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10th International Conference on Air Transport – INAIR 2021, TOWARDS AVIATION REVIVAL

RESTART: ANALYSIS OF POST-COVID 19 CAPACITY IN SECURITY CHECKPOINTS AT MEXICO CITY AIRPORT

Miguel Mujica Mota\textsuperscript{a}, Paolo Scala\textsuperscript{a}, Alejandro Di Bernardi\textsuperscript{b}, Angel Orozco\textsuperscript{c}

\textsuperscript{a}Amsterdam University of Applied Sciences,
\textsuperscript{b}National University of La Plata,
\textsuperscript{c}Independent Researcher

Abstract

COVID-19 arrived in the world suddenly and unexpectedly. It caused major disruptions at economical, operational and other levels. In the case of flight traffic, the operations were reduced to 10\% of their original levels. The question after COVID-19 is how to restart the operations and how to keep the balance between safety and capacity. In this paper we present an analysis using simulation techniques for understanding the impact in a security area of an important airport in Latin America; the airport of Mexico City. The results allow to illustrate the potential congestion given by the implemented covid-19 restriction, even when the traffic recovers only by 25\% of the pre-covid-19 traffic. The congestion can be mitigated by applying some layout changes (snake queue vs parallel queue) and when more capacity is added to the system (extra security lane). The results will raise situational awareness for airport stakeholders when implementing the actions suggested by different international institutions like WHO, IATA or ICAO.

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Peer-review under responsibility of the scientific committee of the 10th International Conference on Air Transport – INAIR 2021, TOWARDS AVIATION REVIVAL

Keywords: AICM; congestion; airports; multimodal; logistics; simulation; decision support systems; COVID

1. Introduction

Until December 2019, the world was, with few exceptions, unaware of the impact that the appearance of a new pandemic would have on our daily lives, and that it would transform everything in a radical and abrupt way.

* Corresponding author.
E-mail address: m.mujica.mota@hva.nl
TOWARDS AVIATION REVIVAL

Naturally, no planning scenario foresaw situations like the ones we are going through, being, to this day, unable to foresee, with a certain level of certainty and confidence. Or what will happen in the immediate future despite the wide range of strategies and intentions that are being carried on.

The emergence of COVID-19 has impacted all value chains and production of economic/financial activity and the commercial air transport system is not an exemption, affecting it directly and forcefully to the point of having close to 90% less than normal operations for this season.

An example of this abrupt decline can be seen in the graph of Figure 1, where possible recovery scenarios for the Latin American and Caribbean region are also seen.

This figure is produced by ICAO for evaluating potential recovery scenarios. Similar situations in other regions of the world, with their natural differences, could be exposed in the present document, however, it goes out of the scope for the present paper as the focus will be on the Latin American traffic. Reality shows us that aircraft are not flying, that they are stopped at different airports around the world, giving the paradox of having the airside occupied and the landside empty at the airport terminals. In this context, the only certainty we have today is that any recovery scenario is uncertain, which leads us to ask ourselves how and when we will return to what we were. It is therefore important to become independent from the temporal projections and to carry out studies through simulations (Mujica et al., 2017), and evaluating different operational milestones. These can represent certain flows and operations in certain areas of the airport as it can be the airside or the landside, but always considering their systemic linkage. In the case of terminals (where this work is focused), different processes can be evaluated considering the capacities of the areas and the resources involved in each task. An example is the security area controls for a passenger and their luggage, without disregarding the general guidelines expressed in the ICAO Annex 9 "Facilitation" (ICAO, 2017a), or in the ICAO Annex 17 "Security" of the Chicago Convention (ICAO, 2017b) and in the ICAO Doc 10144 about "Management of Aviation Safety Risks related to Covid-19" (ICAO, 2020b) among other important documents.

In this context, the present work evaluates through simulation different processes of a specific area of Mexico City Airport terminal (Terminal 1 Checkpoint J) considering social distancing in the process of security and boarding pass control for passengers and their respective hand luggage. This study is just a taste of what type of problems the airports will face at different areas of the terminal buildings once the recovery is taking place. The
insight obtained from the study can be extrapolated to other processing areas like check in, passport control or boarding gates.

For analyzing the recovery phase, different scenarios with a certain passenger mix will be evaluated assuming different percentages of traffic.

The Key Performance Indicators (KPIs) evaluated are:

- Queue length (average number of passengers queuing)
- Queuing time (average time spent queuing per passenger)
- Capacity (number of passengers processed in a hour)

In the next sections we present the different scenarios and at the end of the paper we conclude with the most important remarks.

2. State of the Art

There are several studies related to security in different areas. For instance, in Janssen et al. (2019), the authors focus on the analysis using ABM using a RISK approach for improving performance in the security of airport terminals. In Al-Safwani et al. (2018) the authors look for reducing vulnerability using an information security control prioritization that can determine the critical vulnerable controls based on diverse assessment criteria. Other authors focus on the use of optimization techniques for selecting the best strategy based on current performance of technology, which is the case of Candalino et al. (2004). The work of Sahin and Feng (2009) focuses on the selection of different technologies for reducing the probability of errors like false positives or false negatives. Other authors like Pettersen and Bjornskau (2015) approach the problem from a more strategic angle. Lee and Jacobson (2011) focus on assigning passengers based on the type of technology available which might be complicated to apply. Stewart and Mueller (2015) present a risk analysis for the pre/check programs in order to increase safety. As it is reviewed, none of the previous studies considered a similar situation as the one we have with the COVID 19. The analysis presented in this paper uses a simulation model based on discrete events to analyze different policies that can be used in the post-covid phase and we developed this model for investigating the effect of the implementations suggested by the different international organisms (ICAO, IATA, ACI, WHO). It aims at investigating the impact in capacity of keeping a separation and also by implementing policies like sanitary corridors that can be used dedicated only for vulnerable people.

3. System Description & Methodology

The methodology followed for this study follows the methodology presented by Mujica et al. (2018). Figure 2 illustrates the steps of the methodology; in this case it was used one layer with the layout and a 2nd layer with the simulation model was built over it. The simulation model developed represents the operations conducted in the security area of an airport terminal. We did not consider the whole terminal building; instead we put focus on the security revision points using real data from Pre-COVID 19 times. This will enable us to illustrate the potential consequences and/or adequate policies to deal with the transition restarting phase.

The model simulates a specific area of the Mexico City Airport terminal (Terminal 1 Checkpoint J). In the security area the following operations are conducted:

- Boarding pass control
- Passengers dropping their small bags/belongings
- Bag scan
- Body scan
The following processes have been simulated to recreate the security operations:

1. Passengers queuing to the boarding pass control. The passengers go to the boarding pass control where they are processed according to a specific processing time. Two different types of queue are tested: a “snake” shape queue, and a “normal” queue. The former is the one traditionally used, the latter is more likely to be used due to the Covid-19 restrictions (see Fig. 1).
2. Passengers bags drop. Passengers reach one of the available bag drop lines based on two criteria: the line that is free will be chosen; if both lines are busy, the line with the shortest queue will be chosen. Passengers drop their bags on the tray, this process is modeled by a certain processing time.
3. Passenger body scan/bag scan. These two operations are done in parallel. People pass through a body scan device and bags pass through a bag scan device.
4. Passenger body scan. Passengers walk through a body scanner. This operation takes a specific time.
5. Passenger bags X-Ray scan. Bags are moved through the X-Ray scan. The scanning operation takes a specific time.
6. Passenger body re-scan/bag re-scan. This operation is conducted based on a specific occurring probability, and it takes a certain time.

Due to the Covid-19, extra measures have been given to the airport operators (ACI, 2020), such as:

- Passenger distance between each other of 1.5 meters
- No adjacent lines
- Frequent cleanings of the tray/equipment area

The Key Performance Indicators (KPIs) evaluated are:

- Capacity (number of passengers processed in a hour)
- Queuing time (average time spent queuing per passenger)
- Probability of re-scan
- Probability of x-ray re-scan
- Probability of personal re-scan

For analyzing the recovery phase, different scenarios with a certain passenger mix will be evaluated.
7. Passenger bags claim. After being scanned, the passengers take their own bags and leave the area. This operation is based on a specific processing time.

4. Case Study

We will evaluate the impact of the different actions suggested by ICAO, IATA or WHO for managing passengers.

The area under study is a security control area in a Mexican airport which has suffered from a lot of congestion during the peak hours of the days during Pre-COVID times. As it can be expected, some days are worse than others depending on the season of the year.

The current layout is illustrated by Figure 3. As it can be seen there are four lines available. However, with the restrictions caused by the COVID-19 regulations, only 2 out of those four lines can be used, as adjacent lines are forbidden. With these restrictions in place, the capacity is expected to decrease.

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Fig. 3 Current layout of security
4.1. Experimental Design and Results

To investigate the effect of the actions implemented at airports due to the Covid-19 pandemic, we have tested different scenarios based on the following parameters:

- **traffic recovery**, for the “traffic recovery” parameter we have tested 5 different values which consider a gradual recovery of the traffic starting from 10% until 30%, this will cover a frame of short-medium term (next 2 years).
- **layout of the queue**, the parameter “layout of the queue” indicates whether a “snake” shaped queue or a parallel queue is utilized (see Figure 4). Due to the COVID-19, the latter is being recommended, however, the former is currently in use in our case study airport.
- **dedicated line for vulnerable passengers**, the parameter “dedicated line for vulnerable passengers” is a boolean where, in a parallel queue layout scenario, means that one security line (and the related queue) will be entirely dedicated to vulnerable passengers. In this context, vulnerable passengers are defined as the ones more exposed to be infected by the virus, due to age or to current illness. In the present study, the amount of passengers with this condition is assumed to be 20% of the total passengers. This value was based on statistics reports. Table 1 summarizes the values used for each of the parameters. It is worth mentioning that the scenario with a dedicated line for vulnerable passengers was considered only for the parallel queue layout.

![Fig. 4. Queue layout: snake queue (left); parallel queue (right)](image)

The base case is chosen as the one currently implemented in Mexico City airport terminal and it has the following parameters: 10% traffic; snake queue; no dedicated line for vulnerable passengers. The simulation of each scenario has been run for 50 replications. Results are presented as average values of the different KPIs. Moreover, an extra scenario was tested based on a potential mitigation of the current restrictions where an extra line is added besides the line for regular passengers and the line for vulnerable passengers, to have in total 3 lines.
Table 1. Experimental Design

| Parameter                               | Value     |
|-----------------------------------------|-----------|
| Traffic recovery                        | 10% 15% 20% 25% 30% |
| Layout of the queue                     | snake     | parallel |
| Dedicated line for vulnerable passengers | yes       | no       |

5. Results

Table 2 and 3 show the results regarding the queue length and queuing time of the pre-security area. The pre-security area is defined as the airport corridor just before entering the security area and undergoing the boarding pass control and security control operations. By measuring its performance in terms of queue length and queuing time we evaluate the level of congestion of the airport and whether the security area is able to process the total inbound passenger flow or not. The results reveal that for the snake queue and parallel queue without a dedicated line for vulnerable passengers we obtained similar results both for queue length and queuing time, generating long queues in the airport corridor once the traffic recovery gets to 25%.

Table 2. Queue length Pre-security (Passengers)

| Queue layout                      |
|-----------------------------------|
| Traffic recovery                  |
| Snake queue                       |
| Parallel queue                    |
| Dedicated line for vulnerable passengers | no | yes | yes + extra line |
| 10%                               | 8,72 | 9,1 | 10,4 | 8,8 |
| 15%                               | 10,8 | 11,1 | 208,4 | 11,1 |
| 20%                               | 26,6 | 33,8 | 700,9 | 14,5 |
| 25%                               | 417,2 | 438,6 | 1191,3 | 44,9 |
| 30%                               | 916 | 932,1 | 1686,5 | 432,0 |

What can be noticed is that the trend for both queue length and queuing time is not linear with the increase of traffic, as it gets congested between 20% and 25% of traffic recovery. Regarding the scenario where a dedicated line is reserved for vulnerable passengers, it generates big queue lengths and high queuing time just with the increase in 15% for the traffic recovery. On the other hand, the extra line scenario, shows better values for all the
scenarios. In this scenario, the queue length starts to get considerably big only when the traffic recovery reaches 30%, while queuing times are kept low. These trends can be better illustrated in Figures 5 and 6.

Table 3. Queuing time Pre-security [min]

| Traffic recovery | Snake queue | Parallel queue |
|------------------|-------------|----------------|
|                  | Dedicated line for vulnerable passengers | no | yes | yes + extra line |
| 10%              | 1,0         | 1,0            | 1,0 | 1,0           |
| 15%              | 1,0         | 1,0            | 18,8| 1,0           |
| 20%              | 2,3         | 4,0            | 19,9| 1,1           |
| 25%              | 11,6        | 12,2           | 20,2| 4,3           |
| 30%              | 12,0        | 12,4           | 20,3| 10,0          |

Another KPI that was measured is the capacity measured in pax/hr. This is presented in Figure 7. It shows that the snake and parallel queue layout without a dedicated line for vulnerable passengers are more efficient than the
scenario with a dedicated line. We notice that the maximum capacity for the scenario with a dedicated line (grey bar) is reached at the 15% traffic recovery scenario with 66 passengers per hour, and from there stays stable for the other scenarios. On the other hand, the snake and parallel queue without a dedicated line scenario reaches the maximum capacity at 20% traffic recovery scenario, with a value of 101 passengers per hour until reaching 105 passengers per hour in both traffic recovery scenarios 25% and 30%. The extra line scenario, shows similar values of capacity as the snake queue and the parallel queue without a dedicated line scenario, in the instances of traffic recovery up to 20%, then the capacity increases up to 127 and 132 passengers per hour for the traffic recovery of 25% and 30%, respectively.

5. Conclusions and Future Work

As the study has illustrated, the impact of COVID-19 in the airport system is dramatic. The different scenarios showed that the new regulations regarding the use of airport facilities due to the Covid-19 will bring issues in terms of capacity management for some areas of the airport. This study has revealed that the security area is very sensitive, as congestion problems start to appear when the traffic starts recovering. The best scenarios were the snake queue layout, and the parallel queue layout. In these two scenarios, the security area started to get congested when 20% of the traffic was recovered. However, these two scenarios were not including any possibility to have an extra dedicated line for vulnerable passengers as it would be desired. The scenario with two parallel queues, where one of them was dedicated to vulnerable passengers, obtained the worst results, where congestion was obtained already at 15% of traffic recovery. The capacity improved considerably when an extra line was added to this scenario, highlighting the sensitivity of the system performance to additional security lines. However, this scenario goes in contrast with the current regulation due to the Covid-19. Despite this study being focused on a specific security area of the terminal, similar performance is expected to the other security areas of the airport, as they have similar layouts and expected number of passengers.

This study revealed future problems that the airport will face once the traffic starts to recover. For that reason, it is strongly suggested that airport operators and other stakeholders use simulation techniques for identifying potential problems and as a support in their plans for the coming months.

Acknowledgements

The authors would like to thank the AUAS Aviation Academy for supporting this study and IGAMT expertise (www.igamt.eu) for the support provided. In addition, the authors would like to thank the Dutch Benelux Simulation Society (www.DutchBSS.org) and EUROSIM for disseminating the results of this work.

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