WITNESS SIMULATION OF FLIGHT ARRIVAL AND DEPARTURE FOR ONE RUNAWAY AIRPORT DESIGN

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SCHOOL OF MECHANICAL ENGINEERING
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WITNESS SIMULATION OF FLIGHT ARRIVAL AND DEPARTURE FOR ONE RUNAWAY AIRPORT DESIGN

by

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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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ABSTRAK

Proses pemulihan kapal terbang melibatkan proses dari saat pesawat tiba sehingga pesawat berlepas lagi. Beberapa proses yang terlibat semasa pemulihan kapal terbang seperti mengisi bahan bakar, penumpang turun dari kapal terbang, pembersihan pesawat, penumpang menaiki kapal terbang dan lain-lain. Oleh itu, masa pemulihan pesawat yang rendah diperlukan untuk mengelakkan kelewatan yang merupakan masalah biasa dalam industry penerbangan dan secara langsung akan mempengaruhi kepercayaan pelanggan. Penyelidikan ini dicadangkan berdasarkan projek Lapangan Terbang Antarabangsa Kulim (KXP) yang kini dalam tahap perancangan. Tujuannya adalah untuk mempelajari process pemulihan kapal terbang untuk pesawat Boeing 737-800 dengan menggunakan perisian simulasi Witness Horizon. Empat model pemulihan pesawt dengan keadaan yang berbeza dikembangkan dan dianalisis dalam penyelidikan ini. Model-model tersebut adalah model tanpa kerosakan, model kerosakan pada kenderaan katering, model kerosakan pada trak bahan bakar dan model kerosakan pada kenderaan katering dan trak bahan bahar. Hasil setiap model dianalisis berdasarkan bahagian, mesin dan tenaga kerja. Setiap bahagian kemudian dibandingkan berdasarkan peratusan kesibukan, peratusan senggang, peratusan kerosakan, purata WIP dan lain-lain. Jadual perbandingan antara semua model dibuat untuk memilih model yang optimum. Model yang optimum adalah model tanpa kerosakan kerana ia mempunyai waktu pemulihan pesawat terdekat dengan masa pemulihan yang dicadangkan untuk pesawat Boeing 737-800 iaitu 37 minit. Sebarang kerosakan seperti yang dimodelkan dalam simulasi akan secara langsung mempengaruhi jadual penerbangan dan menyebabkan kelewatan.

ABSTRACT

Aircraft turnaround processes involved the process from the moment aircraft arrive until it departs again. Some of the processes involved during aircraft turnaround such as refueling, disembarking, cleaning, passengers boarding and others. Therefore, low aircraft turnaround time is desired in order to avoid delay which is the common problem in aviation industry and will directly impacted customer trust. This research was proposed based on Kulim International Airport (KXP) project that is currently in planning stage. The aims is to study the aircraft turnaround process for a Boeing 737-800 by using Witness Horizon simulation software. Four models of aircraft turnaround with different situation were developed and analyzed in this research. The models are no breakdown model, breakdown on catering vehicle model, breakdown on fuel truck model and breakdown on both catering vehicle and fuel truck. The result of each model is analyzed based on parts, machines and labor performance. Each section is then compared based on percentage of busy, percentage of idle, percentage of breakdown, average WIP and others. A table of comparison of all models was created to choose the optimal model. The optimal model is no breakdown model as it has the nearest aircraft turnaround time with the proposed aircraft turnaround time of a Boeing 737-800 of 37 minutes. Any breakdown as modelled in the simulation will directly impacted flight schedule and causes delays.

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LIST OF ABBREVIATIONS

ADPI	Aeroport de Paris Ingenierie
APU	Auxiliary power unit
ATP	Aircraft turnaround process
KLIA	Kuala Lumpur International Airport
KXP	Kulim International Airport
LTO	Landing and take-off
MCT	Minimum connection time
PCA	Preconditioned air
PIA	Penang International Airport
PTB	Passenger terminal building
RCPSP	Resource constraint project scheduling problem
TOBT	Target off block time
WIP	Work in process

CHAPTER 1

INTRODUCTION

1.1 Project Background

Airport serve as the hub for all commercial passenger flights, as it allowed planes to take-off and land, as well as providing critical maintenance facilities. Airport operations are separated into two categories which are landside processes and airside processes. Landside processes is when the passengers arrive, drop off their bags, and go through security, and airside processes whereby the passengers' board and depart planes. Airside operations include aircraft take-off and landing, along with taxiing procedures (Ashford *et al.*, 2013). It is essential to have an effective airport operations in order to maintain the punctuality, performance and safety of all processes involved. When the capacity of an airport is limited due to congestion, the demand for the services of an airport exceeds the capacity the airport can sustained. Airport flight schedule is the key to the planning and execution of airline operations (Rangel, 2006). Airline success depends on the efficient aircraft turnaround, particularly for regional and momentary operations. The existing ground operating procedures have been fine-tuned for the facilities and aircraft types that are available (Schmidt, 2017).

Managing airport take-offs and landings is a complex issue that plays a significant role in airport management. Runways and air traffic controllers are using minimal resources, so air traffic careful planning is required to minimize peak demand and satisfy as many airlines' requirement as possible. Nevertheless, unforeseeable delays make it difficult to schedule planes correctly and in advance. Congestion delays can be handled by runway expansion or shorter separation standards (Rodríguez-Díaz *et.al.,* 2017). Reducing idle time on the ground would lead to increased airplane utilization and more flexibility in time management. Factors that control the airplane turnaround time include:

- Passenger boarding and deboarding
- Aircraft fuelling
- Cargo unloading and loading
- Cabin cleaning
- Galley servicing

Some of the process of turnaround could not operate simultaneously, thus process such as boarding could not start before other processes finished because of safety reasons. Improving any of these factors would decrease the turn time, the most critical factor is the boarding time, as it is the longest part of turn time of airplane (Qiang *et al.*, 2014).

For this project, the case study will be based on the new airport, Kulim International Airport which is planned for construction at Sungai Petani, Kedah. The government of the state intends to construct the new airport to support the growing capacity of the passengers. The development and construction placed in 600 hectares of land comprises of the main Kulim International Airport (KXP), Kedah Aerocity, Kulim Airport City and including two additional development of Sungai Petani Inner Kedah Expressway (SPIKE) (*Proposed Kulim Airport project to cost RM6.8b, says Tok Pa | Malaysia | Malay Mail*, 2nd July 2020). Figure 1.1 shows the map of Kulim International Airport.

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

The main purpose of the development of Kulim International Airport is to draw more foreign investors with maximum infrastructure available. Moreover, construction of new airport is high in expenditure which is expected to cost about RM 6.8 billion and requires time for construction of 4 years as it is expected to operate on January 2024 (*Proposed Kulim Airport project to cost RM6.8b - Mustapa*, 3rd July 2020). The passenger terminal building (PTB) to be developed in three phase, where the first phase targeted to accommodates 6 million passengers while the second phase and three phase, for each phase, accommodates additional 7 million passengers. Eventually, the three phases of development will sum up a capacity of 20 million passengers. In 2019, Penang International Airport handle 8.5 million passengers which exceeds its maximum capacity of 6.5 million passengers. (*Our Airports | Malaysia Airports Holdings Berhad (MAHB)*, n.d.)

In this project, WITNESS simulation software will be used to simulate the aircraft turnaround from the moment the plane landed until it departs again. The WITNESS software helps in building a dynamic simulation model that represent some part of the real world sufficient to ensure that visualization using this model is adequately accurate predictor of the reality. Moreover, WITNESS provides a graphical interface to build simulation models as it allows automating simulation experiments, optimizing material flow across the facility and generating animated models. (Shinde and Nimbalkar, 2017)

1.2 Problem Statement

To ensure the airport run smoothly when it is ready to operate, a good proposed planning is needed as many passengers and travellers are expected to use the facilities in the airport. This research will be focused on the time taken for the each process involved during aircraft arrival until depart and compare the models of assigned situation. The optimized time for each process will eventually reduce the turn-around time of the aircraft and avoiding the flight delays. Airplane turn-around time need the effective coordination of all resources to ensure the punctuality of the aircraft and keep the passengers waiting as short as possible.

1.3 Objectives

This research aims:

- To study the steps and process flow of aircraft turnaround.
- To simulate the aircraft turnaround process by using WITNESS Horizon.
- To analyze the time taken for each process in aircraft turnaround and to propose a solution to improve the aircraft turnaround.

1.4 Scope of Work

The scope of study will be more focused on the simulation of aircraft turnaround process of Boeing 737-800 at airport terminal. There are four model for this project which are no breakdown, breakdown on catering vehicle machine, breakdown on fuel truck machine and breakdown on both machines. In this context, the lead time of each process is used as the performance measure for this research. The proposed solution will be simulated by the WITNESS simulation software to evaluate the performances and effectiveness. Chapter 2 will discussed the related work regarding aircraft turnaround process and Chapter 3 will discussed the methodology of this paper. Chapter 4 will discuss the results obtained from the simulation and Chapter 5 will conclude the project.

CHAPTER 2

LITERATURE REVIEW

2.1 Kulim International Airport (KXP)

Kulim International Airport, also known as KXP Project, is an airport construction project located in Malaysian city of Kulim, Kedah and borders the state of Penang. The state government of Kedah filed a request to the country's Prime Minister for approval to establish Kulim International Airport in 2016. Initially, based on reports that cargo traffic to Penang International Airport (PIA) was reduced by 10.5% annually due to overcapacity, thus KXP will begin as an air cargo airport. Due to PIA could not cater the demand, multinational corporations in Kulim having difficulty to complete their shipments due to this matter. Hence, they employ trucks to transport their shipments to Kuala Lumpur International Airport (KLIA), Singapore or Thailand in order to deliver them via air freight (*Kedah wants full-fledged airport in Kulim | The Edge Markets, 15th April 2016)*. Figure 2.1 showed the news article of 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.

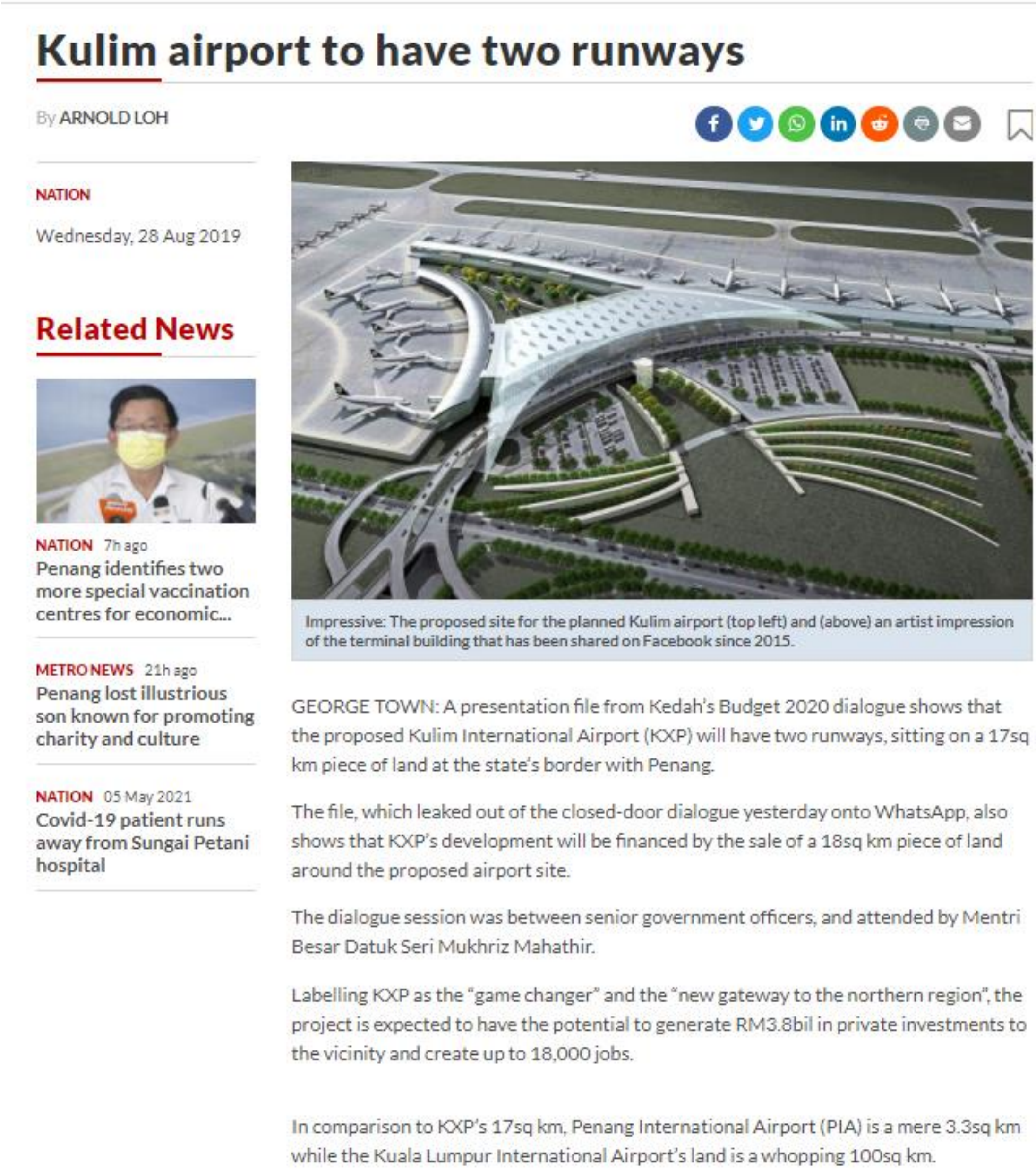
She added that the state had organised a workshop earlier this year to cross-study and compare details based on the findings by the Northern Corridor Implementation Agency for Kedah, and international auditor KPMG Malaysia for the Economic Planning Unit.

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

In addition, Kulim International Airport is built on a 17 square-kilometers of land near the state's border of Penang, will have two runways. The project is planned to bring RM3.8 billion in private investment and creating employment opportunities up to 18,000 in the surrounding area. PIA is only 3.3 square-kilometers in size compared to KXP's 17 square-kilometers, whereas KLIA's land area is a massive 100 square-kilometers. The new airport is planned to have 60 aircraft movements per hour, including landings and take-offs, which emphasis the need of having two runways. If there are no delays, it is equals to one flight movement per minute as it is good for controlling cargo and flights with precision *(Kulim airport to have two runways | The Star, 28th August 2019*). Figure 2.2 illustrated the article news of Kulim International Airport.



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

In construction project, consultant is needed to make the construction process more efficient. Some of the consultant roles are service engineer, project managers, cost consultant and architects. For the construction of Kulim International Airport, Aeroport de Paris Ingenierie (ADPI) has been hired by KXP AirportCity Holdings Sdn Bhd to create a development masterplan. ADPI is a French engineering firm that specializes in the design and development of new airports and the expansion of existing airport around the world. On the other hand, KXP Airportcity has also hired a team of experts to conduct research, assessments, and evaluations for the project (*ADPI appointed as masterplan consultant for Kulim Airport*, 10th February 2020). Figure 2.3 displayed the news article regarding ADPI.

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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 2.3 ADPI News Article (Source: ADPI Appointed As Masterplan Consultant For Kulim Airport, 10th February 2020)

2.2 Overview of Aircraft Turnaround Processes

An aircraft's turnaround involves all activities required to be finished when it arrives at the terminal until it prepared for departure. Flight delays usually occur because the high turnaround time. The factors that contributed to flight delays are weather, air traffic control, and ground crew. Several tasks need to carried out by the ground crew when the flight has arrived and parked. The tasks are unload luggage, load luggage, disembark passenger, servicing, maintenance and embark passengers. For huge commericial airplane, it would require more time to unload the baggage as the number of passengers are high (Timajo *et al.*, 2014). The aircraft type, number of passengers and amount of loaded and unloaded cargo significantly affects the turnaround time (Schmidt, 2018).

Boarding of passengers also contribute to flight delays as passengers may not aware of seat arrangement, as it will take longer time. A good boarding strategies is needed to reduce the boarding time as well as reduce the turnaround time. Air traffic control is the controller of aircraft movement, including the clearance of take-off, taxiing and landing. For busy airport, as the number of flights that arrive and depart is high, it has the possibility of traffic jam. Due to this matter, some of the aircrafts are not permitted to taxiing to parking bay, which invitably cause delay of the aircrafts (Timajo *et al.*, 2014).

Another research by (Schmidt, 2017) make a review of aircraft turnaround operations and simulations. This paper comprised all information from aircraft turnaround, capacity constraints, schedule disruptions, boarding strategies of passengers and costs. Airport behaviours are divided into landside procedures and airside procedures. Landside procedures in which the passengers arrive, drop their baggage, go through security and pass-through security. Meanwhile, the airside procedures whereby the passengers board and disembark the aircraft and it is also include the aircraft’s take off and landing as well as taxiing procedures. Figure 2.4 illustrated the generic airport with landside and airside elements.

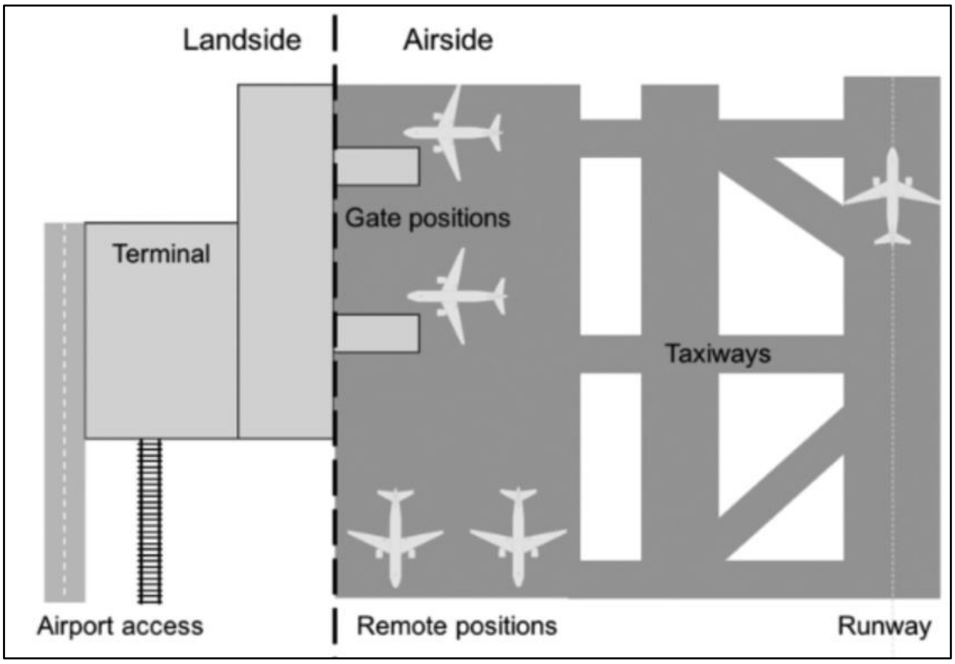

Figure 2.4 Generic Airport With Landside And Airside Element (Schmidt, 2017)

Based on Figure 2.4, the parking location may be placed either at the terminal, also known as gate position or on the apron, also known as remote position. After the chocks have been mounted on the wheels, the ground power supply is attached. This enables the motors and the auxiliary power unit (APU) to be deactivated. The preconditioned air (PCA) unit is connected when the climate conditions is required. At the terminal parking places, the passenger boarding bridge docks at the front left side entrance. On the remote apron locations, passengers stair or aircraft stairs are used on the aft and forward left side door. When the door are unlocked, passenger disembarkation starts and the cargo and baggage are unloaded simultaneously. The potable water is also resupplied at this time.

Figure 2.5 illustrated the top view of the ramp layout at the gate position for aircraft with short-to-medium haul. For the exit and entry of passengers, the left side doors are used and the right doors are used for catering and freight handling. Sometimes, because of the interface positions of the airplane, the position of the service vehicle is predefined.

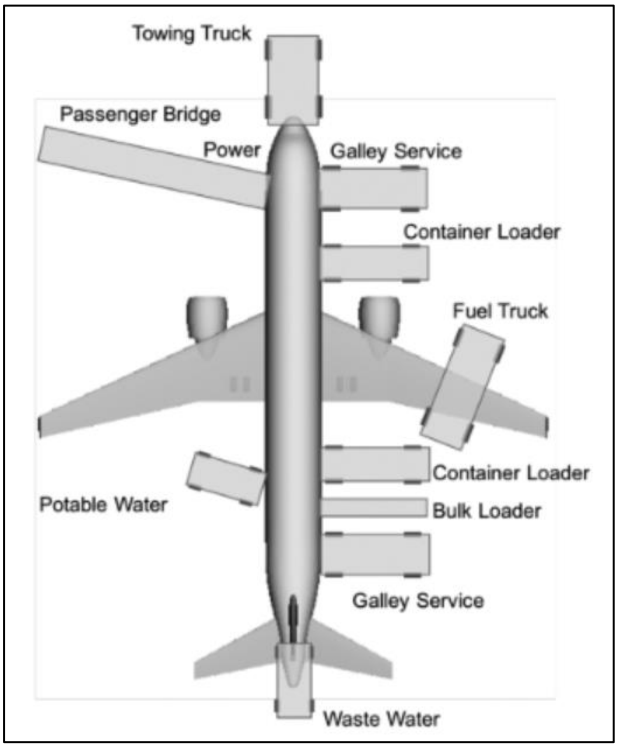

Figure 2.5 Ramp Layout At Gate Position For Single-Aisle Aircraft (Source: Schmidt, 2017)

Figure 2.6 is the Gantt chart which display the duration of turnaround process. In several cases, the critical path consists of operations of the passenger and aircraft cabin, but the fuelling process in some situations can become the critical path (Schmidt, 2017)

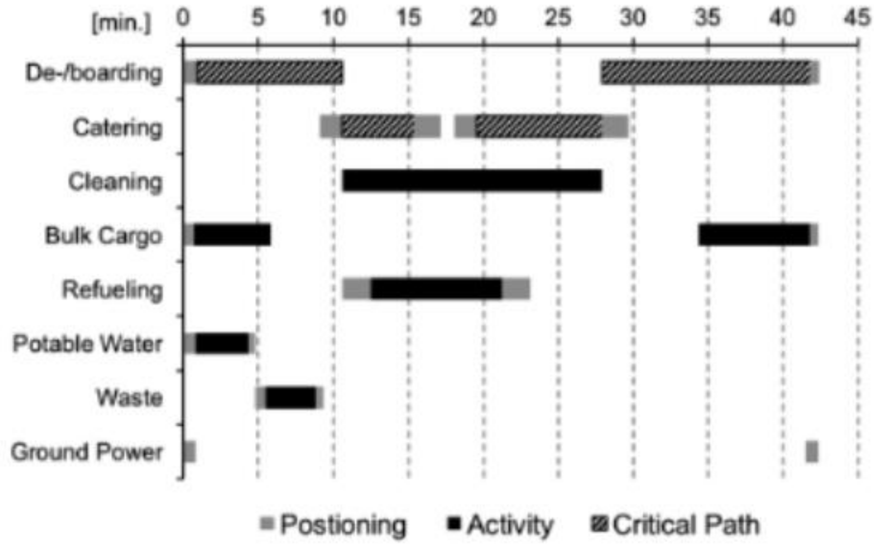

Figure 2.6 Turnaround Gantt Chart For Single-Aisle Aircraft (Source: Schmidt, 2017)

The turnaround time in the single-aisle aircraft segments for 100 to 200 passengers is 35 minutes on average, the maximum is 51 min. This can be presented as in Figure 2.7. The required time is about 17 minutes on average for regional airplanes and 61 minutes for twin-aisle airplanes. Nevertheless, the actual aircraft turnaround time is stochastic as number of passengers, refuelling, cargo loads might differ for flights (Schmidt, 2017)

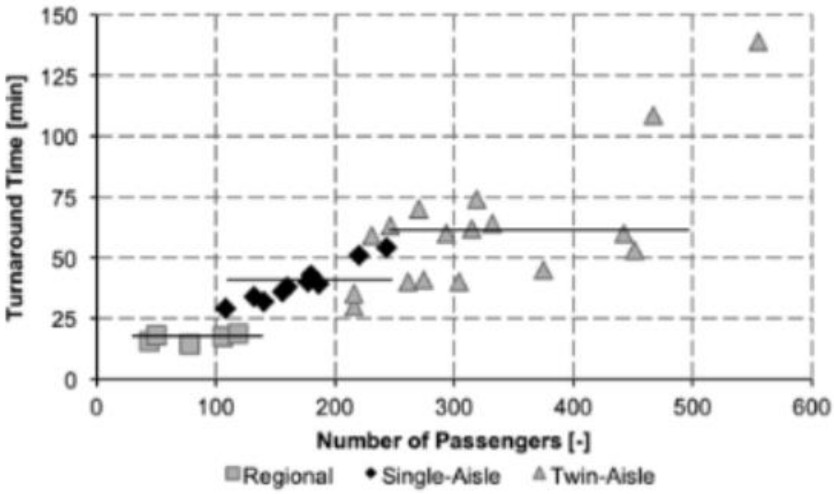

Figure 2.7 Turnaround Time Correlation With The Number Of Passengers For Regional, Single-Aisle And Twin-Aisle Aircraft (Source: Schmidt, 2017)

2.3 Current Studies of Aircraft Turnaround

Research by (Antonio *et al.*, 2017) studied on using simulation to estimate critical paths in aircraft turnaround process and produce the survival functions. According to this paper, nearly 45% of delays were related to the late arrival of aircraft, passengers, crew or cargo. Additionally, about 30% of the delays were ascribed to the aircraft itself. Some of the delays are unequivocally associated with the turnaround process. A simulation approach is used to evaluate the turnaround process by taking into account the stochastic times of each process. From this, the critical path is determined as well as the survival function of the process. To test the simulation-survival approach, the numerical test is carried out by using the Weibull probablibity distributions to the model. The result shows the critical processes are disembarking-,cleaning- and boarding meanwhile the less critical processes are catering, refueling and maintenance.

Meanwhile research by (Schultz and Fricke, 2008) investigate on how to improve the turnaround reliability by reducing the process times especially on the critical path. The critical path of the aircraft turnaround have been identified as boarding, deboarding, unloading, loading, fuelling and servicing. Some of the factors that may affect the turnaround time include manpower, transfer volume (fuel), equipment type for servicing and load figures. The method used in this paper mainly focused on statistical method. Weibull distribution was used for probing data fitting. The critical process identified is then analysed by using chi-square test. The most critical process is loading, unloading, boarding and deboarding. Therefore, from the result, by improving the reliability of boarding or deboarding process will decrease the turnaround time meanwhile improving the reliability of loading and unloading showed no impact on the turnaround time.

In addition, research by (Wu and Caves, 2004) designed an analytical model to simulate the effectiveness of aircraft turnaround activities at the airport by using circumstances of different performance in aircraft punctuality. By using the European carrier flight data, they implemented the idea of scheduling the buffer time into the ground time of the activities of turnaround. From the result, the right use of schedule buffer time is capable in handling the performance of punctuality of aircraft turnaround via reducing system costs. In addition, the effect of inbound aircraft arrival punctuality on the departure punctuality of turnaround has been found to be significant and the distribution of the arrival time of a turnaround aircraft also affect the schedule buffer time. The pros of sustaining a high turnaround punctuality and reliability are to boost the schedules punctuality as well as reduce the operational disruption at the terminals and to optimize the airline resources utilization. However, the turnaround operation's success often relies on the ground services and the willingness of an airline to accomplish its operational objectives.

Furthermore, research by (Evler *et al.*, 2018) present the stochastic control of turnaround at HUB airport. This paper used the stochastic turnaround model which are stochastic target time prediction of target off block time (TOBT) and deterministic optimization of parallel turnaround operations using resource constraint project scheduling problem (RCPSP). The stochastic prediction of TBOT is taken from previous studies using Monte Carlo network processes simulation. Different sequencing approaches are expended from previous studies into a microscopic, multi-stakeholder model within the optimization problem under the target of reducing network-wide costs for ground operations. Both procedures are merged into a simulation algorithm and implemented with assumed costs and process parameters at an exemplary HUB airport. The efficacy of the procedures has been shown to work.

In particular, once greater arrival delays are propagated from one aircraft to several simultaneous turnarounds, network costs are increased in a non-linear way.

On the other hand, research by (Schultz *et al.*, 2020) studied the effects of operational process adjustments for aircraft turnaround, which are mostly induced by pandemic-related constraints. The current pandemic situation requires several modifications of standard operating procedures for some turnaround sub-processes which are passengers must maintain the physical distance that have been decided by the government during aircraft boarding and deboarding, and the cabin must be disinfected. The result from the study indicate that pre-pandemic turnaround times cannot be sustained for the same seat arrangement. Nevertheless, using an apron position whereby the rear aircraft door for boarding is added, and a seat allocation method with empty middle seats (occupied seat of 67%), the pre-pandemic turnaround can be achieved without the need of additional cleaning crew. The aircraft turnarounds at terminal settings necessitate 10% more ground time with additional staff and 20% more ground time without additional staff.

2.4 Simulation Softwares

A research by (Chung, 2013) used a simulation based approach to investigate the aircraft turnaround activities in airline hubs. The focus is on how higher turnaround time can cause flight delays. Flight delays have several disadvantages such as customer dissatisfaction, lower system productivity and others. Therefore, a simulation model focused on the activities related to the turnaround operation was developed to better understand the impact of flight delays. The simulation model were developed by using software called Arena.

The input data for the ground handling operation were obtained from passenger airline's primary hub located in the U.S. By using Arena Input Analyzer simulation software, the obtained data was examined and fitted to a theoretical probability distribution. The result obtained by using the simulation is slightly different than the actual system times (the interval between the aircraft arrival and departure). To test the validity of the simulation, a u-test were conducted for comparison. By using alpha = 0.05, and the critical value for Z-distribution at 0.05 fall in between -1.96 and 1.96, the result of the u test is -0.48. Since the result of the u-test fall in between -1.96 and 1.96, thus the result is accepted and considered valid.

The efficiency and duration of turnaround operations have a significant impact on flight departure punctuality, as flight departure may be prolonged if the turnaround activities are not finished on time. The efficiency of turnaround is critical not just for improving aircraft timeliness, but also for maintaining the aircraft rotation stability and flight connections. An effective turnaround is also critical for maintaining the Minimum Connection Time (MCT) between flights, which is defined as the least time required for a passenger and luggage to transfer from one flight to the next. Furthermore, in order to maximize aircraft utilization, short turnaround times between flights are essential, which increase the likelihood of upcoming flights undergoes delayed. Extra time, other than the time strictly required for turnaround activities, is frequently included in the scheduling, to prevent potential delays from late arrival aircrafts and to lessen the possibility of delays associated with ground handling operations (Malandri, *et al.*, 2019).

The performance of turnaround activities is frequently jeopardized by different disruptive events beyond the airlines' control, such as strikes or technical breakdowns, which can have a detrimental impact on the punctuality and regularity of the operations, creating major delays and unforeseen congestion. Disruptive incidents in air travel cause operations to depart significantly from the schedule, resulting in a reduction in system capacity, hence increased flight delays (Malandri, *et al.*, 2019).

Research by (Malandri, *et al.*, 2019) focused on evaluating performance losses caused by ground handling service provider, as well as to promote the creation of a strategy for calculating of ground handler strikes at large airports. By using AnyLogic, a general simulation programme, a discrete event model is created. The established airside model is divided into two hierarchical sub-systems; which are the landing-and-take-off (LTO) cycle and the aircraft turnaround activities. After the model has been constructed and validated, the industrial behaviours of ground handlers are simulated, and the resulting consequences are assessed using a set of performance metrics. The impact is assessed by taking into account the increase in average turnaround time and the number of late departing flights. As the number of operators of ground handlers reduces, the turnaround activities take longer time to complete, which cause departure delays and knock-on delays. The simulation model was run based on Lisbon International Airport, as the result reveal there is no much difference of turnaround time with the reference, a journal by (Khammash *et al.*, 2017) as it hardly increase by 4%.

2.5 Comparison between Arena and Witness simulation software

Also, research by (Nikakhtar *et al.*, 2011) make a comparison between performance indicators' average value of Arena and Witness simulation software. To analyse the output data, this paper implemented an advanced inferential statistical technique. ARENA is based on SIMAN, and it is essentially a high-level graphical front end for SIMAN in which models are created by placing icons on a drawing board and then connecting these icons or blocks to build model logic. ARENA offers ten different random number streams to choose from, or the user can choose the default stream. ARENA's distributions are all based on a multiplicative congruential generator for uniformly distributed values in the range of 0 to 1.

Moreover, WITNESS is a discrete-event simulation programme which is widely used in the manufacturing industry, an object-oriented modelling environment. The queuing theory is a concept that used by this software. WITNESS uses a combined multiple recursive generator to generate pseudo random numbers. This technique creates random numbers between 0.0 and 1.0. This amount was used by Witness to sample from statistical distributions for activity durations, breakdown timings, setup intervals, and PERCENT rules. After running several simulation, the result from Witness displayed slight different with minor effect size due to the dissimilar equation used by the software.

However, some of the feature that not own by Arena is the generation of charts for each reports. WITNESS can also display some data in form of pie-charts, time-series and histograms by generating reports. This reports allows users to observed the performance, details of the stimulated model and help to improving the operation of the model (Shinde and Nimbalkar, 2017)

2.6 Literature Finding

From the literatures review conducted, it can be understood the current studies on aircraft turnaround mostly used analytical model, stochastic model, which is quite difficult to be conducted. The researches also identified processes such as disembarking, boarding loading and unloading as the processes that mainly contributed to higher time of aircraft turnaround. In addition, Arena simulation software is one of the software that researcher used to simulate ground handling operation. Since simulation of aircraft turnaround using Witness simulation is not available yet, this project will focused on using this software.

This software is chosen because WITNESS is a comprehensive discrete event and continuous process simulator, which can display the dynamics of complex systems. Moreover, WITNESS offers a graphical interface to create models for simulation as it allows a dynamic animated computer model to represent a real-world process and make it possible to automate simulation experiments, and create animated models. On the other hand, this project also focused to study the steps and process flow of aircraft turnaround. Figure 2.8 illustrated the sketch of the ground handling operation. Based on Figure 2.8, there are several turnaround process such as passenger boarding and disembarking through boarding bridge, fuel truck for refuelling, cabin cleaning, baggage loading and unloading, the galley service, wastewater pumping and potable water pumping. The sketching can be the reference when developing the simulation model.

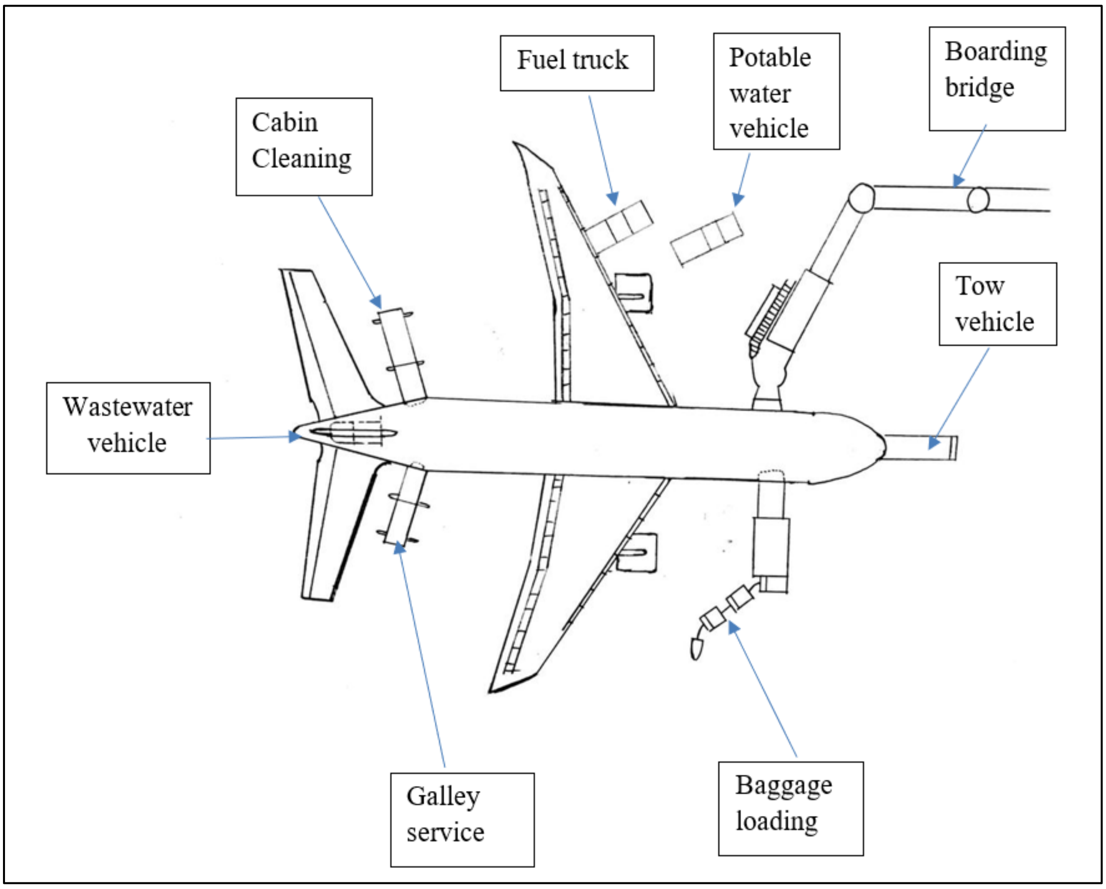

Figure 2.8 Sketching of Aircraft and Related Tools during Turnaround Process

CHAPTER 3

METHODOLOGY

To develop the model using simulation, a framework has been created in accordance with the research objectives. Figure 3.1 shown a flow chart that consists of four phases; Planning, Defining and Designing, Execution and Testing and lastly Analysis and Decision making. Each phases comprises of several steps. The detailed of each step will further explained in this chapter. The simulation model will be developed using Witness Horizon software.

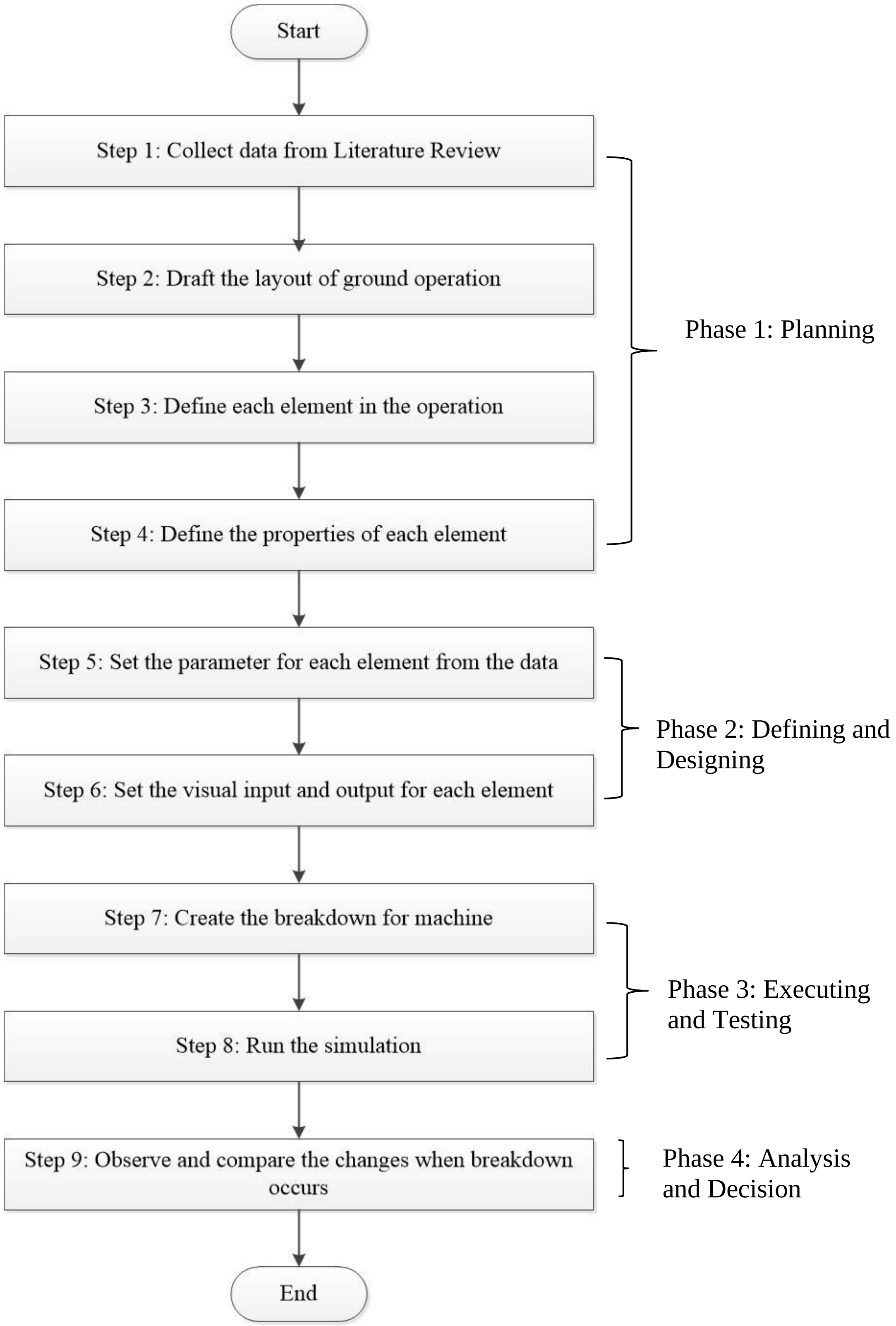

Figure 3.1 Research framework