Airport capacity analysis and configuration

by

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Executive Summary

Lanseria International Airport is being subjected to infrastructure upgrades to accommodate an increase in demand in passenger numbers. These demands will be fulfilled by other airlines that will be operating from Lanseria International Airport in the future. Before any agreements can be made Lanseria International Airport must perform an analysis in order to determine if such upgrade possibilities are feasible. This project focuses on the capacity analysis of the land and airside of Lanseria Airport. The analysis will determine the optimal number of aircraft operations that can be performed during peak hours without causing congestion and delays within the terminal or on the apron.

Simulation modeling will be used to address this problem. Simulation is a flexible technique that can be used to reflect real life situations as well as possible future solutions. These solutions can be evaluated according to time performance measures before the final decision is made. The arrival and departure processes of domestic flights will be modeled as well as the passenger flow throughout these processes. The type of data needed for the model as well as methods for determining these data is described. Different scenarios will be described and evaluated in the simulation model in order to eliminate bottlenecks in the system. This project will provide quantitative information about the number of aircraft operations that can be accommodated as well as the resources required. The results will serve as decision support for the managers of Lanseria International Airport.

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1. Introduction

1.1 Lanseria International Airport

In 1972 Fanie Haacke and Abe Sher, both pilots at the time, saw an opportunity to identify the ideal site for what it is known today as Lanseria International Airport. Hannes Rall, the Minister of Transport in 1974 opened Lanseria International Airport to air traffic on 16 August 1974. From 1979 to 1991 Lanseria was the base for the 4 Impala Squadron and 41 Reconnaissance Squadron which was one of South Africa's foremost reconnaissance squadrons. Today Lanseria International Airport is privately owned by a consortium of investors. The airport is situated ten kilometers north-west of Johannesburg.

Lanseria International airport handles upwards of 300 aircraft movements daily. Although the airport mainly caters for general aviation it has recently seen an increase in its commercial passenger flights. The airport processed more than 170, 000 passengers pass through it in 2006 and these numbers have since increased.

There are a number of airlines operating from Lanseria, with the best known being Kulula Air. They offer daily flights to and from Cape Town and Durban. Kulula Air is the only airline operating scheduled flights from Lanseria International Airport. The reason for the low operating capacity at Lanseia International Airport is that Kulula Air does not have available aircraft in their fleet to accommodate an increase in demand. However, other airlines are also now interested in operating from Lanseria International Airport. This will lead to more aircraft operations per day. This presents the purpose for this project: To determine if the airport can accommodate this increase in airport operations and if so, how many more aircraft operations can be accommodated. Lanseria has a single, centralized terminal building that handles passengers, baggage, visitors and personnel.

1.2 Overview of airport functionality

An airport system consists of many integrated components (figure 1) to provide facilities and services for air transportation.

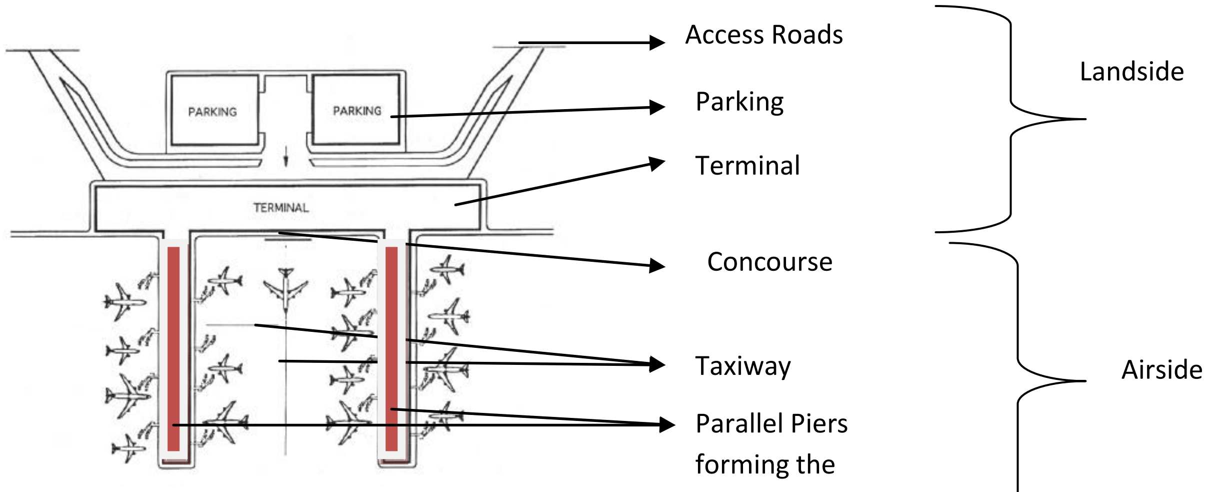


Figure1: Layout of Airport

The airport can be divided into two areas, namely landside and airside. Landside includes the access roads, parking facilities and the terminal. The airside includes the runway, taxiway and the apron, Masoumi (2004). The taxiway is the route an airplane follows from the runway to the correct parking bay on the apron. The apron is the physical and functional aspect of the terminal. It is where enplaning and deplaning occurs. The concourse is the interface between the main terminal and the aircraft.

1.3 Elements of an airport

The airport environment is complex with various elements and operations. Each of these elements and operations needs to be carefully considered when designing for an airport in order to achieve an optimal result.

1.3.1 The Passenger Terminal Concept

The passenger terminal design influences the performance and profitability of the airport. It has an effect on the walking distance of passengers, aircraft maneuvering delays, transfer volumes and construction cost to mention a few. The terminal concept can be divided into four groups: pier, linear, satellite and transporter, Pitt (2001).The apron at Lanseria International Airport is designed in the form of a linear configuration as described by figure 2. In the linear concept, aircraft are park in a linear manner along the terminal.

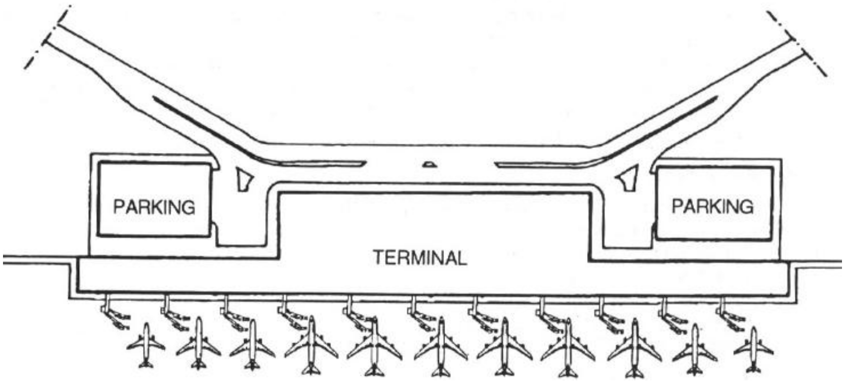


Figure 2. Centralized terminal with linear apron configuration.

1.3.2 Passengers

Passengers can be classified into three categories. First, originating passengers are passengers that are travelling from Lanseria International Airport to another destination. Secondly, terminating passengers are passengers that are travelling to Lanseria International airport. Finally transfer passengers are passengers that are changing from one airplane to another in order to reach their final destination. The type of passenger has an effect on the amount of time that the passenger spends in the airport system.

1.3.4 Baggage

Svrcek(1994) explains that in air transport, baggage is separated from the passenger during the duration of the trip. It is essential that the separation and reuniting of baggage and passenger be done with maximum efficiency and reliability. Unlike passengers, baggage is not inconvenienced when travelling long distances. The travelling distance is directly influenced by the geometry of the passenger terminal building.

1.3.5 Runway and Taxiways

The layout of the runways and taxiways directly affects an airfield's capacity. Aircraft use runways to land and depart at an airport. The location and orientation of the runways are not the main concern but the percent of time that a particular runway or combination of runways is in use and the length, width, weight bearing capacity, and instrument approach capability of each runway at the airport . All these parameters determine which type of aircraft may operate on the runway. Taxiways have also significant impact on airside capacity. They provide, in addition to the access between terminals and runways, safe and efficient use of the airside. Exit taxiways in particular are of considerable magnitude since the number and location of exits directly determines the runway occupancy time of an aircraft. For aircraft departures, aircraft wait on a taxiway and can't enter the runway, accelerate and take off before instructions are delivered.

2. Project Aim

The aim of this project is to determine the maximum capacity of the airport with regards to the amount of passengers that can be processed and the number of aircraft operations that can be performed.

3. Project Rationale

Gauteng has experienced incredible growth over the years, which has resulted in the demand for better infrastructure to accommodate the expansion. As part of The City of Johannesburg's Department of Economic Development's strategy for infrastructure development, they have identified aviation infrastructure, especially airport infrastructure, as an important aspect to improve in order to facilitate and accommodate economic growth.

Given the location and expansion possibilities, Lanseria International Airport has been identified as the optimal choice for expansion within the City of Johannesburg for infrastructure development. The expected growth at Lanseria International Airport may be close to or more than the airport's capacity, which in turn will lead to congestion and delay. The consequences for the airport industry, as well as the traveling public, are greater inconvenience, higher costs and a decline in quality.

This project is aimed at the design phase of the development process and focuses on the capacity available at the airport for passengers and aircraft. The capacity influences the number of aircraft that can be accommodated as well as the processing time of the passengers and the handling of baggage. Passenger convenience, cost and time associated with the operations at an airport are the key performance measures that will be used for the evaluation of different alternatives during this project. When it is completed this project will present a solution to the capacity requirements at the airport.

4. Project Scope

4.1 Included in Scope

Airport operations are centered on three major elements. These include passengers, baggage and aircraft. It is the aim of every airport to have these three flow efficiently and uninterrupted in and out of the airport. The passenger terminal building is the place where all three these elements come together. In order to determine how to efficiently operate the airport, the project will be divided into two parts, an analysis of the airside as well as an analysis of the landside.

Airside:

It is necessary to determine the maximum capacity of the runway, therefore to determine how many aircraft operations can be accommodated given certain constraints. The airport parking and apron space may be a constraint during busy hours. Its reported capacity of 21 medium aircraft and up to 74 small aircraft may not be adequate considering that most of the parking bays may be in use by operators based at the airport. The high general aviation activity necessitates parking and apron management. The capacity of apron services needs to be verified and improved (if necessary) to match the apron bay and parking capacity for rapid turnaround of aircraft. This will reduce bay occupancy time through rapid services and turnaround.

Landside:

Within the terminal building, passengers and baggage are subjected to various processes. The operation of these processes, with regards to passengers and baggage, lead to congestion and in turn delays occur within the terminal building. Therefore it is necessary to compute the terminal capacity to determine the maximum passengers and baggage that can be accommodated without causing delays.

Firstly, the As-Is situation of the terminal will be modeled. This refers to the flow of passengers through the various processes in the terminal. An analysis of the situation will identify bottlenecks in the system. Secondly, an optimal To-Be situation will be determined by modeling different feasible scenarios of change for the current system.

4.2 Excluded from Scope

This process will focus on the domestic arrivals and departures of aircraft at Lanseria International Airport. International flights will not be addressed due to the random nature of International flights at Lanseria International Airports. There are no scheduled international flights and the aircraft type and load factors differ incalculably. Secondly, this project will not address the design of the layout of the terminal with regards to restaurants and other facilities inside the main terminal, as these are secondary issues.

4.3 Constraints

Lanseria International Airport is privately owned, however it has to comply with international standards and regulations.
Regulations and restrictions with regards to this project include the following:
Departing passengers and their baggage should be subjected to security scans.
Hand luggage can only be a certain size.

5. Literature study

This literature review reveals various decision support techniques for the analysis of an airport. The motivation for this study is to determine an appropriate method to solve the capacity analysis problem presented with at Lanseria International Airport. The different elements completed in this literature study can be illustrated using the breakdown structure shown in Figure 2.

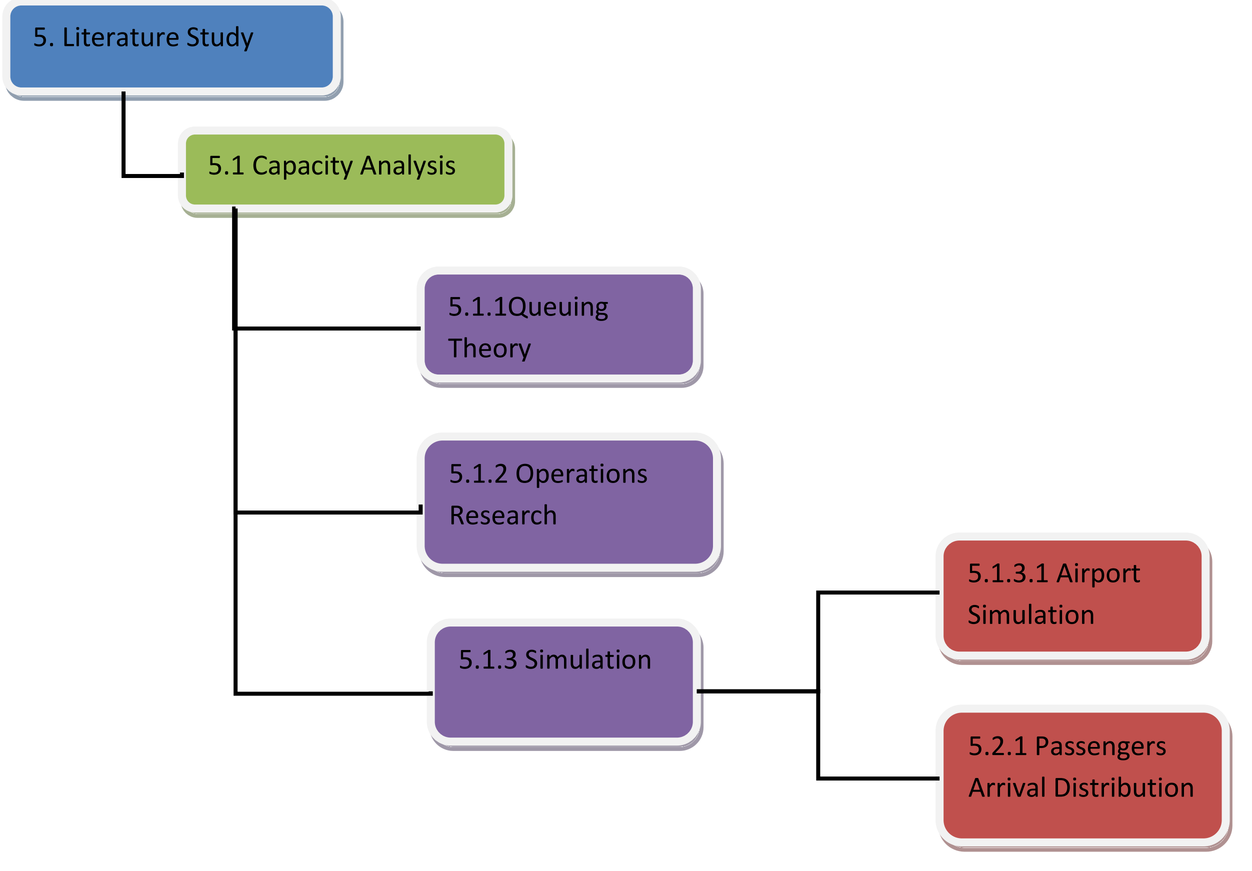


Figure 3: Literature Study Structure

5.1.1 Queuing Theory

Queuing Theory has been widely applied within the airport system to optimize processes. Analyzing a system using queuing theory provides insight into the queue lengths and waiting times. The arrival rate, service rate and the number of servers are all that is required to analyze a system using queuing theory. According to Livesey et al (2003) a queuing model is essentially concerned with the input process and service mechanism of the system. The input process at an airport is a combination of the time when passengers arrive before their departure and the number of bags that a passenger checks in. The service mechanism is

“first-come, first-served,” so the order of bags checked is conserved through the screening process. Queuing models allow the input process to follow any probabilistic distribution. Park et al (2003) proposed a *M/M/n* queuing model. The first *M* stands for a Poisson-type passenger arrival flow, the second *M* for exponential service time, and *n* is the number of service counters. This model computes the total waiting time of passengers, given the cumulative arrival function at the check-in counter and the service rate for each time period.
According to Odoni & Naufville (2002) this method has not proven efficient for design, mainly because airports are never essentially in a steady state condition and queues are often undisciplined. Other problems associated with queuing theory as mentioned by W. David Kelton (2007) are the following:

- The estimates of the service and arrival rates aren’t exact.
- The formulas don’t provide any information on the natural variability in the system

5.1.2 Operations research

Operations Research is a method used to produce quantative results for a certain situation. Svrcek (1994) argues that earlier work done to minimize passenger travel distance was approached through linear programming models. Linear programming provides the analyst with the option of minimizing or maximizing a selected performance measure. For passenger terminal design, the main objective is to minimize passenger walking distances and the time a passengers spends in the terminal. These are feasible objective functions for a linear program. However, in the airport environment there are many uncertain and random factors which make it difficult to determine a mathematical model which will accurately represent the system. Fernandes (2002) utilized Data Envelopment Analysis (DEA) to study the need for airport enlargement and improvement to contemplate future demand scenarios. This procedure is a mathematical technique based on linear programming.

When cost is the determining performance measure, it is possible to set up a mathematical equation which will evaluate the options and determine the options that results in the lowest cost (Yanbing Ju, 2004). Analytical modeling of passenger flow in airport terminals under transient demand patterns is especially difficult due to the complex structure of a terminal. Therefore studies in this area either do not account for expandability or focus only on one particular area of the terminal.

5.1.3 Simulation

Simulation has been found to be one of the most effective management sciences. Simulation can be applied in various functional areas. A survey conducted by Watson, (1983) showed that simulation is applied in the following functional areas: Production, Corporate Planning, Engineering, Finance, Research and Development, Marketing, Data Processing and Personnel. H.A. Reijers (1999) stated that simulation can be used for strategic decision making. It is used to determine the long term effect of certain decisions.

A simulation model makes it possible to examine the effect of possible actions or decisions. A model will always represent a simplified version of reality. A simulation model describes a system, the interaction among processes, people, resources and objects present in the system that is modeled. It provides an understanding of complex systems and helps in various stages of a development process. Whether doing design or testing, simulation modeling can be applied. (Liene Freivalde, 2008).

There are many benefits when working with simulation. When compared to other methodologies, simulation is more comprehensive in terms of design elements, the measures of performance and the expansion possibilities (Masoumi, 2004). The simulation approach of analyzing a model, as opposed to the analytical approach, provides more flexibility and convenience.

Simulation modeling has different aspects. The following is a graphical representation of a simulation categorization as adapted from work done by Steve Park and Larry Leemis on discrete event simulation.

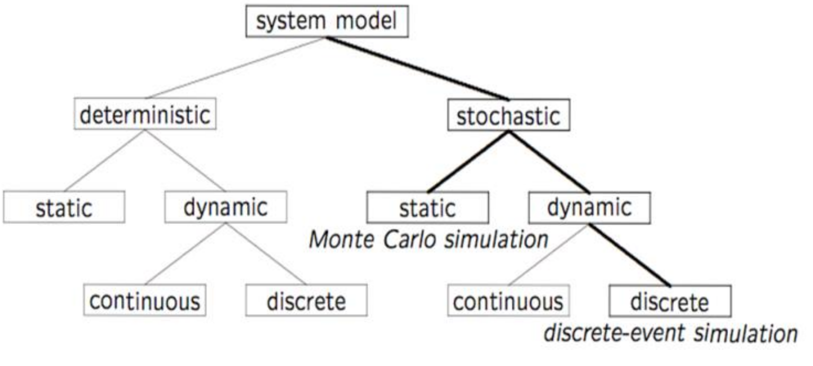


Figure 4. Categorization of a simulation model

The simulation model can be decomposed into a hierarchical structure. The top level represents simulation model. The second level is a choice between deterministic or stochastic modeling. A deterministic model is one in which the variables are determinable according to certain parameters, whereas with stochastic models, randomness is present and therefore the variables are described by probability distributions. The final decomposition is between continuous and discrete modeling. In discrete event simulation, the system is represented as a sequence of events. With the occurance of each event the state of the system changes. Continuous simulation can be defined as the modeling of a system over a period of time in which variables change continuously with respect to time, (Wouter Duivesteijn, 2006). According to Reijers et al, (1999) discrete event simulation can be divided into two parts. The one being terminating, which means that there is a definite start and end to the simulation model. The other is non-terminating discrete event simulation. This type of simulation model wil continue for as long as is specified by the analyst. The results obtained from such an anlysis will yield the steady state behaviour of the process. Matloff, (2008) described three paradigms associated with discrete event simulation. The first is the activity-oriented paradigm in which the model evaluates activities with small increments of time to observe the long run averages of performance measures. This simulation will be very slow due to the small increments in time, further this may lead to no state changes of the system for exmple there will be no new entries for a specific time period. The second paradigm is the event-oriented paradigm which implies that with every new time period a new event is generated. The event-oriented approach provides easy implementation, fast execution speed and flexibility. The third paradigm is the process-oriented paradigm. This paradigm states that each activity is based on a process.

5.1.3.1 Airport Simulation:

Assessment of possibilities is difficult in real life, since it corresponds to changing operational procedures and future traffic characteristics. It is therefore important to have sophisticated simulation tools in place to aid decision support. The simulation model is able to quantify and illustrate the implications for passenger service and operational performance of accommodating an airline schedule through terminal facilities. Airport simulation has the characteristics of a discrete event and stochastic simulation model.

Valentin et al, (2002) states that simulation is particularly useful in the airport environment. The processes are complex, stochastic and involve many moving objects. Simulation has been applied for the following topics to name a few:

- Airstrip management and taxiing
- Airport gate planning

- Airport terminal and passenger modeling
- Airport baggage handling
- Interterminal passenger transport

The reasons for using simulation in the airport environment as described by Michel R. Gatersleben, (1999) are the following:

- Process Interdependancy: the passengers move from one process to another in a systematic manner.
- Dynamics: The state of the airport is constantly changing due to flight arrivals and departures.
- Future Scenarios: The effect of increased demand or new developments can be examined in advance.
- Evaluation of solutions: To determine if a solution will be feasible within the airport environment, simulation modeling makes testing of solutions possible.

Numerous studies and work have been done on the subject of airport modeling. As mentioned by Valentin et al,(2002) the time spent by passengers to reach the end of an area can be determined by simulation modeling. They also argue that the use of simulation modeling for determining the separation between infrastructures makes the modeling of complex airports easy.

Ju et al, (2002) researched the airport waiting room using Arena 9.01. The purpose of their research was to determine the effect of different infrastructure design options and the benefits that these possibilities could yield. The simulation model presented them with answers to whether the waitng room can meet the requirements.

The entire terminal proces have been simulated by Tomoki Oyama, (2003) to examine passenger flows for international departures. They first examined the service time of each of the processes in the terminal. Then they examined the waiting time passengers spend waiting for service.

Airport simulation modeling as employed by Pendergraft et al, (2004) is a good benchmark for attempting airport simulation. They first modelled a baseline (As-Is) situation. The baseline model was used as a foundations for experimenting with alternatives designs. In order to create such models they went through a three step process. The first step is Process Decomposition. The purpose of this step is to determine all the activities involed in terminal operations. These activities will serve as the foundation for the baseline model. The second step is to determine Process Times and Percentages. Processing times of the activities determined in the first step are collected. The percentages refers to the percentage of time that a certain situation occurs within a process. The final step is determining the distribution of customer arrivals. The determining factor for the passenger arrival pattern is passenger arrival behaviour, which represents how early a passenger arrives for the flight.

The check-in process of the airport terminal has been modeled and examined by Appelt et al, (2007).The goal of their study was to determine delays and solutions to improve efficiency. There are peak times associated with aircraft operations. It was established that delays occur during these peak hours.

Data collection is also an important aspect in simulation modeling for accurately representing the actual system. The data that were collected included inter arrival times, time spent in queue, service times, party size, number of bags, number of employees servicing a customer and the number of check-in counters. Party size and the number of bags passengers are checking in presents various possibilities that can occur at the check-in counter with respect to the service time. The simulation should account for all these possibilities. Arena software was used for building the simulations. Various building blocks are available in Arena to model a process. As utilized by Appelt et al, (2007) the decision block can accommodate the possibilities presented at the check-in counter. Passengers are assigned a specific service time according to their attributes with regards to party size and the number of bags they are carrying.
A project by Gatersleben et al, (1999) focuses on the analysis and redesign of passenger handling in a terminal building. Dynamic modeling plays an important role in this project. Their investigation can be divided into two aspects. First the airport resources that is used during operations. These resources refer to the number of check-in counters, employees, baggage handling belts, etc. Secondly the flow of passengers through the terminal and the time associated with it. The simulation model which represent passenger movements from check-in to boarding and from deplaning to baggage reclaim was modeled in Arena. The model incorporated all the resources and processing times for all the activities involved. Performance indicators for the system include resource utilization, the number of passengers in all waiting areas, process times, waiting times and queue lengths.

A study done by James, (2009) addressed facility related decision problems of airports. In order to solve this problem, they categorized all the airport aspects involved in the decision making into three categories, namely, fixed facilities which are fixed to a position, variable facilities which can be deployed to where it is needed and transient entities which are items that move through the system. The table below shows the allocation of the airport aspects into the various categories.

Items	Airport Terminal
Fixed Facilities	Runway Parking Bayes Terminal Space
Variable Facilities	X-ray machines Check-in counters Immigration counters
Transient Entities	Passengers Flights Baggage

Table 1: Allocation of Airport Aspects into various categories

Discrete-Event Simulation models were developed based on each of these categories, therefore problems associated with every category could be resolved.

As seen from these previous studies, simulation is an effective method for solving airport related difficulties. Therefore simulation modeling will be applied as a decision support technique in order to solve the capacity problem at Lanseria International Airport.

5.1.3.2 Passengers Arrival Distribution

Simulation modeling requires accurate data in order to reflect a real life situation. One of the difficulties in modeling an airport system is the estimation of passenger arrival rates. The passenger arrival distribution pattern is the rate at which enplaning passengers arrive at check-in counters for processing. As concluded by McComas (1990) interarrival times are often modelled using an exponential distribution. Chun et al (1999) identifies that passenger arrival rates will depend on many factors such as the time of departure and the destination of the flight. The passenger arrival rate is a nonstationary distribution with more passengers arriving during the middle part of the check-in counter opening period. In their simulation model, they used a passenger turn-up profile to generate the passenger arrival rates using an exponential distribution with time-varying mean. The passenger turn-up profile records the portion of passengers out of the total average load of a flight that will turn-up in each time interval within the check-in duration. The number of time intervals depends on the check-in duration. For domestic flights at Lanseria International Airport the check-in counters open two hours prior to the departure time. Rauch et al (2006) also used actual observed data to estimate the arrival distributions of passengers. An analysis of the observed data showed that the arrival rate of passengers is a function of time. Statistical software can be used to fit the data to the most useful analytical distribution. Livesey et al (2003) modelled the passenger arrival numbers using a normal distribution. They recorded passenger arrival figures varying from 45 to 120 min prior to departure of peak hour flights. Gilliam (1979) also determined that passenger arrivals can be modelled by a normal distribution.

6. Final solution

6.1 Introduction

According to Solak et al (2009), the airport terminal capacity planning problem deals with determining the optimal design and expansion capacities for different areas of the terminal in the presence of uncertainty with regards to future demand levels. This, together with the urgent need to better use assets, handle more flights and quickly respond to delays in order to meet passenger needs, is the purpose of the solution. Liene Freivalde (2008) suggests that congestions and delays at an airport are the result of ineffective management of passenger flows in the airport terminals. Airport capacity analysis covers all the above mentioned factors and will therefore be the focus for this solution. Airport capacity analysis are undertaken for two purposes: firstly to measure objectively the capability of various components of an airport system for handling passenger and aircraft flows and secondly to estimate the delays experienced in the system at different levels of demand.

As mentioned in the literature study, simulation is a process of building a model of a system and conducting experiments on that system to determine the performance of the system under varying conditions. In order to provide an analysis of existing and future airport facilities, given that real life testing is expensive or not possible, computer simulation modeling techniques were used as a solution to the problem. Arena version 10.00 from Rockwell Software was used to model the airport system. According to Chun et al (1999), a simulation project involves many complex activities including collecting data, building models, executing simulations, generating alternatives, analyzing outputs and presenting results as well as making and implementing recommendations based on the results. The following is a graphical representation of the simulation cycle.

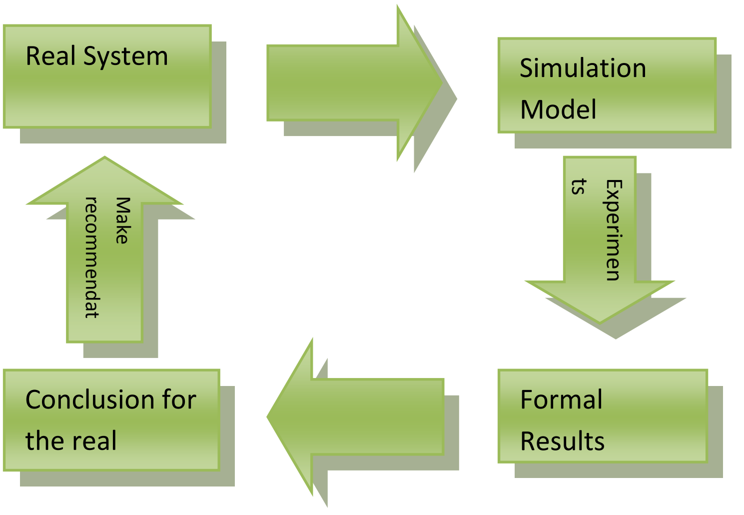


Figure 5: Simulation Cycle

The following was the objectives of the simulation model:

- to determine maximum capacity of Lanseria International Airport with respect to aircraft and passengers operations.
- to find the bottlenecks in the system.
- to analyze the existing passenger flows.
- to model different future possibilities of aircraft and passenger movements.

6.2 Data Collection

R. Rauch(2006) points out the fact that simulation studies require an exact description of processes and representative data. Therefore correct data is essential to get valid and valuable results about bottlenecks and to define relevant scenarios.

6.2.1Methodologies

Various methodologies have been applied in the data collection phase. The four main processes used are:

- Observation
- Time studies
- Discussing the problem with managers and other experts in the field

6.2.1.1Observation

Gatersleben et al (1999) states that the first step of a project should be to understand and describe the current situation completely, as it yields a reference for model validation. All processes included in the landside as well as the airside operations have been observed to gain insight into the passenger, baggage and aircraft flows. Observations were scheduled over a time period of three weeks and an effort was made to cover the operating hours between 06:30 and 17:00.

6.2.1.2Time Studies

Time studies were used to determine passenger arrival rates, processing times of the check-in and security processes, boarding times, aircraft turnaround times and other time related inputs needed for the simulation model.

6.2.1.3Expert Personnel

Personnel at Lanseria International Airport were consulted and interviewed and provided information with regards to flight schedules, operational procedures and the distribution and classification of flights and passenger.

The work of David R. Pendergraft, (2004) will be used as a framework for collecting the required data. The first aspect of the simulation model is to determine the As-Is (baseline) system. As referenced in the literature study, a three step process was used of which the steps include:

- Process Decomposition
- Process times and Persentages
- Distribution of Arrivals and Departures

6.2.2 Process Decomposition

There are two processes present in the airport system, the arrival and the departure process. Passengers, baggage and aircraft are present in arrival departure processes and can thus be seen as actors in the system. Each actor has an influence on the system but their actions and operations differ throughout the processes involved in the system. Their operations will be described separately in order to provide a better understanding of how the airport system operates.

6.2.2.1 Passengers

Passenger flow has an impact on the landside capacity with respect to the terminal building. The domestic arrival process consists of the following activities: Passengers arrive at Lanseria International Airport on the airside. After deplaning they enter the terminal (landside) through a door connected to the airside. Once inside the terminal the passengers proceed to the carousel for baggage reclaim. When passengers have collected their luggage they exit the terminal building.

The domestic departure process is more complex than the arrival process because of the extra activities involved. Passenger flow for the departure process originates at the landside. The process starts with passengers arriving at the check-in process prior to their flight. After the check-in process passengers proceed to the security check. Then they move into the waiting area before boarding the aircraft.

6.2.2.2 Aircraft

Aircraft operations influence the airside capacity. Runway capacity is normally the deciding factor for determining the airside capacity. Factors affecting runway capacity include the characteristics of demand and the layout and design of the runway system, (Wright, 1992). With respect to Lanseria International Airport the demand characteristics include the touch and go operations of the scheduled aircraft. This means that an aircraft will depart again right after all the necessary services have been completed and the passengers have boarded the aircraft. Another characteristic is the percentage of aircraft operations that are arrivals and departures. The runway system of Lanseria International Airport operates on a single runway. This implies that arrivals and departures are operated from the same runway.
Aircraft, whether arriving or departing, occupy the runway for a certain amount of time. During this time other aircraft can’t utilize the runway. The arriving process of an aircraft can be described by the following: The aircraft touches down on the runway. From there it proceeds to an available parking bay close to terminal via various taxiways. While stationed at the parking bay, the aircraft undergoes various operations after which it departs again. However during peak arrival periods the runway capacity may be exceeded and many flights would not be given landing clearance. Thus, aircraft would have to “hold” until they receive landing clearance from local Air Traffic Control Tower (ATCT). The holding period introduces flight delay and costly fuel expenditure for the airline. As flights arrive during a particular holding period, the queue of flights awaiting landing clearance begins to grow. Each arrival flight takes turn, in a First-In-First-Out (FIFO) manner, to access the runway. If arriving flights enter the terminal airspace of their destination airport without an available runway for landing, they will observe a cycling process around the local air space until landing clearance is issued by the ATCT. The departure process is much simpler because after passengers have boarded the aircraft the plane proceeds to the runway to take off.

6.2.2.3 Baggage

The baggage handling system can also be modeled as arrival and departure processes. The arrival process starts at check-in. The baggage is weighed and tagged (a label containing the details of the passenger and flight is attached to the bag) after which it is placed on a conveyor belt which transports the baggage to the basement. While on the belt the baggage passes through an x-ray machine for security purposes. It is required to manually search every fifth bag. To conduct a manual search, an employee removes the bag from the conveyor and search through its content after which the bag is closed and placed on the conveyor again. Employees load the baggage from the belt into baggage carts. A baggage cart can transport 50 bags. The baggage carts are transported to the aircraft where the baggage is loaded onto the plane. The departure process originates when an aircraft has landed. Baggage is again loaded into the baggage carts and transported to the basement where it is put onto a conveyor belt which conveys the baggage to the carousel.

Even though passengers, baggage and aircraft operations differ, somewhere in the system they all influence each other. It is the objective of every airport system that these three flow efficiently through the processes required. The following is a description of the interaction of the passengers, baggage and aircraft in an airport system.

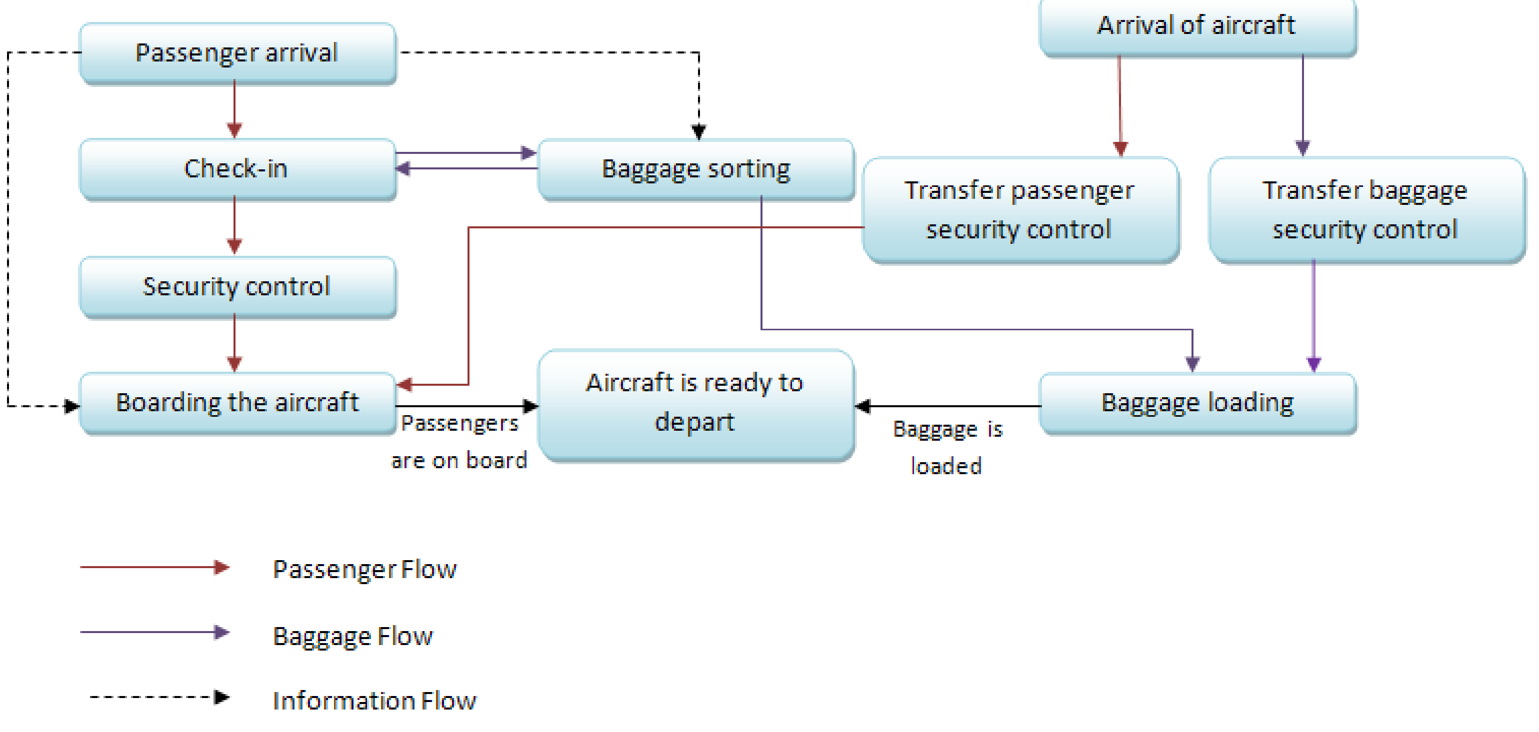


Figure 6: Arrival and Departure Process Flow

6.2.3. Process Times and Percentages:

This is the most important but also the most complex phase in the data collection process. There are various inputs needed for the simulation model. These inputs of an airport system can be divided into entity related information, process information and facility information.

6.2.3.1 Entity Information

The entities of the airport system are the passengers, baggage and aircraft.

Passenger attributes include the party size and number of bags carried by the passenger. This information will be incorporated in the check-in process under process information.

Aircraft attributes include the type and load factor. A summary of the Aircraft types operating from Lanseria International Airport can be viewed in Appendix A. All aircraft currently operates at 90% load factor.

6.2.3.2 Process Information

Process information refers to the type and number of resources available and the processing time needed to complete the process.

Check-in process:

Passengers arriving at the check-in counters have various attributes associated with them. First the party size and secondly the number of bags will be the attributes assigned to passengers. The service time of the check-in counter is the time it takes from the time a party arrives at the counter until the time the party leaves the check-in process. Four counters are operated during check-in from two hours prior to departure time. Table 2 provides the information regarding the check-in process at Lanseria International Airport. This data regarding party size and the number of bags was gathered by observing several departure flights' check-in procedures. During these observations time studies was also performed in order to determine the processing times.

Party Size	**Frequency**	**Number of Bags**	**Frequency**	**Time per party size per number of bags (seconds)**		
				min	max	average
1.00	0.44	0.00	0.13	40.00	70.00	55.00
		1.00	0.80	20.00	225.00	83.83

		2.00	0.07	90.00	90.00	90.00
2.00	0.38	1.00	0.31	35.00	210.00	87.50
		2.00	0.69	75.00	219.00	113.00
3+	0.18	3.00		80.00	300.00	160.00

Table 2: Check-in process data

Security check process:

The security check point provides many possible activities. First a passenger removes all objects that require special searches, like laptops, camera etc. The passenger also removes items such as keys, coins and jewelry that may interfere with the scan. These items are placed in a basket. The basket is scanned by the x-ray machine to ensure no illegal objects are taken unto the aircraft. The passenger then proceeds through the security check point. The passenger and basket can either set off an alarm or move through without any complications. If the alarm is set off by the passenger, he is subjected to an individual search by a security officer. If the objects in the basket set off the alarm it will also be searched manually. Percentages of the combination of possible situations should be determined as well as the time associated with each combination. There are two security check point available for domestic departures. Table 3 gives a summary of the processes at the security check as well as the processing time and frequency of occurrence of these processes. This data was determined in the same manner as for the check-in process.

Security Process	Time per passenger	Frequency of occurrence
Putting of objects in the basket	19 - 35	1
Going through the metal detector	2.3 - 3.5	1
Manual security check of passenger	18 - 29	0.35
Manual security check of luggage	32 - 180	0.15
Collecting items after scan	26 - 80	1

Table 3: Security Check Point Data

Boarding process:

Boarding starts 30 minutes prior to departure time.

Aircraft arrival process

The arrival distribution will be discussed in the next section.

Aircraft turnaround times range from 30 – 45 minutes

Deplaning Process

Each aircraft requires two sets of stairs for disembarking of passengers

One ground power unit is needed

One passenger assist unit is required

One toilet and water service unit is required

The equipment available at Lanseria International Airport can only service one aircraft at a time.

Passengers including assisted passengers evacuate the aircraft in 15 minutes.

Baggage Loading/ Offloading Process:

Baggage carts (Dolly's) are used to transport baggage

There are 20 dolly's available for loading and unloading

Each dolly can transport approximately 50 bags

Baggage Reclaim:

The baggage collection is done by a roller bed (carousel) with a capacity of 120 bags per aircraft at the international terminal and the domestic arrival has a carousel with a capacity of 300 bags per hour.

All passengers receive their baggage in 15 minutes.

6.2.3.3 Facility Information

The airport operates 24 hours per day. The airport has two runways as follows:

Number	1	2
Category	3C	2B
Orientation	06L/24R	06R/24L
Configuration (parallel / cross)	main	parallel
Length (m)	2910	1760

Width (m)	30	23

Table 4: Lanseria Airport Runways

The airport runway physical dimensions allow it to handle up to category 3C aircraft according to ICAO recommendations. The airport is currently handling category 4C aircraft (particularly B737 and B757) which requires wider runways.

Figure 7: Aerial View of Lanseria International Airport Runways and Taxiways

The following is a summary of Lanseria International Airport Terminal Component Capacities

Terminal	Area	Current Units
International Departure	Check-in (Counters)	3
	Emigration (counters)	2
	Boarding (Gates)	1
	Screening (Check Points)	1
International Arrivals	Meet & Greet (Hall)	1
	Entrance and Processing (Hall)	1
	Baggage Handling (Belts & Hall)	1
	Customs (Counters)	4
	Immigration (Counters)	2
Domestic Departure	Check-in (Counters)	6
	Boarding (Gates)	2
	Screening (Check Points)	1
Domestic Arrivals	Meet & Greet (Hall)	1
	Entrance and Processing (Hall)	1
	Baggage Handling (Belts & Hall)	1
Trolleys	No. of trolleys available	200

Table 5: Lanseria International Airport Terminal Component Capacities

There are 6 parking bays available on the apron

Previous work done on airport terminal simulation incorporated the walking time between processes but the distances travelled between processes at Lanseria International Airport are short and will therefore not have a significant effect on the total time a passenger spends in the system.

The waiting room inside the terminal has 520 seats available.

Airport ground space influences the number of passengers that can be accommodated according to a certain set of standard. The following is a summary of the floor calculations of Lanseria International Airport. The floor plan for Lanseria International Airport is available in Appendix B.

	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**

Table 6: Floor space calculations

The International Air Transport Association (IATA) has published Space Design Standards based on a level of service concept, where Level A is Excellent and Level D is desirably the lowest level achieved in peak operations. Level F is the point of system breakdown or congestion. These standards have been adopted for terminal planning and are shown in Table 7. Lanseria International Airport has adopted Level C for planning purposes. Therefore when looking at the domestic check-in area, which covers 20 percent of the entire domestic departure area, the maximum allowable passengers for that area is 130.

Level of Service	A	B	C	D	E
Check-in Queue	1.8	1.6	1.4	1.2	1.0
Wait/Circulate	2.7	2.3	1.9	1.5	1.0
Hold Room	1.4	1.2	1.0	0.8	0.6
Bag Claim Area	2.0	1.8	1.6	1.4	1.2
Government Inspection	1.4	1.2	1.0	0.8	0.6

Table 7: IATA Levels of Service Space Standards based on Peak Hour Passenger Numbers (m^2)

Level A: Excellent service, free flow, direct routes, no delay, excellent level of comfort.
Level B: High level service, condition of stable flow, high level of comfort.
Level C: Good level of service, conditions of stable flow, provides acceptable throughput, related sub-systems in balance.
Level D: Adequate level of service, condition of unstable flow, delay for passengers, conditions acceptable for short periods of time.
Level E: Unacceptable levels of service, conditions of unstable flow, sub-systems not in balance, represents limiting capacity of the system.
Level F: System breakdown, unacceptable congestion and delays.

6.2.4 Distribution of Arrivals and Departures

6.2.4.1 Aircraft Arrival and Departure Distribution

The current schedule is used to determine the arrival and departure rates. The arrival rate will be determined for the peak hour. Brunetta et al (2006) explains the peak hour as a representative hour of busy conditions within a functional component. A peak hour is typically defined from historical records by frequency of occurrence. With respect to Lanseria International Airport the peak period occurs on a Thursday. This was determined by consulting with personnel at Lanseria International Airport. Therefore the model will present the airport system with respect to a Thursday. The following is the Arrival and Departure Schedules for a Thursday at Lanseria International Airport.

Departure schedule	
Schedule departure time	Time between Departures
06:00	0
06:15	15
07:55	100
08:30	35
11:20	170
13:50	150
14:40	50
17:10	150
18:25	75
20:00	95
20:15	15
21:45	90
22:30	45

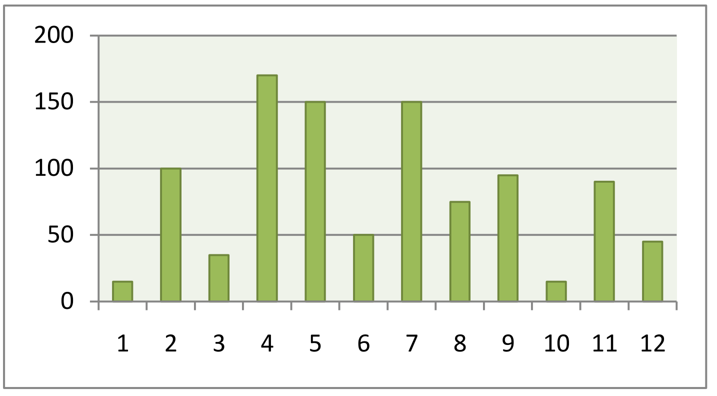


Table 8: Departure schedule

Arrival schedule	
Scheduled arrival time	Time between arrivals
07:25	0
08:00	35
10:50	170
13:20	150
14:10	50
16:40	150
17:55	75
19:30	95
19:35	5
21:15	100
22:00	45
23:05	65
00:50	105

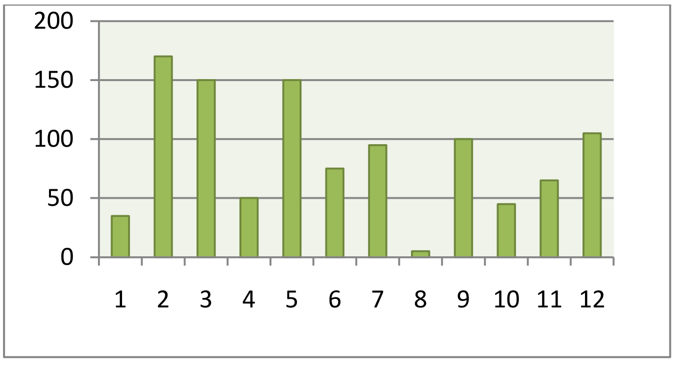
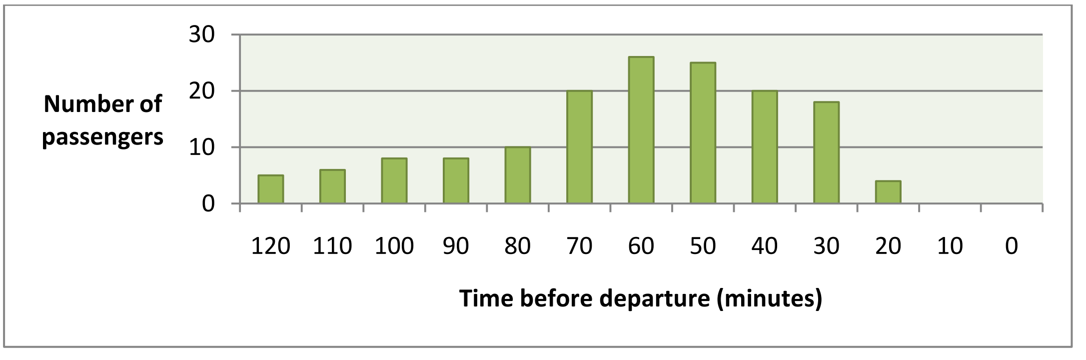


Table 9: Arrival Schedule

6.2.4.2 Passenger Arrival Distribution

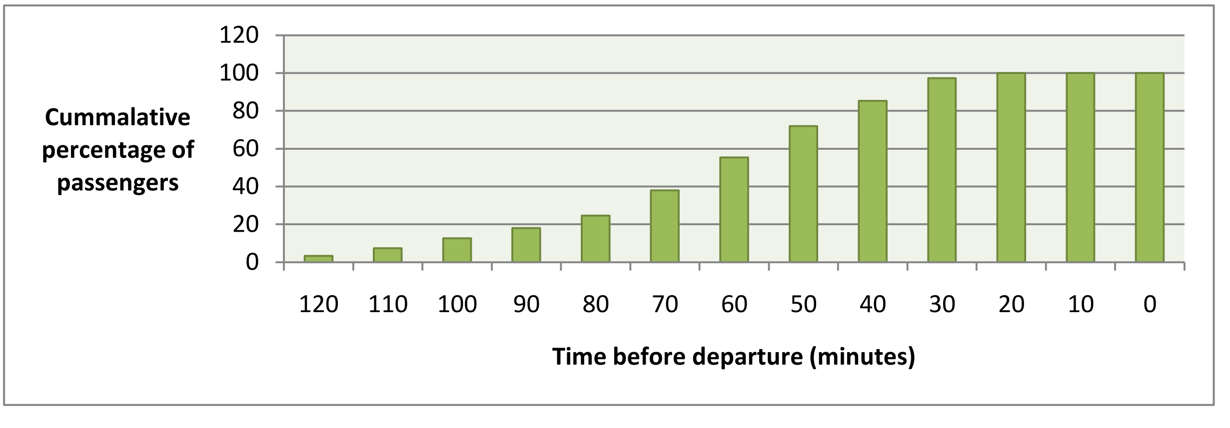
Passengers start entering the airport two hours prior to their departure time. Lanseria International Airport specifies that passenger can check-in from two hours before the departure time. As mentioned in the literature study the arrival distribution can be determined by counting the number of passengers arriving in ten minute intervals for the two hour check-in period before the time of departure. Arena Input Analyzer is used to fit a distribution to the data collected.

Time before departure (minutes)	**120**	**110**	**100**	**90**	**80**	**70**	**60**	**50**	**40**	**30**	**20**	**10**	**0**
Number of passengers	5	6	8	8	10	20	26	25	20	18	4	0	0



Arena Input Analyzer was used to fit a distribution to the passenger arrival rate. The following equation was calculated: NORM(11.5, 8.77). This will be used as an input to the simulation model.

Time before departure (minutes)	**120**	**110**	**100**	**90**	**80**	**70**	**60**	**50**	**40**	**30**	**20**	**10**	**0**
Cumulative percentage of passengers	3.3	7.3	12.6	18	25	38	55	72	85	97.3	100	100	100



6.3 The Simulation Model

Run Parameters

According to Kelton et al, (2007) most simulation models can be classified as either terminating or steady state. A terminating simulation is one in which the model dictates specific starting and stopping conditions as a natural reflection of how the real world system operates. As the name suggests, the model will terminate according to some predefined rule. A steady state simulation is one in which the quantities to be estimated are defined in the long run. For such a model, the initial conditions does not matter. For this simulation a terminating conition will be specified according to the maximum allowable passengers in the domestic departure area. As calculated previously this amounts to 130 passengers.

In the work done by Charles J. Kim (2005) the model is simulated for the entire peak period. This time was chosen so that all possible flights can be considered in the final simulation results. For Lanseria International Airport the model will be run for an entire Thursday as this is the peak period. These parameters will be used to run the simulation model for Lanseria International Airport. The departure simulation will otherwise terminate if the maximum allowable passengers per m^2 have been exceeded.

Arena Model

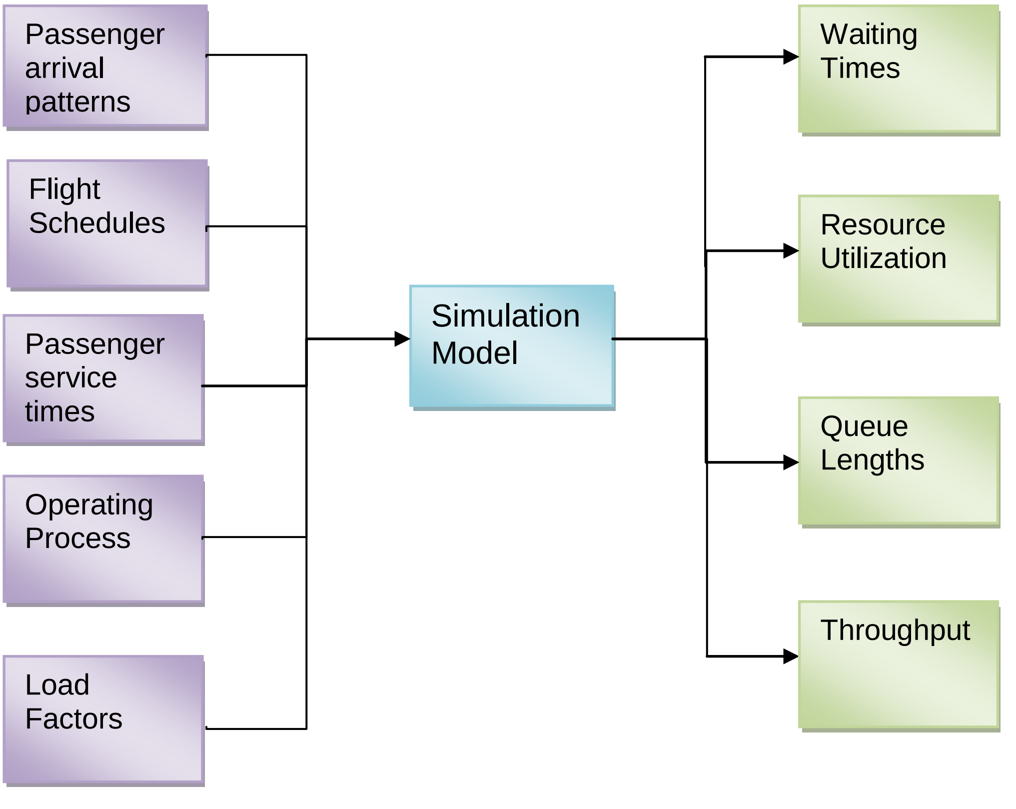


Figure 7: Inputs and Outputs of Simulation Model

The departure process includes the passenger and baggage flow from the check-in process until both the passengers and baggage are on the aircraft. For the simulation model, the baseline or current situation is modeled in order to determine if the model is valid and accurate. This model uses the current flight schedule as input. Figure 9 is a graphical representation of the departure simulation model.

The arrival process includes the passenger, baggage and aircraft movements on the apron as well as the baggage claim area of the terminal. This process is initiated by the aircraft arrival schedule. The passengers and baggage have the same arrival distribution as the aircraft for they arrive at the same time. Passengers don't require any resources or participate actively in any processes; therefore they are modeled as a batch. Figure 8 gives a graphical representation of the arrival simulation model. Baggage is also modeled as a batch movement because through observations it has become clear that the time it takes to move all the baggage is the time that influences the system.

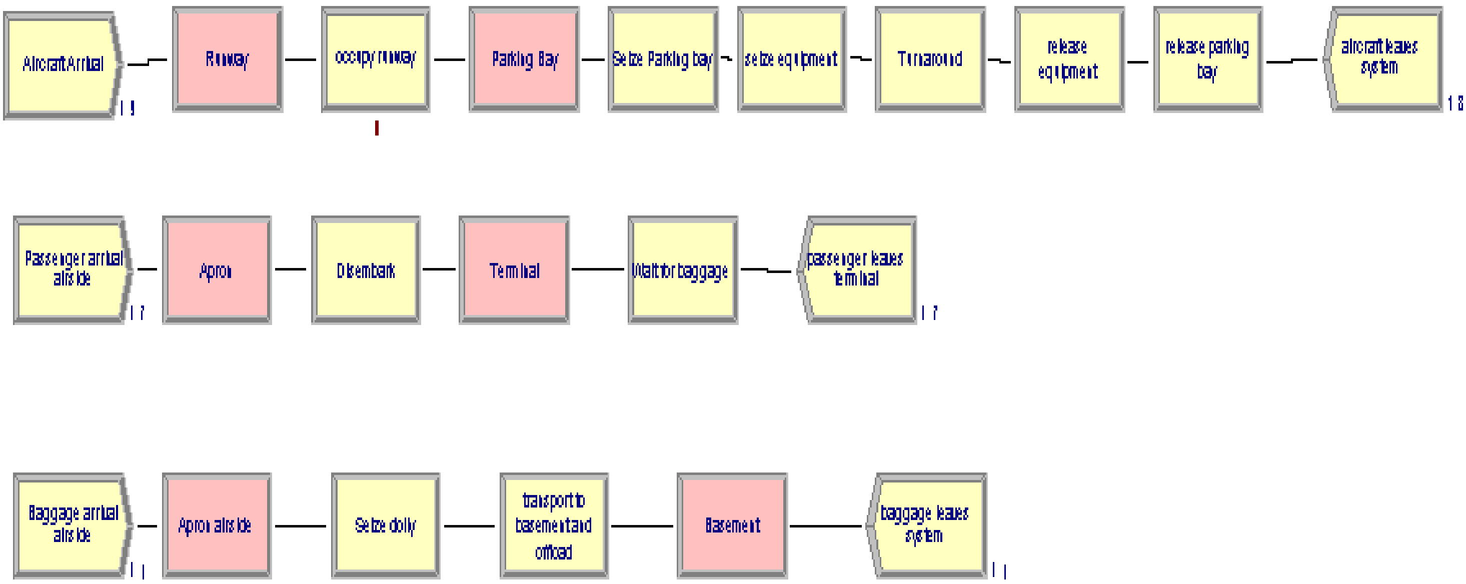


Figure 8: Arrival Simulation Model

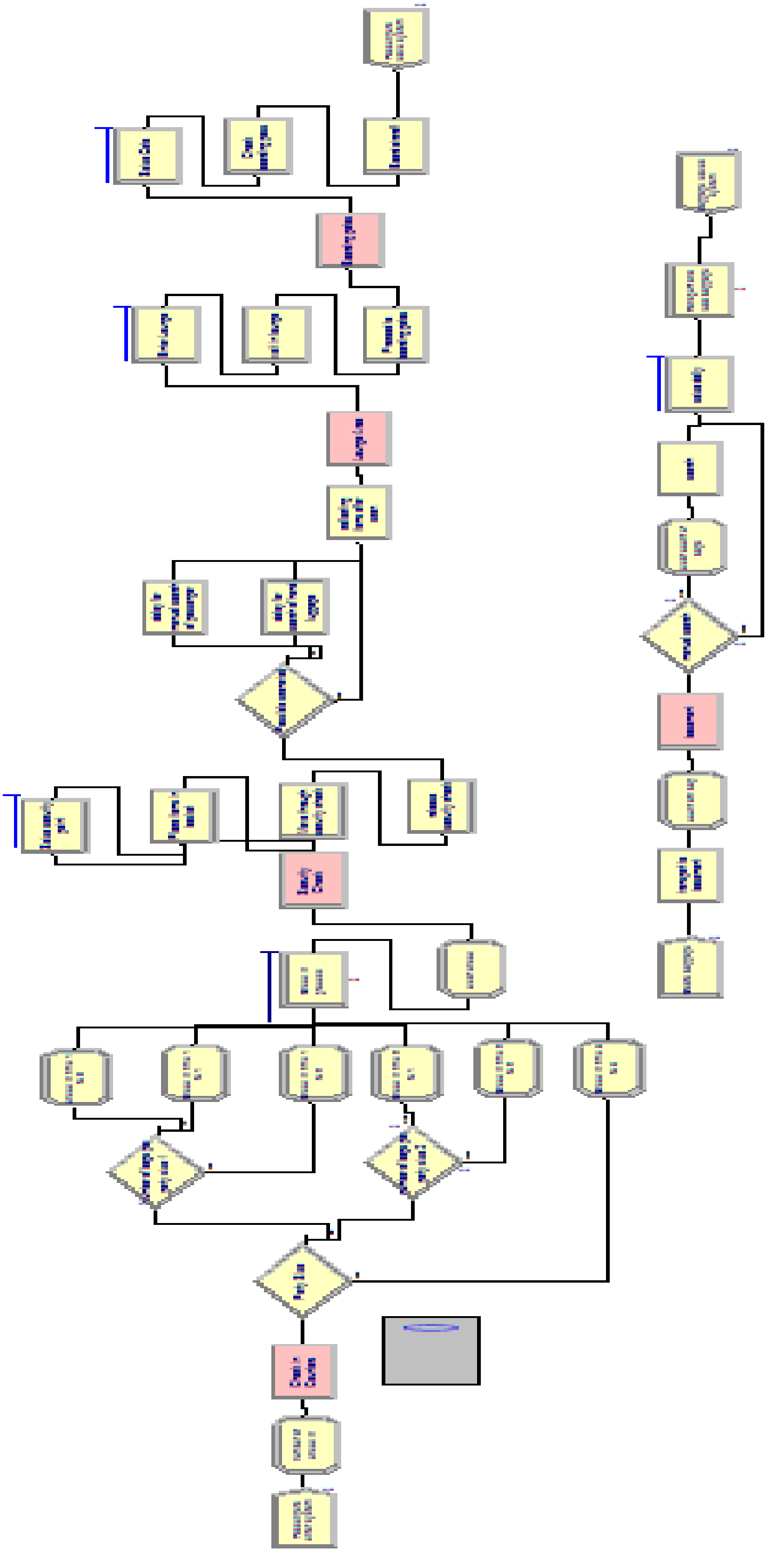


Figure 9: Departure Simulation Model

6.4 Model Validation

According to Sargent (2005) model verification is often defined as "ensuring that the computer program of the computerized model and its implementation are correct." The following is graphical representation of the interfaces between the real world and the simulation world as described by Sargent (2005).

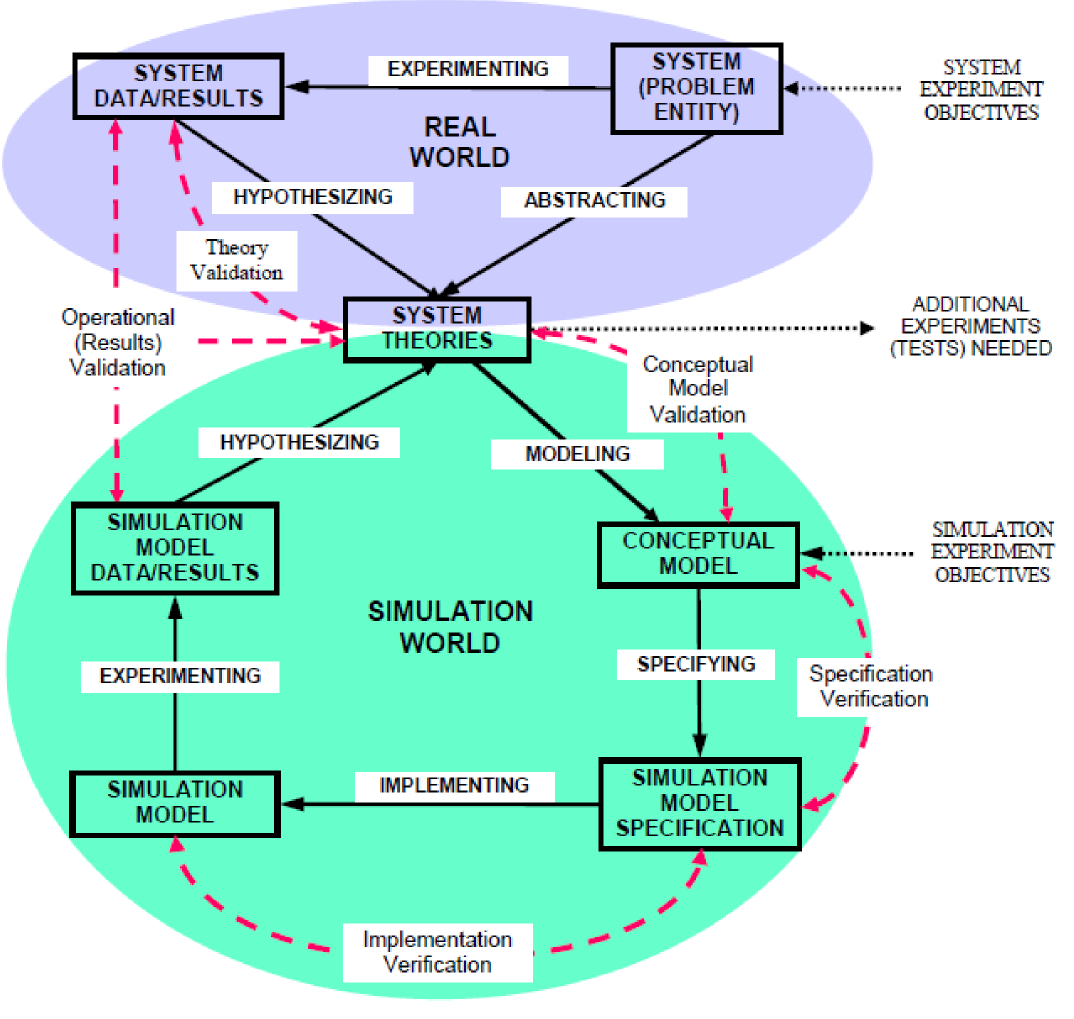


Figure 11: Real World and Simulation World Relationships with Verification and Validation

A combination of techniques can be used to validate the simulation model. These techniques have been explained by Sargent (2005). The applicable techniques used to verify this simulation model includes:

Animation: The model's operational behavior is displayed graphically as the model moves through time. For example the movements of parts through a factory during a simulation run are shown graphically.

Degenerate Tests: The degeneracy of the model's behavior is tested by appropriate selection of values of the input and internal parameters. For example, does the average number in the queue of a single server continue to increase over time when the arrival rate is larger than the service rate?

Event Validity: The "events" of occurrences of the simulation model are compared to those of the real system to determine if they are similar. For example the observed queue length and the simulation queue lengths should be similar.

Face Validity: Asking individuals knowledgeable about the system whether the model and/or its behavior are reasonable. For example, is the logic in the conceptual model correct and are the model's input-output relationships reasonable.

Fortunately there is a real system, current system at Lanseria International Airport, therefore comparison between the simulated results and the real system data could easily be made. Expert personnel at the airport also concluded that the logic within the simulation model was accurate and correct. Comparison of the model results with the actual system showed that the model quite accurately represents the actual system.

6.5 Results

The current situation was evaluated to serve as a baseline for experimentation with future possibilities. Outputs required from the models between which comparisons will be made and analyzed include the following:

- The throughput number of aircraft, passengers and baggage.
- The waiting time for all the processes in the terminal and the apron.
- The utilization of airside equipment and resources.

These outputs will be determined for various scenarios. The first scenario is the modeling of the current system. The second scenario will test the increase of aircraft operations on the current system. The final scenario will evaluate future possibilities with regards to the configuration of the processes in order to optimize the system and thereby increase the level of service offered to passengers.

Arrival Process:

Scenario 1: The current system analysis

Throughput per day:

Number Out	Value
aircraft	27.0000
baggage	34.0000
passengers	34.0000

Waiting Times

Waiting Time	Average	Half Width	Minimum Value	Maximum Value
occupy runway.Queue	1.3351	(Insufficient)	0.00	3.8922
Seize dolly.Queue	0.00	(Insufficient)	0.00	0.00
seize equipment.Queue	110.34	(Insufficient)	0.00	185.59
Seize Parking bay.Queue	8.8764	(Insufficient)	0.00	65.1844

Other

Number Waiting	Average	Half Width	Minimum Value	Maximum Value
occupy runway.Queue	0.04581388	(Insufficient)	0.00	1.0000
Seize dolly.Queue	0.00	(Insufficient)	0.00	0.00
seize equipment.Queue	3.4543	(Insufficient)	0.00	5.0000
Seize Parking bay.Queue	0.3416	(Insufficient)	0.00	3.0000

Resource Utilization

Number Scheduled	Average	Half Width	Minimum Value	Maximum Value
dolly	20.0000	(Insufficient)	20.0000	20.0000
equipment	1.0000	(Insufficient)	1.0000	1.0000
parking bays	6.0000	(Insufficient)	6.0000	6.0000
runway apron	1.0000	(Insufficient)	1.0000	1.0000

Scheduled Utilization	Value
dolly	0.07148952
equipment	0.9977
parking bays	0.7420
runway apron	0.0947

Scenario 2: Increase aircraft operations to four per hour.

Throughput per day.

Number Out	Value
aircraft	26.0000
baggage	68.0000
passengers	68.0000

Waiting Times

Waiting Time	Average	Half Width	Minimum Value	Maximum Value
occupy runway.Queue	4.2376	(Insufficient)	0.00	10.7822
Seize dolly.Queue	0.00	(Insufficient)	0.00	0.00
seize equipment.Queue	164.96	(Insufficient)	0.00	203.04
Seize Parking bay.Queue	217.59	(Insufficient)	0.00	574.17

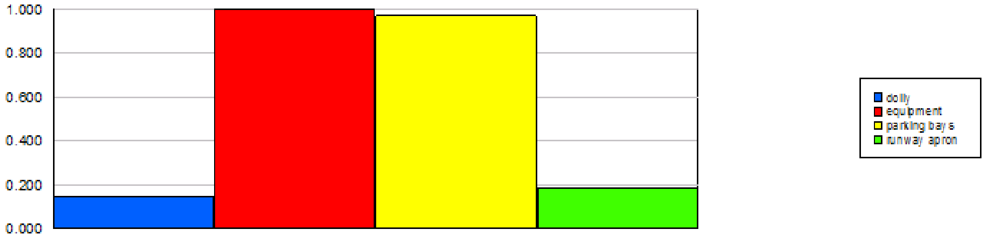
Other

Number Waiting	Average	Half Width	Minimum Value	Maximum Value
occupy runway.Queue	0.2867	(Insufficient)	0.00	3.0000
Seize dolly.Queue	0.00	(Insufficient)	0.00	0.00
seize equipment.Queue	4.8281	(Insufficient)	0.00	5.0000
Seize Parking bay.Queue	17.1707	(Insufficient)	0.00	37.0000

Resource Utilization

Number Scheduled	Average	Half Width	Minimum Value	Maximum Value
dolly	20.0000	(Insufficient)	20.0000	20.0000
equipment	1.0000	(Insufficient)	1.0000	1.0000
parking bays	6.0000	(Insufficient)	6.0000	6.0000
runway apron	1.0000	(Insufficient)	1.0000	1.0000

Scheduled Utilization	Value
dolly	0.1449
equipment	0.9977
parking bays	0.9710
runway apron	0.1827



From the results of the simulation model it is clear to see that more than two aircraft operations lead to congestion for the airside operations. It is the aircraft operations that cause the bottleneck for the airside operations. Specifically it is the unavailability of equipment during the turnaround time of the aircraft.

Scenario 2: Future possibilities

The configuration changes that were evaluated include: Acquire an extra set of equipment for apron operations while keeping the demand at 4 operations per hour.

Throughput per day.

Number Out	Value
aircraft	54.0000
baggage	68.0000
passengers	68.0000

Waiting Times

Waiting Time	Average	Half Width	Minimum Value	Maximum Value
occupy runway.Queue	4.1065	(Insufficient)	0.00	10.7962
Seize dolly.Queue	0.00	(Insufficient)	0.00	0.00
seize equipment.Queue	64.1135	(Insufficient)	0.00	85.8535
Seize Parking bay.Queue	53.8087	(Insufficient)	0.00	163.35

Other

Number Waiting	Average	Half Width	Minimum Value	Maximum Value
occupy runway.Queue	0.2778	(Insufficient)	0.00	3.0000
Seize dolly.Queue	0.00	(Insufficient)	0.00	0.00
seize equipment.Queue	3.6447	(Insufficient)	0.00	4.0000
Seize Parking bay.Queue	3.8125	(Insufficient)	0.00	11.0000

Resource Utilization

Number Scheduled	Average	Half Width	Minimum Value	Maximum Value
dolly	20.0000	(Insufficient)	20.0000	20.0000
equipment	2.0000	(Insufficient)	2.0000	2.0000
parking bays	6.0000	(Insufficient)	6.0000	6.0000
runway apron	1.0000	(Insufficient)	1.0000	1.0000

Scheduled Utilization	Value
dolly	0.1461
equipment	0.9968
parking bays	0.9397
runway apron	0.1858

The simulation of these different scenarios of the airside system gave insight into possibilities and future situations that can occur at Lanseria International Airport. It became evident that extra equipment is necessary for any increase in aircraft operations. However the apron infrastructure, the runway and parking bays, can accommodate an increase in aircraft operations.

Departure Process

Scenario 1: Model the current terminal situation

Total Time	Average	Half Width	Minimum Value	Maximum Value
Passengers	1742.02	(Correlated)	215.59	4312.93

Number Out	Value
Passengers	946.00

Waiting time

Waiting Time	Average	Half Width	Minimum Value	Maximum Value
Check in process.Queue	673.22	189.027	0.00	2757.10
Enter Lounge.Queue	0.00	0.000000000	0.00	0.00
Seize Gate.Queue	1.3470	0.242863857	0.00	19.4483
Seize security point.Queue	1.3440	0.305024359	0.00	32.2000

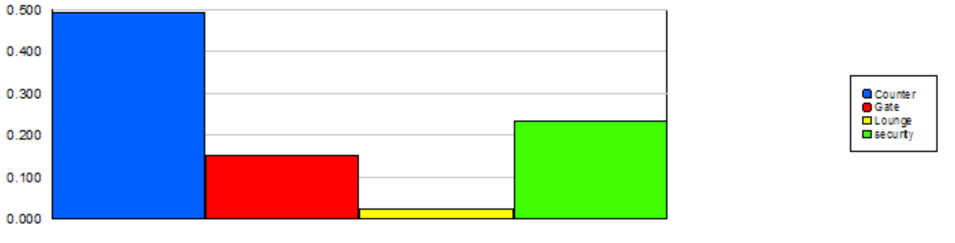
Other

Number Waiting	Average	Half Width	Minimum Value	Maximum Value
Check in process.Queue	10.4614	5.05606	0.00	86.0000
Enter Lounge.Queue	0.00	(Insufficient)	0.00	0.00
Seize Gate.Queue	0.02071192	0.007620840	0.00	2.0000
Seize security point.Queue	0.02088436	(Insufficient)	0.00	2.0000

Resource Utilization

Number Scheduled	Average	Half Width	Minimum Value	Maximum Value
Counter	4.0000	(Insufficient)	4.0000	4.0000
Gate	1.0000	(Insufficient)	1.0000	1.0000
Lounge	540.00	(Insufficient)	540.00	540.00
security	2.0000	(Insufficient)	2.0000	2.0000

Scheduled Utilization	Value
Counter	0.4929
Gate	0.1522
Lounge	0.02393695
security	0.2322



Scenario 2: Increase passenger arrivals in order to fill four aircraft operations per hour.

Throughput

Total Time	Average	Half Width	Minimum Value	Maximum Value
Passengers	1808.24	(Correlated)	287.75	4639.34

Other

Number In	Value
Passengers	1187.00

Number Out	Value
Passengers	1184.00

Waiting Time

Time

Waiting Time	Average	Half Width	Minimum Value	Maximum Value
Check in process.Queue	708.72	(Correlated)	0.00	2770.79
Enter Lounge.Queue	0.00	0.000000000	0.00	0.00
Seize Gate.Queue	1.8468	0.476302374	0.00	30.5198
Seize security point.Queue	1.3894	0.283308228	0.00	29.5883

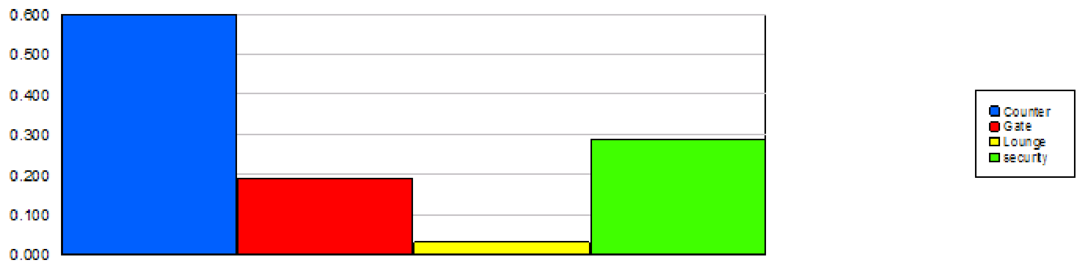
Other

Number Waiting	Average	Half Width	Minimum Value	Maximum Value
Check in process.Queue	13.6997	(Correlated)	0.00	92.0000
Enter Lounge.Queue	0.00	(Insufficient)	0.00	0.00
Seize Gate.Queue	0.03560781	0.014812858	0.00	3.0000
Seize security point.Queue	0.02685807	0.007997478	0.00	2.0000

Resource Utilization

Number Scheduled	Average	Half Width	Minimum Value	Maximum Value
Counter	4.0000	(Insufficient)	4.0000	4.0000
Gate	1.0000	(Insufficient)	1.0000	1.0000
Lounge	540.00	(Insufficient)	540.00	540.00
security	2.0000	(Insufficient)	2.0000	2.0000

Scheduled Utilization	Value
Counter	0.5989
Gate	0.1892
Lounge	0.03054934
security	0.2887



The check-in process is the cause for the congestion in the terminal. During peak times which are early in the morning and again in the afternoon, queuing times are too high for the expected level of service. The other processes in the terminal can facilitate an increase in aircraft departures.

Scenario 3: Optimizing possibilities for the check in process. Open another counter during these peak hours.

Throughput

Total Time	Average	Half Width	Minimum Value	Maximum Value
Passengers	1495.80	96.68571	276.56	3126.52

Other

Number In	Value
Passengers	1176.00

Number Out	Value
Passengers	1164.00

Waiting Time

Waiting Time	Average	Half Width	Minimum Value	Maximum Value
Check in process.Queue	423.94	101.877	0.00	1676.51
Enter Lounge.Queue	0.00	0.000000000	0.00	0.00
Seize Gate.Queue	2.1921	0.734714164	0.00	48.7495
Seize security point.Queue	3.0984	0.509394410	0.00	36.1891

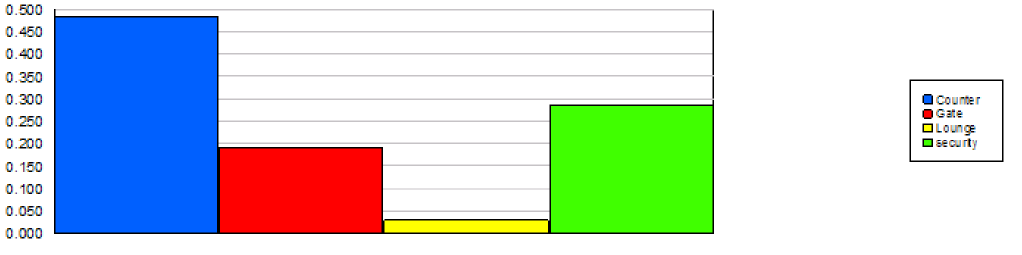
Other

Number Waiting	Average	Half Width	Minimum Value	Maximum Value
Check in process.Queue	8.1325	(Correlated)	0.00	66.0000
Enter Lounge.Queue	0.00	(Insufficient)	0.00	0.00
Seize Gate.Queue	0.04162188	0.020160288	0.00	4.0000
Seize security point.Queue	0.05943692	0.019038262	0.00	3.0000

Resource Utilization

Number Scheduled	Average	Half Width	Minimum Value	Maximum Value
Counter	5.0000	(Insufficient)	5.0000	5.0000
Gate	1.0000	(Insufficient)	1.0000	1.0000
Lounge	540.00	(Insufficient)	540.00	540.00
security	2.0000	(Insufficient)	2.0000	2.0000

Scheduled Utilization	Value
Counter	0.4830
Gate	0.1903
Lounge	0.02903324
security	0.2857



As can be seen from the decrease in queue length as well as in queuing time, adding another counter will improve the check in process if the aircraft operations should increase.

7. Conclusion

This project was performed to serve as a decision support tool in the strategic planning of Lanseria International Airport. The need for these strategic plans is the possibilities of more airlines operating from Lanseria International Airport and whether the airport can accommodate extra flights and if so, then how many.

The simulation models provided insight into the complex system, which is Lanseria International Airport. Different scenarios were modeled and key performance indicators were recorded for each of the scenarios. From an analysis of the results it seems that Lanseria International Airport can with the current infrastructure accommodate three domestic aircraft movements. In total this results in a capacity of six aircraft operations per hour. However, if there is a further need to increase capacity, acquiring equipment for apron operations and adding another counter during peak hours for the check-in process, that capacity could too be reached. The terminal operations can also be upgraded to accommodate passenger and aircraft increases more efficiently. Further studies on the cost implication of these alternatives will provide a deeper insight for decision analysis.

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9. Appendix

A: Aircraft Classification

Geometric Design Classification

Design Group	Wingspan (ft)	Example Aircraft
I	<49	Cessna 152-210, Beechcraft A36
II	49-78	Saab 2000, EMB-120, Saab 340, Canadair RJ-100
III	79-117	Boeing 737, MD-80, Airbus A-320
IV	118-170	Boeing 757, Boeing 767, Airbus A-300
V	171-213	Boeing 747, Boeing 777, MD-11, Airbus A-340
VI	214-262	A3XX-200 or VLCA (planned)

Operational Classification

Design Group	Approach Speed (knots)	Example Aircraft
A	<91	All single engine aircraft, Beechcraft,Baron 58,
B	91-120	Business jets and commuter aircraft (Beech 1900, Saab 2000, Saab 340,Embraer 120, Canadair RJ, etc.)
C	121-140	Medium and Short Range Transports(Boeing 727, B737, MD-80, A320,F100, B757, etc.)
D	141-165	Heavy transports(Boeing 747, L-1011, MD-11, DC-10,A340, A300)
E	>166	BAC Concorde and military aircraft

Aircraft Types

Aircraft type	Code	Seating capacity	Average
Boeing 727-200	722	189 (c)	189
Boeing 737-200	732	95 (2)	113
		130 (c)	
Boeing 737-260			
Boeing 737-300 (FODZY	733	128 (2)	
		149 (c)	139
Boeing 737-400	734	146 (2)	157

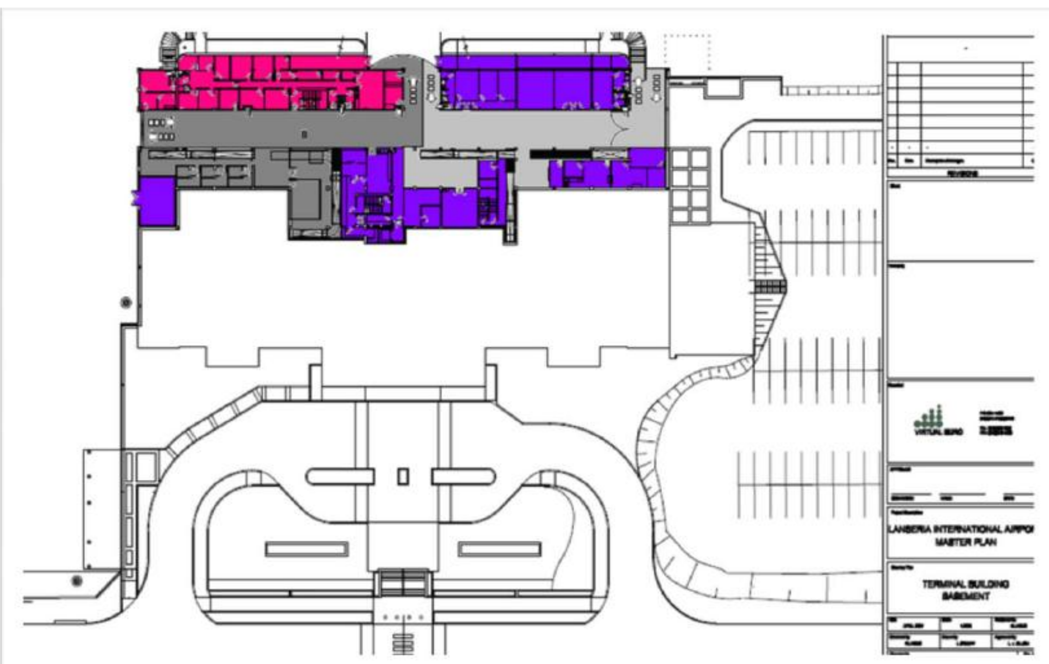
		168 (c)	
Boeing 737-500	735	110 (2)	121
		132 (c)	
Boeing 737- 600	736	110 (2)	121
		132 (c)	
Boeing 737-700	737	126 (2)	138
		149 (c)	
Boeing 737-800	738	162 (2)	176
		189 (c)	
Boeing 747-100	741	330 (3)	407
		385 (2)	
		505 (c)	
Boeing 747-300	743	420 - 422 (2)	422
Boeing 747-400	744	358 - 416 (3)	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)	238
		224 (2)	
		255 - 290 (c)	
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)	351
		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)	157
		172 (2)	
Fokker F28	F28	85	85

B. Floor Plans

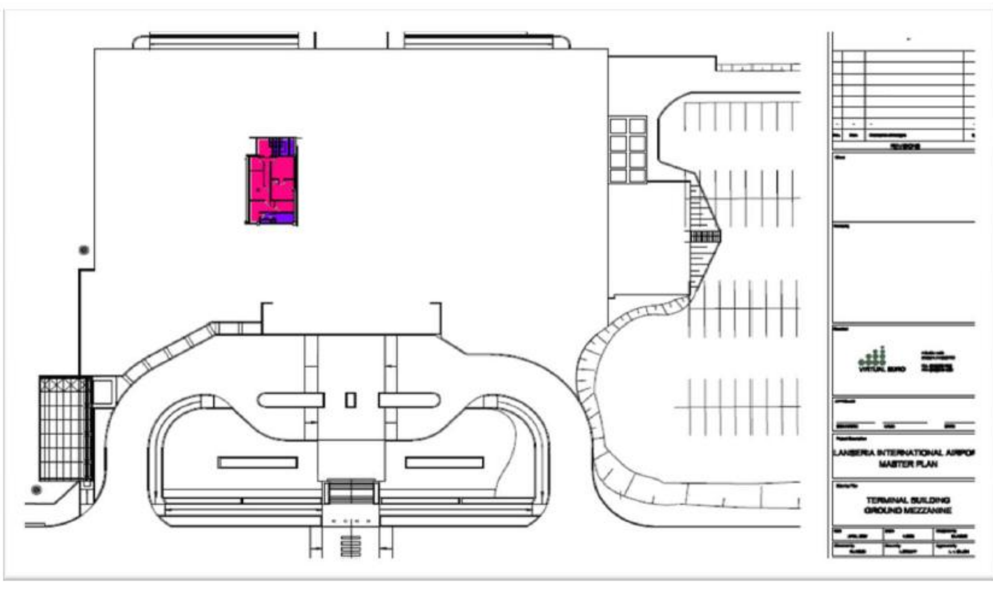
	Bathroom
	Other
	Offices
	Shops
	Domestic Arrivals
	Domestic Departures
	International Arrivals
	International Departures
	Domestic Baggage
	International Baggage

Basement



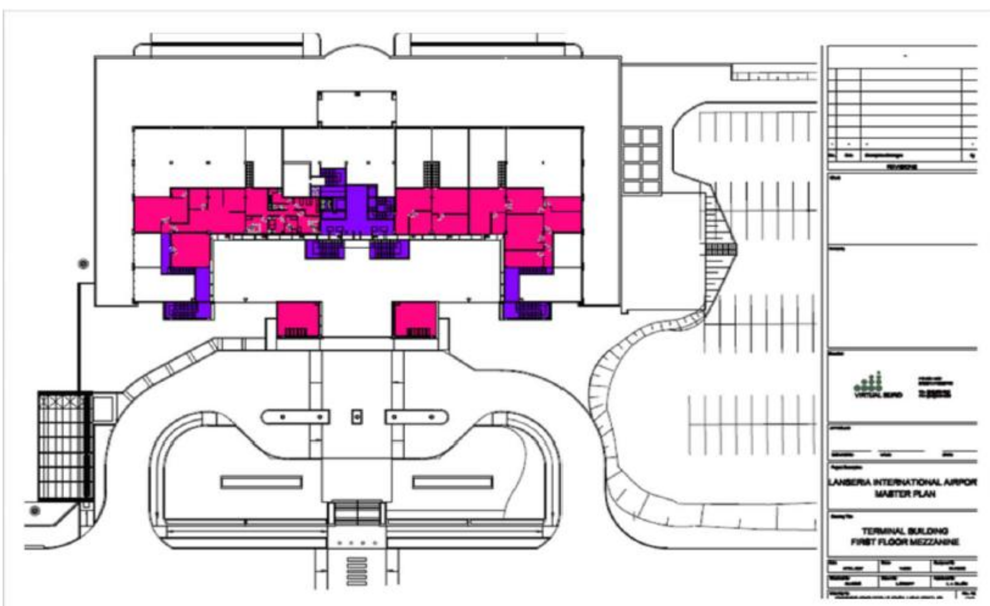
Ground Floor

Ground Floor Mezzanine

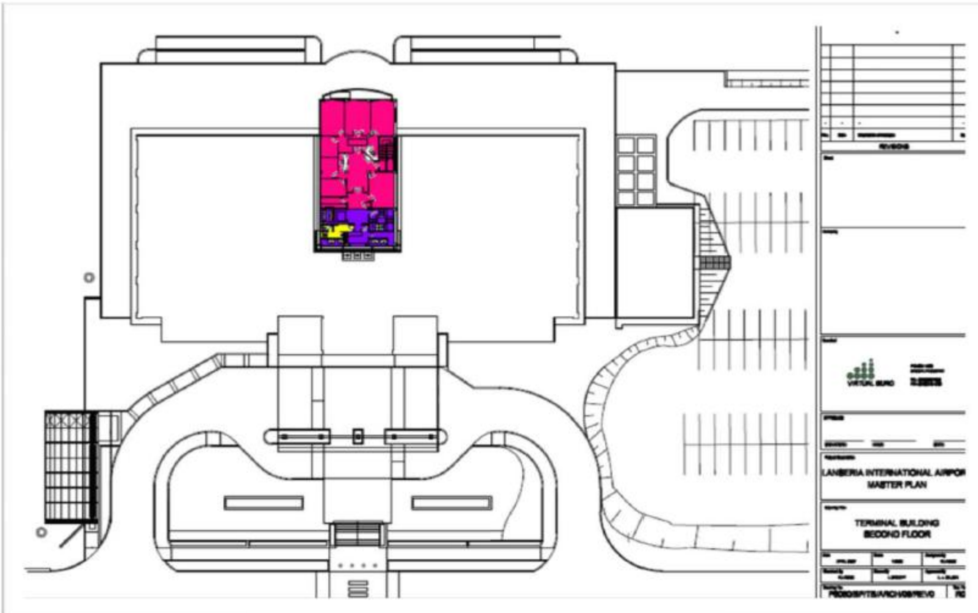


First Floor

First Floor Mezzanine



Second Floor



Second Floor Mezzanine