SIMULATION OF CHECK-IN PASSENGER FLOW FOR INTERNATIONAL DEPARTURE DUE TO COVID19 SITUATIONS

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SIMULATION OF CHECK-IN PASSENGER FLOW FOR INTERNATIONAL DEPARTURE DUE TO COVID19 SITUATIONS

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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.

Signed… (Nur Azwahana Binti Ismail)

Date…… (9/8/2022)

STATEMENT 1

This thesis is the result of my own investigations, except where otherwise stated. Other sources are acknowledged by giving explicit references. Bibliography/references are appended.

Signed… (Nur Azwahana Binti Ismail)

Date…… (9/8/2022)

STATEMENT 2

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LIST OF ABBREVIATIONS

Symbol	Description
ACI	Airports Council International
ADRM	Airport Development Reference Manual
CCAS	Check-In Counter Assignment System
COVID-19	Coronavirus disease
EASA	European Union Aviation Safety Agency
EMCO	Enhanced Movement Control Order
HIA	Hamad International Airport
IATA	International Air Transport Association
IRSS	Intelligent Resource Simulation System
KXP	Kulim International Airport
MCO	Movement Control Order
MOH	Malaysian Ministry of Health
NCER	Northern Corridor Economic Region
SLAM	Sidam Logistics, Aerospace, and Manufacturing Hub
SST	Self-Service Technology
USM	Universiti Sains Malaysia
WHO	World Health Organization

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SIMULATION OF CHECK-IN PASSENGER FLOW FOR INTERNATIONAL DEPARTURE DUE TO COVID19 SITUATIONS

ABSTRAK

Lapangan terbang merupakan aspek penting dalam sistem pengangkutan udara kerana ia berfungsi sebagai penghubung antara ketibaan dan pelepasan. Pandemik global telah diisytiharkan pada 11 Mac 2020 oleh Pertubuhan Kesihatan Sedunia (WHO) berikutan penularan pantas COVID-19. Wabak COVID-19 yang berterusan adalah salah satu daripada krisis kesihatan global yang paling serius pada tahun 2020 menyebabkan industri penerbangan menghadapi krisis yang tidak pernah berlaku sebelum ini. Dalam pandemik ini, lapangan terbang mesti mengambil langkah pencegahan secara berkesan untuk mengawal penularan COVID-19 dan menyesuaikan diri dengan keadaan. Sehubungan itu, kajian ini bertujuan untuk membangunkan proses daftar masuk aliran penumpang untuk pelepasan antarabangsa akibat situasi COVID-19. Dua perkara paling penting untuk difikirkan sepanjang proses pelepasan antarabangsa semasa wabak COVID-19 ialah kaunter daftar masuk dan teknologi layan diri. Penyelidikan ini berdasarkan Lapangan Terbang Antarabangsa Kulim (KXP). Perisian simulasi WITNESS telah digunakan untuk mencadangkan penyelesaian dan menilai prestasi dan kebolehpercayaannya. Keputusan kecekapan buruh menunjukkan model simulasi dengan penggunaan teknologi layan diri dan kaunter daftar masuk dan buruh terendah mempunyai perubahan kecekapan buruh yang paling tinggi dengan peningkatan sebanyak 12.80%. Hasil perbandingan penambahbaikan penggunaan mesin menunjukkan bahawa model dengan elemen yang lebih asas mempunyai pengurangan paling rendah dengan -21.67% untuk kiosk, -5.44% untuk kaunter ekonomi, dan -4.63% untuk kaunter kelas perniagaan dalam peratusan sibuk antara model yang lain.

SIMULATION OF CHECK-IN PASSENGER FLOW FOR INTERNATIONAL DEPARTURE DUE TO COVID19 SITUATIONS

ABSTRACT

The airport is an important aspect of the air transportation system as it serves as a link between arrivals and departures. The global pandemic was declared on March 11th, 2020 by the World Health Organization (WHO) due to the rapid spread of COVID-19. The ongoing COVID-19 outbreak is one of the most serious global health crises of 2020 causing the aviation industry to face an unprecedented crisis. In this pandemic, the airport must effectively take a prevention to control the spread of COVID-19 and to adapt to the situation. Accordingly, this study aims to develop the check-in process of passenger flow for international departure due to COVID-19 situations. Two of the most crucial things to think about throughout this international departure process during the COVID-19 epidemic were the check-in counter and the self-service technology. This research was based on Kulim International Airport (KXP). WITNESS simulation software was used to propose the solution and to evaluate its performance and reliability. The result of labour efficiency shows that simulation models with the use of self-service technology and the lowest check-in counter and labour have the highest changes in labour efficiency with an increase of 12.80%. The result of the comparison of machine utilisation improvement shows that models with more basic elements have the lowest reduction with -21.67% for the kiosk, -5.44% for the economy counter, and -4.63% for the business class counter in busy percentage among other models..

CHAPTER 1

INTRODUCTION

1.1 Introduction

An airport is an operational system that consists of a framework of infrastructure, facilities, and personnel that collectively generate a service to a customer (Guizzi et al., 2009). The airport is an important aspect of the air transportation system since it is the place where a modal transfer from air to land or vice versa takes place (Norman J. Ashford et al., 2013). Furthermore, an airport serves as a link between arrivals and departures, as well as a vital service for ticketing, boarding, deboarding, documentation, and passenger and goods control, ensuring a smooth flow from a continuous arrival (user flow) to a discrete departure system (which are the scheduled flights).

On December 30, 2019, the first case of COVID-19 was reported in the province of Wuhan, China. The global pandemic was declared on March 11th, 2020 by the World Health Organization (WHO) due to the rapid spread of COVID-19 (Pereira & Soares de Mello, 2021). The first crossing border restrictions were implemented after a large European cluster of COVID-19 cases were identified in March 2020. Then it was followed by international and intercontinental flights, such as flights from Europe to the United States and vice versa (Kierzkowski & Kisiel, 2020)

The ongoing COVID-19 outbreak is one of the most serious global health crises of 2020 (Serrano & Kazda, 2020) causing the aviation industry to face an unprecedented crisis since March 2020 (Dabachine et al., 2020). COVID-19 has pushed the aviation sector to respond fast to adapt to the situation (Serrano & Kazda, 2020). In this epidemic, the airport security must effectively take a prevention and control period to ensure the personal rights and interests of ordinary passengers, and balance the security inspection cost and navigation (Li, 2020).

Accordingly, this study seeks to study the passenger flow for international departures due to COVID-19 situations in order to reduce the ability of the airport to manage passenger flow while minimising the potential spread of the virus with the focus entities of the check-in departure terminal building. Hence, this study proposes simulations, discussions of the potential effects of these measures, as well as a test of the implementation. The project background, the problem statement, objectives, scope of work, and organisation of the thesis will be discussed in further detail in this section.

1.2 Project Background

1.2.1 The COVID-19 Pandemic Experience in Malaysia

The virus spread rapidly to every continent, and the WHO declared the outbreak a pandemic on March 11, 2020, as a result of its rapid spread. On January 25, 2020, the first confirmed case of the disease in Malaysia was reported. It was discovered that the outbreak was connected to three Chinese nationals who had previously had close contact with a person who was infected in Singapore. After making their way via Singapore, they arrived in Malaysia on the 24th of January 2020. They were taken to Sungai Buloh Hospital in Selangor, Malaysia, where they received their medical treatment (Borneo Post Online, 2020; New Straits Times, 2020).

The first Malaysian was verified to have COVID-19 on February 4, 2020 as shown in a news headline from BERNAMA in Figure 1.1. After returning from Singapore, the 41-year-old man developed a fever and a cough. He was treated at Hospital Sungai Buloh, Selangor. (Bernama, 2020a). On the same day, a four-year-old Chinese national girl who had been hospitalised in Langkawi's Sultanah Maliha Hospital since January 29, 2020, recovered, was discharged, and was permitted to return to China (Bernama, 2020b). Since the beginning of the pandemic, this was the first case of COVID-19 recovery that has been reported in Malaysia.

Español தமிழ்

BERNAMA.com

First case of Malaysian positive for coronavirus

04/02/2020 05:31 PM

KUALA LUMPUR, Feb 4 -- A 41-year-old man is the first Malaysian who has tested positive for the novel coronavirus 2019 (2019-nCoV).

He is one of two new positive cases, bringing to 10 the number of coronavirus cases in Malaysia so far.

Health Minister Datuk Seri Dr Dzulkefly Ahmad said the other case involved a 63-year-old man from China who arrived at the KL International Airport on Jan 18.

"As for the Malaysian, he was in Singapore from Jan 16 to 23 to attend a conference which was also attended by several international delegations including from China.

Figure 1.1 News Headline from BERNAMA (Source: (Bernama, 2020a))

In addition, on February 6th, 2020, a Malaysian woman in her 40s tested positive for COVID-19. She was the younger sibling of the man who had tested positive for the virus on February 4th, 2020, despite having never visited an infected location. As a result of local transmission, she was the first COVID-19 case in Malaysia. She developed a cough the following day after developing a fever, sore throat, and cough on February 1st, 2020. On February 3, 2020, she was put into isolation at Sultanah Bahiyah Hospital in Alor Setar (Malaysiakini, 2020).

During the first wave, there were just 22 positive cases, all of which were discharged well. After eleven days without no reported cases, the second outbreak wave began on February 27, with 553 positive cases confirmed by March 16. Around 16,000 people attended the Tabligh gathering in Sri Petaling from February 27 to March 3, 2020, which was linked to this series of incidents (Babulal & Othman, 2020; DG of Health, 2020). On the 12th of March 2020, the first case of sporadic COVID-19 was recorded in Malaysia. The infected individual had not been to an affected location, nor had they come into contact with infected people (COVID-19 MALAYSIA, 2020).

1.2.2 Impact of Movement Control Order (MCO) in Malaysia to Aviation Industry

After the number of confirmed cases surpassed 553 on March 16, 2020, the Malaysian government made the decision to impose a nationwide Movement Control Order (MCO) from March 18 to March 31 in order to prevent the spread of the disease (Tang, 2020) as shown in Figure 1.2. All public hospitals in Malaysia have changed since the MCO was implemented in an effort to conserve the scarce resources needed to fight this pandemic (Khor et al., 2020). The government has restricted travel to other states and areas impacted by COVID-19 as of March 18, 2020. A family could only send one person out to buy basics (Elengoe, 2020). Below are the 6 restrictions set by the government (NEWSTRAITSTIMES, 2020):

1. Large-scale gatherings of any kind, including religious, sporting, social, and cultural events, were prohibited.
2. All establishments of business and worship were momentarily forced to close their doors. For the purchase of necessities, however, there were a variety of

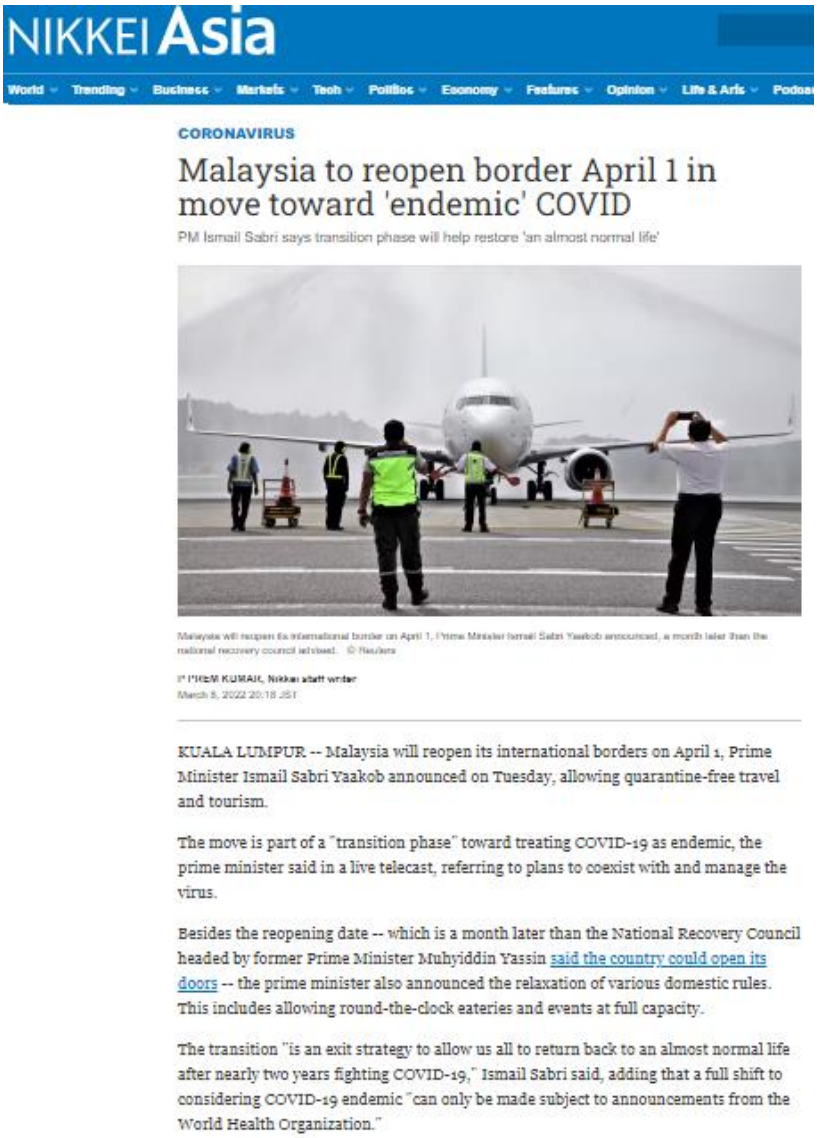
outlets accessible, including supermarkets, markets, grocery stores, and convenience stores.

3. After travelling outside of the country, people were mandated to undergo testing and screening required for the purpose of COVID-19 detection and to self-isolate themselves.
4. Tourists and other visitors from outside the country were not permitted entry into Malaysia. All primary, secondary, and pre-university institutions, including government and private kindergartens, as well as tahfiz centres, daily schools, international schools, boarding schools, and other educational establishments, were shut down.
5. Every public and academic institution in the country, including those for higher education and vocational training, was ordered close.
6. Only essential government and private services were open such as retail, banking, electricity, water, prison, transportation, telecommunications, energy, fire, postal, finance, defense, irrigation, lubricants, oil, fuel, gas, broadcasting, pharmacy, health, port, airport, safety, cleaning, and food supply.

Figure 1.2 News Headline from TheStar (Source: (Tang, 2020))

1.2.3 COVID-19 Endemic Transition in Aviation Industry

Many countries have now started to slowly transition to endemic COVID-19 and are reopening their borders. On April 1, 2022, Malaysia's Prime Minister Ismail Sabri Yaakob announced Malaysia would reopen international borders in a move toward endemic COVID-19 (Kumar, 2022). Figure 1.3 shows the news headline from NIKKEI ASIA of Malaysia to move towards Endemic COVID. Other Southeast Asian countries, such as Thailand and the Philippines, have reopened international borders and resumed quarantine-free tourist arrivals since February 2022 (Newton, 2022).



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CORONAVIRUS

Malaysia to reopen border April 1 in move toward 'endemic' COVID

PM Ismail Sabri says transition phase will help restore 'an almost normal life'

Malaysia will reopen its international border on April 1, Prime Minister Ismail Sabri Yaakob announced, a month later than the national recovery council advised. © Reuters

By PIYUM KUMAR, Nikkei staff writer
March 8, 2022 20:18 JST

KUALA LUMPUR -- Malaysia will reopen its international borders on April 1, Prime Minister Ismail Sabri Yaakob announced on Tuesday, allowing quarantine-free travel and tourism.

The move is part of a "transition phase" toward treating COVID-19 as endemic, the prime minister said in a live telecast, referring to plans to coexist with and manage the virus.

Besides the reopening date -- which is a month later than the National Recovery Council headed by former Prime Minister Muhyiddin Yassin said the country could open its doors -- the prime minister also announced the relaxation of various domestic rules. This includes allowing round-the-clock eateries and events at full capacity.

The transition "is an exit strategy to allow us all to return back to an almost normal life after nearly two years fighting COVID-19," Ismail Sabri said, adding that a full shift to considering COVID-19 endemic "can only be made subject to announcements from the World Health Organization."

Figure 1.3 News headline from NIKKEI ASIA (Source: (Kumar, 2022))

A preventive measure restriction in an airport should be taken into consideration to control the spread of COVID-19 (IATA, 2020). The MOH and WHO, as well as other national and international health organizations, have established guidelines for important health and safety measures that must be followed to ensure a safe and healthy travel experience. In this endemic, a passenger terminal capacity typically includes the following systems (ATEŞ et al., 2021):

- Check-in,

- Passport control,
- Security control,
- Departure facilities (doors and waiting rooms)
- Arrival facilities (baggage collection, customs, immigration, and lounge greeter/ a farewell)
- The facilities of transit and transfer.
- Ground operations for the Airbridge and open parking position.
- Baggage handling operations.
- Vaccine control procedures
- The test procedure of COVID-19.

IATA has established some rules and standards to ensure that the quality requirements of the passenger support service in the terminal area are met. Social distancing is one of the primary factors that will affect the capacity of airports. The overall experience of a passenger at an airport can be challenging and time-consuming. Delays could occur with parking, checking in, security screening, and boarding. Customer satisfaction is increased when less time is spent on the process. Although passengers acknowledge the necessity for greater security, delayed boarding, cancelled flights, and longer waiting times have created a dissatisfied passenger environment. Therefore, operational efficiency at an airport can directly influence safety, user, and customer satisfaction, as well as the financial performance of the airport.

1.2.4 Kulim International Airport (KXP)

Kulim International Airport (KXP) is constructed in Kuala Muda, Kedah, Malaysia. The high-impact Kedah Aerotropolis project is being implemented, and one of the projects included is KXP. Kedah Aerotropolis, which is intended to lead the state's economic transformation, is a metropolitan subregion with an airport at the hub of its infrastructure, land use, and economy. Figure 1.4 displays the FMT headline. Kedah Menteri Besar Sanusi Md reportedly indicated that all project-related concerns, including financing, land acquisition, and technical requirements, had been resolved or were being appropriately managed in a news report that was published by FMT on January 20, 2022. He added that the project was on track to be a success (FMT Reporters, 2022).

Kedah MB sees clear road ahead for new Kulim airport

FMT Reporters - January 30, 2022 9:40 PM

715 Shares | 580 | 78 | 39

An artist's impression of the proposed Kulim airport terminal. The project is part of the proposed Kedah Aerotropolis industrial hub. (Facebook pic)

ALOR SETAR: Kedah menteri besar Sanusi Md Nor foresees "no more obstacles" in the way of Kedah's proposed multibillion-ringgit international airport project in Kulim, near Sungai Petani.

He said he had written to the prime minister, Ismail Sabri Yaakob, and "he basically agreed because this project is a PFI (private finance initiative) ... and if it is PFI, the federal government has no objection".

Figure 1.4 News headline from FMT (Source: (FMT Reporters, 2022))

KXP and Sidam Logistics, Aerospace, and Manufacturing Hub (SLAM) are expected to boost the economy in NCER (NCER Malaysia, 2021). These projects will help expand e-commerce in Southern Thailand. KXP's ability to combine marine, air, and surface transit is a major advantage over other airports. KXP's closeness to Penang Port on Pulau Pinang allows for cheaper and faster sea-to-air transit. KXP has land for 20 to 50 years of expansion. Figure 1.5 illustrates the distance between KXP and key industrial areas in the region, and Figure 1.6 depicts the economic growth in NCER.

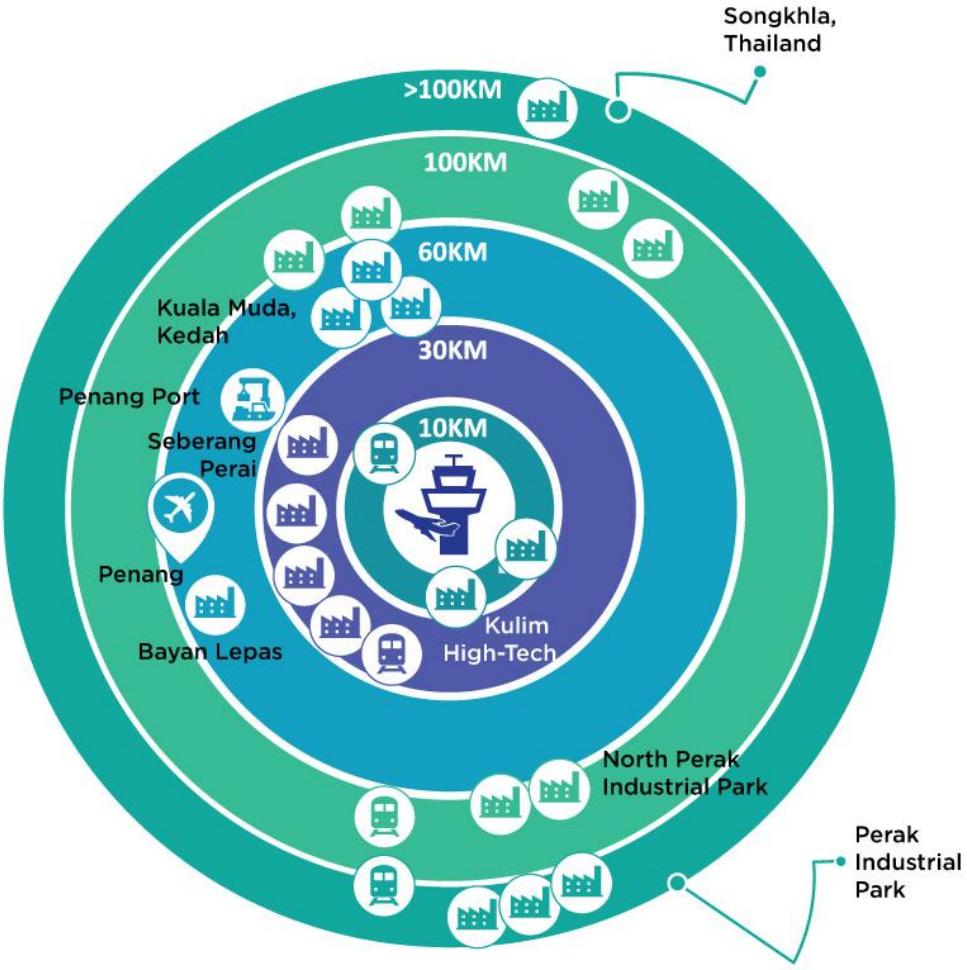
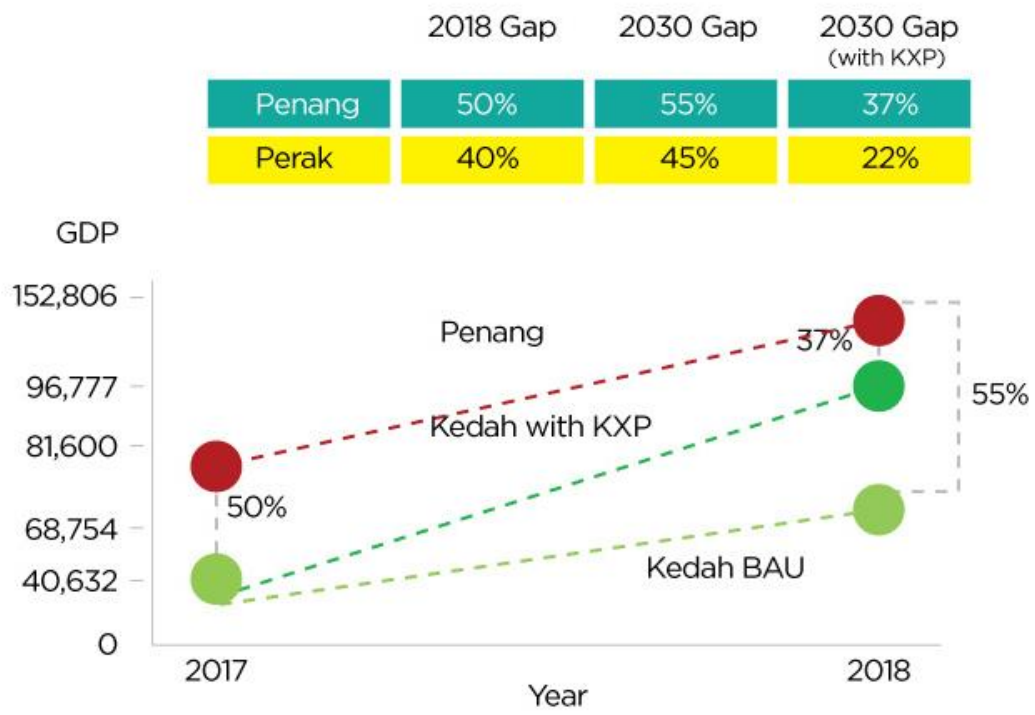


Figure 1.5 Distance Between KXP and Key Industrial Areas in The Region (Source: (NCER Malaysia, 2021))



KXP & SLAM: Levelling Up the Economic Growth in NCER

With **KXP**, Kedah's annual **GDP growth rate** is projected to be at **7.5%** instead of the current 4.5% per annum. The project is also expected to **reduce the GDP gap** between Penang and Kedah to **37% by 2030** from 50% presently. Together with **SLAM**, KXP will be **the game changer** in reducing the economic disparity within NCER, benefitting not only the state of Kedah, but **all states in the region**.

Figure 1.6 KXP and SLAM: Levelling Up the Economic Growth in NCER (Source: (NCER Malaysia, 2021))

1.3 Problem Statement

The COVID-19 outbreak has had a significant impact on the operations of the aviation sector. One place where the COVID-19 virus has spread internationally is airports. Before the spread of COVID-19, the departure floor consists of the facilities for check-in, baggage X-ray inspection, security check, and departure examination where there will be staff in charge of every process. However, in this epidemic, a good passenger simulation model with appropriate application of countermeasures is required, including minimising inter-person interaction, sanitary measures, social distance, minimising the time spent for security checks, boarding, and other processes. In order to prevent the COVID-19 from spreading while simultaneously ensuring that the airport operates efficiently and takes the necessary precautions in this endemic situation, a simulation model for passenger flow for international departure is required.

1.4 Objectives

The aims and focus of this study are:

- To develop the check-in process of the passenger flow for international departure due to COVID-19 situations.
- To present a simulation model for the check-in process before and after COVID of an international departure passenger using WITNESS Horizon.
- To investigate the impact of digital baggage check-in or self-baggage check-in on passenger flow and employee performance.

1.5 Scope of Work

The scope of study will be more focused on the simulation of passenger flow for international departure. The simulation model will be applied for Kulim International Airport, Kedah with the preventive measure of COVID-19 such as physical or social distancing in check in, security check, airport ventilation, body temperature screening using calibrated non-contact thermometers and emergency handling. This study seeks to simulate an operation system that is suitable to use for both Pre-COVID-19 and Post-COVID-19 situations. WITNESS simulation software will be used to propose the solution and to evaluate the performance and its reliability. This study will be focusing on check-in area as check-in is the most crucial stages in an airport.

To simulate passenger flow in international departing passenger terminal buildings, designed data sets will be used in this study. Data from simulations of passenger flow using iterations and various distribution techniques will be presented in this study. The change in passenger flow before and after COVID-19 will be examined using the simulation model created for Kulim International Airport. The international departure flow system will be simulated with several scenarios to manage the pre-post COVID-19 passenger flow. In accordance with contemporary social distance rules, the generated data will illustrate passenger flow fluctuations based on various statistical distribution approaches.

1.6 Organisation of Thesis

This report is divided into five major chapters. Each chapter will discuss the general information and details that will be covered from the project's introduction to its conclusion. The introduction to this project will be covered in Chapter 1. This chapter will go over the project's background, problem statement, objective, and scope of project. The simulation of passenger flow for international departure will be the primary areas of study. The simulation model will be applied for Kulim International Airport, Kedah with the preventive measure of COVID-19.

In Chapter 2, the literature review will be discussed. In this chapter, previous research on this project is reviewed, including studies on the flow of passengers via international departure passenger terminal buildings, the impact of COVID-19 on passenger flow, a simulation model for travellers check in at airports, and self-service technologies. This chapter presents additional research on this study, as well as COVID-19 prevention strategies such as physical or social distance during security screening, airport ventilation, body temperature screening using calibrated non-contact thermometers, and emergency response.

Chapter 3 discusses the detailed design process for the airport check-in departure simulation model for Kulim International Airport. This chapter is structured according to a research framework, with a focus on the passenger process flow for international departure. This study aims to simulate a suitable operation system for both Pre-COVID-19 and Post-COVID-19 situations. Using the simulation software WITNESS, the performance and reliability of the proposed solution will be evaluated. This study will focus on the check-in area because checking in is one of the most important stages in an airport. The international departure flow system was simulated with several scenarios to manage passenger flow pre-post COVID-19.

Following the completion of "Chapter 3," the following chapter is referred to as "Chapter 4," and it contains both the results and the discussion of the previous chapter. The findings from the feature research are presented in this chapter. It is possible to make improvements in the subsequent research by gaining these findings and applying them. This chapter contains a comparison and analysis of the findings from the previous chapters. An example of this would be an investigation into how the simulation model built for Kulim International Airport was used to carry out an examination of how the change in passenger flow both before and after COVID-19 was carried out.

The final chapter of this study is chapter 5, which presents the conclusion of this simulation study, which simulates passenger flow for international departure. This chapter includes a summary of the project's implementation as well as its achievements. The limitations of this project, such as the needs for future investigations into how to improve the efficiency of this system in the future, are also covered in this chapter. In accordance with today's social distance norms, the collected data will indicate changes in passenger flow based on various statistical distribution methodologies.

CHAPTER 2 LITERATURE REVIEW

2.1 Introduction

A literature review supports the decision-making process by providing an overview and analysis of the possibilities of a proposed project based on previously published works on a particular topic. This contributes to the overall success of the decision-making process. Through the process of conducting a literature review, prior to carrying out an investigation, a familiarity with and understanding of the existing research in a related field is established. This review also served as a means of forming the requirements for and the feasibility evaluation associated with this study.

A brief summary of the methods and findings from the literature review is included in this final report to provide a context for the discussions of needs and viability that follow. It is necessary for this study to finish its literature review before moving on to the phase where the project is being developed. During the first stage of the project's development, studies like KXP, Check-in, COVID-19 precautions in airports, a simulation model of airport check-in passenger services, self-service technology (SST), and simulation software were done for the literature review part of the project.

2.2 Kulim International Airport (KXP)

As a part of the NCER Strategic Development Plan 2021-2025, this project will be constructed in an area that is 3,965 hectares in size and will entail the development of major infrastructure projects. Figure 2.1 portrays a map of the project's location, and Figure 2.2 provides a closer view at the project site of the KXP construction project. In addition to the SLAM, the Kedah Aerotropolis features a new airport that goes by the

name of Kulim International Airport (Bridger, 2020). Figure 2.3 shows how both Kulim International Airport (KXP) and the Kedah Aerotropolis are set up.

Figure 2.1 The Map of Project Location (Source: (Saad, 2021))

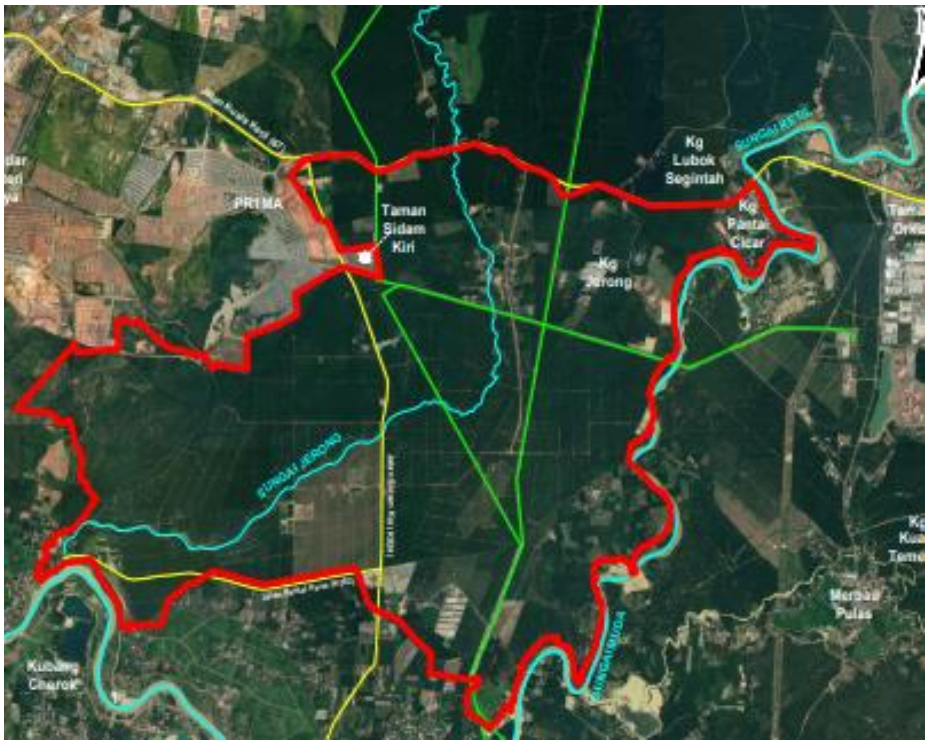


Figure 2.2 The Closer View of Project Site (Source: (Saad, 2021))

Figure 2.3 Layout Plan Kulim International Airport (KXP) and Kedah Aerotropolis (Source: (Saad, 2021))

Kulim International Airport in Malaysia has been chosen as the use case for the simulation study to manage the passenger flow for international departures as a result of COVID-19 situations. These tasks will be carried out in accordance with the passenger flow procedures outlined in the "Airport Pandemic Measures and Certification Circular" during the COVID-19 phase. The conformity of this simulation with the EASA-specified parameters for social separation will be ensured at the airport. The following Table 2.1 below are the assets of the airport:

Table 2.1 Assets of Kulim International Airport (Source: (FYP-KXP-2021-Confidential, 2020))

No	Asset	Capacity
1.	Number of Conventional Check-In Counters (Economy)	16 counters
2.	Number of Conventional Check-In Counters (CIP)	2 counters
3.	Number of Conventional Check-In Counters (OOG)	4 counters
4.	Number of Self-Service Kiosks	12 counters
5.	Number of Baggage Drop-Off Counters (Economy)	5 counters
6.	Number of Baggage Drop-Off Counters (CIP)	1 counter
7.	Number of Boarding Pass Check Before Security	4 counters
8.	Number of Security Control (Economy)	6 X-rays
9.	Number of Security Control (Fast Track)	1 X-ray

10.	Number of Boarding Pass Control	• 4 counters (Domestic) • 4 counters (International)
11.	Number of Emigration (National)	2 counters
12.	Number of Emigration (Fast Track)	1 counter
13.	Number of Emigration (Automated)	2 counters
14.	Number of Sanitary Inspections	3 counters

2.3 Check-In

The procedure of confirming the presence of a passenger on a flight is completed at the airport during the check-in process. It comprises creating a boarding pass for passengers with airline tickets in order for them to be admitted to the flight in compliance with the stated rules and to check any baggage. The published research contains studies that use simulation, optimization, and hybrid studies that use both methods for the check-in process. Optimization and simulation are both used in hybrid investigations.

The São Paulo also known as Guarulhos International Airport, has developed 273 different case scenarios for use at the check-in terminals for international departures. According to the findings of the study (ATEŞ et al., 2021) the most significant aspects are the length of time it takes for a check-in counter to process a passenger's registration, the number of check-in counters that are dedicated to each airline, the availability of self-service technologies, and the hours during which check-in desks are fully operational. The passenger and event flow from this study is depicted in Figure 2.4.

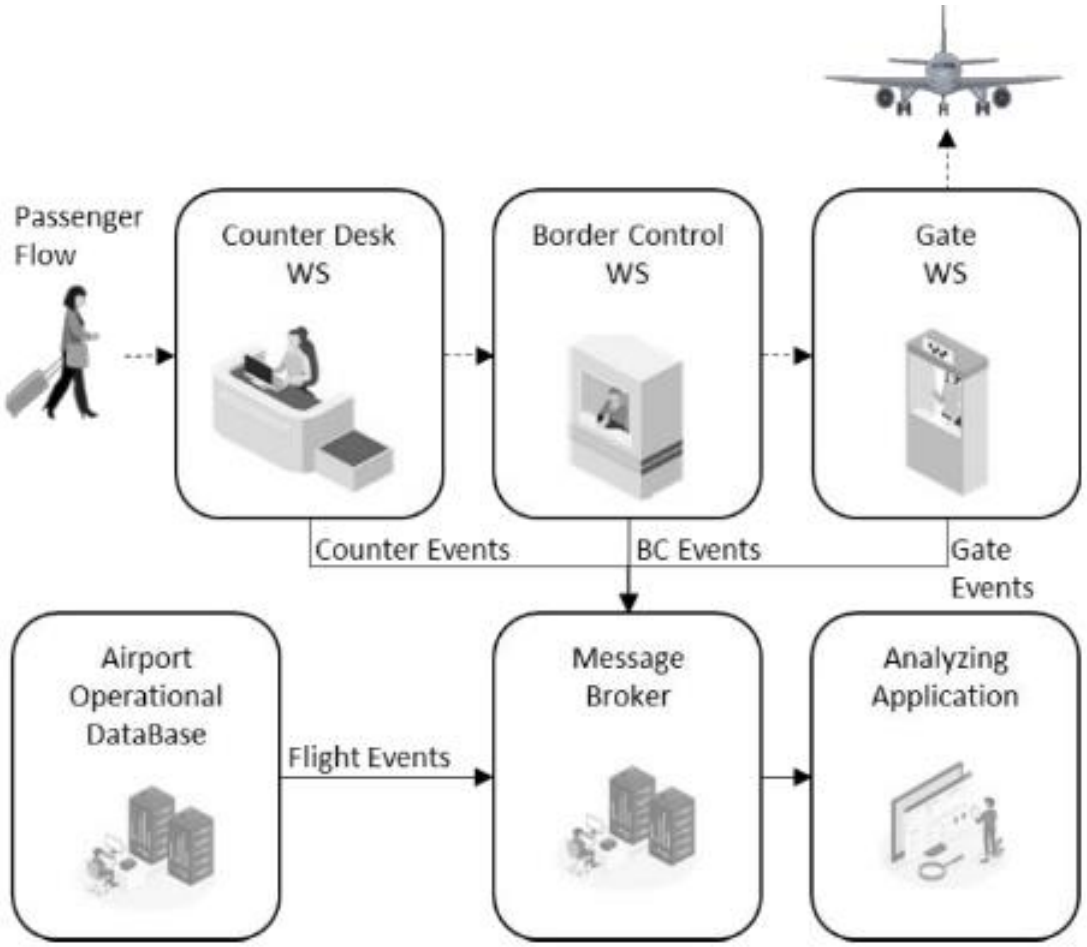


Figure 2.4 Passenger and Event Flow (Source: (ATEŞ et al., 2021))

Ateş (2021) simulates the performance of the terminal operation at Izmir Adnan Menderes Airport in terms of check-in, boarding, and gate opening and closing times pre and post COVID-19. According to research, passengers spend 61% of their departure travel time in the check-in queue, and 39% of their departure travel time on security checks, boarding, and other procedures. On the land side, passengers would be spread out at the restricted and check-in areas, allowing operations at the gates to move more quickly.

Takakuwa (2003) develop a simulation for international departure passenger flow as shown in Figure 2.5. From the study, the waiting time of the passenger in the check-in counters are 80%. Chun and Wai (1999) created an intelligent resource simulation system (IRSS) to estimate resource needs of an airport by entering statistical check-in data. Check-in counter assignment system (CCAS) makes it easy to choose the best counter number and when to open. They discovered that thanks to the procedures in place, up to 40% of the resources are saved.

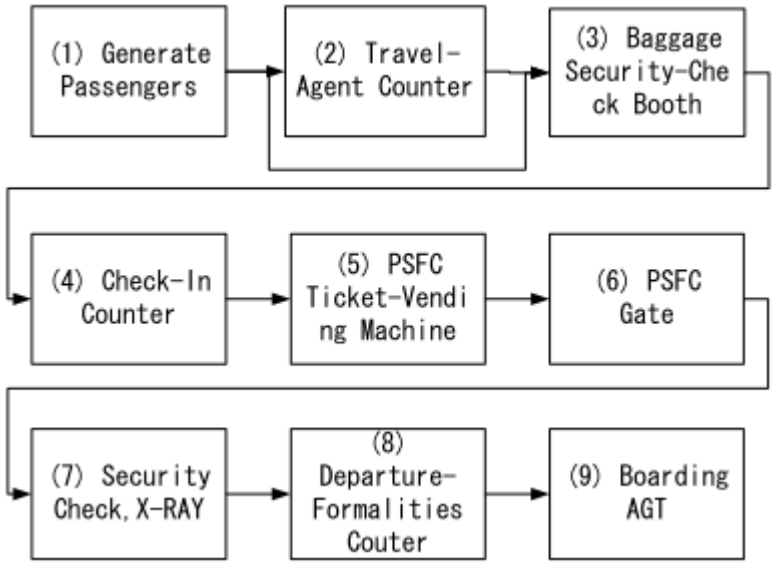


Figure 2.5 Flow of Passengers (Source: (Takakuwa et al., 2003))

In order to improve the effectiveness of the check-in counters at Kuwait international airport, a study authored by Al-Sultan (2018) used a simulation of the check-in system. Before the actual operations began, it was observed that the check-in system has variable capacity and check-in planning. This was before the actual operations began. According to the findings of their study at the check-in area, just a small percentage of travellers make use of the kiosks. As a consequence of this, they based their simulation model on the assumption that only a small fraction of travellers (about 2 percent) would use an express kiosk (Al-Sultan, 2018).