Air Time;
Another Measure of the Quality of Passenger Service

by

Juan Jaime Blake Betancourt

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Signature of Author...
Engineering Systems Division
September 12th, 2003

Certified by...
Arnold I. Barnett
George Eastman Professor of Management Science
Thesis Supervisor

Accepted by...
Dava J. Newman
Associate Professor of Aeronautics and Astronautics and Engineering Systems
Director, Technology and Policy Program

Accepted by...
Arthur C. Smith
Chairman, Department Committee on Graduate Students

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ABSTRACT.

The proposal of a new metric called "Air Time" and its various components, show the advantage of having a broader perspective of the travel process of airline passengers. Travel time is basically affected by three different factors. These factors are the length of the flight, the frequency of the flight and the day on which this flight is operated. Particular attention is paid to the ground side component of the Air Time and on how this component is affected by the three variables mentioned above.

The Air Time offers the possibility of making comparisons of the different parts of the travel process while looking at the whole picture of it. These comparisons range from comparing two airlines operating on the same route to compare the performance of the different stages of the travel process in different times.

The relation of these three variables to the Air Time is well determined and statistical analysis is done in order to show how each of these variables affects the Air Time and its various components. As a result of the statistical analysis, at the end is possible to estimate the ground side component of the Air Time for a given flight based on its haul, frequency and day of operation.

The information provided by the Air Time and its different components, can assist airlines and airport as an additional tool in operations planning. Also, the information provided by this new metric can benefit the public by allowing people to better understand what it really means, in terms of time, to engage in a flight with a particular airline and thus improving the competition among airlines.

Thesis Supervisor: Arnold I. Barnett

Title: George Eastman Professor of Management Science

Contents.

1 Introduction.

The time an air traveler passenger actually spends in an airplane is only a fraction of the total time for his journey from origin to destination. Time spent in airports - including connecting points where the passenger changes planes - could be a substantial portion of the total trip time. Yet, existing time metrics about passenger travel tend to concentrate on airplanes, and only on a small part of the flight.

For example, At present time and under the provisions of 14 CFR Part 234 of the U.S. DOT's regulations, the ten major airlines in the US are required to report on-time performance data to the Office of Airline Information (OAI) in the Bureau of Transportation Statistics (BTS) in the U.S. Department of Transportation. These provisions require the airlines to report performance on their operations from and to the 27 largest airports in the US - these airlines voluntarily report on all their routes and flights. The on-time performance metric currently in use by the DOT considers a flight to be "On-Time" if it arrived at the destination gate no more than fifteen minutes after the scheduled arrival time shown in the carrier's Computerized Reservations System (CRS).

Along with this metric, the BTS generates other statistics related to flight operations such as Taxi-Out time, Airborne Time, etc. All these additional statistics, however, are just the various components of the on-time performance record. These statistics, although useful, are not enough to answer the simple question "how long does it take for an average passenger to travel from A to B by plane?"

Arriving at the airport is the very first step in engaging in any flight. Passengers need to get to the airport with enough time to check-in, go through security, etc. The way in which this arrival process occurs may depend on the kind of flight in question, whether this is a long or short haul flight. It may depend on the day of the week in which this flight is operated or on the frequency of flights to the destination airport. It may also depend on the perception a passenger may have of a particular airline and whether this passenger considers the airline to be efficient or not. On-time records tell us nothing about the arrival process of passengers or the travel process as a whole.

Here we propose an Air Time metric, which would be the sum of the times a passenger spends in the different stages of the process he has to go through since his arrival at the departing airport till his arrival at the destination airport. In other words, by Air Time we mean a comprehensive metric of the total elapsed time between a traveler's arrival at his airport of origin and his arrival at his destination airport.

Having and using the Air Time metric could have significant advantages for both the airlines and the passengers. Airlines, for instance, could take advantage of a better understanding of the arrival process of passengers to the airport as a function of the kind of flight and use this information as an additional tool in planning the number of people they need at the counters to serve their customers more efficiently.

Using accurate statistics of the arrival process of passengers and the Air Time metric, could also help airlines in predicting how the introduction or removal of a given flight would affect their current operations. Knowing each part of the travel process of a passenger, could also be a guideline for airlines to identify areas where customer service could be improved and made more efficient.

The Air Time metric, if done extensively, could also be used to compare across airlines and have a better understanding of their performance. The Air Time metric, by the way it is composed would also serve to compare among airports. Is it possible that it takes longer to fly from A to B than from C to B, where A and C are two different airports in the same city, such as O'Hare and Midway in Chicago?

Passengers would also benefit from this metric by knowing better what they can expect when engaging in a trip with a particular airline. For a passenger it should not only be important knowing whether a flight or a particular airline has a good or bad on-time record but also how long it takes on average to engage on a particular flight with a given airline and how this time may compare with other airlines. The information, provided by the Air Time, would improve competition among airlines and would benefit customers.

Therefore, by putting together all the different stages of a trip in the Air Time metric, airlines and the public in general, could have a better understanding of what really means, in terms of time, engaging in a particular flight.

In this research, we show the way in which the Air Time is calculated as well as the different components it has and what each one of them represents. We will also perform the statistical analysis required to obtain each of the Air Time components and to be able, at the end to estimate the arrival pattern of passengers to a given flight as a function of the distance, frequency, day of the week and load factor of the flight.

Therefore, our primary objective in doing this research is to show the ease with which the Air Time is calculated and the many advantages which could results of using it extensively. We would like, as well, to illustrate which are its main components, and how these components are affected by different factors involved in the travel process such as the haul of a flight or the frequency of flights to a given destination.

2 Air Time, General Discussion.

As referred to in the introduction section, by Air Time we basically mean the total elapsed time between the arrival of a passenger at his airport of origin till the moment he arrives to his destination airport. For example, for a given passenger A, we could have the following case.

PAX A.

Arrival Time at Boston Logan Airport	8:20 AM
Pushback on FGT 000, BOS-CLE	9:15 AM
Arrival Time at Cleveland Hopkins (gate)	10:48 AM

Air Time = 10:48 – 8:20

<u>Air Time: 2 hours and 28 minutes</u>

For this simple example, we could basically distinguish two quantities involved in the calculation of the Air Time metric. The first one, which we call the Counter to Flight Time (CF time), is the elapsed time between the arrival of a passenger to the airport of origin till the moment in which the airplane leaves the gate. The second one, called the Airplane Time (AP time), is the elapsed time from the moment the plane leaves the gate at the airport of origin till the moment it reaches the gate at the destination airport. Therefore, for this simple case, we have a CF time of 55 minutes and an AP time of 1 hour and 33 minutes.

Notice the difference in scope of the Air Time when compared with the DOT's on-time record which would consider the flight to be on-time if its arrival time is within fifteen minutes of the scheduled arrival time shown in the carrier's Computerized Reservation System (CRS).

Therefore, passengers interested in looking at the statistics of a flight, if looking only at the on-time records would only get a small picture of the process. They could only see the average delay of the flight. This statistics, however, would not provide the public with any information regarding the total time involved in such flight, how this time is distributed among the different stages of the travel process or how this time may vary from one airline to another. The main advantage of the Air Time is, then, that it focuses on the entirety of the journey and not only on certain parts of it ignoring others.

The implementation of this new metric could also help in comparing airline performance in different times for a given origin-destination pair. The Air Time clearly depends on many different factors such as security processing time, promptness of aircraft departure, air traffic congestion en route, connecting time at hub, etc. These various factors are unlikely to be independent. In fact, in recent years, some of them have been negatively correlated.

As an example of the correlation existing among these different factors, consider the security processing time and the air traffic congestion. Recent events have forced the airline industry to adopt more stringent and time consuming security procedures. Many times we have heard of longer lines in the security checking points at the airports and therefore the necessity of arriving earlier at the airport of origin.

Could we say then, that due to this increase in the time needed to go through security corresponds an increment in the total time we spend in our journey? This question is difficult to answer with the available statistics. Indeed the security processing time may have increased but it could be true as well that the air traffic congestion has done the opposite maintaining or even reducing the Air Time. To illustrate this, consider this hypothetical example for a given passenger traveling the route Boston - New York City.

FLG 001 BOS-JFK Leaves 8:00 AM / Arrives 8:45 AM (Schedule Times)

August 2001.

PAX A.

Arrival Time at Boston Logan Airport	7:10 AM	
Pushback on FGT 001, BOS-JFK	8:30 AM	CF = 1 hour and 20 minutes.
Arrival Time at JFK (gate)	9:30 AM	AF = 1 hour.

Air Time: 2 hours and 20 minutes.

August 2002.

PAX A.

Arrival Time at Boston Logan Airport	6:30 AM	
Pushback on FGT 001, BOS-JFK	8:00 AM	CF = 1 hour and 30 minutes.
Arrival Time at JFK (gate)	8:45 AM	AP = 45 minutes.

Air Time: 2 hours and 15 minutes.

With this hypothetical example we can see the value of having a more comprehensive metric of the travel process of passengers. As illustrated here, the Air Time has the advantage of looking at the broader picture of the travel process.

The Air Time is not only a number used to measure the time of a travel but rather it is a metric which can compare among the different components of the travel time while looking at the overall picture of it. It also reflects how passengers perceive the different processes of an air travel such as going through the check-in counters, security lines, etc.

A huge advantage of this metric is that we do not need to know in detail the statistics of the different parts of the travel process in order to have the overall picture of it. For example, we do no need to have the particular statistics of the security checking process because this time would be included in the mean CF time of the flight

Therefore, with this kind of statistics, we are not only able to compare in different time period but also to compare across competing airlines operating in a given route. To illustrate this case consider the following hypothetical example.

Boston – Chicago O'Hare, Spring 2003 (non-stop service)

Carrier	Average Air Time
American	4 hours, 6 minutes
United	4 hours, 33 minutes

Further scrutiny of the data might suggest that the reason for this 27-minute difference is that United passengers may arrive to the airport earlier, perhaps because its check-in procedures are less efficient and predictable than American's – should it be the case, it would be reflected in the mean CF time, where United's mean CF time would be larger than American's.

These are only some of the applications the Air Time may have. The calculation of its components generates other valuable information which can assist in airport planning and airline operations as well. For example, on average, how much earlier do long haul passengers arrive to the airport of origin compared with short haul passengers?

The Air Time is an easy to calculate metric. The data required to calculate it is already available and the advantages of using it are many. The metric is made of many different components and could be broken down in great detail. Not doing so, however, does not affect its capacity to accurately reflect the overall travel experience of passengers. We proceed in the next section to clearly define each of the main components of the Air Time metric.

2.1 Air Time, Main Components.

As noted, the Air Time is a measure of the total time an air traveler spends through out his journey, excluding the travel time to and from airports. Air Time is the sum of three basic quantities, counter to flight time (CF time), Airplane time (AP time) and the flight's departure delay (D). The first quantity we consider is the time a passenger spends at the departure airport. This time, which we call CF time (counter to flight time), is the time from the moment in which the passenger approaches the airline's counter for the first time in order to check-in to the scheduled departure time (SDT) of the flight. Therefore, the CF time includes the time required to go through security and the time needed to get to the gate- CF time differs for passengers on the same flight. The average value of CF time for all passengers, however, reflects the consensus of how much in advance of scheduled departure time it is necessary to arrive at the airport.

The mean CF time describes the arrival pattern of passengers to a flight depending on the perception they have of the flight, the airport and the airline. Therefore, the Air Time can be used to identify different arriving patterns depending on factors such as the frequency of a flight, the distance to the destination airport or the day of the week in which a particular flight is operated. In chapter four we will analyze these relations in more detail to have a better understanding of how each of these factors influence the mean CF time of a flight. Also during this analysis, we will see which of these factors affects the most the mean CF time of a flight.

The second quantity of the Air Time metric is the AP time (Airplane time). This is the actual time the passenger spends inside the airplane and includes the taxi time and the actual fly time. This quantity is measured by the moment the plane leaves the gate at the departure airport - OUT time- till the time the plane reaches the gate at the destination airport – IN time. Therefore, we define the AP time as IN time minus OUT time.

Finally, the flight's departure delay D measures how off of schedule was the actual departure of the flight. The reason we need D in calculating the Air Time is that the CF time is measured from the moment a passenger first approaches the check-in counter to the scheduled departure of a flight and the AP time is measured from the real departure time of the flight till the moment it gets to the gate at the destination airport. In reality, the scheduled departure time and the real departure time are not always the same. While an airline hopes to leave "On Time" the reality is that it does not happen for all flights.

Therefore, we define the flight's departure delay D to be the OUT time – time at which the plane leaves the gate – minus the scheduled departure time (SDT).

With $D = OUT - SDT$

the Air Time is given by $CF + AP + D$.

Given that for a particular flight we can calculate the distribution of the CF time, we are also able to calculate the mean and standard deviation of this distribution and since AP and D are constants for that flight we have that:

$$E[\text{Air Time}] = E[CF] + AP + D$$

and

$$\text{Std}(\text{Air Time}) = \text{Std}(CF)$$

From this simple equation, there are four quantities of interest very easy to calculate. Two of these quantities are the percentage of time spent on ground (GF) and the percentage of time spent on the plane (PF). These quantities follow the equations where we define:

$$GF = (E[CF] + D) / E[\text{Air Time}]$$

and $PF = 1 - GF$.

The last two quantity of interest are first, the ATM = E[Air Time] / Mile (air time per mile), which reflects the average speed of travel when we also include the time at the airport, during which the passenger is effectively traveling at speed zero.

And second, the Real Fly time Factor (RFT) defined as the Actual Flying Time (AFT) divided by the average Air Time or RFT = AFT / E[Air Time]. Notice that this factor, the RFT factor, reflects the fraction of the Air Time in which we really move from origin to destination. It reflects how the time in which we really fly compares to the Air Time.

We intend to calculate the Air Time with actual data, and to investigate how it is affected by three different factors. These factors are the frequency of flights on the route of travel, the distance to destination airport and whether or not the flight is on a busy or non-busy day. While it is obvious that AP will vary with distance, it is not clear whether CF or D will also do so. Perhaps passengers on long journeys or on busy days allow extra time at the airport. Perhaps passengers arrive at the airport earlier when there are few flights per day to their destination rather than many flights, and thus missing the flight has especially bad consequences. These three factors will affect the arrival behavior of passenger to the departing airport and consequently the Air Time.

In our study, we will devote particular attention to the CF time which up to now has not been analyzed in detail. The CF time, as mentioned above, is expected to vary depending on the different characteristics of the flight and it is our intention to show the nature of these relations. The AP time is not itself the same on all days. While the distance to the destination airport is the same, AP time may be affected by weather condition, air traffic, etc.

As defined, the Air Time does not include two relevant quantities: the time between arrival at the airport and arrival at the ticket counter, and the time between arrival at the destination airport and the time the passenger retrieves his luggage. Current data limitations preclude estimation of these quantities on a flight-by-flight basis. But these limitations should ideally be overcome in the future to make Air Time more illuminating.

2.2 Data Used.

The data used for the purpose of illustrating the use and value of the Air Time metric and the different parameters associated with it, was obtained from a major North American airline, based on its operations at a major hub. Due to a confidentiality agreement, we are unable to specify which airline and at which hub or routes this data is from. All data was received in the form of flight histories, which include all relevant information about the specifics of a particular flight such as number of passengers on the flight, record of transactions[1] made for that flight, time at which each transaction was made, etc. Additionally to this information, data related to the real departure and arrival time of two different flight numbers in the days considered was received.

In total, we received 2,212 flight records, which represent all flights operated by the airline at this hub during the time of our study. From among these flights, there are 29 different domestic routes, 26 of them which operate under non-stop service. The flight records received, correspond to domestic flights operated by the airline in four different months – Dec. 2002, Jan. 2003, Feb. 2003, and Mar. 2003 - and on 5 days (business days) on each month. Table 2.2.1 summarizes the days for which we obtained these flight histories – we refer to these days as the time period of the study or just the time period.

Month	Monday	Tuesday	Wednesday	Thursday	Friday
Dec. 2002	16	17	18	19	20
Jan. 2003	13	14	15	9	10
Feb. 2003	10	11	NO	13	14
Mar. 2003	17	18	19	20	21

Table 2.2.1 / Days with Available Data that Constitute the Time Period of Study.

[1] Each time the record of a flight is modified by an agent (e.g. opening the flight, assigning or changing a passenger's seat, etc) this operation or "transaction" is recorded in the flight's history along with the time, date and agent who did it.

The flight records given by the airline were text documents. In order to extract the relevant information from these files, several programs were done in Visual Basic to classify, read, summarize, and process all relevant information related to the each flight.

The final result of analyzing each of these flight records was the cumulative distribution function (CDF) of the arrival process of passengers –CF time - for that particular flight in a period of 3 hours prior to the scheduled departure time of the flight as well as the probability mass function (PMF). Once having the CDF, we can calculate the mean and standard deviation of the arrival distribution.

To calculate the mean CF time for a given flight we only use the passengers served by the airline from which we received the information. Sometime, the number of passengers which our analysis shows to be on a flight is only a small fraction of the total capacity of the plane or the actual number of passengers on that flight. The reason for this, sometimes small number, is that many passengers can check-in in another city and get to the gate without having passed through the airline's counters or that many passengers, due to code share agreements among airlines, could check-in in the counters of another airline. Also, many passengers can get to the airport with electronic tickets and go directly to the gate. For this research, we only focus on passengers who checked-in at the airline's counters.

The information related to the real departure and arrival time of a flight, was obtained directly from the main computer system of the airline. Given that this information had to be retrieved for each flight on a particular day, we limited ourselves in this illustrative exercise to four flights serving two different routes operated in this time period. For example, Flight 315 on route 2 will be studied on two separate days.

Our main interest in this research is to illustrate the use of the Air Time as a comprehensive metric of the travel experience of passengers. One of the main components of this metric, as we have said, is the CF time. The CF time has largely remained unattended and in this study we want to show how the arrival process of passengers to the airport, described by the CF time, is affected by the different variables of a flight. Is in the study of the CF time where this research contributes with new knowledge about the air travel process.

Given that it is one of the main purposes of this research to see how the mean CF time of a flight is affected by the haul, frequency and day of the week, we classified individual flights into two groups on each of three dimensions

First, we consider the distance and frequency variables. We will classify flights in either long haul or short haul flights and high frequency or low frequency flights. The criteria to determine if a flight is a long /short haul flight or a high/low frequency flight is presented in table 2.2.2

By Distance	
Short Haul Flight < 560 mi	Long Haul Flight => 560 mi

Threshold for Distance; Approximate Flying Time is an Hour or Less.

By Frequency	
Low Frequency # of Flights < 45 in Time period	High Frequency # of Flights =>45 in Time Period

Threshold for Frequency; Median Frequency on the 26 Routes Considered.

Table 2.2.2 / Rules for Partitioning Flights by Distance & Frequency.

According to the criteria shown in table 2.2.2, we present all flights available to the study in table 2.2.3. Table 2.2.3 shows all the routes and flights available together with their frequency (total number of flights in time period) and the length of the flight. Table 2.2.3

classifies each route depending on the haul of the flight. It considers route number one the route with the shortest haul and route 26 the route with the longest haul.

Route Number	# of Flights in Time Period of Study	Flight Length in Miles	
1	35	190	Short Haul Flights
2	53	190	
3	49	190	
4	25	202	
5	53	226	
6	39	263	
7	127	287	
8	41	408	
9	53	421	
10	316	439	
11	32	445	
12	35	457	
13	18	475	
14	71	506	
15	13	530	
16	35	541	
17	18	554	
18	**72**	**590**	**Long Haul Flights**
19	**19**	**645**	
20	**26**	**730**	
21	**106**	**773**	
22	**75**	**797**	
23	**3**	**905**	
24	**69**	**955**	
25	**65**	**1003**	
26	**68**	**1427**	

Table 2.2.3 / Classification of Flights According to their Haul.

The last variable to be considered is the day of the week in which the flight is operated. We classify a day to be a Busy or Non-Busy day depending on the total number of domestic flights operated by the airline during that day. That number reflects demand for travel, and thus the number of passengers one might find on line at the ticket counter. Under this criterion, we are able to select the day with the highest number of flights as the busy day and the one with the lowest number of flights as the non-busy day. The results of applying these criteria were to select Thursday as the Busy day and Tuesday as the Non-Busy day as shown on table 2.2.4.

Busy Day	**Non- Busy Day**
Thursday	**Tuesday**

Table 2.2.4 / Busy and Non-Busy Day Selection.

We illustrate the use of the Air Time metric by selecting four different routes from among the 26 routes available. These four routes have been selected in a way such that the mixture of leisure and business passengers can be assumed as equal in all of them. Table 2.2.5 summarizes the selected routes to be used.

Route Number	**# of Flights in T.P.**	**Miles**	
2	53	190	
4	25	202	**Short Haul Flights**
20	**26**	**730**	
22	**75**	**797**	**Long Haul Flights**

Table 2.2.5 / Routes to be Used in the Study Classified by Distance.

For this first part of the analysis, we are interested in looking at the different combination of the three variables affecting the passengers' arrival behavior and consequently the Air Time. As mentioned before, these elements are:

- Frequency
- Distance
- Day of Week (Busy / Non-Busy)

The selection of flights shown in table 2.2.5 defines six sets of flights. The first two sets, those corresponding to short / long haul flights are clearly indicated by the table. The sets corresponding to high / low frequency can be easily determined from the data on table 2.2.5 Therefore, we can also classify these four routes by flight frequency as shown in table 2.2.6. Finally, each of these flights will be analyzed on a busy and non-busy day making up for the last two sets to be considered.

Route	# of Flights in T.P.	Miles	
2	53	190	
22	75	797	**High Frequency**
4	**25**	**202**	
20	**26**	**730**	**Low Frequency**

Table 2.2.6 / Routes to be Used in the Study Classified by Frequency.

We can verify the accuracy of the selection of the Busy / Non-Busy day by comparing the number of passengers handled by the airline on these days. To do this, for instance, we consider the passengers on Route 2 flying on Tuesdays and Thursdays on the different flights operated by the airline on those days. These data is presented on tables 2.2.7 and 2.2.8 for Tuesdays and Thursdays respectively.

Table 2.2.9 summarizes the results of tables 2.2.7 and 2.2.8 by comparing the total number of passengers carried by each flight number on Tuesdays and Thursday. As we will see along the study the selection of these days as the Busy and Non-Busy days will produce similar results in the other routes.

PAX / Flight #			Airplane	PAX on	% of Capacity	
Day	Flight	Date	Capacity	Airplane	Used	
Tuesday	307	17-Dec	142	54	38.0%	Total PAX
Tuesday	307	14-Jan	97	62	63.9%	Per Flight #
Tuesday	307	11-Feb	97	45	46.4%	161
Tuesday	315	17-Dec	142	79	55.6%	Total PAX
Tuesday	315	14-Jan	142	70	49.3%	Per Flight #
Tuesday	315	18-Mar	142	80	56.3%	229
Tuesday	405	17-Dec	97	68	70.1%	Total PAX
Tuesday	405	14-Jan	97	75	77.3%	Per Flight #
Tuesday	405	18-Mar	97	68	70.1%	211
			Total	601		

PAX / Month			Airplane	PAX on	% of Capacity	
Day	Flight	Date	Capacity	Airplane	Used	
Tuesday	307	17-Dec	142	54	38.0%	Total PAX
Tuesday	315	17-Dec	142	79	55.6%	Dec
Tuesday	405	17-Dec	97	68	70.1%	201
Tuesday	307	14-Jan	97	62	63.9%	Total PAX
Tuesday	315	14-Jan	142	70	49.3%	Jan
Tuesday	405	14-Jan	97	75	77.3%	207
Tuesday	307	11-Feb	97	45	46.4%	Total PAX
Tuesday	315	18-Mar	142	80	56.3%	Feb & Mar
Tuesday	405	18-Mar	97	68	70.1%	193
			Total	601		

Table 2.2.7 / Total Number of Passenger Handled by the Airline on Tuesdays / Route 2.

PAX / Flight #			Airplane	PAX on	% of Capacity	
Day	Flight	Date	Capacity	Airplane	Used	
Thursday	307	19-Dec	142	64	45.1%	Total PAX
Thursday	307	9-Jan	97	43	44.3%	per Flight #
Thursday	307	13-Feb	97	97	100.0%	204
Thursday	315	19-Dec	142	112	78.9%	Total PAX
Thursday	315	9-Jan	142	79	55.6%	per Flight #
Thursday	315	20-Mar	142	120	84.5%	311
Thursday	405	19-Dec	97	64	66.0%	Total PAX
Thursday	405	9-Jan	97	68	70.1%	per Flight #
Thursday	405	20-Mar	97	93	95.9%	225
			Total	740		

PAX / Month			Airplane	PAX on	% of Capacity	
Day	Flight	Date	Capacity	Airplane	Used	
Thursday	307	19-Dec	142	64	45.1%	Total PAX
Thursday	315	19-Dec	142	112	78.9%	Dec
Thursday	405	19-Dec	97	64	66.0%	240
Thursday	307	9-Jan	97	43	44.3%	Total PAX
Thursday	315	9-Jan	142	79	55.6%	Jan
Thursday	405	9-Jan	97	68	70.1%	190
Thursday	307	13-Feb	97	97	100.0%	Total PAX
Thursday	315	20-Mar	142	120	84.5%	Feb & Mar
Thursday	405	20-Mar	97	93	95.9%	310
			Total	740		

Table 2.2.8 / Total Number of Passenger Handled by the Airline on Thursdays / Route 2.

Flight	Tuesday PAX	Thursday PAX
307	161	204
315	229	311
405	211	225
Total	**601**	**740**

Table 2.2.9 / PAX Handled on each Flight Number for ALL Flights Operated on the Busy / Non-Busy Days / Route 2.

With these three different variables –distance, frequency and day- we are able to form 8 possible triplets. In the next chapter, chapter 3, we analyze each of these triplets to determine which combination of parameters affects the most the mean CF time of a flight. We conclude this section by presenting in table 2.2.10 a summary of the triplets and the routes associated with these variables that we will consider in our study.

Day of Week	Frequency	Distance	Route
Non-Busy Day	High Frequency	Short Haul	2
Busy Day	High Frequency	Short Haul	2
Non-Busy Day	Low Frequency	Short Haul	4
Busy Day	Low Frequency	Short Haul	4
Non-Busy Day	High Frequency	Long Haul	22
Busy Day	High Frequency	Long Haul	22
Non-Busy Day	Low Frequency	Long Haul	20
Busy Day	Low Frequency	Long Haul	20

Table 2.2.10 / Triplets to be Considered Along with their Associated Route.

3 Data Analysis I.

The analysis we will do in this chapter, is done by first taking for each route one flight on Tuesday and one flight on Thursday of the month of December. The days we will select for this purpose are Tuesday Dec. 17th, 2002 and Thursday Dec. 19th, 2002 which as we already saw comply with the definitions of Non-Busy and Busy days respectively.

This selection will generate eight different groups of flights to be studied, which correspond to each one of the triplets mentioned in table 2.2.10. Chapter 3 will, therefore, be divided in eight sections each one of them taking care of a particular triplet.

We will begin each section by first analyzing a particular flight in a given route in order to obtain the mean CF time and standard deviation of the arrival process of that flight and, if possible[2], all the other quantities of interest associated with the Air Time metric.

Afterwards, we will take all[3] available flights in the route operated either on all Tuesdays or Thursdays in the time period of our study and calculate for each of these flights its mean CF time and standard deviation. We then average these results to present the mean values for both the Busy and Non-Busy days corresponding to each route.

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[2] The Airline only provided us with the information required to calculate the AP time and the FDD D for four flights. Two of these flights correspond to Route 2 and the other two to Route 22. Out of these four flights, two were operated on Tuesday, Dec. 17th, 2002 and the other two on Thursday, Dec. 19th, 2002.

[3] By all we mean all flights operated in either the busy or the non-busy days of the time period of our study (e.g. all flights operated on Tuesdays for Route 2 would be part of the analysis of the short-haul, high-frequency, non-busy day triplet).

3.1 Non-Busy - High Frequency - Short Haul Case.

For this first part of the analysis, we take Flight 315 / Route 2 operated on Tuesday Dec. 17th, 2002. According to our classification of flights given on tables 2.2.5 and 2.2.6 this is a high frequency flight since this route has 53 flights in the time period considered and it is also a short haul flight with the destination airport at only 190 miles away from the airport of origin. Also, as stated on table 2.2.4 and verified on table 2.2.9, Tuesday is considered to be the Non-Busy day.

After processing the flight's history given by the airline, we are able to obtain the flight's arrival distribution function and consequently its mean CF time and standard deviation. These results are shown on table 3.1.1 and the complete CDF, PMF and 1-CDF functions are shown on table 3.1.2. We then present table 3.1.3 as a summary of the arrival process to the flight given in table 3.1.2.

Flight	315	**Date**	17-Dec
Dest.	Route 2	**Departs**	955
Dist.	190	**Freq.**	53
Min	164	**Mean**	79.75
Max	18	**Std**	37.86

Table 3.1.1 / Summary of Results for Flight 315 / Dec. 17th, 2002.

These results show that on average, passengers flying on this flight arrived to the airline's check-in counter 79.75 minutes prior to the scheduled departure time of the flight at 9:55 AM. These results also show that the first passenger to check-in for the flight did so 164 minutes before the scheduled departure time and the last passenger to check-in did so only 18 minutes before SDT.

Minutes	CDF	1-CDF	PMF
164	0.019608	0.980392	0.019608
163	0.039216	0.960784	0.019608
158	0.058824	0.941176	0.019608
156	0.098039	0.901961	0.039216
152	0.117647	0.882353	0.019608
122	0.137255	0.862745	0.019608
116	0.156863	0.843137	0.019608
107	0.176471	0.823529	0.019608
104	0.196078	0.803922	0.019608
103	0.215686	0.784314	0.019608
98	0.235294	0.764706	0.019608
95	0.254902	0.745098	0.019608
94	0.294118	0.705882	0.039216
93	0.313725	0.686275	0.019608
86	0.333333	0.666667	0.019608
85	0.352941	0.647059	0.019608
84	0.411765	0.588235	0.058824
83	0.490196	0.509804	0.078431
82	0.509804	0.490196	0.019608
81	0.529412	0.470588	0.019608
80	0.54902	0.45098	0.019608
79	0.568627	0.431373	0.019608
72	0.607843	0.392157	0.039216
71	0.627451	0.372549	0.019608
68	0.647059	0.352941	0.019608
62	0.666667	0.333333	0.019608
54	0.686275	0.313725	0.019608
49	0.745098	0.254902	0.058824
48	0.764706	0.235294	0.019608
46	0.784314	0.215686	0.019608
42	0.823529	0.176471	0.039216
39	0.843137	0.156863	0.019608
38	0.901961	0.098039	0.058824
35	0.921569	0.078431	0.019608
34	0.941176	0.058824	0.019608
26	0.960784	0.039216	0.019608
25	0.980392	0.019608	0.019608
18	1	0	0.019608

Table 3.1.2 / Distribution Function for the Arrival Process of Passengers at the Counter Relative to the Scheduled Departure Time of Flight 315 / Dec. 17th, 2002.

Table 3.1.1, gives us then, the value of the mean CF time for Flight 315 / Route 2 operated on Tuesday Dec. 17th 2002 which is 79.75 minutes. In order to calculate the actual Air Time for this flight, we need to know the AP time and the flight's departure delay (FDD) D. The first quantity, the AP time for this flight, can be easily read from table 3.1.4

Minutes	% of PAX Checked
151 - 180	11.76
121 - 150	1.96
91 – 120	17.65
61 – 90	35.29
31 – 60	27.45
0 – 30	5.89
Total	**100.00**

Table 3.1.3 / Summary of the Arrival Process for Flight 315 / Dec. 17th, 2002.

Table 3.1.4 has four different values given by the airline. The first value under the label of "OUT" is the time at which the plane left the gate, the push-out time. The second value under the label of "OFF" represents the time at which the plane took off from the departing airport.

Flight	315	**Dest.**	Route 2
Date	17-Dec	**Departs**	955
Out	**Off**	**On**	**In**
1005	1020	1047	1050
Time from Scheduled Departure to Actual Arrival at Destination Airport			**55 Min.**

Table 3.1.4 / Airplane's Operations Times.

The third value under the label of "ON" represents the actual time at which the plane landed at the destination airport, and finally, the value under the label of "IN" is the time at which the plane reached the gate at the destination airport and the passengers were allowed to leave the airplane.

From the information given in table 3.1.4, we determine the AP time as "Time IN" minus "Time OUT" or 10:50 minus 10:05 which gives us a value for the AP time of 45 minutes. We also get from this same table the data to calculate the flight's departure delay D which for this case is "Time OUT" minus SDT or 10:05 minus 9:55. Therefore, we have that D equals 10 minutes. The value of D that we get in the Air Time metric is in fact one of the statistics generated by the DOT's on-time records.

This example shows as well that the "On-Time" metric and its different components are included in the Air Time and can be easily derived from it, and illustrates the limitations of considering the on-time records as the only statistics of flight performance while, on the other hand, shows the benefits of having a broader view of the travel process given by the Air Time metric.

With the values of the mean CF time, AP time and flight's departure delay (FDD) D, we calculate the average Air Time for this flight to be

E[Air Time] = 79.75 + 45 + 10

E[Air Time] = 134.75 minutes

Now that we have the Air Time, we proceed to calculate the other three quantities of interest – GF, PF, ATM and RFT.

GF = (79.75 + 10) / 134.75

GF = 0.6660

PF = 1 – GF = 0.3340

And for the ATM we have the relation ATM = E[Air Time] / Mi from which we get:

ATM = 134.75 / 190 = 0.7092

With this information we see that an average passenger who engaged in this flight spent 66.60% of his total travel time on the ground at the departing airport. This measure, however, is still a little bit misleading and the results can be even more dramatic because passengers can spend time in the plane while the plane is on the ground.

Therefore, if we really want to have an accurate understanding on how compares the time on which an average passenger actually flies – the time in which we really move from origin to destination – to the time he spends on ground either on the plane or in any other stage of the process, we calculate the Real Fly Time factor (RFT).

We defined the RFT factor as the Actual Flying Time (AFT) divided by the E[Air Time]. From table 3.1.4 we determine the AFT to be 27 minutes. This is the actual time the airplane was on the air (On Time – Off Time). Thus we calculate for this particular flight the RFT as:

RFT = AFT / E[Air Time]

RFT = 27 / 134.75

RFT = 0.2004

This means that an average passenger on this flight spent only 20.04% of the total time of his entire journey in actually moving himself from origin to destination. This type of information provided by the Air Time metric could change the way people travel, particularly on short haul routes like this one. Suppose that is reasonable to assume that on average a person would spend the same time in going from his house to the airport than from his house to the highway which leads to the destination city and that the same is true for the destination city. Then for this particular case, driving from origin to destination (only on the highway) takes a person an average of 180 minutes –on this route the highway time is three hours- compared to the 134.75 required to travel by air.

Information like this, provided by the Air Time, could lead many people to think twice on how to go from one place to another, particularly when traveling to recreational places where it is common for families to go together and the price of saving 45 minutes on the highway can be rather high.

From this data we also see that the average time per mile was almost 0.71 minutes. It is interesting to note that if an airplane travels on average at 600 mi/hr then the minimum ATM we could obtain is 0.1 min / mi – provided the RFT is one.

This implies that the longer the flight the smaller the ATM a passenger will experience. Therefore, if we consider the ATM as a measure of how efficiently is our time spent while traveling by air, we see that long haul flights are more time efficient than short haul flight. Therefore, the Air Time metric allows us to determine the time-efficiency of a flight which can be used to compare across different airlines.

We conclude this section with table 3.1.5 which includes all flights on Route 2 operated on Tuesdays during the time period considered. This table shows for each flight its mean CF time, standard deviation and Min/Max values of the arrival process distribution.

Table 3.1.5 also presents the average mean CF time obtained by averaging the mean CF times of all the flights operated on Tuesdays. Similar results are shown for the standard deviation and the Min / Max values of the arrival process distribution.

Dest Route 2

Tuesday

Flight	Date	Min	Max	Mean	Std
307	17-Dec	132	6	60.78	39.35
307	14-Jan	175	4	99.44	58.72
307	11-Feb	173	37	85.76	37.49
315	17-Dec	164	18	79.75	37.86
315	14-Jan	169	-1	87.16	47.65
315	18-Mar	145	21	69.95	29.47
405	17-Dec	150	8	69.13	40.52
405	14-Jan	135	29	86.38	27.82
405	18-Mar	119	18	74.89	28.22
	Average	151.33	15.56	79.25	38.57

# of Flights	Month	Mean
3	**17-Dec**	69.88
3	**14-Jan**	91.00
1	**11-Feb**	85.76
2	**18-Mar**	72.42

Table 3.1.5 / Summary of Results / All flights on Route 2 Operated on Tuesdays.

3.2 Busy - High Frequency - Short Haul Case.

In this section, we again look at Flight 315 / Route 2. By our definitions, this is a high frequency flight since there are 53 flights in the time period considered and it is also a short haul flight for which the destination airport is only 190 miles away from the departing airport. We focus our attention, though, on the flight operated on Thursday Dec 19^{th} 2002, which as we argued is the busy day.

After processing the flight's history given by the airline, we obtain the flight's arrival distribution function, mean CF time and standard deviation. These results are shown on table 3.2.1. Table 3.2.2 presents a summary of the arrival process to this flight.

Flight	315	**Date**	19-Dec
Dest.	Route 2	**Departs**	955
Dist.	190	**Freq.**	53
Min	167	**Mean**	72.18
Max	19	**Std**	37.63

Table 3.2.1 / Summary of Results for Flight 315 / Dec. 19^{th}, 2002.

These results show that an average passenger on this flight arrived to the airline's check-in counter 72.18 minutes prior to the scheduled departure time of the flight at 9:55 AM. The first surprising result that we get in this study is that the mean CF time of a flight operated on the Busy day is shorter than the mean CF time of the same flight but operated on the Non-Busy day. So, for our short-haul / high frequency route we have 72.18 and 79.75 minutes for the mean CF times of the Busy and Non-Busy days respectively. These results are not an isolated case due to the particular selection of flights to be analyzed, but rather the tendency that we will observe all along our research.

This is an interesting an unexpected result given that one would think that on the Busy day the mean CF time of a flight should be larger than on the Non-Busy day. The reason of why this may happen could be better understood if the statistics of the queue to get to the check-in counters were available.

Nevertheless, we can speculate that the reason for this behavior may, in part, be caused by the airline itself. If we think that an average passenger does not really distinguish what an airline would consider to be a Busy or Non-Busy day, then we could assume that the time at which passengers decide to arrive at the airport is independent of the Busy/Non-Busy factor. However, on the Busy days, when there are indeed more passengers traveling, arriving passengers to the airport find a larger queue to get to the check-in counters. If left alone, many of these passengers could not get to the counter on time for check in before the closing time of the flight. So it is common practice for airlines to call to the counter passengers when the flight is about to close which would yield a shorter mean CF time for the flight. However, as already said, this is pure speculation and verification is required.

In order to calculate the E[Air Time] for this flight, we need to know the AP time as well as the flight's departure delay D. The AP time for this flight can be easily read from table 3.2.3

Minutes	% of PAX Checked
151 -180	9.23%
121- 150	1.54%
91 – 120	10.77%
61 – 90	38.46%
31 – 60	30.77%
0 – 30	9.23%
Total	**100.00%**

Table 3.2.2 / Summary of the Arrival Process for Flight 315 / Dec.19th, 2002.

Table 3.2.3 has four different values given by the airline. The value under the label of "OUT" is the time at which the plane left the gat. The second value under the label of "OFF" represents the time at which the plane took off. The third value under the label of "ON" represents the actual time at which the plane landed at the destination airport and finally, the value under the label of "IN" is the time at which the plane reached the gate at destination airport and passengers were allowed to leave the plane.

Flight	315	**Dest.**	Route 2
Date	19-Dec	**Departs**	955
Out	**Off**	**On**	**In**
955	1010	1045	1050
Time from Scheduled Departure to Actual Arrival at Destination Airport			**55 Min.**

Table 3.2.3 / Airplane's Operations Times.

From the information in table 3.2.3, we calculate the AP time as "Time IN" minus "Time OUT" or 10:50 – 9:55 which gives us a value for the AP time of 55 minutes. Notice that for this case, the flight's departure delay D has a value of zero which means that the flight left the gate on time at the SDT. With these values and the mean CF time we calculate the E[Air Time] for this flight as:

E[Air Time] = 72.18 + 55 + 0

E[Air Time] = 127.18 minutes

Now that we have the Air Time, we calculate the other quantities of interest associated with the Air Time metric – GF, PF, RFT and ATM.

GF = (72.18 + 0) / 127.18 = 0.5676

PF = 1 – GF = 0.4324

We get the ATM = E[Air Time] / Mi as:

ATM = 127.18 / 190 = 0.6694

With this information, we conclude that an average passenger on this flight spent almost 56.76% of his total travel time on ground at the departing airport. This quantity, as in the previous section, can be a little misleading because passengers can spend time in the plane while the plane is on the ground.

To see how the real flying time – the time in which we really move from origin to destination – compares to the Air Time, the total time of our journey which includes all different stages of this process including the real flying time, we calculate the Real Fly Time factor (RFT).

We again define the RFT factor as the Actual Fly Time (AFT) divided by the E[Air Time]. From table 3.2.3 we determine the AFT to be 35 minutes. This is the actual time the airplane was on the air (On Time – Off Time). Thus we calculate that for this particular flight the RFT is:

RFT = AFT / E[Air Time]

RFT = 35 / 127.18 = 0.2752

Therefore, an average passenger on this flight spent only 27.52% of the total time of his journey in actually moving himself from origin to destination and the average time per mile was 0.6694 minutes compared to 0.7092 minutes of the previous subsection, which means that in this flight the time of passengers was used a little bit more efficiently.

We end this section with table 3.2.4 which includes all flights on Route 2 operated on Thursdays during the time period considered. This table shows for each flight its mean CF time, standard deviation and Min/Max values of the arrival process distribution. Table 3.2.4 also presents the average mean CF time obtained by averaging the mean CF times of all the flights operated on Thursdays. Similar results are shown for the standard deviation and the Min / Max values of the arrival process distribution.

Dest Route 2

Thursday

Flight	**Date**	**Min**	**Max**	**Mean**	**Std**
307	19-Dec	142	33	84.27	30.72
307	9-Jan	160	12	64.79	40.44
307	13-Feb	155	-3	74.86	40.39
315	19-Dec	167	19	72.18	37.63
315	9-Jan	162	49	87.30	28.34
315	20-Mar	164	21	74.33	30.05
405	19-Dec	141	8	74.88	36.54
405	9-Jan	180	23	89.60	45.36
405	20-Mar	179	-6	75.86	36.33
	Average	161.11	17.33	77.56	36.20

# of Flights	**Month**	**Mean**
3	**19-Dec**	77.11
3	**9-Jan**	80.56
1	**13-Feb**	74.86
2	**20-Mar**	75.09

Table 3.2.4 / Summary of Results / All flights on Route 2 Operated on Thursdays.

3.3 Non-Busy - Low Frequency - Short Haul Case.

We now turn our attention to the frequency factor and explore how low frequency affects the mean CF time of a flight. To illustrate this case, we consider Flight 353 / Route 4 operated on the non-busy day Tuesday Dec.17th 2002. This flight according to the definitions given by tables 2.2.5 and 2.2.6 is a short haul flight with the destination airport at 202 miles from the airport of origin and it is also a low frequency flight with only 25 flights in the time period of our study.

We present in table 3.3.1, the number of passengers handled on Route 4 on the Busy and Non-Busy days of our study. In this case, even though Flight 353 / Route 4 operated on Thursday Dec 19th 2002 carried less passenger than the one operated on Tuesday in the same month, we still consider Tuesday as the Non-Busy day given that for all flights operated on Tuesdays and Thursdays in the route on the time period considered, more passengers were handled on Thursdays than on Tuesdays. Also, as said in section 2.2, we classified the Non-Busy / Busy days by the total number of domestic flights operated by the airline and by the total number of passengers handled by the airline in the different days of the week and under these definitions Thursday still remains to be the Busy day.

PAX / Flight Day	Flight	Date	Airplane Capacity	PAX on Airplane	% of Capacity Used	
Tuesday	353	17-Dec	109	**63**	57.80%	**Total PAX**
Tuesday	353	14-Jan	97	**46**	47.42%	**On Tuesdays**
Tuesday	353	18-Mar	97	**75**	77.32%	**184**
Thursday	353	19-Dec	109	**47**	43.12%	**Total PAX**
Thursday	353	9-Jan	97	**73**	75.26%	**On Thursdays**
Thursday	353	20-Mar	97	**85**	87.63%	**205**

Table 3.3.1 / Total Number of Passenger Handled on Tuesdays & Thursdays by Flight 353 / Route 4.

After analyzing the flight's history of Flight 353 / Route 4 operated on Tuesday Dec 17th 2002, we obtained the mean CF time and standard deviation of the arrival process distribution. Table 3.3.2 presents a summary of these results and table 3.3.3 presents the summary of the arrival process to the flight.

Flight	353	**Date**	17-Dec
Dest.	Route 4	**Departs**	1430
Dist.	202	**Freq.**	25
Min	150	**Mean**	106.72
Max	12	**Std**	31.68

Table 3.3.2 / Summary of Results for Flight 353 / Dec. 17th, 2002.

Minutes	**% of PAX Checked**
151 - 180	0.00%
121 - 150	41.03%
91 - 120	25.64%
61 - 90	25.64%
31 - 60	5.13%
0 – 30	2.56%
Total	**100.00%**

Table 3.3.3 / Summary of the Arrival Process for Flight 353 / Dec.17th, 2002.

From these results we see that an average passenger flying on this flight, arrived at the counter 106.72 minutes before the scheduled departure time of the flight at 14:30 Hrs – mean CF time. This reflects a significant increment in the mean CF time of the flight when compare to Flight 315 / Route 2 operated on the same date for which the mean CF time was 79.75

minutes. This result, which we will see all along our study, is the first indication we get that low frequency tends to increase the mean CF time of a flight.

For this flight, the airline did not provide us with the times at which the airplane left the gate, took off and arrived at the destination airport. For this reason we are unable to calculate the Air Time metric and the other statistics associated with it.

We conclude this section with table 3.3.4 which includes all flights on Route 4 operated on Tuesdays during the time period considered. This table shows for each flight its mean CF time, standard deviation and the times at which the first and last passenger checked-in.

Table 3.3.4 also presents the average mean CF time obtained by averaging the mean CF times of all the flights operated on Tuesdays. Similar results are shown for the standard deviation and the Min / Max values of the arrival process distribution.

If we compare the results of table 3.3.4 with those of table 3.1.5, we see that the average mean CF time for the low frequency flights is significantly higher than the average mean CF time for the high frequency flight – 94.17 compared to 79.25 respectively- showing the frequency effect on the mean CF time.

Dest Route 4

Tuesday

Flight	Date	Min	Max	Mean	Std
353	17-Dec	150	12	106.72	31.68
353	14-Jan	144	5	78.48	33.36
353	18-Mar	165	0	97.30	40.61
	Average	**153**	**5.67**	**94.17**	**35.22**

Table 3.3.4 / Summary of Results / All flights on Route 4 Operated on Tuesdays.

3.4 Busy - Low Frequency - Short Haul Case.

We continue the analysis with Flight 353 / Route 4 operated on the busy day Thursday Dec. 19th 2002. This is a short haul, low frequency flight. The destination airport is 202 miles from the departing airport and the total number flights during the time period of our study is 25. After processing the flight's history, we obtained the statistics for this flight which include the mean CF time and standard deviation of the arrival distribution. Table 3.4.1 presents these results and table 3.4.2 presents the summary of the arrival process of passengers to the flight.

Flight	353	**Date**	19-Dec
Dest.	Route 4	**Departs**	1430
Dist.	202	**Freq.**	25
Min	126	**Mean**	58.06
Max	25	**Std**	28.47

Table 3.4.1 / Summary of Results for Flight 353 / Dec. 19th, 2002.

Minutes	**% of PAX Checked**
151 - 180	0.00%
121 - 150	3.03%
91 - 120	9.09%
61 – 90	30.30%
31 – 60	36.36%
0 – 30	21.21%
Total	**100.00%**

Table 3.4.2 / Summary of the Arrival Process for Flight 353 / Dec. 19th, 2002.

The result of this analysis shows a mean CF time for the flight of 58.06 minutes. This time is significantly smaller than the time we obtained in the previous subsection of 106.72 minutes for the Non-Busy day and it is actually one of the smallest we can find among the mean CF times of all the flights in the study. This result is congruent with our previous argument that on the busy day the mean CF time is smaller than on the non-busy day.

This result, however, differs from what it was expected. As seen in the previous sections, the higher the frequency the shorter the expected mean CF time of a flight. Therefore, according to this general rule, which will be verified many times along the study, the flight operated on Route 2 on this same day should, on average, have a shorter mean CF time than this flight. We consider this result as an isolated case, non-representative of what in general occurs.

For this flight, as in the previous subsection, the airline did not provide us with the times at which the airplane left the gate, took off and arrived at the destination airport; reason for which we are unable to calculate the Air Time for this flight.

We end this section with table 3.4.3 which includes all flights on Route 4 operated on Thursdays during the time period considered. This table shows for each flight its mean CF time, standard deviation and Min/Max values of the arrival process distribution. Table 3.4.3 also presents the average mean CF time obtained by averaging the mean CF times of all the flights operated on Thursdays. Similar results are shown for the standard deviation and the Min / Max values of the arrival process distribution.

Dest Thursday	Route 4				
Flight	**Date**	**Min**	**Max**	**Mean**	**Std**
353	19-Dec	126	25	58.06	28.47
353	9-Jan	167	22	77.89	35.72
353	20-Mar	141	-7	70.38	35.12
	Average	144.67	13.33	68.78	33.10

Table 3.4.3 / Summary of Results / All flights on Route 4 Operated on Thursdays.

3.5 Non-Busy - High Frequency - Long Haul Case.

With this section, we begin the analysis of long haul flights. We focus our attention on Flight 595 / Route 22. This flight complies with our definitions of a high frequency, long haul flight given in tables 2.2.5 and 2.2.6. It has 75 flights operated in the time period considered and the destination airport is 797 miles from the departing airport.

PAX / Flight # Day	Flight	Date	Airplane Capacity	PAX on Airplane	% of Capacity Used	Total PAX per Flight #
Tuesday	579	14-Jan	97	59	60.8%	59
Tuesday	583	17-Dec	142	51	35.9%	Total PAX
Tuesday	583	14-Jan	97	70	72.2%	per Flight #
Tuesday	583	18-Mar	97	47	48.5%	168
Tuesday	589	17-Dec	142	107	75.4%	Total PAX
Tuesday	589	14-Jan	97	56	57.7%	per Flight #
Tuesday	589	18-Mar	97	74	76.3%	237
Tuesday	595	17-Dec	142	69	48.6%	Total PAX
Tuesday	595	18-Mar	142	67	47.2%	per Flight #
						136
			Total	**600**		

PAX / Month Day	Flight	Date	Airplane Capacity	PAX on Airplane	% of Capacity Used	
Tuesday	583	17-Dec	142	51	35.9%	Total PAX
Tuesday	589	17-Dec	142	107	75.4%	per Month
Tuesday	595	17-Dec	142	69	48.6%	227
Tuesday	579	14-Jan	97	59	60.8%	Total PAX
Tuesday	583	14-Jan	97	70	72.2%	per Month
Tuesday	589	14-Jan	97	56	57.7%	185
Tuesday	583	18-Mar	97	47	48.5%	Total PAX
Tuesday	589	18-Mar	97	74	76.3%	per Month
Tuesday	595	18-Mar	142	67	47.2%	188
			Total	**600**		

Table 3.5.1 / Total Number of Passenger Handled by the Airline on Tuesdays / Route 22.

PAX / Flight # Day	Flight	Date	Airplane Capacity	PAX on Airplane	% of Capacity Used	
Thursday	579	9-Jan	109	94	86.2%	Total PAX per Flight # 94
Thursday	583	19-Dec	142	80	56.3%	Total PAX
Thursday	583	9-Jan	97	40	41.2%	per Flight #
Thursday	583	20-Mar	97	94	96.9%	214
Thursday	589	19-Dec	109	108	99.1%	Total PAX
Thursday	589	9-Jan	142	100	70.4%	per Flight #
Thursday	589	20-Mar	142	136	95.8%	344
Thursday	595	19-Dec	142	100	70.4%	Total PAX
Thursday	595	20-Mar	142	118	83.1%	per Flight #
						218
			Total	**870**		

PAX / Flight # Day	Flight	Date	Airplane Capacity	PAX on Airplane	% of Capacity Used	
Thursday	583	19-Dec	142	80	56.3%	Total PAX
Thursday	589	19-Dec	109	108	99.1%	per Month
Thursday	595	19-Dec	142	100	70.4%	288
Thursday	579	9-Jan	109	94	86.2%	Total PAX
Thursday	583	9-Jan	97	40	41.2%	Per Month
Thursday	589	9-Jan	142	100	70.4%	234
Thursday	583	20-Mar	97	94	96.9%	Total PAX
Thursday	589	20-Mar	142	136	95.8%	per Month
Thursday	595	20-Mar	142	118	83.1%	348
			Total	**870**		

Table 3.5.2 / Total Number of Passenger Handled by the Airline on Thursdays / Route 22.

We look at the operation of this flight on the non-busy day Tuesday Dec. 17th, 2002. We verify that indeed we can take this day as the non-busy day by looking at tables 3.5.1 and 3.5.2. These two tables show the number of passengers handled by each flight operated both on Tuesdays and Thursdays of the time period considered. We see that Thursday as a whole and in the particular case of Flight 595 handled more passengers than Tuesday thus verifying Tuesday as the non-busy day.

We present the results of analyzing the flight's history for Flight 595 / Route 22 operated on Tuesday Dec. 17th 2002 in tables 3.5.3 and 3.5.4. These results include a summary of the arrival process and the mean CF time and standard deviation.

Flight	595	**Date**	17-Dec
Dest	Route 22	**Departs**	1425
Dist.	797	**Freq.**	75
Min	145	**Mean**	83.78
Max	49	**Std**	21.89

Table 3.5.3 / Summary of Results for Flight 595 / Dec. 17th, 2002.

Minutes	% of PAX Checked
151 – 180	0.00%
121 – 150	4.35%
91 – 120	21.74%
61 – 90	56.52%
31 – 60	17.39%
0 – 30	0.00%
Total	**100.00%**

Table 3.5.4 / Summary of the Arrival Process for Flight 595 / Dec. 17th, 2002.

The results of table3.5.3 show a mean CF time for this flight of 83.78 minutes. This result indicates an increase in the mean CF time of this flight when compare to the mean CF time of Flight 315 / Route 2, also a high frequency flight operated on the same day but on a short haul route and for which the mean CF time was 79.75 minutes.

This preliminary result indicates that the mean CF time of a flight increases as the haul of the flight grows. For the flights mentioned above, there is an increase of 4.03 minutes in the mean CF time of the long haul flight when compared to the short haul / high frequency flight, due to an increase of 607 miles to the destination airport.

The impact of the distance increase, however, may be reduced by the higher frequency of the long haul flight compared to the short haul / high frequency flight -75 vs. 53 flights in the time period considered respectively.

To calculate the Air Time metric and other quantities of interest, we first need the AP time and the FDD D. Table 3.5.5 shows the real times at which the plane left the gate, took off, landed and arrived to the gate at the destination airport.

Flight	595	**Dest.**	Route 22
Date	17-Dec	**Departs**	1425
Out	**Off**	**On**	**In**
1425	1435	1615	1620
Time from Scheduled Departure to Actual Arrival at Destination Airport			**115 Min.**

Table 3.5.5 / Airplane's Operations Times.

From the data in table 3.5.5 we calculate an AP time of 115 minutes and a FDD D of zero minutes meaning that the plane left the gate on time. With these values and the mean CF time of 83.78 we already had we calculate the E[Air Time] as:

E[Air Time] = 83.78 + 115 + 0 = 198.78 minutes

With the Air Time we now calculate the other four quantities of interest where:

GF = (83.78 + 0) / 198.78 = 0.4215 and PF = 1- GF = 0.5785

We calculate the ATM as:

ATM = E[Air Time] / Miles = 198.78 / 797 = 0.2494

These results show that, on average, a passenger of this flight spent 42.15% of the total time of his journey on the ground at the departure airport. If we compare these results to those of section 3.1, we observe a significant reduction in both, the GF and the ATM of Flight 595 / Route 22 compared to those of Flight 315 / Route 2 for which the GF and ATM had values of 0.6660 and 0.7092 respectively. These results as it was expected confirm the idea that the longer the flight the smaller the GF and the ATM.

We now look at the Real Fly Time factor (RFT) of an average passenger on this flight. From the data of table 3.5.5 we calculate an AFT (Actual Fly Time) of 100 minutes. With this value of the AFT we calculate the RFT to be:

RFT = AFT / E[Air Time] = 0.5031

Therefore, we see that an average passenger of this flight spent 50.31% of the total time of his journey in actually flying from origin to destination. This is a significant increase in the RFT if compared to the RFT of Flight 315 / Route 2 which was only 20%. This example also illustrates what is the significance of the arrival process for different flights, captured by the Air Time metric.

We conclude this section with table 3.5.6 which includes all flights on Route 22 operated on Tuesdays during the time period considered. This table shows for each flight its mean CF time, standard deviation and Min/Max values of the arrival process distribution.

Table 3.5.6 also presents the average mean CF time obtained by averaging the mean CF times of all the flights operated on Tuesdays. Similar results are shown for the standard deviation and the Min / Max values of the arrival process distribution.

Dest Route 22

Tuesday

Flight	Date	Min	Max	Mean	Std
579	14-Jan	167	29	89.03	31.29
583	17-Dec	170	15	75.35	45.66
583	14-Jan	142	41	83.06	31.16
583	18-Mar	133	-4	89.00	35.82
589	17-Dec	166	-4	92.81	36.57
589	14-Jan	163	19	103.74	34.26
589	18-Mar	164	5	92.73	37.78
595	17-Dec	145	49	83.78	21.89
595	18-Mar	158	37	95.75	33.93
	Average	156.44	20.78	89.47	34.26

# of Flights	Month	Mean
3	**17-Dec**	83.98
3	**14-Jan**	91.94
3	**18-Mar**	92.49

Table 3.5.6 / Summary of Results/ All Flights on Route 22 Operated on Tuesdays.

3.6 Busy - High Frequency - Long Haul Case.

Consider now for analysis Flight 595 / Route 22operated on Thursday Dec. 19th 2002 which corresponds to the long haul, high frequency, and busy day case. By processing the flight's history given by the airline we obtain the flight's arrival distribution function and consequently its mean CF time and standard deviation. These results are shown on tables 3.6.1 and table 3.6.2 which summarizes arrival process to the flight.

Flight	595	**Date**	19-Dec
Dest	Route 22	**Departs**	1425
Dist.	797	**Freq.**	75
Min	141	**Mean**	77.66
Max	25	**Std**	29.08

Table 3.6.1 / Summary of Results for Flight 595 / Dec. 19th, 2002.

Minutes	% of PAX Checked
151 - 180	0.00%
121 - 150	16.07%
91 - 120	14.29%
61 - 90	44.64%
31 - 60	23.21%
0 - 30	1.79%
Total	**100.00%**

Table 3.6.2 / Summary of the Arrival Process for Flight 595 / Dec. 19th, 2002.

From Table 3.6.1 we read a mean CF time for the flight of 77.66 minutes. This result shows the same behavior as the one observed for all other flights studied so far and this is that the busy day has a smaller mean CF time than the non-busy day. These results also show that the mean CF time for this flight is larger than the mean CF time for the short haul / high frequency flight considered in section 3.2 which had a value of 72.18 minutes. Therefore, we see again that the increment of 607 miles in the haul of the flight increased the mean CF time, in this case, by 5.48 minutes; illustrating once more the effect of the distance in the mean CF time.

We now calculate the E[Air Time] using the mean CF time of 77.66 minutes and the values for the AP time and the FDD D which we get from table 3.6.3. We calculate a value for the AP time of 125 minutes and a value of zero for the FDD D which means the flight left the gate on time.

We now calculate the E[Air Time] as:

E[Air Time] = 77.66 + 125 + 0 = 202.66 minutes

Flight	595	**Dest.**	Route 22
Date	19-Dec	**Departs**	1425
Out	**Off**	**On**	**In**
1425	1445	1625	1630
Time from Scheduled Departure to Actual Arrival at Destination Airport			**125 Min.**

Table 3.6.3 / Airplane's Operations Times.

We now calculate the other quantities of interest as:

GF = 77.66 / 202.66

GF = 0.3832

PF = 1 – GF = 0.6168

and ATM = E[Air Time] / Mi = 202.66 / 797

ATM = 0.2543

Therefore, we see that an average passenger on this flight spent 38.32% of the total time of his journey on the ground at the departure airport. We now calculate the Real Fly Time factor (RFT). In order to do so, we first calculate the Actual Fly Time (AFT). From table 3.6.3 we get a value of 100 minutes for the AFT and thus

RFT = AFT / E[Air Time] = 100 / 202.66

RFT = 0.4934

This implies that an average passenger of this flight spent 49.34% of the total time of his journey in actually moving from origin to destination. We end this section with table 3.6.4 which includes all flights on Route 22 operated on Thursdays during the time period considered. This table shows for each flight its mean CF time, standard deviation and Min/Max values of the arrival process distribution. Table 3.6.4 also presents the average mean CF time obtained by averaging the mean CF times of all the flights operated on Thursdays. Similar results are shown for the standard deviation and the Min / Max values of the arrival process distribution.

Dest Route 22

Thursday

Flight	Date	Min	Max	Mean	Std
579	9-Jan	148	-1	91.13	27.01
583	19-Dec	130	-5	69.32	41.05
583	9-Jan	103	18	73.50	22.04
583	20-Mar	177	-22	77.33	46.16
589	19-Dec	160	-71	59.85	58.24
589	9-Jan	174	-16	114.35	35.68
589	20-Mar	179	-84	68.53	51.16
595	19-Dec	141	25	77.66	29.08
595	20-Mar	173	17	84.53	33.71
	Average	153.89	-15.44	79.58	38.24

# of Flights	Month	Mean
3	**19-Dec**	68.94
3	**9-Jan**	93.00
3	**20-Mar**	76.80

Table 3.6.4 / **Summary of Results / All Flights on Route 22 Operated on Thursdays.**

3.7 Non-Busy - Low Frequency - Long Haul Case.

We continue our study looking at Flight 488 / Rout 20. This flight is a long haul flight, for which the destination airport is 730 miles away from the departure airport, and it's also a low frequency flight with only 26 flights in the time period considered. We take Tuesday Dec. 17th, 2002 as the Non-Busy day and verify this selection with table 3.7.1

PAX / Flight Day	**Flight**	**Date**	**Airplane Capacity**	**PAX on Airplane**	**% of Capacity Used**	**Total PAX**
Tuesday	488	17-Dec	142	**94**	66.20%	**on Tuesdays**
Tuesday	488	14-Jan	142	**102**	71.83%	**196**
Thursday	488	19-Dec	142	**127**	89.44%	**T. PAX on Th.**
Thursday	488	9-Jan	142	**142**	100.00%	**269**

Table 3.7.1 / Total number of Passengers Handled on Tuesdays & Thursdays by Flight 488 / Route 20.

Table 3.7.2 presents the results of analyzing the flight's history given by the airline which include the mean CF time and standard deviation of the arrival process of passengers to the flight. Table 3.7.3 summarizes the arrival process of passengers to the flight.

Flight	488	**Date**	17-Dec
Dest	Route 20	**Departs**	1635
Dist.	730	**Freq.**	26
Min	178	**Mean**	105.15
Max	25	**Std**	37.45

Table 3.7.2 / Summary of Results for Flight 488 / Dec. 17th, 2002.

Minutes	% of PAX Checked
151 - 180	16.67%
121 - 150	19.44%
91 - 120	23.61%
61 - 90	31.94%
31 - 60	6.94%
0 - 30	1.39%
Total	**100.00%**

Table 3.7.3 / (Summary of the Arrival Process for Flight 488 / Dec. 17th, 2002.

These results show a mean CF time of 105.15 minutes. In this case, however, we do not observe an increment in the CF time due to an increment of distance when compare to Flight 353 / Route 4 operated on the same non-busy day for which the mean CF time for that flight was 106.72 minutes. This is an interesting result because both flights have practically the same frequency (Route 4 / 25 flights and Route 20 / 26 flights) and shows that probably distance is not the most important factor in determining the mean CF time of a flight.

For this flight, the airline did not provide us with enough information to calculate the Air Time and other quantities of interest. We end the section with table 3.7.4 which includes all flights on Route 20 operated on Tuesdays during the time period considered. This table shows for each flight its mean CF time, standard deviation and Min/Max values of the arrival process distribution. Table 3.7.4 also presents the average mean CF time obtained by averaging the mean CF times of all the flights operated on Tuesdays. Similar results are shown for the standard deviation and the Min / Max values of the arrival process distribution.

Dest	Route 20				
Tuesday					
Flight	**Date**	**Min**	**Max**	**Mean**	**Std**
488	17-Dec	178	25	105.15	37.45
488	14-Jan	173	25	91.75	40.66
	Average	175.5	25	98.45	39.06

Table 3.7.4 / Summary of Results / All Flights on Route 20 Operated on Tuesdays.

3.8 Busy - Low Frequency - Long Haul Case.

We conclude chapter two with the analysis of Flight 488 / Route 20 operated on Thursday Dec. 19th 2002 which corresponds to the long haul, low frequency, and busy day case. The results of the analysis are presented in tables 3.8.1 and 3.8.2

Flight	488	**Date**	19-Dec
Dest	Route 20	**Departs**	1635
Dist.	730	Freq.	26
Min	172	**Mean**	96.38
Max	20	**Std**	34.34

Table 3.8.1 / Summary of Results for Flight 488 / Dec. 19th, 2002.

Minutes	% of PAX Checked
151 – 180	6.60%
121 – 150	10.38%
91 – 120	48.11%
61 – 90	16.04%
31 – 60	15.09%
0 – 30	3.77%
Total	**100.00%**

Table 3.8.2 / Summary of the Arrival Process for Flight 488 / Dec. 19th, 2002.

Table 3.8.1 shows a mean CF time for the flight of 96.38 minutes. This result, as it was expected, is smaller than the one we obtained in the previous section for the Non-Busy day of 105.15 minutes. It is also larger than the 77.66 minutes mean CF time for the (Busy, High Frequency, Long Haul) Flight of section 3.6 which indicates, as before, the significance of the frequency in the mean CF time calculation.

For this flight, as in the previous subsection, the airline did not provide us with the times at which the airplane left the gate, took off and arrived at the destination airport. For this reason we are unable to calculate the Air Time and the other statistics of interest.

We end this section and the chapter with table 3.8.3 which includes all flights on Route 20 operated on Thursdays during the time period considered. This table shows for each flight its mean CF time, standard deviation and Min/Max values of the arrival process distribution. Table 3.8.3 also presents the average mean CF time obtained by averaging the mean CF times of all the flights operated on Thursdays. Similar results are shown for the standard deviation and the Min / Max values of the arrival process distribution.

Dest Route 20

Thursday

Flight	Date	Min	Max	Mean	Std
488	19-Dec	172	20	96.38	34.34
488	9-Jan	179	-7	109.43	42.68
	Average	175.5	6.5	102.90	38.51

Table 3.8.3 / Summary of Results / All Flights on Route 20 Operated on Thursdays.

4.0 Summary of Results.

At this time, we have analyzed a total of 46 domestic flights operated in four[4] different routes. We selected each of this flights and routes depending on the different variables affecting the Air Time such as frequency, haul and the day in which the flights were operated. The result of this selection criteria[5], allowed us to classify a flight in one of two groups in each of three dimensions (Distance, Frequency, Day of Operation). The final result was to accommodate each flight in one of the eight possible triples[6] depending on whether the flight was long or short haul, high or low frequency, or operated on a busy or non-busy day.

Out of these 46 flights, we calculated the complete Air Time metric for four of them. For the reminder, we calculated the mean CF time of the flight. It is in studying the CF time rather than the AP time or the flight's departure delay D that we add something new to data widely available. The mean CF time, as we have seen already, is an extremely important component of the Air Time which captures the ground side of an air travel and reflects among many other things the passenger's perception of the travel process as, for example, the security process.

We divide this chapter in two additional sections, section 4.1 and section 4.2. These two sections will summarize the findings of section 3. Section 4.1 will be devoted to the results regarding the mean CF time of a flight whereas section 4.2 will present the Air Time and other quantities of interest for the four flights for which we could calculate the complete Air Time and will comment on these results.

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[4] For the criteria on which and how routes were selected please refer to section 2.2 and tables 2.2.5 and 2.2.6.
[5] To see how the threshold for dividing a flight into long / short haul or high / low frequency were determined please refer to section 2.2 and table 2.2.2 in the same section. For the criteria for selecting the busy / non-busy day please refer as well to section 2.2 and tables 2.2.4, 2.2.7, 2.2.8 and 2.2.9 in the same section.
[6] See table 2.2.10 details.

4.1 E[CF], Main Results.

The results of section 3 show a direct relation between the Air Time and each of the three variables considered in the analysis, namely the distance, frequency and day of operation of the flight. The relation between the Air Time and the haul of a flight is perhaps the most evident of them, at least for what the Actual Flying Time (AFT) refers to. It is clear that the longer the haul the larger the time we need to traverse that distance. However, it is important to remember that the AFT is only one of the components of the Air Time and that the other components, like for instance the CF time of a passenger, can be affected by whether the flight is short or long haul. This relation between the mean CF time of a flights and its haul, or the relation between the mean CF time and the frequency or day in which the flight is operated is far from being obvious.

The study of the Air Time, however, has shaded light on these relations and on how each of these factors affects the different components of the Air Time. In particular, the Air Time metric has provided us with valuable information about the CF time of passengers, which up to now had being kept forgotten, and on how we can benefit from this new knowledge.

We present in this section the main findings on the mean CF time of flight and how it is affected by the three different variables considered. In doing so, we first present the results for the eight individual flights studied, those selected as a case study for each of the eight possible triples, and afterwards in a subsequent subsection the results of considering all[7] available flights on the busy and non-busy days in the time of our study.

[7] According to the definition of busy and non-busy days, we selected Tuesday as the Non-Busy day and Thursdays as the busy day. When referring to ALL available flights we consider only ALL flights operated on Tuesdays (for non-busy case) and Thursdays (for busy case) during the time period of our study – e.g. a flight operated on Wed. would never be considered.

4.1.1 E[CF], One Flight per Case.

We present the results on the mean CF time of section 3 in table 4.1.1.1. This table is divided in two parts. The first part, part A, shows the results on the mean CF time of each of the individual flights analyzed in the order in which we found them – each triplet number corresponds to the subsection in chapter three where the results were obtained.

Summary of Results / One Flgt. Per Route						
# of Triplet	Triplet (Day	, Frequency,	Haul)	Route / Flight	E[CF] (min.)
1	(Non-Busy	, High,	Short)	2 / 315	79.75
2	(Busy	, High,	Short)	2 / 315	72.18
3	(Non-Busy	, Low,	Short)	4 / 353	106.72
4	(Busy	, Low,	Short)	4 / 353	58.06
5	(Non-Busy	, High,	Long)	22 / 595	83.78
6	(Busy	, High,	Long)	22 / 595	77.66
7	(Non-Busy	, Low,	Long)	20 / 488	105.15
8	(Busy	, Low,	Long)	20 / 488	96.38
Part A	(Order as Considered for Study)				
# of Triplet	Triplet (Day	, Frequency,	Haul)	Route / Flight	E[CF] (min.)
4	(Busy	, Low,	Short)	4 / 353	58.06
2	(Busy	, High,	Short)	2 / 315	72.18
6	(Busy	, High,	Long)	22 / 595	77.66
1	(Non-Busy	, High,	Short)	2 / 315	79.75
5	(Non-Busy	, High,	Long)	22 / 595	83.78
8	(Busy	, Low,	Long)	20 / 488	96.38
7	(Non-Busy	, Low,	Long)	20 / 488	105.15
3	(Non-Busy	, Low,	Short)	4 / 353	106.72
Part B	(Rank be E[CF])				

Table 4.1.1.1 / Results for each of the eight individual flights studied.

At the beginning of our study, one of the main questions we wanted to answer was which of the eight possible combinations of factors affecting the Air Time and in particular the mean CF time of a flight had the greater effect in increasing or decreasing the mean CF time of a flight. To easily answer this question, we present the mean CF times of the eight flights studied from shortest to largest in table 4.1.1.1 part B.

Thus, from table 4.1.1.1 part B we see that the shortest mean CF time corresponds to triplet 4 (Busy, Low, Short) with 58.06 minutes followed by triplet 2 (Busy, High, Short) with 72.18 minutes. This result, however, is not entirely in accordance with the majority of the evidence found in chapter 3.

The majority of the evidence presented in chapter three supports three hypothesis in relation with each of the affecting variables considered in the study. These hypotheses are:

1. - The mean CF time component of the Air Time has, on average, a larger value on the Non-Busy day than on the Busy day.
2. - To an increment in the haul of the flight, corresponds and increment of the Air Time and in particular of the mean CF time of the flight.
3. - To an increment in the frequency of the flight, corresponds a decrease of the mean CF time of the flight and consequently of the Air Time.

Therefore and according to the majority of the evidence, we should consider that triplet number 2 (Busy, High, Short) should be the one which on average would produce the shortest mean CF time. We then, do not consider the result of triplet 4 as a representative case of what on average occurs but rather an isolated case. We will present later on in this section more evidence which support this conclusion.

As for the combination of factors producing the largest mean CF time, we read from table 4.1.1.1 part B triplet number 3 (Non-Busy, Low, Short) with 106.72 minutes followed by triplet number 7 (Non-Busy, Low, Long) with 105.15 minutes. Once again and according to our three hypotheses, we take triplet number 7 as the case which, on average, would produce the largest mean CF time. Notice that route four occupies the first and last place which suggests that the flights considered in this route correspond to atypical events.

The most unexpected and yet unexplained[8] result found in chapter 3 was that for each individual flight analyzed, the mean CF time of the flight operated on the Busy day was shorter than its corresponding mean CF time on the Non-Busy day. These results are presented in table 4.1.1.2 part A

Busy day. Dec. 17th, 2002
Non-Busy day. Dec. 19th, 2002

Part	Route	Miles	Flgt. #	E[CF] (min.) Non-Busy Day	E[CF] (min.) Busy Day	Difference Non-Busy - Busy (min.)	% of Change with respect to Busy day
	2	190	315	79.75	72.18	7.56	10.47%
	4	202	353	106.72	58.06	48.66	83.80%
Part	20	730	488	105.15	96.38	8.78	9.11%
A	22	797	595	83.78	77.66	6.12	7.88%

Busy day. Dec. 17th, 2002
Non-Busy day. Dec. 19th, 2002

Part	Route	Miles	Flgt. #	E[Interarrival Time] (min.) Non-Busy Day	Busy Day	Difference Non-Busy - Busy (min.)	% of Change with respect to Busy day
	2	190	315	2.92	2.59	0.33	12.58%
	4	202	353	3.63	3.16	0.48	15.06%
Part	20	730	488	2.15	1.45	0.71	48.86%
B	22	797	595	4.36	2.07	2.29	110.39%

Table 4.1.1.2 / Comparison of the E[CF] time and E[Interarrival Time] for the Busy/Non-Busy cases.

To have a better view of the arrival process on the Busy / Non-Busy days, table 4.1.1.2 part B presents the mean Interarrival Time between passengers arriving at each flight. These Interarrival[9] times show as well a smaller mean value for the busy day than for the non-busy

[8] For a possible argument of why this may happen, please refer to section 3.2.
[9] Interarrival times are considering from the time a passenger arrives to the check-in counter till the moment the next passenger does the same. In case of groups of passengers arriving within the same minute (e.g. three

day. Therefore, we see that on the busy day not only the mean CF time of a flight is shorter but also that passengers are served with smaller intervals between them. We present in table 4.1.1.3 the mean interarrival times and Probability Mass Functions (PMF) of flight 315 operated on both the busy and non-busy day. The PMF was calculated from the Cumulative Distribution Function (CDF) of the passenger's arrival process to the flight (e.g. for Flight 315 on Dec. 17th, 2002 the CDF used is the one shown in table 3.1.2).

Interarrival Time's Probability Mass Function

Flight 315		Flight 315	
Non-Busy Day Tuesday Dec. 17th, 2002		Busy Day Thursday Dec. 19th, 2002	
Minutes Between PAX Arrivals	PMF	Minutes Between PAX Arrivals	PMF
0	0.260	0	0.297
1	0.320	1	0.313
2	0.040	2	0.141
3	0.100	3	0.063
4	0.040	4	0.047
5	0.060	5	0.063
6	0.040	7	0.016
7	0.060	9	0.016
8	0.040	18	0.031
9	0.020	32	0.016
30	0.020		
E[Int. Time] (min.)	**2.92**	E[Int. Time] (min.)	**2.59**

Table 4.1.1.3 / Comparison of PMFs & E[Interarrival Time]s for Flight 315.

passenger getting to the counter in the same minute) one passenger is assigned with the time elapse from the arrival of the prior passenger to the time of his arrival while the others are assigned a zero-minute interarrival time.

To better understand how the results of chapter 3 support the three hypotheses presented above, and to have a clearer view of the relationship which holds between the mean CF time of a flight and the variables affecting it, we present the same results of table 4.1.1.1 but in a different fashion. For each case we take two variables fixed and see how the mean CF time is affected by the remaining variable which we allow to vary. The main idea then, is to observe how the mean CF time is affected by a particular factor and the trend of the relation.

This analysis is presented in table 4.1.1.4 which is divided in three parts, each one corresponding to setting fixed two variables while allowing the third to vary. For the first part of the table, part A, we hold constant the haul and the frequency of the flight while allowing the day of the week to vary from busy to non-busy.

Part A

Haul & Frequency Fixed		E[CF] (min.)	E[CF] (min.)	Difference	% of Change
Haul	Frequency	Non-Busy Day	Busy Day	Non-Busy - Busy (min.)	with respect to Busy Day
Short	High	79.75	72.18	7.56	10.47%
Short	Low	106.72	58.06	48.66	83.80%
Long	High	83.78	77.66	6.12	7.88%
Long	Low	105.15	96.38	8.78	9.11%

Part B

Frequency & Day Fixed		E[CF] (min.)	E[CF] (min.)	Difference	% of Change
Frequency	Day	Long Haul	Short Haul	Long - Short Haul (min.)	with respect Short Haul
High	Busy	77.66	72.18	5.48	7.59%
High	Non-Busy	83.78	79.75	4.04	5.06%
Low	Busy	96.38	58.06	38.32	65.99%
Low	Non-Busy	105.15	106.72	-1.57	-1.47%

Part C

Haul & Day Fixed		E[CF] (min.)	E[CF] (min.)	Difference	% of Change
Haul	Day	High Freq.	Low Freq.	High - Low Freq. (min.)	with respect Low Freq.
Short	Busy	72.18	58.06	14.12	24.33%
Short	Non-Busy	79.75	106.72	-26.97	-25.27%
Long	Busy	77.66	96.38	-18.72	-19.42%
Long	Non-Busy	83.78	105.15	-21.37	-20.32%

Table 4.1.1.4 / One dimension analysis on the results of chapter 3.

The results for the first part of table 4.1.1.4, part A, have already been discussed before and were presented in table 4.1.1.2 part A. To see the effect of the haul of a flight in the mean CF time, we look at table 4.1.1.4 part B. Here, we have set the frequency and day of the week fixed allowing the distance to vary. We notice that out of the four pairs of data, three of them support the theory that to an increment in distance corresponds an increment in the mean CF time of the flight. The non-matching pair includes flight 353[10] / route 4 which, as we have argued, is non-representative of what on average occur. Indeed, the value of 106.72 minutes presented in this flight seems too large even for long haul flights. To see the effect of the frequency in the mean CF time, we present a similar analysis as the one for distance. This shows that out of four data pairs, three support the idea that to an increment in frequency corresponds a decrement in the mean CF time.

[10] This flight when considered for the frequency analysis also affects the results by having a mean CF value extremely low of 58.06 minutes. This value is one of the smallest values we've found for a mean CF time and the smallest of the 46 flight-group of our study. The two randomly selected flights on Route 4 have values at the end sides of the distribution which prevent us from really being able to observe the average behavior on the short haul, low frequency route.

4.1.2 E[CF], Route Results.

In what follows, we now turn our attention to the analysis of all[11] available flights in the four routes considered. This represents considering, as said before, a total of 46 flights. The presentation of these results follow the same format as the one of section 4.1.1 and the conclusions that these results support are the same as well. For this reason and in the interest of time, we limit ourselves to just showing the results which are laid on tables 4.1.2.1 and 4.1.2.2.

Summary of Results / All Flgts Analyzed						
# of Triplet	Triplet (Day	, Frequency,	Haul)		Route	E[CF] (min.)
1	(Non-Busy	, High,	Short)		2	79.25
2	(Busy	, High,	Short)		2	77.56
3	(Non-Busy	, Low,	Short)		4	94.17
4	(Busy	, Low,	Short)		4	68.78
5	(Non-Busy	, High,	Long)		22	89.47
6	(Busy	, High,	Long)		22	79.58
7	(Non-Busy	, Low,	Long)		20	98.45
8	(Busy	, Low,	Long)		20	102.90
Part A	(Order as Considered for Study)					
# of Triplet	Triplet (Day	, Frequency,	Haul)		Route / Flight	E[CF] (min.)
4	(Busy	, Low,	Short)		4	68.78
2	(Busy	, High,	Short)		2	77.56
1	(Non-Busy	, High,	Short)		2	79.25
6	(Busy	, High,	Long)		22	79.58
5	(Non-Busy	, High,	Long)		22	89.47
3	(Non-Busy	, Low,	Short)		4	94.17
7	(Non-Busy	, Low,	Long)		20	98.45
8	(Busy	, Low,	Long)		20	102.90
Part B	(Ranked by Average E[CF])					

Table 4.1.2.1 / Average results for all flights available in each of the eight categories.

[11] Only flights operated on Tuesdays and Thursdays in the time period of the study.

Note: All the mean CF times presented in this section, are the average of the mean CF times of the flights available for that category. For example, the average mean CF time of triplet 4 (Busy, Low, Short) of 68.78 is the result of averaging the mean CF times of the three flights available for this case which are 58.06, 77.89 and 70.38 as illustrated in table 3.4.3.

Part A

Haul & Frequency Fixed		E[CF] (min.)	E[CF] (min.)	Difference Non-Busy - Busy (min.)	% of Change with respect to Busy Day
Haul	Frequency	Non-Busy Day	Busy Day		
Short	High	79.25	77.56	1.69	2.17%
Short	Low	94.17	68.78	25.39	36.91%
Long	High	89.47	79.58	9.89	12.43%
Long	Low	98.45	102.90	-4.46	-4.33%

Part B

Frequency & Day Fixed		E[CF] (min.)	E[CF] (min.)	Difference Long - Short Haul (min.)	% of Change with respect Short Haul
Frequency	Day	Long Haul	Short Haul		
High	Busy	79.58	77.56	2.02	2.60%
High	Non-Busy	89.47	79.25	10.22	12.90%
Low	Busy	102.90	68.78	34.13	49.62%
Low	Non-Busy	98.45	94.17	4.28	4.55%

Part C

Haul & Day Fixed		E[CF] (min.)	E[CF] (min.)	Difference High - Low Freq. (min.)	% of Change with respect Low Freq.
Haul	Day	High Freq.	Low Freq.		
Short	Busy	77.56	68.78	8.78	12.77%
Short	Non-Busy	79.25	94.17	-14.92	-15.84%
Long	Busy	79.58	102.90	-23.33	-22.67%
Long	Non-Busy	89.47	98.45	-8.98	-9.12%

Table 4.1.2.2 / One dimension analysis on the results of chapter 3 for all available flight per combination.

4.1.3 E[CF], Regression Analysis.

With all the analysis we have done so far, we have come to have a good understanding on how the relationship between the mean CF time of a flight and the variables affecting it functions. We have not been able, however, to quantify how much these variables affect the mean CF time. There is also another variable which could be related to the mean CF time and of which we have not talk much about. This is the load factor. In general, the load factor should be related to the busyness factor in that on the busy day there are more people and the load factor in general should be higher.

To understand better the quantitative relation of all these four variables to the mean CF time and actually being able to predict the mean CF time of a flight, we model the relationships which hold between these variables and the mean CF time. To do this, we assume a linear relation of the variables of the form shown in equation E.4.1.3.0

$$\hat{E}[CF] = \beta 0 + \beta 1 * X1 + \beta 2 * X2 + \beta 3 * X3 + \beta 4 * X4 \qquad \textbf{(E.4.13.0)}$$

Where each X represents:

X1 : Haul of the flight (Miles)

X2 : Frequency (Number of flights in the days considered)

X3 : Load Factor (Number of PAX)

X4 : Day of the week (Logic variable; takes 1 for Busy day and 0 for Non-Busy day)

We, therefore, want to estimate the vector of regressors **β** given by equation E.4.1.3.1.

$$\boldsymbol{\beta} = (\mathbf{X'}\,\mathbf{X})^{\wedge}(-1)\,\mathbf{X'}\,\mathbf{E[CF]} \qquad \textbf{(E.4.1.3.1)}$$

We obtain matrixes **X** (M.4.1.3.1) and **E[CF]** (M4.1.3.2) from table 4.1.3.1 which summarizes all relevant data of the 46 flights used in the study.

Total # of Flights		46		# of Flights	Flight's	Busy
		Flight's	Haul	in Study	Load	Day
Route	Flight #	E[CF] time	(miles)	(frequency)	Factor (%)	(TRUE = 1)
2	307	60.7778	190	18	38.00	0
2	307	99.4400	190	18	63.90	0
2	307	85.7600	190	18	46.40	0
2	315	79.7451	190	18	55.60	0
2	315	87.1613	190	18	49.30	0
2	315	69.9464	190	18	56.30	0
2	405	69.1250	190	18	70.10	0
2	405	86.3846	190	18	77.30	0
2	405	74.8889	190	18	70.10	0
2	307	84.2667	190	18	45.10	1
2	307	64.7857	190	18	44.30	1
2	307	74.8571	190	18	100.00	1
2	315	72.1846	190	18	78.90	1
2	315	87.3030	190	18	55.60	1
2	315	74.3288	190	18	84.50	1
2	405	74.8750	190	18	66.00	1
2	405	89.6000	190	18	70.10	1
2	405	75.8551	190	18	95.90	1
4	353	106.7179	202	6	57.80	0
4	353	78.4783	202	6	47.42	0
4	353	97.3023	202	6	77.32	0
4	353	58.0606	202	6	43.12	1
4	353	77.8929	202	6	75.26	1
4	353	70.3846	202	6	87.63	1
22	579	89.0250	797	18	60.80	0
22	583	75.3462	797	18	35.90	0
22	583	83.0625	797	18	72.20	0
22	583	89.0000	797	18	48.50	0
22	589	92.8140	797	18	75.40	0
22	589	103.7410	797	18	57.70	0
22	589	92.7273	797	18	76.30	0
22	595	83.7826	797	18	48.60	0
22	595	95.7500	797	18	47.20	0
22	579	91.3333	797	18	86.20	1
22	583	69.3182	797	18	56.30	1
22	583	73.5000	797	18	41.20	1
22	583	77.3333	797	18	96.90	1
22	589	59.8472	797	18	99.10	1
22	589	114.3540	797	18	70.40	1
22	589	68.5333	797	18	95.80	1
22	595	77.6607	797	18	70.40	1
22	595	84.5270	797	18	83.10	1
20	488	105.1528	730	4	66.20	0
20	488	91.7458	730	4	71.83	0
20	488	96.3774	730	4	89.44	1
20	488	109.4321	730	4	100.00	1

Table 4.1.3.1 / Summary of results for all flights used in study.

X =

	(miles)	(frequency)	(load factor)	(busy)
1	190	18	38.00	0
1	190	18	63.90	0
1	190	18	46.40	0
1	190	18	55.60	0
1	190	18	49.30	0
1	190	18	56.30	0
1	190	18	70.10	0
1	190	18	77.30	0
1	190	18	70.10	0
1	190	18	45.10	1
1	190	18	44.30	1
1	190	18	100.00	1
1	190	18	78.90	1
1	190	18	55.60	1
1	190	18	84.50	1
1	190	18	66.00	1
1	190	18	70.10	1
1	190	18	95.90	1
1	202	6	57.80	0
1	202	6	47.42	0
1	202	6	77.32	0
1	202	6	43.12	1
1	202	6	75.26	1
1	202	6	87.63	1
1	797	18	60.80	0
1	797	18	35.90	0
1	797	18	72.20	0
1	797	18	48.50	0
1	797	18	75.40	0
1	797	18	57.70	0
1	797	18	76.30	0
1	797	18	48.60	0
1	797	18	47.20	0
1	797	18	86.20	1
1	797	18	56.30	1
1	797	18	41.20	1
1	797	18	96.90	1
1	797	18	99.10	1
1	797	18	70.40	1
1	797	18	95.80	1
1	797	18	70.40	1
1	797	18	83.10	1
1	730	4	66.20	0
1	730	4	71.83	0
1	730	4	89.44	1
1	730	4	100.00	1

M.4.1.3.1

E[CF] =

(E[CF])
60.7778
99.4400
85.7600
79.7451
87.1613
69.9464
69.1250
86.3846
74.8889
84.2667
64.7857
74.8571
72.1846
87.3030
74.3288
74.8750
89.6000
75.8551
106.7179
78.4783
97.3023
58.0606
77.8929
70.3846
89.0250
75.3462
83.0625
89.0000
92.8140
103.7410
92.7273
83.7826
95.7500
91.3333
69.3182
73.5000
77.3333
59.8472
114.3540
68.5333
77.6607
84.5270
105.1528
91.7458
96.3774
109.4321

M.4.1.3.2

With these two matrixes, we get the regressor vector $\boldsymbol{\beta}$ as:

$$\boldsymbol{\beta} = \begin{vmatrix} 84.3177 \\ 0.0131 \\ -0.6717 \\ 0.1096 \\ -9.1863 \end{vmatrix}$$

M.4.1.3.3

We now calculate the mean square error defined by equation E.4.1.3.4 as:

$$MSe = SSe \,/\, (n - v) \qquad \textbf{(E.4.1.3.4)}$$

where

$$SSe = \mathbf{E[CF]'\,E[CF]} - \boldsymbol{\beta}'\,\mathbf{X'\,E[CF]} \qquad \textbf{(E.4.1.3.5)}$$

We calculate a value for the SSe of 5948.72 and so we have for MSe that:

$$MSe = 5948.72 \,/\, (46 - 5) = 145.09$$

And finally, the standard error of our estimate $\hat{E}[CF]$ is 12.05 minutes. We now rewrite equation E.4.1.3.0 with the values calculated for each of the regressors as:

$$\hat{E}[CF] = 84.3177 + 0.0131 * X1 - 0.6717 * X2 + 0.1096 * X3 - 9.1863 * X4 \qquad \textbf{(E.4.1.3.6)}$$

The results of the regression analysis quantify the relation between the mean CF time of a flight and each of the factors affecting it. Now we not only have a qualitative relation, as we had in subsections 4.1.1 and 4.1.2, but rather a quantitative relation which allows us to predict the mean CF time of a flight.

We now test the results of our regression analysis to determine the significance of each of the β regressors calculated. We use the t-statistics to test for significance of regressors with $\alpha = 0.05$ which determines the t-critical value of 1.675. The results of this test are presented in table 4.1.3.2. This test shows that out of the five regressors calculated four of them are significant in estimating $\hat{E}[CF]$.

Test for Significance of Regressors			α = 0.05	t-critical =	1.675
Associated Variable	**Regressor**	**Value**	**Standard Error**	**t-observed**	**Regressor Significance**
Eq. Constant	β0	84.3177	9.3496	9.0183	yes
Distance	β1	0.0131	0.0061	2.1475	yes
Frequency	β2	-0.6717	0.3409	-1.9704	yes
Load Factor	β3	0.1096	0.1113	0.9847	no
Day	β4	-9.1863	3.9672	-2.3156	yes

Table 4.1.3.2 / t-statistics. Significance of Regressors.

Notice that as argued before in subsections 4.1.1 and 4.1.2 an increment in the distance produces an increment in the mean CF time which is captured in equation E.4.1.3.6 by the positive value of the regressor β1 associated with the distance (β1 = 0.0131). Similarly, we see that the negative value of β2 implies a negative slope in the linear relation between the mean CF time and the frequency. Thus, an increment in the frequency is associated with a decrement of the mean CF time. Likewise, we see the same kind of relation for β4 which validates our previous conclusion that on the busy day the mean CF time is shorter than on the non-busy day.

As for the β3, we see that an increase in the load factor of the flight increases the mean CF time, however, with the data available and the corresponding test result, we can not consider that the load factor is a significant parameter in determining the mean CF time.

At this point we would like to test our model to see how well it behaves. In order to do so we introduce, for the first time in the analysis, a new flight. This is Flight 405 on Route 2 operated on Dec. 16th, 2002[12]. Notice that this flight has never before been used in any of the analysis we have done before. This flight had a capacity of 97 PAX and the actual number of passengers on that flight was 26. This yields a load factor of 26.8%

The mean CF time for Flight 405 on Route 2 operated on Dec. 16th, 2002 was 91.02 minutes. This value is the actual mean CF time of the flight and was calculated with the same software and methods with which we have obtained all other mean CF values through out our study. To be able to use equation E.4.1.3.6 we need to determine the frequency of the flights on that day. By reviewing our database we see that on Dec. 16th, 2002 there were two flights operated on Route 2 per day or four for the two day period assumed by the regression. These flights were flight 307 and flight 405. Therefore, the value of frequency is 4. By substituting these numbers in equation E.4.1.3.6 we estimate a value for $\hat{E}[CF]$ of 87.06 which is 3.96 minutes short of the real mean CF time and has an error of 4.55%.

[12] Due to the number of flights operated by the airline on Monday, this day is also considered a non-busy day and therefore the value of X4 is zero.

We conclude this subsection by doing a linear regression analysis of the relationship which holds between the mean CF time per mile and the haul of the flight. This analysis allows us to see whether people arrive much earlier for long flights than for short ones, so that "CF per mile" is fairly constant. We will model this relation by the linear equation described in equation E.4.13.7

$$\hat{E}[CFM] = \beta 0 + \beta 1 * X1 \qquad \textbf{(E.4.1.3.7)}$$

To calculate the **β** vector corresponding to equation E.4.1.3.7, and the standard error of our estimate Ê[CFM] we use the data of the 46 flights in our study which yield following vectors for **X** and **E[CFM]**[*]

[*] E[CFM] = E[CF] / Miles. E[CFM] values calculated from table 4.1.3.1

$$\mathbf{X} = \begin{vmatrix} 190 \\ 190 \\ 190 \\ 190 \\ 190 \\ 190 \\ 190 \\ 190 \\ 190 \\ 190 \\ 190 \\ 190 \\ 190 \\ 190 \\ 190 \\ 190 \\ 190 \\ 190 \\ 202 \\ 202 \\ 202 \\ 202 \\ 202 \\ 202 \\ 797 \\ 797 \\ 797 \\ 797 \\ 797 \\ 797 \\ 797 \\ 797 \\ 797 \\ 797 \\ 797 \\ 797 \\ 797 \\ 797 \\ 797 \\ 797 \\ 797 \\ 797 \\ 730 \\ 730 \\ 730 \\ 730 \end{vmatrix} \qquad \textbf{E[CFM]} = \begin{vmatrix} 0.31988 \\ 0.52337 \\ 0.45137 \\ 0.41971 \\ 0.45874 \\ 0.36814 \\ 0.36382 \\ 0.45466 \\ 0.39415 \\ 0.44351 \\ 0.34098 \\ 0.39398 \\ 0.37992 \\ 0.45949 \\ 0.39120 \\ 0.39408 \\ 0.47158 \\ 0.39924 \\ 0.52831 \\ 0.38851 \\ 0.48169 \\ 0.28743 \\ 0.38561 \\ 0.34844 \\ 0.11170 \\ 0.09454 \\ 0.10422 \\ 0.11167 \\ 0.11645 \\ 0.13016 \\ 0.11635 \\ 0.10512 \\ 0.12014 \\ 0.11460 \\ 0.08697 \\ 0.09222 \\ 0.09703 \\ 0.07509 \\ 0.14348 \\ 0.08599 \\ 0.09744 \\ 0.10606 \\ 0.14404 \\ 0.12568 \\ 0.13202 \\ 0.14991 \end{vmatrix}$$

M.4.1.3.4 **M.4.1.3.5**

We thus get as a result for $\boldsymbol{\beta}$ the vector:

$$\boldsymbol{\beta} = \begin{vmatrix} 0.5076296 \\ -0.0005043 \end{vmatrix}$$

M.4.1.3.6

With this **β** vector we rewrite equation E.4.13.7 as

$$\hat{E}[CFM] = 0.5076296 - 0.0005043 * X1 \qquad \textbf{(E.4.1.3.7)}$$

The calculation of the standard error of our estimate proceeds as before and yields a value of 0.0449943

We finally test these results using t-statistics test for significance of regressors with $\alpha = 0.05$ which determine the t-critical value of 1.669. The results of this test are presented in table 4.1.3.3 showing that both regressors are significant estimating in Ê[CFM].

Test for Significance of Regressors		α = 0.05	t-critical =	1.669	
Associated Variable	**Regressor**	**Value**	**Standard Error**	**t-observed**	**Regressor Significance**
Eq. Constant	β0	0.5076296	1.2558E-02	40.4	yes
Distance	β1	-0.0005043	2.2398E-05	-22.5	yes

Table 4.1.3.3 / t-statistics. Significance of Regressors.

As we can see from the value of β1, while people arrive earlier for longer flights, they do not arrive so much earlier that the rule " double flight length mean arrive twice as early" is accurate.

4.2 Air Time, Complete Statistic.

We present in this section a summary of the available[1] results for the complete Air Time metric obtained in chapter 3. We begin by summarize this results in table 4.2.1, where the not shaded part of the table has the values of the different components of the Air Time whereas the shaded part has the E[Air Time] value and the other quantities of interest derived from the metric.

Route # Flight # Haul (Miles) Date (year 2002) Day	2 315 190 Dec. 17th Non-Busy	2 315 190 Dec. 19th Busy	22 595 797 Dec. 17th Non-Busy	22 595 797 Dec. 19th Busy
E[CF] (min.)	79.75	72.18	83.78	77.66
AP (min.)	45	55	115	125
D (min.)	10	0	0	0
AFT (min.)	27	35	100	100
E[Air Time] (min.)	134.75	127.18	198.78	202.66
GF	0.6660	0.5676	0.4215	0.3832
PF	0.3340	0.4324	0.5785	0.6168
RFT	0.2004	0.2752	0.5031	0.4934
ATM (min./Mile)	0.7092	0.6694	0.2494	0.2543

Table 4.2.1 / Summary of results from chapter 3 / Air Time complete statistic.

We also present here the same kind of analysis as in section 4.1.1 by setting fixed two variables while allowing the third to vary. Given that all the four flights for which we could calculate the complete metric operate on high frequency routes, this analysis is only done for the haul and day variables.

[1] The airline only provided enough information for the complete calculation of the Air Time on four different flights all of them operating in high frequency routes.

We first present in table 4.2.2 the results of setting fixed the haul and the frequency. Part A of the table compares the results for high frequency, short haul flights operated on both the busy and non-buy days whereas part B does the same but for the long haul case.

Route # **Flight #** **Haul** (Miles) **Date** (year 2002) **Day**	**2** **315** **190** **Dec. 17th** **Non-Busy**	**2** **315** **190** **Dec. 19th** **Busy**	**Difference** **Non-Busy -** **Busy Day** (minutes)	**% of** **Change** **with respect** **to** **Busy day**
E[CF] (min.)	79.75	72.18	7.56	10.47%
AP (min.)	45	55	-10	-18.18%
D (min.)	10	0		
AFT (min.)	27	35	-8	-22.86%
E[Air Time] (min.)	134.75	127.18	7.56	5.94%
GF	0.6660	0.5676		
PF	0.3340	0.4324		
RFT	0.2004	0.2752		
ATM (min./Mile)	0.7092	0.6694	Part A	

Route # **Flight #** **Haul** (Miles) **Date** (year 2002) **Day**	**22** **595** **797** **Dec. 17th** **Non-Busy**	**22** **595** **797** **Dec. 19th** **Busy**	**Difference** **Non-Busy -** **Busy Day** (minutes)	**% of** **Change** **with respect** **to** **Busy day**
E[CF] (min.)	83.78	77.66	6.12	7.88%
AP (min.)	115	125	-10	-8.00%
D (min.)	0	0		
AFT (min.)	100	100	0	0.00%
E[Air Time] (min.)	198.78	202.66	-3.88	-1.91%
GF	0.4215	0.3832		
PF	0.5785	0.6168		
RFT	0.5031	0.4934		
ATM (min./Mile)	0.2494	0.2543	Part B	

Table 4.2.2 / One dimension comparison of results – haul and frequency fixed.

We conclude this section and the chapter with table 4.2.3 which makes a similar analysis as before but now allowing varying the haul of the flight. Notice that with the available data, it has no meaning comparing, for example, the AFT of the flights.

Route # **Flight #** **Haul** (Miles) **Date** (year 2002) **Day**	**2** **315** **190** **Dec. 17th** **Non-Busy**	**22** **595** **797** **Dec. 17th** **Non-Busy**	**Difference** **Non-Busy -** **Busy Day** (minutes)	**% of** **Change** **with respect** **to** **Busy day**
E[CF] (min.)	79.75	83.78	4.04	4.82%
E[Air Time] (min.)	134.75	198.78		
GF	0.6660	0.4215		
PF	0.3340	0.5785		
RFT	0.2004	0.5031		
ATM (min./Mile)	0.7092	0.2494	Part A	

Route # **Flight #** **Haul** (Miles) **Date** (year 2002) **Day**	**2** **315** **190** **Dec. 19th** **Busy**	**22** **595** **797** **Dec. 19th** **Busy**	**Difference** **Non-Busy -** **Busy Day** (minutes)	**% of** **Change** **with respect** **to** **Busy day**
E[CF] (min.)	72.18	77.66	5.48	7.05%
E[Air Time] (min.)	127.18	202.66		
GF	0.5676	0.3832		
PF	0.4324	0.6168		
RFT	0.2752	0.4934		
ATM (min./Mile)	0.6694	0.2543	Part B	

Table 4.2.3 / One dimension comparison of results – day and frequency fixed.

5 Air Time, Current Limitations.

The Air Time metric, as it stands now, is missing two very important components of the travel process. These components are (1) the *queuing time required to get to the check-in counter* and (2) the *luggage retrieval time at the destination airport.*

In our study we did not use these two components because we were unable to get statistics of them from the airline. Nevertheless, it appears that statistics about these components could be obtained and their introduction to the Air Time metric would extend the scope of this metric from the time in which a passenger arrives to the departure airport till the time the passenger leaves the destination airport with his luggage, thus making the Air Time an even more comprehensive metric.

The introduction of these two components would be both, interesting and useful. It would be of interest because it would extend the scope of the Air Time to contemplate the entire journey of a traveler. By having a bigger picture of the travel process we would achieve a better understanding of it. This in turn would lead to better comparisons among routes and airlines and would give better information to the public on airline performance.

It would be useful because it could probably help to clarify, for instance, why on average, on the non-busy days or days for which the load factor is small the mean CF time of a flight turns out to be larger than on busy days where the load factor is high. One possibility , as mentioned earlier, is that all passengers arrive at the airport with the same time ahead of the SDT but passengers traveling on the busy day find a longer queue to get to the counters. This longer queue implies more time to get service which results in service received closer to the SDT of the flight thus showing a smaller CF time. This question, however, could be better understood if we had information about the queue which at present time is unavailable to us.

The Air Time as considered in this study, only focused on passengers checking at the airline's counter. However, the use of the metric should be extended to include all kinds of passengers like, for example, those checking in computerized kiosk, where the Air Time of a passenger should be significantly smaller when compared to someone who checks at the counter.

Also, additional components should be introduced in the Air Time metric to reflect the connecting flight process. This new component should reflect the time passengers require to go from one flight to another and the consequences of missing the connecting flight which in a good number of cases could result in an increment of the Air Time of several hours.

The Air Time is meant to be a comprehensive metric of the travel process with the capacity of comparing across different airlines and routes as well as in different times. Therefore, it should include in its calculation all the different parts of the travel process and all the different kind of traveler in order to produce real and valuable information.

6 Conclusions.

Through out our study, we have seen the meaning of the Air Time metric and how to calculate its different components. What each of these components represents and how they are affected by the different variables involved in a flight like the haul of a flight or the frequency of the flight. At this point, we would like to point to the main results of the study.

First, as we saw in chapter two and three, the Air Time is a very easy to calculate metric and it is made of three basic components which are the counter to flight time (CF), the airplane time (AP) and the flight's departure delay D. These three components considered in the study encompass the time spend by a traveler from the moment he arrives at the airline's counter till the moment he leaves the airplane at the destination airport.

Second, the Air Time metric, along with its different components, not only allows us to make comparisons across different airlines, routes or the performance of airlines in different times but also allows us to compare between the different components of the travel process to identify how each one of them is affected by particular events (e.g. Sep. 11th.).

Third, the Air Time captures the perception passengers have of the travel process, particularly the time required to go through the different stages of the process at the departing airport (e.g., check-in, security, etc). Therefore, the information provided by the Air Time could be an additional tool for airlines and airports to better plan their operations

Fourth, our research showed that it possible, with a high degree of exactitude, to predict the mean CF time of a flight based on the frequency, haul, load factor and day of operation of the flight. We saw that we can model the mean CF time of a flight by a linear equation with four variables and we also saw how each one of them affect the mean CF time of the flight.

We conclude this section and our research with the recommendation of implementing the use of the Air Time metric in the airline industry as a more comprehensive metric of airline performance and airline service. Air Time has shown to be a comprehensive measure of airline performance and the passenger's travel experience. It measures the quality of airline service much better than some other metrics currently in use like the on-time records which only look at whether the flight was on schedule or not. Better metrics help to obtain better results and it is time to move on as on how we measure the quality of the service given by airlines.

Finally we would like to thank the airline which gave us information required to do this research and to all the people in that airline who made this research possible by giving us data and valuable ideas and comments.