.12853	0.98640	PIT--Arr_10L_ 10R _Dep_ 10C_ 14--I	PIT	I
0.46941	0.23580	0.23106	0.97991	STL--Arr_11_ 12R _Dep_ 12L_ 12R--I	STL	I
0.46624	0.29063	0.28977	0.99704	MCI--Arr_1L_ 1R _Dep_ 1L_ 1R--I	MCI	I
0.46541	0.51656	0.51145	0.99010	PHL--Arr_9R_ 17 _Dep_ 8_ 9L_ 17--V	PHL	V
0.46452	0.43547	0.43111	0.98998	DTW--Arr_3R_ 4L _Dep_ 3L_ 4R--I	DTW	I
0.46339	0.61768	0.61628	0.99772	MEM--Arr_18L_ 18R _Dep_ 18C_ 18L_ 18R--I	MEM	I
0.45961	0.26652	0.26113	0.97978	MIA--Arr_26R_ 30 _Dep_ 26L_ 27--I	MIA	I
0.45886	0.24716	0.24660	0.99776	BNA--Arr_20C_ 20L_ 20R _Dep_ 20C_ 20L_ 20R--I	BNA	I
0.45842	0.31213	0.30983	0.99263	MEM--Arr_9_ 36L_ 36R _Dep_ 36C_ 36L_ 36R--I	MEM	I
0.45077	0.47831	0.17002	0.35545	PIT--Arr_10R _Dep_ 10C_ 14--I	PIT	I
0.44603	0.28759	0.28572	0.99352	RDU--Arr_5L_ 5R _Dep_ 5L_ 5R--I	RDU	I
0.44365	0.66654	0.66551	0.99845	DFW--Arr_35C_ 35R_ 36L _Dep_ 31L_ 35L_ 36R--I	DFW	I
0.44145	0.39804	0.39760	0.99890	LAS--Arr_19L_ 19R_ 25L _Dep_ 19L_ 19R_ 25R--V	LAS	V
0.44082	0.28353	0.28209	0.99491	RDU--Arr_23L_ 23R _Dep_ 23L_ 23R--V	RDU	V
0.43927	0.39413	0.39291	0.99691	FLL--Arr_27L_ 27R _Dep_ 27L_ 27R--V	FLL	V
0.43825	0.75000	0.33841	0.45122	LGA--Arr_31 _Dep_ 31--V	LGA	V

0.43808	0.07452	0.07318	0.98199	DEN--Arr_16L_ 16R_ 17R _Dep_ 8_ 17L_ 17R_ 25--I	DEN	I
0.43436	0.14893	0.14571	0.97839	BWI--Arr_10_ 15L _Dep_ 15L_ 15R--I	BWI	I
0.43416	0.54059	0.23713	0.43866	HOU--Arr_22 _Dep_ 22--V	HOU	V
0.42973	0.21056	0.20414	0.96952	IAD--Arr_1C_ 1R _Dep_ 1R_ 30--I	IAD	I
0.42471	0.64597	0.64386	0.99673	MEM--Arr_36L_ 36R _Dep_ 36C_ 36L_ 36R--I	MEM	I
0.42284	0.50020	0.49783	0.99527	CVG--Arr_36C_ 36L_ 36R _Dep_ 36C_ 36R--I	CVG	I
0.41518	0.73487	0.73487	1.00000	DEN--Arr_34R_ 35L_ 35R _Dep_ 8_ 25_ 34L_ 34R--I	DEN	I
0.41498	0.31576	0.28395	0.89926	BWI--Arr_33L_ 33R _Dep_ 28--I	BWI	I
0.41274	**1.00000**	**0.53275**	**0.53275**	**JFK--Arr_22L _Dep_ 22R_ 31L--V**	**JFK**	**V**
0.41265	**0.80065**	**0.31723**	**0.39622**	**IND--Arr_32 _Dep_ 32--I**	**IND**	**I**
0.41245	0.20327	0.19796	0.97387	STL--Arr_11_ 12L _Dep_ 12L_ 12R--I	STL	I
0.40831	0.60869	0.25405	0.41736	BNA--Arr_20R _Dep_ 20R--I	BNA	I
0.40803	**0.82250**	**0.36307**	**0.44142**	**JFK--Arr_13L _Dep_ 13R--V**	**JFK**	**V**
0.40679	0.60025	0.59933	0.99846	ORD--Arr_4R_ 9R_ 10 _Dep_ 4L_ 9R_ 32L_ 32R--I	ORD	I
0.40678	0.64368	0.63132	0.98080	BOS--Arr_4L_ 4R _Dep_ 4L_ 4R_ 9--I	BOS	I
0.40336	0.28486	0.28408	0.99728	IND--Arr_23L_ 23R _Dep_ 23L_ 23R--I	IND	I
0.40321	0.26185	0.20151	0.76955	PBI--Arr_9L_ 9R_ 13 _Dep_ 9L_ 9R_ 13--V	PBI	V
0.40243	0.20254	0.19751	0.97515	IAD--Arr_19C_ 19L _Dep_ 19L_ 30--I	IAD	I
0.40027	**0.95531**	**0.39098**	**0.40927**	**JFK--Arr_4R _Dep_ 4L--V**	**JFK**	**V**
0.40018	0.56732	0.56228	0.99112	MEM--Arr_27_ 36L_ 36R _Dep_ 36L_ 36R--I	MEM	I
0.39776	0.12468	0.12432	0.99713	PBI--Arr_27L_ 27R _Dep_ 27L_ 27R--V	PBI	V
0.39711	0.41092	0.38010	0.92499	MCO--Arr_17L_ 18R _Dep_ 17R_ 18R--I	MCO	I
0.39557	0.57590	0.33494	0.58158	CLE--Arr_24R _Dep_ 24L_ 24R--I	CLE	I
0.39335	0.73161	0.35738	0.48848	JFK--Arr_31R _Dep_ 31L--V	JFK	V
0.39094	0.67084	0.66984	0.99851	ORD--Arr_4R_ 9R_ 10 _Dep_ 4L_ 9R_ 32L--I	ORD	I
0.39080	0.37351	0.16266	0.43548	HOU--Arr_22 _Dep_ 22--I	HOU	I
0.39060	0.23496	0.23431	0.99723	STL--Arr_30L_ 30R _Dep_ 29_ 30L--I	STL	I
0.37958	0.29901	0.29693	0.99304	RDU--Arr_23L_ 23R_ 32 _Dep_ 23L_ 23R--I	RDU	I
0.37834	0.30490	0.30366	0.99593	MCI--Arr_19L_ 19R _Dep_ 19L_ 19R--I	MCI	I

0.37821	0.29173	0.28961	0.99273	MCO--Arr_35R_ 36R _Dep_ 35L_ 36L--I	MCO	I
0.37762	0.58053	0.22434	0.38644	CLE--Arr_24L _Dep_ 24R--I	CLE	I
0.37487	0.58971	0.23114	0.39195	BWI--Arr_10 _Dep_ 15R--I	BWI	I
0.37364	0.35822	0.35710	0.99688	MEM--Arr_18L_ 18R_ 27 _Dep_ 18C_ 18L_ 18R--I	MEM	I
0.37342	0.37329	0.37239	0.99757	FLL--Arr_9L_ 9R _Dep_ 9L_ 9R--I	FLL	I
0.37254	0.38721	0.35546	0.91801	LAS--Arr_1L_ 25R _Dep_ 1R--V	LAS	V
0.36984	0.13871	0.13242	0.95462	STL--Arr_11_ 12L _Dep_ 12R--I	STL	I
0.36854	**1.00000**	**0.55800**	**0.55800**	**LGA--Arr_22 _Dep_ 13--V**	**LGA**	**V**
0.36804	0.63175	0.56914	0.90089	EWR--Arr_11_ 22L _Dep_ 22R--V	EWR	V
0.36648	0.24207	0.23909	0.98769	SJC--Arr_11_ 12L_ 12R _Dep_ 11_ 12L_ 12R--I	SJC	I
0.36342	0.37192	0.35574	0.95649	IAD--Arr_1C_ 1R _Dep_ 30--I	IAD	I
0.36145	0.56023	0.55675	0.99378	CVG--Arr_18C_ 18L_ 18R _Dep_ 18C_ 18L--I	CVG	I
0.36064	0.29650	0.28931	0.97575	MIA--Arr_26R_ 30 _Dep_ 26L_ 27--V	MIA	V
0.36041	0.12558	0.11607	0.92429	PBI--Arr_9L_ 9R _Dep_ 9L_ 9R--V	PBI	V
0.36000	**0.87070**	**0.86135**	**0.98926**	**CLT--Arr_36C_ 36R _Dep_ 36C_ 36R--I**	**CLT**	**I**
0.35996	0.55977	0.52861	0.94434	EWR--Arr_4R_ 11 _Dep_ 4L--V	EWR	V
0.35719	0.26135	0.25982	0.99415	RDU--Arr_5L_ 5R_ 32 _Dep_ 5L_ 5R--I	RDU	I
0.35712	0.76034	0.31534	0.41474	RDU--Arr_23R _Dep_ 23R--I	RDU	I
0.35694	0.44482	0.41651	0.93635	EWR--Arr_4R_ 11 _Dep_ 4L--I	EWR	I
0.35609	0.22840	0.19306	0.84529	HOU--Arr_12L_ 12R _Dep_ 12R--V	HOU	V
0.35326	0.55287	0.54680	0.98902	IAH--Arr_26L_ 26R _Dep_ 15L_ 15R--I	IAH	I
0.35295	0.58141	0.25827	0.44421	RDU--Arr_23R _Dep_ 23R--V	RDU	V
0.35212	0.67155	0.29745	0.44293	IND--Arr_32 _Dep_ 32--V	IND	V
0.35158	0.51857	0.48328	0.93195	JFK--Arr_13L_ 22L _Dep_ 13R--V	JFK	V
0.34682	0.27372	0.27173	0.99273	MCO--Arr_17L_ 18R _Dep_ 17R_ 18L--I	MCO	I
0.34620	0.19093	0.18793	0.98428	DTW--Arr_21R_ 22L_ 22R _Dep_ 21R_ 22L--I	DTW	I
0.34416	0.19899	0.19273	0.96855	PIT--Arr_28R_ 32 _Dep_ 28L_ 28R--I	PIT	I
0.34177	0.06138	0.05958	0.97070	ORD--Arr_27L_ 27R_ 28 _Dep_ 22L_ 32L--I	ORD	I
0.33949	0.24341	0.24334	0.99973	BNA--Arr_2C_ 2L_ 2R _Dep_ 2C_ 2L_ 2R--V	BNA	V

0.33921	**1.00000**	**0.25909**	**0.25909**	**MDW--Arr_4R _Dep_ 31C--I**	**MDW**	**I**
0.33810	0.09290	0.09221	0.99255	HOU--Arr_12L_ 12R _Dep_ 4_ 22--I	HOU	I
0.33783	0.43501	0.42603	0.97935	DTW--Arr_21L_ 22R _Dep_ 21R_ 22L--I	DTW	I
0.33680	0.32619	0.32374	0.99248	MCO--Arr_17L_ 18L _Dep_ 17R_ 18R--V	MCO	V
0.33442	0.36065	0.35925	0.99612	STL--Arr_12L_ 12R _Dep_ 12L_ 12R--I	STL	I
0.33404	0.51783	0.51738	0.99914	MEM--Arr_18L_ 18R _Dep_ 18C_ 18L_ 18R--V	MEM	V
0.33290	0.23803	0.23772	0.99872	SJC--Arr_11_ 12L_ 12R _Dep_ 11_ 12L_ 12R--V	SJC	V
0.32825	0.25844	0.25660	0.99290	IAD--Arr_19C_ 19L _Dep_ 19L_ 30--V	IAD	V
0.32747	**1.00000**	**0.57314**	**0.57314**	**LGA--Arr_22 _Dep_ 31--V**	**LGA**	**V**
0.32720	0.27035	0.26897	0.99487	RDU--Arr_5L_ 5R _Dep_ 5L_ 5R--V	RDU	V
0.32592	0.52264	0.20234	0.38716	MDW--Arr_31C _Dep_ 22L--V	MDW	V
0.32369	0.67619	0.28719	0.42471	BWI--Arr_10 _Dep_ 15L_ 15R--I	BWI	I
0.32265	0.44443	0.19964	0.44921	HOU--Arr_12R _Dep_ 12R--V	HOU	V
0.32163	**1.00000**	**0.45202**	**0.45202**	**DCA--Arr_1 _Dep_ 1--I**	**DCA**	**I**
0.32161	0.42912	0.23124	0.53888	BNA--Arr_20R _Dep_ 20C_ 20R--I	BNA	I
0.31944	0.54564	0.54424	0.99742	MEM--Arr_18L_ 18R _Dep_ 18L_ 18R--V	MEM	V
0.31904	0.53458	0.53320	0.99742	IAH--Arr_26L_ 26R_ 27 _Dep_ 33L_ 33R--V	IAH	V
0.31814	0.48748	0.42131	0.86426	SEA--Arr_16C_ 16L _Dep_ 16L--I	SEA	I
0.31749	0.56011	0.54458	0.97227	CLT--Arr_18C_ 23 _Dep_ 18C_ 18L--I	CLT	I
0.31411	0.55276	0.55237	0.99928	DFW--Arr_31R_ 35C_ 35R_ 36L _Dep_ 31L_ 35L_ 36R--I	DFW	I
0.31204	0.37325	0.16484	0.44162	ABQ--Arr_21 _Dep_ 21--V	ABQ	V
0.30995	0.42121	0.40383	0.95873	IAD--Arr_19C_ 19L _Dep_ 30--V	IAD	V
0.30825	0.23972	0.23952	0.99916	CVG--Arr_18C_ 18L_ 18R _Dep_ 18C_ 18L_ 27--I	CVG	I
0.30534	0.68712	0.68626	0.99875	MSP--Arr_30L_ 30R _Dep_ 30L_ 30R--I	MSP	I
0.30468	**0.80743**	**0.36349**	**0.45018**	**DCA--Arr_19 _Dep_ 19--I**	**DCA**	**I**
0.30458	0.24302	0.24102	0.99177	BWI--Arr_10_ 15L _Dep_ 15L_ 15R--V	BWI	V
0.30135	0.63931	0.28406	0.44432	RDU--Arr_5L _Dep_ 5L--I	RDU	I
0.30127	0.27620	0.27281	0.98772	SEA--Arr_16L_ 16R _Dep_ 16C_ 16L--I	SEA	I
0.29746	0.15376	0.15259	0.99241	HOU--Arr_12L_ 12R _Dep_ 4_ 22--V	HOU	V

0.29704	0.51227	0.50802	0.99172	PHL--Arr_9R_ 35 _Dep_ 8_ 9L_ 35--V	PHL	V
0.29366	0.31325	0.30999	0.98959	IAD--Arr_19L_ 19R _Dep_ 19L_ 30--V	IAD	V
0.29302	0.27727	0.26947	0.97185	BOS--Arr_4L_ 4R _Dep_ 4R_ 9--I	BOS	I
0.29157	0.32092	0.31720	0.98842	MCO--Arr_17L_ 18L _Dep_ 17R_ 18R--I	MCO	I
0.29119	**0.93906**	**0.16420**	**0.17485**	**MSY--Arr_19 _Dep_ 28--I**	**MSY**	**I**
0.29060	0.58481	0.26044	0.44534	BNA--Arr_20R _Dep_ 20R--V	BNA	V
0.28986	0.57633	0.33338	0.57846	CLE--Arr_24L _Dep_ 24L_ 24R--I	CLE	I
0.28891	0.31746	0.31742	0.99987	DEN--Arr_16L_ 16R_ 17R _Dep_ 8_ 17L_ 17R--V	DEN	V
0.28815	0.65749	0.53114	0.80783	IAD--Arr_12_ 19L_ 19R _Dep_ 19L--I	IAD	I
0.28799	0.37101	0.37098	0.99993	DEN--Arr_34R_ 35L_ 35R _Dep_ 8_ 34L_ 34R--V	DEN	V
0.28562	0.28727	0.28427	0.98956	RDU--Arr_23L_ 23R_ 32 _Dep_ 23L_ 23R--V	RDU	V
0.28244	0.87412	0.39310	0.44971	MDW--Arr_31C _Dep_ 31C--I	MDW	I
0.28111	**1.00000**	**0.50392**	**0.50392**	**JFK--Arr_4R _Dep_ 4L_ 31L--V**	**JFK**	**V**
0.28015	0.50923	0.49790	0.97774	DTW--Arr_21L_ 22L_ 22R _Dep_ 21R_ 22L--I	DTW	I
0.27661	0.75468	0.34339	0.45501	IAD--Arr_1L _Dep_ 1R_ 30--V	IAD	V
0.27496	**1.00000**	**0.49851**	**0.49851**	**LGA--Arr_4 _Dep_ 13--V**	**LGA**	**V**
0.27418	0.16076	0.15925	0.99066	SJC--Arr_29_ 30L _Dep_ 29_ 30L_ 30R--I	SJC	I
0.27183	0.51189	0.51093	0.99811	SLC--Arr_16L_ 16R_ 17 _Dep_ 16L_ 16R_ 17--I	SLC	I
0.27091	0.32321	0.12342	0.38187	HOU--Arr_4 _Dep_ 30L--V	HOU	V
0.26764	0.53296	0.12080	0.22666	MSY--Arr_1 _Dep_ 28--I	MSY	I
0.26560	0.48752	0.46182	0.94729	LAS--Arr_1L_ 25L _Dep_ 1R--V	LAS	V
0.26513	0.26273	0.25962	0.98814	STL--Arr_11_ 12R _Dep_ 12L_ 12R--V	STL	V
0.26241	0.42350	0.16020	0.37828	PIT--Arr_28L _Dep_ 28C--V	PIT	V
0.26015	0.33207	0.32974	0.99297	IAD--Arr_1L_ 1R _Dep_ 1R_ 30--V	IAD	V
0.25923	0.39364	0.37674	0.95708	MDW--Arr_22L_ 31C _Dep_ 22L--V	MDW	V
0.25769	0.61893	0.24254	0.39187	BWI--Arr_10 _Dep_ 15L_ 15R--V	BWI	V
0.25681	0.26142	0.26004	0.99472	PIT--Arr_28L_ 28R _Dep_ 28C_ 28R--V	PIT	V
0.25595	0.57591	0.26252	0.45585	RDU--Arr_5L _Dep_ 5L--V	RDU	V
0.25241	0.40586	0.37984	0.93590	IAD--Arr_1L_ 1R _Dep_ 30--V	IAD	V

0.25222	0.53156	0.53112	0.99916	SLC--Arr_34L_ 34R_ 35 _Dep_ 34L_ 34R_ 35--I	SLC	I
0.25168	0.65391	0.65283	0.99836	MSP--Arr_12L_ 12R _Dep_ 12L_ 12R_ 17--I	MSP	I
0.25116	0.43735	0.41011	0.93770	LAS--Arr_1L_ 1R _Dep_ 7L--V	LAS	V
0.25006	0.38272	0.17235	0.45033	HOU--Arr_4 _Dep_ 4--I	HOU	I
0.24969	0.24375	0.24360	0.99937	BNA--Arr_20C_ 20L_ 20R _Dep_ 20C_ 20L_ 20R--V	BNA	V
0.24961	0.59466	0.23662	0.39790	CLE--Arr_6L _Dep_ 6R--V	CLE	V
0.24920	0.25399	0.24863	0.97892	BWI--Arr_33L_ 33R _Dep_ 28_ 33R--I	BWI	I
0.24886	0.17517	0.16311	0.93114	BOS--Arr_22L_ 27 _Dep_ 22R--I	BOS	I
0.24845	0.25059	0.25037	0.99911	CVG--Arr_36C_ 36L_ 36R _Dep_ 27_ 36C_ 36R--V	CVG	V
0.24783	0.34239	0.33989	0.99272	TPA--Arr_36L_ 36R _Dep_ 36L_ 36R--I	TPA	I
0.24668	0.17450	0.16578	0.95004	ABQ--Arr_26_ 30 _Dep_ 26_ 30--V	ABQ	V
0.24553	0.48166	0.46434	0.96405	DTW--Arr_21L_ 22R _Dep_ 21R--V	DTW	V
0.24498	0.57279	0.56557	0.98740	CLT--Arr_18R_ 23 _Dep_ 18L_ 18R--I	CLT	I
0.24474	0.14751	0.13161	0.89217	CLE--Arr_6L_ 10 _Dep_ 6R--I	CLE	I
0.23827	0.30522	0.30483	0.99871	MEM--Arr_27_ 36L_ 36R _Dep_ 36C_ 36L_ 36R--I	MEM	I
0.23705	0.26314	0.25343	0.96311	BNA--Arr_20C_ 20R _Dep_ 20C_ 20R--I	BNA	I
0.23626	0.24206	0.23766	0.98181	STL--Arr_29_ 30R _Dep_ 29_ 30L--I	STL	I
0.23271	0.34465	0.34136	0.99044	MCO--Arr_17L_ 18R _Dep_ 17R_ 18R--V	MCO	V
0.22911	0.20234	0.20141	0.99536	IND--Arr_IN_ ONE _Dep_ ONE_ OUT--V	IND	V
0.22628	0.15374	0.15195	0.98834	PIT--Arr_28R_ 32 _Dep_ 28C_ 28R--V	PIT	V
0.22586	0.59946	0.59860	0.99857	DFW--Arr_31R_ 35C_ 35R_ 36L _Dep_ 31L_ 35L_ 36R--V	DFW	V
0.22298	0.62354	0.62304	0.99920	DFW--Arr_35C_ 35R_ 36L _Dep_ 31L_ 35L_ 36R--V	DFW	V
0.22236	0.20846	0.15695	0.75290	HOU--Arr_12L_ 12R _Dep_ 22--V	HOU	V
0.21684	0.54777	0.54581	0.99642	MSP--Arr_30L_ 30R _Dep_ 30L_ 30R--V	MSP	V
0.21528	0.73807	0.73480	0.99557	SFO--Arr_28L_ 28R _Dep_ 28L_ 28R--V	SFO	V
0.21522	0.49434	0.49430	0.99992	IAH--Arr_26L_ 26R_ 27 _Dep_ 15L_ 15R--I	IAH	I
0.21478	0.17392	0.17321	0.99590	PIT--Arr_28R_ 32 _Dep_ 28L_ 28R--V	PIT	V
0.21474	0.28925	0.28789	0.99528	RDU--Arr_5L_ 5R_ 32 _Dep_ 5L_ 5R--V	RDU	V
0.21430	0.57790	0.24586	0.42544	CLE--Arr_24R _Dep_ 24L--V	CLE	V

0.21314	0.27346	0.10678	0.39047	MSY--Arr_19 _Dep_ 28--V	MSY	V
0.21301	0.44331	0.44249	0.99815	BOS--Arr_22L_ 27 _Dep_ 22L_ 22R--V	BOS	V
0.21224	0.33861	0.33606	0.99245	MCO--Arr_35R_ 36L _Dep_ 35L_ 36R--V	MCO	V
0.21152	0.55401	0.25491	0.46012	BNA--Arr_2L _Dep_ 2L--V	BNA	V
0.20675	0.54923	0.54781	0.99740	CVG--Arr_36C_ 36L_ 36R _Dep_ 36C_ 36R--V	CVG	V
0.20637	0.43291	0.13994	0.32324	HOU--Arr_4 _Dep_ 30L--I	HOU	I
0.20551	0.43312	0.27405	0.63274	HOU--Arr_4 _Dep_ 4--V	HOU	V
0.20466	0.54066	0.20581	0.38067	MDW--Arr_4R _Dep_ 31C--V	MDW	V
0.20405	0.59599	0.59338	0.99563	MCO--Arr_17L_ 18R _Dep_ 17L_ 17R_ 18L_ 18R--V	MCO	V
0.20130	0.51346	0.51111	0.99543	CVG--Arr_18C_ 18L_ 18R _Dep_ 18C_ 18L--V	CVG	V
0.19676	0.22711	0.22637	0.99677	SJC--Arr_29_ 30L _Dep_ 29_ 30L_ 30R--V	SJC	V
0.19562	0.51949	0.51942	0.99986	DFW--Arr_13R_ 17C_ 17L_ 18R _Dep_ 13L_ 17R_ 18L--I	DFW	I
0.19327	0.50215	0.49831	0.99234	DTW--Arr_3R_ 4L _Dep_ 3L_ 4R--V	DTW	V
0.19323	0.89414	0.71333	0.79779	FLL--Arr_9L_ 9R _Dep_ 9L_ 9R--V	FLL	V
0.19244	0.88290	0.87846	0.99497	CLT--Arr_36C_ 36R _Dep_ 36C_ 36R--V	CLT	V
0.19192	0.64727	0.64159	0.99122	MEM--Arr_36L_ 36R _Dep_ 36C_ 36L_ 36R--V	MEM	V
0.19007	0.16814	0.16010	0.95218	PIT--Arr_10L_ 10R _Dep_ 10C_ 14--V	PIT	V
0.18864	0.22052	0.21059	0.95495	ABQ--Arr_3_ 8 _Dep_ 3_ 8--V	ABQ	V
0.18857	0.55960	0.15135	0.27045	HOU--Arr_4 _Dep_ 12R--I	HOU	I
0.18637	0.78398	0.39792	0.50756	MDW--Arr_22L _Dep_ 22L--V	MDW	V
0.18516	0.50779	0.46124	0.90833	BOS--Arr_27_ 32 _Dep_ 33L--V	BOS	V
0.18028	0.57624	0.54576	0.94711	SEA--Arr_16C_ 16L _Dep_ 16L--V	SEA	V
0.17932	0.61556	0.61091	0.99244	IAH--Arr_8L_ 8R _Dep_ 15L_ 15R--V	IAH	V
0.17916	0.91538	0.58993	0.64446	BOS--Arr_4R _Dep_ 4R_ 9--V	BOS	V
0.17599	0.91432	0.91432	1.00000	ATL--Arr_8L_ 9R_ 10 _Dep_ 8R_ 9L_ 10--I	ATL	I
0.17573	0.42024	0.37415	0.89032	PDX--Arr_10L_ 10R _Dep_ 10L_ 10R--I	PDX	I
0.17508	0.88262	0.88112	0.99831	ATL--Arr_26R_ 27L_ 28 _Dep_ 26L_ 27R--I	ATL	I
0.17491	0.48988	0.46868	0.95673	DTW--Arr_21L_ 22R _Dep_ 22L--I	DTW	I
0.17302	0.27334	0.27114	0.99194	STL--Arr_11_ 12L _Dep_ 12L_ 12R--V	STL	V

0.17192	0.15549	0.14724	0.94697	MSY--Arr_1_ 10 _Dep_ 1--I	MSY	I
0.16937	0.77085	0.51031	0.66201	MDW--Arr_4R _Dep_ 4R--V	MDW	V
0.16909	0.73161	0.72903	0.99648	MSP--Arr_30L_ 30R_ 35 _Dep_ 30L_ 30R--I	MSP	I
0.16856	0.17437	0.17183	0.98543	SEA--Arr_34C_ 34R _Dep_ 34C_ 34R--I	SEA	I
0.16855	0.58717	0.58279	0.99256	IAH--Arr_8L_ 8R _Dep_ 9_ 15L_ 15R--V	IAH	V
0.16805	0.59042	0.24399	0.41324	BWI--Arr_10 _Dep_ 15R--V	BWI	V
0.16487	0.64424	0.64418	0.99991	DEN--Arr_34R_ 35L_ 35R _Dep_ 25_ 34L_ 34R--V	DEN	V
0.16483	0.39524	0.15902	0.40235	PIT--Arr_10R _Dep_ 10C_ 14--V	PIT	V
0.16383	0.25570	0.25293	0.98915	STL--Arr_29_ 30R _Dep_ 29_ 30L--V	STL	V
0.16262	0.36009	0.32209	0.89448	BOS--Arr_22L_ 27 _Dep_ 22R--V	BOS	V
0.16219	0.43334	0.27293	0.62984	BNA--Arr_2L _Dep_ 2C_ 2L--V	BNA	V
0.16031	0.54946	0.39610	0.72090	SAN--Arr_27 _Dep_ 27--I	SAN	I
0.15809	0.66440	0.66426	0.99978	DFW--Arr_17C_ 17L_ 18R _Dep_ 13L_ 17R_ 18L--I	DFW	I
0.15746	0.41261	0.41177	0.99797	DFW--Arr_13R_ 17C_ 17L_ 18R _Dep_ 17R_ 18L--I	DFW	I
0.15484	0.45292	0.42398	0.93609	IAD--Arr_1C_ 1R _Dep_ 30--V	IAD	V
0.15362	0.16469	0.16450	0.99884	ABQ--Arr_26_ 30 _Dep_ 21_ 26_ 30--V	ABQ	V
0.15194	0.78859	0.69890	0.88627	MDW--Arr_31C _Dep_ 31C--V	MDW	V
0.15011	0.35915	0.34496	0.96051	STL--Arr_30L_ 30R _Dep_ 29_ 30L--V	STL	V
0.14919	0.49663	0.49400	0.99470	MCO--Arr_17L_ 17R_ 18L_ 18R _Dep_ 17L_ 17R_ 18L_ 18R--I	MCO	I
0.14879	0.37087	0.16503	0.44497	MSY--Arr_1 _Dep_ 1--V	MSY	V
0.14845	0.27560	0.27414	0.99470	BNA--Arr_20C_ 20R _Dep_ 20C_ 20R--V	BNA	V
0.14600	0.23400	0.23283	0.99499	BNA--Arr_2C_ 2L _Dep_ 2C_ 2L--V	BNA	V
0.14587	0.43695	0.43442	0.99422	STL--Arr_30L_ 30R _Dep_ 30L_ 30R--V	STL	V
0.14465	0.15517	0.14719	0.94860	MSY--Arr_10_ 19 _Dep_ 19--I	MSY	I
0.13650	0.58847	0.58540	0.99478	TPA--Arr_18L_ 18R _Dep_ 18L_ 18R--V	TPA	V
0.13247	0.30919	0.30523	0.98718	BNA--Arr_2C_ 2L _Dep_ 2C_ 2L--I	BNA	I
0.13165	0.32812	0.31511	0.96034	MSY--Arr_10_ 19 _Dep_ 19--V	MSY	V
0.13031	0.73839	0.73831	0.99988	DFW--Arr_17C_ 17L_ 18R _Dep_ 13L_ 17R_ 18L--V	DFW	V
0.12956	0.27689	0.10870	0.39258	MSY--Arr_1 _Dep_ 28--V	MSY	V

0.12674	0.52800	0.52795	0.99992	MCO--Arr_17L_ 17R_ 18L_ 18R _Dep_ 17L_ 17R_ 18L_ 18R--V	MCO	V
0.12338	0.61298	0.61206	0.99851	ORD--Arr_22R_ 27L_ 28 _Dep_ 22L_ 32L_ 32R--I	ORD	I
0.12139	0.67862	0.63389	0.93408	MCO--Arr_17L_ 18R _Dep_ 17L_ 17R_ 18L_ 18R--I	MCO	I
0.11739	0.37091	0.35550	0.95845	BWI--Arr_33L_ 33R _Dep_ 28_ 33R--V	BWI	V
0.10904	0.45390	0.43751	0.96391	PHL--Arr_26_ 27R _Dep_ 27L--V	PHL	V
0.10816	0.82650	0.82496	0.99814	ORD--Arr_22R_ 27L_ 28 _Dep_ 22L_ 32L--V	ORD	V
0.10772	0.39619	0.37826	0.95473	MCO--Arr_17L_ 18R _Dep_ 17R_ 18L--V	MCO	V
0.10390	0.45010	0.27577	0.61268	BNA--Arr_20R _Dep_ 20C_ 20R--V	BNA	V
0.10363	0.97839	0.37764	0.38598	BOS--Arr_22L _Dep_ 22R--V	BOS	V
0.10346	0.55418	0.50972	0.91977	DTW--Arr_21L_ 22R _Dep_ 21R_ 22L--V	DTW	V
0.09893	0.60289	0.58000	0.96203	LAS--Arr_7R_ 19R _Dep_ 7L--V	LAS	V
0.09605	0.50495	0.49529	0.98087	IND--Arr_23L_ 23R _Dep_ 23L_ 23R--V	IND	V
0.09589	0.62397	0.62368	0.99953	BOS--Arr_4L_ 4R _Dep_ 4L_ 4R_ 9--V	BOS	V
0.09516	0.95004	0.94510	0.99480	ORD--Arr_22R_ 27L_ 28 _Dep_ 22L_ 32L--I	ORD	I
0.09481	0.68526	0.41593	0.60696	CLE--Arr_24R _Dep_ 24L_ 24R--V	CLE	V
0.09466	0.63377	0.63364	0.99981	DFW--Arr_13R_ 17C_ 17L_ 18R _Dep_ 17R_ 18L--V	DFW	V
0.08663	0.67473	0.51403	0.76183	OAK--Arr_27L_ 27R_ 29 _Dep_ 27L_ 27R_ 29--V	OAK	V
0.08386	0.26942	0.25964	0.96368	STL--Arr_11_ 12L _Dep_ 12R--V	STL	V
0.08329	0.36727	0.34564	0.94111	MCO--Arr_35R_ 36R _Dep_ 35L_ 36L--V	MCO	V
0.08050	0.48592	0.48459	0.99725	BOS--Arr_4L_ 4R _Dep_ 4R_ 9--V	BOS	V
0.07864	0.70365	0.42841	0.60884	CLE--Arr_6L _Dep_ 6L_ 6R--V	CLE	V
0.07633	0.37619	0.17485	0.46479	ABQ--Arr_8 _Dep_ 8--V	ABQ	V
0.07495	0.71509	0.71197	0.99565	MSP--Arr_30L_ 30R _Dep_ 17_ 30L_ 30R--I	MSP	I
0.07297	0.35795	0.31508	0.88024	BWI--Arr_33L_ 33R _Dep_ 28--V	BWI	V
0.06608	0.24721	0.24568	0.99381	SJC--Arr_29_ 30R _Dep_ 29_ 30R--V	SJC	V
0.06419	0.84252	0.84216	0.99956	ORD--Arr_27L_ 27R_ 28 _Dep_ 22L_ 32L--V	ORD	V
0.06219	0.99750	0.84667	0.84879	DCA--Arr_19 _Dep_ 19--V	DCA	V
0.06166	0.98839	0.66704	0.67487	SEA--Arr_16C _Dep_ 16C_ 16L--I	SEA	I
0.06132	0.45836	0.45824	0.99972	MEM--Arr_18L_ 18R_ 27 _Dep_ 18C_ 18L_ 18R--V	MEM	V

0.05848	1.00000	0.66798	0.66798	SEA--Arr_16C _Dep_ 16C_ 16L--V	SEA	V
0.05771	0.49038	0.49016	0.99956	MCI--Arr_19L_ 19R _Dep_ 19L_ 19R--V	MCI	V
0.05605	0.71164	0.50080	0.70372	CLE--Arr_24L _Dep_ 24L_ 24R--V	CLE	V
0.05269	0.41250	0.40960	0.99299	MCO--Arr_35R_ 36L _Dep_ 35L_ 36R--I	MCO	I
0.04747	0.82914	0.47877	0.57743	BWI--Arr_33L _Dep_ 28--V	BWI	V
0.04605	0.76982	0.73552	0.95545	DFW--Arr_13R_ 17C_ 17L_ 18R _Dep_ 13L_ 17R_ 18L--V	DFW	V
0.04168	0.91725	0.91699	0.99971	DEN--Arr_26_ 35L_ 35R _Dep_ 25_ 34L_ 34R--V	DEN	V
0.03521	0.96401	0.86164	0.89380	PHL--Arr_26_ 27R_ 35 _Dep_ 27L_ 35--V	PHL	V
0.02811	0.54338	0.54054	0.99476	STL--Arr_12L_ 12R _Dep_ 12L_ 12R--V	STL	V
0.02788	0.56748	0.24540	0.43245	MDW--Arr_22L _Dep_ 22L--I	MDW	I
0.02395	0.78628	0.78617	0.99985	DEN--Arr_34R_ 35L_ 35R _Dep_ 8_ 25_ 34L_ 34R--V	DEN	V
0.02003	0.55700	0.55278	0.99241	LAX--Arr_24R_ 25L _Dep_ 24L_ 25R--I	LAX	I
0.01775	0.65020	0.65012	0.99987	DEN--Arr_16L_ 16R_ 17R _Dep_ 8_ 17L_ 17R_ 25--V	DEN	V
0.00885	0.60307	0.26386	0.43752	CLE--Arr_24L _Dep_ 24R--V	CLE	V
0.00819	0.55453	0.41833	0.75439	SJC--Arr_29_ 30L_ 30R _Dep_ 29_ 30L_ 30R--V	SJC	V
0.00522	0.80593	0.54991	0.68233	IAD--Arr_12_ 19C_ 19L _Dep_ 19L--I	IAD	I
0.00468	0.93579	0.89163	0.95280	LAS--Arr_19R_ 25L _Dep_ 19L_ 25R--V	LAS	V
0.00191	0.57169	0.56944	0.99606	PDX--Arr_10L_ 10R _Dep_ 10L_ 10R--V	PDX	V
0.00000	0.52020	0.51948	0.99861	DTW--Arr_3R_ 4L_ 4R _Dep_ 3L_ 4R--V	DTW	V
0.00000	0.52681	0.29801	0.56569	CLE--Arr_6L _Dep_ 6L_ 6R--I	CLE	I
0.00000	0.54389	0.54248	0.99741	MEM--Arr_27_ 36L_ 36R _Dep_ 36L_ 36R--V	MEM	V
0.00000	0.55997	0.55741	0.99543	DTW--Arr_21L_ 22L_ 22R _Dep_ 21R_ 22L--V	DTW	V
0.00000	0.57056	0.56826	0.99596	TPA--Arr_36L_ 36R _Dep_ 36L_ 36R--V	TPA	V
0.00000	0.57237	0.53776	0.93953	MEM--Arr_18L_ 18R_ 27 _Dep_ 18L_ 18R--I	MEM	I
0.00000	0.58576	0.56467	0.96400	DTW--Arr_21L_ 22R _Dep_ 22L--V	DTW	V
0.00000	0.60264	0.60149	0.99808	MSP--Arr_30L_ 30R _Dep_ 17_ 30L_ 30R--V	MSP	V
0.00000	0.62084	0.61553	0.99144	PDX--Arr_28L_ 28R _Dep_ 28L_ 28R--V	PDX	V
0.00000	0.62692	0.34692	0.55337	BNA--Arr_2L _Dep_ 2C_ 2L--I	BNA	I
0.00000	0.64542	0.58834	0.91156	CVG--Arr_18C_ 18L_ 18R _Dep_ 18C_ 18L_ 27--V	CVG	V

0.00000	0.64771	0.61059	0.94268	IAH--Arr_26L_ 26R _Dep_ 15L_ 15R--V	IAH	V
0.00000	0.65349	0.65171	0.99728	LAX--Arr_24L_ 24R_ 25L_ 25R _Dep_ 24L_ 24R_ 25L_ 25R--I	LAX	I
0.00000	0.66763	0.65594	0.98250	CLT--Arr_18C_ 23 _Dep_ 18C_ 18L--V	CLT	V
0.00000	0.66834	0.59597	0.89171	SEA--Arr_16C_ 16L _Dep_ 16C_ 16L--V	SEA	V
0.00000	0.68109	0.65770	0.96565	SEA--Arr_34C_ 34R _Dep_ 34C_ 34R--V	SEA	V
0.00000	0.70735	0.32856	0.46449	SFO--Arr_28R _Dep_ 1L_ 1R--V	SFO	V
0.00000	0.72610	0.33228	0.45762	SFO--Arr_28R _Dep_ 1L_ 1R--I	SFO	I
0.00000	0.72908	0.69467	0.95280	MIA--Arr_8L_ 9 _Dep_ 8R_ 12--V	MIA	V
0.00000	0.73006	0.73006	1.00000	IAH--Arr_26L_ 26R_ 27 _Dep_ 15L_ 15R--V	IAH	V
0.00000	0.73020	0.72551	0.99358	MEM--Arr_18L_ 18R_ 27 _Dep_ 18L_ 18R--V	MEM	V
0.00000	0.75881	0.74566	0.98267	SLC--Arr_16L_ 16R_ 17 _Dep_ 16L_ 16R_ 17--V	SLC	V
0.00000	0.76617	0.73164	0.95493	LAX--Arr_24R_ 25L _Dep_ 24L_ 25R--V	LAX	V
0.00000	0.78074	0.74389	0.95280	SFO--Arr_28L_ 28R _Dep_ 1L_ 1R--V	SFO	V
0.00000	0.79879	0.37160	0.46521	IAD--Arr_1C _Dep_ 1R_ 30--V	IAD	V
0.00000	0.80295	0.31291	0.38970	IAD--Arr_1C _Dep_ 1R_ 30--I	IAD	I
0.00000	0.80522	0.77811	0.96633	IAD--Arr_12_ 19L_ 19R _Dep_ 19L--V	IAD	V
0.00000	0.81384	0.50684	0.62278	EWR--Arr_4R _Dep_ 4L--V	EWR	V
0.00000	0.82163	0.81858	0.99628	DTW--Arr_21R_ 22L_ 22R _Dep_ 21R_ 22L--V	DTW	V
0.00000	0.82364	0.82325	0.99953	ORD--Arr_14R_ 22R_ 27L _Dep_ 22L_ 28--V	ORD	V
0.00000	0.84763	0.84669	0.99889	LAX--Arr_24R_ 25L _Dep_ 24L_ 24R_ 25L_ 25R--I	LAX	I
0.00000	0.86267	0.86119	0.99828	ATL--Arr_8L_ 9R_ 10 _Dep_ 8R_ 9L--I	ATL	I
0.00000	0.87287	0.27258	0.31227	BNA--Arr_2L _Dep_ 2L--I	BNA	I
0.00000	0.88033	0.88021	0.99987	ORD--Arr_4R_ 9R_ 10 _Dep_ 4L_ 9R_ 32L_ 32R--V	ORD	V
0.00000	0.90671	0.90670	0.99999	ORD--Arr_22R_ 27L_ 28 _Dep_ 22L_ 32L_ 32R--V	ORD	V
0.00000	0.91085	0.90434	0.99285	ORD--Arr_22R_ 28 _Dep_ 22L_ 32L_ 32R--V	ORD	V
0.00000	0.91601	0.90968	0.99310	LAX--Arr_24R_ 25L _Dep_ 24R_ 25L--I	LAX	I
0.00000	0.92004	0.80311	0.87291	SLC--Arr_34L_ 34R_ 35 _Dep_ 34L_ 34R_ 35--V	SLC	V
0.00000	0.94222	0.91294	0.96893	IAD--Arr_12_ 19C_ 19L _Dep_ 19L--V	IAD	V
0.00000	0.94814	0.45831	0.48338	SEA--Arr_16C _Dep_ 16L--I	SEA	I

0.00000	0.94935	0.94924	0.99989	ORD--Arr_4R_ 9R_ 10 _Dep_ 4L_ 9R_ 32L--V	ORD	V
0.00000	0.97593	0.90724	0.92961	RDU--Arr_5L_ 5R_ 32 _Dep_--I	RDU	I
0.00000	0.98164	0.97775	0.99604	LAX--Arr_24R_ 25L _Dep_ 24R_ 25L--V	LAX	V
0.00000	0.99242	0.99205	0.99962	DEN--Arr_7_ 16L_ 16R _Dep_ 8_ 17L_ 17R--V	DEN	V
0.00000	0.99932	0.99862	0.99930	CLT--Arr_36L_ 36R _Dep_ 36L_ 36R--I	CLT	I
0.00000	1.00000	0.99604	0.99604	CLT--Arr_18R_ 23 _Dep_ 18L_ 18R--V	CLT	V
0.00000	1.00000	0.68340	0.68340	BOS--Arr_4R _Dep_ 4R_ 9--I	BOS	I
0.00000	1.00000	0.56054	0.56054	LGA--Arr_31 _Dep_ 4--V	LGA	V
0.00000	1.00000	0.42846	0.42846	SEA--Arr_16C _Dep_ 16L--V	SEA	V
0.00000	1.00000	0.21617	0.21617	ABQ--Arr_8 _Dep_ 8--I	ABQ	I
0.00000	1.00000	0.20618	0.20618	ABQ--Arr_26_ 30 _Dep_ 26_ 30--I	ABQ	I
0.00000	1.00000	0.06226	0.06226	LAS--Arr_1L_ 1R _Dep_ 7L--I	LAS	I
0.00000	1.00000	0.06226	0.06226	LAS--Arr_1L_ 25L _Dep_ 1R--I	LAS	I
0.00000	1.00000	0.06226	0.06226	LAS--Arr_7R_ 19R _Dep_ 7L--I	LAS	I

Appendix 11: The Weighted Configuration Candidate Data

BetaK Value	BCC Value TechEff	CCR Value TechEff	Scale Efficiency	Configuration	LOCID	Visibility	Total Operations	Airport Operations	Percent Ops
0.84117	0.24015	0.10625	0.44242	TEB--Arr_24 _Dep_ 24--V	TEB	V	3601	51920	0.06936
0.83847	0.10395	0.05178	0.49811	TEB--Arr_6 _Dep_ 1--I	TEB	I	3820	51920	0.07357
0.83414	0.36445	0.35919	0.98559	SFO--Arr_19L_ 19R _Dep_ 10L_ 10R--I	SFO	I	5569	361208	0.01542
0.83369	0.22639	0.10125	0.44723	TEB--Arr_1 _Dep_ 1--V	TEB	V	3456	51920	0.06656
0.83305	0.21933	0.09148	0.41710	TEB--Arr_1 _Dep_ 1--I	TEB	I	322	51920	0.00620
0.83044	0.09824	0.04892	0.49797	TEB--Arr_19 _Dep_ 24--I	TEB	I	3413	51920	0.06574
0.82101	0.18446	0.07725	0.41879	TEB--Arr_19 _Dep_ 19--I	TEB	I	274	51920	0.00528
0.80855	0.23882	0.10693	0.44773	TEB--Arr_19 _Dep_ 19--V	TEB	V	4080	51920	0.07858
0.80320	0.11668	0.08006	0.68611	TEB--Arr_6 _Dep_ 1--V	TEB	V	11547	51920	0.22240
0.79724	0.13226	0.13217	0.99928	TEB--Arr_19 _Dep_ 24--V	TEB	V	19442	51920	0.37446
0.78922	0.27612	0.10860	0.39332	TEB--Arr_24 _Dep_ 24--I	TEB	I	254	51920	0.00489
0.78442	0.67641	0.62877	0.92957	JFK--Arr_22L_ 22R _Dep_ 22R--I	JFK	I	5503	415653	0.01324
0.77819	0.78128	0.38701	0.49535	LGA--Arr_4 _Dep_ 13--I	LGA	I	20098	372243	0.05399
0.76141	0.45161	0.40982	0.90745	PHX--Arr_25L_ 26 _Dep_ 25R--I	PHX	I	1989	453066	0.00439
0.75447	0.72348	0.33490	0.46289	JFK--Arr_4R _Dep_ 4L--I	JFK	I	8362	415653	0.02012
0.75338	**0.84405**	**0.39226**	**0.46473**	**JFK--Arr_4R _Dep_ 4L_ 31L--I**	**JFK**	**I**	4712	415653	0.01134
0.74612	0.20238	0.20238	1.00000	DEN--Arr_26_ 35L_ 35R _Dep_ 25_ 34L_ 34R--I	DEN	I	219	617913	0.00035
0.74424	0.60487	0.60239	0.99590	IAH--Arr_26L_ 26R_ 27 _Dep_ 33L_ 33R--I	IAH	I	2655	557317	0.00476
0.73366	0.75130	0.37430	0.49820	EWR--Arr_4R _Dep_ 4L--I	EWR	I	28078	413478	0.06791
0.73255	0.60145	0.59785	0.99403	ORD--Arr_27L_ 28 _Dep_ 22L_ 32L_ 32R--V	ORD	V	14724	863020	0.01706
0.72962	**0.83397**	**0.39018**	**0.46786**	**PHL--Arr_9R _Dep_ 8_ 9L--I**	**PHL**	**I**	9742	459819	0.02119
0.72069	**0.83601**	**0.39808**	**0.47616**	**LGA--Arr_22 _Dep_ 13--I**	**LGA**	**I**	16021	372243	0.04304
0.71986	**1.00000**	**0.38660**	**0.38660**	**JFK--Arr_22L _Dep_ 22R_ 31L--I**	**JFK**	**I**	1500	415653	0.00361
0.71659	0.77546	0.36456	0.47012	JFK--Arr_22L _Dep_ 22R--I	JFK	I	7447	415653	0.01792
0.69999	**1.00000**	**0.34092**	**0.34092**	**JFK--Arr_13L _Dep_ 13R--I**	**JFK**	**I**	1216	415653	0.00293
0.69973	**0.81066**	**0.39854**	**0.49162**	**EWR--Arr_22L _Dep_ 22R--I**	**EWR**	**I**	24583	413478	0.05945
0.69849	0.06715	0.06293	0.93703	CLE--Arr_6L_ 10 _Dep_ 6L_ 6R--I	CLE	I	82	222790	0.00037
0.69577	**1.00000**	**0.41611**	**0.41611**	**LGA--Arr_31 _Dep_ 4--I**	**LGA**	**I**	2352	372243	0.00632
0.69553	0.44476	0.38683	0.86975	PHX--Arr_7R_ 8 _Dep_ 7L--I	PHX	I	1775	453066	0.00392
0.66217	0.33509	0.32789	0.97851	LAS--Arr_19R_ 25L _Dep_ 19L_ 25R--I	LAS	I	502	415772	0.00121
0.66198	0.18116	0.17056	0.94149	HOU--Arr_12L_ 12R _Dep_ 12R--I	HOU	I	2031	124850	0.01627
0.66175	0.23796	0.23234	0.97639	IAD--Arr_1L_ 1R _Dep_ 1R_ 30--I	IAD	I	1439	329263	0.00437
0.65615	0.40587	0.39735	0.97901	SFO--Arr_19L_ 19R _Dep_ 10L_ 10R--V	SFO	V	5880	361208	0.01628
0.65405	0.31799	0.29428	0.92542	JFK--Arr_13L_ 22L _Dep_ 13R--I	JFK	I	2061	415653	0.00496
0.64793	0.25194	0.24684	0.97974	PHL--Arr_9R_ 35 _Dep_ 8_ 9L_ 35--I	PHL	I	832	459819	0.00181
0.64703	0.34051	0.33433	0.98186	PHL--Arr_9R_ 17 _Dep_ 8_ 9L_ 17--I	PHL	I	5122	459819	0.01114

0.64189	0.10326	0.10229	0.99058	PBI--Arr_9L_ 9R_ 13 _Dep_ 9L_ 9R_ 13--I	PBI	I	438	85880	0.00510
0.64156	0.74208	0.29384	0.39596	LGA--Arr_31 _Dep_ 31--I	LGA	I	677	372243	0.00182
0.63857	0.42248	0.41855	0.99070	STL--Arr_30L_ 30R _Dep_ 30L_ 30R--I	STL	I	1896	232916	0.00814
0.62965	**1.00000**	**0.21631**	**0.21631**	**ABQ--Arr_21 _Dep_ 21--I**	**ABQ**	**I**	101	99101	0.00102
0.62494	0.74754	0.20859	0.27904	MSY--Arr_1 _Dep_ 1--I	MSY	I	140	99834	0.00140
0.62241	0.44771	0.19188	0.42858	HOU--Arr_12R _Dep_ 12R--I	HOU	I	1041	124850	0.00834
0.62184	0.26629	0.18672	0.70118	ABQ--Arr_3_ 8 _Dep_ 8--I	ABQ	I	263	99101	0.00265
0.62161	0.37185	0.34077	0.91641	LAS--Arr_1L_ 25R _Dep_ 1R--I	LAS	I	2053	415772	0.00494
0.61618	0.51156	0.51059	0.99810	DEN--Arr_34R_ 35L_ 35R _Dep_ 25_ 34L_ 34R--I	DEN	I	3779	617913	0.00612
0.60556	0.37030	0.35334	0.95422	IAD--Arr_19L_ 19R _Dep_ 30--I	IAD	I	7599	329263	0.02308
0.60403	0.12985	0.12756	0.98236	PBI--Arr_9L_ 9R _Dep_ 9L_ 9R--I	PBI	I	287	85880	0.00334
0.60401	0.45099	0.44726	0.99172	JFK--Arr_22L_ 22R _Dep_ 22R_ 31L--V	JFK	V	16975	415653	0.04084
0.60102	**1.00000**	**0.37537**	**0.37537**	**JFK--Arr_31R _Dep_ 31L--I**	**JFK**	**I**	1649	415653	0.00397
0.59580	0.23080	0.23034	0.99801	BNA--Arr_2C_ 2L_ 2R _Dep_ 2C_ 2L_ 2R--I	BNA	I	4374	150360	0.02909
0.59213	0.22541	0.21953	0.97392	PHL--Arr_26_ 27R_ 35 _Dep_ 27L_ 35--I	PHL	I	2240	459819	0.00487
0.58481	0.79386	0.35019	0.44113	LGA--Arr_22 _Dep_ 31--I	LGA	I	4733	372243	0.01271
0.58237	0.63412	0.51715	0.81553	BOS--Arr_27_ 32 _Dep_ 33L--I	BOS	I	517	337060	0.00153
0.57998	0.31607	0.28324	0.89614	EWR--Arr_11_ 22L _Dep_ 22R--I	EWR	I	1302	413478	0.00315
0.57961	0.35519	0.35460	0.99834	DEN--Arr_34R_ 35L_ 35R _Dep_ 8_ 34L_ 34R--I	DEN	I	4827	617913	0.00781
0.57753	0.31386	0.31249	0.99564	OAK--Arr_9L_ 9R_ 11 _Dep_ 9L_ 9R_ 11--I	OAK	I	3190	174586	0.01827
0.57249	0.43080	0.39480	0.91642	DTW--Arr_21L_ 22R _Dep_ 21R--I	DTW	I	2531	452450	0.00559
0.56793	0.77859	0.34484	0.44291	MDW--Arr_4R _Dep_ 4R--I	MDW	I	9681	213443	0.04536
0.56031	0.25819	0.25669	0.99419	ORD--Arr_14R_ 22R_ 27L _Dep_ 22L_ 28--I	ORD	I	827	863020	0.00096
0.55812	0.74328	0.70683	0.95096	JFK--Arr_22L_ 22R _Dep_ 22R--V	JFK	V	11668	415653	0.02807
0.55790	0.31175	0.11957	0.38353	PIT--Arr_28L _Dep_ 28C--I	PIT	I	544	143935	0.00378
0.54960	0.73454	0.34532	0.47011	JFK--Arr_22L _Dep_ 22R--V	JFK	V	18159	415653	0.04369
0.53606	0.18614	0.18187	0.97708	IND--Arr_IN_ ONE _Dep_ ONE_ OUT--I	IND	I	2322	168847	0.01375
0.53413	0.32799	0.32102	0.97873	BOS--Arr_22L_ 27 _Dep_ 22L_ 22R--I	BOS	I	2938	337060	0.00872
0.53406	0.49203	0.48886	0.99356	IAH--Arr_8L_ 8R _Dep_ 9_ 15L_ 15R--I	IAH	I	12879	557317	0.02311
0.53348	0.26865	0.26700	0.99388	RDU--Arr_23L_ 23R _Dep_ 23L_ 23R--I	RDU	I	2049	165589	0.01237
0.53334	0.54310	0.54204	0.99805	MEM--Arr_18L_ 18R _Dep_ 18L_ 18R--I	MEM	I	10517	330691	0.03180
0.53329	**0.85344**	**0.75196**	**0.88110**	**JFK--Arr_31L_ 31R _Dep_ 31L--I**	**JFK**	**I**	3015	415653	0.00725
0.53283	0.68511	0.29737	0.43405	PHL--Arr_9R _Dep_ 8_ 9L--V	PHL	V	5602	459819	0.01218
0.53229	0.31641	0.31261	0.98798	IAH--Arr_8L_ 8R _Dep_ 15L_ 15R--I	IAH	I	6985	557317	0.01253
0.53114	0.10741	0.10112	0.94139	HOU--Arr_12L_ 12R _Dep_ 22--I	HOU	I	1785	124850	0.01430
0.52967	0.21211	0.20767	0.97904	PBI--Arr_27L_ 27R_ 31 _Dep_ 27L_ 27R_ 31--I	PBI	I	363	85880	0.00423
0.52837	0.41031	0.27749	0.67629	MDW--Arr_22L_ 31C _Dep_ 22L--I	MDW	I	359	213443	0.00168
0.52808	0.49132	0.22573	0.45944	CLE--Arr_6L _Dep_ 6R--I	CLE	I	11429	222790	0.05130

0.52637	**1.00000**	**0.17628**	**0.17628**	**MDW--Arr_31C _Dep_ 22L--I**	**MDW**	**I**	333	213443	0.00156
0.52483	0.17220	0.17217	0.99980	PBI--Arr_27L_ 27R_ 31 _Dep_ 27L_ 27R_ 31--V	PBI	V	14288	85880	0.16637
0.52459	0.33297	0.31651	0.95057	IAD--Arr_1L_ 1R _Dep_ 30--I	IAD	I	8137	329263	0.02471
0.51534	0.46793	0.46598	0.99583	FLL--Arr_27L_ 27R _Dep_ 27L_ 27R--I	FLL	I	4484	225773	0.01986
0.51217	0.27054	0.26755	0.98893	MIA--Arr_8L_ 9 _Dep_ 8R_ 12--I	MIA	I	3678	288651	0.01274
0.51195	0.73461	0.30303	0.41250	BOS--Arr_22L _Dep_ 22R--I	BOS	I	4939	337060	0.01465
0.50984	0.16496	0.16086	0.97515	ABQ--Arr_3_ 8 _Dep_ 3_ 8--I	ABQ	I	348	99101	0.00351
0.50886	0.54287	0.53737	0.98987	SFO--Arr_28L_ 28R _Dep_ 28L_ 28R--I	SFO	I	3779	361208	0.01046
0.50505	0.29816	0.29771	0.99849	OAK--Arr_9L_ 9R_ 11 _Dep_ 9L_ 9R_ 11--V	OAK	V	7190	174586	0.04118
0.50417	0.21084	0.20350	0.96521	IAD--Arr_19L_ 19R _Dep_ 19L_ 30--I	IAD	I	2257	329263	0.00685
0.50021	0.28470	0.28352	0.99584	CVG--Arr_36C_ 36L_ 36R _Dep_ 27_ 36C_ 36R--I	CVG	I	3446	276981	0.01244
0.49905	0.15165	0.14120	0.93108	JFK--Arr_22L_ 22R _Dep_ 22R_ 31L--I	JFK	I	284	415653	0.00068
0.49892	0.60005	0.59589	0.99306	MEM--Arr_36L_ 36R _Dep_ 36L_ 36R--I	MEM	I	8487	330691	0.02566
0.49234	0.57290	0.24834	0.43347	IAD--Arr_1L _Dep_ 1R_ 30--I	IAD	I	2756	329263	0.00837
0.49170	0.33846	0.32301	0.95433	IAD--Arr_19L_ 19R _Dep_ 30--V	IAD	V	6731	329263	0.02044
0.49070	0.29146	0.29089	0.99803	IND--Arr_5L_ 5R _Dep_ 5L_ 5R--I	IND	I	5283	168847	0.03129
0.48967	0.15244	0.14882	0.97624	PBI--Arr_27L_ 27R _Dep_ 27L_ 27R--I	PBI	I	262	85880	0.00305
0.48871	0.48812	0.18718	0.38346	BWI--Arr_33L _Dep_ 28--I	BWI	I	2689	246929	0.01089
0.48608	0.14032	0.13957	0.99466	PIT--Arr_28L_ 28R _Dep_ 28C_ 28R--I	PIT	I	7332	143935	0.05094
0.48351	0.53634	0.23671	0.44135	CLE--Arr_24R _Dep_ 24L--I	CLE	I	11866	222790	0.05326
0.47986	0.09732	0.09677	0.99431	DEN--Arr_16L_ 16R_ 17R _Dep_ 8_ 17L_ 17R--I	DEN	I	262	617913	0.00042
0.47871	0.38688	0.36736	0.94956	IAD--Arr_19C_ 19L _Dep_ 30--I	IAD	I	5825	329263	0.01769
0.47792	0.15394	0.14853	0.96484	CLE--Arr_24L_ 24R _Dep_ 24L_ 24R--I	CLE	I	167	222790	0.00075
0.47759	0.28255	0.28137	0.99580	TPA--Arr_18L_ 18R _Dep_ 18L_ 18R--I	TPA	I	4024	200831	0.02004
0.47466	0.13030	0.12853	0.98640	PIT--Arr_10L_ 10R _Dep_ 10C_ 14--I	PIT	I	2208	143935	0.01534
0.46941	0.23580	0.23106	0.97991	STL--Arr_11_ 12R _Dep_ 12L_ 12R--I	STL	I	4228	232916	0.01815
0.46624	0.29063	0.28977	0.99704	MCI--Arr_1L_ 1R _Dep_ 1L_ 1R--I	MCI	I	7720	168235	0.04589
0.46541	0.51656	0.51145	0.99010	PHL--Arr_9R_ 17 _Dep_ 8_ 9L_ 17--V	PHL	V	17937	459819	0.03901
0.46452	0.43547	0.43111	0.98998	DTW--Arr_3R_ 4L _Dep_ 3L_ 4R--I	DTW	I	23213	452450	0.05131
0.46339	0.61768	0.61628	0.99772	MEM--Arr_18L_ 18R _Dep_ 18C_ 18L_ 18R--I	MEM	I	10495	330691	0.03174
0.45961	0.26652	0.26113	0.97978	MIA--Arr_26R_ 30 _Dep_ 26L_ 27--I	MIA	I	1924	288651	0.00667
0.45886	0.24716	0.24660	0.99776	BNA--Arr_20C_ 20L_ 20R _Dep_ 20C_ 20L_ 20R--I	BNA	I	4175	150360	0.02777
0.45842	0.31213	0.30983	0.99263	MEM--Arr_9_ 36L_ 36R _Dep_ 36C_ 36L_ 36R--I	MEM	I	1962	330691	0.00593
0.45077	0.47831	0.17002	0.35545	PIT--Arr_10R _Dep_ 10C_ 14--I	PIT	I	1003	143935	0.00697
0.44603	0.28759	0.28572	0.99352	RDU--Arr_5L_ 5R _Dep_ 5L_ 5R--I	RDU	I	2638	165589	0.01593
0.44365	0.66654	0.66551	0.99845	DFW--Arr_35C_ 35R_ 36L _Dep_ 31L_ 35L_ 36R--I	DFW	I	20932	644199	0.03249
0.44145	0.39804	0.39760	0.99890	LAS--Arr_19L_ 19R_ 25L _Dep_ 19L_ 19R_ 25R--V	LAS	V	16929	415772	0.04072
0.44082	0.28353	0.28209	0.99491	RDU--Arr_23L_ 23R _Dep_ 23L_ 23R--V	RDU	V	9019	165589	0.05447

0.43927	0.39413	0.39291	0.99691	FLL--Arr_27L_ 27R _Dep_ 27L_ 27R--V	FLL	V	38453	225773	0.17032
0.43825	0.75000	0.33841	0.45122	LGA--Arr_31 _Dep_ 31--V	LGA	V	18108	372243	0.04865
0.43808	0.07452	0.07318	0.98199	DEN--Arr_16L_ 16R_ 17R _Dep_ 8_ 17L_ 17R_ 25--I	DEN	I	98	617913	0.00016
0.43436	0.14893	0.14571	0.97839	BWI--Arr_10_ 15L _Dep_ 15L_ 15R--I	BWI	I	1720	246929	0.00697
0.43416	0.54059	0.23713	0.43866	HOU--Arr_22 _Dep_ 22--V	HOU	V	3861	124850	0.03093
0.42973	0.21056	0.20414	0.96952	IAD--Arr_1C_ 1R _Dep_ 1R_ 30--I	IAD	I	2373	329263	0.00721
0.42471	0.64597	0.64386	0.99673	MEM--Arr_36L_ 36R _Dep_ 36C_ 36L_ 36R--I	MEM	I	8017	330691	0.02424
0.42284	0.50020	0.49783	0.99527	CVG--Arr_36C_ 36L_ 36R _Dep_ 36C_ 36R--I	CVG	I	13489	276981	0.04870
0.41518	0.73487	0.73487	1.00000	DEN--Arr_34R_ 35L_ 35R _Dep_ 8_ 25_ 34L_ 34R--I	DEN	I	9275	617913	0.01501
0.41498	0.31576	0.28395	0.89926	BWI--Arr_33L_ 33R _Dep_ 28--I	BWI	I	206	246929	0.00083
0.41274	**1.00000**	**0.53275**	**0.53275**	**JFK--Arr_22L _Dep_ 22R_ 31L--V**	**JFK**	**V**	57548	415653	0.13845
0.41265	**0.80065**	**0.31723**	**0.39622**	**IND--Arr_32 _Dep_ 32--I**	**IND**	**I**	615	168847	0.00364
0.41245	0.20327	0.19796	0.97387	STL--Arr_11_ 12L _Dep_ 12L_ 12R--I	STL	I	1691	232916	0.00726
0.40831	0.60869	0.25405	0.41736	BNA--Arr_20R _Dep_ 20R--I	BNA	I	747	150360	0.00497
0.40803	**0.82250**	**0.36307**	**0.44142**	**JFK--Arr_13L _Dep_ 13R--V**	**JFK**	**V**	15330	415653	0.03688
0.40679	0.60025	0.59933	0.99846	ORD--Arr_4R_ 9R_ 10 _Dep_ 4L_ 9R_ 32L_ 32R--I	ORD	I	2714	863020	0.00314
0.40678	0.64368	0.63132	0.98080	BOS--Arr_4L_ 4R _Dep_ 4L_ 4R_ 9--I	BOS	I	1694	337060	0.00503
0.40336	0.28486	0.28408	0.99728	IND--Arr_23L_ 23R _Dep_ 23L_ 23R--I	IND	I	12534	168847	0.07423
0.40321	0.26185	0.20151	0.76955	PBI--Arr_9L_ 9R_ 13 _Dep_ 9L_ 9R_ 13--V	PBI	V	47740	85880	0.55589
0.40243	0.20254	0.19751	0.97515	IAD--Arr_19C_ 19L _Dep_ 19L_ 30--I	IAD	I	1812	329263	0.00550
0.40027	**0.95531**	**0.39098**	**0.40927**	**JFK--Arr_4R _Dep_ 4L--V**	**JFK**	**V**	7916	415653	0.01904
0.40018	0.56732	0.56228	0.99112	MEM--Arr_27_ 36L_ 36R _Dep_ 36L_ 36R--I	MEM	I	2679	330691	0.00810
0.39776	0.12468	0.12432	0.99713	PBI--Arr_27L_ 27R _Dep_ 27L_ 27R--V	PBI	V	8203	85880	0.09552
0.39711	0.41092	0.38010	0.92499	MCO--Arr_17L_ 18R _Dep_ 17R_ 18R--I	MCO	I	324	319963	0.00101
0.39557	0.57590	0.33494	0.58158	CLE--Arr_24R _Dep_ 24L_ 24R--I	CLE	I	2491	222790	0.01118
0.39335	0.73161	0.35738	0.48848	JFK--Arr_31R _Dep_ 31L--V	JFK	V	45158	415653	0.10864
0.39094	0.67084	0.66984	0.99851	ORD--Arr_4R_ 9R_ 10 _Dep_ 4L_ 9R_ 32L--I	ORD	I	7800	863020	0.00904
0.39080	0.37351	0.16266	0.43548	HOU--Arr_22 _Dep_ 22--I	HOU	I	1118	124850	0.00895
0.39060	0.23496	0.23431	0.99723	STL--Arr_30L_ 30R _Dep_ 29_ 30L--I	STL	I	17734	232916	0.07614
0.37958	0.29901	0.29693	0.99304	RDU--Arr_23L_ 23R_ 32 _Dep_ 23L_ 23R--I	RDU	I	2617	165589	0.01580
0.37834	0.30490	0.30366	0.99593	MCI--Arr_19L_ 19R _Dep_ 19L_ 19R--I	MCI	I	7551	168235	0.04488
0.37821	0.29173	0.28961	0.99273	MCO--Arr_35R_ 36R _Dep_ 35L_ 36L--I	MCO	I	3973	319963	0.01242
0.37762	0.58053	0.22434	0.38644	CLE--Arr_24L _Dep_ 24R--I	CLE	I	7575	222790	0.03400
0.37487	0.58971	0.23114	0.39195	BWI--Arr_10 _Dep_ 15R--I	BWI	I	10778	246929	0.04365
0.37364	0.35822	0.35710	0.99688	MEM--Arr_18L_ 18R_ 27 _Dep_ 18C_ 18L_ 18R--I	MEM	I	4214	330691	0.01274
0.37342	0.37329	0.37239	0.99757	FLL--Arr_9L_ 9R _Dep_ 9L_ 9R--I	FLL	I	15885	225773	0.07036
0.37254	0.38721	0.35546	0.91801	LAS--Arr_1L_ 25R _Dep_ 1R--V	LAS	V	34722	415772	0.08351
0.36984	0.13871	0.13242	0.95462	STL--Arr_11_ 12L _Dep_ 12R--I	STL	I	322	232916	0.00138

0.36854	**1.00000**	**0.55800**	**0.55800**	**LGA--Arr_22 _Dep_ 13--V**	**LGA**	**V**	80385	372243	0.21595
0.36804	0.63175	0.56914	0.90089	EWR--Arr_11_ 22L _Dep_ 22R--V	EWR	V	70968	413478	0.17164
0.36648	0.24207	0.23909	0.98769	SJC--Arr_11_ 12L_ 12R _Dep_ 11_ 12L_ 12R--I	SJC	I	753	135325	0.00556
0.36342	0.37192	0.35574	0.95649	IAD--Arr_1C_ 1R _Dep_ 30--I	IAD	I	8530	329263	0.02591
0.36145	0.56023	0.55675	0.99378	CVG--Arr_18C_ 18L_ 18R _Dep_ 18C_ 18L--I	CVG	I	10047	276981	0.03627
0.36064	0.29650	0.28931	0.97575	MIA--Arr_26R_ 30 _Dep_ 26L_ 27--V	MIA	V	50796	288651	0.17598
0.36041	0.12558	0.11607	0.92429	PBI--Arr_9L_ 9R _Dep_ 9L_ 9R--V	PBI	V	10825	85880	0.12605
0.36000	**0.87070**	**0.86135**	**0.98926**	**CLT--Arr_36C_ 36R _Dep_ 36C_ 36R--I**	**CLT**	**I**	5631	496390	0.01134
0.35996	0.55977	0.52861	0.94434	EWR--Arr_4R_ 11 _Dep_ 4L--V	EWR	V	40339	413478	0.09756
0.35719	0.26135	0.25982	0.99415	RDU--Arr_5L_ 5R_ 32 _Dep_ 5L_ 5R--I	RDU	I	3340	165589	0.02017
0.35712	0.76034	0.31534	0.41474	RDU--Arr_23R _Dep_ 23R--I	RDU	I	878	165589	0.00530
0.35694	0.44482	0.41651	0.93635	EWR--Arr_4R_ 11 _Dep_ 4L--I	EWR	I	1573	413478	0.00380
0.35609	0.22840	0.19306	0.84529	HOU--Arr_12L_ 12R _Dep_ 12R--V	HOU	V	10341	124850	0.08283
0.35326	0.55287	0.54680	0.98902	IAH--Arr_26L_ 26R _Dep_ 15L_ 15R--I	IAH	I	24533	557317	0.04402
0.35295	0.58141	0.25827	0.44421	RDU--Arr_23R _Dep_ 23R--V	RDU	V	9559	165589	0.05773
0.35212	0.67155	0.29745	0.44293	IND--Arr_32 _Dep_ 32--V	IND	V	5356	168847	0.03172
0.35158	0.51857	0.48328	0.93195	JFK--Arr_13L_ 22L _Dep_ 13R--V	JFK	V	55654	415653	0.13390
0.34682	0.27372	0.27173	0.99273	MCO--Arr_17L_ 18R _Dep_ 17R_ 18L--I	MCO	I	3345	319963	0.01045
0.34620	0.19093	0.18793	0.98428	DTW--Arr_21R_ 22L_ 22R _Dep_ 21R_ 22L--I	DTW	I	647	452450	0.00143
0.34416	0.19899	0.19273	0.96855	PIT--Arr_28R_ 32 _Dep_ 28L_ 28R--I	PIT	I	680	143935	0.00472
0.34177	0.06138	0.05958	0.97070	ORD--Arr_27L_ 27R_ 28 _Dep_ 22L_ 32L--I	ORD	I	35	863020	0.00004
0.33949	0.24341	0.24334	0.99973	BNA--Arr_2C_ 2L_ 2R _Dep_ 2C_ 2L_ 2R--V	BNA	V	22220	150360	0.14778
0.33921	**1.00000**	**0.25909**	**0.25909**	**MDW--Arr_4R _Dep_ 31C--I**	**MDW**	**I**	938	213443	0.00439
0.33810	0.09290	0.09221	0.99255	HOU--Arr_12L_ 12R _Dep_ 4_ 22--I	HOU	I	1609	124850	0.01289
0.33783	0.43501	0.42603	0.97935	DTW--Arr_21L_ 22R _Dep_ 21R_ 22L--I	DTW	I	52044	452450	0.11503
0.33680	0.32619	0.32374	0.99248	MCO--Arr_17L_ 18L _Dep_ 17R_ 18R--V	MCO	V	9223	319963	0.02883
0.33442	0.36065	0.35925	0.99612	STL--Arr_12L_ 12R _Dep_ 12L_ 12R--I	STL	I	13265	232916	0.05695
0.33404	0.51783	0.51738	0.99914	MEM--Arr_18L_ 18R _Dep_ 18C_ 18L_ 18R--V	MEM	V	16378	330691	0.04953
0.33290	0.23803	0.23772	0.99872	SJC--Arr_11_ 12L_ 12R _Dep_ 11_ 12L_ 12R--V	SJC	V	6626	135325	0.04896
0.32825	0.25844	0.25660	0.99290	IAD--Arr_19C_ 19L _Dep_ 19L_ 30--V	IAD	V	9684	329263	0.02941
0.32747	**1.00000**	**0.57314**	**0.57314**	**LGA--Arr_22 _Dep_ 31--V**	**LGA**	**V**	84178	372243	0.22614
0.32720	0.27035	0.26897	0.99487	RDU--Arr_5L_ 5R _Dep_ 5L_ 5R--V	RDU	V	8329	165589	0.05030
0.32592	0.52264	0.20234	0.38716	MDW--Arr_31C _Dep_ 22L--V	MDW	V	8560	213443	0.04010
0.32369	0.67619	0.28719	0.42471	BWI--Arr_10 _Dep_ 15L_ 15R--I	BWI	I	5121	246929	0.02074
0.32265	0.44443	0.19964	0.44921	HOU--Arr_12R _Dep_ 12R--V	HOU	V	3840	124850	0.03076
0.32163	**1.00000**	**0.45202**	**0.45202**	**DCA--Arr_1 _Dep_ 1--I**	**DCA**	**I**	23004	271959	0.08459
0.32161	0.42912	0.23124	0.53888	BNA--Arr_20R _Dep_ 20C_ 20R--I	BNA	I	464	150360	0.00309
0.31944	0.54564	0.54424	0.99742	MEM--Arr_18L_ 18R _Dep_ 18L_ 18R--V	MEM	V	13643	330691	0.04126

0.31904	0.53458	0.53320	0.99742	IAH--Arr_26L_ 26R_ 27 _Dep_ 33L_ 33R--V	IAH	V	27256	557317	0.04891
0.31814	0.48748	0.42131	0.86426	SEA--Arr_16C_ 16L _Dep_ 16L--I	SEA	I	1334	333510	0.00400
0.31749	0.56011	0.54458	0.97227	CLT--Arr_18C_ 23 _Dep_ 18C_ 18L--I	CLT	I	3104	496390	0.00625
0.31411	0.55276	0.55237	0.99928	DFW--Arr_31R_ 35C_ 35R_ 36L _Dep_ 31L_ 35L_ 36R--I	DFW	I	10675	644199	0.01657
0.31204	0.37325	0.16484	0.44162	ABQ--Arr_21 _Dep_ 21--V	ABQ	V	4615	99101	0.04657
0.30995	0.42121	0.40383	0.95873	IAD--Arr_19C_ 19L _Dep_ 30--V	IAD	V	11647	329263	0.03537
0.30825	0.23972	0.23952	0.99916	CVG--Arr_18C_ 18L_ 18R _Dep_ 18C_ 18L_ 27--I	CVG	I	14807	276981	0.05346
0.30534	0.68712	0.68626	0.99875	MSP--Arr_30L_ 30R _Dep_ 30L_ 30R--I	MSP	I	18851	426844	0.04416
0.30468	**0.80743**	**0.36349**	**0.45018**	**DCA--Arr_19 _Dep_ 19--I**	**DCA**	**I**	7512	271959	0.02762
0.30458	0.24302	0.24102	0.99177	BWI--Arr_10_ 15L _Dep_ 15L_ 15R--V	BWI	V	9475	246929	0.03837
0.30135	0.63931	0.28406	0.44432	RDU--Arr_5L _Dep_ 5L--I	RDU	I	2527	165589	0.01526
0.30127	0.27620	0.27281	0.98772	SEA--Arr_16L_ 16R _Dep_ 16C_ 16L--I	SEA	I	7758	333510	0.02326
0.29746	0.15376	0.15259	0.99241	HOU--Arr_12L_ 12R _Dep_ 4_ 22--V	HOU	V	10877	124850	0.08712
0.29704	0.51227	0.50802	0.99172	PHL--Arr_9R_ 35 _Dep_ 8_ 9L_ 35--V	PHL	V	20952	459819	0.04557
0.29366	0.31325	0.30999	0.98959	IAD--Arr_19L_ 19R _Dep_ 19L_ 30--V	IAD	V	9439	329263	0.02867
0.29302	0.27727	0.26947	0.97185	BOS--Arr_4L_ 4R _Dep_ 4R_ 9--I	BOS	I	1406	337060	0.00417
0.29157	0.32092	0.31720	0.98842	MCO--Arr_17L_ 18L _Dep_ 17R_ 18R--I	MCO	I	536	319963	0.00168
0.29119	**0.93906**	**0.16420**	**0.17485**	**MSY--Arr_19 _Dep_ 28--I**	**MSY**	**I**	333	99834	0.00334
0.29060	0.58481	0.26044	0.44534	BNA--Arr_20R _Dep_ 20R--V	BNA	V	10182	150360	0.06772
0.28986	0.57633	0.33338	0.57846	CLE--Arr_24L _Dep_ 24L_ 24R--I	CLE	I	2166	222790	0.00972
0.28891	0.31746	0.31742	0.99987	DEN--Arr_16L_ 16R_ 17R _Dep_ 8_ 17L_ 17R--V	DEN	V	24193	617913	0.03915
0.28815	0.65749	0.53114	0.80783	IAD--Arr_12_ 19L_ 19R _Dep_ 19L--I	IAD	I	1276	329263	0.00388
0.28799	0.37101	0.37098	0.99993	DEN--Arr_34R_ 35L_ 35R _Dep_ 8_ 34L_ 34R--V	DEN	V	19415	617913	0.03142
0.28562	0.28727	0.28427	0.98956	RDU--Arr_23L_ 23R_ 32 _Dep_ 23L_ 23R--V	RDU	V	24880	165589	0.15025
0.28244	0.87412	0.39310	0.44971	MDW--Arr_31C _Dep_ 31C--I	MDW	I	10520	213443	0.04929
0.28111	**1.00000**	**0.50392**	**0.50392**	**JFK--Arr_4R _Dep_ 4L_ 31L--V**	**JFK**	**V**	27680	415653	0.06659
0.28015	0.50923	0.49790	0.97774	DTW--Arr_21L_ 22L_ 22R _Dep_ 21R_ 22L--I	DTW	I	616	452450	0.00136
0.27661	0.75468	0.34339	0.45501	IAD--Arr_1L _Dep_ 1R_ 30--V	IAD	V	9021	329263	0.02740
0.27496	**1.00000**	**0.49851**	**0.49851**	**LGA--Arr_4 _Dep_ 13--V**	**LGA**	**V**	34507	372243	0.09270
0.27418	0.16076	0.15925	0.99066	SJC--Arr_29_ 30L _Dep_ 29_ 30L_ 30R--I	SJC	I	616	135325	0.00455
0.27183	0.51189	0.51093	0.99811	SLC--Arr_16L_ 16R_ 17 _Dep_ 16L_ 16R_ 17--I	SLC	I	9977	316852	0.03149
0.27091	0.32321	0.12342	0.38187	HOU--Arr_4 _Dep_ 30L--V	HOU	V	4378	124850	0.03507
0.26764	0.53296	0.12080	0.22666	MSY--Arr_1 _Dep_ 28--I	MSY	I	319	99834	0.00320
0.26560	0.48752	0.46182	0.94729	LAS--Arr_1L_ 25L _Dep_ 1R--V	LAS	V	33845	415772	0.08140
0.26513	0.26273	0.25962	0.98814	STL--Arr_11_ 12R _Dep_ 12L_ 12R--V	STL	V	7482	232916	0.03212
0.26241	0.42350	0.16020	0.37828	PIT--Arr_28L _Dep_ 28C--V	PIT	V	4346	143935	0.03019
0.26015	0.33207	0.32974	0.99297	IAD--Arr_1L_ 1R _Dep_ 1R_ 30--V	IAD	V	12342	329263	0.03748
0.25923	0.39364	0.37674	0.95708	MDW--Arr_22L_ 31C _Dep_ 22L--V	MDW	V	7528	213443	0.03527

0.25769	0.61893	0.24254	0.39187	BWI--Arr_10 _Dep_ 15L_ 15R--V	BWI	V	7248	246929	0.02935
0.25681	0.26142	0.26004	0.99472	PIT--Arr_28L_ 28R _Dep_ 28C_ 28R--V	PIT	V	62024	143935	0.43092
0.25595	0.57591	0.26252	0.45585	RDU--Arr_5L _Dep_ 5L--V	RDU	V	9764	165589	0.05897
0.25241	0.40586	0.37984	0.93590	IAD--Arr_1L_ 1R _Dep_ 30--V	IAD	V	40391	329263	0.12267
0.25222	0.53156	0.53112	0.99916	SLC--Arr_34L_ 34R_ 35 _Dep_ 34L_ 34R_ 35--I	SLC	I	19967	316852	0.06302
0.25168	0.65391	0.65283	0.99836	MSP--Arr_12L_ 12R _Dep_ 12L_ 12R_ 17--I	MSP	I	37053	426844	0.08681
0.25116	0.43735	0.41011	0.93770	LAS--Arr_1L_ 1R _Dep_ 7L--V	LAS	V	27831	415772	0.06694
0.25006	0.38272	0.17235	0.45033	HOU--Arr_4 _Dep_ 4--I	HOU	I	3196	124850	0.02560
0.24969	0.24375	0.24360	0.99937	BNA--Arr_20C_ 20L_ 20R _Dep_ 20C_ 20L_ 20R--V	BNA	V	26531	150360	0.17645
0.24961	0.59466	0.23662	0.39790	CLE--Arr_6L _Dep_ 6R--V	CLE	V	15776	222790	0.07081
0.24920	0.25399	0.24863	0.97892	BWI--Arr_33L_ 33R _Dep_ 28_ 33R--I	BWI	I	3228	246929	0.01307
0.24886	0.17517	0.16311	0.93114	BOS--Arr_22L_ 27 _Dep_ 22R--I	BOS	I	712	337060	0.00211
0.24845	0.25059	0.25037	0.99911	CVG--Arr_36C_ 36L_ 36R _Dep_ 27_ 36C_ 36R--V	CVG	V	11730	276981	0.04235
0.24783	0.34239	0.33989	0.99272	TPA--Arr_36L_ 36R _Dep_ 36L_ 36R--I	TPA	I	3544	200831	0.01765
0.24668	0.17450	0.16578	0.95004	ABQ--Arr_26_ 30 _Dep_ 26_ 30--V	ABQ	V	13110	99101	0.13229
0.24553	0.48166	0.46434	0.96405	DTW--Arr_21L_ 22R _Dep_ 21R--V	DTW	V	24579	452450	0.05432
0.24498	0.57279	0.56557	0.98740	CLT--Arr_18R_ 23 _Dep_ 18L_ 18R--I	CLT	I	16605	496390	0.03345
0.24474	0.14751	0.13161	0.89217	CLE--Arr_6L_ 10 _Dep_ 6R--I	CLE	I	179	222790	0.00080
0.23827	0.30522	0.30483	0.99871	MEM--Arr_27_ 36L_ 36R _Dep_ 36C_ 36L_ 36R--I	MEM	I	9757	330691	0.02950
0.23705	0.26314	0.25343	0.96311	BNA--Arr_20C_ 20R _Dep_ 20C_ 20R--I	BNA	I	279	150360	0.00186
0.23626	0.24206	0.23766	0.98181	STL--Arr_29_ 30R _Dep_ 29_ 30L--I	STL	I	4438	232916	0.01905
0.23271	0.34465	0.34136	0.99044	MCO--Arr_17L_ 18R _Dep_ 17R_ 18R--V	MCO	V	11600	319963	0.03625
0.22911	0.20234	0.20141	0.99536	IND--Arr_IN_ ONE _Dep_ ONE_ OUT--V	IND	V	11974	168847	0.07092
0.22628	0.15374	0.15195	0.98834	PIT--Arr_28R_ 32 _Dep_ 28C_ 28R--V	PIT	V	4416	143935	0.03068
0.22586	0.59946	0.59860	0.99857	DFW--Arr_31R_ 35C_ 35R_ 36L _Dep_ 31L_ 35L_ 36R--V	DFW	V	121162	644199	0.18808
0.22298	0.62354	0.62304	0.99920	DFW--Arr_35C_ 35R_ 36L _Dep_ 31L_ 35L_ 36R--V	DFW	V	16020	644199	0.02487
0.22236	0.20846	0.15695	0.75290	HOU--Arr_12L_ 12R _Dep_ 22--V	HOU	V	27280	124850	0.21850
0.21684	0.54777	0.54581	0.99642	MSP--Arr_30L_ 30R _Dep_ 30L_ 30R--V	MSP	V	11337	426844	0.02656
0.21528	0.73807	0.73480	0.99557	SFO--Arr_28L_ 28R _Dep_ 28L_ 28R--V	SFO	V	40190	361208	0.11127
0.21522	0.49434	0.49430	0.99992	IAH--Arr_26L_ 26R_ 27 _Dep_ 15L_ 15R--I	IAH	I	54217	557317	0.09728
0.21478	0.17392	0.17321	0.99590	PIT--Arr_28R_ 32 _Dep_ 28L_ 28R--V	PIT	V	10336	143935	0.07181
0.21474	0.28925	0.28789	0.99528	RDU--Arr_5L_ 5R_ 32 _Dep_ 5L_ 5R--V	RDU	V	15956	165589	0.09636
0.21430	0.57790	0.24586	0.42544	CLE--Arr_24R _Dep_ 24L--V	CLE	V	21326	222790	0.09572
0.21314	0.27346	0.10678	0.39047	MSY--Arr_19 _Dep_ 28--V	MSY	V	3868	99834	0.03874
0.21301	0.44331	0.44249	0.99815	BOS--Arr_22L_ 27 _Dep_ 22L_ 22R--V	BOS	V	45374	337060	0.13462
0.21224	0.33861	0.33606	0.99245	MCO--Arr_35R_ 36L _Dep_ 35L_ 36R--V	MCO	V	13831	319963	0.04323
0.21152	0.55401	0.25491	0.46012	BNA--Arr_2L _Dep_ 2L--V	BNA	V	5800	150360	0.03857
0.20675	0.54923	0.54781	0.99740	CVG--Arr_36C_ 36L_ 36R _Dep_ 36C_ 36R--V	CVG	V	33245	276981	0.12003

0.20637	0.43291	0.13994	0.32324	HOU--Arr_4 _Dep_ 30L--I	HOU	I	827	124850	0.00662
0.20551	0.43312	0.27405	0.63274	HOU--Arr_4 _Dep_ 4--V	HOU	V	18726	124850	0.14999
0.20466	0.54066	0.20581	0.38067	MDW--Arr_4R _Dep_ 31C--V	MDW	V	8621	213443	0.04039
0.20405	0.59599	0.59338	0.99563	MCO--Arr_17L_ 18R _Dep_ 17L_ 17R_ 18L_ 18R--V	MCO	V	9442	319963	0.02951
0.20130	0.51346	0.51111	0.99543	CVG--Arr_18C_ 18L_ 18R _Dep_ 18C_ 18L--V	CVG	V	11564	276981	0.04175
0.19676	0.22711	0.22637	0.99677	SJC--Arr_29_ 30L _Dep_ 29_ 30L_ 30R--V	SJC	V	5658	135325	0.04181
0.19562	0.51949	0.51942	0.99986	DFW--Arr_13R_ 17C_ 17L_ 18R _Dep_ 13L_ 17R_ 18L--I	DFW	I	22636	644199	0.03514
0.19327	0.50215	0.49831	0.99234	DTW--Arr_3R_ 4L _Dep_ 3L_ 4R--V	DTW	V	40288	452450	0.08904
0.19323	0.89414	0.71333	0.79779	FLL--Arr_9L_ 9R _Dep_ 9L_ 9R--V	FLL	V	155773	225773	0.68995
0.19244	0.88290	0.87846	0.99497	CLT--Arr_36C_ 36R _Dep_ 36C_ 36R--V	CLT	V	12454	496390	0.02509
0.19192	0.64727	0.64159	0.99122	MEM--Arr_36L_ 36R _Dep_ 36C_ 36L_ 36R--V	MEM	V	4037	330691	0.01221
0.19007	0.16814	0.16010	0.95218	PIT--Arr_10L_ 10R _Dep_ 10C_ 14--V	PIT	V	18774	143935	0.13043
0.18864	0.22052	0.21059	0.95495	ABQ--Arr_3_ 8 _Dep_ 3_ 8--V	ABQ	V	20303	99101	0.20487
0.18857	0.55960	0.15135	0.27045	HOU--Arr_4 _Dep_ 12R--I	HOU	I	539	124850	0.00432
0.18637	0.78398	0.39792	0.50756	MDW--Arr_22L _Dep_ 22L--V	MDW	V	24150	213443	0.11314
0.18516	0.50779	0.46124	0.90833	BOS--Arr_27_ 32 _Dep_ 33L--V	BOS	V	34869	337060	0.10345
0.18028	0.57624	0.54576	0.94711	SEA--Arr_16C_ 16L _Dep_ 16L--V	SEA	V	9602	333510	0.02879
0.17932	0.61556	0.61091	0.99244	IAH--Arr_8L_ 8R _Dep_ 15L_ 15R--V	IAH	V	28790	557317	0.05166
0.17916	0.91538	0.58993	0.64446	BOS--Arr_4R _Dep_ 4R_ 9--V	BOS	V	9242	337060	0.02742
0.17599	0.91432	0.91432	1.00000	ATL--Arr_8L_ 9R_ 10 _Dep_ 8R_ 9L_ 10--I	ATL	I	9146	961520	0.00951
0.17573	0.42024	0.37415	0.89032	PDX--Arr_10L_ 10R _Dep_ 10L_ 10R--I	PDX	I	32182	215794	0.14913
0.17508	0.88262	0.88112	0.99831	ATL--Arr_26R_ 27L_ 28 _Dep_ 26L_ 27R--I	ATL	I	60896	961520	0.06333
0.17491	0.48988	0.46868	0.95673	DTW--Arr_21L_ 22R _Dep_ 22L--I	DTW	I	1462	452450	0.00323
0.17302	0.27334	0.27114	0.99194	STL--Arr_11_ 12L _Dep_ 12L_ 12R--V	STL	V	10038	232916	0.04310
0.17192	0.15549	0.14724	0.94697	MSY--Arr_1_ 10 _Dep_ 1--I	MSY	I	2299	99834	0.02303
0.16937	0.77085	0.51031	0.66201	MDW--Arr_4R _Dep_ 4R--V	MDW	V	41385	213443	0.19389
0.16909	0.73161	0.72903	0.99648	MSP--Arr_30L_ 30R_ 35 _Dep_ 30L_ 30R--I	MSP	I	20315	426844	0.04759
0.16856	0.17437	0.17183	0.98543	SEA--Arr_34C_ 34R _Dep_ 34C_ 34R--I	SEA	I	731	333510	0.00219
0.16855	0.58717	0.58279	0.99256	IAH--Arr_8L_ 8R _Dep_ 9_ 15L_ 15R--V	IAH	V	31455	557317	0.05644
0.16805	0.59042	0.24399	0.41324	BWI--Arr_10 _Dep_ 15R--V	BWI	V	17585	246929	0.07121
0.16487	0.64424	0.64418	0.99991	DEN--Arr_34R_ 35L_ 35R _Dep_ 25_ 34L_ 34R--V	DEN	V	37534	617913	0.06074
0.16483	0.39524	0.15902	0.40235	PIT--Arr_10R _Dep_ 10C_ 14--V	PIT	V	4461	143935	0.03099
0.16383	0.25570	0.25293	0.98915	STL--Arr_29_ 30R _Dep_ 29_ 30L--V	STL	V	7398	232916	0.03176
0.16262	0.36009	0.32209	0.89448	BOS--Arr_22L_ 27 _Dep_ 22R--V	BOS	V	34354	337060	0.10192
0.16219	0.43334	0.27293	0.62984	BNA--Arr_2L _Dep_ 2C_ 2L--V	BNA	V	6989	150360	0.04648
0.16031	0.54946	0.39610	0.72090	SAN--Arr_27 _Dep_ 27--I	SAN	I	26324	207874	0.12663
0.15809	0.66440	0.66426	0.99978	DFW--Arr_17C_ 17L_ 18R _Dep_ 13L_ 17R_ 18L--I	DFW	I	20514	644199	0.03184
0.15746	0.41261	0.41177	0.99797	DFW--Arr_13R_ 17C_ 17L_ 18R _Dep_ 17R_ 18L--I	DFW	I	3233	644199	0.00502

0.15484	0.45292	0.42398	0.93609	IAD--Arr_1C_ 1R _Dep_ 30--V	IAD	V	43554	329263	0.13228
0.15362	0.16469	0.16450	0.99884	ABQ--Arr_26_ 30 _Dep_ 21_ 26_ 30--V	ABQ	V	8779	99101	0.08859
0.15194	0.78859	0.69890	0.88627	MDW--Arr_31C _Dep_ 31C--V	MDW	V	81069	213443	0.37982
0.15011	0.35915	0.34496	0.96051	STL--Arr_30L_ 30R _Dep_ 29_ 30L--V	STL	V	61003	232916	0.26191
0.14919	0.49663	0.49400	0.99470	MCO--Arr_17L_ 17R_ 18L_ 18R _Dep_ 17L_ 17R_ 18L_ 18R--I	MCO	I	3388	319963	0.01059
0.14879	0.37087	0.16503	0.44497	MSY--Arr_1 _Dep_ 1--V	MSY	V	5030	99834	0.05038
0.14845	0.27560	0.27414	0.99470	BNA--Arr_20C_ 20R _Dep_ 20C_ 20R--V	BNA	V	8065	150360	0.05364
0.14600	0.23400	0.23283	0.99499	BNA--Arr_2C_ 2L _Dep_ 2C_ 2L--V	BNA	V	8826	150360	0.05870
0.14587	0.43695	0.43442	0.99422	STL--Arr_30L_ 30R _Dep_ 30L_ 30R--V	STL	V	9063	232916	0.03891
0.14465	0.15517	0.14719	0.94860	MSY--Arr_10_ 19 _Dep_ 19--I	MSY	I	2479	99834	0.02483
0.13650	0.58847	0.58540	0.99478	TPA--Arr_18L_ 18R _Dep_ 18L_ 18R--V	TPA	V	92789	200831	0.46203
0.13247	0.30919	0.30523	0.98718	BNA--Arr_2C_ 2L _Dep_ 2C_ 2L--I	BNA	I	1179	150360	0.00784
0.13165	0.32812	0.31511	0.96034	MSY--Arr_10_ 19 _Dep_ 19--V	MSY	V	29980	99834	0.30030
0.13031	0.73839	0.73831	0.99988	DFW--Arr_17C_ 17L_ 18R _Dep_ 13L_ 17R_ 18L--V	DFW	V	40110	644199	0.06226
0.12956	0.27689	0.10870	0.39258	MSY--Arr_1 _Dep_ 28--V	MSY	V	4307	99834	0.04314
0.12674	0.52800	0.52795	0.99992	MCO--Arr_17L_ 17R_ 18L_ 18R _Dep_ 17L_ 17R_ 18L_ 18R--V	MCO	V	72856	319963	0.22770
0.12338	0.61298	0.61206	0.99851	ORD--Arr_22R_ 27L_ 28 _Dep_ 22L_ 32L_ 32R--I	ORD	I	5483	863020	0.00635
0.12139	0.67862	0.63389	0.93408	MCO--Arr_17L_ 18R _Dep_ 17L_ 17R_ 18L_ 18R--I	MCO	I	310	319963	0.00097
0.11739	0.37091	0.35550	0.95845	BWI--Arr_33L_ 33R _Dep_ 28_ 33R--V	BWI	V	60509	246929	0.24505
0.10904	0.45390	0.43751	0.96391	PHL--Arr_26_ 27R _Dep_ 27L--V	PHL	V	15832	459819	0.03443
0.10816	0.82650	0.82496	0.99814	ORD--Arr_22R_ 27L_ 28 _Dep_ 22L_ 32L--V	ORD	V	36268	863020	0.04202
0.10772	0.39619	0.37826	0.95473	MCO--Arr_17L_ 18R _Dep_ 17R_ 18L--V	MCO	V	67850	319963	0.21206
0.10390	0.45010	0.27577	0.61268	BNA--Arr_20R _Dep_ 20C_ 20R--V	BNA	V	6446	150360	0.04287
0.10363	0.97839	0.37764	0.38598	BOS--Arr_22L _Dep_ 22R--V	BOS	V	8952	337060	0.02656
0.10346	0.55418	0.50972	0.91977	DTW--Arr_21L_ 22R _Dep_ 21R_ 22L--V	DTW	V	113787	452450	0.25149
0.09893	0.60289	0.58000	0.96203	LAS--Arr_7R_ 19R _Dep_ 7L--V	LAS	V	21076	415772	0.05069
0.09605	0.50495	0.49529	0.98087	IND--Arr_23L_ 23R _Dep_ 23L_ 23R--V	IND	V	79871	168847	0.47304
0.09589	0.62397	0.62368	0.99953	BOS--Arr_4L_ 4R _Dep_ 4L_ 4R_ 9--V	BOS	V	25620	337060	0.07601
0.09516	0.95004	0.94510	0.99480	ORD--Arr_22R_ 27L_ 28 _Dep_ 22L_ 32L--I	ORD	I	3821	863020	0.00443
0.09481	0.68526	0.41593	0.60696	CLE--Arr_24R _Dep_ 24L_ 24R--V	CLE	V	11864	222790	0.05325
0.09466	0.63377	0.63364	0.99981	DFW--Arr_13R_ 17C_ 17L_ 18R _Dep_ 17R_ 18L--V	DFW	V	40671	644199	0.06313
0.08663	0.67473	0.51403	0.76183	OAK--Arr_27L_ 27R_ 29 _Dep_ 27L_ 27R_ 29--V	OAK	V	120043	174586	0.68759
0.08386	0.26942	0.25964	0.96368	STL--Arr_11_ 12L _Dep_ 12R--V	STL	V	7075	232916	0.03038
0.08329	0.36727	0.34564	0.94111	MCO--Arr_35R_ 36R _Dep_ 35L_ 36L--V	MCO	V	46386	319963	0.14497
0.08050	0.48592	0.48459	0.99725	BOS--Arr_4L_ 4R _Dep_ 4R_ 9--V	BOS	V	31366	337060	0.09306
0.07864	0.70365	0.42841	0.60884	CLE--Arr_6L _Dep_ 6L_ 6R--V	CLE	V	15938	222790	0.07154
0.07633	0.37619	0.17485	0.46479	ABQ--Arr_8 _Dep_ 8--V	ABQ	V	4971	99101	0.05016
0.07495	0.71509	0.71197	0.99565	MSP--Arr_30L_ 30R _Dep_ 17_ 30L_ 30R--I	MSP	I	6123	426844	0.01434

0.07297	0.35795	0.31508	0.88024	BWI--Arr_33L_ 33R _Dep_ 28--V	BWI	V	30686	246929	0.12427
0.06608	0.24721	0.24568	0.99381	SJC--Arr_29_ 30R _Dep_ 29_ 30R--V	SJC	V	4481	135325	0.03311
0.06419	0.84252	0.84216	0.99956	ORD--Arr_27L_ 27R_ 28 _Dep_ 22L_ 32L--V	ORD	V	30154	863020	0.03494
0.06219	0.99750	0.84667	0.84879	DCA--Arr_19 _Dep_ 19--V	DCA	V	88836	271959	0.32665
0.06166	0.98839	0.66704	0.67487	SEA--Arr_16C _Dep_ 16C_ 16L--I	SEA	I	30411	333510	0.09118
0.06132	0.45836	0.45824	0.99972	MEM--Arr_18L_ 18R_ 27 _Dep_ 18C_ 18L_ 18R--V	MEM	V	50215	330691	0.15185
0.05848	1.00000	0.66798	0.66798	SEA--Arr_16C _Dep_ 16C_ 16L--V	SEA	V	29174	333510	0.08748
0.05771	0.49038	0.49016	0.99956	MCI--Arr_19L_ 19R _Dep_ 19L_ 19R--V	MCI	V	71884	168235	0.42728
0.05605	0.71164	0.50080	0.70372	CLE--Arr_24L _Dep_ 24L_ 24R--V	CLE	V	28430	222790	0.12761
0.05269	0.41250	0.40960	0.99299	MCO--Arr_35R_ 36L _Dep_ 35L_ 36R--I	MCO	I	1658	319963	0.00518
0.04747	0.82914	0.47877	0.57743	BWI--Arr_33L _Dep_ 28--V	BWI	V	57794	246929	0.23405
0.04605	0.76982	0.73552	0.95545	DFW--Arr_13R_ 17C_ 17L_ 18R _Dep_ 13L_ 17R_ 18L--V	DFW	V	254897	644199	0.39568
0.04168	0.91725	0.91699	0.99971	DEN--Arr_26_ 35L_ 35R _Dep_ 25_ 34L_ 34R--V	DEN	V	30296	617913	0.04903
0.03521	0.96401	0.86164	0.89380	PHL--Arr_26_ 27R_ 35 _Dep_ 27L_ 35--V	PHL	V	286814	459819	0.62375
0.02811	0.54338	0.54054	0.99476	STL--Arr_12L_ 12R _Dep_ 12L_ 12R--V	STL	V	58721	232916	0.25211
0.02788	0.56748	0.24540	0.43245	MDW--Arr_22L _Dep_ 22L--I	MDW	I	1206	213443	0.00565
0.02395	0.78628	0.78617	0.99985	DEN--Arr_34R_ 35L_ 35R _Dep_ 8_ 25_ 34L_ 34R--V	DEN	V	70821	617913	0.11461
0.02003	0.55700	0.55278	0.99241	LAX--Arr_24R_ 25L _Dep_ 24L_ 25R--I	LAX	I	34544	588143	0.05873
0.01775	0.65020	0.65012	0.99987	DEN--Arr_16L_ 16R_ 17R _Dep_ 8_ 17L_ 17R_ 25--V	DEN	V	74444	617913	0.12048
0.00885	0.60307	0.26386	0.43752	CLE--Arr_24L _Dep_ 24R--V	CLE	V	25997	222790	0.11669
0.00819	0.55453	0.41833	0.75439	SJC--Arr_29_ 30L_ 30R _Dep_ 29_ 30L_ 30R--V	SJC	V	95590	135325	0.70637
0.00522	0.80593	0.54991	0.68233	IAD--Arr_12_ 19C_ 19L _Dep_ 19L--I	IAD	I	592	329263	0.00180
0.00468	0.93579	0.89163	0.95280	LAS--Arr_19R_ 25L _Dep_ 19L_ 25R--V	LAS	V	238830	415772	0.57443
0.00191	0.57169	0.56944	0.99606	PDX--Arr_10L_ 10R _Dep_ 10L_ 10R--V	PDX	V	64195	215794	0.29748
0.00000	0.52020	0.51948	0.99861	DTW--Arr_3R_ 4L_ 4R _Dep_ 3L_ 4R--V	DTW	V	28664	452450	0.06335
0.00000	0.52681	0.29801	0.56569	CLE--Arr_6L _Dep_ 6L_ 6R--I	CLE	I	752	222790	0.00338
0.00000	0.54389	0.54248	0.99741	MEM--Arr_27_ 36L_ 36R _Dep_ 36L_ 36R--V	MEM	V	13620	330691	0.04119
0.00000	0.55997	0.55741	0.99543	DTW--Arr_21L_ 22L_ 22R _Dep_ 21R_ 22L--V	DTW	V	15189	452450	0.03357
0.00000	0.57056	0.56826	0.99596	TPA--Arr_36L_ 36R _Dep_ 36L_ 36R--V	TPA	V	89300	200831	0.44465
0.00000	0.57237	0.53776	0.93953	MEM--Arr_18L_ 18R_ 27 _Dep_ 18L_ 18R--I	MEM	I	352	330691	0.00106
0.00000	0.58576	0.56467	0.96400	DTW--Arr_21L_ 22R _Dep_ 22L--V	DTW	V	23358	452450	0.05163
0.00000	0.60264	0.60149	0.99808	MSP--Arr_30L_ 30R _Dep_ 17_ 30L_ 30R--V	MSP	V	28171	426844	0.06600
0.00000	0.62084	0.61553	0.99144	PDX--Arr_28L_ 28R _Dep_ 28L_ 28R--V	PDX	V	88165	215794	0.40856
0.00000	0.62692	0.34692	0.55337	BNA--Arr_2L _Dep_ 2C_ 2L--I	BNA	I	743	150360	0.00494
0.00000	0.64542	0.58834	0.91156	CVG--Arr_18C_ 18L_ 18R _Dep_ 18C_ 18L_ 27--V	CVG	V	147963	276981	0.53420
0.00000	0.64771	0.61059	0.94268	IAH--Arr_26L_ 26R _Dep_ 15L_ 15R--V	IAH	V	78016	557317	0.13998
0.00000	0.65349	0.65171	0.99728	LAX--Arr_24L_ 24R_ 25L_ 25R _Dep_ 24L_ 24R_ 25L_ 25R--I	LAX	I	8880	588143	0.01510
0.00000	0.66763	0.65594	0.98250	CLT--Arr_18C_ 23 _Dep_ 18C_ 18L--V	CLT	V	13024	496390	0.02624

0.00000	0.66834	0.59597	0.89171	SEA--Arr_16C_ 16L _Dep_ 16C_ 16L--V	SEA	V	53854	333510	0.16148
0.00000	0.68109	0.65770	0.96565	SEA--Arr_34C_ 34R _Dep_ 34C_ 34R--V	SEA	V	65162	333510	0.19538
0.00000	0.70735	0.32856	0.46449	SFO--Arr_28R _Dep_ 1L_ 1R--V	SFO	V	35337	361208	0.09783
0.00000	0.72610	0.33228	0.45762	SFO--Arr_28R _Dep_ 1L_ 1R--I	SFO	I	24380	361208	0.06750
0.00000	0.72908	0.69467	0.95280	MIA--Arr_8L_ 9 _Dep_ 8R_ 12--V	MIA	V	188154	288651	0.65184
0.00000	0.73006	0.73006	1.00000	IAH--Arr_26L_ 26R_ 27 _Dep_ 15L_ 15R--V	IAH	V	216071	557317	0.38770
0.00000	0.73020	0.72551	0.99358	MEM--Arr_18L_ 18R_ 27 _Dep_ 18L_ 18R--V	MEM	V	10854	330691	0.03282
0.00000	0.75881	0.74566	0.98267	SLC--Arr_16L_ 16R_ 17 _Dep_ 16L_ 16R_ 17--V	SLC	V	125444	316852	0.39591
0.00000	0.76617	0.73164	0.95493	LAX--Arr_24R_ 25L _Dep_ 24L_ 25R--V	LAX	V	127109	588143	0.21612
0.00000	0.78074	0.74389	0.95280	SFO--Arr_28L_ 28R _Dep_ 1L_ 1R--V	SFO	V	194497	361208	0.53846
0.00000	0.79879	0.37160	0.46521	IAD--Arr_1C _Dep_ 1R_ 30--V	IAD	V	16445	329263	0.04994
0.00000	0.80295	0.31291	0.38970	IAD--Arr_1C _Dep_ 1R_ 30--I	IAD	I	2057	329263	0.00625
0.00000	0.80522	0.77811	0.96633	IAD--Arr_12_ 19L_ 19R _Dep_ 19L--V	IAD	V	30513	329263	0.09267
0.00000	0.81384	0.50684	0.62278	EWR--Arr_4R _Dep_ 4L--V	EWR	V	72501	413478	0.17534
0.00000	0.82163	0.81858	0.99628	DTW--Arr_21R_ 22L_ 22R _Dep_ 21R_ 22L--V	DTW	V	47729	452450	0.10549
0.00000	0.82364	0.82325	0.99953	ORD--Arr_14R_ 22R_ 27L _Dep_ 22L_ 28--V	ORD	V	32425	863020	0.03757
0.00000	0.84763	0.84669	0.99889	LAX--Arr_24R_ 25L _Dep_ 24L_ 24R_ 25L_ 25R--I	LAX	I	19572	588143	0.03328
0.00000	0.86267	0.86119	0.99828	ATL--Arr_8L_ 9R_ 10 _Dep_ 8R_ 9L--I	ATL	I	79773	961520	0.08297
0.00000	0.87287	0.27258	0.31227	BNA--Arr_2L _Dep_ 2L--I	BNA	I	193	150360	0.00128
0.00000	0.88033	0.88021	0.99987	ORD--Arr_4R_ 9R_ 10 _Dep_ 4L_ 9R_ 32L_ 32R--V	ORD	V	74325	863020	0.08612
0.00000	0.90671	0.90670	0.99999	ORD--Arr_22R_ 27L_ 28 _Dep_ 22L_ 32L_ 32R--V	ORD	V	171519	863020	0.19874
0.00000	0.91085	0.90434	0.99285	ORD--Arr_22R_ 28 _Dep_ 22L_ 32L_ 32R--V	ORD	V	35883	863020	0.04158
0.00000	0.91601	0.90968	0.99310	LAX--Arr_24R_ 25L _Dep_ 24R_ 25L--I	LAX	I	8824	588143	0.01500
0.00000	0.92004	0.80311	0.87291	SLC--Arr_34L_ 34R_ 35 _Dep_ 34L_ 34R_ 35--V	SLC	V	153843	316852	0.48554
0.00000	0.94222	0.91294	0.96893	IAD--Arr_12_ 19C_ 19L _Dep_ 19L--V	IAD	V	16207	329263	0.04922
0.00000	0.94814	0.45831	0.48338	SEA--Arr_16C _Dep_ 16L--I	SEA	I	55008	333510	0.16494
0.00000	0.94935	0.94924	0.99989	ORD--Arr_4R_ 9R_ 10 _Dep_ 4L_ 9R_ 32L--V	ORD	V	152555	863020	0.17677
0.00000	0.97593	0.90724	0.92961	RDU--Arr_5L_ 5R_ 32 _Dep_--I	RDU	I	825	165589	0.00498
0.00000	0.98164	0.97775	0.99604	LAX--Arr_24R_ 25L _Dep_ 24R_ 25L--V	LAX	V	26585	588143	0.04520
0.00000	0.99242	0.99205	0.99962	DEN--Arr_7_ 16L_ 16R _Dep_ 8_ 17L_ 17R--V	DEN	V	19632	617913	0.03177
0.00000	0.99932	0.99862	0.99930	CLT--Arr_36L_ 36R _Dep_ 36L_ 36R--I	CLT	I	43187	496390	0.08700
0.00000	1.00000	0.99604	0.99604	CLT--Arr_18R_ 23 _Dep_ 18L_ 18R--V	CLT	V	213536	496390	0.43018
0.00000	1.00000	0.68340	0.68340	BOS--Arr_4R _Dep_ 4R_ 9--I	BOS	I	10023	337060	0.02974
0.00000	1.00000	0.56054	0.56054	LGA--Arr_31 _Dep_ 4--V	LGA	V	82666	372243	0.22208
0.00000	1.00000	0.42846	0.42846	SEA--Arr_16C _Dep_ 16L--V	SEA	V	36100	333510	0.10824
0.00000	1.00000	0.21617	0.21617	ABQ--Arr_8 _Dep_ 8--I	ABQ	I	113	99101	0.00114
0.00000	1.00000	0.20618	0.20618	ABQ--Arr_26_ 30 _Dep_ 26_ 30--I	ABQ	I	6	99101	0.00006
0.00000	1.00000	0.06226	0.06226	LAS--Arr_1L_ 1R _Dep_ 7L--I	LAS	I	0	415772	0.00000

0.00000	1.00000	0.06226	0.06226	LAS--Arr_1L_ 25L _Dep_ 1R--I	LAS	I	0	415772	0.00000
0.00000	1.00000	0.06226	0.06226	LAS--Arr_7R_ 19R _Dep_ 7L--I	LAS	I	0	415772	0.00000