

**T.C.**

**ALTINBAS UNIVERSITY**

**Institute of Under-graduate studies**

**Industrial Engineering**

**Project Report on**

**“Airport System Simulation”**

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**Abstract**

Airports are intermodal hubs and natural interfaces between road transportation and air transportation. Over the years numbers of airports have increased and the usage of airports has increased, with this increase, advancement and utilization of airport resources must be put into place. In this project, the execution of simulation to determine the optimal use of resources and provide an easily accessible airport will take place.

**Acknowledgment**

First and foremost, we would like to praise the Almighty and thank the Almighty God for bringing us thus far and giving us strength, and because of his blessings, we are finally able to accomplish this project. Without his blessing, we wouldn’t have gone this far. The project cannot be complete without the effort and cooperation of our group members, which consists of Mahmoud Zain, Abdurrahman Sa’id, Hamza Malah, and Yahya Algasim. We have worked for hand in hand and with full commitment to the success of this project.

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**CHAPTER ONE**

**Introduction**

As it is our final year semester at Altinbas University as undergraduates of Industrial Engineering, a design project is required to complete our credits. After haven’t taken our senior project design 1 (one), we have decided to work as a team to execute and utilize our skills for the success of this project.

After thorough research on what topic to present, we have concluded on simulating an airport operation, by providing essential needs to passengers and minimizing airport resources like time, finance, and Airport space.

Airports have been around for decades. The requirements for airports have increased in complexity and scale since the earliest days of flying, from the increase in the number of people visiting the airport every day to the need for more hospitability and accessibility airports. A variety of challenges come with this increase in demand, monitoring the safety of the airport, the availability of food and drinks for the entire population of the airport, the availability of restrooms, a quick boarding system, the number of flight waiting rooms, and many other things like shops for different ornaments and gifts, a barber may be required in the airport, a hotel for transit passengers, all of this need to be taken into consideration when organizing the airport.

1. **Simulation**

Simulation, according to Shannon (1975), is “the process of designing a model of a real system and conducting experiments with this model for the purpose either of understanding the behavior of the system or of evaluating various strategies (within the limits imposed by a criterion or set of criteria) for the operation of the system.” According to this definition, simulation reflects the operation of a real-world process and structure over time. Simulation provides for the utilization and enhancement of a system. In this project, an application called Simio will be used to optimize and study an airport.

1. **Simio**

Simio is an application used to provide an actual virtual representation of all elements involved in an operation. It provides a platform where a system can be studied and optimized.

**Uses of Simio**

It optimizes the use of critical resources

It Predicts the impact of proposed process changes

It improves performance through optimized facility design

1. **Airport Simulation**

Airport Simulationis the computer-based modelling of any real-world process involved with an airport. Airport simulation organizes the industry by analyzing and experimenting with the system to optimize time and cost necessities associated with physical testing.

1. **Problem statement**

These changes require a simulation to determine the suitable number of every component in the airport. In this project, we are going to simulate the number of people visiting the airport every day, and determine the following:

* Number of bus stops and metal detecting scanners needed to maintain a quick and safe entrance to the airport.
* Number of waiting areas, restrooms, and restaurants/coffeehouses needed to accommodate the number of people at the airport.
* Number of ticketing and passport control counters needed.
* Number of boarding areas.
* Number of runways and airplane offloading area.
* Number of passport control counters for arrivals.
* Combining the Luggage with the passenger after arriving.

1. **Literature Review**

The requirement for services like restaurants or restrooms becomes more and more challenging with the increase in the number of people in a certain area and acquiring an excessive amount of each service is not an ideal solution to the problem, also, each place requires different kinds of services. for example, malls require restaurants, restrooms, and a huge variety of shopping places with all kinds of different goods like household electronics and furniture as well as clothing and so on, but for airports, electronics and furniture are not supposed to be sold in airports, because nobody would go to the airport to buy a TV and take it with them on the airplane.

for airports the requirements are:

* Bus stops
* Restaurants
* Restrooms
* Coffeeshops
* Waiting areas
* Metal detecting scanners
* Boarding stations
* Passport control stations.
* Runways

1. **Methodological Approach**

Simio is an application used to provide an actual virtual representation of all elements involved in an operation. While Takt time method is a simple process that determines the required number of workers/servers, using the processing time of each step and the available time at hand, while considering the required number of units that need to be produced.

* Simulation using the Simio application
* Takt time method

1. **Assumption and constraints**

Assumptions are beliefs that we agree to be true, assumption may either be true or not be true. Assumptions are built into research or project plan. Constraints are limitations we know to be true; constraints must be accounted for in the project or the plan. constraints are factors that limit one to the full exercise of a project or a plan.

Assumptions and constraints:

* Number of passengers
* Number of passenger’s relatives or Number of people not traveling
* Number of passengers using bus
* Mean Passengers of transport passengers use to the airport

Processing time assumptions:

* Bus offloading
* Waiting area
* Restaurants & coffeehouses
* Restrooms
* Ticketing counters
* Passport control
* Runways
* Airplane offloading
* Luggage offloading

**CHAPTER TWO**

**AIRPORT SIMULATION**

**Background Studies**

1. **Airport and its structures**

An airport is a facility where air passengers come aboard from and to places around the world using air transportation. Airports can be partitioned into landside and airside. Landside depictions cover how passengers arrive/depart the air terminal and travel through the terminal structure to board the airplanes. Airside portrays the movement of the planes on the airport’s surface.

At the exceptionally least, an airport comprises one runway (or helipad), yet other normal parts are hangers and terminal buildings. Aside from these, an airport might have an assortment of offices and infrastructure, including fixed-base operator services, aviation authority, passenger facilities like eateries and parlous, hotels, and emergency services.

Smaller or less-developed airports often have only a single runway that is less than 1,000 meters long (3,300 ft). International airports typically have paved runways of 2,000 meters (6,600 feet) or more. Rather than asphalt or concrete, many tiny airports have dirt, grass, or gravel runways.

Airports provide the necessary infrastructure to facilitate the shift from air to ground transportation. As a result, academics define airport operation and logistics as “the full set of activities required to transfer passengers and commodities from surface to air transport modes using airplanes” (Ashford et al., 2013). These activities can be supplemented in a variety of ways, including ensuring that travelers arrive on time for their connecting flights, acting as a retailer, and providing transportation.

1. **Characteristics of an airport**

Airports provide the necessary infrastructure to facilitate the shift from air to ground transportation. As a result, scholars define airport operation and logistics as the full set of activities required to transfer passengers and products from ground to air transport modes using airplanes (Ashford et al., 2013). These activities can be supplemented in a variety of ways, including ensuring that travellers arrive on time for their connecting flights, acting as a retailer, providing lodging for travellers, and/or operating a car park.

Rapid commercialization, growing capacity constraints, new technologies, airline consolidations, the advent of low-cost carriers, corporate responsibility for promoting a sustainable environment, and the need to keep safety and security issues a priority are just a few of the issues that airport stakeholders must contend with. In this setting, larger, broader, and more sophisticated expertise is required to ensure that airports are managed successfully and efficiently. The characteristics of some of the mentioned airports are listed below, and the airport structure will be analyzed afterward.

* The types of aircraft that can use the Airport are determined by the length and breadth of the runways, as well as the supporting aeronautical infrastructure. They are an important component of the airport's infrastructure.
* A series of taxiways connect the runway to the aprons. These are used to assign airplanes to parking places. The location of links between taxiways and runways affects how rapidly planes can depart the runway and how many brief movements the runway can accept in a given amount of time.
* The aprons are the aircraft's effective parking zones. They frequently have a constraining effect on the Airport's capacity, and their organization is critical to the facility's efficient operation. With the rising size of aircraft, apron areas are often the most important airside component of the airport plan.
* The terminal is fed by the aprons. Terminals can be built in a variety of ways, but one of the main goals of modern terminals is to connect the planes directly, eliminating any secondary passenger movements via bus or other means.
* Car parking and highway access are the most important support activities for the terminals. Car parking requirements are the major landside land usage at every airport. Car parking may be in a multi-story structure near the terminals (with hefty parking fees), or it may be spread out at ground level with accompanying internal transit connections. As airports grow, they are often unable to accommodate this car parking, resulting in a second type of off-airport parking commonly connected with hotels and primarily private operators.

1. **Airport Structures**

Airport structure defines and synchronizes all airport operations, although “the various processes bring multiple of players whose jurisdictions is to deliver parts of the required services The airport players are: landslide and airside.

Diagram

Description automatically generated

Figure 1.10: Airport structure

Landside areas include parking lots, fuel tank farms, and access roads. Airside areas include all areas accessible to aircraft, including runways, taxiways, and ramps. Access from landside areas to airside areas is tightly controlled at most airports, for safety reasons and adequate service. The landside zone is subject to fewer special restrictions and is part of the public domain, but entry to the airside zone is restricted. All elements of the airport around the aircraft, as well as parts of the buildings restricted to employees, are included in the airside area, as are sections of these extended to traveling airside shopping, dining, or waiting passengers. Passengers and personnel may be subjected to security or border control checks before being allowed to access the airside zone, depending on the airport. Passengers arriving from an international flight, on the other hand, must go through border control and customs to go to the landside region, where they will disembark unless they are in airside transit.

For inter-terminal airside transit, most multi-terminal airports have (variously referred to) flight/passenger/air links buses moving walkways and/or people movers. Their airlines can arrange for the passenger’s luggage to be delivered directly to their destination. Employees at most large airports are given a secure key card, sometimes known as an airside pass, to aid in the trustworthy, standardized, and efficient verification of their identities.

Passengers on commercial flights use terminals to reach airside regions, where they can buy tickets, clear security, check or claim luggage, and board planes. Concourses are the waiting spaces that let passengers board planes, while the term is frequently used interchangeably with terminal. A **ramp** is a place where planes park near a terminal to load passengers and luggage. **Aprons** are aircraft parking zones that are located away from terminals.

Depending on aviation traffic density and available funds, both major and small airports can be towered or uncontrolled. Most international airports have air traffic control on-site due to their large capacity and active airspace.

1. **Airport Immigration**

Crossing international borders normally necessitates passing through a checkpoint, and international airports, being the first point of entry into a new country, have checkpoints that travellers must pass through before departing the airport. Customs and immigration are offices that often work hand in hand. Customs and immigration officers examine visitors to see if they have the proper documentation to enter the nation, if they're legally permitted to be there, and if they're bringing anything unlawful with them. On an international trip, you'll pass through customs and immigration twice: once when you arrive in the foreign country you're visiting and again when you return home.

**Immigration** is a government parastatal that enforces law and order for the safety and wellbeing of a country. The works independently in protecting a country by registering and approving citizens’ and non-citizens’ access or exit from a country. When you enter a nation other than the one from where your flight originated, you must go through the immigration process. This inspection process will be administered by each country's agency. The immigration process takes only a few minutes for the great majority of passengers, though lines to obtain your turn can get long if several international flights arrive at the same time.

**Procedures upon arrival at the Immigration**

* Upon arrival, passengers must proceed to the airport's immigration and passport control area, where passengers are separated into multiple lines. There is usually a line for citizens of the host country (those who have a passport from that country), a line for citizens of the area (EU, ECOWAS, etc.), and a line for non-immigrant tourists. To avoid confusion and losing time, make sure you enter the proper line.
* If passengers are not a national of the host country, passengers will most likely go via the non-immigrant guest line when going through immigration.
* In the immigration area, using your cell phone of cell phone is mostly prohibited or cameras. Cell phone calls are not permitted in this area and may be confiscated. Avoiding the use of devices in the immigration and inspection area is a smart idea. Maintaining a calm attitude, there will be nothing to worry about as long as a passenger is honest and follow instructions.
* Officials will look over your required passenger travel documents (passport, visa, green card, disembarkation card (issued by a flight attendant during the flight), immunization documentation, letters of confirmation or support, and so on.)

1. **International Customs**

A customs airport has been designated by the country's competent customs authority as an airport for the unloading of imported goods and the loading of export goods or any class of such products. Such locations shall be the only inland container depots for the unloading of imported products, as well as the loading and clearing of export goods of any class. International commercial flights may not be available at customs airports, but if they are, customs officials may only be present on scheduled international flights. Boarding stations may be located at or near such airports for customs officers boarding or disembarking vessels.

International airports are defined by their customs facilities, which frequently necessitate a higher level of physical protection. In most cases, international airports contain a complex of facilities where passengers may board planes and goods can be stored and loaded.

After clearing immigration and retrieving luggage, passengers must pass through customs before being permitted to leave the airport. **Customs** is a government agency in the country that oversees regulating the movement of commodities into and out of the country, including animals, transportation, food, personal effects, and dangerous materials. Just as each country has an agency that facilitates the Immigration Process, the country you enter will have its laws and regulations regarding the import and export of goods into and out of a country. It is the responsibility of the respective customs agency to enforce these policies.

Most countries have tight regulations regarding the transfer of soil, sand, and dirt from one country to another, as it is critical to avoid the introduction of non-native species. Certain nations will have stringent restrictions regarding this transfer, and you may be asked questions or be required to clean your shoes, close your personal effects, and go through customs before leaving. The customs clearance process takes only a few minutes for most passengers.

1. **Shops and Food Services**

This service is crucial in airports since it provides entertainment and relaxation. Shops and food courts can be found in most international airports. Passengers can get food and drinks from these services before boarding their aircraft. To service travelers, many well-known chain restaurants have opened locations in major airports. The toy and Gift Shop at Istanbul Airport, for example, provides Duty-Free for international passengers. Duty-free shops are common in international locations, where travelers are not compelled to pay the customs duty taxes on purchases.

For premium travelers, larger airlines frequently operate member-only lounges. Because airports cater to a captive audience, the costs paid for food are often greater than those found elsewhere in the vicinity. However, several airports have begun to restrict food pricing to maintain them comparable to "street prices. “Airport Support Services**.**

In most nations, airports are mandated to have safety safeguards. Various countries have different rules, yet some characteristics are universal. Baggage searches, metal screenings of individual passengers, and restrictions prohibiting the possession of any material that may be used as a weapon are all standard procedures at airport security. Standardized screening techniques, which all passengers must go through (e.g., luggage X-rays, metal detecting scans), and elevated-risk screening (pat-downs and strip searches), which only a subset of passengers are chosen for. In most nations, airports are mandated to have safety safeguards. Various countries have different rules, yet some characteristics are universal. Baggage searches, metal screenings of individual passengers, and restrictions prohibiting the possession of any material that may be used as a weapon are all standard procedures at airport security. Standardized screening techniques, which all passengers must go through (e.g., luggage X-rays, metal detecting scans), and elevated-risk screening (pat-downs and strip searches), which only a subset of passengers are chosen for.abstract

1. **Airport Operations**

* Aircraft maintenance
* pilot services
* aircraft rental and hangar rental are most often performed by a fixed base operator (FBO). At major airports, particularly those used as hubs, airlines may operate their support facilities.

A vast team of personnel works together outside the terminal to guarantee that planes can land, take off, and move around promptly and safely. Passengers are typically unaware of these processes, yet they are extremely sophisticated at large airports.

**Air Traffic Control**

ATC (air traffic control) is a system in which ground-based controllers direct aircraft movements, usually by VHF radio push-to-talk. In complicated operations where traffic moves in all three dimensions, this integrated oversight improves safety and speed. At airports, air traffic control tasks are typically split into two categories: ground and tower.

Except for runway traffic, Ground Control oversees directing all ground traffic in defined "movement areas." Planes, baggage trains, snowploughs, grass cutters, fuel trucks, and a variety of other vehicles fall into this category. Ground Control will tell these vehicles which taxiways to take, which runways to use (if they're planes), where to park, and when it's safe to cross runways. When a plane is ready to take off, it will come to a halt just short of the runway and be handed over to Tower Control. A plane will leave the runway and return to Ground Control after it has landed.

Aircraft on the runway and in the regulated airspace immediately surrounding the airport is controlled by Tower Control. The position of an airplane in three-dimensional space is identified and accurately located by tower controllers using radar. They direct airplanes on how to safely join and depart the circuit and manage the sequencing of aircraft in the traffic pattern. Aircraft that are simply traveling through the airspace must also inform Tower Control to ensure that they do not interfere with other traffic.

**Traffic Pattern vs. Scheduled Operations**

A traffic pattern is used at smaller airports and military airfields to ensure smooth traffic flow between departing and arriving aircraft. This pattern is often a circuit with five "legs" that create a rectangle (two legs and the runway form one side, with the remaining legs each form another side). Each leg is given a name (as shown in the diagram), and ATC instructs pilots on how to enter and exit the circuit. Traffic patterns are flown at a specified altitude, usually 1000 feet above ground level. Most traffic patterns are left-handed, which means that all turns are to the left. Right-handed layouts can exist; however, they are typically used to overcome barriers such as a mountain or to minimize noise levels for occupants. The planned circuit aids pilots in searching for other planes and reduces the risk of a mid-air collision.

A circuit is rarely employed at large airports. On the other hand, ATC schedules planes to land while they are still hours away from the airport. Airplanes can then make the most direct approach to the runway and land without having to worry about other planes interfering with their landing. While this technique keeps the airspace clear and makes flying easier for pilots, it necessitates a comprehensive knowledge of how aircraft plan to utilize the airport ahead of time and is thus limited to large commercial airliners flying on pre-scheduled flights. The system has recently advanced to the point that controllers can forecast if an aircraft will be delayed on landing before it takes off, allowing the aircraft to be delayed on the ground rather than squandering valuable fuel waiting in the air.

**Navigation Signs**

Taxiing aircraft and airport vehicles are given directions and information by airport guidance signs, which aid in the safe and efficient movement of aircraft. Smaller airports may have fewer or no signage, instead of relying on diagrams and charts.

At airports, there are two types of signage, each with various variations:

• Yellow location signs on a black background. Identify the runway or taxiway you are currently on or about to enter.

• Exit/Direction signs - black on yellow. The intersecting taxiways the aircraft is approaching are identified, with an arrow indicating which way to turn.

• Other – Several airports use traditional traffic signals such as stop and yield signs throughout the airport.

Signs with mandatory instructions are white on red. They depict runway entrances or key places. Vehicles and aircraft must come to a halt at these signs until the control tower gives the all-clear.

• White on red runway signs. These signs simply indicate an upcoming runway intersection.

• Frequency Change Signs - Usually stop signs with a request to change frequencies. These signs are used in various sectors of ground control at airports.

• Possessing A single solid yellow bar across a taxiway denotes a location where ground control might require a stop. If you see two solid yellow bars and two dashed yellow bars, you're approaching a runway junction holding position; runway holding lines must never be crossed without permission. During low visibility operations, a line of red lights across a taxiway is utilized at some airports to indicate holding positions.

**Lighting**

Many airports include illumination that assists pilots in navigating the runways and taxiways at night, in the rain or fog. Green lights on runways signify the start of the runway for landing, while red lights indicate the end of the runway. White lights spaced out on both sides of the runway indicate the edge of the runway. Some airports have more complex runway illumination, such as lights that run down the runway's centreline and lights that help mark the approach. Pilot Controlled Lighting can help low-traffic airports save money on electricity and staffing. Blue lights show the taxiway's edge, and some airports have green lights embedded in the taxiway that indicate the centreline.

**Wind Indicators**

To obtain maximum performance, planes take off and land in the wind. The ATIS or ATC can provide wind speed and direction information, but pilots require instantaneous information while landing. A windsock is kept on the runway for this purpose.

1. **Airport Safety and security**

In most nations, airports are mandated to have safety safeguards. Various countries have different rules, yet some characteristics are universal. Baggage searches, metal screenings of individual passengers, and restrictions prohibiting the possession of any material that may be used as a weapon are all standard procedures at airport security. Standardized screening techniques, which all passengers must go through (e.g., luggage X-rays, metal detecting scans), and elevated-risk screening (pat-downs and strip searches), which only a subset of passengers are chosen for.

**Safety**

In the operation of an airport, air safety is a major concern, and practically every airfield has emergency equipment and procedures in place. One or more emergency vehicles and their crews are stationed at commercial airports to cope with airfield accidents, crew and passenger extractions, and the hazards of highly flammable aviation fuel. Bomb threats, hijackings, and terrorist activity are all situations that the crews have been taught to cope with. Debris, nesting birds, and weather conditions such as ice or snow are all potential airfield dangers for

airplanes. Cleaning equipment must be used to keep the fields clear of debris so that loose material does not become a projectile and enter an engine duct. Birds breeding near an airstrip raise similar worries, and workers are frequently called in to dissuade the birds from settling down. Ice and snow removal equipment can increase traction on the landing strip in bad weather. Equipment is used to spray special dicing chemicals over the wings of waiting for aircraft.

**CHAPTER THREE**

AIRPORT OPERATION

1. **Introduction**

In this chapter, simulated airport operations will be initiated, it is an operation in which certain data have been fixed or assumed for the population and usage. It is an operation that helps optimize airport resources and passengers’ accessibility. This part of the project can be adapted or used for current airports or future airports.

The requirement for services like restaurants or restrooms becomes more and more challenging with the increase in the number of people in a certain area and acquiring an excessive amount of each service is not an ideal solution to the problem, also, each place requires different kinds of services. for example, malls require restaurants, restrooms, and a huge variety of shopping places with all kinds of different goods like household electronics and furniture as well as clothing and so on, but for airports, electronics and furniture are not supposed to be sold in airports, because nobody would go to the airport to buy a TV and take it with them on the airplane.

for airports the requirements are:

* Bus stops
* Metal detecting scanners
* Restaurants
* Restrooms
* Coffeeshops
* Waiting areas
* Boarding stations
* Passport control stations.
* Runways
* Luggage conveyor belts

1. **Scanner and Metal Detecting Devices**

The airport scanners use waves to create an image. The waves that bounce off the body could reveal if someone is carrying things under their clothing. These images are not stored.

## **What does the Body Scanner see?**

There are two types of body scanners: the millimetre wave scanner and the backscatter X-ray. The millimetre-wave scanner uses high-frequency radio waves to make an image of the body which shows objects hidden under clothes. The backscatter X-ray scanners detect the radiation that reflects from the human body.

At airports, schools, companies, and any other public location where scan and detection technologies are employed, a sense of security can be established. These devices allow security professionals to quickly monitor who enters a specific location and what they bring inside with them. Scan and detection systems, including walk-through metal detectors, handheld detectors, luggage scanners, and other kinds, are routinely employed in most public locations.

Scanners and detectors are classified into two types.

* X-ray Machine
* Metal detector

1. **Advantages of Scanner and Detecting Devices**

**Convenient**

Handheld metal detectors, for example, are simple to use and do not require any technical knowledge. They are typically lightweight, allowing you to easily hold them in your hands while using them. They are equipped with a handle, allowing you to easily move them through the body while searching for any suspicious metal object or weapon.

**Consistent and Trustworthy**

The scanning and sensing devices are consistent and dependable. Security personnel can use these devices at events, government offices or buildings, public places like shopping malls, movie theaters, airports, railway stations, and other places where high security is required. These devices are the most basic and dependable ways to improve security. **Detection of**

**Non-Metal Objects**

Metal detectors, such as walk-through scanners, have a clear flaw when it comes to liquefied substance, cream, or plastic smuggled goods that one can easily conceal on his or her body while passing through the detection process. Furthermore, different types of plastic or liquid objects can be extremely dangerous in a public place. A full-body scanner can be a very useful tool in this situation. It can aid in limiting the transport or smuggling of drugs or other illegal substances into or out of a facility.

**Evade Uncomfortable Strip Searches and Offensive Patting While Searching**

Several people, particularly women, are extremely uncomfortable with security personnel touching and removing their clothes while they conduct a thorough search of a person's body to determine whether he or she is concealing any illegal substance or stolen object on their body. Many people believe their privacy has been violated. Furthermore, these types of searches are time-consuming and inappropriate for places such as airports, excavation sites, jails, and other sensitive workplaces. The scan and detection devices also save employees from an uncomfortable and embarrassing situations while also speeding up security procedures.

1. **Simulation of Scanner and metal detecting devices**

The metal scanning station is considered; there are 126,711 persons a day who will be scanned for metal, and the scanning process is expected to take between 4 and 7 seconds for each person.

The first scanning station is at the entrance of the airport, this station is not a very sophisticated scan, but it is to make sure that no guns or sharp tools or bombs go through the airport without being registered. The second station for scanning and detecting metals is located after passport control, Passport control is the area in an airport where passports are checked, it’s a passport control station in which passports are being stamped, that determines a passenger’s entrance or exit into a country.

In this section, we will focus only on the first metal detector and scanning station at the entrance to the airport. considering that 37million passengers fly every year from this airport. Which means.

Per day = Total amount of passengers / Number of days in a year

= 37,000,000/ 365

=101,369 passengers fly from this airport in a day.

For passengers that come along with their families, it is required to make assumptions about the number of people that accompany passengers to the airport, as the first scan is not only accessible to passengers but also accessible to nontravelers. assuming that the number of non-travelers that access the scan is one-fourth of the number of passengers. Which is,

Non travelers = ¼ \* Total number of passengers

= ¼ \* 37,000,000

= 9,250,000 non travelers per year

Non travellers per day = Total number of non-travelers per year / number of days in year

= 9,250,000/ 365

= 25,342 non travelers per day

the total is going to be (25,342 + 101,369 = 126,711) both passengers and non-travellers’ people per day.

**Table 3.10: Data under scanner and detecting devices**

|  |  |  |
| --- | --- | --- |
|  | Definition | value |
| 1 | number of people arrivals per day | 126,711 people |
| 2 | number of bus arrivals per day | 2100 buses |
| 3 | number of people a bus can carry | 40 people |
| 4 | buses interarrival time | 41 seconds |
| 5 | bus offloading processing time | 5 minutes |
| 6 | non-bus interarrival time | 2.06 seconds |
| 7 | scanning time | 4 to 7 seconds |

**Takt time method**

The takt time method is a simple process that determines the required number of workers/servers, using the processing time of each step and the available time at hand, while considering the required number of units that need to be produced.

**For example,** let's assume that we have only 420 minutes to produce 250 units of a certain product, each product takes 8 minutes to finish manufacturing from start to finish.

**solution:**

step 1: simply divide the time we have by the required number of units

Step 2: divide the processing time of each unit by the value we determined in step1

Graphical user interface, application, table, Excel

Description automatically generated

**Figure 3.10: Take time example**

technically we only need 4.76 workers, but practically we need 5 workers because a fractured number is not realistic when considering the number of workers.

We will be applying this method throughout the project to determine the required number of servers for passport control and metal scanners and any other server-related purposes

**The arrival of passengers before departure**

The arrival of passengers at the airport is random, as some passengers come in buses, personal cars, and trains (if the facility is provided). A bus carries up to 40 passengers, knowing this, the required number of buses is 2100 buses a day, for passengers that get dropped by off either by their family members, taxi, or those who drive in and park their cars at the airport until they are back from their journey. A separate source point is defined for each passenger to avoid congestion. A more detailed explanation will be seen later.

Number of passengers that use buses = Number of passengers \* 2/3 (two-thirds of the number of passengers)

= 126,711 \* 2/3

=84,474 passengers

= 84,474 / 40

= approximately 2100 buses

Number of passengers using other means of transport = Total number of passengers \* 1/3 (one-third of the number of passengers)

= 126,711 \* 1/3

= 42,237

Graphical user interface, application

Description automatically generated

**Figure 3.11: the arrival of passengers before departure**

after implementing the Takt time method, we determined that we need at least 8 bus stops and at least 10 scanners.

**Buses Arrival Simulation**

Diagram

Description automatically generated with medium confidence

To prevent the buses from going to a bus stop that already has a bus offloading in it, all input nodes of all separates must be assigned to a node list, and then change the entity destination to select from a node list in the output node of the buses source point, by selecting the node list, and also set the input buffer for all of the separators to 0, this way, any new bus arriving will only go to an empty separator (this node list method will be used a lot in the project).

Diagram

Description automatically generatedA picture containing chart

Description automatically generated

The upper output node of each separator is the node where the "parent" entity will exit after being processed, the lower node will be where the new entities exit after being processed "child entities" or in this case “passengers”.

Diagram

Description automatically generated

Connecters allow entities to transfer instantly without wasting time going through a path. (Connecters are used here instead of paths because this part is just to build a more logical movement through the transfer nodes).

**Assumption of time**

An assumption was also made regarding time, the time it takes a passenger to go through the scanning machine. The time it takes each person and their luggage to be fully scanned and monitored carefully is assumed to be 4-7 seconds as the search and scan are not sophisticated. It is a scan where mainly metals, guns, explosives, and any deadly items are prevented within the terminal.

Graphical user interface

Description automatically generated with medium confidence

By using the function randomly. Uniform (4, 7)**.** The server will randomly choose a number between 4 and 7 seconds as a processing time for the entity that just entered the server.The “Random. Uniform (min, max)” will be used function throughout this project.

1. **Restaurants, Restrooms, Waiting areas, and Airline offices**

First, it is required to determine the number of people this part of the simulation should deal with, as well as the proportions of passengers and non-passengers who will go where (restaurants or coffeehouses, restrooms, waiting areas, flying company's offices, or directly to the ticket/luggage counters). Furthermore, a processing timer must be set for each station, keeping in mind that an entity doesn't need to visit all stations. Assuming the percentages of travellers and non-travellers are:

* Restaurants - 5%
* Restrooms -10%
* Waiting areas - 15%
* Passengers who will go to the ticket/luggage counters directly after entering the airport - 65%
* Flying company’s offices - 5%

As established in the previous step, 126,711 people are entering the airport every day, which means there will be 1 arrival every 0.68 seconds. However, it is not possible to divide this number by the ratios assumed previously, because a portion of entities will reroute into the simulation after going to a certain area.

(126,711 / 24h) / 60m

= 88 passengers

= 60s / 88 passengers

= a passenger every 0.68s

After going through “restaurants or coffeehouses”:

* Percentage of people going to the flying company’s offices: 1%
* Percentage of people going to the waiting areas: 69%
* Percentage of people going to the restrooms: 10%
* Percentage of people going to the ticket/luggage counters: 20%

After going through the flying company’s offices

* Percentage of people going to the restaurants or coffeehouses: 10%
* Percentage of people going to the waiting areas: 70%
* Percentage of people going to the restrooms: 15%
* Percentage of people going to the ticket/luggage counters: 5%

After going through the waiting areas, all entities will go to the ticket/luggage counters.

After going through the restroom

* Percentage of people going to the restaurants or coffeehouses: 15%
* Percentage of people going to the waiting areas: 53%
* Percentage of people going to the flying company’s offices: 2%
* Percentage of people going to the ticket/luggage counters: 30%

A demo test has been done in SIMIO to figure out the value each area has to handle so that determining the number of servers required is possible.

Chart

Description automatically generated with medium confidence

**Figure3.12 Showing the value each area must handle**

Restaurants or coffeehouses: 9579 people

waiting areas: 39474 people

flying company’s offices: 6976 people

restrooms: 15113 people

Each area's processing time must be estimated.

* Restaurants: from 15 to 35 minutes.
* flying company’s offices: from 2 to 10 minutes.
* waiting areas: from 1 to 80 minutes.
* restrooms: from 1 to 7 minutes.

Also, the total number of people going inside the airport includes the non-passengers, the non-passengers will go through the simulation but will not go to the next step in the simulation (ticketing/luggage counters), subtracting 25% of the people who are going to the ticket/luggage counters and rout them back to the entrance of the airport is needed.

**Table 3.11: Data under Restaurants, Restroom, and airline office**

|  |  |  |
| --- | --- | --- |
|  | Definition | value |
| 1 | Interarrival time | 0.68 seconds |
| 2 | Percentage of people who will go to restaurants or coffee shops | 5% |
| 3 | Percentage Of people who will go to flying company’s offices | 5% |
| 4 | Percentage Of people who will go to waiting areas | 15% |
| 5 | Percentage Of people who will go to restrooms | 10% |
| 6 | Percentage Of people who will go to ticket/luggage counters | 65% |
| 7 | Percentage Of people who will go back to the entrance | 25% (after the simulation) |
| 8 | Restaurants or coffee shops process time | 15 to 35 minutes |
| 9 | Flying company’s offices process time | 2 to 10 minutes |
| 10 | Waiting areas process time | 1 to 80 minutes |
| 11 | Restrooms process time | 1 to 7 minutes |
| 12 | Number of people that will go to restaurants or coffee shops | 9579 people |
| 13 | Number of people that will go to flying company’s offices | 6976 people |
| 14 | Number of people that will go to waiting areas | 39474 people |
| 15 | Number of people that will go to restrooms | 15113 people |

**Table 3.12: Rerouting logic**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Restaurants or coffee shops | | flying company’s offices | | waiting areas | restrooms | |
| offices | 1% | shops | 10% | All will go to the ticket and luggage counters. | shops | 15% |
| waiting areas | 69% | waiting areas | 70% | waiting areas | 53% |
| restrooms | 10% | restrooms | 15% | offices | 2% |
| ticket counters | 20% | ticket counters | 5% | ticket counters | 30% |

**Solution:**

A screenshot of a computer

Description automatically generated with medium confidence

required capacity:  
167 restaurants or coffeehouses, 30 offices, 1111 waiting areas, and 42 restrooms.

**Simulation:**

Chart

Description automatically generatedfirst, separating the arrivals by the weights assumed previously.

Also, these are the nodes that entities will reroute to after finishing processing.

using connectors in this section of the simulation is a must so that there is no wasted time in the simulation.

a path with the selection weight of 65% is set to go straight to the ticket/luggage counters.

Diagram

Description automatically generated

In total: 11 waiting areas, each one can handle 100 people at once, and input nodes are in a node list.

Diagram

Description automatically generated with medium confidence

In total: 4 restrooms, 2 of which can handle 10 people at once, and 2 of which can handle 11 at once, input nodes are in a node list and the input buffer is set to be 3.

Diagram

Description automatically generated

In total: 8 restaurants and coffeehouses, each one of them can handle 21 people at once, input nodes are in a node list and the input buffer is set to be 0.

Chart

Description automatically generated

In total, we have 15 offices, and each one of them can handle 2 people at once, these offices can be assigned to different flying companies, input nodes are in a node list and the input buffer is set to be 2.

Diagram

Description automatically generated

After both passengers and non-passengers go through the simulation a path that has a selection weight of 25% is set to go back to the entrance, this resembles the non-passengers going back to the same entrance they came in through, and there is another path that weights 75% for all other passengers to go the next step in the simulation.

1. **Ticketing, luggage counter, and passport control**

To begin, an accurate count of the number of participants in this simulation is rewired. Passengers will be the only ones going to the Ticket/Luggage counters; thus, this part of the simulation is going to be dealing with only the passengers, 101,369 passengers are expected to arrive each day or once every 0.857 seconds. Which is:

= (101,369 / 24h) / 60m

= 70 passengers a minute

= 60s / 70 passengers

= 0.857 seconds.

Passengers are classified into the first and second class, the ratios are 33% of passengers are first class and 67% of passengers are second class, so that means 33452 passengers are first class and 67917 passengers are second class. In addition, the number each flight can accommodate must be taken into consideration; it is estimated that it could accommodate up to 400 passengers every flight (it differs from one airplane to another, but in this project, it is assumed all flights can board a maximum of 400 passengers).

Passengers' passports and identity must be verified, tickets printed, and luggage transferred to the luggage truck so that it may deliver the luggage to the allocated plane. It is assessed that processing time is to be between one and four minutes for each person.

The Ticket-Luggage counters, on the other hand, will stop issuing tickets and taking luggage half an hour before departure for each aircraft and start printing tickets and taking passports 3 hours 30 minutes before departure, so it is important to keep this in mind. Passenger check-in time is assumed to be 0.5 seconds to 1 minute for the second class, and from 0.2 to 0.75 minutes for the first class.

**Table 3.13: Data under ticketing, luggage counter, and passport control**

|  |  |  |
| --- | --- | --- |
|  | Definition | value |
| 1 | Number of first-class passengers | 33452 passengers |
| 2 | Number of second-class passengers | 67917 passengers |
| 3 | interarrival time | 0.857 seconds |
| 4 | passengers per flight | 400 passengers |
| 5 | Passengers Ticket process time | 1 to 4 minutes |
| 6 | Second class Passengers passport process time | From 0.5 to 1 minutes |
| 7 | first class Passengers passport process time | From 0.2 to 0.75 minutes |
| 8 | Ticket - luggage counters operating time | 3 hours (10800 seconds) |

**Solution** A screenshot of a computer

Description automatically generated with medium confidence

* 6 servers per flight.
* 12 servers for the first-class passengers
* 36 servers for the second-class passengers

**Simulation:**

First, let’s consider the logic needed to establish:

* Only 400 passengers should go on each flight.
* If the timer reeds 10800 seconds (3 hours), the Ticket - luggage counters should close, and all new entities will be directed to a new flight.
* the process must reset once we reach the last flight counter.
* the timer must start counting as soon as a new entity gets issued for a new flight.

**Logic:**

A screenshot of a computer

Description automatically generated with medium confidence

**First:** the logic needs to know once a new entity enters this path (the path that leads to the flight ticketing counters.



The logic needs to start counting the time, each time a new entity enters this path the code assigns whatever value is in the timer to “timer\_end1”.



The logic needs to count how many entities have entered for this flight, (each time an entity enters we will add one to this integer).

**Second:** the second path will decide what to do with the values we gathered in the first path.

Shape

Description automatically generated with medium confidenceA screenshot of a computer

Description automatically generated with medium confidence

this will decide whether “count1” is bigger than or equal to 400.A picture containing application

Description automatically generated

A picture containing graphical user interface

Description automatically generatedIf it is true, then it will assign the starting time for the next flight (because when it reaches 400 in the current flight, a new flight will start now because the first flight is full).

it will also set the value of “count1” to be 0, making it ready for the next time we want to use these Ticket - luggage counters

Shape

Description automatically generated with medium confidence

If the first case is not true (which isn’t true from 0 to 399, SIMIO will keep checking the time as long as the first “if statement” is false, then it will decide if the time difference is bigger than or equal to 10800 seconds or not, if it is not true then it will do nothing, if it true then it will do the same steps we have explained earlier.

A picture containing chart

Description automatically generated

A picture containing chart

Description automatically generated

These labels are to show us the logic in action for each flight.

Chart

Description automatically generated

**Assigning/starting flights logic**

To assign the flights a bigger function that can cover the entire process is needed:

Diagram

Description automatically generated

A picture containing chart

Description automatically generated

Which is running in the very first path coming out of the course point.

Diagram

Description automatically generated

The first step in this algorithm is to add 1 to an integer each time a new entity enters this path, (each time a new entity gets generated this value will increase by 1), this integer will help the logic to assign different nodes for the entities to go to once we fill up the flight that we are working with at that point of time.

Diagram

Description automatically generated

Next, it will decide Werther this integer is bigger than the number of passengers that all previous flights must have taken, in this case, it is 0 because it is the first flight.

Diagram

Description automatically generated

Then it will check if this integer is what it is supposed to be considering the sequence of flights we are working with:

for the first flight, this value should be 400 passengers

For the second flight, this value should be 800 passengers

For the third flight, this value should be 1200 passengers

And so on until it reaches 3200 passengers for the last flight.

Diagram

Description automatically generated

If it is true, then it will set all incoming entities to go to the next flight counters. (If it is true then that means the first flight is full and now, it should open a new flight).

Chart

Description automatically generated

If the first “if statement” is not true (which it isn’t until it is true), it will keep checking the difference between the starting and ending times for this flight.

A screenshot of a computer

Description automatically generated with medium confidence

if it is true and passes 10800 seconds (3 hours), it will transfer all incoming entities to the same node it would have transferred to if the entity count has reached 400.

Diagram

Description automatically generated

And it will also set the global counter to be 400 (or whatever the value of the station that it is working at), simulating as if this flight has gotten all the passengers it needs, and so that it starts counting from 400 because of the timer “if statement” get initiated, then that means that the counter is not at what it is supposed to be if we don’t set it to what it is supposed to be then this would cause the next flight to start counting from a number lower than what it is supposed to start counting at, and it would receive more then 400 passengers.

Diagram

Description automatically generated

After that, it will repeat the process again and again until it reaches 3200 passengers (increasing 400 at a time).

Diagram

Description automatically generated

Diagram

Description automatically generated

At the very last flight, we will set this global integer back to 0 so that it loops again and again, both in the passenger count and in the timer detection function.

Diagram

Description automatically generated

Also, it set the timer back to 0 so that SIMIO is not dealing with huge numbers (it doesn’t affect the simulation whether it is set back to 0 or not).

Diagram

Description automatically generated with medium confidence

A picture containing graphical user interface

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Diagram

Description automatically generated

Diagram

Description automatically generated

Once the tickets and luggage have been issued, passengers will be directed to the passport control station by the first- and second-class passenger ratios.

1. **Boarding area / Runway**

First, we must determine how many people we are dealing with in this portion of the simulation, which is the number of passengers we established earlier: 101,369 passengers per day. This means that there will be one arrival every 85.7 percent of a second.

(101,369 / 24h) / 60m

= 70 passengers

= 60s / 70 passengers

=0.857 seconds.

In this portion of the simulation, we must provide restaurants and restrooms. We will configure the ratios so that 75% of participants proceed directly to their designated waiting area, 10% to the restrooms, and 25% to the restaurants. The rerouting logic is going to be as follows: after going through “restaurants” the processing time is from 15 to 35 minutes:

* To the waiting areas: 70%
* Returning to the restrooms: 30%

After going through “restrooms” the processing time is from 1 to 7 minutes:

* Back to the restaurants or coffeehouses: 30%
* To the waiting areas: 70%

Chart

Description automatically generatedTo determine the values each area must handle, we will do a demo simulation test:

**16,108 passengers will go to the restrooms.**

**19,957 passengers will go to the restaurants.**

We will also determine the processing time for each flight, which is the time required for passengers to board the aircraft. We predicted that this value would take 30 minutes. In addition, we must estimate the time required for each aircraft to be inspected and prepared for passengers; we estimated this value to be 30 minutes.

**Table 3.14: Data under boarding and Runway**

|  |  |  |
| --- | --- | --- |
|  | Definition | value |
| 1 | The number of passengers that will go to restrooms | 16108 passengers |
| 2 | The number Of passengers that will go to restaurants. | 19957 passengers |
| 3 | interarrival time | 0.857 seconds |
| 4 | The number of passengers per flight | 400 passengers |
| 5 | The rest rooms process time | From 1 to 7 minutes |
| 6 | The restaurants coffeeshops process time | From 15 to 35 minutes |
| 7 | flight process time | 30 minutes |
| 8 | Airplane process time | 30 minutes |

**Solution:**

Text

Description automatically generated with medium confidence

Figure: showing data under boarding and runway

* We need the restaurants to handle 347 people at once.
* We need the restrooms to handle 45 people at once.

First, let’s consider the logic required for this part of the simulation:

* Only 400 passengers should go on each flight.
* If the timer reeds 10800 seconds (3 hours), the flight should take off even if it didn’t get all the 400 passengers, and all new entities will be directed to a new flight.
* We need the process to be reset once we reach the last flight.
* We need the timer to start counting as soon as a new entity gets issued for a new flight.

**Simulation issues under boarding and runway:**

Unfortunately, the student version of SIMIO is limited only to 150 steps (add-on-process triggers), and after trying to code the logic in SIMIO we noticed that we can only do 8 flights at once in the entire airport, with the 3 hour operating time of each flight, and the processing time of 30 minutes, the entire airport would be filled up and the first issued flight wouldn’t have finished getting its passengers on to the airplane.

We weren’t able to make the airplane fly away if the time passes 3 hours, we did a lot of research but we weren’t able to find anything useful, we tried setting an integer value for each flight to represent the number of passengers each flight should carry, and in the case of the time is 3 hours, this integer would change to whatever is the number of passengers that flight has received, simulating that the flight received all passengers it needs, Unfortunately, that didn’t work at all, because you can’t set a changeable value as a “batch quantity”.

**Simulation**

This part of the simulation is going to look a lot like that of the previous simulation, we will be using the same timer and the same logic.

Diagram

Description automatically generated with medium confidence

First, we must separate passengers by the ratios we estimated previously.

Timeline

Description automatically generated

After that, we can assign the passengers to go to the restrooms and the restaurants and coffeehouses, we will also reroute passengers back into the simulation based on the rerouting values we estimated previously.

Diagram

Description automatically generated

Diagram

Description automatically generated

This is the preparation server that checks the fuel, mechanical issues, and other things that each airplane must be checked for the safety of the passengers and the working staff before take-off, also we added a secondary airplane source point that generates 4 READY FOR TAKEOFF airplanes just because we can’t start the simulation without ready airplanes (it would cause a lot of delays.) Also, the output node of the server is selected from a node list (the same node list method we used in the bigging parts of the project), this will prevent the airplanes to go to departer areas that already have airplanes.

Graphical user interface

Description automatically generated

We must assign a value to each entity that the passenger source point makes, this value will help us with the combiners later, we will make a new “state assignment” the “state variable name” is “ModelEntity.Priority” and the new value is one.

Diagram

Description automatically generated with medium confidence

Each combiner represents a boarding area (as well as a writing area for the passengers), once the combiner receives 400 batch quantity, it will start the processing time (passengers would walk to the airplane), unfortunately, the parent input buffer can’t be set to 0, if it were to be set to 0, no parent entity’s would choose to go to that combiner, we set it to be one (although it is unrealities to have 2 airplanes at once at the same abording area, we couldn’t find a solution for this problem as well).

A screenshot of a computer

Description automatically generated with medium confidence

After that the airplanes will go to the Runway, we have 2 runways each one can handle only 1 airplane at a time, and each airplane takes 7 minutes to take off, also “transferndoe8\_1” is set to choose from a node list that is why each runway input buffer is set to 0.

Diagram, schematic

Description automatically generated

As an added feature, we added a cargo station that generates cargo airplanes, these cargo airplanes will go to the same runways as the passenger airplanes.

1. **Arrival after departure**

As usual, we have to determine the number of passengers that we are dealing with in this part of the simulation, we assumed that there will be one airplane arriving randomly from 1 to 15 minutes and it takes 7 minutes to path find to a parking place where it can offload passengers and their luggage, as we have established before, each airplane can carry up to 400 passengers, we also assumed the time each airplane takes to offload the passengers and their luggage to be 20 minutes. We also assumed that not all passengers have big size luggage (the luggage that must be given at the ticket-luggage counters), some passengers will only have hand luggage and they don’t have to go to the luggage conveyor belt to take their luggage, we assumed that only 300 out of 400 passengers will have big luggage.

To find the values that we are going to deal with in every part of the simulation, we should do a demo in the SIMIO test:

The values we should determine the number of airplanes per day, this will also help us determine the number of passengers per day, it will also help determine the number of passenger buses and luggage cars per day.

A screenshot of a computer

Description automatically generated with medium confidence

We will have to deal with 173 flights a day, each flight carries 400 passengers and 300 luggage, and will generate 4 passenger buses and 1 luggage car, in total we have:

* 173 flights.
* 692 passenger buses.
* 173 luggage cars.
* 69,200 passengers.
* 51,900 big luggage bags.

We also assumed that each passenger bus takes 2 minutes to offload the passengers, each luggage car takes 20 minutes for the luggage, and each passenger takes from 75% of a minute to 2 minutes to check in.

**Solution:**

Graphical user interface, application

Description automatically generated

We need 3 airplane stops, 1 path for the airplanes, 1 passenger bus stop, and 3 luggage car offloading areas.

Table

Description automatically generatedWe also need 67 check-in counters.

**Logic:**

let’s consider the logic required for this part of the simulation:

* Only 300 passengers and 300 luggage should go to each conveyor belt.
* We need the process to be reset once we reach the last flight counter.

We will use the very same algorithm we used in the previous parts of the simulation, only this time we will be running 2 functions simultaneously, one function to count the number of luggage and one function to count the number of passengers after checking in.

Diagram

Description automatically generated

These are the combiners (we have 10 in total) that going to combine the 300 passengers with the 300 luggage.

**Simulation:**

A screenshot of a map

Description automatically generated with medium confidenceGraphical user interface

Description automatically generated with medium confidencethis is the bigging of the simulation, this is the source point of the airplanes which will then choose to land on 2 different paths, (eventhood in the simulation we only need 1 path, but we added 1 extra to speed up the simulation).

After that, the airplanes will go to a series of separates and combiners. The separators will generate the passengers and the luggage. The combiners will combine the passenger buses and the luggage to go to the next step.

Diagram

Description automatically generated

these are the source points of the passenger buses and the luggage cars, as we can see that they will only generate only once, and the generated buses and luggage cars will get cycled around the simulation.

The passenger buses will generate 25 and the luggage car will generate 10 and then both will stop.

Diagram

Description automatically generated

These are the bus passenger bus stops, although we only need just 1 bus stop, having 4 or 2 is more realistic because buses arrive in batches of 4 (each airplane arrival generates 4 passenger buses), so it is not realistic to have them park one by one to offload the passengers, even though it wouldn’t cause any delay if we only have 1 bus stop, also the buses will be sent back to the simulation after offloading.

Diagram

Description automatically generated with medium confidence

After that, passengers will be sent to check-in, this one server will represent the 67 check-in counters, (we didn’t add 67 individual servers because of the limitation of only 200 elements in each simulation).

A picture containing diagram

Description automatically generated

These are the combiners that will separate the luggage from the luggage cars, after processing, the luggage cars will be sent back to the simulation.

A screenshot of a game

Description automatically generated with medium confidence

This part is the combining part where passengers will take their luggage and then exit the airport.

N**ote:** we noticed that the number of passport control counters both in the Departures and the arrivals part of the simulation is bigger than what we usually see in real life airports, that might be due to the process time estimation we did, it could be exaggerated, or it could be because we are dealing the average number of passengers through the entire year, in reality, some months of the year are the busiest and some barely have any flights, due to that, the passport controlee process time might be different from time to time.

**CHAPTER FOUR**

1. **Problems encountered**

**Simulation issues**

Due to limitations in the SIMIO student version (150 steps (add-on process triggers), it was limited to only do 8 flights at a time in the entire airport and that is with the 3 hour operating time of Ticket - luggage counters, and only 6 counters per flight, and processing times ranging from 1 to 4 minutes, the entire airport would be completely packed before the first issued flight had finished processing its passengers.

Naturally, the real solution is to expand the number of separate counters to accommodate more flights at the same time. However, we are limited to only 8 flights due to the complicity that necessitates a large number of steps for implementing the logic so that SIMIO does not provide more than 400 passengers per flight and also for continuously monitoring the time so that the ticket and luggage counters close even if they do not receive 400 passengers if the timer reaches 10800 seconds or longer (3 hours).

Additionally, when running a large number of servers in the simulation (48 in this case), the node list method, which prevents passengers from being routed to a server that already has a large number of entities in it, causes a lot of lag and may even cause the software to crash, it is not possible to implement it in this bigger part of the simulation, even though it is preferable to use it if a powerful PC is available.

Diagram

Description automatically generated

In addition, there were some difficulties in constructing a timer function so that SIMIO can determine when it is time for the aircraft to finish and cease accepting passengers; as a result, we devised a novel technique for SIMIO to determine the time by creating a timer within the simulation.

Each second, a new entity will be created and then destroyed by the sink element; a counter will count the entities passing through a transfer node; we are counting in seconds to overcome these issues; and we will determine how long it would take for the airport to fill up with passengers, given that the first flight must have completed printing tickets and collecting luggage before that time:

Considering the ticketing counters, If the interarrival time is 0.857, then the airport that can accommodate 8 planes at once, with each flight carrying 400 passengers (a total of 3200 passengers in the entire airport), will take around 45.7 minutes (0.857 \* 3200 = 2742 seconds = 2742 / 60 = 45.7 minutes) to fill up with passengers.

**Discovered SIMIO bugs**

Timeline

Description automatically generated

We learned the hard way that if the paths between transfer nods are short (same as demonstrated in the picture), then adding the process wouldn’t be applied correctly, SIMIO would sometimes apply the add on process correctly, and sometimes would skip a few steps, and sometimes would do the process correctly but only once and will not repeat the process, it is a good idea not to put a lot of simulation elements into a small space in SIMIO.

Graphical user interface, table

Description automatically generated

we need 22 instead of 6 Tickets - luggage counters.

Unfortunately, because it is not possible to implement the node list method, the capacity must be increased to allow for failures. Therefore, all servers are configured to process 5 passengers concurrently (now the total process capacity is 30), despite the actual amount being 6. Also.

Also, We weren’t able to make the airplane fly away if the time passes 3 hours, we did a lot of research but we weren’t able to find anything useful, we tried setting an integer value for each flight to represent the number of passengers each flight should carry, and in the case of the time is 3 hours, this integer would change to whatever is the number of passengers that flight has received, simulating that the flight received all passengers it needs, Unfortunately, that didn’t work at all, because you can’t set a changeable value as a “batch quantity”.

**CHAPTER FIVE**

**Conclusion**

The dynamics of the airport industry today call for more effective organizational structures that allow flexibility and more efficient use of resources. A necessary change is the departmental representation of airports' ground transportation divisions. Such representation will increase airport use and effectiveness in many ways, including

• Increasing throughput to the airside,

• Securing appropriate fees for use of airport facilities and business opportunities,

• Providing better management for growing landside activities

•Facilitating changes and growth  
• Giving more attention to landside safety issues, and  
• Giving due representation in the master plan development.

This project has analyzed present and prospective service levels by focusing on airport operations and structure. Traditionally, these studies have concentrated on the required processing facilities, such as check-in, security, immigration, customs, and restaurant services, as well as the airside boarding lounge and boarding gates. Unfortunately, travellers spend a substantial portion of their time in the airport outside of these facilities; consequently, it is essential to include these and all other processes in the simulations.

To develop or maintain an effective airport, it is vital to incorporate modern features into its structure and operations. Airport operations are intricate to facilitate cooperation with other facilities. We proposed the first set of advanced decisions about the utilization of discretionary facilities in this project. All scenarios were simulated to demonstrate the progression of having a well-simulated airport. The simulations demonstrated the distribution of passengers in the space and demonstrated that peak operation times, which are generated by such simulations, are reduced when passengers are distributed among the full range of facilities. Additionally, passengers spend a large amount of time in the corridors, allowing for immediate exploitation of this space.

In conclusion, SIMIO is a great system simulation software, it can run mutual algorithms at once at a great extent of accuracy, but each simulation has its limits and assumptions that can’t be done without, we had to estimate a lot of process times and ratios, nonetheless, we learned a lot about SIMIO logic and algorithms, the capability of the “decide” add on process is similar to the “if else statement” in the programming world, where if a case is true, then the program will decide to do the next step and if it not true the program will do other steps, this was useful for the timer mechanism we used in our project, where we programmed SIMIO to keep track of the time and check whether the timer has passed its limit or not, until the number of passengers reads the specified number of passengers for that flight, also the “assign” add on process is useful to assign new values to integers in the case if a “decide” function is true or not, which helped us build the logic and chain the steps together using both the “decide” and the “assign” add on process together, we also learned a lot about how combiners, separates, and servers work with correlation to the input buffer capacity of each of them, we also learned a lot about the rerouting logic of delivery trucks and buses, we also benefited greatly from the Takt time method which was very helpful with determining the required servers for each process.

**Reference**

LLC, S. (n.d.). *The story of Simio*. Simio. Retrieved May 19, 2022, from https://www.simio.com/about-simio/

*Introduction to simulation - informs-sim.org*. (n.d.). Retrieved May 19, 2022, from https://www.informs-sim.org/wsc08papers/005.pdf

*Immigration & Customs*. Learning Abroad Center. (n.d.). Retrieved May 19, 2022, from https://umabroad.umn.edu/resources/travel/immigration-customs

Keyes, S. (2019, October 1). *What are customs and immigration at an airport?* Customs and Immigration Definition. Retrieved May 19, 2022, from https://scottscheapflights.com/glossary/customs-and-immigration

*Airport security measures and their influence on ... - researchgate*. (n.d.). Retrieved May 19, 2022, from https://www.researchgate.net/publication/260995886\_Airport\_security\_measures\_and\_their\_influence\_on\_enplanement\_intentions\_Responses\_from\_leisure\_travelers\_attending\_a\_Canadian\_University

*Appendix 1: The airport 1 characteristics of airports - Fingal*. (n.d.). Retrieved May 19, 2022, from https://www.fingal.ie/sites/default/files/2019-03/Appendix%201%20-%20Airport.pdf

Center for Air Transportation Systems Research. (n.d.). Retrieved May 19, 2022, from https://catsr.vse.gmu.edu/

Lehmann, C. (1970, January 1). *Characteristics of airports*. SpringerLink. Retrieved May 19, 2022, from https://link.springer.com/chapter/10.1007/978-3-658-23036-4\_8?noAccess=true+https%3A%2F%2Fonlinepubs.trb.org%2FOnlinepubs%2Ftrr%2F1992%2F1373%2F1373-003