# 4 CHAPTER FOUR: DATA COLLECTION AND ANALYSIS

## 4.1 Introduction

This chapter is a compilation of all data that was used in developing the cost model. The default values that have been compiled from references are elaborated upon, in the first part. The second part of the chapter deals with the translation of the data, into a format that can be applied to the present study.

## 4.2 Model default values

This information entails the background and discussion on which the specific values have been chosen.

### 4.2.1 Depreciation period

The depreciation period is the time within which an airline is charged for the expense of the flight equipment losing its value over time. The time that will be used in this study depends on the economic life of the aircraft and ever-changing technology, which may deem the aircraft obsolescent.

With this in mind, Doganis (1989) quotes that airlines have adopted a depreciation period of between 14-16 years for large wide-bodied jets and 8-10 years for smaller short-haul aircraft. For this study, average periods of 15 years and 9 years are used for the wide-bodied and small-bodied aircraft respectively.

### 4.2.2 Residual value

The residual value is a final worth of the total cost, of the aircraft at the end of its useful life; it is expressed as a percentage of the total cost.

The value quoted by Doganis (1989) as assumed by most airlines is 10 percent. This will be the residual value used in this study.

### 4.2.3 Interest rate

World Bank (2002), in the development indicator, especially for African countries, indicates that the interest rate, at which money is lent to governments, is 8%. This value used cuts across African countries with varying economic conditions i.e. foreign exchange rates, inflation, etc.

### 4.2.4 Annual insurance rate

The insurance premium paid out for each aircraft is calculated as a percentage of the full replacement price. This of course depends on the number of factors, which may include the number of aircraft, security and risk factors involved, geographical location, etc.

Doganis (1989) quotes that the value may range between 1,5-3 percent. As a measure to cut across African countries varying economic and security conditions, the annual insurance rate has been selected as 3 percent.

### 4.2.5 Lost time

There is a lot of time which the aircraft loses that is included in the block time, which is defined as the time from engine on to engine off. This time depends on factors like the traffic at origin and destination airports, weather conditions, mechanical state of the aircraft, size of the aircraft, security reasons, etc. The components of lost time are elaborated on below.

**Ground manoeuvre time**

This is defined as the sum of the time from when the engine is started up to take-off time at departure and the time taken from landing to the time the engine is switched off at arrival. This time depends on the length of the apron, taxiway and runway and the air traffic at the given origin and destination, airports.

Doganis (1989) and the Air Transport Association (1963) both state that unless it's a weather problem, the ground manoeuvre time does not exceed 30 minutes even for busy international airports and ranges between 20 - 30 minutes.

The African continent has a few busy airports e.g. Johannesburg International, Jomo Kenyatta International, Cairo International, etc, with average headways of even less 10 minutes per landing. For the purpose of this study, the average time for ground manoeuvre is taken to be 20 minutes.

**Air manoeuvre time**

The air manoeuvre time is defined as the time the aircraft takes to climbs to its cruise altitude at take-off and the time it takes to get to the ground from the flying altitude at landing. This take-off component is included within the block time and is the time the aircraft burns most fuel and travels at relatively lower speeds. On short sectors, most of the flight time is covered either in climb or descent time but as the sector distance increases more time is spent at the cruising speed.

Kane (1996) shows that the ATA quotes the average air manoeuvre time, regardless of sector length to be about 6 minutes. This value will be used in the model.

**Servicing time**

When the engine of an aircraft are switched off, and the passengers depart from the aircraft, the aircraft has to undergo a number of activities that can be carried out simultaneously. The activities include servicing of the engines, Check A which involves detecting abnormalities with the system, leakages, refueling if necessary especially for long journeys, cleaning, restocking of foods and beverages, passenger loading, etc.
Kulula Airlines is a low-cost, short haul, domestic air carrier in South Africa that minimises costs by utilising an aircraft with minimal fleet and maximum frequency for any given route. The route schedule for the Johannesburg to Cape Town route for the 25$^{th}$ April 2003 is shown in Table 15. It will be used to show the "servicing" times derived. (Kulula Airlines, 2003)

**Table 15: Flight schedule for JBG- CPT route for Kulula.com**

| Flights from Jo'burg to Cape Town | Departure time | Arrival time |
|---|---|---|
| 25 Apr 2003 | 0630 | 0840 |
| 25 Apr 2003 | 0925 | 1130 |
| 25 Apr 2003 | 1100 | 1305 |
| 25 Apr 2003 | 1220 | 1425 |
| 25 Apr 2003 | 1515 | 1720 |
| 25 Apr 2003 | 1810 | 2015 |
| **Flights from Cape Town to Jo'burg** | **Depart** | **Arrive** |
| 25 Apr 2003 | 0630 | 0825 |
| 25 Apr 2003 | 0925 | 1120 |
| 25 Apr 2003 | 1220 | 1415 |
| 25 Apr 2003 | 1400 | 1555 |
| 25 Apr 2003 | 1515 | 1710 |
| 25 Apr 2003 | 1810 | 2005 |

Source: Kulula airlines (2003)

Table 16 shows the servicing times derived from Table 15.

**Table 16: Aircraft servicing time.**

| | Departs | Arrives | Depart | Arrives | Departs | Arrives | Departs | Arrives | Departs | Arrives |
|---|---|---|---|---|---|---|---|---|---|---|
| | JHB | CPT | CPT | JHB | JHB | CPT | CPT | JHB | JHB | CPT |
| Aircraft 1 | 0630 | 0840 | 0925 | 1130 | 1220 | 1425 | 1515 | 1720 | 1810 | 2015 |
| Servicing time (min) | | 45 | | 60 | | 50 | | 60 | | |
| | CPT | JHB | JHB | CPT | CPT | JHB | JHB | CPT | CPT | JHB |
| Aircraft 2 | 0630 | 0825 | 0925 | 1120 | 1220 | 1415 | 1515 | 1720 | 1810 | 2005 |
| Servicing time (min) | | 60 | | 50 | | 60 | | 50 | | |
| | | | JHB | CPT | CPT | JHB | | | | |
| Aircraft 3 | | | 1100 | 13.05 | 1400 | 1555 | | | | |
| Servicing time (min) | | | | 55 | | | | | | |

From Table 16, the average servicing and refueling time is calculated for all the aircraft to give a default value of 54 minutes. This time will also be assumed for larger aircraft, for which more manpower will be used.

### 4.2.6 Usable operating hours

Stratford (1973) suggests that, for any given aircraft to be utilized efficiently in a bid to spread out operating costs over its useful life, it will be in use for a maximum of 14 hours in any operating day, whether daytime or nighttime. This means that the frequency, over which an aircraft should be used, will depend on the flight time and will be dictated by the usable hours in a day. In a year, the aircraft will be assumed to be in use for 52 weeks.

### 4.2.7 Fuel and oil

Emery (2002), gives the average cost of fuel prices for the African situation for 2002 prices in Table 5. Therefore the default price value of fuel of US$ 0,895/US gal will be used for the model. Turbo jet technologies (2002), gives the cost of oil as US$ 0,233/ US gal. The fuel to oil ratio that will be used is 20:1 adopted from the Turbine design website.

### 4.2.8 Passenger demand within Africa

On the African Airline Association (AFRAA) web site, the 1999 Annual Report gives a summary of the air traffic movements and growth rates for Africa. The report states that system wide in 1999 airlines carried 29,6 million passengers representing a 3% growth over 1998.

Of these, 11,4 million passengers were flying within the domestic market, 4,3 million and 13,9 million passengers were flying within Africa and on international markets respectively.

Table 17 shows the number and percentage of passengers carried in the various markets between 1994 and 1999. The number of passengers moving within the Africa region, as a percentage of passenger demand is 15%. This average value may not be representative because it could include the passengers who flew within Africa via Europe, but will be taken as 15 % for the purposes of this study.

**Table 17: African air travel passenger percentages**

| Year | Domestic (Millions) | Domestic (%) | Within Africa (Millions) | Within Africa (%) | International (Millions) | International (%) |
|---|---|---|---|---|---|---|
| 1994 | 10,8 | 43 | 3,1 | 12 | 11,5 | 45 |
| 1995 | 11,6 | 44 | 3,0 | 11 | 12,0 | 45 |
| 1996 | 12,4 | 44 | 3,5 | 13 | 12,3 | 43 |
| 1997 | 12,1 | 42 | 3,6 | 13 | 13,0 | 45 |
| 1998 | 11,5 | 46 | 4,1 | 14 | 13,1 | 40 |
| 1999 | 11,4 | 39 | 4,3 | 15 | 13,9 | 46 |

Source: AFRAA annual report 2000

### 4.2.9 Summary

Table 18 gives a summary of the default values that will be used in the model, specified for different aircraft types, giving references for their sources:

**Table 18: Default values used in the model**

| ITEM | DEFAULT VALUES | REFERENCE |
|---|---|---|
| Depreciation period (years) | 9 | Doganis (1989) |
| Residual value (%) | 10 | Doganis (1989) |
| Interest rate (%) | 8 | World Bank (2002) |
| Annual insurance rate (%) | 3 | Doganis (1989) |
| Ground manoeuvre time (hrs) | 0,25 | ATA (1963) |
| Air manoeuvre time (hrs) | 0,10 | Kane (1996) |
| Service and refueling time (hours) | 0,90 | Kulula airlines (2003) |
| Usable hours in a day | 14 | Stratford (1973) |
| Operating weeks in a year | 52 | Stratford (1973) |
| Cost of fuel (US$/US gal) | 0,895 | Emery (2002) |
| Cost of oil (US$/quart) | 0,233 | Turbo jet technologies (2002) |
| Average international air passengers moving within Africa region (%) | 15 | AFRAA (2000) |

## 4.3 Aircraft types

Aircraft types to be compared need to be applicable to the present aviation industry. Data relevant to the African industry was collected and the most common aircraft types were chosen. The aircraft to be considered will include short, medium and long haul aircraft, which fly all routes within Africa.

A report "Who Operates What" by Air Claims Limited, UK in the African Aviation magazine (June 2000) contained data on Africa's major airlines and their fleets. The 40 most common aircraft types were chosen and then narrowed down to the 11 aircraft modes from "in-flight" magazines from airlines that fly over wide regions within Africa. These airlines include South African Airlines (2002), Kenya Airways (2003) and British Airways (2002).

### 4.3.1 Aircraft specifications

In order to calculate the cost of running the chosen aircraft, technical specifications were collected. The detailed specifications for each of the aircraft chosen are shown below, with their sources:

- Cruising speed, (Jackson 1997)
- Passenger Capacity, (Jackson 1997)
- Engine type, Number, Thrust, (Turbine design Inc.2003, Rolls Royce 2003)
- Max fuel Capacity, (Jackson 1997)
- Crew Number, (Jackson 1997)
- The Maximum Take-off Gross weight (ToGWmax), (Jackson 1997)
- Maximum range, (Jackson 1997)

### 4.3.2 Engine Specifications

Jenkinson et al (2001) gives aircraft data for different aircraft types and engines. This data will be used to calculate the amount of fuel and oil consumption for each engine type during climbing, descent and cruising. Table 19 gives engine data for different jet aircraft.

**Table 19: Aircraft engine data**

| Aircraft Type | Fokker F28 | Boeing 737-200 | Boeing 737-300 | Airbus A320 | Airbus A340-200 | Boeing 747-200 | Boeing 757 | Boeing 747-400 | |
|---|---|---|---|---|---|---|---|---|---|
| **Engine type** | **RB 183 555** | **JT15D** | **CFM 56 -3C1** | **V2500-A1** | **CFM56 -5C2** | **RB211 -524H** | **RB211-535E4** | **CF6 80 C2-B2** | **Average % Change** |
| Thrust | 9 900 | 16 000 | 23 500 | 25 000 | 31 200 | 60 600 | 43 100 | 52 500 | |
| Climb Thrust | | 3 045 | | 5 070 | | 11 813 | 9 110 | 12 650 | |
| % Change max'm to climb | | 19,0% | | 20,3% | | 19,5% | 21,1% | 24,1% | 21% |
| Cruise thrust | 3 730 | 2 414 | 5 540 | 5 620 | 7 580 | 12 726 | 8 495 | 12 000 | |
| % Change max to cruise | 37,7% | 15,1% | 23,6% | 22,5% | 24,3% | 21,0% | 19.7% | 22,9% | 22% |
| **SFC (Ib/hr/Ib)** | | | | | | | | | |
| Engine SFC (Ib/hr/Ib) | 0,56 | 0,56 | 0,33 | 0,35 | 0,32 | 0,563 | 0,607 | 0,32 | |
| Cruise SFC (Ib/hr/Ib) | 0,8 | 0,541 | 0,667 | 0,581 | 0,545 | 0,57 | 0,598 | 0,576 | |
| % Change from engine to cruise | 142,9% | 96,6% | 202,1% | 166,0% | 170,3% | 101,2% | 98,5% | 180,0% | 150% |

From the data averages, an aircraft climbs with thrust on average of about 21% of the maximum engine thrust with the engine SFC. At cruising, the thrust reduces from the maximum thrust by about 22% but the cruising SFC increases to 150% of the engine SFC.

The reason why SFC is lower at take off than at cruising was suggested in an aviation website (Airliners.net (2003)) that "the lower SFC at Take Off thrust is due to higher thermal efficiency as the engine is running hotter, but it can't be maintained at this condition continuously while the cruise thrust can".

For the model, fuel consumption during air maneuver and cruising will be separated and different calculations using equation 2-16 with thrust and SFC dependant on whether the aircraft is cruising or during air manoeuvre, before descent. Air manoeuvre time is assumed 15 minutes to include both climbing and descending from cruising irrespective of the politics surrounding the altitude that an aircraft will fly and degrees of freedom.

## 4.4 Capital costs

Pyramid Media Group is an online air guide website with information on the aviation industry. It gives the average aircraft prices for the most common aircraft from 1997-2001. Table 20 shows the aircraft prices that are relevant to this study. Even though a projection could be done of 2003, since the prices seem to be increasing by 2%, unaccountable factors like increased security specifications of aircraft since 9/11 could have changed this rate, therefore year 2000 prices will be used in the study. For the values of the year 2000 that were missing, the last representative price was used instead.

**Table 20: Capital costs for aircraft types**

| Capital (US$ mil) | Embraer Erj135-Jet | Fokker F 50 | Boeing 737-200 | Boeing 737-400 | Airbus A320-200 | Airbus A340 200 | Boeing 737-800 | Boeing 767-200 | Boeing 747-200 | Boeing 767-300ER | Boeing 747-400 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1996 | - | - | 41 | 45 | - | - | 51 | 82.5 | - | - | 165 |
| 1997 | - | - | 41,5 | 45 | - | 99 | 51,5 | 82 | - | - | 168 |
| 1998 | - | - | - | 46,5 | - | 106 | 54 | - | - | - | 176 |
| 1999 | - | - | - | 47,25 | - | 113 | 55,25 | - | - | - | 180 |
| 2000 | 19 | 29 | - | 48 | 51 | 121 | 56,5 | - | - | - | 185 |

Source: Pyramid Media Group Website (2003)

## 4.5 Airport handling fees

The airport charges which include the passenger service fee, landing fee and airport fee used in this study are those applied by the Airports Company South Africa (ACSA), stemming from the fact that it is the only available data.

These may not be applicable to most African countries since South Africa has one of the busiest African airports, Johannesburg International airport. The data was originally stated in the Airports Company Act 1993 (Act No. 44 of 1993) it was later amended and can be found in the Airports Company Amendment Act 1998, (Act No. 2 of 1998). The rates in the Act were in South African Rand, but for this study they have been changed to US$ using the rate for May 2003 at ≈ 8 Rand to the US dollar.

### 4.5.1 Passenger service fee

The passenger service fee according to this act is charged per embarking passenger. Table 21 is an excerpt from Annexure C of the Airports Company Amendment Act (2 of 1998), that provides tariffs, and fees that can be applied.

The value that was adopted for the study is that for passengers disembarking from the aircraft at an airport outside South Africa, Botswana Lesotho, Namibia or Swaziland. This value is therefore assumed to be US$ 6 per passenger in Africa, an average of the cost of passenger handling assuming that deregulation within the African continent will stipulate lower costs for passengers flying from one African country to another.

**Table 21: Passenger service fees**

| Specifications | VAT Exclusive | Inclusive | |
|---|---|---|---|
| | R | R | US$ |
| Passenger service charge per embarking passenger where such passengers will disembark from the aircraft at an airport within the Republic of South Africa | 19,30 | 22,00 | 2,75 |
| Passenger service charge per embarking passenger where such passengers will disembark from the aircraft at an airport within Botswana, Lesotho, Namibia or Swaziland | 40,35 | 46,00 | 5,75 |
| Passenger service charge per embarking passenger where such passengers will disembark from the aircraft at an airport within any state or territory other than those mentioned in paragraphs 1 and 2 | **59,65** | **68,00** | **8,50** |

Source: Airports Company Act, 1998 (Act No. 2 of 1998)

### 4.5.2 Landing fees

The landing and parking fees according to this act are based on the Maximum Take Off Weight (MToW) of the aircraft concerned. Table 22 shows an excerpt of Annexure A of the Act, weight specific charges for "landing charges in respect of an aircraft which lands at an ACSA airport and which has been engaged in a flight where the airport of departure of the aircraft was not "within South Africa, Botswana, Lesotho, Namibia or Swaziland". These charges are applied to determine the landing charges for each aircraft considered in the model.

**Table 22: Weight specific landing fees**

| MTOW (kg) of the aircraft (Up to and including) | Per single landing | | |
|---|---|---|---|
| | VAT Exclusive | Inclusive | Total |
| | R | R | US$ |
| 5 000 | 23,68 | 27 | 3,38 |
| 10 000 | 38 | 43,32 | 5,42 |
| 15 000 | 57,18 | 65,18 | 8,15 |
| 20 000 | 74,42 | 84,84 | 10,61 |
| 25 000 | 92,03 | 104,91 | 13,11 |
| 30 000 | 110,12 | 125,54 | 15,69 |
| 40 000 | 148,6 | 169,41 | 21,18 |
| 50 000 | 186,11 | 212,17 | 26,52 |
| 60 000 | 223,27 | 254,53 | 31,82 |
| 70 000 | 261,03 | 297,57 | 37,20 |
| 80 000 | 298,05 | 339,78 | 42,47 |
| 90 000 | 335,94 | 382,97 | 47,87 |
| 100 000 | 373,94 | 426,29 | 53,29 |
| And thereafter, for every additional 2 000kg | 65,43 | 74,59 | 9,32 |

Source: Airports Company Act, 1998 (Act No. 2 of 1998)

### 4.5.3 Parking charges

The parking charges in the Act are also weight specific and are incurred after an initial free four-hour period while charges are allocated per 24-hour period. Table 23 is an excerpt from Annexure B of the Airports Amendment Act giving the specified charges per weight.

**Table 23: Weight specific parking fees**

| MTOW (kg) of the aircraft (Up to and including) | Per 24 hr period | | |
|---|---|---|---|
| | VAT | | |
| | Exclusive | Inclusive | |
| | R | R | US$ |
| 2 000 | 13,23 | 15,08 | 1,89 |
| 3 000 | 27,2 | 31,01 | 3,88 |
| 4 000 | 38,73 | 44,15 | 5,52 |
| 5 000 | 53,18 | 60,63 | 7,58 |
| 10 000 | 78,3 | 89,26 | 11,16 |
| 15 000 | 102,96 | 117,37 | 14,67 |
| 20 000 | 129,79 | 147,96 | 18,50 |
| 25 000 | 154,92 | 176,61 | 22.13 |
| 50 000 | 204,94 | 233,63 | 29,20 |
| 75 000 | 255,08 | 290,79 | 36,35 |
| 100 000 | 305,83 | 348,65 | 43,58 |
| 150 000 | 384,74 | 438,60 | 54,83 |
| 200 000 | 464,27 | 529,27 | 66,16 |
| 300 000 | 530,8 | 605,11 | 75,64 |
| 400 000 | 668,55 | 762,15 | 95,27 |
| And thereafter, for every additional | 102,96 | 117,37 | 14,67 |

Source: Airports Company Act, 1998 (Act No. 2 of 1998)

## 4.6 Summary

The data that has been collected and analysed, in a form that will be applicable to the cost model being developed is summarised in Table 24.

**Table 24: Data summary for aircraft types**

| AIRCRAFT CHARACTERISTICS | Embraer Erj 135-JET | Fokker F 50 | Boeing 737-200 | Boeing 737-400 | Airbus A320-200 | Airbus A340 200 | Boeing 737-800 | Boeing 767-200 | Boeing 747-200 | Boeing 767-300ER | Boeing 747-400 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Cruising Speed (Kph) | 833 | 448 | 760 | 815 | 833 | 861 | 810 | 850 | 895 | 897 | 914 |
| Passenger Capacity | 37 | 56 | 130 | 168 | 180 | 295 | 189 | 255 | 291 | 290 | 401 |
| ToGWmax (Kg) | 21 100 | 19 950 | 52 437 | 68 040 | 73 500 | 27 500 | 78 240 | 136 985 | 374 850 | 181 890 | 390 100 |
| Max fuel Capacity (US gal) | 5 187 | 1 357 | 5 163 | 5 701 | 6 300 | 3 6984 | 6 878 | 16 700 | 53 858 | 24 140 | 48 445 |
| Engine type | AE3007 | PW125B | JT8D-15A | CFM 56-3B-2 | CFM56-5A3 | CFM56-5C2 | CFM56-7B24 | CF6-80A | RB211-524D4 | CF6-80C2B6F | PW 4056 |
| Engine maximum thrust (Ibf) | 7 400 | 5 000 | 16 000 | 22 000 | 25 000 | 31 200 | 24 000 | 48 000 | 53 000 | 61 500 | 47 000 |
| Engine SFC (Ib/hr/Ibf) | 0,39 | 0,391 | 0,585 | 0,38 | 0,33 | 0,32 | 0,36 | 0,35 | 0,37 | 0,32 | 0,359 |
| Cruise SFC (Ib/hr/Ibf) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Maximum range (km) | 3 019 | 1 300 | 3 700 | 3 810 | 5 615 | 13 500 | 5 670 | 12 250 | 7 900 | 12 500 | 13 480 |
| Number of Engines | 2 | 2 | 2 | 2 | 2 | 4 | 2 | 2 | 4 | 2 | 4 |
| Crew Number | 5 | 5 | 6 | 7 | 7 | 8 | 7 | 7 | 8 | 8 | 8 |
| Capital Cost of aircraft (US$ million) | 19 | 29 | 42 | 48 | 51 | 121 | 57 | 87 | 150 | 197 | 185 |
| Change from engine thrust to climb thrust (%) | 21 | 21 | 21 | 21 | 21 | 21 | 21 | 21 | 21 | 21 | 21 |
| Change of engine thrust to cruise thrust (%) | 22 | 22 | 22 | 22 | 22 | 22 | 22 | 22 | 22 | 22 | 22 |
| Change from Engine SFC to Cruise SFC (%) | 150 | 150 | 150 | 150 | 150 | 150 | 150 | 150 | 150 | 150 | 150 |
| Fuel consumption during air manoeuvre (US gal/hr) | 180,91 | 122,55 | 586,75 | 524,06 | 517,16 | 1251,73 | 541,61 | 1 053,13 | 2 458,57 | 1 233,67 | 2 115,42 |
| Maximum cruise Fuel Consumption (US gal/hr) | 284,29 | 192,58 | 922,03 | 823,52 | 812,69 | 1 967,00 | 851,10 | 1 654,93 | 3 863,46 | 1 938,63 | 3 324,23 |
| Oil consumption climbing (US gal/hour) | 9,05 | 6,13 | 29,34 | 26,20 | 25,86 | 62,59 | 27,08 | 52,66 | 122,93 | 61,68 | 105,77 |
| Oil consumption cruising (US gal/hour) | 14,21 | 9,63 | 46,10 | 41,18 | 40,63 | 98,35 | 42,56 | 82,75 | 193,17 | 96,93 | 166,21 |
| Passenger service charge (US$) | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 |
| Landing Fees (US$ per single landing) | 13 | 11 | 296 | 352 | 399 | 1257 | 399 | 790 | 1853 | 1816 | 1881 |
| Parking Fees (US$ per 24 hour period) | 22 | 19 | 37 | 37 | 37 | 76 | 37 | 67 | 96 | 75 | 96 |