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Original Article

Simulation of the impact of Covid-19 outbreak for airport terminal operations at Sam Ratulangi International Airport

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Indonesian airport regulators have taken steps to keep their airports operational during the Covid-19 pandemic. Measures such as implementing physical distance, checking body temperature and checking health documents have affected the efficiency of the airport terminal. Covid-19 Crisis Management has made major operational adjustments. This action has been effectively carried out in situations where passenger transport has been limited due to regulatory agency flight restrictions. However, it is still unclear what the output will be when the demand normalizes. The purpose of this paper is to compare terminal operations before and after the occurrence of Covid-19. This paper evaluates the impact of Covid-19 measures on airport terminal performance using simulation tests of CAST 8 terminal simulation software. The model represents Sam Ratulangi International Airport (IATA: MDC) in Manado, Indonesia. This model covers the departure and the arrival areas. The flight schedule of the selected date taken from the flight radar website generates the passengers, the farewellers, and the meeters. IATA ADRM 11th Edition is the guidelines to determine the level of service. Adjustments for Covid-19 scenarios include number of passengers, physical distance, processing flow, and waiting time. The results show that the waiting time of each process has increased latency and at some point the latency exceeds the optimum service level. The simulation results allow local airport authorities to maintain a specified level of service at MDC airport.

Keywords: airport terminal; operation performance; covid-19 measures; MDC airport

1. Introduction

The Covid19 outbreak has forced many industries to make adjustments in order to maintain business continuity. One of the industries affected is the aviation industry. When the Covid-19 hit, the Government of the Republic of Indonesia issued Government Regulation No. 21/2020 [1] and Presidential Decree No. 12/2020 [2]. The impact of those regulations is the decreasing number of passengers at the airport, such as the average annual passenger traffic of Soekarno-Hatta International Airport in Cengkareng, Indonesia decreased by 43.48% [3]. The International Air Transport Association (IATA), together with The International Civil Aviation Organization (ICAO), has made several adjustments to both flight restrictions and passengers handling regulations in airport terminals, including physical distancing, wearing a mask and face-shield, real-time body temperature checking and health documents screening [4]. Indonesian local airport regulators follow IATA, ICAO and WHO in implementing operational standards at airport terminals.

Sam Ratulangi International Airport (IATA: MDC) is one of the international airports in north-eastern Indonesia. The MDC airport is a part of the National Air Transport Hub as the primary

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distribution centre [5] managed by PT Angkasa Pura I. The number of passengers in MDC Airport has also decreased due to the Covid-19 outbreak. MDC Airport, on the other hand, already has a terminal expansion plan which will start operating in 2022. Expansion plans were already underway before the Covid-19 outbreak. Airport terminal design and the calculation of level of service did not take changes in the airport's new normal operational standards into account. The implementation of the Covid-19 measures is currently going smoothly when the number of passengers is still declining. However, it is still unclear how the airport operations will be running once the airport expansion is completed and the passengers normalized. The purpose of this paper is to compare the performance of MDC airport pre and post the Covid-19 outbreak.

ICAO has issued a document [6] outlining measures to reduce the spread of the Covid-19 virus in the aviation industry, including airports, aircraft, crew and cargo. The airport module also regulates physical distancing, departure and arrival processions, sanitation, cleaning, and airside area. Although this solution can reduce the spread of the virus, it affects passenger queuing in almost all checkpoints including check-in, security control and boarding [7]. Additional control points to screen the health document reduce the area and throughput of the terminal [8]. The purification process also increases the dwell time [9]. A decrease in the number of flights due to flight restrictions [10] affects the efficiency of airport operations [11]. In addition to introducing new regulations for a new normal era, several airport regulators have prepared long-term plans [12] to convert non-passenger revenue into capital to accelerate the technology [13] and arrival and departure processing time.

The impact of the Covid19 outbreak on airport operations and capacity may include delays in boarding/disembarkation (due to sanitation and cleaning), changes in passenger flow including additional processes (temperature check, in-time Covid-19 test, and health certificate verification), and increased turnaround times (additional processing issues), limited processor availability, or increased dwell time or holding area [14]. The agent-based simulation results [15] showed that the waiting time in the procession from the moment a passenger entered the terminal to the boarding point increased according to the physical distance, whereas the time spent at the boarding point was relatively unchanged because the previous procession took longer.

2. Materials and Methods

2.1. Software

This research uses the CAST Terminal Simulation Software version 8.0.0.43. The software is copyrighted by Airport Research Centre GmbH (2001-2021).

2.2. Simulation Scenario

The CAST model of MDC Airport is a projection of the 2022 plan and includes departure and arrival zones. Research areas include check-in halls, security checkpoints (SCPs), boarding lounge, emigration control, immigration control, baggage reclaim hall and customs control. The simulation consists of three scenarios (Table 1): a pre-COVID-19 (Scenario 1), a post-COVID-19 scenario with a throughput of 100% (Scenario 2), and a post-COVID-19 scenario with a throughput of 70% (Scenario 3).

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Table 1. Three different scenarios.

	Scenario 1: Pre Covid-19	Scenario 2: Post Covid-19 – 100%	Scenario 3: Post Covid-19 – 70%
Queuing distance	1 m	1.5 m	1.5 m
Comfort distance to persons	50%: 1 m 50%: 0.9 m	50%: 2 m 50%: 1.5 m	50%: 2 m 50%: 1.5 m
Farewellers and Meeters Percentage	40%: 0 30%: 1 20%: 2 10%: 3	60%: 0 40%: 1	60%: 0 40%: 1
Health screening	No	Yes	Yes

2.3. Passengers Projection

The expansion plan of MDC Airport in 2022 is expected to accommodate up to 3,800,000 passengers per year, up from the original 2,618,000 passengers in 2017. The expected number of passengers during peak hours in 2022 is 2,052 pax/hour, and 1,806 pax/hour for domestic flights and 246 passengers for international flights. This study used data from the Flightradar24 website for flight schedules. The flight schedule for the study is during peak hours from 10am to 11am local time on 7 November 2020, and there may be assumption of additional flights to meet expected passenger numbers during peak hour in 2022. Table 2 presents recalculation of passenger numbers for all scenarios.

Table 2. Passenger's projection of three different scenarios.

		Scenario 1 and 2	Scenario 3
Domestic		1.788 pax	1.255 pax
	Arrival	904 pax	634 pax
	Departure	884 pax	621 pax
International		264 pax	186 pax
	Arrival	132 pax	93 pax
	Departure	132 pax	93 pax
Total		2.052 pax	1.441 pax

2.4. Simulation Settings

The arrival of passengers at the arrival curbside uses the scenario as listed in table 3. ADRM 11th Edition [16] provides guidelines for defining the level of service modelling in this study.

Table 3. Passenger's entry time.

		Before departing time
Domestic	0%	02:00:00
	20%	01:45:00
	90%	01:15:00
	100%	01:00:00
International	0%	02:00:00
	40%	01:50:00
	70%	01:40:00
	90%	01:30:00
	100%	01:15:00

3. Results

3.1. Passenger Flow

The difference in passenger flow pre and post COVID-19 is an additional health check in both the departure flow as shown in Figure 1 and the arrival flow as shown in Figure 2.

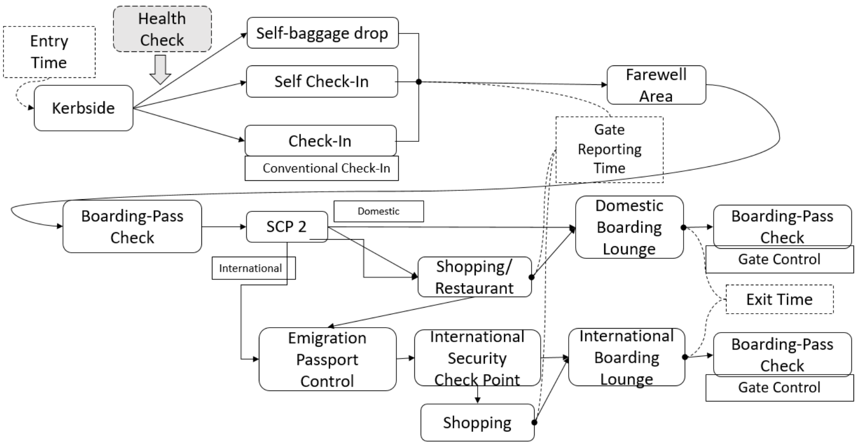

Figure 1. Departure flow, there is additional health check in post Covid-19 scenario.

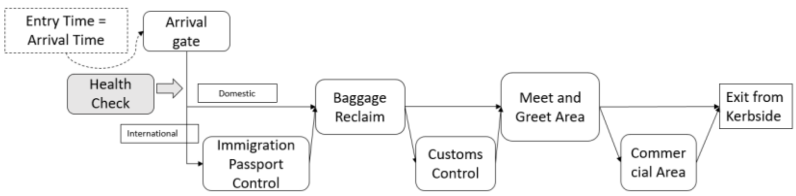

Figure 2. Arrival flow, there is additional health check in post Covid-19 scenario.

3.2. Check-In Hall

In Scenario 1, passengers do not need to present medical documents and the passengers are more dispersed in the check-in hall (Figure 3). Simulation results show that there is excessive congestion of passengers on the curbside during medical examinations in Scenario 2 (Figure 4). The passenger accumulation in Scenario 3 (Figure 5) is not as much as in Scenario 2. The distribution of passenger flow at the check-in counter (Figure 6) is more evenly distributed in Scenario 2 and 3 since the passengers spend more time checking their health than in Scenario 1. However, the longest waiting time for passengers falls under Scenario 2 (Figure 7).

Figure 3. Check-in hall simulation in Scenario 1.

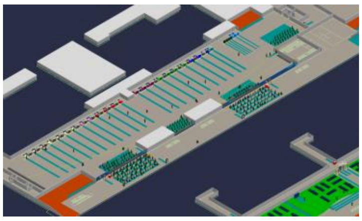

Figure 4. Check-in hall simulation in Scenario 2.

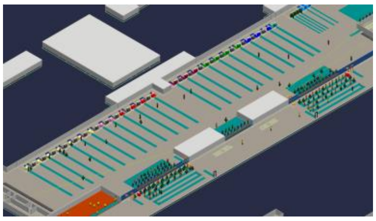

Figure 5. Check-in hall simulation in Scenario 3.

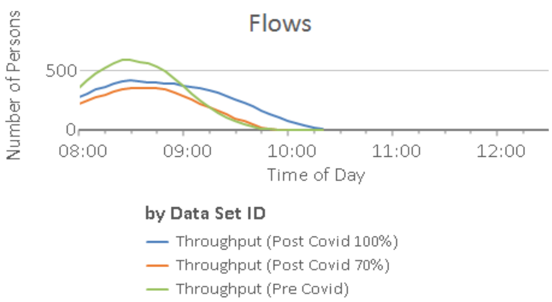

Figure 6. Flows of check-in hall for three different scenarios.

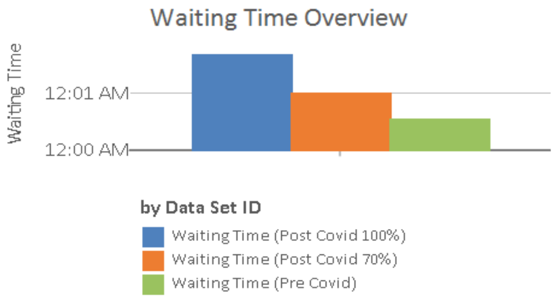

Figure 7. Waiting time overview of check-in hall for three different scenarios.

3.3. Security Check Point

In Scenario 1, passenger congestion is evident in the SCP (Figure 8), but this congestion shows an optimal design at least for Scenario 2 (Figure 9) and Scenario 3 (Figure 10). The most common passenger traffic is in Scenario 2, while Scenario 1 and 3 still have different numbers of passenger congestion initially (Figure 11). The highest waiting time for passengers occurs in Scenario 1 (Figure 12) because passengers spend more time at the health screening and check-in hall.

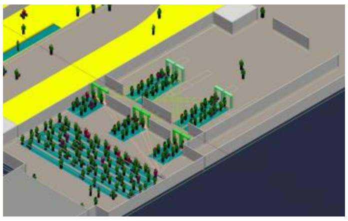

Figure 8. SCP simulation in Scenario 1.

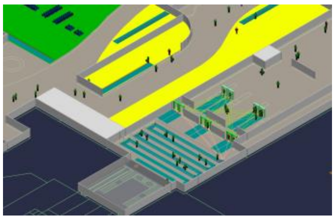

Figure 9. SCP simulation in Scenario 2.

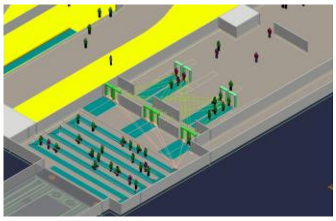

Figure 10. SCP simulation in Scenario 3.

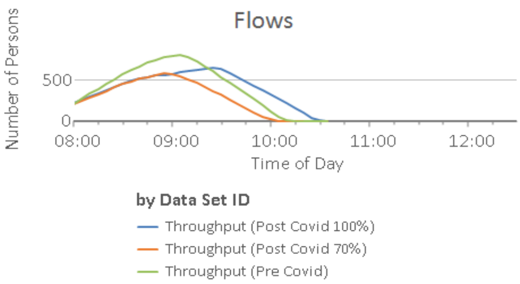

Figure 11. Flows of SCP for three different scenarios.

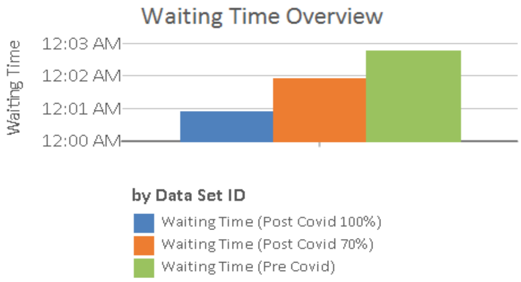

Figure 12. Waiting time overview of SCP for three different scenarios.

3.4. Boarding Lounge

Passengers seem to be piling up more in Scenario 1 (Figure 13) compared to Scenario 2 as the most increased dwelling usage (figure 14) and slightly higher usage in Scenario 3 (Figure 15). The reason may be that passengers are still stuck at the previous checkpoint which takes a longer time. In Scenario 2, there are passengers boarding the plane late (Figure 16). The passenger distribution is more even in Scenario 3 than in Scenario 1 (Figure 17).

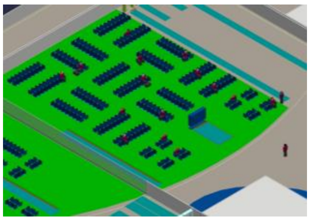

Figure 13. Boarding lounge simulation in Scenario 1.

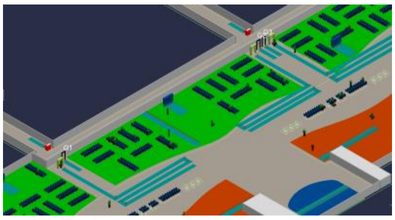

Figure 14. Boarding lounge simulation in Scenario 2.

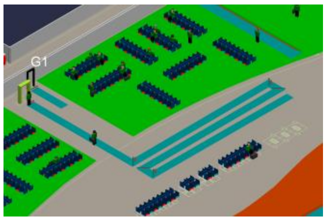

Figure 15. Boarding lounge simulation in Scenario 3.

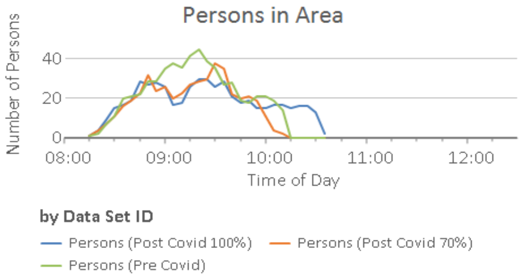

Figure 16. Persons in boarding lounge for three different scenarios.

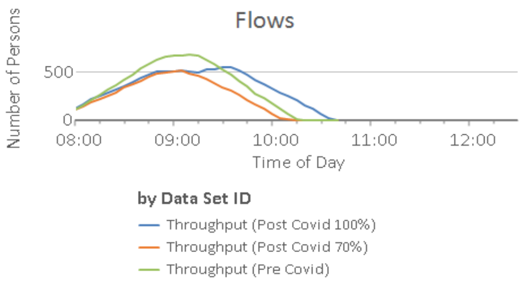

Figure 17. Flows of boarding lounge for three different scenarios.

3.5. Emigration Control

In Scenario 1, there is more accumulation of the passengers in emigration control (Figure 18) compared to Scenario 2 which has the shortest lines of passengers (Figure 19), or Scenario 3 where there is still fewer queues (Figure 20). As seen in the boarding lounge, Scenario 2 shows a tardy passenger (Figure 21). On the other hand, the longest waiting time occurs in scenario 1 due to the accumulation of queues (Figure 22), whereas in Scenarios 2 and 3, accumulation does not occur because passengers are still at the previous checkpoint.

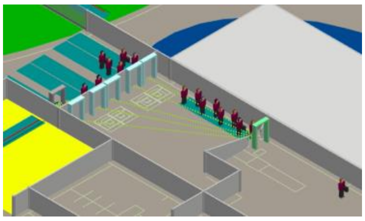

Figure 18. Emigration simulation in Scenario 1.

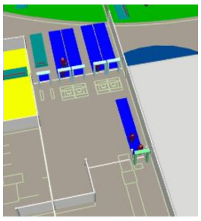

Figure 19. Emigration simulation in Scenario 2.

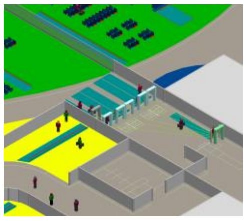

Figure 20. Emigration simulation in Scenario 3.

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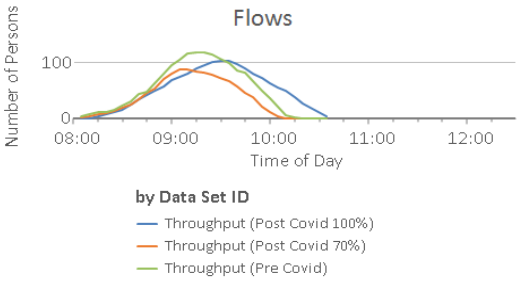

Figure 21. Flows of emigration for three different scenarios.

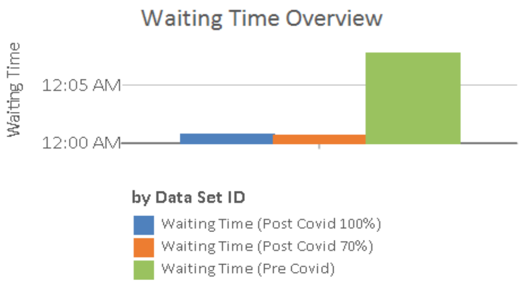

Figure 22. Waiting time overview of emigration for three different scenarios.

3.6. Imigration Control

In Scenario 1, congestion occurs at the immigration office because passengers go straight to the immigration office as soon as they get off the plane (Figure 23). However, when passengers need to perform a health screening counter, the accumulation occurs at the health screening counter, and the accumulation at the immigration check-in is relatively small in both Scenario 2 (Figure 24) and Scenario 3 (Figure 25). The passenger flow of the three scenarios did not show any significant difference volume except for a decrease in the number of passengers (Figure 26). The longest waiting times at the Immigration control occurred in Scenario 1 (Figure 27). In Scenarios 2 and 3, the passenger was still trapped at the health screening checkpoint.

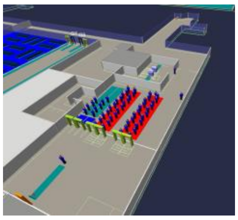

Figure 23. Immigration simulation in Scenario 1.

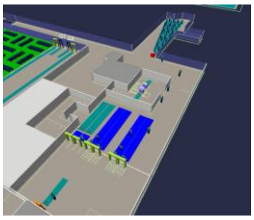

Figure 24. Immigration simulation in Scenario 2.

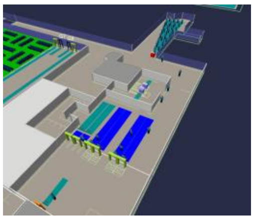

Figure 25. Immigration simulation in Scenario 3.

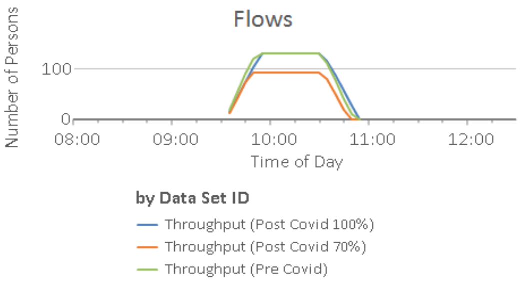

Figure 26. Flows of immigration for three different scenarios.

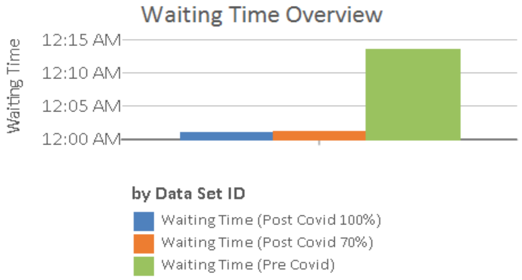

Figure 27. Waiting time overview of immigration for three different scenarios.

3.7. Baggage Reclaim Hall

The simulation shows that the passenger densities in Scenario 1 (Figure 28), Scenario 2 (Figure 29), and Scenario 3 (Figure 30) are not significantly different from each other. Likewise, the flow of people in the three scenarios is not significantly different (Figure 31), while the number of passengers are indeed fewer in Scenario 3. However, the longest waiting times are observed in Scenario 1 (Figure 32), since passengers go directly to the baggage reclaim hall after disembarking. Meanwhile, in Scenarios 2 and 3, the distribution is more even as many passengers are still stuck at health screening counter.

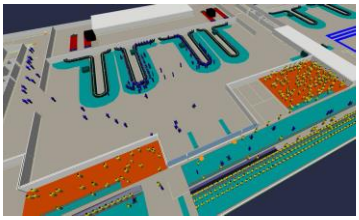

Figure 28. Baggage reclaim hall simulation in Scenario 1.

Figure 29. Baggage reclaim hall simulation in Scenario 2.

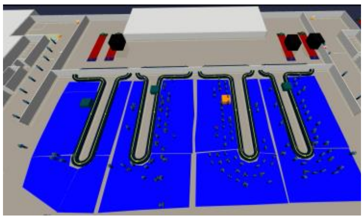

Figure 30. Baggage reclaim hall simulation in Scenario 3.

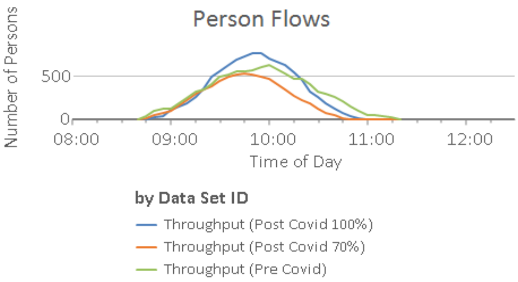

Figure 31. Person flows of baggage reclaim hall for three different scenarios.

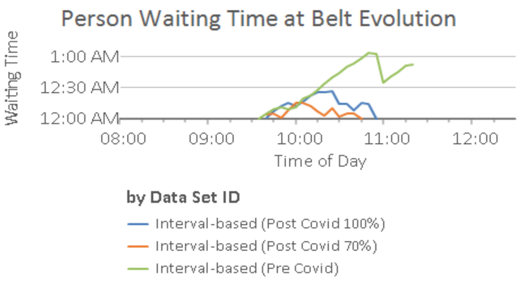

Figure 32. Person waiting time at belt evolution for three different scenarios.

3.8. Customs Control

Customs control looks very crowded in Scenario 1 (Figure 33) and having the worst-case level of service, sub-optimum levels. The same thing happened in Scenario 2 (Figure 34) and Scenario 3 (Figure 35). The flows in the three scenarios do not differ significantly, only in Scenario 3 the graph is decreased because of fewer passengers (Figure 36). Scenarios 1 and 3 have approximately waiting time of about 20 minutes, while Scenario 2 has only about 10 minutes (Figure 37).

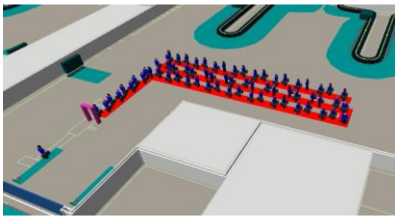

Figure 33. Customs control simulation in Scenario 1.

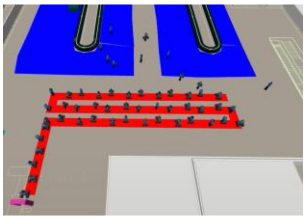

Figure 34. Customs control simulation in Scenario 2.

Figure 35. Customs control simulation in Scenario 3.

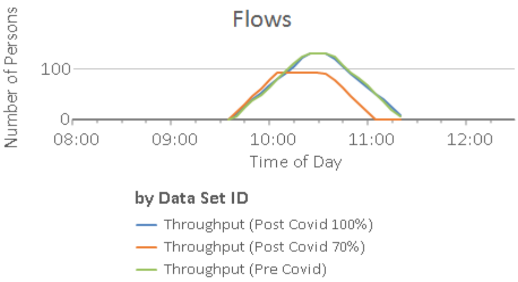

Figure 36. Flows of customs control for three different scenarios.

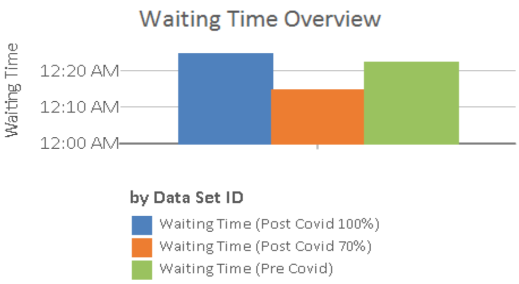

Figure 37. Waiting time overview of customs control for three different scenarios.

4. Discussion and Conclusion

The Covid19 outbreak presents new challenges to the aviation industry, such as flight restrictions, additional departure and arrival processions, cleaning and sanitation, safety protocols and other initiatives. However, the aviation industry still faces financial problems and has to adapt to the new normal conditions. By implementing Covid-19 measures at airports, the airport regulators are helping to increase the confidence of passengers choosing flights for the transportation alternatives. These measures are very effective when there are significant restrictions on the number of passengers. However, as the measures are implemented, problems will arise at the airport when passengers return to 70-100%.

Each airport will face different constraints based on infrastructure, passenger forecasts and other variables. The simulation results from this study show that there are several obstacles to passenger service at MDC airports. This study assumes a 2022 flight schedule based on passenger projection data from the 2022 master plan. Physical distancing affects the queue space capacity and number of active counters reduction for each checkpoint. The addition of health screening control to the departure procession caused congestion with passengers on the curbside, causing passengers to spend more time in the initial procession, affecting subsequent processions. If the health screening process is extended, the distribution of passengers in the next checkpoint will be more evenly distributed with shorter waiting times. However, if passengers do not arrive early, they will board the plane late. The arrival process also has an impact from the addition of the health screening process after disembarkation. However, there is no delay in tracking departure times due to congestion at the health screening counters, as there is no deadline for passengers to leave the airport. The health check process allows passengers to come later at the baggage reclaim area. This will help delay the accumulation of passengers in the baggage reclaim area while waiting for the cleaning and hygiene process of the bags before being transferred to the belt. The longer arrival process makes the meters wait longer so that the accumulation of meters occurs on the curbside.

Local airport regulators need to make adjustments to MDC airport operations when passenger numbers return to normal and Covid-19 measures are still required. Online procedures or contactless technology can help passengers speed the processing up and reduce waiting times. Passengers should arrive at the airport early to estimate the length of the departure process to avoid delays in boarding. Meeters must arrive at the airport later than the passenger's arrival time to avoid meter build-up on the curbside. However, Covid-19 measures, or implementation of respective health protocols, will help increase public confidence in the choice of flights as a mode of transport so that the aviation industry can survive in the future.

Acknowledgments
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