Industry White Paper
Aircraft Operating and Delay Cost per Enplanement

PREPARED FOR:

Airports Council International – North America

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1. Introduction

This Industry White Paper was prepared by Ricondo & Associates, Inc. at the request of and in consultation with the Airports Council International-North America (ACI-NA) Finance Committee to document the results of research, analysis, and feedback received from the airport industry in regards to examining a more comprehensive approach to measuring an airport's cost per enplaned passenger (CPE). This introduction chapter describes the traditional CPE and its issues, background regarding an alternative approach to CPE, and explains the primary objectives used in the development of a more comprehensive measure.

It is important to note that the CPE described in this Industry White Paper is not intended to replace the traditional CPE. It should only be viewed as an optional metric or tool to assist airport operators in calculating additional airline costs that are not measured through the traditional CPE. Due to the use of system-wide data, the approached described in this White Paper is most applicable to airports with a large volume of activity, such as the 20 busiest airports when measured by aircraft operations.[1]

1.1 Traditional Cost per Enplaned Passenger

In general, an airport CPE has traditionally been used to measure the average cost to airlines for typical rates and charges at an airport, such as terminal rents and charges, aircraft landing fees, and aircraft apron use charges, as applicable, by the total number of departing or enplaning passengers. As such, the CPE is the industry-accepted metric that has been used for decades to measure the relative cost of an airport's airline rates and charges.

While considered a reasonable cost metric, it is also generally known within the airport industry that using CPE in its simplistic form for comparison purposes can pose certain issues. Those using the traditional CPE when comparing relative airport costs should be aware of the following inherent pitfalls.

1. Airline rates and charges components included in the CPE can differ amongst airports. For example, certain airports may only include primary rates and charges components (e.g., terminal rents and landing fees), while certain other airports may include additional facility use charges such as loading bridges, baggage systems, remain overnight apron charges, etc. Therefore, in many cases,

[1] An analysis has not been performed to estimate the optimum application of the CPE described in this White Paper. This White Paper focuses on the 20 busiest airports in terms of operations, but this set of airports could reasonably expand or contract. Further refinement possibilities include the use of airport-specific data in order to have individual airport information instead of an averaged data set.

comparisons may not be on an "apples-to-apples" basis, and further research and footnotes are generally required. However, it should be noted that over the past several years ACI-NA through its Finance Committee has taken strides to improve this consistency primarily through its Airport Performance Benchmarking Survey.

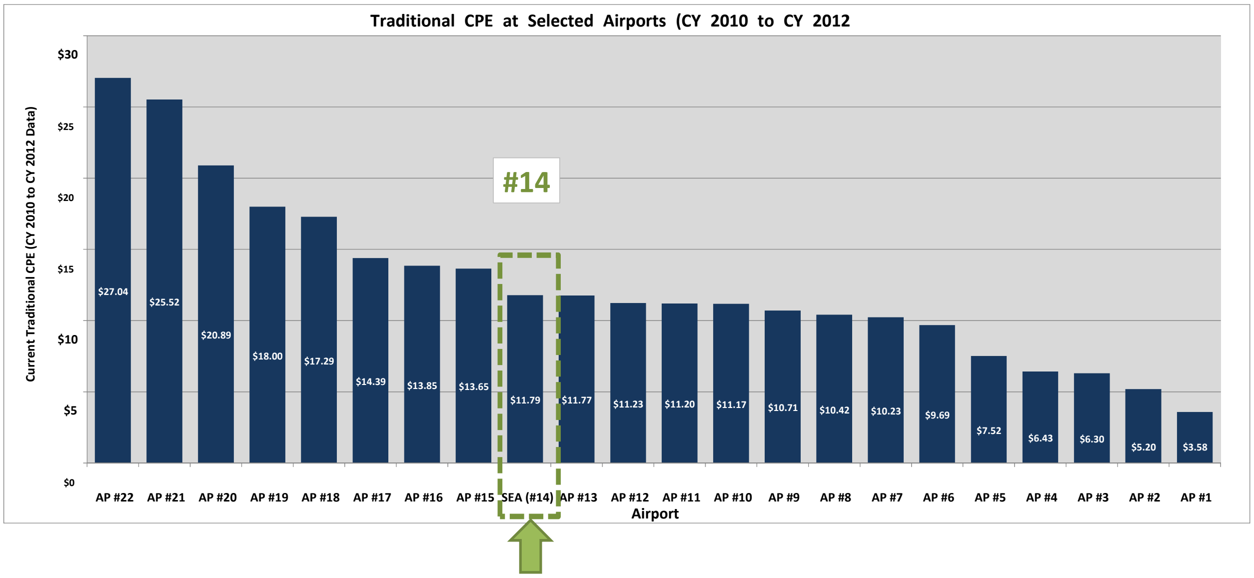
2. In addition to inconsistency among airports in the inclusion of rates and charges components, there can also be inconsistency in how airlines may pay for the use of an airport. For instance, at certain airports, airlines may pay directly for operating expenses on equipment such as loading bridges, baggage conveyance systems, etc. Whereas, certain other airport operators may be obligated for these operating expenses, and, thus, include them as a cost component within the airline rate base. Even though these costs exist at both airports, the CPE would include the operating expenses in the latter case and not in the former; thus, causing additional discrepancy. This inconsistency in CPE can also be further exacerbated on the capital side in cases where certain airport operators may use special facility debt to finance facility development.

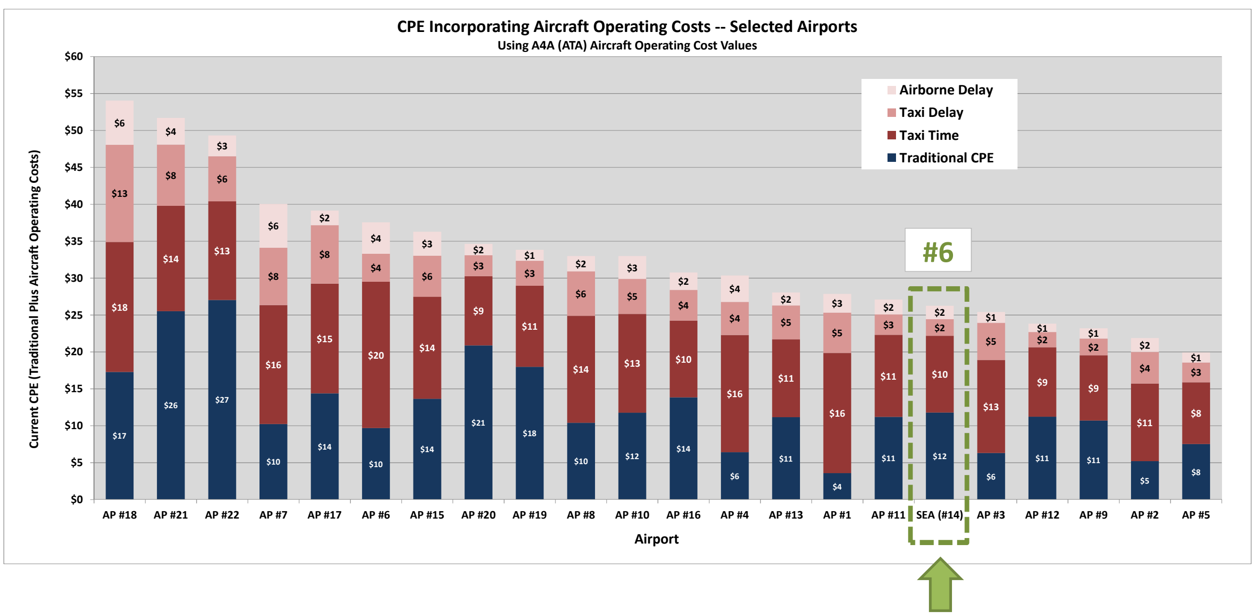
3. A third issue with the traditional CPE is that it does not effectively measure the "full" cost to the airlines for operating at an airport. As described above, the traditional CPE only measures airport rates and charges costs that airlines pay. Generally included in the airport rate base are both capital and operating expenses for certain facility improvements that were implemented to reduce aircraft operating costs. Therefore, including only the costs for such facilities in the CPE and not recognizing associated benefits can distort the relative cost of an airline to operate at an airport. For example, an airport that has not invested in facilities may be more prone to congestion and/or delay. From a traditional CPE standpoint, such an airport can be presented as a "lower-cost" airport than one that may have recently invested in airfield improvements to improve capacity and delay because it is reflecting the associated operating and capital costs in its CPE.

To further demonstrate this third issue, a case example is presented below on **Exhibit 1** for Seattle-Tacoma International Airport (SEA). As presented on the top chart, SEA's CPE on a traditional basis ranks as the 14th lowest when compared to select airports. SEA's relatively higher-cost traditional CPE is somewhat driven by recent capacity investments in its airfield resulting in increased capital costs and operating expenses in the airline rate base. However, when including airline aircraft operating costs (an approach presented later in this document) to each of the selected airports, SEA's relative cost position becomes more favorable as it shifts to the 6th lowest. Much of this shift in position can be attributed to relative efficiencies gained through SEA's investment in airfield capacity.

The issues described above are real limitations on the use of the traditional CPE as a relative airport cost comparison measure. The primary focus of this Industry White Paper is to present an approach for consideration by the airport industry to calculate a more comprehensive CPE to include airline aircraft operating costs.

Exhibit 1: SEA Case Study (CY 2010 to CY 2012 Data)





NOTES:

1./ Traditional CPE as presented in the top chart is the average cost to airlines for typical rates and charges at an airport, such as terminal rents and charges, aircraft landing fees, and aircraft apron use charges, as applicable, by the total number of departing or enplaning passengers.

2./ The bottom chart adds airline aircraft operating costs per enplaned passenger (an approach presented later in this document) to each of the selected airports to traditional CPE for each airport presented.

SOURCE: Traditional CPE – Ratings agency press releases, Bond Official Statements, FAA CATS database; Aircraft Operating Costs – FAA ASPM database; Aircraft planning manuals, ICAO Aircraft Engine Emissions Databank, A4A; Calculations – Ricondo & Associates, Inc., January 2014.

PREPARED BY: Ricondo & Associates, Inc., January 2014.

1.2 Background on an Alternative Approach

In consideration of the above described issues with the traditional CPE, the airport industry has been exploring alternative ways to calculate a more comprehensive CPE. This section provides some background regarding the use of alternative approaches over the past several years.

In 2009, airport management at Dallas-Fort Worth International Airport (DFW) examined an alternative approach to traditional CPE to give consideration to costs associated with aircraft delay and to measure the benefits of recent airport capital improvements. Original data for this analysis was obtained from a report published by the University of Westminster in May 2004, entitled "Evaluating the True Cost to Airlines of One Minute of Airborne or Ground Delay". This report was one of the first to differentiate the costs of airborne and ground delays, therefore producing more relevant results in the calculation of the cost of delay. DFW also started including the alternative measure for its CPE within its annual financial report starting in Fiscal Year 2010.

In October 2011, the DFW approach to an alternative CPE was presented to the ACI-NA Finance Committee at its annual conference. The Finance Committee recommended refining the alternative CPE methodology in collaboration within a committee subgroup. After consulting with various industry stakeholders, the methodology has been further refined in 2012 and 2013 to better capture the essential input statistics in the analysis and assess the benefits and limitations of such metrics. The alternative approach has also been presented at several ACI-NA conferences and Finance Committee meetings including the following:

- 2012 Airport Economics and Human Capital Conference
- 2012 World Conference and Exhibition
- 2013 Airport CFO Summit
- 2013 Annual Conference and Exhibition
- 2014 CEO Forum

In 2012, SEA also used this alternative CPE approach, as described above, to evaluate the impact of its recent airfield capital program investment. The results of this analysis were presented to the airlines operating at SEA to help demonstrate its value.

The ACI-NA through its Finance Committee continues to be involved with further assessing an alternative method to developing a more comprehensive CPE measure.

1.3 Objectives of this Study

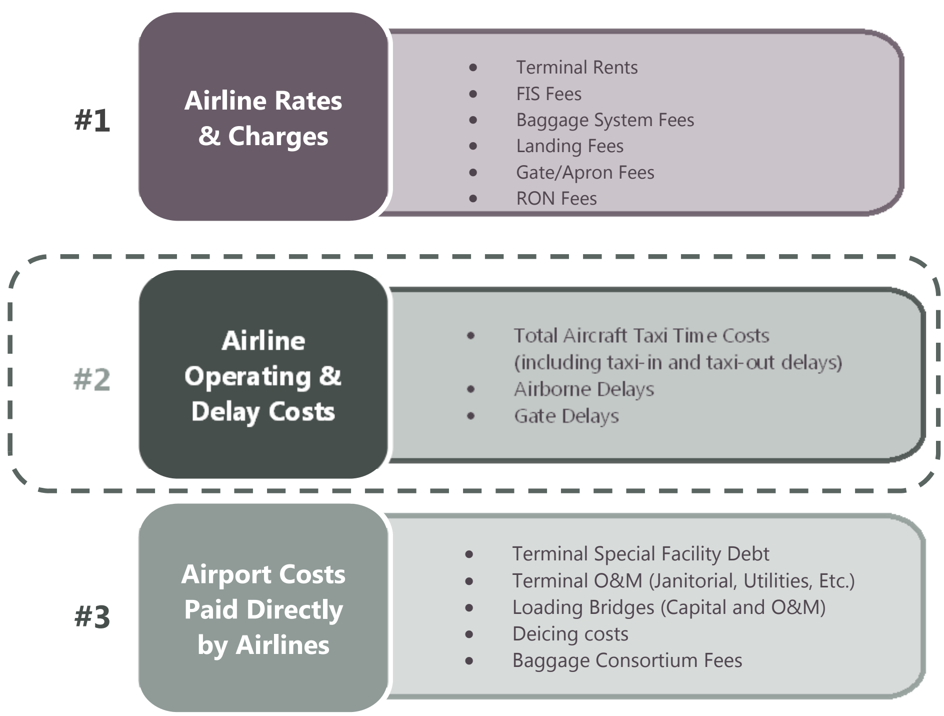
The objectives of this analysis were defined jointly with the ACI-NA Finance Committee Steering Group. The study objectives include:

1. Develop an additional measure that builds on the traditional CPE to better capture the "full" cost to airlines of doing business at an airport.
2. Develop a metric that considers the return on airport capital investments.
3. Develop a metric that maintains a balance of not being overly complex; yet, is an effective measure that could be used industry-wide.
4. Develop a metric that would be acceptable for use by airport operators, airlines, and other industry stakeholders.

As indicated above, this alternative CPE measure is not intended to replace traditional CPE. It should be viewed only as an optional metric or tool to help calculate additional airline costs not captured through traditional CPE.

Exhibit 2 below presents the primary components of airport-related costs. The primary emphasis of this study is primarily related to deriving the costs related to #2 below. Cost component #3, or airport costs paid directly by the airlines, continues to be an issue with regards to traditional CPE as presented above. These costs warrant additional study and continue to be an area of focus for the ACI-NA Finance Committee; however, this component is not addressed further within the context of this Industry White Paper.

Exhibit 2: Components of Cost at an Airport



SOURCE: Ricondo & Associates, Inc., January 2014.
PREPARED BY: Ricondo & Associates, Inc., January 2014.

This Industry White Paper presents an approach for consideration by the airport industry to calculate a more comprehensive CPE to include airline aircraft operating costs. To do so, this document is organized in a manner to (1) identify the aircraft operating environment at airports, (2) describe how to obtain aircraft operating and delay statistics, (3) identify the source(s) for quantifying the associated aircraft operational costs, and (4) demonstrate how to calculate a CPE measuring aircraft operating and delay costs. For the purposes of this study, this measure will be referred to as the Aircraft Operating and Delay CPE or "AOD CPE".

The analysis aims to calculate airport-specific operational costs incurred by airlines. The costs are measured on a "per enplaned passenger" basis in order to align with the same "per enplaned passenger" metric typically used for measuring traditional airline-airport financial agreement costs. For purposes of this analysis, in order to capture those operational costs associated with inbound aircraft, those delays have been included in the per enplaned passenger metric even though those costs would be associated with deplaning passengers.

2. Aircraft Operating Environment at Airports

There are many factors that can impact the reliability of aircraft operations throughout the national airspace system. These can range from congestion within enroute airspace, on approach to an airport, and/or on airfields and within terminal areas while taxiing. In addition, weather conditions, aircraft reliability, airline servicing delays, among other issues can play a role. This chapter examines how the airport environment can impact aircraft operations.

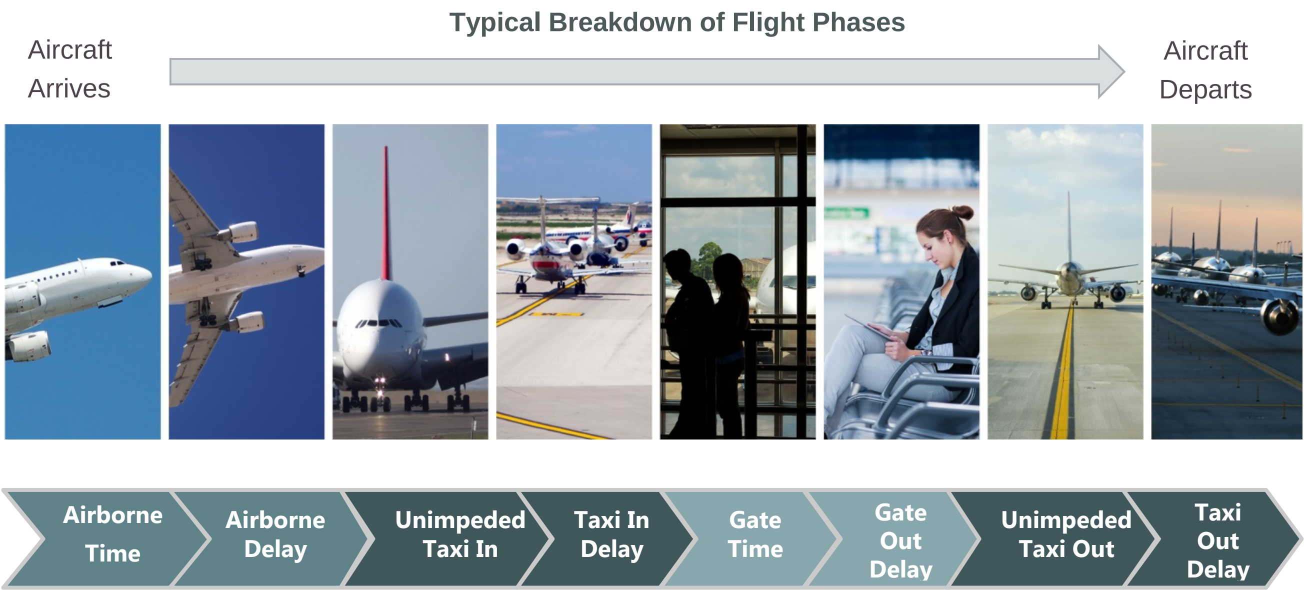
2.1 Phases of a Flight

The initial step in determining how an airport environment may affect aircraft operations is to review the various phases of a flight, irrespective of whether the phases can be deemed airport-related.

Air carrier flights within the U.S. are recorded in the Federal Aviation Administration (FAA) Aviation System Performance Metrics (ASPM) databases by phase of flight. **Exhibit 3** illustrates these phases of flight.

The flight phases are generally divided into two main categories: departing and arriving. They can be further subdivided into the following phases: airborne, taxi, and at-gate. Each of these phases as defined per FAA ASPM is described below.

Exhibit 3: Typical Phases of Flight



SOURCE: Ricondo & Associates, Inc., April 2014.
PREPARED BY: Ricondo & Associates, Inc., January 2014.

2.1.1 AIRBORNE

For statistics purposes, a flight becomes airborne when it takes off (wheels **off** the ground) and remains airborne until it lands (wheels **on** the ground). A flight can be delayed while airborne due to a number of factors. However, in this analysis, only the delay that occurs at the destination airport is considered and included in the analysis. This delay, which usually takes the form of an aircraft being placed into a holding pattern or reducing air speed for approach, is reported by the FAA in the ASPM database.

2.1.2 TAXIING

There are two distinct taxi phases during a flight: before take-off and after landing. The taxi phase that precedes take-off commences when the main cabin door is closed and the parking brake is released. It ends when the airborne phase begins, or when the wheels are off the ground. The taxi phase that succeeds landing starts when the wheels touch the runway and continues until the parking brake is applied.

2.1.3 AT-GATE

The third portion of a flight consists of the time that is spent at the gate. Gate time starts when a flight arrives at the gate (following the inbound taxi phase) and ends when the flight departs the gates (or when the outbound taxi phase begins). In order to make a gate available, airlines may tow aircraft that are scheduled to remain on the ground for a longer duration away from the gate to a hardstand position.

2.2 Airport-Related Phases

As described above, not all the phases of flights are impacted by the airport operating environment. For the purposes of calculating the CPE, the airport impacts to the flight phases are described. This section provides these additional considerations for each of the phase included in this analysis.

2.2.1 AIRBORNE

In general, once a flight is airborne, it departs an airport environment until it reaches the general airspace area of its destination airport. At this point in the flight it can be delayed while airborne due to the operating conditions at the destination airport. This study includes delay that occurs as a result of operating conditions at the destination airport. This delay, which may require an aircraft to be placed in a holding pattern and/or experience a decrease in speed, is reported by the FAA as part of the ASPM database.

2.2.2 TAXIING

The taxi phase of a flight is conducted completely within the airport environment. The amount of time an aircraft spends taxiing at an airport is related to both the relative distance between runways and gates, and delays caused by other aircraft traffic using the airfield and taxiway system. In certain cases, the lack of an available terminal gates can increase the amount of time an aircraft taxis during an arrival operation, as the aircraft may be forced to hold in a designated area to wait for the gate to become available.

Aircraft taxi time is reported within the FAA's ASPM database. Total taxi time is further subdivided into two categories: unimpeded time and delay. For the purposes of this study, the total taxi time is included in this analysis as both physical layout and delays contribute to the cost of an aircraft to operate at an airport.

2.2.3 AT-GATE

The cost of any operating issue occurring while an aircraft is at a gate is generally not considered an airport-related contributing factor. In other words, the majority of departure delays experienced at the gate are airline related. For example, such delays can include aircraft mechanical issues, airline loading or enplaning issues, aircraft servicing issues, among several other reasons. However, it should be noted that in some cases aircraft congestion related to airport configuration, such as linear or pier terminal configuration, could be considered an airport contributing factor for delay. Given the current difficulty to distinguish this as a cause for the delay and that the majority of gate delays are generally assumed to be the responsibility of the airlines, these aircraft operational costs are not considered in this study as part of the airport environment.

2.3 FAA ASPM Components

As described above, the FAA ASPM reports aircraft operating time within two components for taxi time: unimpeded time and delay. It also reports airborne time in terms of delay. A further description of each component is contained below. Additional details on the FAA ASPM data is discussed in Chapter 3.

2.3.1 UNIMPEDED COMPONENT

The FAA ASPM database provides unimpeded taxi times as reported by the air carriers based on a 12-month observation. The unimpeded taxi time component for arriving and departing aircraft is obtained directly from the FAA.

2.3.2 DELAY COMPONENT

The FAA ASPM database analyzes the data that is reported and provides three types of delay metrics: airborne delay, taxi delay and at-gate delay.

- Airborne delay corresponds to the amount of delay caused by airborne holding.
- Taxi delay is calculated by the FAA. This measure includes the difference between the actual taxi time of a flight and the unimpeded taxi time on the same route.
- At-gate delay corresponds to the difference between the scheduled arrival/departure time of a flight and its actual arrival/departure time.

These delays are measured through different FAA reporting systems and are not necessarily additive. As such, each delay is treated separately throughout the study and is only added with other "compatible" delays at the appropriate time in the calculation as described later.

3. Obtaining the Aircraft Operating and Delay Statistics

This chapter focusses on how to obtain the associated aircraft operating time data to be used in this analysis to calculate the AOD CPE.

3.1 FAA ASPM Data

3.1.1 DATABASE

The ASPM database currently provides information on all flights occurring at 77 airports (ASPM Airports) in the United States as well as all flights by 22 air carriers (ASPM Carriers) currently in operation. ASPM Carriers' flights include those flights to international and domestic destination, at both ASPM Airports and non-ASPM airports.[2]

The ASPM database has been developed using different reporting systems depending on the flight phase. It includes flight plan information, Traffic Flow Management System (TFMS) data, OOOI which stands for gate **O**ut, wheels **O**ff, wheels **O**n and gate **I**n data and Aviation System Quality and Performance records.[3]

Flight plan and flight message data are captured by the TFMS. The FAA's airspace lab then assembles the TFMS data into one record per flight. Only instrument flight rules (IFR) flights are included in TFMS data, which is captured by the FAA's enroute computers. Visual flight rules (VFR) flights and non-enroute IFR traffic is excluded from this reporting system.[4]

OOOI data provides next-day data for a key set of airlines. This data is calculated based on the times of actual aircraft movement, which is provided on a next-day basis by ARINC (private aviation communication company, http://www.arinc.com/) and on a monthly basis from the U.S. DOT's Airline Service Quality Performance (ASQP) system. These times are used to derive numerous statistics in the ASPM database.[5] OOOI data was originally intended to automate the payroll functions within an airline, where flight crews were paid

2 Federal Aviation Administration, *ASPM System Overview,* 2012.

3 *Ibid.*

4 Federal Aviation Administration, *Traffic Flow Management System (TFMS),* 2012.

5 Federal Aviation Administration, OOOI Data, 2009.

different rates depending on the flight phase.[6] Most of these times are detected and transmitted automatically by sensors such as door, parking brakes and strut switch sensors in ACARS-equipped aircraft. Times are calculated as follows:

- Gate out time is calculated when the parking brake is released
- Wheels off is calculated when the air/ground sensor on the landing gear is set to "airborne" state
- Wheels on is calculated when the air/ground sensor on the landing gear is set to "ground' state
- Gate in time is calculated when the parking brake is applied.

When actual times are not available, they can be estimated using various techniques (ASPM Estimation Techniques).[7]

The ASQP uses data filed by airlines each month with the U.S. DOT's Bureau of Transportation Statistics (BTS). As described in 14 CFR Part 234, carriers with 1 percent or more of total domestic scheduled service passenger revenues are required to report data for their flights involving any airport in the 48 contiguous states that account for 1 percent or more of domestic scheduled service passenger enplanements.[8] As of April 2011, 15 carriers report data though the ASQP system.[9]

3.1.2 REPORTING RESPONSIBILITY

Data is reported by multiple sources, with different update cycles. The Enhanced Traffic Management System (ETMS) data is updated daily and provides flight records by combining electronic messages transmitted to the host computer. It includes aircraft ID, flight plan times, AZ and DZ times (arrival and departure messages sent to computer respectively when flights are activated and completed), arrival and departure airport, and aircraft and flight type.

ARINC provides OOOI data with a daily update using actual flight times for ACARS-equipped aircraft. ACARS stands for Aircraft Communication Addressing and Reporting System. It is a digital datalink system for transmission of short message between aircraft and ground station.

ASQP data is provided by BTS. Data is reported by the carriers on a monthly basis.

Unimpeded taxi times are updated based on unimpeded taxi data reported by airports and carriers. It is updated every year and is calculated based on observed data from the previous year.[10]

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6 Aircraft Communications Addressing and Reporting System (ACARS), 2012.

7 Federal Aviation Administration, *ASPM: Estimation Techniques,* 2012

8 Federal Aviation Administration, *Airline Servce Quality Performance (ASQP),* 2011.

9 Federal Aviation Administration, *ASQP: Carrier Codes and Names*, 2012.

10 Federal Aviation Administration, *ASPM : Data Sources and Update Cycle*, 2012.

3.1.3 DATA AVAILABILITY

All flight operations occurring at the 77 ASPM Airports are included in the ASPM database for further analysis.[11]

The 77 ASPM Airports include:

1. Albuquerque International Sunport (ABQ)
2. Ted Stevens Anchorage International (ANC)
3. Hartsfield-Jackson Atlanta International* (ATL)
4. Austin-Bergstrom International (AUS)
5. Bradley International (BDL)
6. Birmingham International (BHM)
7. Nashville International (BNA)
8. Boston Logan International* (BOS)
9. Buffalo Niagara International (BUF)
10. Bob Hope (Burbank/Glendale/Pasadena) (BUR)
11. Baltimore/Washington International* (BWI)
12. Cleveland Hopkins International* (CLE)
13. Charlotte Douglas International* (CLT)
14. Cincinnati/Northern Kentucky International* (CVG)
15. Dallas Love Field (DAL)
16. Dayton International (DAY)
17. Ronald Reagan Washington National* (DCA)
18. Denver International* (DEN)
19. Dallas/Fort Worth International* (DFW)
20. Detroit Metropolitan Wayne County* (DTW)
21. Newark Liberty International* (EWR)
22. Fort Lauderdale/Hollywood International* (FLL)
23. Gary Chicago International (GYY)
24. Honolulu International* (HNL)
25. Houston Hobby (HOU)
26. Westchester County (HPN)
27. Washington Dulles International* (IAD)
28. George Bush Houston Intercontinental* (IAH)
29. Indianapolis International (IND)
30. Long Island Mac Arthur(ISP)

40. Memphis International* (MEM)
41. Manchester (MHT)
42. Miami International* (MIA)
43. Milwaukee General Mitchell International (MKE)
44. Minneapolis/St. Paul International* (MSP)
45. Louis Armstrong New Orleans International (MSY)
46. Oakland International (OAK)
47. Kahului (OGG)
48. Omaha Eppley Airfield (OMA)
49. Ontario International (ONT)
50. Chicago O'Hare International* (ORD)
51. Oxnard (OXR)
52. Palm Beach International (PBI)
53. Portland International* (PDX)
54. Philadelphia International* (PHL)
55. Phoenix Sky Harbor International* (PHX)
56. Pittsburgh International* (PIT)
57. Palm Springs International (PSP)
58. Providence Francis Green State (PVD)
59. Raleigh/Durham International (RDU)
60. Greater Rockford (RFD)
61. Southwest Florida International (RSW)
62. San Diego International* (SAN)
63. San Antonio International (SAT)
64. Louisville International (SDF)
65. Seattle/Tacoma International* (SEA)
66. San Francisco International* (SFO)
67. Norman Mineta San Jose International (SJC)
68. San Juan Luis Munoz International (SJU)
69. Salt Lake City International* (SLC)

[11] Federal Aviation Administration, *ASPM Airports,* 2009.

31. Jacksonville International (JAX)
32. New York John F. Kennedy International* (JFK)
33. Las Vegas McCarran International* (LAS)
34. Los Angeles International* (LAX)
35. New York LaGuardia* (LGA)
36. Long Beach (LGB)
37. Kansas City International (MCI)
38. Orlando International* (MCO)
39. Chicago Midway* (MDW)
70. Sacramento International Airport (SMF)
71. John Wayne Airport-Orange County (SNA)
72. Lambert Saint Louis International* (STL)
73. Stewart International (SWF)
74. Teterboro (TEB)
75. Tampa International* (TPA)
76. Tucson International (TUS)
77. Van Nuys (VNY)

Airports followed by an asterisk (*) denote those airports that are part of the Operational Evolution Partnership (OEP 35). OEP 35 airports represent large airports with a significant activity, which serve large metropolitan areas. It is estimated that 70 percent of passengers fly from, to, through these airports.[12]

In addition, all operations from the ASPM Carriers are included in the ASPM database.[13] Current ASPM Carriers included in the ASPM database include:

1. Air Canada (ACA)
2. Alaska Airlines (ASA)
3. American Airlines (AAL)
4. America West (AWE)
5. Atlantic Coast (BLR)
6. Atlantic Southeast Airlines (CAA)
7. Continental Airlines (COA)
8. ExpressJet Airlines (BTA)
9. Frontier Airlines (FFT)
10. Independence Air (IDE)
11. Mesa Airlines (ASH)
12. Pinnacle Airlines (FLG)
13. Southwest Airlines (SWA)
14. United Airlines (UAL)
15. US Airways (USA)
16. Airtran Airways (TRS)
17. Aloha Airlines (AAH)
18. American Eagle (EGF)
19. ATA Airlines (AMT)
20. Atlantic Southeast Airlines (ASQ)
21. Comair (COM)
22. Delta Air Lines (DAL)
23. FedEx (FDX)
24. Hawaiian Airlines (HAL)
25. Jetblue Airways (JBU)
26. Northwest Airlines (NWA)
27. Skywest Airlines (SKW)
28. TWA (TWA)
29. United Parcel Service (UPS)
30. Virgin America (VRD)

[12] Federal Aviation Administration, *OEP 35*, 2009

[13] Federal Aviation Administration, 2012.

Some of these carriers are no longer in operation, but their historical operations dating back to January 2000 are maintained in ASPM.

Appendix B presents the step-by-step process to retrieve the latest operating and delay data from the ASPM database.

3.1.4 ACCURACY

As described previously, aircraft operating times and delay are calculated using different types of data, reported through various components of the ASPM system. **Table 1** summarizes the types of aircraft operating times and delay considered in the study.

Table 1: Summary of Aircraft Operating Times and Delays

FLIGHT PHASE	CALCULATION	SOURCE	ACCURACY
Taxi Actual Time	OOOI Wheels On to OOOI Gate In	ARINC (Next Day) ASQP (Monthly)	Actual
Unimpeded Taxi Time	12-month observations average	Airports and Airlines Observations	Average of observation
Taxi Delay	Actual Taxi Time – Unimpeded Taxi Time	FAA ASPM Calculated	Accuracy is tied to unimpeded taxi time accuracy
Airborne Actual Time	OOOI Wheels Off to OOOI Wheels On	ARINC (Next Day) ASQP (Monthly)	Actual
Airborne Estimated Time Enroute (ETE)	Calculated by Flight Plan	Airline	Assumed to be estimated when flight plan is filed by airline
Airborne Delay	Airborne Actual Time – Airborne ETE	FAA ASPM Calculated	Accuracy is tied to ETE
Gate In Delay	OOOI Gate In – Flight Plan/Scheduled Gate In Time	ARINC (Next Day) ASQP (Monthly)	Accuracy is tied to scheduled gate-in time
Gate Out Delay	OOOI Gate Out – Flight Plan/Scheduled Gate Out Time	ARINC (Next Day) ASQP (Monthly)	Accuracy is tied to scheduled gate-out time

SOURCE: Federal Aviation Administration, June 22, 2012.
PREPARED BY: Ricondo & Associates, Inc., January 2014.

Taxi-in delay is calculated by subtracting the unimpeded taxi delay from the actual taxi time. Reports can be generated with the inclusion of early flights.

Taxi-in time is calculated by measuring the difference between the Wheels On time and the Gate In Time.

Taxi-out delay is calculated by subtracting the unimpeded taxi delay from the actual taxi time. Reports can be generated with the inclusion of early flights.

Taxi-out time is calculated by measuring the difference between the Gate Out Time and the Wheels Off Time.

Gate arrival delay is the difference between the actual gate in time (parking brake applied) and the scheduled or flight plan gate in time. It is based on actual times. The gate arrival delay is the delay of one minute or more compared to the flight plan.

Gate departure delay is the difference between the actual gate out time (parking brake released) and the scheduled or flight plan gate out time. It is based on actual times.

Airborne delay is the amount of delay caused by airborne holding, in minutes. Effective October 1, 2008, all airborne holding delays are reported by the Air Traffic Control System Command Center (ATCSCC) using automation. All enroute and arrival delays are combined and reported as "Airborne" delays. Airborne delays are reported for all aircraft which incur 15 minutes or more of cumulative airborne delay throughout the route of flight. Airborne delay is the difference between the actual airborne time and the flight plan Estimated Time Enroute (ETE).

4. Aircraft Operational Costs

The prior chapter examined the sources of data to calculate the appropriate amount of aircraft operating time and delay. This chapter describes various sources of information that can be used to assign costs to this time, and presents a recommendation for this study to ultimately calculate the AOD CPE.

4.1 Existing Analysis and Studies

Aircraft operating costs on a unit basis vary throughout the duration of a flight depending on phase. For example, the cost per minute of a flight is intuitively higher while an aircraft is airborne as compared to when it is taxiing. This is primarily due to the airborne phase requiring increased engine thrust and fuel burn.

Multiple studies have estimated aircraft operating costs associated with delayed aircraft operations. The studies considered for the AOD CPE analysis are presented in the next several sections.

4.1.1 EVALUATING THE TRUE COST TO AIRLINES OF ONE MINUTE OF AIRBORNE OR GROUND DELAY

The report entitled, "Evaluating the True Cost to Airlines of One Minute of Airborne or Ground Delay", was prepared by the University of Westminster and published in May 2004 in partnership with Eurocontrol. It offered a comprehensive analysis of the cost of delay to airlines while clearly differentiating airborne and ground delay. This report served as the basis for the original AOD CPE analyses and research for DFW in 2009.

4.1.2 EUROPEAN AIRLINE DELAY COST REFERENCE VALUE

In 2011, the University of Westminster prepared an update to the study aforementioned for Eurocontrol. The cost data were further refined in partnership with major aviation stakeholders including airlines and regulatory agencies. The data presented in this study provide a valuable insight into the costs of delay associated with extra fuel consumption, but also with additional crew workload and the resulting impact to the European airspace system. The study further refined the data for a range of aircraft and various scenarios that could best serve different stakeholders' needs. It provides the cost of delay in discreet duration increments (5 minutes, 15 minutes, 30 minutes, 60 minutes, etc.). The cost metrics provided consider fleet ownership, fuel, crew, maintenance, and passenger value of time. However, not all of the components are included depending on the scenarios. The study also includes an analysis of the reactionary costs, which accounts for the downstream impacts of operational delays.

While the study provides a comprehensive review of the components and includes considerations for various phases of flight and multiple aircraft types, it does have its inherent limitations. Part of the analysis is hard-coded in the study and may not be adjusted or updated. In addition, data is only available for a specific set of 12 aircraft, and all the costs mentioned are provided based on the European regulatory environment and in Euros. Finally, the analyses appear complex in nature and can be very challenging to use for the purposes of this AOD CPE study.

4.1.3 U.S. DEPARTMENT OF TRANSPORTATION FORM 41 DATA

The U.S. DOT publishes U.S. airlines' financial and operating statistics. It categorizes the data in numerous fields including, but not limited to, fuel cost, airlines fleet composition, flight hours, material and labor costs, and outsourcing costs. While Form 41 provides updated data for U.S. carriers in dollars, it comes with the limitation that most values are provided in a block hour format. Therefore, separate taxi and airborne costs are not included through Form 41 reporting.

4.1.4 ANNUAL AND PER-MINUTE COST OF DELAYS FOR U.S. AIRLINES

Airlines for America (A4A) is a trade organization that represents the airline industry through its U.S. airline members. It provides guidance, expertise and assistance to the U.S. airlines. A4A publishes an annual table summarizing the Annual and Per-Minute Cost of Delays to U.S. Airlines. It essentially derives the direct costs associated with delay for the airlines, assuming the following components: fuel, crew, maintenance, aircraft ownership and additional miscellaneous costs based on U.S. DOT Form 41 data. In 2012, A4A estimated that 92 million of system delay minutes drove $7.2 billion in direct aircraft operating costs for schedule U.S. passenger airlines only. It estimated the cost of aircraft block time (taxi plus airborne) was $78.1 per minute, broken down in five components as listed in **Table 2**.

Table 2: A4A Airlines Direct Cost of Delay per Block Minute (CY 2012)

	DIRECT AIRCRAFT OPERATING COST PER BLOCK MINUTE	DELTA VS 2011
Fuel	$39.26	5.3%
Crew - Pilots/Flight Attendants	$16.26	1.7%
Maintenance	$12.02	3.1%
Aircraft Ownership	$7.92	-1.1%
Other	$2.71	5.0%
Total	**$78.17**	**3.5%**

SOURCE: http://www.airlines.org/Pages/Annual-and-Per-Minute-Cost-of-Delays-to-U.S.-Airlines.aspx, Airlines for America, Data retrieved October 2013.
PREPARED BY: Ricondo & Associates, Inc., January 2014.

4.1.5 AOD CPE COSTS METRICS

Each of the aforementioned sources of data were reviewed for their use in this AOD CPE study. Based on collaborative discussions and alignment with the overall study objectives, the A4A cost values were determined to be the best fit for the AOD CPE analysis. The primary reasons for this are the following:

- These costs are based on U.S. airline operations and presented in U.S. Dollars.
- The information is publicly available and updated on an annual basis.
- These costs are reported by the airlines.
- They are based on U.S. DOT Form 41 data, which can be further analyzed if needed.

As indicated above, one drawback to using the A4A unit costs are that they are not presented by phase of flight or by whether the aircraft is airborne or taxiing on the ground. Therefore, additional analysis was needed to better reflect the difference in aircraft operating costs between the taxi and airborne phases, as discussed in the next section of this document.

Table 3 summarizes the set of data proposed to be used for the analysis:

Table 3: AOD Sources for Cost by Phase of Flight

	RECOMMENDED SOURCE	
Fuel	Form 41-Derived	
Crew	A4A Costs	Pilot costs available from Form 41 / flight attendants costs would need to be estimated
Maintenance	A4A Costs	Airframe, engine, materials, overhauls, flight equipment
Aircraft Ownership	A4A Costs	Depreciation and amortization
Other	A4A Costs	No details provided but included for consistency with airlines methodology

SOURCE: Ricondo & Associates, Inc., January 2014.
PREPARED BY: Ricondo & Associates, Inc., January 2014.

4.2 Refining the Fuel-Associated Cost

As presented in Table 3 above, A4A published cost statistics are proposed to be used for the AOD CPE for most categories with the sole exception of fuel cost. In general, the categories of crew, maintenance, aircraft ownership, and other are essentially assumed to be fixed throughout both the airborne and taxi phases of a flight. However, the fuel cost, as described previously, does vary materially throughout the flight based on the required engine thrust and fuel burn rate. Fuel burn as presented by A4A for 2012 has an average cost throughout a flight of $39.26 per minute, the largest category of aircraft operating cost. Given fuel's significant impact on cost and the difference in where aircraft operating cost is experienced among airports, the ACI-NA Finance Committee recommended that additional research be conducted to attempt to refine this unit cost by whether an aircraft is airborne or taxiing.

To avoid under- or overestimating the cost of fuel as part of the AOD CPE analysis, the cost is estimated for the taxi and airborne phases using data obtained from the International Civil Aviation Organization (ICAO) Aircraft Engine Emissions Databank. While this database does not provide cost information, the Aircraft Engine Emissions Databank provides aircraft fuel consumption (fuel burn) for four phases of flight based on a pre-determined power setting: take-off at 100 percent, climb at 85 percent, approach at 30 percent and idle at seven (7) percent. These consumption metrics have been used for the analyses prepared by the University of Westminster as well. The database is populated by the engine manufacturers directly and is continuously updated.

The databank includes engine fuel flow for all jet aircraft but does not provide data for turbo propulsion engines, such as those found on the ATR-72 or Bombardier Q400. Data for the turboprop aircraft found in the fleet of the U.S. scheduled airlines was researched on an individual basis.

For the purpose of the analysis, assumptions found in the European Airline Delay Cost Reference Values (study previously described) were used. For the taxi phase, it is assumed that the engine power is set at 7 percent (or idle as referenced in the databank). For the airborne phase, which would be in the vicinity of the airport during arrival, a power setting of 30 percent is used (or approach as referenced in the databank). These two power settings were reviewed and deemed appropriate for the study.

The actual average cost of fuel per gallon is reported by BTS in its TranStats tool. For calendar year (CY) 2012, the average cost of one gallon of fuel to the airlines was $3.17 (as reported by carriers with $20 million or more in annual revenues).

Finally, U.S. DOT Form 41 T100 database (Air Carriers: T-100 Segment for All Carriers) provides the aircraft mix for all U.S. scheduled airlines by summarizing the number of operations by aircraft type, as listed in **Table 4**. Due to large number of aircraft types that operated in the overall fleet, only the 59 aircraft types with the most departures at the 20 busiest airports (in terms of operations) have been included. Together, these 59 aircraft types represent more than 99% of the total annual departures at these airports. Table 4 provides the share of each aircraft type departures and the overall cumulative share.

A weighted average for both the taxi and airborne phases was calculated based on the engine fuel flow data presented in **Appendix A** and fleet mix distribution presented above. As such, the fuel cost per minute of aircraft operation during CY 2012 was estimated at:

- Taxi Phase: $13.11
- Airborne Phase: $36.39

Table 4: Aircraft Fleet Mix Sorted by Departures Share

CUMULATIVE SHARE	SHARE BY TYPE	AIRCRAFT TYPE
10.2%	10.6%	Canadair RJ-200ER /RJ-440
19.1%	9.3%	Boeing 737-700/700LR
27.3%	8.6%	Embraer-145
33.1%	6.0%	Airbus Industrie A320-100/200
38.6%	5.8%	Boeing 737-800
43.6%	5.2%	McDonnell Douglas DC9 Super 80/MD81/82/83/88
48.3%	4.9%	Boeing 757-200
52.7%	4.6%	Canadair RJ-700
56.8%	4.4%	Airbus Industrie A319
59.9%	3.2%	Boeing 737-300
62.1%	2.4%	Canadair CRJ 900
64.4%	2.3%	Cessna 208 Caravan
66.5%	2.3%	Boeing 717-200
68.3%	1.8%	Embraer ERJ-175
70.0%	1.8%	De Havilland DHC8-400 Dash-8
71.6%	1.7%	Embraer 190
73.3%	1.7%	Boeing 767-300/300ER
74.9%	1.7%	Beech 1900 A/B/C/D
76.5%	1.7%	Embraer-140
78.0%	1.6%	Cessna C206/207/209/210 Stationair
79.5%	1.5%	Cessna C-402/402A/402B
80.8%	1.4%	Embraer 170
82.0%	1.3%	Embraer EMB-120 Brasilia
83.2%	1.3%	De Havilland DHC8-100 Dash-8
84.3%	1.2%	Boeing 737-400
85.4%	1.1%	Boeing 777-200ER/200LR/233LR
86.3%	0.9%	Airbus Industrie A321
87.0%	0.8%	Boeing 747-400
87.8%	0.8%	Boeing 737-900
88.5%	0.8%	Airbus Industrie A300-600/R/CF/RCF
89.2%	0.7%	Boeing 737-500
89.8%	0.6%	Airbus Industrie A330-200
90.4%	0.6%	Saab-Fairchild 340/B
90.9%	0.6%	McDonnell Douglas MD-11
91.5%	0.6%	McDonnell Douglas MD-90
92.0%	0.6%	Embraer-135
92.5%	0.5%	De Havilland DHC8-300 Dash 8
92.9%	0.4%	Piper PA-31 (Navajo)/T-1020
93.4%	0.4%	Boeing 767-200/ER/EM
93.7%	0.4%	Boeing 757-300
94.1%	0.4%	Canadair RJ-100/RJ-100ER
94.4%	0.4%	De Havilland Twin Otter DHC-6
94.8%	0.4%	McDonnell Douglas DC-9-50
95.1%	0.4%	De Havilland DHC2 Beaver
95.4%	0.3%	Aerospatiale/Aeritalia ATR-72

SOURCE: U.S. DOT Form 41 T100 Data, CY 2011 Departures Data, December 2012.
PREPARED BY: Ricondo & Associates, Inc., January 2014.

The busiest 20 airports in terms of operations are shown in **Table 5**. While this White Paper focuses on the 20 busiest airports, an analysis has not been performed to estimate the optimum application of the CPE described in this White Paper. This set of airports could reasonably expand or contract. It is also worth noting that further refinement could be beneficial. Calculating airport-specific operating costs rather than using an averaged data set could more accurately depict airport operating costs for purposes of assessing individual airports.

Table 5: Aircraft Fleet Mix Sorted by Departures Share (Top 20 Airports)

RANK	AIRPORT CODE	AIRPORT NAME	TOTAL ANNUAL DEPARTURES (CY 2012)
1	ATL	Hartsfield - Jackson Atlanta International Airport	456,037
2	ORD	Chicago O'Hare International Airport	428,482
3	DFW	Dallas/Fort Worth International Airport	315,395
4	DEN	Denver International Airport	298,142
5	LAX	Los Angeles International Airport	287,333
6	CLT	Charlotte/Douglas International Airport	255,254
7	IAH	George Bush Intercontinental/Houston Airport	242,968
8	DTW	Detroit Metropolitan Wayne County Airport	207,799
9	PHL	Philadelphia International Airport	207,510
10	PHX	Phoenix Sky Harbor International Airport	201,564
11	EWR	Newark Liberty International Airport	200,913
12	MSP	Minneapolis-St Paul International/Wold-Chamberlain Airport	197,461
13	JFK	John F Kennedy International Airport	196,728
14	SFO	San Francisco International Airport	195,981
15	LGA	La Guardia Airport	179,423
16	MIA	Miami International Airport	173,892
17	LAS	Mc Carran International Airport	171,387
18	BOS	General Edward Lawrence Logan International Airport	162,455
19	SEA	Seattle-Tacoma International Airport	151,336
20	MCO	Orlando International Airport	141,146

SOURCE: U.S. DOT Form 41 T100 Data, CY 2011 Departures Data, December 2012.
PREPARED BY: Ricondo & Associates, Inc., January 2014.

Table 6 presents the recommended aircraft operating unit costs by both the taxi and airborne flight phases for use in the AOD CPE analysis. It is important to note that the resulting fuel unit costs for each phase presented below are lower than the average fuel cost calculated by A4A of $39.26. This appears to make intuitive sense as the average A4A cost would include the takeoff and cruising airborne fuel burn rates, which are more costly than the approach and taxi fuel burn rates assumed in this study.

Table 6: AOD CPE Costs per Minute (CY 2012)

	TAXI COST PER MINUTE SUMMARY	AIRBORNE COST PER MINUTE SUMMARY
Fuel	**$13.11**	**$36.39**
Crew	$16.26	$16.26
Maintenance	$12.02	$12.02
Aircraft Ownership	$7.92	$7.92
Other	$2.71	$2.71
Total	**$52.02**	**$75.30**

SOURCES: All Costs but Fuel, A4A, July 2013; Engine Fuel Flow, Aircraft Engine Database, July 2013; Aircraft Operations Share, DOT Form 41 T100; CY 2012 Fuel Cost per Gallon, BTS TranStats. January 2014.

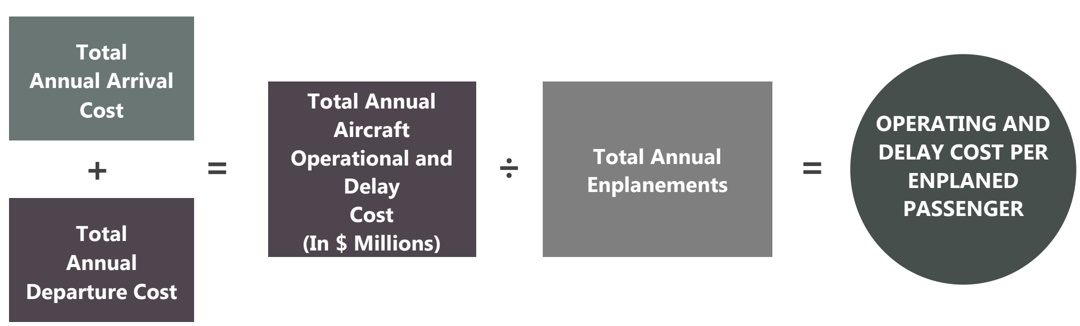
PREPARED BY: Ricondo & Associates, Inc., January 2014.

5. Calculating the Airport Operational and Delay Cost per Enplanement

5.1 Airport Operational and Delay Cost per Enplanement

The AOD CPE analysis uses a combination of air carrier operating statistics combined with aircraft operational costs to calculate the average aircraft operational costs in the airport environment on a per enplaned passenger basis. **Exhibit 4** presents a graphic representation of the overall methodology to derive the AOD CPE.

Exhibit 4: AOD CPE Calculation



SOURCE: Ricondo & Associates, Inc., January 2014.
PREPARED BY: Ricondo & Associates, Inc., January 2014.

5.1.1 FLIGHT COMPONENTS STATISTICS

Activity statistics are obtained from the FAA ASPM database, as described above. Two subsystems of the FAA ASPM database are used, including:

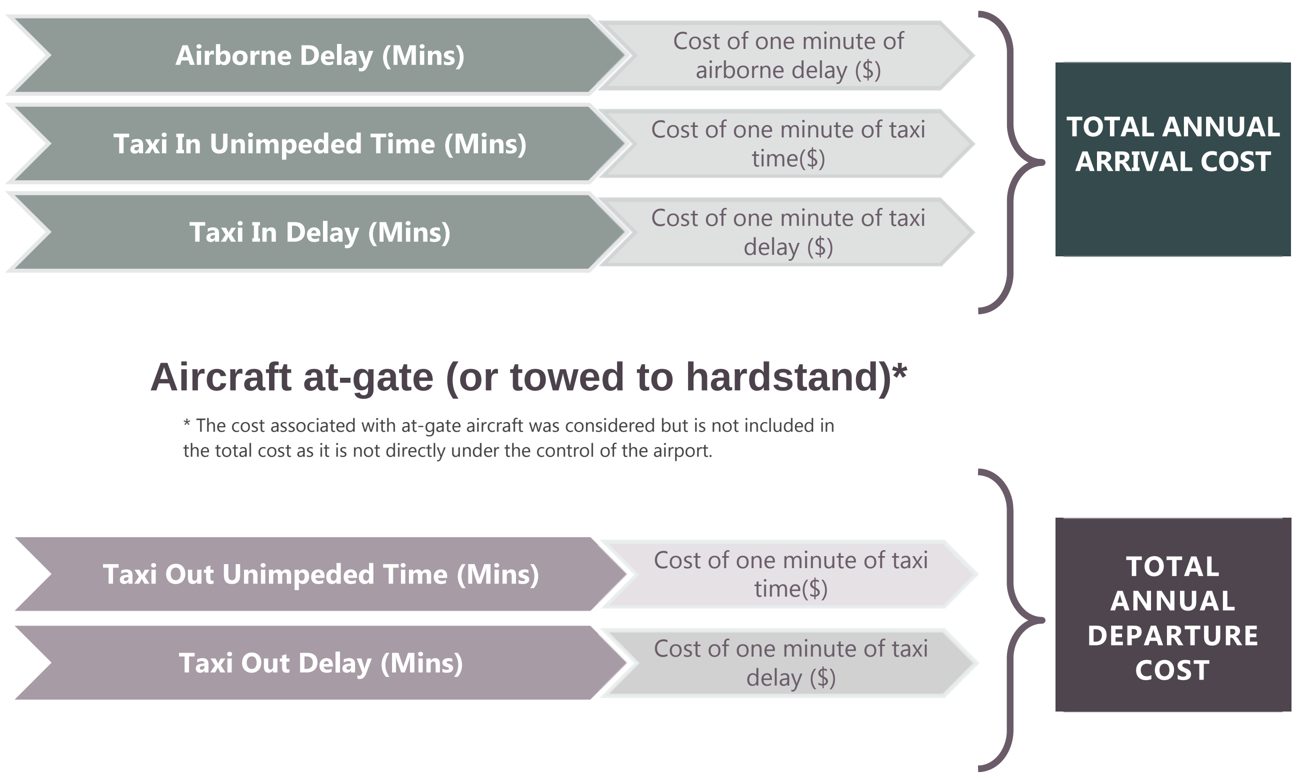
- Airport Analysis Database: provides information on aircraft departure and arrival times and flight delays compared to the schedule and flight plan times.
- Taxi Time Database: provides data on actual and unimpeded taxi times by airport.

When retrieving the delay statistics from the Airport Analysis database, the delay metrics are obtained based on the flight plan times (rather than scheduled times).

5.1.2 AIRCRAFT OPERATING AND DELAY COSTS

In order to translate the FAA ASPM activity statistics into operating and delay costs, the appropriate taxi and airborne unit costs shown on Table 5 above are multiplied as presented in **Exhibit 5**.

Exhibit 5: Aircraft Operating and Delay Cost per Enplanement Breakdown



SOURCE: Ricondo & Associates, Inc., January 2014.
PREPARED BY: Ricondo & Associates, Inc., January 2014.

5.2 Applying the AOD CPE to a Case Study Airport

To further illustrate how to calculate the AOD CPE, a case study airport has been selected. This section provides the AOD CPE methodology and results when applied to DFW for CY 2012. The approach and results are summarized in **Table 7**.

Table 7: AOD CPE Case Study – Dallas Fort Worth International Airport (CY 2012)

		DFW METRICS
Annual Departure Operating Cost:		
Average Taxi Out Unimpeded Time (minutes)1/	[A]	11.1
Average Taxi Out Delay (minutes) 1/	[B]	3.4
Average Taxi Out Time (minutes)	[C]=[A]+[B]	14.5
Total Departures1/	[D]	319,815
Total Taxi Out Time (minutes)	[E]=[C]*[D]	4,624,525
Taxi Cost per Minute2/	[F]	$52.02
Total Annual Departure Operating Cost (millions)	**[G]=[E]*[F]**	**$240.6**
Annual Arrival Operating Cost:		
Average Airborne Delay (minutes) 1/	[H]	2.0
Total Arrivals1/	[I]	319,149
Total Airborne Delay (minutes)	[J]=[H]*[I]	638,298
Airborne Cost per Minute2/	[K]	$75.30
Total Airborne Delay Cost (millions)	**[L]=[J]*[K]**	**$48.1**
Average Taxi In Unimpeded Time (minutes) 1/	[M]	5.4
Average Taxi In Delay (minutes) 1/	[N]	3.6
Average Taxi In Time (minutes)	[O]=[M]+[N]	9.0
Total Arrivals1/	[I]	319,149
Total Taxi In Time (minutes)	[P]=[O]*[I]	2,881,915
Taxi Cost per Minute2/	[F]	$52.02
Total Taxi In Cost (millions)	**[Q]=[P]*[F]**	**$149.9**
Total Arrival Operating Cost (millions)	**[R]=[L]+[Q]**	**$198.0**
Total Aircraft Operating and Delay Cost (millions)	**[S]=[G]+[R]**	**$438.5**
DFW Enplaned Passengers (millions) 3/	[T]	29.3
AOD CPE	**[U]=[S] / [T]**	**$14.97**

NOTES:

1/ FAA ASPM Database

2/ Table 6

3/ DFW Statistics Web Page

SOURCES: All Costs but Fuel, A4A, July 2013; Engine Fuel Flow, Aircraft Engine Database, July 2013; Aircraft Operations Share, DOT Form 41 T100; CY 2012 Fuel Cost per Gallon, BTS TranStats.; Enplanements Statistics, DFW Airport Statistics, July 2013; Ricondo & Associates, Inc.,, January 2014.
PREPARED BY: Ricondo & Associates, Inc., January 2014.

As reported in the FAA ASPM, the average taxi out time (unimpeded plus delay) at DFW in CY 2012 was 14.5 minutes. Total CY 2012 departures at DFW for which the average taxi out time was calculated were 319,815. Therefore, total taxi out minutes at DFW for CY 2012 was approximately 4.6 million. Based on an average taxi cost per minute of $52.05, this represented a total taxi out cost of $240.6 million.

The average airborne delay at DFW in CY 2012 was 2.0 minutes per arrival based on a total of 319,149 arrivals. Therefore, total airborne delay minutes at DFW was approximately 638,000. Based on an average airborne cost of $75.30 per minute, this amounted to a total cost of $48.1 million.

Finally, the average taxi in time (unimpeded plus delay) at DFW in CY 2012 was 9.0 minutes per arrival based on 319,149 arrivals. This represents approximately 2.9 million minutes. Which, when multiplied by the taxi unit cost of $52.02 amounts to approximately $149.9 million of taxi in cost.

In summary when adding all the components, the overall cost of taxiing and airborne delay at DFW in CY 2012 was approximately $438.5 million. This would equate to an AOD CPE of $14.597 when divided by total annual enplanements of approximately 29.3 million in CY 2012.

5.3 Limitations of the Study

While the AOD CPE study provides a methodology to evaluate airline aircraft operating costs at airports, the study does have some limitations. There may also be opportunities to further refine the analysis, as needed.

5.3.1 CERTAIN LIMITATIONS

The AOD CPE analysis attempts to provide a different perspective on CPE. However as mentioned earlier, this analysis does not intend to create a metric that would replace the traditional CPE. It should be viewed only as an optional metric or tool to help calculate additional airline costs not captured by traditional CPE.

Due to the use of system-wide data, the AOD CPE is most relevant to airports with a large volume of activity, such as the 20 busiest airports when measured by aircraft operations. A specific correlation between the accuracy of the data and the airport volume has not been determined at this time. Opportunities for further refinement as described in the next section could help address this issue.

The accuracy of the statistics used in the analysis depends directly on the accuracy of the data provided in the FAA databases. While some data is reported automatically and is considered accurate, other elements, such as the estimated enroute time are estimated for the purposes of flight plan filing.

Another central metric of the analysis is the cost of fuel. Calculating the cost of fuel required extensive research to gather aircraft engine fuel flow data and will require similar efforts to update it. A more streamlined source to access this data would provide more accurate results with less risk of miscalculating this variable.

5.3.2 OPPORTUNITIES FOR FURTHER REFINEMENT

Currently, the methodology proposes to use a fleet mix based on the top 20 airports' operating fleets to calculate the average cost per minute of fuel consumption. Further refinement would be possible to adjust the fleet mix based on each airport's operating fleet. This would provide a more accurate cost based on the type of fleet operating at that particular airport. For instance, it could be assumed that Los Angeles International Airport or John F. Kennedy International Airport would have a higher fuel cost due to their heavier aircraft fleet mix, while airports with smaller fleet mixes may have a lower than average fuel cost per enplanement.

The study does not include the costs associated with the propagation of delay. The propagation of delay corresponds to the total delay generated in a network by the delay of one flight. For example, one flight arriving late will impact flights waiting for connecting passengers at that airport as well as subsequent flights by the same aircraft throughout the day. The European Airline Delay Cost Reference Values study provides consideration for the impact of delay propagation, based on an analysis of American Airlines activity. The FAA also publishes a propagation factor for each airport in the U.S., which is usually used for benefit cost analyses. Primary airports with large connecting activity would have a greater delay propagation factor than non-hub airports.

Some of the delay statistics could also be refined in coordination with FAA Air Traffic Control to better understand the flow control delay attribution. This could allow for improvement of the accuracy of the delay statistics used for the analysis, and their attribution to the subject airport.

Finally, coordination with other aviation stakeholder organizations such as A4A could allow for a better understanding of their calculation of block time cost per minute which is based on U.S. DOT Form 41 data.

Appendix A

Aircraft Fuel Flow Data

Table A-1 (1 of 2): Aircraft Fuel Flow Data

AIRCRAFT TYPE	NUMBERS OF DEPARTURES	RUNNING TOTAL	NUMBER OF ENGINE TYPES AVAILABLE	ENGINE TYPE	NUMBER OF ENGINES	FUEL FLOW (KG/S) APPROACH	FUEL FLOW (KG/S) IDLE
Saab-Fairchild 340/B	113,148	1.1%	1	GE CT7-9B	2	0.086	0.030
Piper PA-31 (Navajo)/T-1020	44,263	1.5%	1	TIO 540-A	2	0.0125	0.003158
Embraer EMB-120 Brasilia	135,665	2.7%	1	PW 118/118A/118B	2	0.06368	0.0421
De Havilland Twin Otter DHC-6	40,582	3.1%	1	PT6A-34/ PT6A-35	2	0.0272	0.0147
De Havilland DHC8-400 Dash-8	189,672	4.9%	1	PW150A	2	0.132	0.040
De Havilland DHC8-300 Dash 8	45,016	5.3%	1	PW 123B	2	0.099	0.030
De Havilland DHC8-100 Dash-8	141,120	6.6%	1	PW 120A/ PW121	2	0.099	0.030
De Havilland DHC2 Beaver	37,782	6.9%	1	PW R-985	1	0	0
Cessna C-402/402A/402B	144,251	8.3%	1	TSIO-520-VB	2	0	0
Cessna C206/207/209/210 Stationair	179,835	10.0%	1	TIO-540-AJ1A	1	0.0125	0.003158
Cessna 208 Caravan	225,188	12.1%	1	PW PT6-114A	1	0.025	0.0138
Beech 1900 A/B/C/D	169,300	13.6%	1	PW PT6A-67D	2	0.0461	0.0256
Aerospatiale/Aeritalia ATR-72	71,288	14.3%	1	PW 127F	2	0.086	0.030
Canadair RJ-200ER /RJ-440	1,109,414	10.3%	1	GE CF34-3B1	2	0.116	0.049
Boeing 737-700/700LR	944,777	33.4%	1	CFM56-7	2	0.274	0.1
Embraer-145	828,655	41.1%	1	RR AE3007A	2	0.117	0.049
Airbus Industrie A320-100/200	582,205	46.5%	2	V2500-A5	2	0.334	0.124
McDonnell Douglas DC9 Super 80/MD81/82/83/88	540,928	51.6%	1	PW JT8D-200	2	0.363	0.137
Boeing 737-800	537,208	56.5%	1	CFM56-7	2	0.274	0.1
Boeing 757-200	514,355	61.3%	4	RR RB211-535E4	2	0.55	0.19
Airbus Industrie A319	454,292	65.6%	2	CFM56-5B	2	0.364	0.117
Canadair RJ-700	449,206	69.7%	2	GE CF34-8C1	2	0.17	0.07
Boeing 737-300	380,724	73.3%	1	CFM56-3	2	0.29	0.114
Canadair CRJ 900	245,882	75.6%	1	GE CF34-8C5	2	0.179	0.064

Table A-1 (2 of 2): Aircraft Fuel Flow Data

AIRCRAFT TYPE	NUMBERS OF DEPARTURES	RUNNING TOTAL	NUMBER OF ENGINE TYPES AVAILABLE	ENGINE TYPE	NUMBER OF ENGINES	FUEL FLOW (KG/S) APPROACH	FUEL FLOW (KG/S) IDLE
Boeing 717-200	231,757	77.7%	1	RR BR 715	2	0.245	0.096
Embraer ERJ-175	185,222	79.4%	1	GE CF34-8E	2	0.168	0.062
Boeing 767-300/300ER	172,727	81.0%	2	GE CF6 80C2	2	0.577	0.192
Embraer-140	163,970	82.6%	1	RR AE3007	2	0.117	0.049
Embraer 190	157,296	84.0%	1	GE CF34-10E	2	0.244	0.088
Embraer 170	138,467	85.3%	1	GE CF34-8E	2	0.168	0.062
Boeing 737-400	123,355	86.5%	1	CFM56-3B-2	2	0.314	0.119
Boeing 777-200ER/200LR/233LR	111,150	87.5%	3	PW 4090	2	0.957	0.268
Canadair RJ-100/RJ-100ER	92,967	88.4%	1	GE CF34-3A1	2	0.119	0.05
Boeing 737-500	84,631	89.2%	1	CFM56-3	2	0.29	0.114
Boeing 747-400	82,318	89.9%	3	RR RB211-524H2-T	4	0.77	0.26
Airbus Industrie A300-600/R/CF/RCF	78,163	90.6%	2	PW JT9D - 7R4H1	2	0.723	0.245
Airbus Industrie A321	73,454	91.3%	2	V2500-A5	2	0.334	0.124
Boeing 737-900	67,175	92.0%	1	CFM56-7BE	2	0.3	0.1
McDonnell Douglas MD-11	57,709	92.5%	4	GE CF6 80C2	3	0.577	0.192
Airbus Industrie A330-200	57,252	93.0%	3	GE CF6-80E1	2	0.714	0.226
McDonnell Douglas DC-9-50	50,053	93.5%	1	PW JT8D-15 or -17	2	0.312	0.137
Embraer-135	48,044	93.9%	1	RR AE3007	2	0.117	0.049
Boeing 767-200/ER/EM	44,336	94.3%	2	GE CF6 80C2	2	0.577	0.192
Boeing 757-300	41,065	94.7%	4	RR B211-535E4B	2	0.55	0.19
McDonnell Douglas DC-10-10	38,066	95.1%	1	GE CF6-6D	3	0.484	0.173

SOURCE: Aircraft Engine Fuel Flows, ICAO Aircraft Engine Emissions Databank, December 2013.
PREPARED BY: RICONDO & ASSOCIATES, INC., JANUARY 2014.

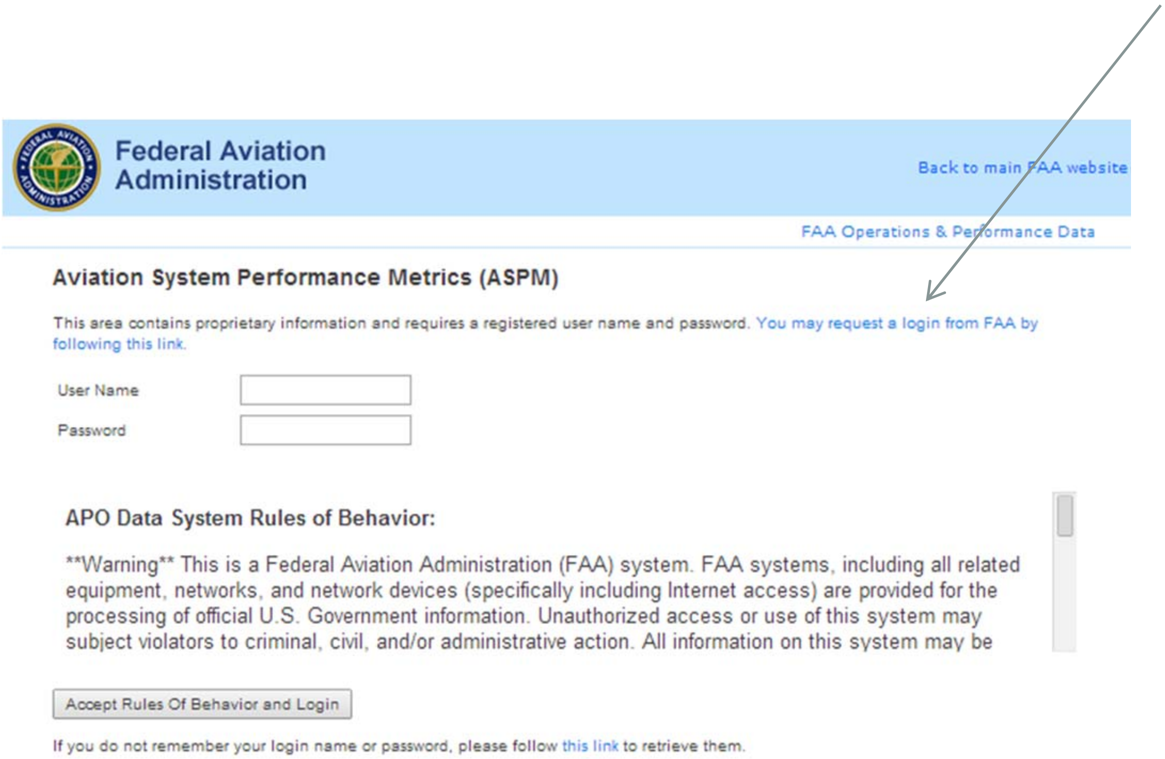
Appendix B

Instructions for FAA ASPM Database Query

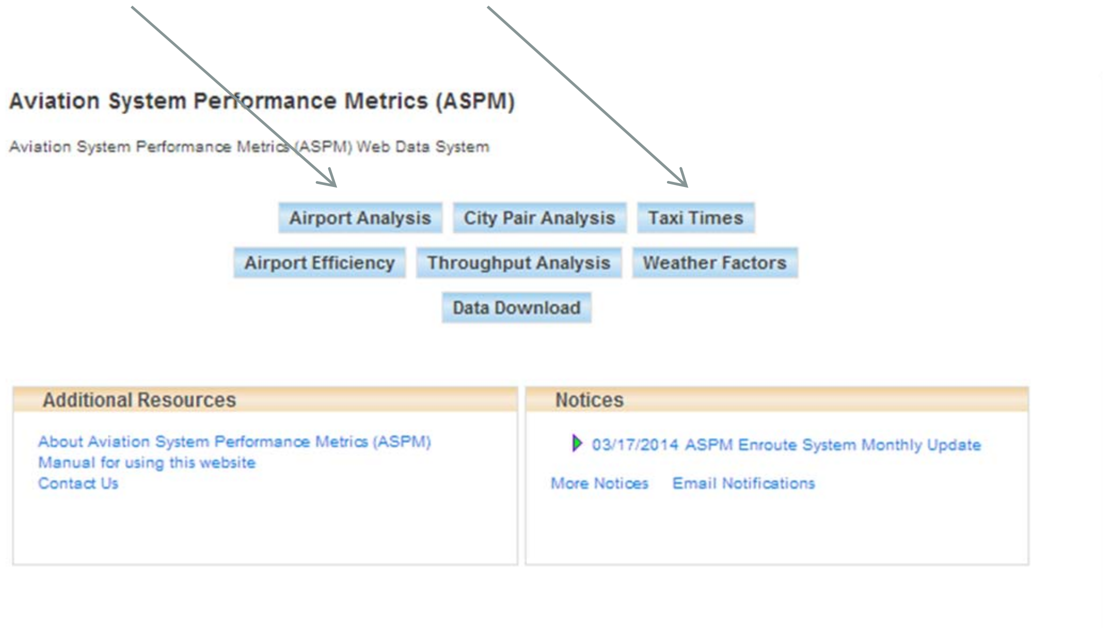
The operating and delay statistics are pulled from the Federal Aviation Administration ASPM database. The ASPM database is a subsystem of the ASPM database which provides operational traffic data for 75 airports in the U.S. The following steps provide instructions for querying the data for the delay and travel time data included in the ADO CPE.

1. To access the ASPM database, go to https://aspm.faa.gov/apm/sys/.

   A registered user name and password is needed to access the database. A login can be requested here.

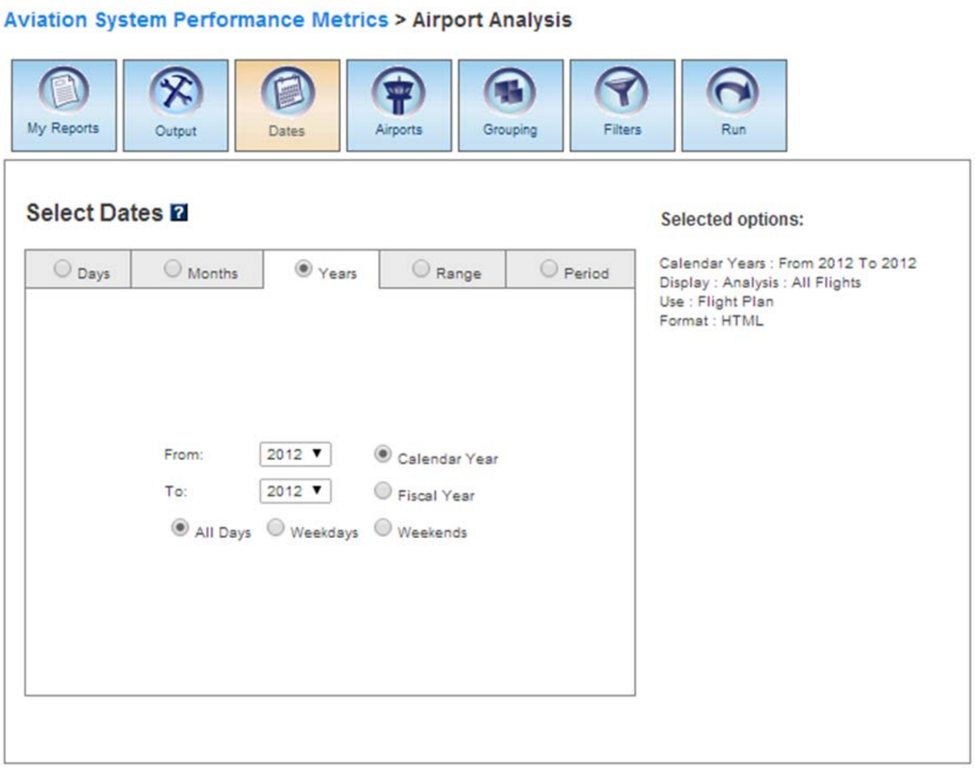


2. After logging in to the ASPM Web Data System, links to the two subsystems of ASPM used for this analysis, the Airport Analysis database and the Taxi Times database, can be found here.

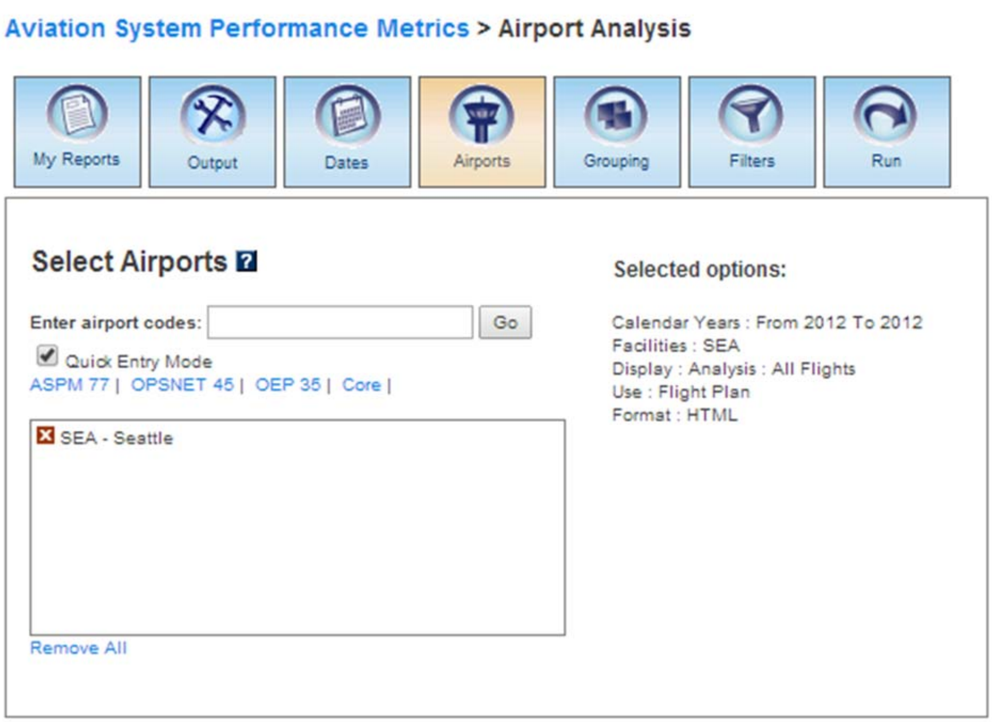


The Airport Analysis link will open the Airport Analysis database, from which a report can be created.

3. The Dates tab allows for the selection of date ranges in multiple formats. For this analysis, the year 2012 was used.



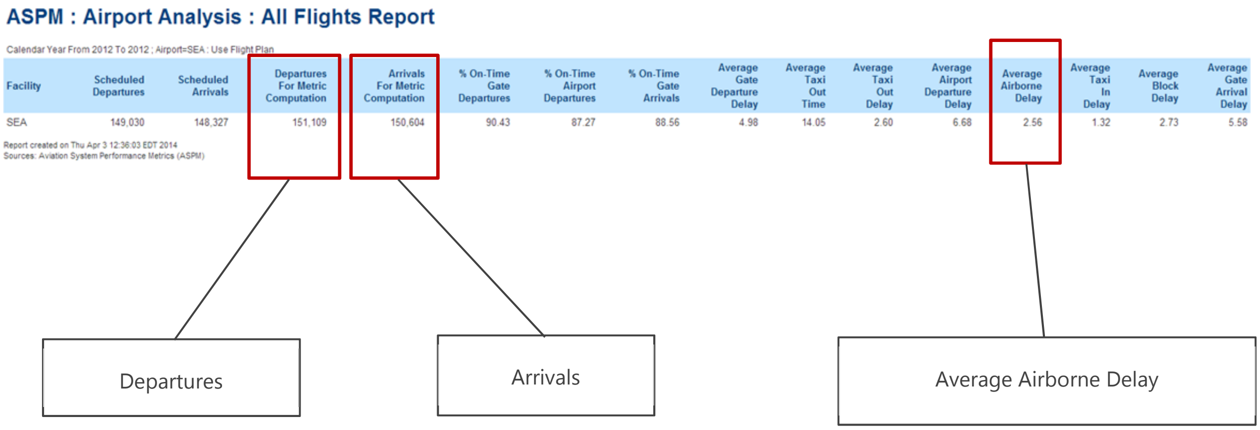
4. In the Airports tab, Seattle is selected by typing in its three-letter airport code (SEA).



The Groupings tab allows for grouping by airport, date, local hour, and GMT hour. Grouping by airport is selected here.

The Filter tab allows the use of flight plan or schedule to filter and the selection of a time window for flights. Flight plan, with no hourly filter, is being used here.

5. The Run tab will generate this report.



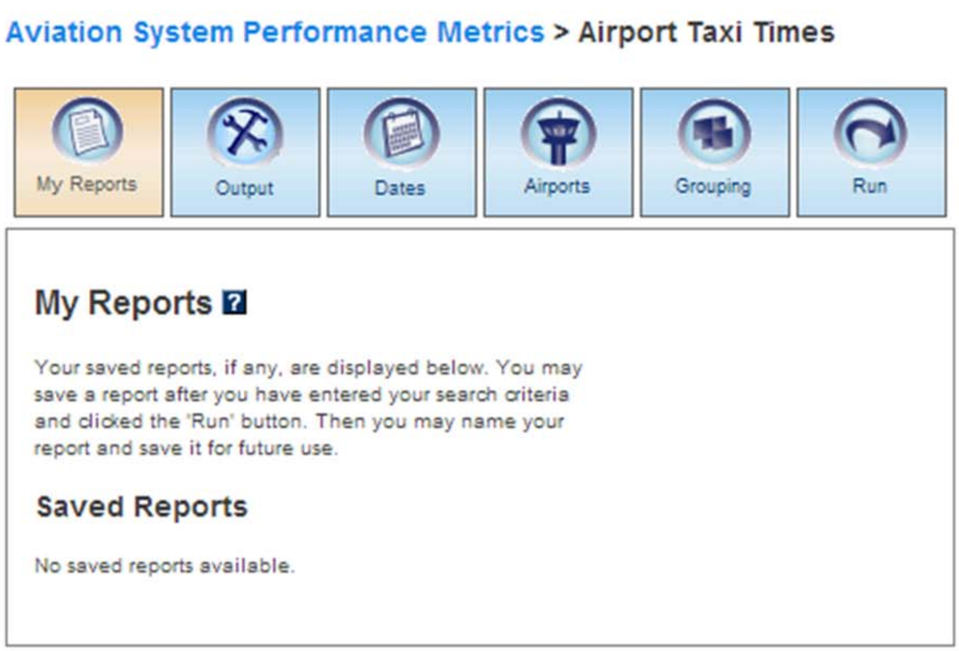
ASPM : Airport Analysis : All Flights Report

Calendar Year From 2012 To 2012 ; Airport=SEA : Use Flight Plan

Facility	Scheduled Departures	Scheduled Arrivals	Departures For Metric Computation	Arrivals For Metric Computation	% On-Time Gate Departures	% On-Time Airport Departures	% On-Time Gate Arrivals	Average Gate Departure Delay	Average Taxi Out Time	Average Taxi Out Delay	Average Airport Departure Delay	Average Airborne Delay	Average Taxi In Delay	Average Block Delay	Average Gate Arrival Delay
SEA	149,030	148,327	151,109	150,604	90.43	87.27	88.56	4.98	14.05	2.60	6.68	2.56	1.32	2.73	5.58

Report created on Thu Apr 3 12:36:03 EDT 2014
Sources: Aviation System Performance Metrics (ASPM)

To create a Taxi Time report, instead of clicking on the Airport Analysis link in Step 3, the Taxi Time link is selected.



6. The same options in the Airports (SEA) and Dates (2012) tabs are selected.

7. With these options selected, the Run button will generate the Taxi Time report below.

ASPM : Taxi Times : Standard Report

Calendar Year From 2012 To 2012 ; Airport=SEA

Facility	Departures For Metric Computation	Total Taxi Out Time	Departures With Taxi Out Time (Minutes)											Average Taxi Out Time	Arrivals For Metric Computation	Total Taxi In Time	Average Taxi In Time
			20-39	40-59	60-119	120-179	≥180	≥40	≥40(%)	<40	≥90	≥60	≥60(%)				
SEA	151,109	2,123,110.00	14,489	631	180	8	0	819	0.54	150,290	41	188	0.12	14.05	150,604	927,527.00	6.16

Report created on Thu Apr 3 12:14:30 EDT 2014
Sources: Aviation System Performance Metrics (ASPM)

Average Taxi Out Time
=
Average Taxi Out Delay
+
Unimpeded Taxi Out Time

Average Taxi In Time
=
Average Taxi In Delay
+
Unimpeded Taxi In Time

Table B-1 shows the total results from the above queries.

Table B-1: Total Aircraft Operating Time

	AVERAGE MINUTES	TOTAL OPERATIONS (ARR OR DEP)	TOTAL MINUTES (000)
Average Airborne Delay	2.56	150,604	385.5
Average Taxi-In Time	6.16	150,604	927.5
Average Taxi-Out Time	14.05	151,109	2,123.1
Total	22.77	n/a	3,436.1

SOURCES: FAA ASPM Database, April 2014.
PREPARED BY: Ricondo & Associates, Inc., January 2014.

Appendix C

List of Acronyms

A4A	Airlines for America
ACARS	Aircraft Communications Addressing and Reporting System
ACI-NA	Airports Council International-North America
AOD	Aircraft Operating and Delay
ASPM	Aviation Service Performance Metrics
ASQP	Airline Service Quality Performance
ATCSCC	Air Traffic Control System Command Center
BTS	Bureau of Transportation Statistics
CPE	Cost Per Enplanement
ETE	Estimated Time Enroute
ETMS	Enhanced Traffic Management System
ICAO	International Civil Aviation Organization
IFR	Instrument Flight Rules
OEP 35	Operational Evolution Partnership
OOOI	gate Out, wheels Off, wheels On and gate In
TFMS	Traffic Flow Management System
VFR	Visual Flight Rules