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Executive summary

A lot of research has been done to determine the size of airports. This includes the determination of airport capacity, runway capacity, check-in capacity and flight scheduling. Since the terminal buildings are the most expensive facilities, it can determine whether an airport is a financial feasible project or not. The main focus of this study will thus be on terminal buildings and their layout.

This document describes different methods to determine the size of passenger terminals, none of these have been tested for South African use. These methods will have to be tested and the student will have to determine which methods or techniques are better to use.

South Africa is hosting the soccer world cup in 2010. Virtual Buro is a subcontractor to get South African airports ready for this big event. They asked the student to analyse these methods and help get South African airports up to international standards.

This will be accomplished by looking at passenger flow, the layout of passenger terminal buildings, the different ways of determining capacity and Occupational Health and Safety regulations

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Abbreviations

BFN	Bloemfontein
CPT	Cape Town
DUR	Durban
ELS	East London
GRJ	George
HLA	Lanseria
JNB	Johannesburg
KIM	Kimberley
MQP	Kruger Mpumalanga International Airport (KMIA)
OHSA	Occupational Health and Safety Act
PLZ	Port Elizabeth

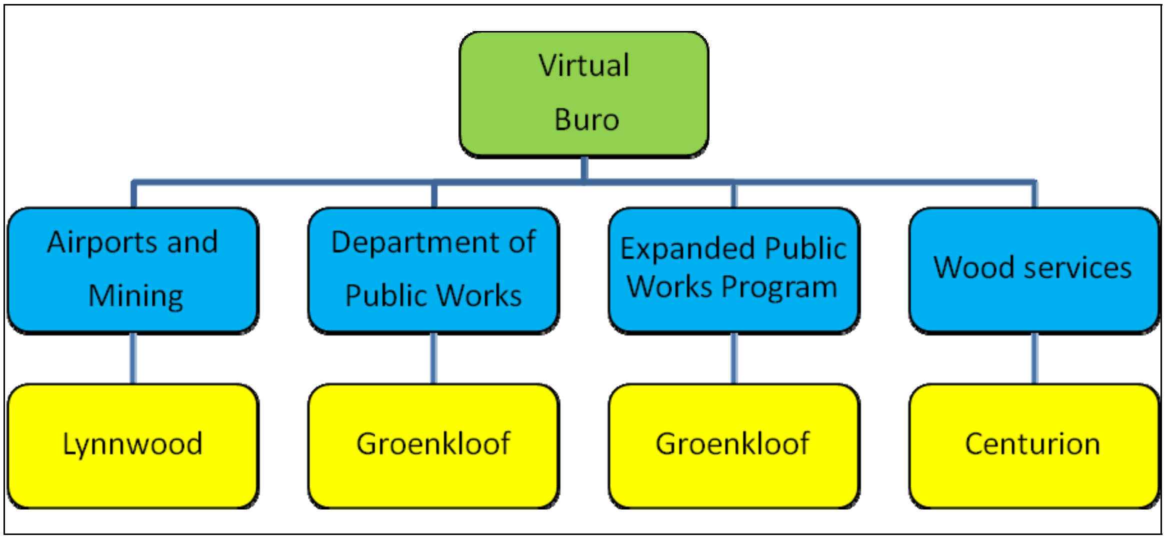
1. Introduction And Background

Virtual Buro is a diversified project consulting company. They have clients in the Airports and Aviation, Mining Municipal infrastructure and Public Works sectors. They provide these clients with the following:

- Regulatory support
- Feasibility and demand assessments
- Project management
- Master and facility planning
- Engineering design
- Procurement Management
- Maintenance and rehabilitation management
- Supervision of construction
- Environmental impact assessment.

Virtual Buro SA was established in 1999. They have expanded into three branches as seen in Figure 1 below and currently have sixty eight employees. This project will be done at the Lynnwood branch. This branch was opened on 1 May 2005. They grew from three employees to thirty six at this branch.

Figure 1: Organisational structure of Virtual Buro



2. Problem Definition

The problem has been identified by Virtual Buro as follows:

The development of a new airport entails the development of a number of facilities of which the passenger terminal building attracts the most attention and it is in most cases also the single most expensive facility. The terminal is expensive; it has a major impact on the overall cost of an airport and also has a major impact on the financial feasibility of an airport. The correct sizing of the terminal at the outset is therefore of utmost importance as a too small terminal will result in a low level of service to passengers and a too large terminal could make the development unfeasible.

Numerous methods are used in the calculation of terminal sizes but none have been tested in South Africa against completed terminal buildings.

Virtual Buro considers it essential that an assessment of South African terminal buildings is undertaken to assess how these terminals compare with accepted international standards.

3. Project Aim

The aim of this project is to establish a tested generic formula/method to determine the facility size of a general passenger terminal at an airport in South Africa based upon the number of passengers at the airport during peak hours. This formula/method will then be used to allocate a certain percentage of space (in square meters), of the total area, for the following:

- Bathrooms
- Offices
- Shops
- Domestic Arrival
- Domestic Departures
- International Arrivals
- International Departures
- Domestic Baggage Handling Area
- International Baggage Handling Area
- Other (include walkways, stairways and storage space)

This project also needs to incorporate Occupational Health and Safety Standards into the development of the formula/method.

The formula/method developed will be used by Virtual Buro to determine the size of a new airport, as well as to better utilise the space of existing airports effectively.

4. Project Scope

4.1 Aspects To Be Addressed

In airport capacity planning there are four distinct elements to consider:

1. Terminal buildings
2. Airspace
3. Airfield
4. Ground access

Only Terminal buildings will be included in the scope of this project.

The analysis and planning of the facility will be divided into two parts:

<u>Part 1</u>: National airports that will be included are East London and George.

<u>Part 2</u>: International airports that will be included are Lanseria, Durban and Kruger Mpumalanga International Airport.

In part one and part two the application of the Health and Safety Act will also be investigated.

4.2 Project Constraints

- The positioning of a new airport will not be included in the scope of this project.
- The analysis of airports will be done on actual floor plans of existing airports, provided to the student by Virtual Buro.
- The student was instructed not to consider the use of simulation software to solve the problem, as this is done by another final year project by Izac Ferreira.
- The scope will only include airport facilities and none of the other projects Virtual Buro is currently working on.

4.3 Terms Of Reference

The terms of reference given to the student are to test the numerous methods that are used to calculate terminal sizes. These methods are currently in use but have never been tested for determining terminal sizes in South Africa.

As the passenger building is the most expensive part it has a major impact on the financial feasibility of an airport.

The correct sizing of a terminal is therefore of the utmost importance as a too small terminal will result in a low level of service but a too large terminal could make the development unfeasible.

5. Deliverables

The specific deliverables of this project will be as follows:

- A method to determine the size of a passenger terminal at an airport in South Africa, as well as taking the Occupational Health and Safety Act into account.
- Guidelines for an ergonomically correct passenger terminal.

6. Collecting Information

6.1 Literature Study

Information gathering is an important aspect of any project. People see Industrial Engineers as experts in the field. To ensure that the work does not disappoint employers, engineers need to do research to make sure that they are fully aware of all possible methods and tools available to solve the problem at hand. Information gathering also insures that not too much time is spent on reinventing the wheel but rather on applying the appropriate tools correctly.

There are different methods available to gather information. The four main processes used are:

- Observation
- Discussing the problem with managers and other experts in the field
- The internet
- The library

6.2 Observation

Terminal buildings are the most expensive facility in the design of an airport. Determining the size of terminal buildings are very important, because a too small terminal will result in a low level of service but a too large terminal could make the development unfeasible. There are various international methods available to determine the size of these terminal buildings, but none of these methods have been tested for South African use.

South Africa will be hosting the soccer world cup in 2010. Virtual Buro has been sub-contracted to make sure that South African airports are ready. They say first impressions last and the first impression tourists will have of South Africa will be the inside of our terminal buildings. It is therefore essential that a thorough analysis of the methods as well as the current layout and capacity utilisation of South African airports are done to be able to compare them with acceptable international standards.

6.3 Discussion With Management

Currently the size of terminal buildings are determined by taking the amount of people (passengers as well as their families) in a peak hour and multiplying that with fifty two square meters per person for an international passenger terminal building and twenty square meters per person for a domestic passenger terminal building. These calculations are then used to determine the size that a terminal building should be. This method has been used for so long that nobody is quite sure why these multiplication factors is used or what is included in the space for example does this include bathrooms, offices and parking. The student has been asked to validate this formula or to formulate a better method.

To be able to achieve this, studies must be undertaken on:

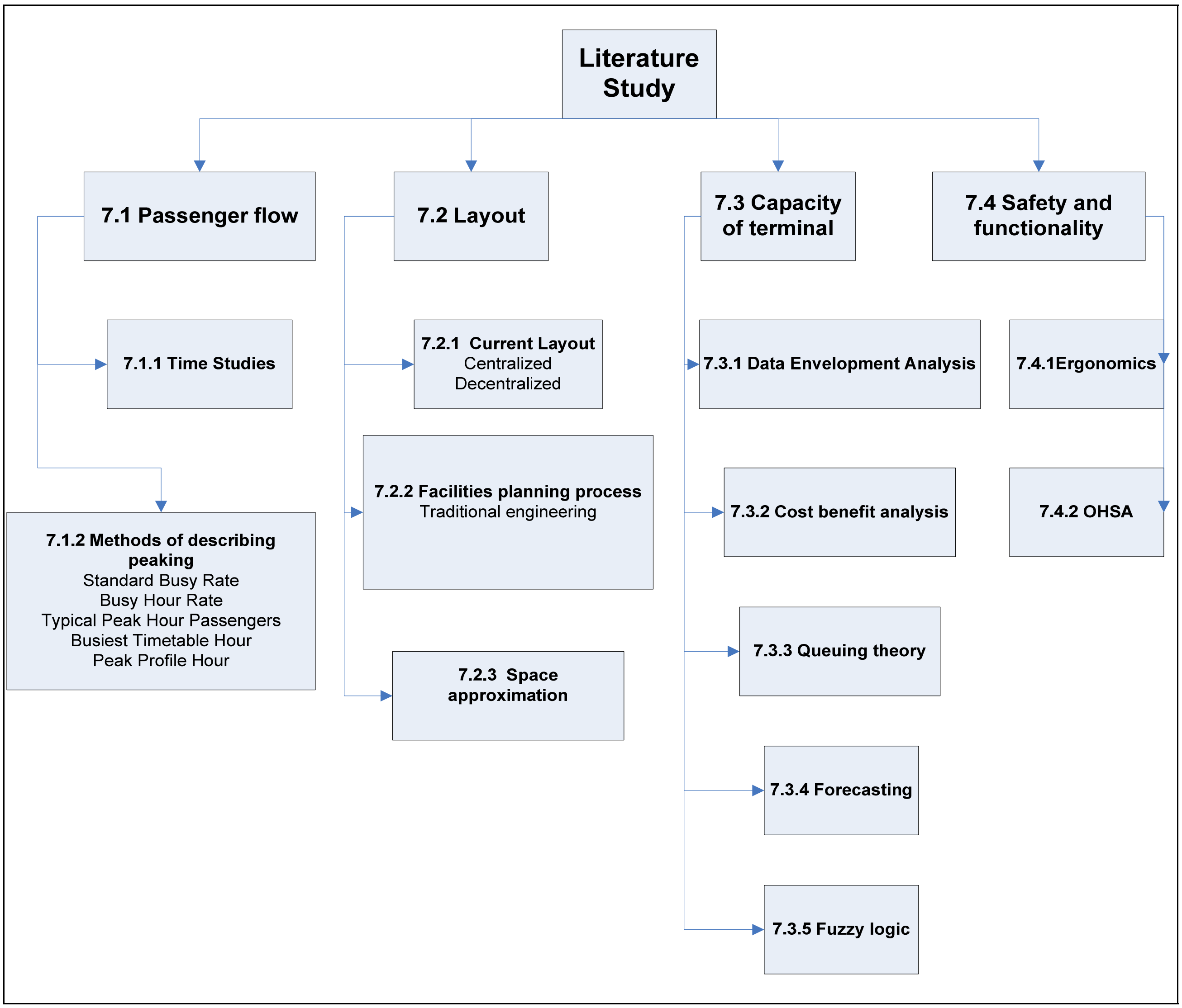
- Current layouts
- Passenger flow
- Methods available to determine the size of the terminal building
- Safety and functionality

7. Research On Techniques

To attain information on the above four approaches (par 6.3), an in depth literature study must be undertaken. This is to ensure that all relevant information is available.

The different elements completed in this literature study can be illustrated using the breakdown structure shown in Figure 2.

Figure 2: Structural breakdown of research



7.1. Passenger Flow

7.1.1 Time Studies

Time studies will be done to determine the peak hour of a day and the amount of people at the airport. This will have to be done continuously throughout the year because there are not only peak hours, but also seasonal peaks.

The variations in demand can be described according to Ashford Stanton & Moore (1995) in terms of:

- Annual variation over time
- Monthly peaks within a particular year
- Daily peaks within a particular month or week
- Hourly peaks within a particular day

Annual variation is the most important aspect to consider when capacity planning and facility layout is done.

The continuous method of time study will be used during each period because:

1. It presents a complete record of the entire observation period
2. It is easier to explain
3. It is better adapted to measuring and recording very short elements

<u>A disadvantage of this method:</u>

More clerical work is involved in calculating

7.1.2 Methods To Describe Peaking

According to Ashford, et al. (1995) the following designing methods are used:

Standard Busy Rate (SBR)

This method is a standard of design in the United Kingdom and elsewhere in Europe, most notably by former British Airports Authority. Standard Busy Rate is also known as the 30th Highest Hour and forms a critical part of the civil engineering practice. This design prevents that an airport terminal will exceed or operate at its full capacity for more than 30 hours per year. This method does not take actual observed annual peak volume into consideration.

Although in practice they use the relationship

Absolute peak hour volume = 1.2 x SBR

In terms of aircraft movements the ratio of the Standard Busy Rate to the absolute peak increases with the increasing annual volume. This is reflected in the fact that as the traffic of an airport develops; extreme peaks of flows tend to disappear.

Disadvantage

This method can lead to intense overcrowding a few hours per year when used for small airports.

Busy Hour Rate (BHR)

The Busy Hour Rate is a modified version of the Standard Busy Rate. This method is also known as the 5 Percent Busy Hour. It was developed to eliminate or at least reduce obstacles involved in using the Standard Busy Rate designing method, when the level of congestion was not similar between airports. The 5 Percent Busy Hour is the hourly rate above which 5 percent of the traffic at the airport is handled.

Steps to calculate the Busy Hour Rate:

- Rank the operational volume in order of magnitude
- Compute the cumulative sum to 5 percent of the annual volume.
- The next ranked volume is the Busy Hour Rate.

Disadvantage

A lot of data must be collected and analysed; this might be beyond the resources of a small airport.

Typical Peak Hour Passengers (TPHP)

This method is used by the Federal Aviation Administration (FAA). It is defined as the peak hour of the average peak day of the peak month. This design method is very similar to the Standard Busy Rate. As airports grow larger the peaks flatten and the troughs between peaks become less pronounced.

Busiest Timetable Hour (BTH)

This method is preferred by small airports with limited data bases. The Busiest Timetable Hour is calculated by using:

- Average load factors, and
- Existing or projected timetables

Disadvantage

Errors in forecasting have an enormous affect using this method.

Peak Profile Hour

This straightforward method is also known as the Average Daily Peak.

Steps to determine the Peak Profile Hour:

- Select the peak month.
- Compute across the month the average hourly volume for each hour.

This gives an average hourly volume for an "average peak day". The Peak Profile Hour is the largest hourly value in the average peak day.

This gives a very similar answer as the Standard Busy Rate design method.

All these methods give approximately the same results. The Busy Hour Rate (BHR) method will be used because it is effective for both small and large airports. South Africa has both National and International airports and a method that can be used for both were selected.

Dwell Time and Hot Spots

Amedeo R. Odoni and Richard de Naufville, from the Massachusetts Institute of Technology, believe that these methods determining peak hour traffic are outdated. They used the principles of dwell time and hot spots. They stated that people will not spend the same amount of time everywhere in the terminal and that they are more likely to gather in certain areas, for example around information booths or in shops.

They define dwell time as the amount of time people spend in a particular area. They explained the application of dwell time as follows, if flow of passengers through a lobby is relatively uniform over time, at a rate of 900 per hour and if their dwell time is 20 minutes or 1/3 of an hour. Then the number of people in the lobby at any time is 900 x 1/3 = 300. Space is thus needed for 300 people and not 900 people.

7.2 Layout

7.2.1 Current Layout

According to Ashford, et al. (1995), terminal layout can be divided into two broad and very different classes:

Centralised layout

Older airports were designed using this concept where processing was carried out in the main terminal building and access to the aircraft gates was attained by piers and satellites or by apron transporters.

Examples are Tampa and Brussels

Advantages of centralised layout:

- There are economies of scale on the use of fixed equipment.
- Similar economics are found with airport authority and other members of staff
- Fewer security personnel are required

Disadvantages of centralised layout:

- As the terminal grows bigger travellers and employees face very long distances that needs to be travelled from their cars to the plane and vice versa

Decentralised layout

These airports either started as centralised layout terminals but added additional terminals to cope with increased traffic, or they were designed as decentralised layout terminals from the beginning. Examples are London Heathrow, Paris and Johannesburg

Advantages of decentralised layout:

- Terminals are kept on human scale
- Passenger volumes never become uncomfortably high
- Walking distances are kept low
- Lots are easier to supervise
- Safer from crime viewpoint
- Curb side drop-off areas are simple to design

Disadvantages of decentralised layout:

- Higher airport staff requirements
- Each unit requires a full range of passenger and staff facilities
- Poor economy in terms of fixed facilities

7.2.2 Facilities Planning Process

Facility planning is a continuous process. A facility is planned only once, in the beginning but it has to keep changing and adapting as the objectives of the facility change and the demand for the facility grows. According to Tompkins et al. (2003) facility planning is not an exact science but the traditional engineering design process can be applied to approach the planning in an organised and structured way as follows:

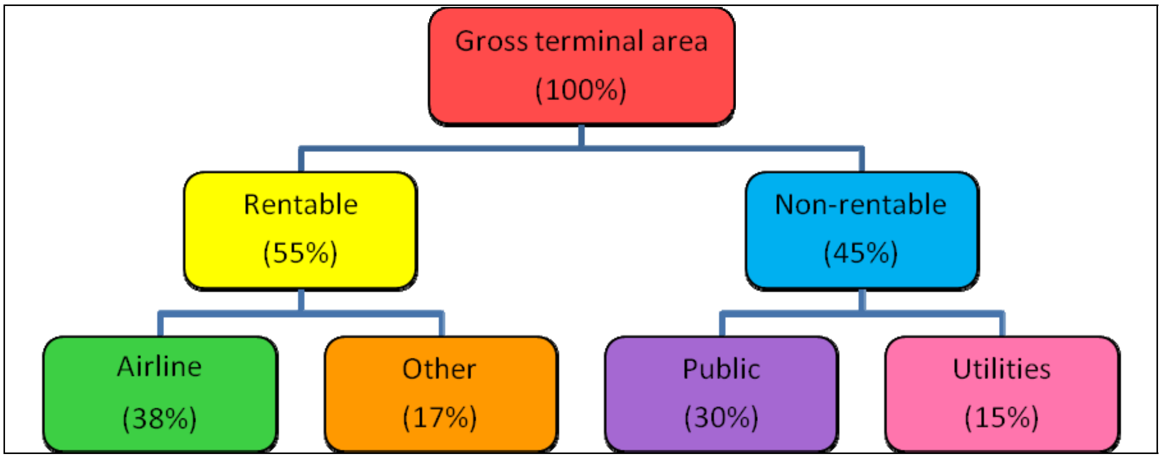
The traditional engineering design process

1. Define the problem
   - Define (or redefine) the objective of the facility
   - Specify the primary function to be performed in accomplishing the objective
2. Analyse the problem
   - Determine the interrelationship among activities.
3. Determine the space requirements for all activities
   - Generate alternative facility plans
4. Evaluate the alternatives
   - Evaluate alternative facility plans
5. Select the preferred design
   - Select a facilities plan
6. Implement the design
   - Implement the facilities plan
   - Maintain and adapt the facilities plan
   - Redefine the objective of the facility

7.2.3 Overall Space Approximations

According to Ashford, et al. (1995), there is no set of rules that can be applied to determine the division of terminal space. The division of space will differ from one airport to the next. They do provide a rough guide of the functional distribution of terminal space in a typical US airport.

Figure 3: Terminal space distribution



The Federal Aviation Administration (FAA) indicates that approximately 55 percent of terminal space should be rentable and 45 percent should not. An approximate breakdown of these space allocations is given as

1. 38 percent for airline operations this include:
   - Administration
   - Operations
   - Baggage
   - Hold rooms
2. 17 percent for concession and airport administration:
   - Concessions
   - Food and beverages
3. 30 percent for public space:
   - Circulation

- Waiting areas
- Rest rooms
- Exits
- Other airport administration

4. 15 percent for utilities:
    - Shops
    - Tunnels
    - Stairways
    - Shafts
    - Mechanical rooms

Floor plans of the South African terminal buildings will now have to be analysed to determine whether the same space approximations are used.

7.3 Methods To Determine The Capacity Of The Terminal

7.3.1 Data Envelopment Analysis (DEA)

This method was used by Elton Fernandes and R.R. Pacheco to analyse 35 Brazilian domestic airports. They determined the level of efficiency of these airports by the number of passengers these airports processed. According to them they used this method to determine the utilisation of capacity of these airports. Determining which airports used their resources effectively and where surplus resources were available. The Data Envelopment Analysis method shows the relationship between the airport infrastructures and the processing of passengers.

According to Fernandes & Pacheco (2000), the method works as follows: "This procedure is a mathematical technique based upon linear programming, which does not require that the functional form relating inputs to outputs be specified. Unlike regression analysis, which optimises a single regression plane in all the observations, Data Envelopment Analysis optimises at each observation for the purpose of constructing an efficient frontier which consists of a discrete curve formed solely by efficient Decision Making Units."

Advantage

This method is very helpful in determining resource utilisation

Disadvantage

It is a very difficult process to apply and if not done correctly may yield unusable outputs.

7.3.2 Cost Benefit Analysis

This method will be used to separate economically feasible projects from unfeasible projects. It is a practical approach to measure the benefits of expanding passenger capacity. This method includes the use of Net Present Value Calculations.

Advantages

This method is very useful when there is limited availability of the following:

- Time
- Research budged
- Data

Disadvantage

This method does not provide exact answers; it can only be used to decide between alternatives.

7.3.3 Queuing Theory

Queuing theory consists of mathematical models dealing with time spent waiting in lines. According to Odoni & Naufville (2002), from the Massachusetts Institute of Technology, this method has not proven efficient for design, mainly because airports are never essentially in a steady state condition and queues are often undisciplined.

This is a specialised field and will not be covered in this project.

7.3.4 Forecasting

Savage, (2003) states that forecasting can be divided into two broad categories:

1. <u>Casual forecasting</u>

   Predicts how an uncertain quantity is related to other quantities.

   Example how advertising can influence sales

2. <u>Time Series Analysis</u>

   Predicts future values based on past values

   Example to predict future demand based upon past sales

This method, however, is not exact and it is a specialised field.

7.3.5 Fuzzy Logic Method

This method predicts the functional time depending on the number of passengers and luggage affecting the capacity. This method was used by R. Koray Kiyildi and M. Karasahin to analyse the capacity of the check-in unit of Antalya Airport in Turkey.
This method was first introduced by Zadeh in 1967.

Human behaviour was previously described as two-valued Aristotelian logic by means of 0 or 1. It existed or it did not exist. The Fuzzy logic approach uses if-then statements to predict human behaviour.

Fuzzy logic takes flight plans, air traffic and runways into account and this is outside of the scope of this project.

7.4 Safety And Functionality

Ergonomics and Occupational Health and Safety are so closely related that it will be handled simultaneously.

7.4.1 Ergonomics

McCormick & Sanders (1982) defines ergonomics as the consideration of human characteristics, expectations and behaviours in the design of the things people use in their work and everyday lives and of the environments in which they work and live.

Thus ergonomics is the interaction of humans and their environment.
This includes:

- Illumination
- Noise
- Temperature
- Ventilation
- Vibration

Ergonomics will enable the student to design a user friendly terminal. For example, a passenger with hand luggage will always carry these parcels around with them so that it does not get lost. When sitting down there is not always adequate space provided at the seats in terminals for this hand luggage. By providing chairs in the waiting area with a compartment under the seat that can only be accessed from the front and not from the side or the back, the passenger will be able to keep his hand luggage at a comfortable distance and be sure that it is not stolen.

7.4.2 Occupational Health And Safety Act

Niebel & Freivalds, (2003), definition of Occupational Health and Safety Act is that this act assures so far as possible every working man and woman in the Nation safe and healthful working conditions and to preserve our human resources.

This Act will be applied to all airport terminals to assure safety for workers, as well as passengers.

The main focus of this study will be on the:

- Environmental Regulation for Workplaces
- Facility Regulation

8. Data Analysis

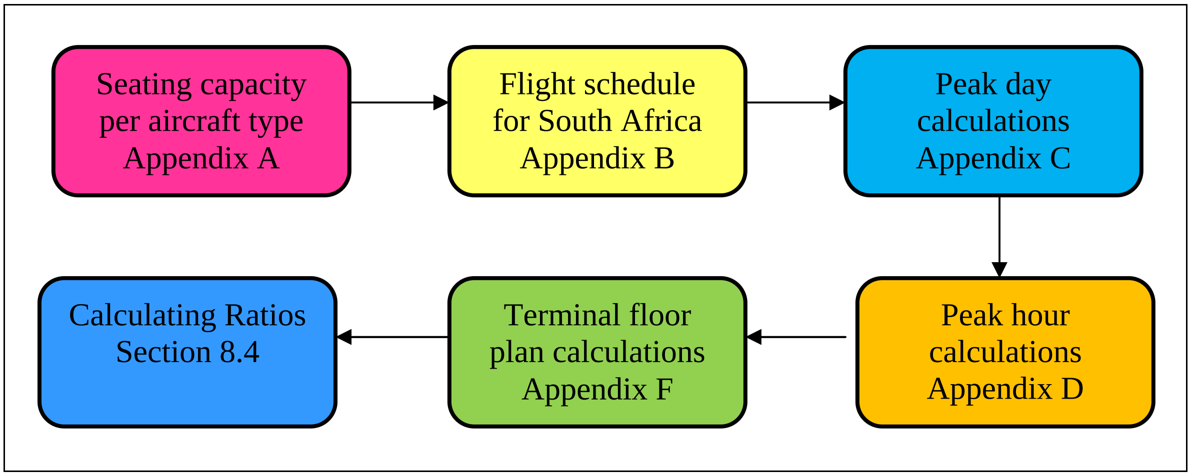
Experts in the field of civil engineering Mr Leon van Biljon, director of Virtual Buro, and Mr Rudolf Lagus, a professor in civil engineering, explained in an interview that the methods described in the literature study (section 7.1), to determine peak hour passenger flow could not be used. The hourly passenger rate for airports in South Africa is not available. These methods are thus not applicable for South Africa.

The only way to determine peak hour passengers would be to integrate all airline schedules flying in and out of South Africa. Combining this flight schedule with the type of aircrafts these airlines use, the amount of passengers per day could be determined.

This method to determine peak passengers per day can be used as a fairly good estimate because these schedules are rarely changed.

The different elements completed in this study can be illustrated using the breakdown structure shown in Figure 4.

Figure 4: Structural breakdown of study



8.1 Seating Capacity

This is defined as the amount of passengers each aircraft can carry. This will differ from one plane to the next and is dependent on the size of the airplane used and the classes the plane is divided into. (See Appendix A)

An example:

The Airbus A300 can carry 200 passengers if it is divided into three classes' namely:

1. First Class
2. Business Class
3. Economy Class.

If it is only divided into two classes namely Business Class and Economy Class it can carry 266 passengers and if there are no classes or in other words all seats are Economy class then the plane can carry up to 360 passengers.

The decision of what arrangement will be used will differ from one airline to the next. Averages for the seating capacity are determined by adding the different seating capacity arrangements and dividing it with the amount of seating arrangements. (Refer to Table 1)

Table 1: Seating Capacity

Aircraft Type	Code	Seating Capacity	Average
Airbus A300	AB3	200 (3)	
		266 (2)	281
		298 - 360 (c)	

8.2 Flight Schedules

This list is a combination of all of the South African airlines as well as other airlines flying in and out of South Africa. Appendix B contains part of the list for domestic flights. The rest of the list and the list for international flights are not included due to space considerations refer to Appendix B on the CD for complete flight schedules.

The frequency symbolised as one to seven is the day of the week that specific flight takes place where one represents Monday and seven represents Sunday.

The following formula was derived to determine the amount of passengers per day:

$$\sum_{i=1}^{9}(xij)y$$

y = seating capacity of the aircraft used by the airline.

x_{ij} = airline flying where i $\in$ {1; 9}is the airline company flying on day j where

j $\in$ {1; 7}day of the week

Table 2: Airline

i	**Airline**
1	1 Time
2	British Airlines (Comair)
3	Emirates
4	Kulula
5	Malaysian Airlines
6	Mango
7	Nationwide*
8	Royal Dutch Airline
9	SAA

* Although Nationwide is no longer in business their clients will have to make use of alternative transportation and are therefore included.

Table 3: Day of the week

j	Day
1	Monday
2	Tuesday
3	Wednesday
4	Thursday
5	Friday
6	Saturday
7	Sunday

Virtual Buro asked that these calculations would be done for a Monday and a Friday as it was predicted that inland flights would peak on a Monday and coastal flights would peak on a Friday. The student did these calculations for everyday of the week and it was found that the assumption made wasn't entirely true. As can be seen in Table 4 there are peaks on Thursdays as well as on Sundays. These calculations were also done separately for international and domestic passengers. An example of these calculations can be seen in Appendix C. For complete results of all airports refer to Appendix C on the CD.

Virtual Buro asked that the assumption be made that the peak hour will be on the peak day. The calculation for peak hour was done by combining the passenger arrival times and passenger departures times of the peak day. The calculations were done separate for international and domestic passengers because international passengers have to be at the airport two hours before their flight and domestic passengers only one hour.

People dropping of or picking up passengers at the airport are called "meeters and greeters". They also play a role in the size of airport terminal buildings.

According to Mr Leon van Biljon and Mr Rudolf Lagus of Virtual Buro past research has shown that meeters and greeters is approximately 0.65 per passenger for domestic passengers and 1.1 per passenger for international passengers. In other words for every 100 domestic or international passengers there will be 65 or 110 additional people respectively.

A summary for domestic flights in terms of their peak day and peak hour calculations for the different airports can be seen in Table 4.

Table 4: Peak hour calculations for domestic passengers

Airport	Peak Day	Peak Hour	# Passengers	Meeters and greeters	Total
HLA	Thursday	6:00,9:00,14:00,16:00	280	182	462
DUR	Friday	8:00-9:00	2086	1356	3442
MQP	Thursday	12:00-13:00	601	391	992
ELS	Monday	10:00-11:00	457	297	754
GRJ	Sunday	17:00-18:00	668	434	1102

Table 5 summarises the results for international flights, the peak days and peak hour. It also shows the number of meters and greeters in an international terminal building.

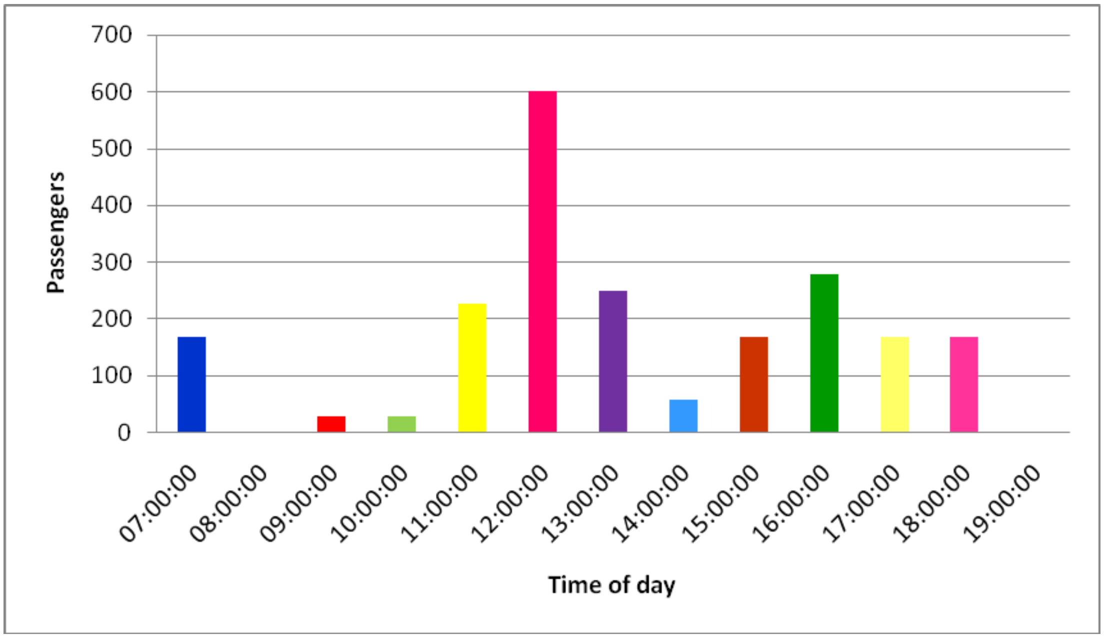
Table 5: Peak hour calculations for international passengers

Airport	Peak Day	Peak Hour	# Passengers	Meeters and greeters	Total
HLA	Tuesday	10:00,15:00	58	64	122
DUR	Wednesday	10:00-12:00	662	728	1390
MQP	Tuesday	11:00,15:00	46	51	97

Virtual Buro asked for the peak hour passengers in the terminal buildings (domestic and international) not for departure and arrival passengers' peak separately. Therefore the departures and arrivals had to be combined to give only two peak hours, one for domestic passengers and one for international passengers.

An example of the domestic peak hour passenger results of MQP is shown in Figure 5.

Figure 5: Peak hour passengers of MQP



The peak hour for domestic passengers can clearly be identified as between 12:00:00 and 13:00:00 on a Thursday.

For complete results refer to Appendix D – Peak Hour calculations, on the CD.

8.3 Facility Calculations

The following airports will be measured and analysed:

- HLA - Lanseria International Airport
- DUR - Durban International Airport
- MQP - Kruger Mpumalanga International Airport
- ELS - East London
- GRJ - George

The first three are international airports and will be analysed to get an estimate for an international terminal multiplication factor. Even though three is not ideal it will be enough to get a fairly good estimate. All five of these airports will be analysed to get a multiplication factor for a domestic terminal size.

The calculations will be done by physically measuring the different areas on the floor plans for each airport.

The areas are then categorised into the following:

- Bathrooms
- Offices
- Shops
- Domestic Arrival
- Domestic Departures
- International Arrivals
- International Departures
- Domestic Baggage Handling Area
- International Baggage Handling Area.
- Other (includes stairways, walkways and storage space)

The categories are shown in identifying colours on the floor plans. Please refer to Appendix E – Floor Plans.

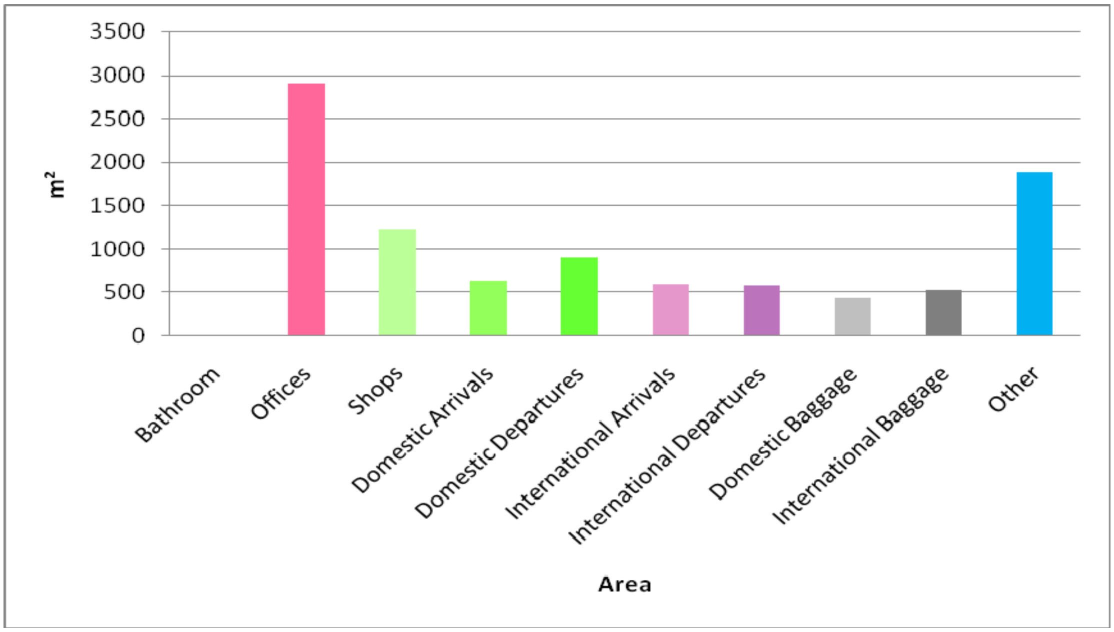
The total of each category for each floor is then calculated.

Lanseria will be used as an example, please refer to Appendix F on the CD for complete results.

Table 6: Lanseria Floor Calculations in (m^2)

	Bathroom	Offices	Shops	Domestic Arrivals	Domestic Departures	International Arrivals	International Departures	Domestic Baggage	International Baggage	Other
Basement	0	276	0	0	0	0	0	430.72	533.2	661.52
Ground Floor	209.2	427.6	162	629.52	905	601.18	581.42	0	0	327.2
Ground Mezzanine	0	136.8	0	0	0	0	0	0	0	32.6
1st Floor	54.4	1145.9	1226	0	0	0	0	0	0	433.24
1st Floor Mezzanine	0	633.6	0	0	0	0	0	0	0	238.2
2nd Floor	15.44	216	0	0	0	0	0	0	0	38.56
2nd Floor Mezzanine	0	65.6	0	0	0	0	0	0	0	150.4
Total	**15.44**	**2901.5**	**1226**	**629.52**	**905**	**601.18**	**581.42**	**430.72**	**533.2**	**1881.72**

Figure 6: Results of Lanseria floor calculations



8.4 Comparing Peak Hour Passengers With Facility Calculations

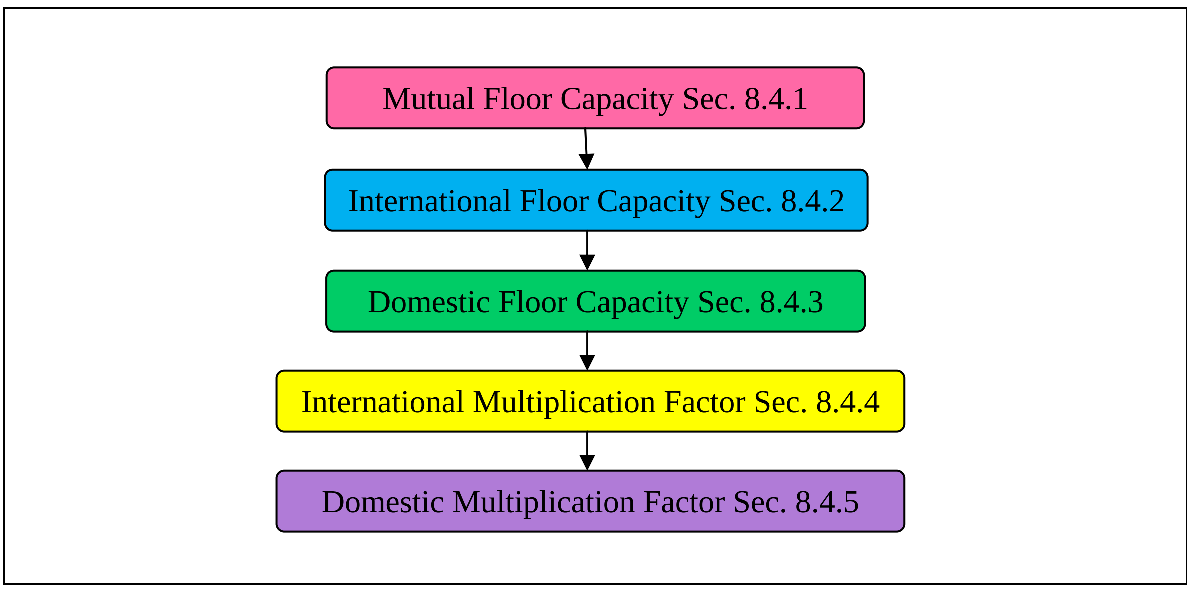
Passengers for domestic flights have to arrive an hour before their flight and passengers for international flights have to arrive two hours before their flight. This will however only influence the size of the departure halls and will not have an influence on the entire airport size.

Three possible alternatives will be investigated.

Alternative:

1. All floor capacity will be included in the calculations.
2. All floor capacity will be included in the calculations except office space.
3. Only passenger processing areas will be included in the calculations and no mutual capacity will be included.

Figure 7: Steps to determine multiplication factors



8.4.1 Mutual Floor Capacity

Alternative 1:
The mutual capacity can be divided into two for domestic terminal capacity and international terminal capacity. This will include all the capacity in Table 6 shown above that doesn't involve domestic or international passenger processing.

Mutual capacity = Bathrooms + Shops + Other + Offices

For Lanseria mutual capacity = (15.44 + 1226 + 1881.72 + 2901.5) / 2

= 3012.33 m^2

Half of the mutual capacity is added to international capacity and the other half of the mutual capacity is added to the domestic capacity.

The results are shown in Table 7 below. For the complete break down structure per floor per airport please refer to Appendix F on the CD.

Table 7: Results of Mutual floor capacity with Alternative 1 (m^2)

Airport	Bathroom	Shop	Other	Offices	Total Mutual Capacity
HLA	15.44	1226	1881.72	2901.5	3012.33
DUR	691.27	1182.6	2455.4	1669.84	2999.55
MQP	216	625	517.84	289	823.92
ELS	350.86	1012.13	622.73	1366.59	1676.15
GRJ	227.24	727.24	1309.88	1420.32	1842.34

Alternative 2:

All mutual terminal capacity will be included in this calculation except office space.

Mutual capacity = Bathrooms + Shops + Other

For Lanseria mutual capacity = (15.44 + 1226 + 1881.72) / 2

= 1561.58 m^2

Table 8: Results of Mutual floor capacity with Alternative 2 (m^2)

Airport	Bathroom	Shop	Other	Total Mutual Capacity
HLA	15.44	1226	1881.72	1561.58
DUR	691.27	1182.6	2455.4	2164.64
MQP	216	625	517.84	679.42
ELS	350.86	1012.13	622.73	992.86
GRJ	227.24	727.24	1309.88	1132.18

Alternative 3:

No mutual capacity will be included in the calculation using this alternative.

8.4.2 International Floor Capacity

International capacity is defined as all areas where international passenger processing takes place as well as departure and arrival halls.

The basis of the calculation will stay the same with all three alternatives and only the Mutual Capacity that is added will change.

.

Alternative 1:

All airport capacity is included in these calculations.

International capacity = International Arrivals + International Departures + International Baggage + Mutual capacity*

*This will be the mutual capacity calculated in Table 7

For Lanseria International capacity = 601.18 + 581.42 + 533.2 + 3012.33

= 4728.13 m^2

International capacity results are shown in Table 9 below. For the complete break down structure per floor per airport refer to Appendix F on the CD.

Table 9: Results of International floor capacity with Alternative 1 (m^2)

Airport	International Arrivals	International Departures	International Baggage	Mutual Capacity	Total International Capacity
HLA	601.18	581.42	533.2	3012.33	4728.13
DUR	1644	1672	57	2999.55	6372.55
MQP	586.6	359.6	340	823.93	2110.13

Alternative 2:
There is no offices space included in the mutual capacity using this alternative.

International capacity = International Arrivals + International Departures + International Baggage + Mutual capacity*

*This will be the mutual capacity calculated in Table 8.

Table 10: Results of International floor capacity with Alternative 2 (m^2)

Airport	International Arrivals	International Departures	International Baggage	Mutual Capacity	Total International Capacity
HLA	601.18	581.42	533.2	1561.58	3277.38
DUR	1644	1672	57	2164.64	5537.6
MQP	586.6	359.6	340	679.42	1956

Alternative 3:
Only international passenger processing areas are included in this alternative.

International capacity = International Arrivals + International Departures + International Baggage*

*No Mutual capacity is included in this method

Table 11: Results of International floor capacity with Alternative 3 (m^2)

Airport	International Arrivals	International Departures	International Baggage	Total International Capacity
HLA	601.18	581.42	533.2	1715.8
DUR	1644	1672	57	3373
MQP	586.6	359.6	340	1285.6

8.4.3 Domestic Floor Capacity

Domestic terminal capacity is defined as all areas where domestic passenger processing takes place as well as departure halls and arrival halls.

The only difference between the alternatives will be the Mutual Capacity that is added.

Alternative 1:

All airport capacity is included in this alternative.

Domestic capacity = Domestic Arrivals + Domestic Departures + Domestic Baggage + Mutual capacity*

*This will be the mutual capacity calculated in Table 7.

For Lanseria Domestic capacity = 629.52 + 905 + 430.72 + 3012.33

= 4977.57 m^2

Domestic capacity results are shown in Table 12. For the complete break down structure, per floor, per airport refer to Appendix F on the CD.

Table 12: Results of Domestic floor capacity with Alternative 1 (m^2)

Airport	Domestic Arrivals	Domestic Departures	Domestic Baggage	Mutual Capacity	Total Domestic Capacity
HLA	629.52	905	430.72	3012.33	4977.57
DUR	3742	3262	57	2999.55	10060.55
MQP	275	625	906	823.92	2629.92
ELS	491.5	1874.14	834.24	1676.15	4876.05
GRJ	1131	1676	199.44	1842.34	4848.78

Alternative 2:
No offices space is included in the calculation of this alternative.

Domestic capacity = Domestic Arrivals + Domestic Departures + Domestic Baggage + Mutual capacity*

*This will be the mutual capacity calculated in Table 8.

Table 13: Results of Domestic floor capacity with Alternative 2 (m^2)

Airport	Domestic Arrivals	Domestic Departures	Domestic Baggage	Mutual Capacity	Total Domestic Capacity
HLA	629.52	905	430.72	1561.58	3526.82
DUR	3742	3262	57	2164.64	9225.6
MQP	275	625	906	679.42	2485.4
ELS	491.5	1874.14	834.24	992.86	4192.7
GRJ	1131	1676	199.44	1132.18	4138.6

Alternative 3:
Only passenger processing areas are included.

Domestic capacity = Domestic Arrivals + Domestic Departures + Domestic Baggage*

*No Mutual capacity is included in this method.

Table 14: Results of Domestic floor capacity with Alternative 3 (m^2)

Airport	Domestic Arrivals	Domestic Departures	Domestic Baggage	Total Domestic Capacity
HLA	629.52	905	430.72	1965.24
DUR	3742	3262	57	7061
MQP	275	625	906	1806
ELS	491.5	1874.14	834.24	3199.9
GRJ	1131	1676	199.44	3006.4

8.4.4 International Multiplication Factor

By dividing the total international floor capacity per airport with the amount of international passengers in a peak hour, or the passengers and their meeters and greeters in a peak hour, the square meters per person can be calculated. This will also be known as the international multiplication factor.

Alternative 1:

All capacity is included in these calculations.

International capacity per person = International floor capacity / Peak hour people

= 4728.13 / 121.8

= 38.81 m^2 / person

This is a lot lower than Virtual Buro's estimate of 52 m^2 / person.

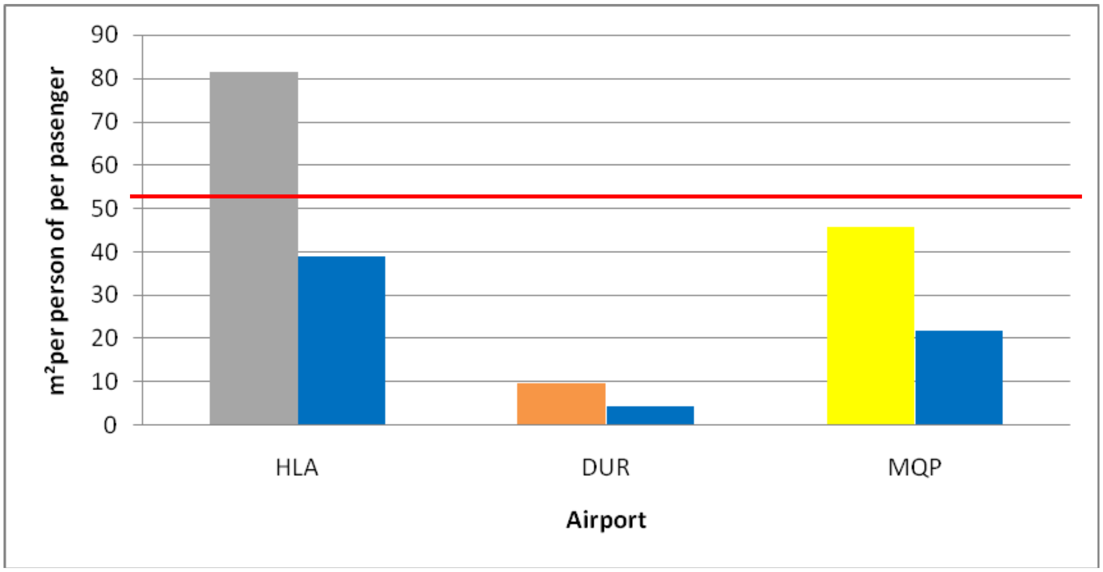
Table 15 is a combination of Table 5 (the peak hour passengers) and Table 9 summarising relevant information used in the calculation of the multiplication factor.

Table 15: Results of International multiplication factor using Alternative 1

Airport	Floor Capacity (m^2)	Peak Hour passengers	Multiplication Factor for Passengers (m^2/person)	People in Peak Hour	Multiplication Factor for people (m^2/person)
HLA	4728.13	58	81.51	121.8	38.81
DUR	6372.55	662	9.63	1390.2	4.5
MQP	2110.13	46	45.86	96.6	21.8
MEAN			45.66		21.7
STDEV			35.94		17.16

As seen in Table 15 Durban has the lowest multiplication factor for both passengers and people. This is because Durban is currently too small. Lanseria on the other hand has the highest multiplication factor this is because there are a lot of unscheduled flights to and from Lanseria that could not be calculated from the flight schedules.

Figure 8: International Multiplication Factor using Alternative 1



The red line indicates the current method used. The coloured blocks is for the case when only the passengers are used and the blue blocks is for the case when the meeters and greeters are also included in the calculation. By only multiplying the peak hour passengers (coloured blocks) with 52 m^2 per person is clearly not an adequate method. More airports will have to be analysed to determine whether this fluctuation stabilises.

Using the passengers and their meeters and greeters (the blue blocks) will give a more accurate estimate than only using the peak hour passengers because it takes all people at the airport into account. Only using the passengers will result in inadequate space. The standard deviation is reduced from 35.94 to 17.16 as seen in Table 15. This proofs that the method of using all people at the airport in a peak hour is more stable than only using the peak hour passengers.

The difference in Figure 8 is shown to demonstrate how big the variation is when only the passengers are used to when the meeters and greeters of the passengers are included. The rest of the calculations will only consist of all people in a peak hour on a specific airport and not just the passengers.

Alternative 2:

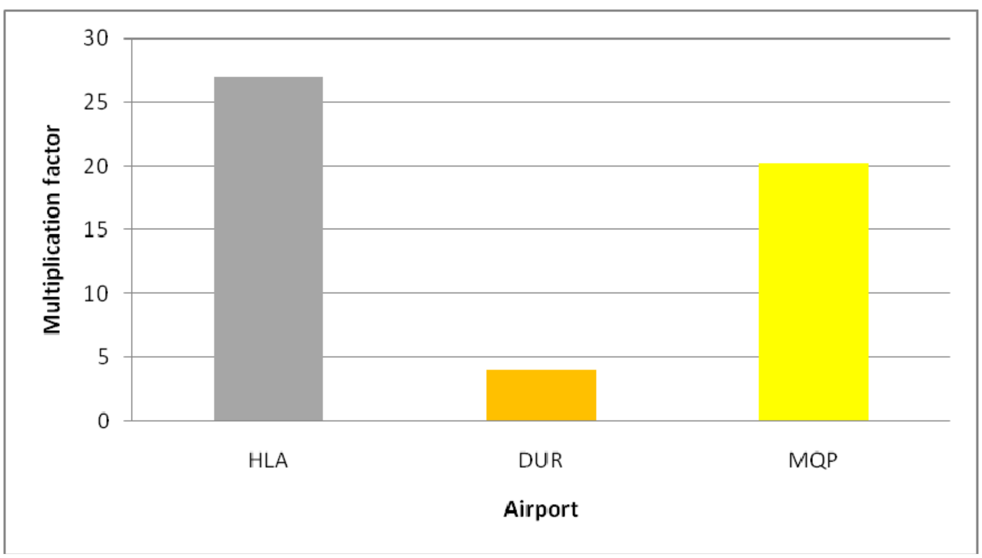
Only office space is excluded from mutual capacity in these calculations.

Table 16: Results of International multiplication factor using Alternative 2

Airport	Floor Capacity (m^2)	Peak Hour passengers	Multiplication Factor for Passengers (m^2/person)	People in Peak Hour	Multiplication Factor for people (m^2/person)
HLA	3277.38	58	56.5	121.8	26.9
DUR	5537.6	662	8.36	1390.2	3.98
MQP	1956	46	42.52	96.6	20.25
MEAN			35.85		17.04
STDEV			24.76		11.79

Again there seems to be the same problem at Durban. Lanseria on the other hand seems to be closer to Mpumalanga. This indicates that there is also a lot of office space at Lanseria.

Figure 9: International Multiplication Factor using Alternative 2



Using alternative 2 the standard deviation is reduced from 17.16 to 11.79. This shows that alternative 2 is better to use than alternative 1.

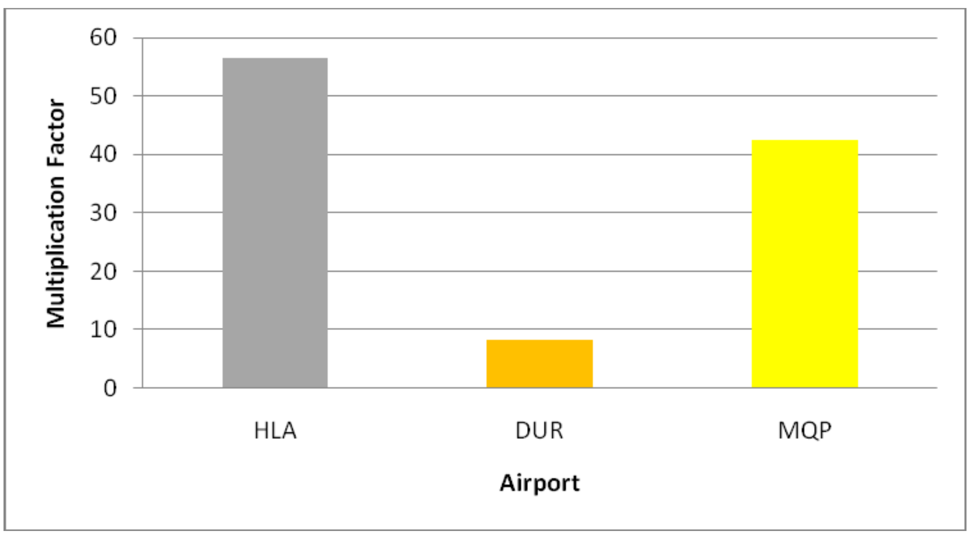
Alternative 3:

Only international passenger processing areas are included in these calculations.

Table 17: Results of International multiplication factor using Alternative 3

Airport	Floor Capacity (m^2)	Peak Hour passengers	Multiplication Factor for Passengers (m^2/person)	People in Peak Hour	Multiplication Factor for people (m^2/person)
HLA	601.18	58	56.5	121.8	4.94
DUR	1644	662	8.36	1390.2	1.18
MQP	586.6	46	42.52	96.6	6.07
MEAN			35.79		4.06
STDEV			24.76		2.56

Figure 10: International Multiplication Factor using Alternative 3



To calculate the multiplication factor only peak hour passengers are used because only passengers are allowed in the passenger processing areas. The meeters and greeters are not allowed in these areas and will therefore not have and influence on the size of these areas.

8.4.5 Domestic Multiplication Factor

By dividing the total domestic floor capacity per airport with the amount of domestic passengers in a peak hour, or the passengers and their meeters and greeters in a peak hour, the square meters per person can be calculated. This will also be known as the domestic multiplication factor.

Alternative 1:

All capacity is included.

Domestic capacity per person = Domestic floor capacity / Peak hour people

= 4977.57 / 280

= 17.77 m^2 / person

This is close to the estimate of 20 m^2 / person that Virtual Buro uses.

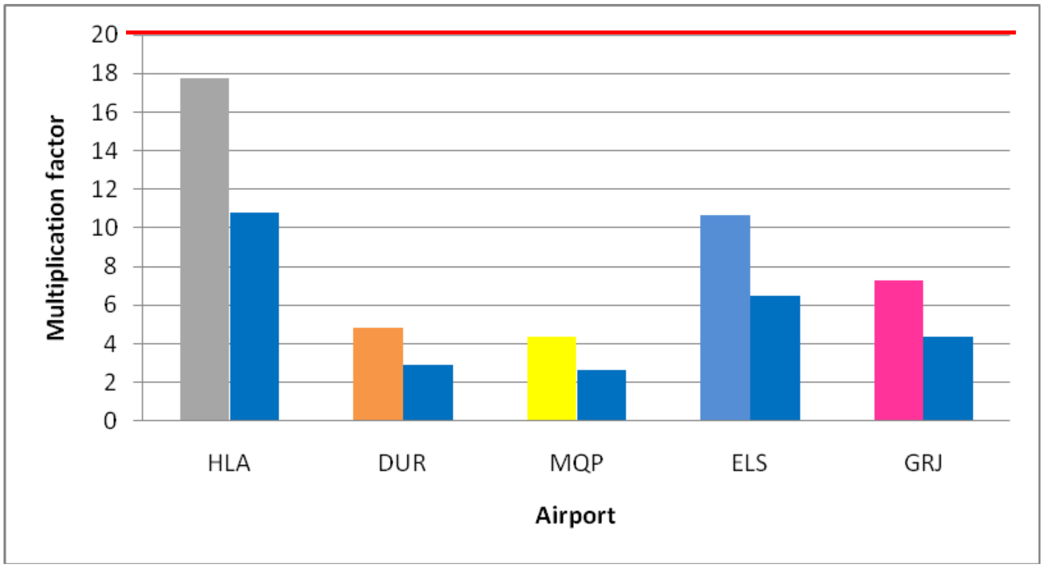
Relevant information from Table 4 and Table 7 were combined to form Table 18 to assist in the calculation of the domestic multiplication factor.

Table 18: Results of Domestic multiplication factor using Alternative 1

Airport	Floor Capacity (m^2)	Peak Hour passengers	Multiplication Factor for Passengers (m^2/person)	People in Peak Hour	Multiplication Factor for people (m^2/person)
HLA	4977.57	280	17.77	462	10.77
DUR	10060.55	2086	4.82	3442	2.92
MQP	2629.92	601	4.38	992	2.65
ELS	4876.05	457	10.67	754	6.47
GRJ	4848.78	668	7.26	1102	4.4
MEAN			9.12		5.44
STDEV			5.82		3.34

As seen with the calculation of the international multiplication factor Durbans' domestic terminal is to small. The same appears to be true for Mpumalanga. Lanseria has a lot of unscheduled flights and that may be the reason why its multiplication factors are bigger than the others.

Figure 11: Domestic Multiplication Factor using Alternative 1



The red line indicates the amount of 20m^2 per passenger currently being used. This multiplication factor is too high. It will result in oversized domestic terminal buildings resulting in projects that are unfeasible. Another method should be implemented.

As in Figure 8 the coloured blocks indicates only the peak hour passengers and the blue blocks indicates the passengers and their meeters and greeters. By using all the people in a peak hour in the domestic terminal and not just the passengers the standard deviation is reduced from 5.8 to 3.34. This indicates a more stable method.

Alternative 2:

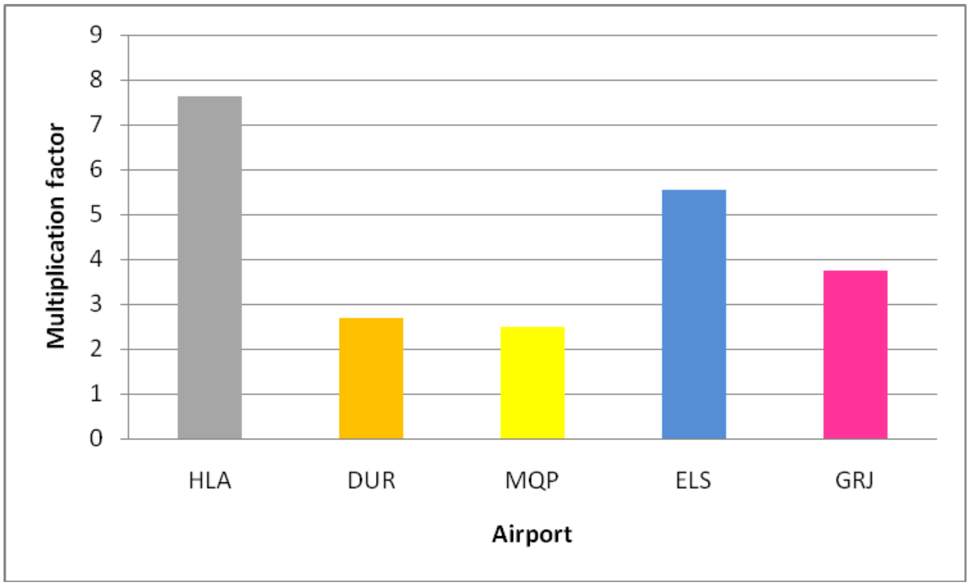
Only office space is excluded with the calculation of the mutual capacity that is added to domestic capacity.

Table 19: Results of Domestic multiplication factor using Alternative 2

Airport	Floor Capacity (m^2)	Peak Hour passengers	Multiplication Factor for Passengers (m^2/person)	People in Peak Hour	Multiplication Factor for people (m^2/person)
HLA	3526.82	280	12.96	462	7.63
DUR	9225.6	2086	4.42	3442	2.68
MQP	2485.4	601	4.14	992	2.5
ELS	4192.7	457	9.17	754	5.56
GRJ	4138.6	668	6.2	1102	3.76
MEAN			7.72		4.43
STDEV			3.7		2.16

By using alternative 2 the standard deviation can be reduced from 3.34 to 2.16. This proofs that alternative 2 is more stable than alternative 1.

Figure 12: Domestic Multiplication Factor using Alternative 2



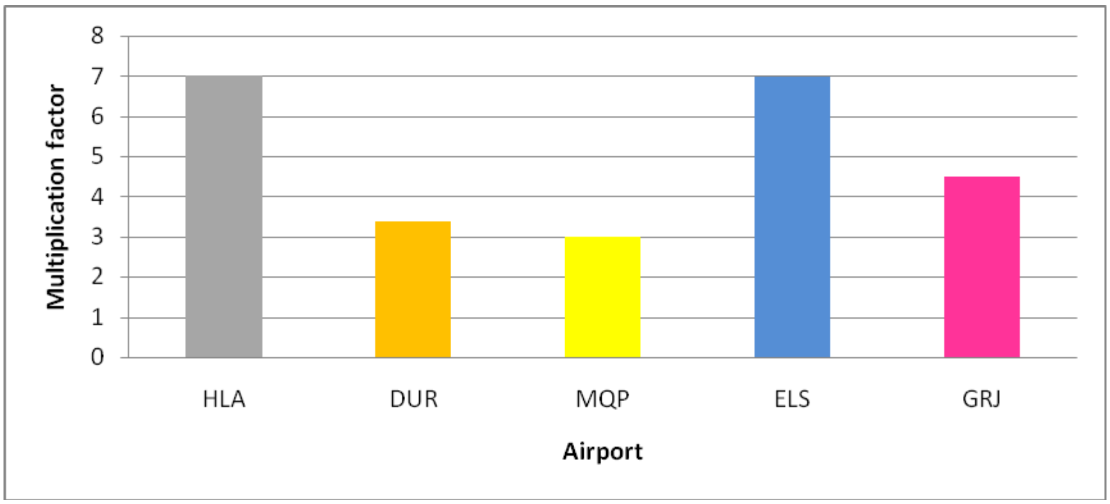
Alternative 3:

Only domestic passenger processing areas are used and no mutual capacity is added.

Table 20: Results of Domestic multiplication factor using Alternative 3

Airport	Floor Capacity (m^2)	Peak Hour passengers	Multiplication Factor for Passengers (m^2/person)	People in Peak Hour	Multiplication Factor for people (m^2/person)
HLA	1965.24	280	7.02	462	4.25
DUR	7061	2086	3.38	3442	2.05
MQP	1806	601	3.00	992	1.82
ELS	3199.9	457	7.00	754	4.24
GRJ	3006.4	668	4.5	1102	2.73
MEAN			5.06		3.01
STDEV			1.93		1.17

Figure 13: Domestic Multiplication Factor using Alternative 3



Only the peak hour passengers can be used and not all the people at the airport with Alternative 3 because only passenger processing areas are used. This means that only the passengers will use these space and not all people have access to these areas.

8.5 Summary And Recommendation

Keep in mind that the different Alternatives are:

1. All floor capacity is included in the calculations
2. All floor capacity is included in the calculations except office space
3. Only passenger processing areas is included in the calculations but no mutual capacity

The purpose was not only to find one multiplication factor for an international terminal building and one multiplication factor for a domestic terminal building but also to know what was included in the space.

8.5.1 International Multiplication Factor Summary

Table 21: Summary of international multiplication factor

	Alternative 1	Alternative 2	Alternative 3
Mean Multiplication Factor	21.7	17.04	35.79
Standard Deviation	17.1552043	11.7916764	24.76491335

Alternative 2 appears to be the best method; it's the most stable out of the three alternatives. This is however much lower than the existing multiplication factor of $52m^2$ per person currently being used by Virtual Buro. This factor has been tested for South Africa and Virtual Buro knows what is included in this space, namely everything except offices.

Alternative 2 has a standard deviation of 11.79; this is very high and the student recommends that more international terminal buildings be analysed before this method is used, to determine whether it stabilises.

8.5.2 Domestic Multiplication Factor Summary

Table 22: Summary of domestic multiplication factor

	Alternative 1	Alternative 2	Alternative 3
Mean Multiplication Factor	5.44	4.43	5.06
Standard Deviation	3.34	2.16	1.93

The student recommends that Alternative 2 be used. It may seem that Alternative 3 is better because it has a smaller standard deviation, as seen in Table 22, but keep in mind that Alternative 3 only includes passenger processing areas. It will result in a lot of additional calculations that will have to be done to determine the size of the entire domestic terminal building. That is not what Virtual Buro wanted.

The student feels that it is up to the airport and Virtual Buro to decide how much space is needed for offices because it will depend on the customer needs. Some airports may want extra office space to rent out to the public, or other office facility needs like boardrooms, etc.

9. Health And Safety

The whole Occupational Health and Safety Act 85 of 1993 has to be considered in the design of terminal buildings.

The emphasis, however, should be on the following regulations of the Act:

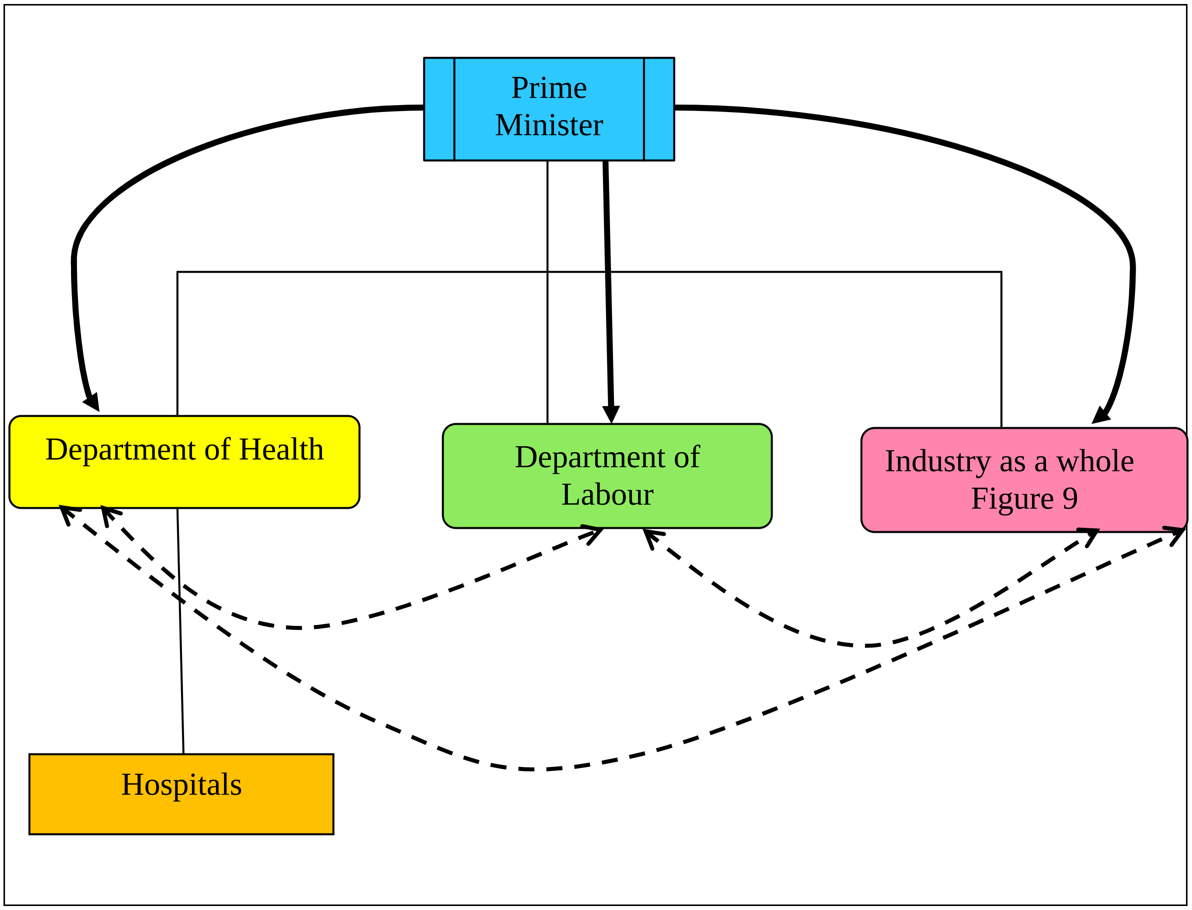
- General Administrative Regulations
- General Safety Regulations
- Environmental Regulations for Workplaces
- Facility Regulations
- Noise-induced Hearing Loss Regulations
- Driven Machinery Regulations
- General Machinery Regulations
- Lift, Escalator and Passenger Conveyor Regulations
- Regulations Concerning the Certificate of Competency
- Electrical Installation Regulations
- Electrical Machinery Regulations

The Occupational Health and Safety Act is clear on what has to be done and what not according to the law but it is not clear on who takes the responsibility for a specific task.

With the help of Mr E Brett, of the University of Pretoria, the OHSA delegation and/or communication channel structure was developed. Refer to Figure 8 on the next page. This structure was extended further for an Organisation, refer to Figure 9. This is only an example of how the structure should look like but it has to be adapted to suite a specific environment.

The case study in Appendix G illustrates what happens if there is no communication. The OHSA delegation and/or communication channel structure was developed to reduce or eliminate instances like these.

Figure 14: OHSA delegation and/or communication structure



There has to be an open communication channel between the Prime Minister and different departments but also between departments.

Figure 15: OHSA delegation and/or communication structure for an Organisation

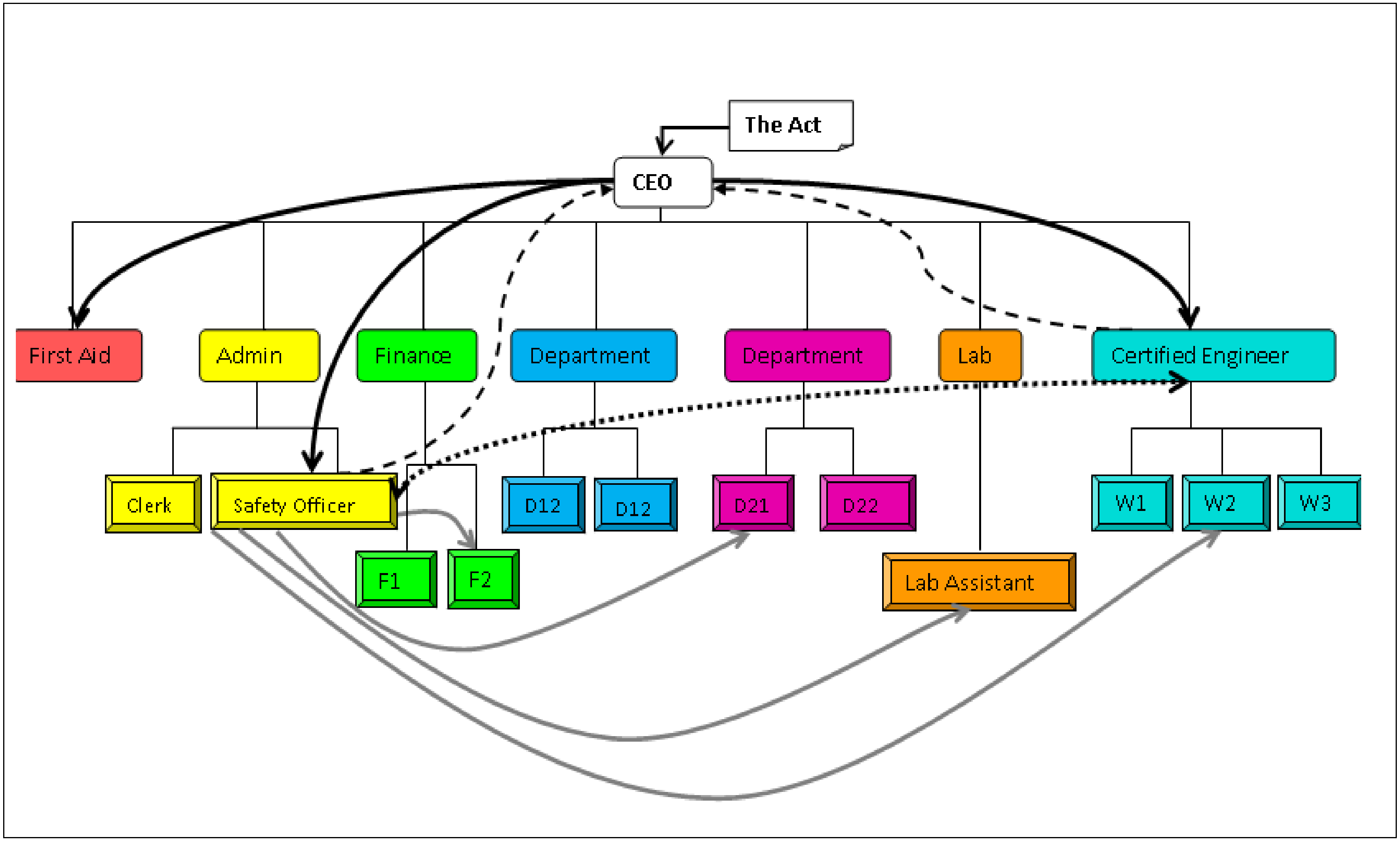
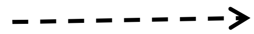


Table 23: Symbols used in Figure 15

Key	**Arrow Used**
CEO Delegation	
Feedback to CEO	
Communication	
Instructions	
OHSA delegation to CEO	

By actively using these communication structures as seen in Figure 14 and Figure 15 the amount of temporary cases opened as seen in the case study, Appendix G can be reduced and the backlog can be eliminated.

Conclusion

By combining flight schedules, the busiest day, peak hour and seating capacity the passenger flow can be predicted. Analysing the floor plans of the airports and dividing the total capacity with the peak hour passengers or, the total amount of people in a peak hour, an estimate can be derived to determine square meters per passenger for an airport.

These ratios will enable Virtual Buro to give clients an immediate approximated answer when asked what the size of their new airports should be.

The more airports that are analysed, the more accurate these ratios will become.

By applying the Occupational Health and Safety Act and focusing on the highlighted paragraphs given, Virtual Buro will be able to deliver safer and more user friendly terminal buildings.

By applying these methods and techniques, a standard process can be developed. Virtual Buro will be able to apply this to any airport to determine the passenger terminal capacity requirements.

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Appendix A - Seating Capacity

Aircraft Type	Code	Seating Capacity	Average
Airbus A300	**AB3**	200 (3)	
		266 (2)	281
		298 - 360 (c)	
Airbus A310	**310**	169 (3)	
		220 (2)	212
		247 (c)	
Airbus A319	**319**	124 (2)	
		134 - 142 (c)	133
Airbus A320	**320**	150 (2)	
		164 - 179 (c)	165
Airbus A321	**321**	185 (2)	
		199 (c)	192
Airbus A330 - 200	**332**	253 (3)	
		293 (2)	309
		380 (c)	
Airbus A330 - 300 **(330)**	**333**	295 (3)	
		335 (2)	347
		412 (c)	
Airbus A340 - 200 **(340)**	**342**	239 - 261 (3)	
		300 (2)	307
		360 (c)	
Airbus A340 - 300 **(340)**	**343**	295 (3)	
		335 (2)	315
Airbus A340 - 500	**345**	313 (3)	
		359 (2)	
		400 (c)	357
Airbus A340 - 600	**346**	380 (3)	
		419 (2)	433
		500 (c)	
Airbus A380	**380**	555 (3)	
		644 (2)	680
		840 (c)	
Boeing 727 - 200	**722**	189 (c)	189
Boeing 737 - 200	**732**	95 (2)	
		130 (c)	113
Boeing 737 - 260			
Boeing 737 - 300 (FODZY)	**733**	128 (2)	

		149 (c)	139
Boeing 737 - 400	**734**	146 (2)	157
		168 (c)	
Boeing 737 - 500 (FODZJ)	**735**	110 (2)	121
		132 (c)	
Boeing 737 - 600	**736**	110 (2)	121
		132 (c)	
Boeing 737 - 700	**737**	126 (2)	138
		149 (c)	
Boeing 737 - 800	**738**	162 (2)	176
		189 (c)	
Boeing 747 - 100	**741**	330 (3)	407
		385 (2)	
		505 (c)	
Boeing 747 - 300	**743**	420 - 422 (2)	422
Boeing 747 - 400	**744**	358 - 416 (3)	485
		480 - 524 (2)	
		568 (c)	
Boeing 757 - 260			
Boeing 763 - 300 ER		218 (3)	352
		269 (2)	
		351 (c)	
Boeing 767 - 200 ER	**762**	181 (3)	
		224 (2)	
		255 - 290 (c)	238
Boeing 767 - 300	**763**		
Boeing 767 - 300 ER	**763**	218 (3)	279
		269 (2)	
		351 (c)	
Boeing 767 - 400 ER	**764**	245 (3)	308
		304 (2)	
		375 (c)	
Boeing 777 - 200	**772**	305 (3)	
		400(2)	
Boeing 777 - 200 ER	**772**	301 (3)	351
		400 (2)	
Boeing 777 - 300	**777**	368 (3)	410
		451 (2)	
Boeing 777 - 300 ER	**773**	356	356
Boeing 777 - 700LR	**777**		

Jetstream 31	**J31**	19	19
Jetstream 41	**J41**	29	29
ATR72 - 500			
McDonnell Douglas	**MD82**	142 (3)	
		172 (2)	157
Fokker F28	**F28**	85	85

Appendix B - Flight Schedules

5.3.2.1	***1 Time***						
1Time fleet consists of MD82 and MD83 with 157 seats each and DC9-110 with 110 seats							
FROM	**TO**	**DEPART**	**ARRIVE**	**FLIGHT**	**AIRCRAFT**	**FREQUENCY**	**CAPACITY**
JNB	CPT	06:30:00	08:40:00	1T135	EQV	----5--	134
JNB	CPT	07:10:00	09:20:00	1T101	EQV	123456-	134
JNB	CPT	07:50:00	10:00:00	1T129	EQV	1------	134
JNB	CPT	08:40:00	10:50:00	1T123	EQV	------7	134
JNB	CPT	09:25:00	11:35:00	1T103	EQV	123456-	134
JNB	CPT	09:45:00	11:55:00	1T119	EQV	------7	134
JNB	CPT	11:05:00	13:15:00	1T133	EQV	-----6-	134
JNB	CPT	11:10:00	13:20:00	1T141	EQV	--3----	134
JNB	CPT	12:45:00	14:55:00	1T109	EQV	12345-7	134
JNB	CPT	13:40:00	15:50:00	1T105	EQV	-----6-	134
JNB	CPT	14:45:00	16:55:00	1T121	EQV	------7	134
JNB	CPT	15:20:00	17:30:00	1T111	EQV	123456-	134
JNB	CPT	16:25:00	18:35:00	1T131	EQV	1-34---	134
JNB	CPT	16:40:00	18:50:00	1T125	EQV	-----6-	134
JNB	CPT	17:25:00	19:35:00	1T127	EQV	---4---	134
JNB	CPT	18:00:00	20:10:00	1T139	EQV	-----6-	134
JNB	CPT	18:30:00	20:40:00	1T115	EQV	12345-7	134
JNB	CPT	19:25:00	21:35:00	1T129	EQV	----5--	134
JNB	CPT	21:00:00	23:10:00	1T117	EQV	----5-7	134
JNB	DUR	06:40:00	07:50:00	1T201	EQV	12345--	134
JNB	DUR	07:00:00	08:10:00	1T209	EQV	-----6-	134
JNB	DUR	08:25:00	09:35:00	1T235	EQV	-2345--	134
JNB	DUR	09:00:00	10:10:00	1T211	EQV	-----6-	134
JNB	DUR	09:20:00	10:20:00	1T227	EQV	------7	134
JNB	DUR	11:30:00	12:40:00	1T203	EQV	12345--	134
JNB	DUR	12:45:00	13:55:00	1T215	EQV	-----6-	134
JNB	DUR	13:00:00	14:10:00	1T223	EQV	----5--	134
JNB	DUR	15:00:00	16:10:00	1T217	EQV	-----6-	134
JNB	DUR	15:35:00	16:45:00	1T205	EQV	1234---	134
JNB	DUR	16:30:00	17:40:00	1T221	EQV	----5--	134
JNB	DUR	17:10:00	18:20:00	1T219	EQV	-----67	134
JNB	DUR	18:05:00	19:15:00	1T225	EQV	----5--	134
JNB	DUR	18:15:00	19:25:00	1T207	EQV	1234--7	134
JNB	DUR	19:40:00	20:50:00	1T229	EQV	------7	134
JNB	DUR	20:40:00	21:50:00	1T237	EQV	----5--	134

FROM	TO	DEPART	ARRIVE	FLIGHT	AIRCRAFT	FREQUENCY	CAPACITY
JNB	PLZ	07:20:00	09:00:00	1T501	EQV	1------	134
JNB	PLZ	10:45:00	12:25:00	1T505	EQV	-234---	134
JNB	PLZ	11:20:00	13:00:00	1T515	EQV	----5--	134
JNB	PLZ	11:30:00	13:10:00	1T511	EQV	------7	134
JNB	PLZ	12:10:00	13:50:00	1T507	EQV	-----6-	134
JNB	PLZ	15:25:00	17:05:00	1T503	EQV	1--4---	134
JNB	PLZ	17:20:00	19:00:00	1T509	EQV	----5-7	134
JNB	GRJ	07:05:00	08:55:00	1T831	EQV	----5--	134
JNB	GRJ	07:50:00	09:40:00	1T821	EQV	1-------	134
JNB	GRJ	08:45:00	10:45:00	1T821	EQV	-----6-	134
JNB	GRJ	09:45:00	11:35:00	1T827	EQV	---4---	134
JNB	GRJ	10:30:00	12:20:00	1T825	EQV	--3----	134
JNB	GRJ	12:00:00	13:50:00	1T823	EQV	-2-----	134
JNB	GRJ	13:00:00	14:50:00	1T833	EQV	------7	134
JNB	GRJ	15:40:00	17:20:00	1T829	EQV	----5-7	134
JNB	ELS	06:50:00	08:15:00	1T301	EQV	1--45--	134
JNB	ELS	09:35:00	10:15:00	1T319	EQV	------7	134
JNB	ELS	10:45:00	12:05:00	1T305	EQV	-----6-	134
JNB	ELS	11:05:00	13:15:00	1T331	EQV	1------	134
JNB	ELS	13:00:00	14:25:00	1T317	EQV	---4---	134
JNB	ELS	13:40:00	15:05:00	1T321	EQV	------7	134
JNB	ELS	14:25:00	15:50:00	1T307	EQV	----5--	134
JNB	ELS	16:00:00	17:25:00	1T309	EQV	-23----	134
CPT	ELS	08:55:00	10:25:00	1T608	EQV	---4---	134
CPT	ELS	09:20:00	10:50:00	1T602	EQV	----5--	134
CPT	ELS	12:35:00	14:05:00	1T604	EQV	------7	134
CPT	ELS	15:20:00	16:50:00	1T606	EQV	1-------	134
DUR	CPT	08:15:00	10:25:00	1T649	EQV	------7	134
DUR	CPT	09:00:00	11:10:00	1T651	EQV	-----6-	134
DUR	CPT	10:20:00	12:25:00	1T657	EQV	-2345--	134
DUR	CPT	13:25:00	15:35:00	1T655	EQV	1------	134
CPT	PLZ	11:40:00	12:50:00	1T708	EQV	1------	134
CPT	PLZ	14:30:00	15:40:00	1T706	EQV	--34---	134
CPT	PLZ	15:40:00	16:50:00	1T702	EQV	----5-7	134
CPT	JNB	06:45:00	08:45:00	1T100	EQV	1234567	134
CPT	JNB	08:20:00	10:20:00	1T118	EQV	----56-	134
CPT	JNB	09:00:00	11:00:00	1T138	EQV	------7	134
CPT	JNB	10:00:00	12:00:00	1T102	EQV	1234567	134
CPT	JNB	12:00:00	14:00:00	1T124	EQV	------7	134
CPT	JNB	12:20:00	14:20:00	1T104	EQV	123456-	134

FROM	TO	DEPART	ARRIVE	FLIGHT	AIRCRAFT	FREQUENCY	CAPACITY
CPT	JNB	13:55:00	15:55:00	1T136	EQV	----5--	134
CPT	JNB	14:10:00	16:10:00	1T134	EQV	-----6-	134
CPT	JNB	15:35:00	17:35:00	1T110	EQV	12345-7	134
CPT	JNB	16:40:00	18:40:00	1T106	EQV	1----6-	134
CPT	JNB	16:55:00	18:55:00	1T120	EQV	------7	134
CPT	JNB	18:00:00	20:00:00	1T112	EQV	12345-7	134
CPT	JNB	19:15:00	21:25:00	1T132	EQV	1-34---	134
CPT	JNB	20:15:00	22:15:00	1T140	EQV	---4---	134
CPT	JNB	21:20:00	23:20:00	1T116	EQV	----5-7	134
DUR	JNB	06:45:00	07:45:00	1T200	EQV	12345--	134
DUR	JNB	07:00:00	08:10:00	1T220	EQV	-----6-	134
DUR	JNB	08:45:00	09:55:00	1T210	EQV	-----6-	134
DUR	JNB	08:50:00	10:00:00	1T202	EQV	12345--	134
DUR	JNB	09:30:00	10:40:00	1T234	EQV	------7	134
DUR	JNB	10:40:00	11:50:00	1T223	EQV	-----6-	134
DUR	JNB	11:10:00	12:20:00	1T240	EQV	------7	134
DUR	JNB	13:20:00	14:30:00	1T204	EQV	12345--	134
DUR	JNB	13:40:00	14:50:00	1T238	EQV	------7	134
DUR	JNB	14:50:00	16:00:00	1T224	EQV	-----6-	134
DUR	JNB	15:00:00	16:10:00	1T208	EQV	------7	134
DUR	JNB	15:20:00	16:30:00	1T228	EQV	----5--	134
DUR	JNB	16:10:00	17:20:00	1T236	EQV	----5--	134
DUR	JNB	16:30:00	17:40:00	1T236	EQV	-234---	134
DUR	JNB	18:15:00	19:25:00	1T206	EQV	1234---	134
DUR	JNB	18:50:00	20:00:00	1T214	EQV	---45-7	134
DUR	JNB	20:00:00	21:10:00	1T232	EQV	----5--	134
DUR	JNB	21:30:00	22:40:00	1T230	EQV	------7	134
PLZ	JNB	13:05:00	14:55:00	1T506	EQV	-234---	134
PLZ	JNB	13:40:00	15:20:00	1T502	EQV	1------	134
PLZ	JNB	16:10:00	16:10:00	1T508	EQV	-----6-	134
PLZ	JNB	17:50:00	19:30:00	1T504	EQV	1--45-7	134
PLZ	JNB	19:40:00	21:20:00	1T510	EQV	----5-7	134
GRJ	JNB	10:45:00	12:45:00	1T822	EQV	1---5--	134
GRJ	JNB	11:45:00	13:35:00	1T822	EQV	-----6-	134
GRJ	JNB	12:25:00	14:15:00	1T828	EQV	---4---	134
GRJ	JNB	13:05:00	14:55:00	1T826	EQV	--3----	134
GRJ	JNB	14:55:00	16:45:00	1T824	EQV	-2-----	134
GRJ	JNB	15:30:00	17:20:00	1T834	EQV	------7	134
GRJ	JNB	18:15:00	20:05:00	1T830	EQV	----5-7	134
ELS	JNB	09:00:00	10:25:00	1T302	EQV	1--45--	134

FROM	TO	DEPART	ARRIVE	FLIGHT	AIRCRAFT	FREQUENCY	CAPACITY
ELS	JNB	11:30:00	12:50:00	1T320	EQV	------7	134
ELS	JNB	12:45:00	14:10:00	1T306	EQV	-----6-	134
ELS	JNB	15:10:00	16:35:00	1T318	EQV	---4---	134
ELS	JNB	15:50:00	17:15:00	1T322	EQV	------7	134
ELS	JNB	16:45:00	18:10:00	1T308	EQV	----5--	134
ELS	JNB	18:00:00	19:25:00	1T310	EQV	123----	134
ELS	CPT	11:30:00	13:00:00	1T607	EQV	---45--	134
ELS	CPT	13:00:00	14:30:00	1T605	EQV	1------	134
ELS	CPT	14:45:00	16:15:00	1T603	EQV	------7	134
CPT	DUR	10:40:00	12:40:00	1T656	EQV	1------	134
CPT	DUR	11:00:00	13:00:00	1T650	EQV	------7	134
CPT	DUR	12:00:00	13:55:00	1T652	EQV	-----6-	134
CPT	DUR	13:15:00	15:15:00	1T658	EQV	-2345--	134
PLZ	CPT	09:40:00	10:50:00	1T707	EQV	1------	134
PLZ	CPT	16:30:00	17:40:00	1T705	EQV	----5-6	134
PLZ	CPT	16:30:00	17:40:00	1T705	EQV	--34---	134

5.3.2.2. British Airways (Comair)

Includes B737-200's, B737-300's and B737-400's. Capacity is taken as the average of the average seat capacity

FROM	TO	DEPART	ARRIVE	FLIGHT	AIRCRAFT	FREQUENCY	CAPACITY
DUR	JNB	06:30:00	07:40:00	BA6200	737	12345--	138
JNB	DUR	07:00:00	08:10:00	BA6201	737	12345--	138
DUR	JNB	09:00:00	10:10:00	BA6202	737	12345--	138
JNB	DUR	09:00:00	10:10:00	BA6203	737	12345-7	138
JNB	DUR	14:15:00	15:25:00	BA6209	737	1234567	138
JNB	DUR	11:15:00	12:25:00	BA6211	737	1234567	138
DUR	JNB	19:45:00	20:55:00	BA6212	737	----5--	138
DUR	JNB	14:00:00	15:10:00	BA6214	737	1234567	138
DUR	JNB	16:00:00	17:10:00	BA6218	737	1234567	138
JNB	DUR	15:30:00	16:40:00	BA6219	737	12345-7	138
DUR	JNB	17:30:00	18:40:00	BA6220	737	12345-7	138
JNB	DUR	18:00:00	19:10:00	BA6221	737	12345-7	138
DUR	JNB	10:15:00	11:25:00	BA6224	737	123456-	138
DUR	JNB	12:00:00	13:10:00	BA6226	737	12345-	138
DUR	JNB	18:30:00	19:40:00	BA6228	737	------7	138
JNB	DUR	16:30:00	17:40:00	BA6229	737	12345-7	138
JNB	PLZ	06:30:00	08:10:00	BA6231	737	12345--	138
PLZ	JNB	06:30:00	08:10:00	BA6232	737	12345--	138
PLZ	JNB	18:00:00	19:40:00	BA6236	737	12345-7	138
JNB	PLZ	15:45:00	17:25:00	BA6237	737	1234567	138

FROM	TO	DEPART	ARRIVE	FLIGHT	AIRCRAFT	FREQUENCY	CAPACITY
PLZ	JNB	09:30:00	11:10:00	BA6238	737	1234567	138
JNB	PLZ	17:30:00	19:10:00	BA6239	737	12345-7	138
JNB	PLZ	11:10:00	12:50:00	BA6241	737	1234567	138
PLZ	JNB	13:25:00	15:05:00	BA6242	737	1234567	138
DUR	CPT	06:30:00	08:35:00	BA6300	737	12345--	138
CPT	DUR	06:30:00	08:25:00	BA6301	737	12345--	138
CPT	DUR	08:30:00	10:25:00	BA6303	737	-----6-	138
DUR	CPT	11:00:00	13:05:00	BA6304	737	-----6-	138
DUR	CPT	18:30:00	20:35:00	BA6306	737	12345--	138
CPT	DUR	11:30:00	13:25:00	BA6311	737	12345--	138
DUR	CPT	14:30:00	16:35:00	BA6312	737	12345-7	138
CPT	DUR	17:30:00	19:25:00	BA6313	737	12345-7	138
CPT	JNB	06:15:00	08:15:00	BA6400	737	12345--	138
CPT	JNB	08:00:00	10:00:00	BA6402	737	-----67	138
CPT	JNB	09:15:00	11:15:00	BA6406	737	1234567	138
JNB	CPT	19:00:00	21:10:00	BA6407	737	12345-7	138
JNB	CPT	10:40:00	12:50:00	BA6409	737	1234567	138
CPT	JNB	10:30:00	12:30:00	BA6410	737	1234567	138
JNB	CPT	07:00:00	09:10:00	BA6410	737	12345--	138
JNB	CPT	08:50:00	11:00:00	BA6411	737	1234567	138
CPT	JNB	12:00:00	14:00:00	BA6414	737	1234567	138
CPT	JNB	14:00:00	16:00:00	BA6416	737	1234567	138
JNB	CPT	12:30:00	14:40:00	BA6417	737	1234567	138
CPT	JNB	16:00:00	18:00:00	BA6418	737	1234567	138
JNB	CPT	14:00:00	16:10:00	BA6419	737	1234567	138
CPT	JNB	17:00:00	19:00:00	BA6422	737	1234567	138
CPT	JNB	07:00:00	09:00:00	BA6424	737	12345--	138
JNB	CPT	15:00:00	17:10:00	BA6425	737	12345-7	138
CPT	JNB	18:00:00	20:00:00	BA6426	737	12345-7	138
JNB	CPT	16:00:00	18:10:00	BA6427	737	1234567	138
CPT	JNB	07:30:00	09:30:00	BA6428	737	12345--	138
JNB	CPT	17:00:00	19:10:00	BA6429	737	12345-7	138
CPT	JNB	20:00:00	22:00:00	BA6430	737	12345--	138
JNB	CPT	18:00:00	20:10:00	BA6431	737	1234567	138
JNB	CPT	20:00:00	22:10:00	BA6435	737	12345--	138
CPT	JNB	19:00:00	21:00:00	BA6438	737	12345--	138
JNB	CPT	06:30:00	08:40:00	BA6441	737	12345--	138

Appendix C – Peak Day Calculations

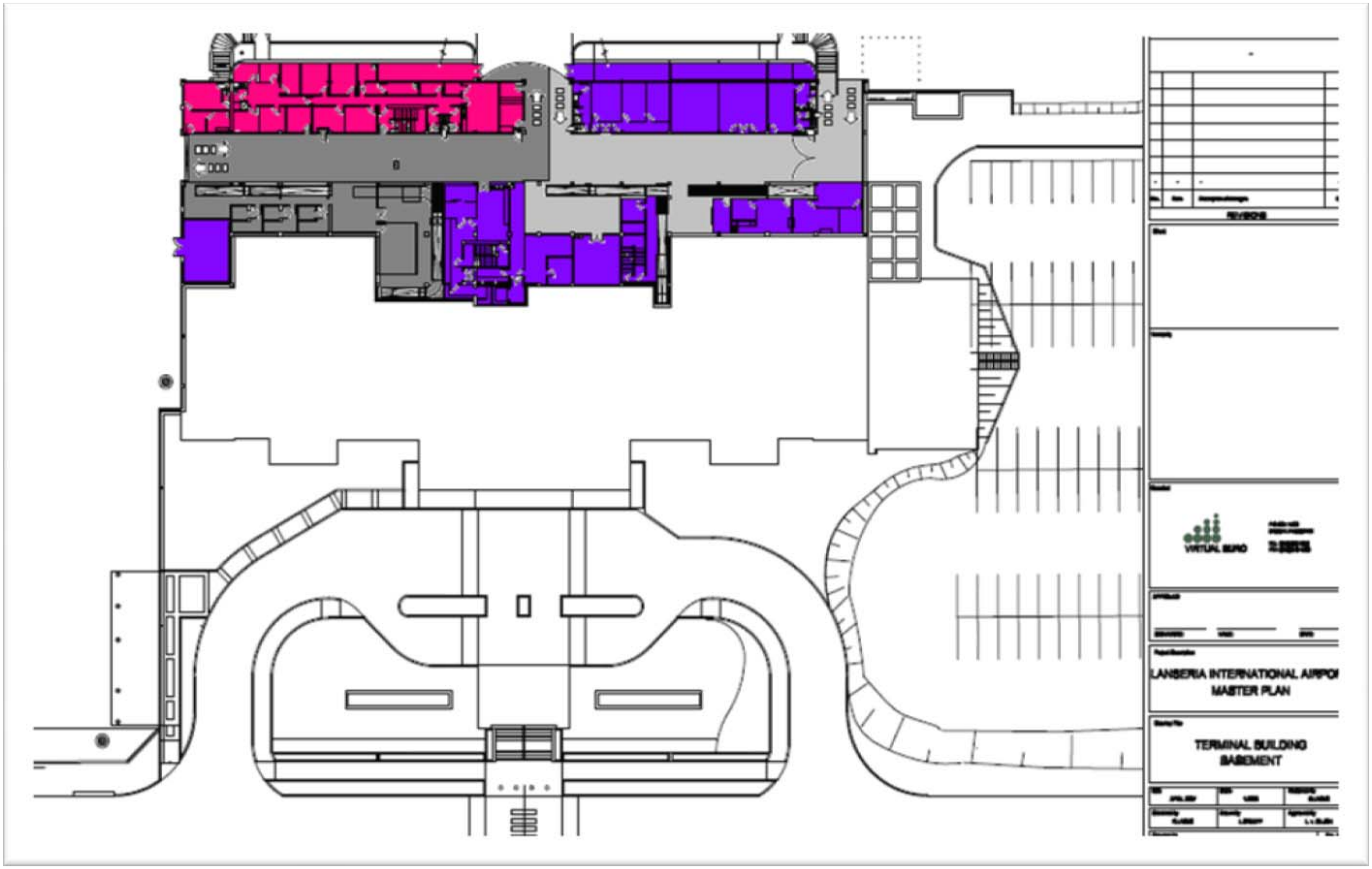
FROM	TO	AT HLA	FLIGHT	AIRCRAFT	FREQUENCY	CAPACITY	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
Domestic							1	2	3	4	5	6	7
HLA	GRJ	10:15:00	MN291	EQV	123----	140	140	140	140				
HLA	CPT	06:00:00	MN451	EQV	12345--	140	140	140	140	140	140		
HLA	CPT	14:45:00	MN461	EQV	----5--	140					140		
HLA	CPT	15:15:00	MN453	EQV	1234---	140	140	140	140	140			
HLA	CPT	16:55:00	MN459	EQV	------7	140							140
HLA	CPT	17:15:00	MN457	EQV	1234---	140	140	140	140	140			
HLA	CPT	19:45:00	MN455	EQV	----5--	140					140		
HLA	DUR	06:45:00	MN501	EQV	12345--	140	140	140	140	140	140		
HLA	DUR	10:15:00	MN503	EQV	----5--	140					140		
HLA	DUR	13:45:00	MN509	EQV	----5-7	140					140		140
HLA	DUR	16:30:00	MN505	EQV	1234---	140	140	140	140	140			
HLA	PLZ	09:00:00	MN301	EQV	1234---	140	140	140	140	140			
HLA	PLZ	10:00:00	MN303	EQV	----5--	140					140		
HLA	PLZ	12:30:00	MN305	EQV	------7	140							140
GRJ	HLA	14:55:00	MN290	EQV	123----	140	140	140	140				
CPT	HLA	08:15:00	MN450	EQV	12345--	140	140	140	140	140	140		
CPT	HLA	11:45:00	MN458	EQV	------7	140							140
CPT	HLA	14:30:00	MN454	EQV	1234---	140	140	140	140	140			

CPT	HLA	19:00:00	MN462	EQV	----5--	140					140		
CPT	HLA	20:15:00	MN452	EQV	1234---	140	140	140	140	140			
CPT	HLA	21:45:00	MN460	EQV	------7	140							140
DUR	HLA	09:40:00	MN502	EQV	12345--	140	140	140	140	140	140		
DUR	HLA	12:55:00	MN510	EQV	------7	140							140
DUR	HLA	13:10:00	MN504	EQV	----5--	140					140		
DUR	HLA	19:35:00	MN506	EQV	1234---	140	140	140	140	140			
DUR	HLA	20:40:00	MN512	EQV	------7	140							140
PLZ	HLA	16:40:00	MN302	EQV	1234---	140	140	140	140	140			
PLZ	HLA	14:05:00	MN304	EQV	----5--	140					140		
PLZ	HLA	16:20:00	MN306	EQV	------7	140							140
Total domestic passengers per day							**1960**	**1960**	**1960**	**1680**	**1680**	**0**	**1120**
International							1	2	3	4	5	6	7
HLA	MPM	06:25	TM 2356	J41	-----6-	29						29	
HLA	MPM	13:35	TM 2344	J41	1------	29	29						
HLA	MPM	15:50	TM 2342	J41	-2-----	29		29					
MPM	HLA	10:20	TM 2341	J41	-2-----	29		29					
MPM	HLA	13:05	TM 2345	J41	-----6-	29						29	
MPM	HLA	13:05	TM 2345	J41	1------	29	29						
HLA	VNX	10:50	TM 2340	J41	-2----	29		29					
HLA	VNX	13:35	TM 2348	J41	-----6-	29						29	
VNX	HLA	15:20	TM 2343	J41	-2----	29		29					
VNX	HLA	17:55	TM 2347	J41	-----6-	29						29	
Total international passengers per day							**58**	**116**	**0**	**0**	**0**	**116**	**0**

Appendix E – Floor Plans

	Bathroom
	Other
	Offices
	Shops
	Domestic Arrivals
	Domestic Departures
	International Arrivals
	International Departures
	Domestic Baggage
	International Baggage

Page Number	Floor
66	Basement
67	Ground Floor
68	Ground Floor Mezzanine
69	First Floor
70	First Floor Mezzanine
71	Second Floor
72	Second Floor Mezzanine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LANSERIA INTERNATIONAL AIRPO
MASTER PLAN
TERMINAL BUILDING
BASEMENT


BASIC PLANNING
VIRTUAL BURO
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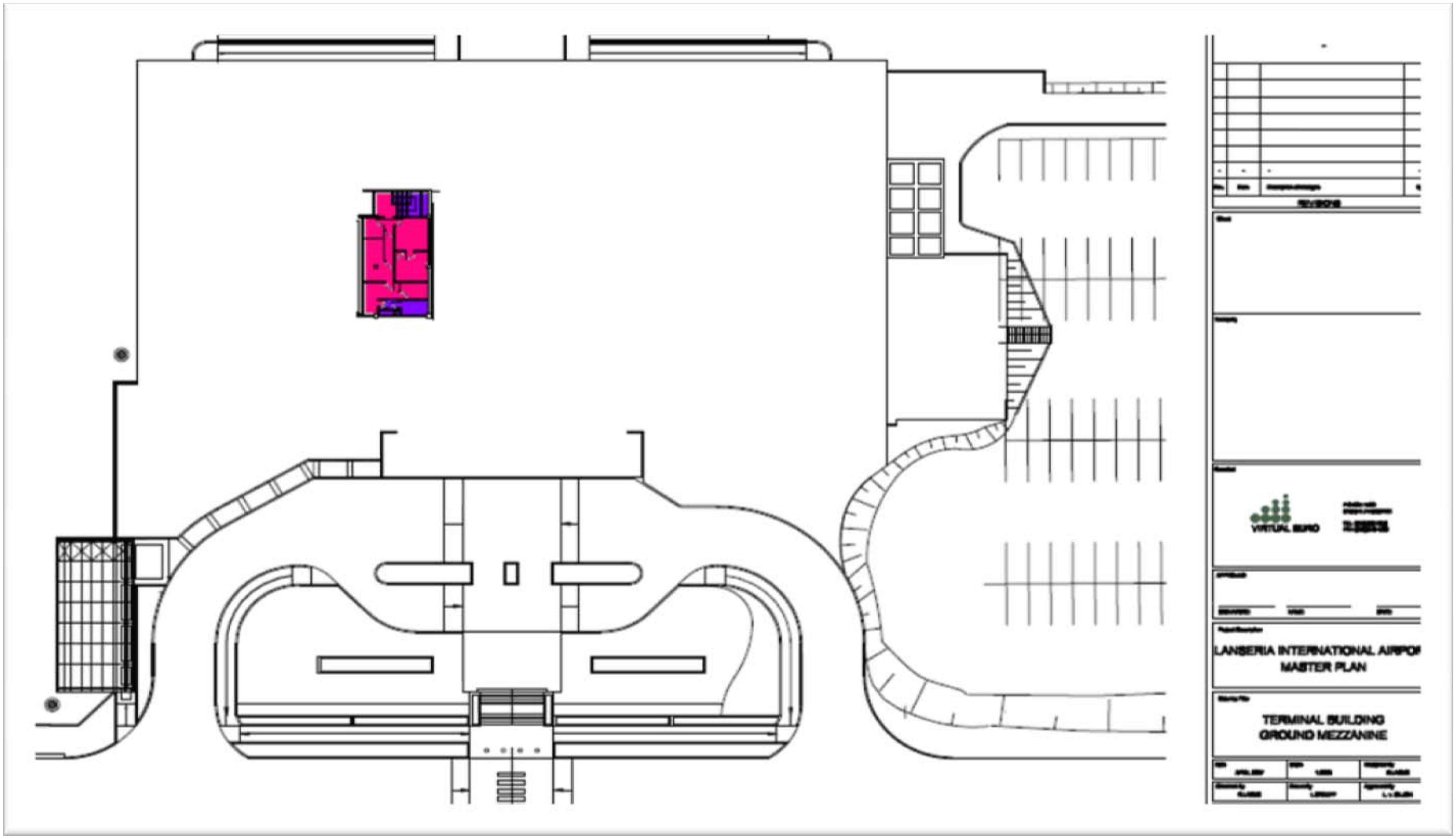
MASTER PLAN
TERMINAL BUILDING
GROUND FLOOR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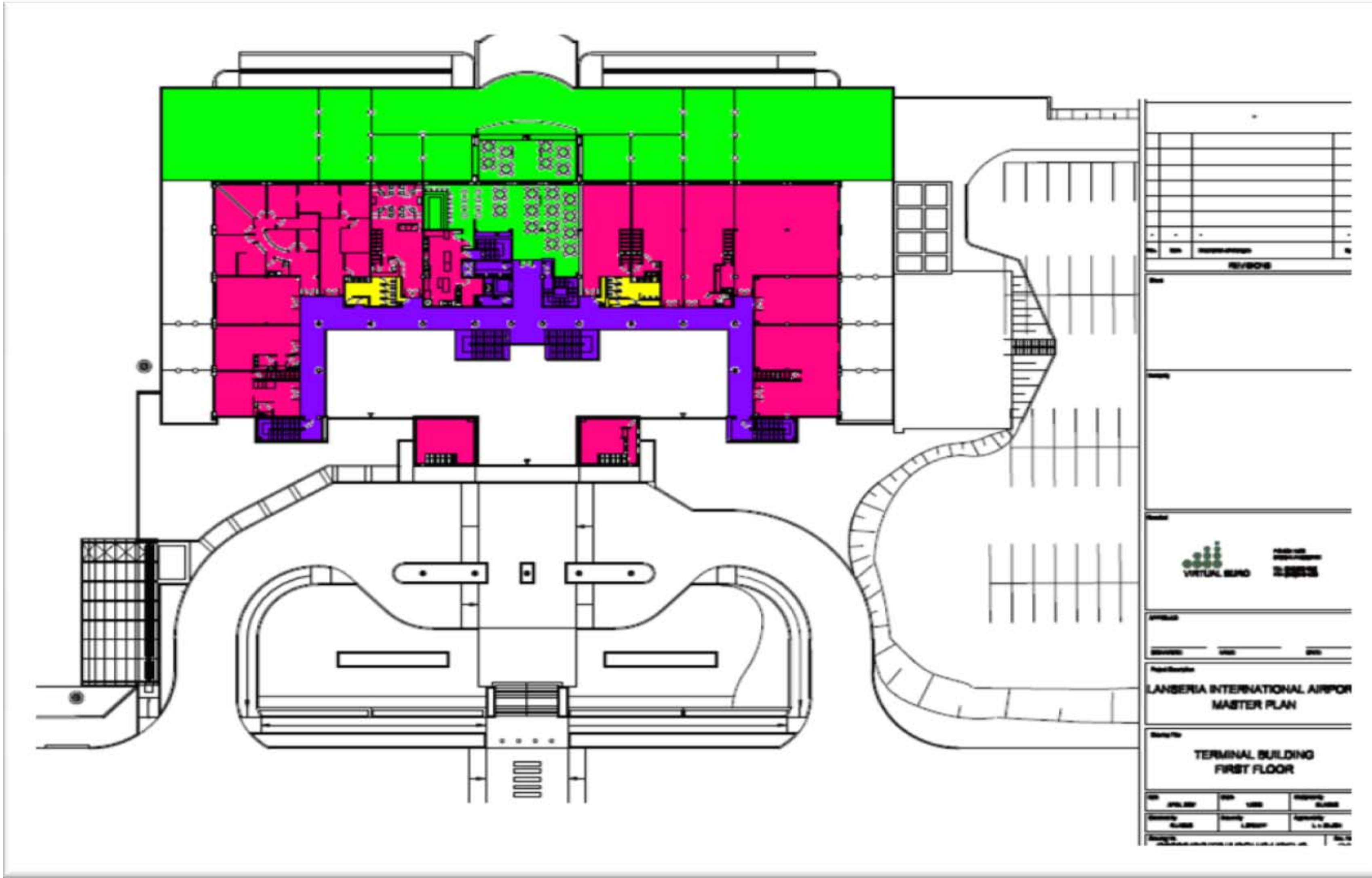
GROUND MEZZANINE


REVISIONS
VIRTUAL BURO
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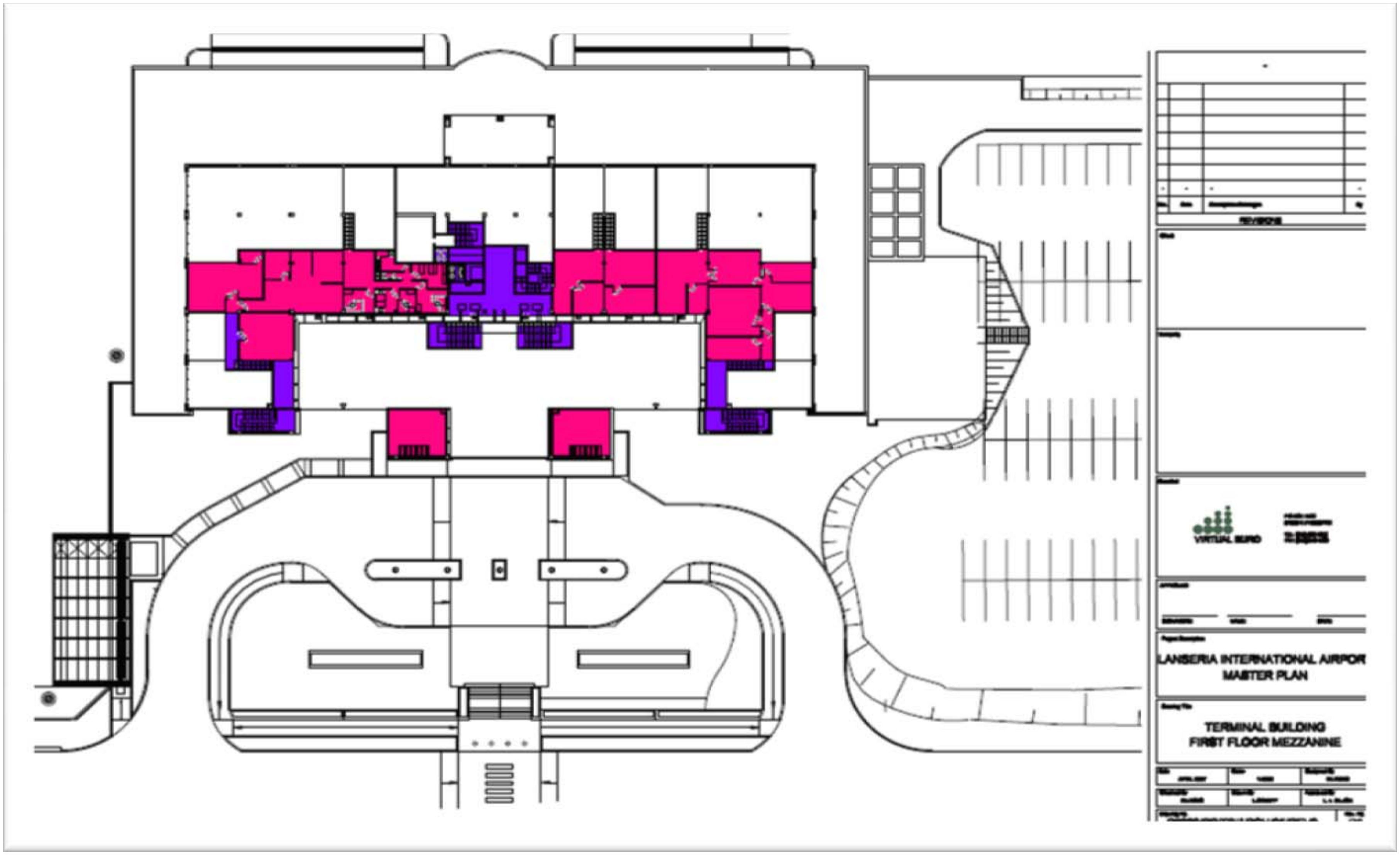
MASTER PLAN
TERMINAL BUILDING
FIRST FLOOR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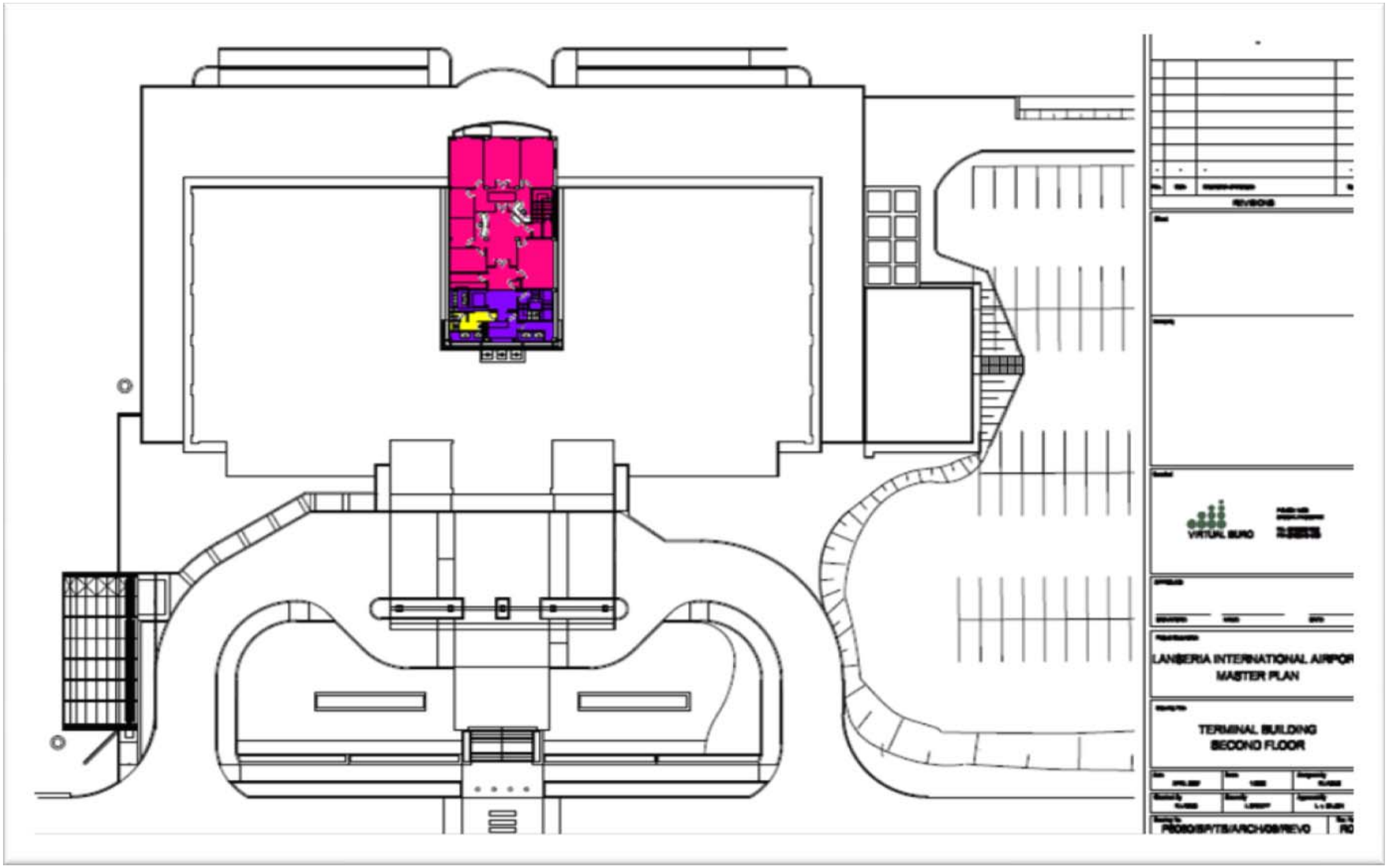
TERMINAL BUILDING
FIRST FLOOR MEZZANINE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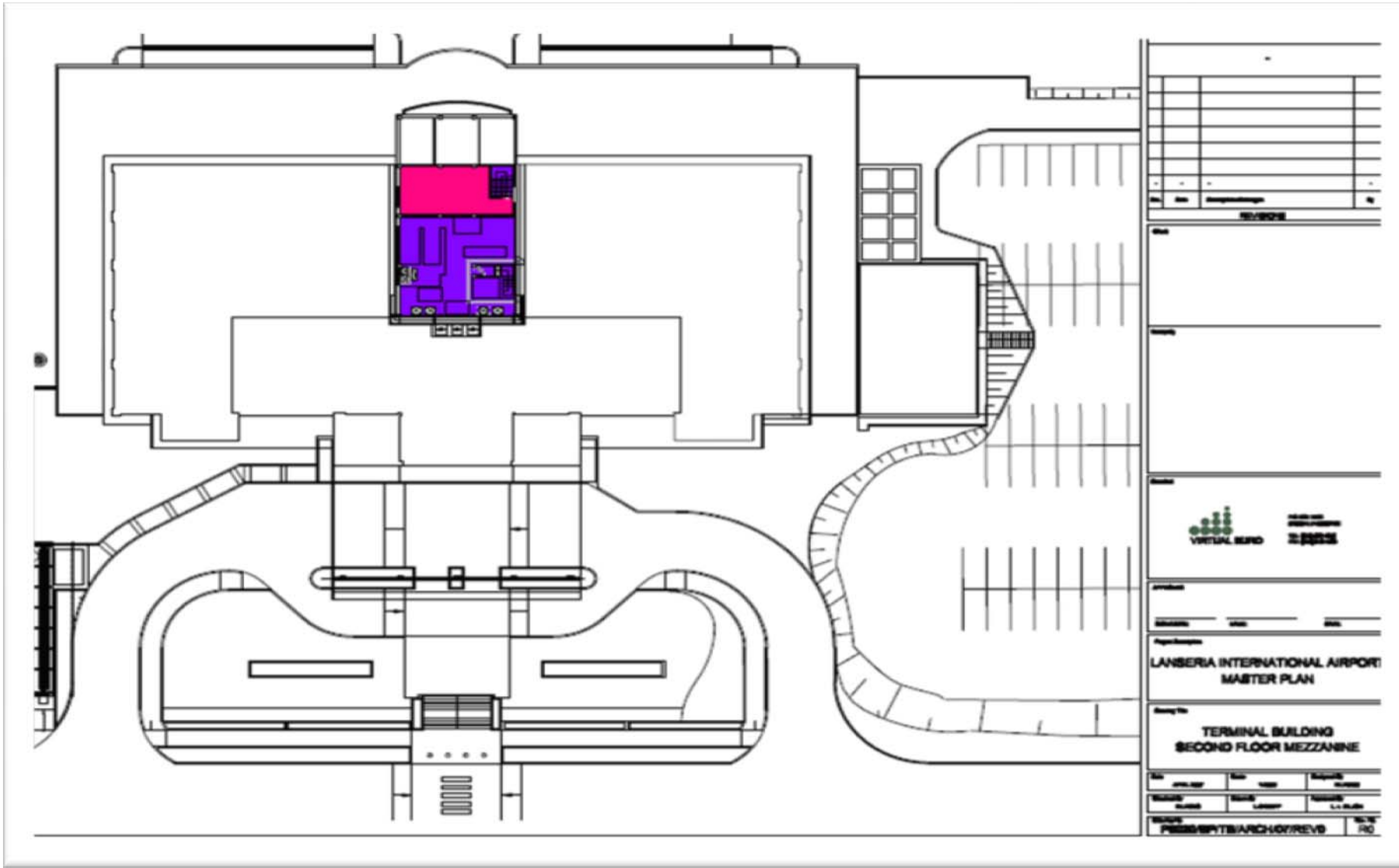
LANSERIA INTERNATIONAL AIRPOR
MASTER PLAN
TERMINAL BUILDING
SECOND FLOOR



VIRTUAL BURO
LANSERIA INTERNATIONAL AIRPORT
MASTER PLAN
TERMINAL BUILDING
SECOND FLOOR MEZZANINE
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Appendix G – Case study