WITNESS SIMULATION OF MACHINE BREAKDOWNS FOR SMALL, MEDIUM AND LARGE AIRCRAFTS DURING TURNAROUND PROCESS

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DECLARATION

This work has not previously been accepted in substance for any degree and is not being concurrently submitted in candidature for any degree.

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Other sources are acknowledged by giving explicit references.
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LIST OF ABBREVIATIONS

ADPI	Aeroport de Paris Ingenierie
ATM	Air Traffic Management
KLIA	Kuala Lumpur International Airport
KXP	Kulim International Airport
LTO	Landing and take off
MCT	Minimum Connection Time
MTBR	Mean Time between Failures
MTTR	Mean Time to Repair
OCC	Operation Control Centre
OEM	Original Equipment Manufacturer
PERT	Project Evaluation and Review Technique
PIA	Penang International Airport
PTB	Passenger Terminal Building
RCPSP	Resource Constraint Project Scheduling Problem
SA	Single Aisle
SESAR	Single European Sky ATM Research
TA	Turnaround
TAT	Turnaround Time
TOBT	Target Off Block Time
USM	University Science Malaysia

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ABSTRAK

Proses pemulihan pesawat termasuk masa yang diambil untuk pesawat tiba dan berlepas. Beberapa aktiviti yang terlibat dalam pusingan pesawat termasuk memunggah dan memuatkan Kargo AFT, memunggah dan memuatkan Kargo FWD, memunggah dan memuatkan pukal, mengisi bahan bakar, menurunkan penumpang, katering, servis tandas, servis air mudah alih, pengiraan penumpang, pembersihan, dan menaiki penumpang. Akibatnya, masa pusing pemulihan pesawat yang singkat diperlukan untuk mengurangkan kelewatan, yang merupakan kebimbangan utama dalam perniagaan pesawat dan mempunyai kesan langsung terhadap kepercayaan pengguna. Penyelidikan ini dibangunkan sebagai tindak balas kepada projek Lapangan Terbang Antarabangsa Kulim (KXP), yang kini dalam peringkat pembangunan dan perancangan. Matlamat projek ini adalah untuk menggunakan perisian simulasi Witness Horizon untuk menganalisis prosedur proses pemulihan pesawat bagi tiga jenis pesawat iaitu untuk Airbus A320 kecil, Airbus A350 sederhana dan Airbus A380 besar. Dalam penyelidikan ini tiga model pemulihan pesawat yang berbeza telah direka bentuk dan dianalisis. Terdapat tiga model yang tiada kerosakan, kerosakan pada mesin bahan api dan kerosakan pada kedua-dua kenderaan katering dan lori bahan api. Setiap keluaran model diperiksa dari segi bahagian, jentera, penimbal dan prestasi buruh. Setiap bahagian kemudiannya dibandingkan berdasarkan peratusan sibuk, terbiar, kerosakan, purata WIP dan faktor lain. Untuk memilih model terbaik, jadual perbandingan semua model telah dibina. Model yang ideal ialah model tanpa kerosakan kerana ia mempunyai masa proses pemulihan yang paling hampir dengan masa pusingan pesawat Airbus yang diunjurkan untuk masa pusingan sebenar. Masa simulasi Airbus A320 untuk model 1 ialah 46 minit, Airbus A350 untuk Model 1 ialah 50 minit dan untuk Airbus A380 ialah 60 minutes. Model 2 dan Model 3 mempunyai masa pemulihan pesawat yang lebih tinggi disebabkan oleh kerosakan mesin.Sebarang kerosakan, seperti yang dimodelkan dalam simulasi untuk Model 2 dan Model 3 akan mempunyai pengaruh serta-merta pada jadual penerbangan dan menyebabkan kelewatan.

WITNESS SIMULATION OF MACHINE BREAKDOWNS FOR SMALL, MEDIUM, AND LARGE AIRCRAFTS DURING TURNAROUND PROCESS

ABSTRACT

Aircraft turnaround process included the time it took for an aircraft to arrive and depart. Some of the activities involved in an aircraft turnaround include unload and load Cargo AFT, unload and load Cargo FWD, unload and load bulk, refuelling, passenger deboarding, catering, toilet servicing, portable water servicing, head counting, cleaning, and passenger boarding. As a result, a short aircraft turnaround time is needed in order to reduce delays, which are a major concern in the aircraft business and have a direct impact on customer trust. This research was developed in response to the Kulim International Airport (KXP) project, which is currently in the development and planning stages. The aim for this project is to use Witness Horizon simulation software to analyse the aircraft turnaround procedure for three types of aircraft which is for small Airbus A320, medium Airbus A350 and large Airbus A380. In this research three distinct aircraft turnaround models were designed and analysed. There are three models which is no breakdown, breakdown on fuel machine and breakdown on both catering vehicle and fuel truck. Each model's output is examined in terms of parts, machinery, buffer, and labour performance. Each part is then compared based on the percentage of busy, idle, breakdown, average WIP, and other factors. To select the best model, a comparison table of all models was constructed. The ideal model is Model 1 (no breakdown) because it has the closest aircraft turnaround time to the projected Airbus aircraft turnaround time for actual turnaround time. Airbus A320 simulation time for Model 1 is 46 minutes, Airbus A350 for Model 1 is 50 minutes and Airbus A380 for Model 1 is 60 minutes. Model 2 and Model 3 have higher turnaround time due to breakdown of machine. Any breakdown, as modelled in the simulation for Model 2 and Model 3 will have an immediate influence on the flight schedule and cause delays.

CHAPTER 1

INTRODUCTION

1.1 Background

Airport currently faced the problem with the issue of schedule disruptions, capacity constraints, and cost pressure. Besides that, airport also faced issues regarding turnaround time and punctuality based on determining scheduled arrival and departure times as well as providing maintenance facilities during turnaround time (Schmidt, 2017). To meet expanding demand, aircraft and airport capacity cannot keep growing at the same rate. When an airport's capacity is constrained owing to congestion, demand for its services exceeds the capacity that the airport can sustain. The key to airline operations planning and execution is the airport flight schedule. Managing airport take-offs and landings is a complicated issue that has a big impact on airport operations. This is because runways and air traffic controllers are working with limited resources A good planning is essential to reduce peak demand and meet the requirement needs of many airlines as feasible. Nonetheless, unanticipated delays make it impossible to arrange flights accurately and ahead of time. Congestion can be alleviated by expanding the runway or lowering the separation rules (Rodríguez-Díaz, 2017). An efficient aircraft turnaround is an important component of an airlines' competitive advantage. It is usually achieved by combining the passenger's egress and ingress with the necessary services such as passenger boarding and deboarding, aircraft fuelling, cargo loading and unloading, cabin cleaning and gallery servicing (Schmidt, 2017).

In spite of the fact that several studies have been done related to turnaround, most of the studies focused on the qualitative approach in investigating the turnaround process without considering every type of size for the runway. This paper will discuss the turnaround process and time at the runway by considering the type of aircraft related to Kulim International Airport (KXP). KXP will be developed and establish a new international airport for the northern region with a vision that this airport will become a major air transport hub and serve the states of Kedah, Penang, Perlis, Perak, and southern provinces of Thailand. The development and construction placed in 600 hectares of this airport will be located at Kuala Muda District between the town of Sungai Petani, Kulim and Kuala Ketil (Baling District) in the state of Kedah as shown in Figure 1.1 with cost RM6.8 billion. The construction will be expected to start in 2024 and it required 4 years to complete (Ejolt, 2020). The passenger terminal building (PTB) will be built in three phases, with the first phase targeting 6 million people and the second and third phases each accommodating an extra 7 million passengers. The three phases of expansion will eventually add up to a total capacity of 20 million passengers. Penang International Airport handled 8.5 million passengers in 2019, exceeding its 6.5 million passenger capacity (*Our Airports | Malaysia Airports Holdings Berhad (MAHB)*, n.d.).

Figure 1.1 The map of Kulim International Airport [*Kulim airport to have two runways | The Star, 28th August 2019)*

The purpose of the KXP airport is to attract foreign investors with maximum infrastructure available and support the growing capacity of the passenger from the Penang Airport. WITNESS simulation software will be used to stimulate the aircraft turnaround during the depart and arrival of the aircraft. The WITNESS simulation software helps in the creation of a dynamic simulation model that accurately represents some aspect of the real world. Furthermore, WITNESS also provides a graphical interface for creating simulation models, which allows for the automation of simulation experiments, the optimization of material flow across the facility, and the generation of animated models (Shinde, 2017).

1.2 Problem Statement

Many passengers are expected to utilize the airport facilities. Therefore, airport runway optimization is going challenge regarding the aircraft turnaround time. The number of passengers, passenger boarding and deboarding, fuel replenishment, cargo loading and unloading, luggage loading and unloading, maintenance, aircraft type, cabin cleaning, and gallery servicing is all affected the turnaround time. The proposed research is needed regarding the time taken data at the runway airport planning and scheduling. The aircraft scheduling problem entails sequencing aircraft on airport runways and scheduling their take-off and landing times while taking into consideration a variety of operational restrictions. The impact of this turnaround time is on the operations' punctuality and regularity, resulting in flight delays, unexpected congestion, and customer trust and satisfaction. The focus of this study will be on the time taken consumed for each process involved arrival and departure for one runway airport design. This project will be focused of the small Airbus (Airbus A320) which can hold 180 passengers medium Airbus (Airbus A350) which can hold 250 - 300 passengers and large Airbus aircraft (Airbus A380) which can hold 550 passengers (Schmidt, 2016).

1.3 Objectives

- To study and determine the process flow of aircraft turnaround
- To stimulate the time process of aircraft turnaround for the small, medium and large aircraft turnaround process at the runway by using WITNESS Horizon

- To analyze and compare the simulation cycle time before and after breakdown of machine

1.4 Scope of Work

In this project, it will be focused on the simulation process of the turnaround for Airbus. The overview of this research will be focussed on the simulation of aircraft turnaround process of all type of Airbus aircraft for the small, medium and large, Airbus planes in this research will be divided into three types of size which are small

(Airbus A320), medium (Airbus A350) and large (Airbus A380). The proposed solution will be stimulated by using Witness Horizon simulation software to evaluate the performance and effectiveness of the turnaround process for each size of aircraft on one runway.

For the simulation, the simulation based on the breakdown and no breakdown for each type of aircraft. Besides that, the simulation also will simulate the time delay caused for each aircraft and time arrival and departure for each aircraft. Other simulation software is also compatible to stimulate this project but due to WITNESS simulation can create simulation model which is nothing more than a dynamic representation of some part of the real world which is sufficient to ensure that visualization is based on an adequate predictor of reality. The turnaround process that will be focused on with this simulation project is regarding the time consumes for the turnaround process for each type of aircraft size. Data from this project will be gained from the historical data from Penang Airport analysis. This is because the data for KXP airport will be approximately similar as the Penang International Airport.

In this research, the performance measure for this study is the lead time of each procedure. The related work on the aircraft turnaround process will be covered in Chapter 2, and the methodology of this paper will be discussed in Chapter 3. The simulation findings will be discussed in Chapter 4, and the project will be concluded in Chapter 5.

CHAPTER 2

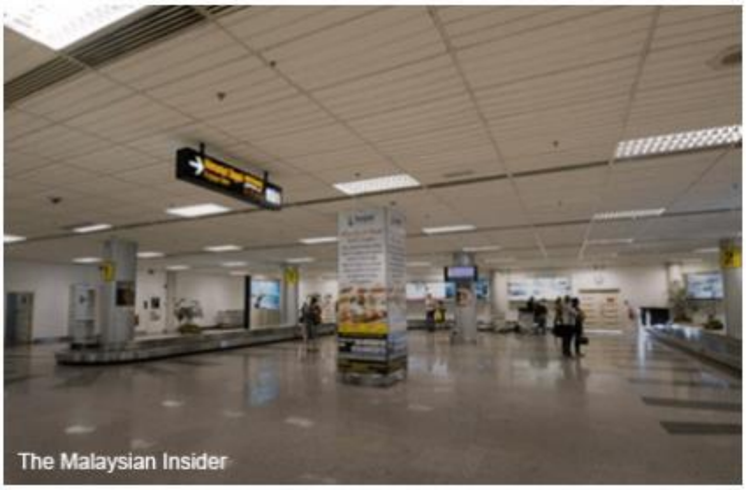
LITERATURE REVIEW

2.1 Kulim International Airport (KXP)

Kulim International Airport, also known as the KXP Project, is a Malaysian airport building project in Kulim, Kedah, which borders the state of Penang. In 2016, the state administration of Kedah requested permission from the country's Prime Minister to develop Kulim International Airport. Based on allegations that cargo traffic to Penang International Airport (PIA) has been dropped by 10.5 percent annually due to overcapacity, KXP would initially operate as an air cargo airport. Because PIA was unable to meet demand, global firms in Kulim were unable to complete their shipments. As a result, they use trucks to convey their products to Kuala Lumpur International Airport (KLIA), Singapore, or Thailand, where they will be delivered via air freight. (Kedah wants full-fledged airport in Kulim | The Edge Markets, 15th April 2016). Figure 2.1 shows the article which related to Kulim International Airport.

Kedah wants full-fledged airport in Kulim

Sangeetha Amarthalingam / The Edge Financial Daily
April 15, 2016 11:19 am +08



This article first appeared in *The Edge Financial Daily*, on April 15, 2016.

KULIM: The proposed Kulim International Airport (code-named KXP) is back to being a full-fledged passenger and cargo airport in the final proposal to be submitted by the Kedah government to the prime minister in the third quarter of 2016.

State science, innovation and information technology, communications, high technology and human resources committee chairman Datuk Norsabrina Mohd Noor said studies conducted by the state indicate that the airport, estimated to cost RM1.6 billion, should be full-fledged to cater to the growth in the Kulim Hi-tech Park (KHTP).

Last year, then menteri besar Datuk Seri Mukhriz Mahathir said KXP would start off as an air cargo airport based on reports that cargo traffic to Penang International Airport (PIA) was declining 10.5% annually due to overcapacity.

Speaking to reporters yesterday, Norsabrina said multinational corporations in Kulim are having trouble meeting their shipment schedules because PIA is reaching its maximum capacity.

"In order to send their shipments out via air freight, the companies use trucks to send them to KLIA (Kuala Lumpur International Airport), Singapore or Thailand.

"This is the biggest problem for us in KHTP, where the companies are not able to air transfer their goods via PIA, which cannot cater to the demand.

"The same goes with passengers. Penang is reaching its maximum capacity," she added, citing studies on PIA's capacity by the Department of Civil Aviation and Malaysia Airports Holdings Bhd.

She added that the state had organised a workshop earlier this year to cross-study and compare details based on the findings by the Northern Corridor Implementation Agency for Kedah, and international auditor KPMG Malaysia for the Economic Planning Unit.

The studies, which would be merged into one final report soon, were concluded in November last year and include options on financing models involving both the federal and state governments.

Norsabrina said the Kedah government has identified 600ha of oil palm land in Sidam Kiri, about 20km from KHTP, for the airport project.

Figure 2.1 News Article of Kulim International Airport (Source: (*Kedah wants full-fledged airport in Kulim | The Edge Markets, 15th April 2016)*.

Besides that, the news article regarding the Kulim International Airport will be operational in 2024 shown in Figure 2.2. Datuk Seri Mukhriz Mahathir, Kedah Menteri Besar, is optimistic that the Kulim International Airport (KXP) will be operational by 2024. Mukhriz further emphasised the importance of developing KXP as the Penang International Airport is more focused on passengers, but KXP would be more focused on freight and logistics. The proposed airport is a component of the Kedah Aerotropolis project, which aims to accelerate the state's economic transformation. The proposal includes the development of an airport as well as facilities for supporting sectors, such as an industrial park near Sidam for a logistics, aerospace, and manufacturing hub (Mukhriz hopes Kulim International Airport will be operational in 2024 | Bernama, 13 January 2020).

Mukhriz hopes Kulim International Airport will be operational in 2024

By Bernama - January 13, 2020 @ 9:43pm

(file pix) Kedah Menteri Besar Datuk Seri Mukhriz Mahathir is hopeful that the Kulim International Airport (KXP) would be operational in 2024. NSTP

KUALA LUMPUR: Kedah Menteri Besar Datuk Seri Mukhriz Mahathir is hopeful that the Kulim International Airport (KXP) would be operational in 2024.

He said the state government already have the master plan on the airport and is currently studying details on it.

"We hope to have it operational in 2024," he said at the Asian Strategy and Leadership Institute (ASLI) Centre Stage exclusive conversation to share his vision for Kedah towards the Shared Prosperity Vision 2030.

The dialogue, co- organised by ASLI and Jeffrey Cheah Institute on Southeast Asia (JCI), is themed "Dynamic Economic Development and Shared Prosperity: The Kedah Way".

Mukhriz also emphasised on the need to develop KXP as the Penang International Airport is more focused on passengers, whereas KXP would cater to cargo and logistics.

"As of today, many industries are still freighting their goods by road to the Kuala Lumpur International Airport," he said.

On Kulim Hi-Tech Park, which the state government is planning to double the size of the park, Mukhriz said he hoped that following the expansion, the park would be able to see exponential growth in investments, especially certain industries involved in artificial intelligence or robotics.

"We hope the investments would not be at the same pace as what we did from 1996 to 2019, which only drew RM31 billion in investments," he said to reporters after the event.

However, he did not provide the time frame for the expansion plan, but noted that the land issue has to be addressed first.

Currently, he said the tech park is owned by the State Economic Development Corporation, but the land area for the planned expansion is owned by the local government of Kulim.

"So we are working on merging the two local governments so that the tech park could be expanded further," he said.

With the ongoing US-China trade war which according to him had created more investment opportunities in the tech park, Mukhriz said the state government should take good advantage of this situation in order to bring in more foreign direct investments.

On the logistics hub in Sidam, he divulged that the state government would sign several agreements with companies involved in aerospace and logistics, including maintenance, repair and overhaul, soon.

However, he declined to reveal further details on the agreements. – BERNAMA

Figure 2.2 News Article of Kulim International Airport (Source: (*Mukhriz hopes Kulim International Airport will be operational in 2024 | Bernama, 13 January 2020).*

Figure 2.3 show the news article regarding the Kulim airport will have two runways. the project is expected to attract RM3.8 billion in private investment and create up to 18,000 jobs in the surrounding area. PIA is merely 3.3 square kilometres in size, while KXP is 17 square kilometres, and KLIA is a gigantic 100 square kilometres. The new airport will feature 60 aircraft movements per hour, including landings and take-offs, emphasising the importance of having two runways. If there are no delays, it is equivalent to one flight movement each minute, which is useful for precisely controlling cargo and flights (Kulim Airport to have Two Runways | The Star, 28 August 2019).

Kulim airport to have two runways

By ARNOLD LOH

NATION

Wednesday, 28 Aug 2019

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Impressive: The proposed site for the planned Kulim airport (top left) and (above) an artist impression of the terminal building that has been shared on Facebook since 2015.

GEORGE TOWN: A presentation file from Kedah's Budget 2020 dialogue shows that the proposed Kulim International Airport (KXP) will have two runways, sitting on a 17sq km piece of land at the state's border with Penang.

The file, which leaked out of the closed-door dialogue yesterday onto WhatsApp, also shows that KXP's development will be financed by the sale of a 18sq km piece of land around the proposed airport site.

The dialogue session was between senior government officers, and attended by Mentri Besar Datuk Seri Mukhriz Mahathir.

Labelling KXP as the "game changer" and the "new gateway to the northern region", the project is expected to have the potential to generate RM3.8bil in private investments to the vicinity and create up to 18,000 jobs.

In comparison to KXP's 17sq km, Penang International Airport (PIA) is a mere 3.3sq km while the Kuala Lumpur International Airport's land is a whopping 100sq km.

Figure 2.3 News Article of Kulim International Airport (Source: Kulim airport to have two runways | The Star, 28th August 2019)

Figure 2.4 shows the news article regarding the masterplan consultant for Kulim Airport that appointed by ADPI. A consultant is required in a construction project to make the construction process more efficient. Service engineers, project managers, cost consultants, and architects are examples of consultant roles. Aeroport de Paris Ingenierie (ADPI) has been recruited by KXP AirportCity Holdings Sdn. Bhd. to prepare a development masterplan for Kulim International Airport. ADPI is a French engineering corporation specialising in the design and development of new airports as well as the extension of existing airports worldwide. KXP Airportcity, on the other hand, has also employed a team of professionals to undertake research, assessments, and evaluations for the project. (ADPI appointed as masterplan consultant for Kulim Airport, 10th February 2020).

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NEWS

ADPI appointed as masterplan consultant for Kulim Airport

Bernama
Published 10 Feb 2020, 9:06 pm

A+ A-

KXP AirportCity Holdings Sdn Bhd has appointed Aeroport de Paris Ingenierie (ADPI) to draw up a development masterplan for the Kulim International Airport (KXP) Aerotropolis.

Kedah Menteri Besar Mukhriz Mahathir said an open tender was called in the last four months for international aerotropolis masterplan consultants to submit their proposals for the project.

"After a two-step selection process, six out of 28 companies that submitted their proposals were shortlisted, of which the eventual consultant ADPI was finally selected," he said after the KXP Airportcity-ADPI signing ceremony at Wisma Darul Aman in Alor Setar today.

He said KXP Airportcity has also appointed a number of competent consultants for several mandatory studies, assessments and evaluation for the project.

Figure 2.4 News Article Kulim International Airport (Source: *ADPI Appointed As Masterplan Consultant for Kulim Airport, 10th February 2020)*

2.2 Aircraft Turnaround Process Overview

The turnaround process begins when the aircraft arrives at the parking place and continues until the aircraft departs. The amount of time necessary to service the aircraft has a direct impact on gate utilisation and the number of aircraft that can be completed per day. In general, the turnaround time is determined by the aircraft type, the number of passengers, the cargo to be loaded and unloaded, and the aircraft operator's business model (Schmidt, 2016).

The turnaround encompasses all actions conducted on the aircraft in preparation for the next aircraft. If there are no periods of inactivity, the turnaround time is equal to the gate time, which is the time the aircraft is parked at the gate. The turnaround time is not the same as the ground time. The total time between touch down and lift-off is defined as ground time. As a result, it covers not only the taxi ride and any waiting time before takeoff, but also the pushback and engine start. In our context, the turn-around time is the amount of time the aircraft spends at the gate. This duration corresponds to the time the aircraft spends "on blocks," which refers to the fact that the aircraft's tyres are restrained with blocks to prevent unintentional motion. The period "off-blocks" is generally referred to as block time, and it is the primary metric of utilization (Clark, 2016).

Figure 2.5 depicts times in a conceptual manner; the lengths of the processes do not represent any relative scale. Understanding the various contributions to ground time is critical since minimising them necessitates different measures. Long taxi periods or queuing for take-off at the runway may increase ground time depending on the kind of operation. Moving ground time is defined as the time spent on the ground while the aircraft is not in a turnaround, as seen in figure 2.5 by the hatched region. The turnaround time is included in the ground time (Futche, 2014).

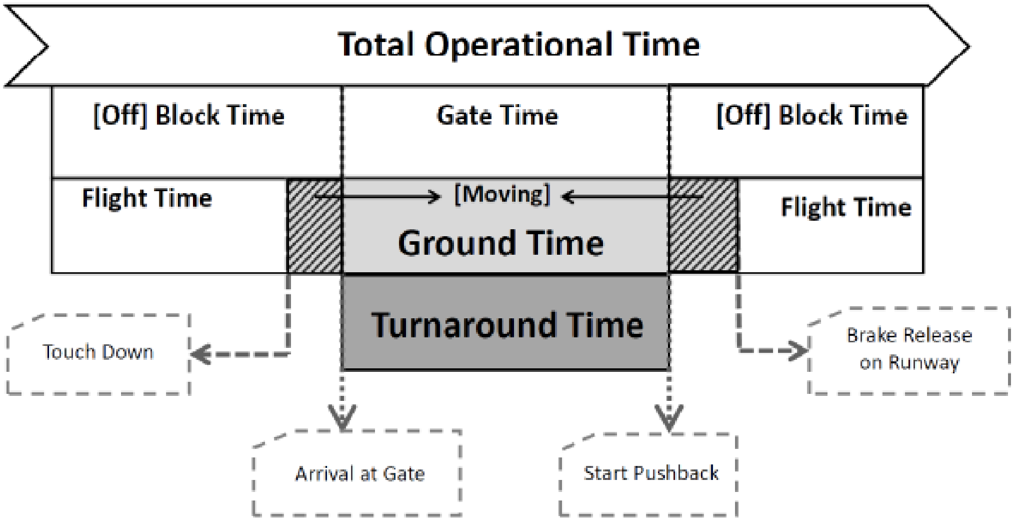

Figure 2.5 Time spent in flight versus time spent on the ground The turnaround time differs from the ground time, which includes cab time and possible departure delays. The moving ground time is represented as a hatching portion of the ground time (Futche, 2014)

Passengers boarding also contributes to flight delays because passengers may be unaware of seat arrangements, which will require more time. A good boarding strategy is required to reduce boarding time as well as turnaround time. Air traffic control is in charge of aircraft movement, including take-off, taxiing, and landing clearance. Because of the high number of flights that arrive and depart from a busy airport, traffic jams are possible. As a result of this issue, certain aircraft are not authorised to taxi to the parking space, causing aircraft delays (Timajo et al, 2014).

The boarding process is driven by the passengers' experience and willingness or ability to follow the proposed protocols (e.g., late arrivals, no-shows, amount of hand luggage, priority passengers) as an exception. The essential path of the turnaround must be within the control of the operational entities in order to produce a credible time stamp for the Target Off Block Time (TOBT) (Schultz, 2018).

Another research (Schmidt, 2017) review aircraft turnaround operations and simulations. This report included all information regarding aircraft turnaround, capacity constraints, schedule problems, passenger boarding strategies, and prices. Airport procedures are separated into two categories: landside procedures and airside procedures. Landside processes involve people arriving, dropping their luggage, going through security, and passing through security. Meanwhile, airside operations involve passengers boarding and disembarking the aircraft, as well as takeoff and landing procedures and taxiing processes. Figure 2.6 depicted a generic airport with both landside and airside features (N.J.Ashford, 2013).

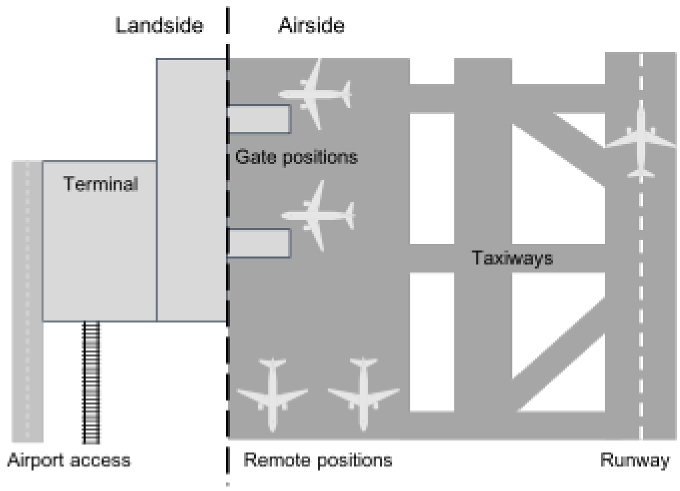

Figure 2.6 Generic Airport With Landside And Airside Element (N.J.Ashford, 2013)

Figure 2.7 displays a typical top view of a short-to-medium-haul aircraft's ramp layout at the gate location. The left side doors are for passenger egress and entry, while the right-side doors are for catering and cargo handling. The position of the service trucks is frequently predefined due to the aircraft interface locations. The time of individual handling procedures in a series is represented by the relevant Gantt-chart (see Figure 2.8). Because of the limited space around the aircraft, the logical chain, regulations, and limits result in a rigid chronological order for some handling operations. These operations are the important path of the turnaround process because they determine the minimum required turnaround time. Most of the time, the critical path comprises of passenger and aircraft cabin operations; but, in some cases, the fueling operation may become the crucial path. Other activities, including as unloading, loading, and aircraft servicing, may usually be carried out without interfering with or affecting the critical path activities (Schimdt, 2018).

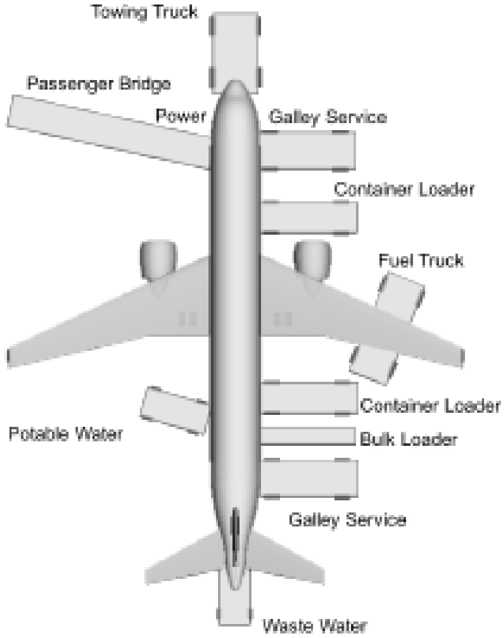

Figure 2.7 Ramp layout at gate position (Schimdt, 2018)

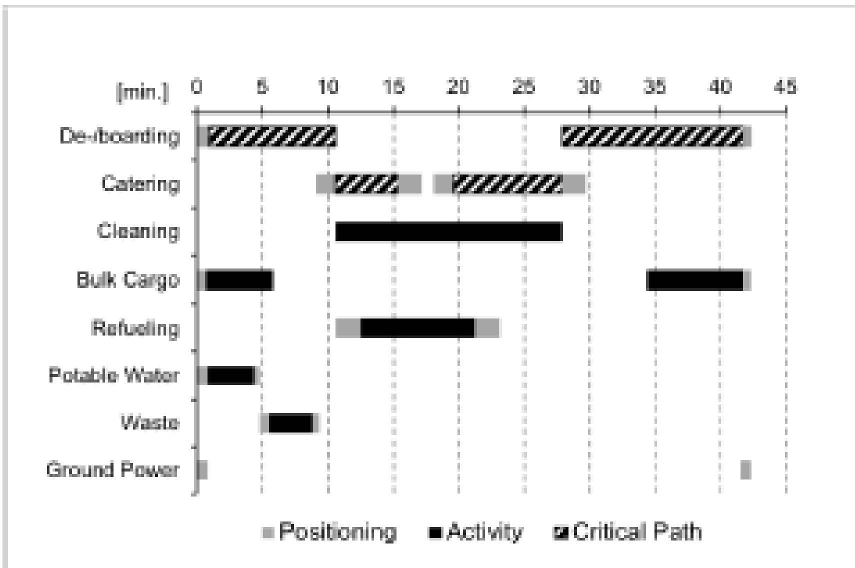

Figure 2.8 Gantt Chart (Schimdt, 2018)

The turnaround time in the SA aircraft segment between 100 and 200 passengers is 35 minutes on average, with a maximum of 51 minutes, as shown in Figure 2.9. The needed time for regional aircraft is around 17 minutes and 61 minutes for TA aircraft. However, an aircraft's real turnaround time is stochastic [61], because passenger numbers, refilled fuel, and cargo loads change from flight to flight. Airlines attempt to manage this volatility by incorporating buffer times, which results in a wide range of scheduled on-block times when compared to original equipment manufacturer (OEM) recommendations. Horizontal lines in the Figure 2.9 shows the median values based on the data from the manufacturer (Schmidt, 2017).

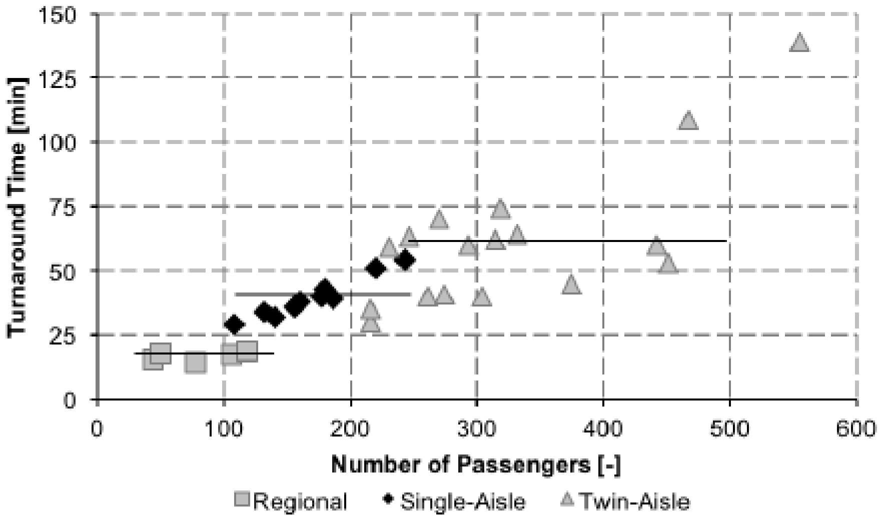

Figure 2.9 Turnaround Gantt Chart for Single-Aisle Aircraft (Schimdt,2017)

2.3 Turnaround Process Case Study

Research by (Schultz, 2008) studied on improving aircraft turnaround reliability by reducing the process time especially on the critical path. The airport, and particularly the turnaround time (TAT) of aircraft at the gate or in a remote location from the terminal, has been identified as a critical component of ATM system performance. Boarding, deboarding, unloading, loading, fuelling, and service have been recognised as the important path of the aircraft turnaround. Manpower, transfer volume (fuel), equipment type for servicing, and load statistics are all elements that might affect turnaround time. The method utilised in this paper was primarily statistical. For probing data fitting, the Weibull distribution was used. The identified important process is next examined using the chi-square test. Loading, unloading, boarding, and deboarding are the most crucial processes. As a result, boosting the dependability of the boarding or deboarding process reduces turnaround time, whereas improving the reliability of loading and unloading has no effect on turnaround time. All of this results in only a limited predictability of the "Earliest Off Block Time," which is a critical time constant for initiating the departure and, subsequently, the arrival sequence.

Research by (Abd Allah, 2012) are regarding real time aircraft operation for critical aircraft turnaround to the airline operation control centre (OCC). This enables the OCC to make quick and correct decisions on how to deal with any challenges to flight timeliness, assign duties, and evaluate performance across all activities. At the moment, these control and evaluation operations are carried out utilising manual procedures and telephone interactions, which results in incorrect data and delays. The data became increasingly suspect due to human involvement and the need to supervise flight preparation. Our answer to these issues is to provide the airline flight preparation management process during the aircraft turnaround, as well as build and implement a rule-based system called Flight Activities Progressions System, which is used to manage and monitor flight preparation during the turnaround. Mobile computing devices, handheld telephones, and wireless network technology General Packet Radio Service is used to implement an airline's real-time system. The system simulates the Project Evaluation and Review Technique (PERT) and the Critical Path Method. PERT is used to evaluate and improve the effectiveness of airline operating procedures as well as the efficiency of airline ground activity allocation. The system deployment results show that real-time operation has the ability to reduce airline operations delays and optimize aircraft ground stop time.

In contrast, (Schultz et al., 2020) investigated the effects of operational process adjustments for aircraft turnaround, which are primarily caused by pandemic-related limitations. The current pandemic crisis necessitates many changes to standard operating procedures for some turnaround sub-processes, such as passengers maintaining the physical distance required by the government during aircraft boarding and deboarding, and the cabin being sanitised. According to the study's findings, pre-pandemic turnaround times cannot be maintained for the same seat layout. Nonetheless, by adding an apron position and a seat allocation technique with empty middle seats (occupied seat of 67%), the pre-pandemic turnaround can be achieved without the need for additional cleaning workers. Aircraft turnarounds at terminals require 10% more ground time with more employees and 20% more ground time without additional manpower.

Besides that, (Evler et al., 2018) present the stochastic control of the HUB airport turnaround. The stochastic turnaround model was utilised in this study, which is stochastic target time prediction of target off block time (TOBT) and deterministic optimization of parallel turnaround operations using resource constraint project scheduling problem (RCPSP). Previous works employing Monte Carlo network processes simulation were used to make the stochastic prediction of TBOT. Different sequencing methodologies from earlier studies are incorporated into a microscopic, multi-stakeholder model within the optimization issue with the goal of lowering network-wide expenses for ground operations. Both techniques are combined into a simulation programme and implemented at an exemplary HUB airport with assumed expenses and process characteristics. The procedures' efficacy has been demonstrated. When greater arrival delays are propagated from one aeroplane to numerous simultaneous turnarounds, network costs rise in a non-linear way.

Research by (Schmidt,2017) evaluates novel layout options and seating solutions for 180-300 seat SA and TA aircraft. The operational evaluation system used consists of an agent-based passenger flow simulation, a handbook-based aircraft design component, and turnaround process modelling. According to the data, a scenario with doors located at 1/4 and 3/4 of the cabin length might save boarding time by up to 47 percent when compared to a single entrance for passenger processing. The use of foldable seats into SA arrangements allows for boarding performance to surpass standard TA concepts by up to 14 percent depending on the seat concept and door layout. When using two doors, the final turnaround assessment could demonstrate that foldable seat concepts have the ability to reduce the difference between the SA and TA configurations from 24% to 6%. However, the actual usefulness of the concepts is dependent on the folding mechanism's sophisticated manageability, certification, passenger acceptability, and the influence of additional foldable seat weight.

2.4 Simulation Software for the Aircraft Turnaround Process

In the context of aircraft turnaround procedures, this research by (Antonio, 2017) shows how simulation may be used not only to examine essential activities and pathways, but also to develop the corresponding survival functions, offering the probability that the turnaround will be completed before a series of target periods. Following an explanation of why the problem is important for both airlines and airports, the paper analyses some relevant work and proposes using Monte Carlo simulation to determine the critical pathways of the turnaround process and construct the accompanying survival function. This study is carried out with the assumption of stochastic completion times for each activity in the process, as opposed to current procedures, which normally assume deterministic timeframes. A set of numerical tests are carried out using the Boeing 737-800 aircraft. Different passenger occupancy levels are investigated, as well as two alternative designs for the turnaround stage.

(Malandri et al., 2019) conducted research on analysing performance losses caused by ground handling service providers and promoting the development of a system for quantifying ground handler strikes at large airports. A discrete event model is developed using AnyLogic, a general simulation tool. The existing airside model is organised into two hierarchical subsystems: the landing-and-take-off (LTO) cycle and aircraft turnaround activities. Following the construction and validation of the model, the industrial behaviours of ground handlers are simulated, and the associated implications are evaluated using a set of performance criteria. The impact is measured by the increase in average turnaround time and the frequency of late leaving planes. As the number of ground handling personnel decreases, turnaround procedures take longer to perform, causing departure delays and knock-on delays. The simulation model was done on Lisbon International Airport, and the results show that there is no variation in turnaround time between the reference, a journal by (Khammash et al., 2017), as it only increases by 4%.

The performance of turnaround tasks is frequently compromised by various disruptive events beyond the airlines' control, such as strikes or technical breakdowns, which can have a negative impact on the punctuality and regularity of operations, causing substantial delays and unanticipated congestion. Disruptive incidents in aviation force operations to deviate significantly from the schedule, resulting in a reduction in system capacity and, as a result, increased flight delays (Malandri, et al., 2019).

Aircraft departure punctuality is affected by the efficiency and duration of turnaround operations, as flight departure may be delayed if the turnaround activities are not completed on time. Turnaround efficiency is crucial not just for improving aircraft timeliness, but also for preserving rotation stability and airline connections. An efficient turnaround is also essential for maintaining the Minimum Connection Time

(MCT) between flights, which is defined as the amount of time it takes for a passenger and luggage to transfer from one flight to the next. Furthermore, quick turnaround times between flights are required to maximise aircraft use, which increases the likelihood of upcoming flights being delayed. Extra time is typically included in the scheduling, in addition to the time technically required for turnaround activities, to avoid potential delays from late arriving aircrafts and to reduce the chance of delays connected with ground handling procedures (Malandri, et al., 2019).

(Chung, 2013) investigated aircraft turnaround activities in airline hubs using a simulation-based approach. The emphasis is on how increased turnaround time can cause flight delays. Flight delays have a number of negative consequences, including consumer discontent and poorer system productivity. To better understand the consequences of flight delays, a simulation model centred on the tasks associated with the turnaround operation was constructed. Arena software was used to create the simulation model.

2.5 Comparison between Witness Simulation and Arena Software

Simulation and subsequent results provide a more detailed description of the Witness system. The first step is to determine the data that will be used in the simulation. The workplace is made up of three fundamental workplaces that are housed in a variety of equipment. A conveyor connects various workplaces, ensuring that parts are transported throughout the entire production hall. The outcome of this study is an evaluation of the efficiency of each workplace and potential ideas to boost the overall productivity of the process, which are displayed using graphs (Vysocký, 2017).

(Nikakhtar et al., 2011) compare the average value of performance metrics in Arena and Witness simulation software. This paper used an advanced inferential statistical technique to analyse the output data. ARENA is based on SIMAN and functions as a high-level graphical front end for SIMAN, in which models are constructed by placing icons on a drawing board and then linking these icons or blocks to build model logic. ARENA provides 10 alternative random number streams from which to pick, or the user can select the default stream. All of ARENA's distributions are based on a multiplicative congruential generator for uniformly distributed values ranging from 0 to 1.

WITNESS is also a discrete-event simulation tool that is frequently used in the manufacturing industry, as well as an object-oriented modelling environment. The queuing theory is a concept that this programme employs. WITNESS generates pseudo random numbers by combining numerous recursive generators. This method generates random numbers ranging from 0.0 to 1.0. Witness sampled from statistical distributions for activity durations, breakdown timings, setup intervals, and PERCENT rules using this amount. After multiple simulations, the result from Witness showed a modest difference with a minor effect size due to the software's dissimilar equation.

However, one function that Arena does not own is the development of charts for each report. WITNESS can generate reports that exhibit data in the form of pie charts, time series, and histograms. This report allows users to observe the performance, specifics of the stimulated model, and contribute to the model's operation (Shinde and Nimbalkar, 2017).

2.6 Literature Finding

According to the literature review, existing studies on aircraft turnaround largely used analytical models, stochastic models, which are challenging to implement. The researchers also identified operations such as disembarking, boarding, loading, and unloading as major contributors to increased aircraft turnaround time. Furthermore, Arena simulation software was employed by researchers to simulate ground handling operations. Because aeroplane turnaround simulation utilising Witness simulation is not yet available, this study will focus on employing this programme.

WITNESS was chosen as a comprehensive discrete event and continuous process simulator capable of displaying the dynamics of complicated systems. Furthermore, WITNESS provides a graphical interface for creating simulation models, since it permits a dynamic animated computer model to represent a real-world process and allows for the automation of simulation experiments and the creation of animation models. This project, on the other hand, aimed to investigate the steps and process flow of an aircraft turnaround. The ground handling operation was sketched out in Figure 2.10. According to Figure 2.10, there are many turnaround processes, including passenger boarding and disembarking via boarding bridge, refuelling by fuel truck, cabin cleaning, baggage loading and unloading, galley service, wastewater pumping, and potable water pumping. When constructing the simulation model, the sketching can be used as a reference.

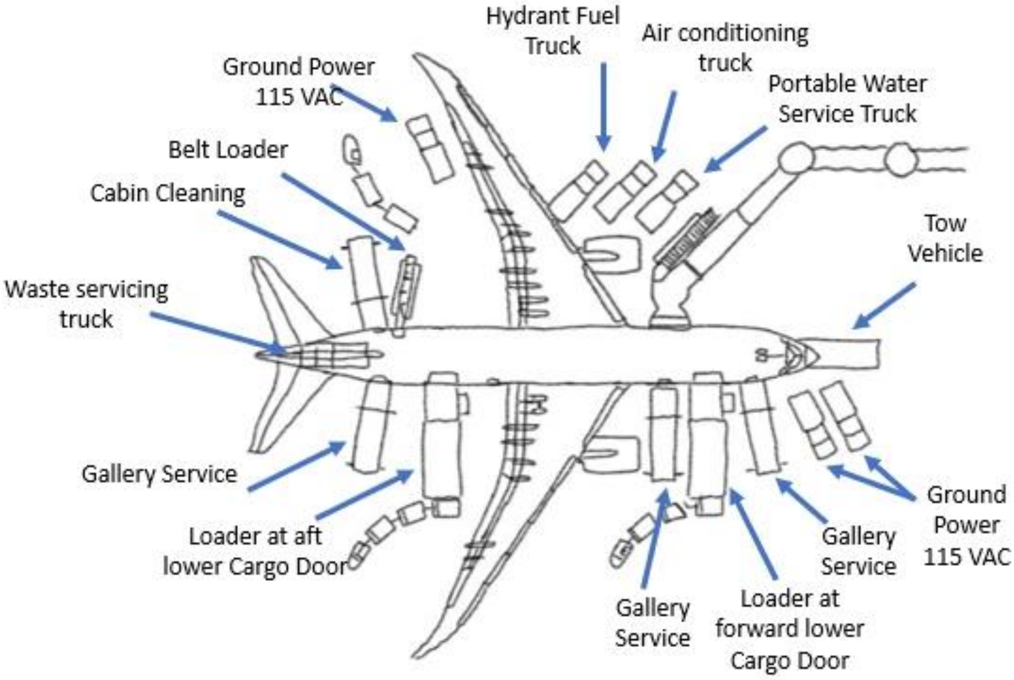

Figure 2.10 Sketching 1 Aircraft Turnaround Process

CHAPTER 3

METHODOLOGY

3.1 Introduction

This research had been conducted in order to develop an approach and achieve the three main objectives as stated in Chapter 1 section 1.3 page 18. This part describes the methodology, framework and process flow that being conducted for this research.

3.2 Flow and Framework

The overall process can be represented in a framework methodology. A framework has been created based on the objectives as stated in Chapter 1 for develop the model using simulation software Witness Horizon. Figure 3.1 shows the flow for the research framework. The framework consists of 4 phase which Planning, Defining, Designing, Execution and Validation and Analysis and Decision making. Each phase was divided to its several tasks and steps that need to be done. Each phase consists of step the detailed of each step and task will be further explained in this chapter.