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Exploring strategies for streamlining security procedures without compromising safety: airport planning and logistical considerations

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Abstract
In the aviation industry, one principal aim is security and safety. On the one hand, governments are interested in globalising their countries and the security of their citizens and visitors while entering and leaving the country. On the other hand, for the aviation industry, it is imperative to guarantee the security of every process. Although aviation is known as the safest mode of transportation, it is the most criticised and scrutinised when an accident happens due to the potential passenger losses. Even if there were only one accident per year, the impact on the public eye would be fatal, and the aviation industry would not be the massive transportation system it is today. In this study, security processes will be analysed and studied through simulations. Apart from safety, another notable characteristic of aviation is the number of passengers who enter airports, take planes, travel, work, and use this system daily. This study focuses on optimising the processes without compromising safety levels. This paper presents various designs and optimisations for airport processing areas by studying parameters such as flight precedence, distribution over long journeys, human factors, and technology. Through this study, readers can better understand airport logistics and the significant influence of these parameters. Balancing all aviation elements is almost an art, requiring careful coordination and management.

Keywords
Airport, capacity, security

1. Introduction

This study optimises airport processing areas, such as security, passport control and customs (*Eurocontrol, 2024*). For that aim, it is important to be conscious that the types of flights determine the airport's infrastructure it will serve and the requirements for each kind of passenger. Higher levels of security are required at airports with international flights. This demand also determines the necessary space.

It is possible to calculate the best space utilisation for each process listed above and introduce new technologies to help use those spaces better. It must not be forgotten that capacity in the aviation industry is limited. With the growing demand for flights, adapting these spaces for maximum efficiency is crucial.

1.1. Literature review

The first step in focusing on this project was to study the field and the correlation between its components. A map based on 1000 articles by ScienceDirect related to airport and aviation security has been elaborated. From this data, we created a conceptual map (*Figure 1*), which helps us understand the importance of and the connections between the elements of the system. The most important focal points are the following concepts: airport and airports, airport terminal, airport security and security, airport quality, airport management and aviation.

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Airports and airports are the centres of this research. At airports, thousands of passengers must deal with obstacles in a sometimes new environment. Airport management and quality are strongly connected to studying common concerns such as infrastructure, passenger satisfaction, privatisation, or airport regulation (*Bolić, Ravenhill, 2020*).

On the other hand, there is no strong relationship between airport management and airport security, which is the main problem this paper aims to study. The concept of an airport terminal is not strongly related either. These two fields are interesting ones that are related to developing a better airport security process (*Calzada, Fageda, 2023*). Furthermore, airport security research dates back to 2015, while the remaining elements are more recent. This is another reason why this field must be investigated.

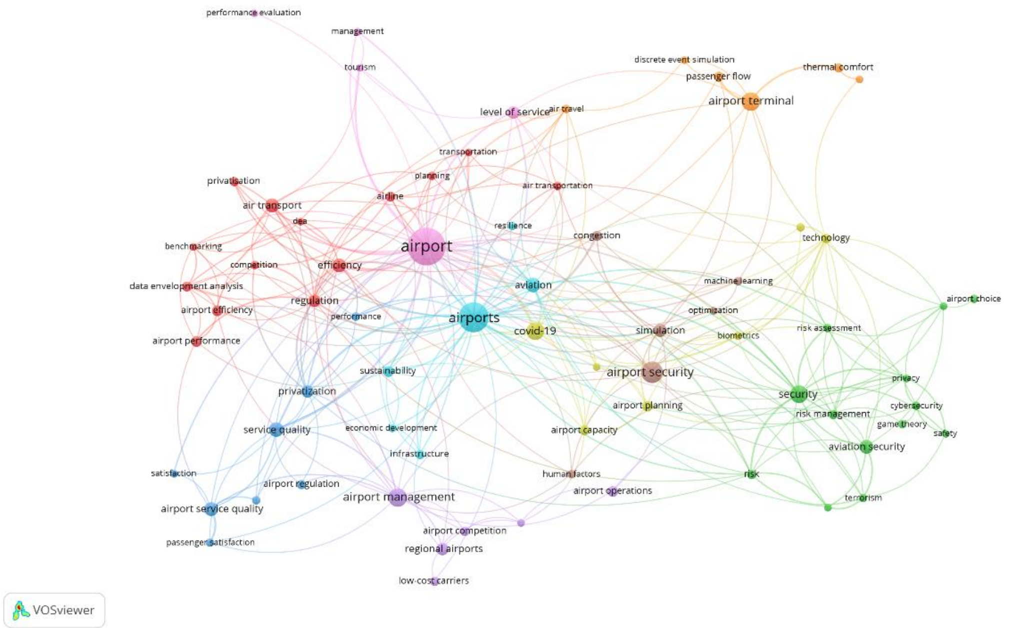

Figure 1. **Conceptual map of the investigated articles**
Source: VOSviewer made by the author

Airport security is an important, up-to-date topic. In this article, the security counters are investigated. The elaborated model also reflects the cognitive attributes of passengers.

2. Data and methods

In this article, the author shows the development of the security counters process. The key indicator is the maximum waiting time for the security process (*Rosenow et al., 2020*). Therefore, the following data had to be gathered about the passengers:

1. Maximum waiting time at security counters: t_{max}
2. Time to process of security check: t_p
3. Number of passengers: PAX
4. Real distribution of passenger's arrivals

From this data, the number of necessary security counters can be obtained. The first step is to compare an ideal distribution of arrivals and the real one over a while.

Table 2. **Comparison between an ideal distribution of arrivals and the real one**

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TIME (min)	0	6	12	18	24	30	36	42	48	54	60
% REAL arrivals	0%	10%	25%	40%	80%	90%	95%	97%	98%	99%	100%
% IDEAL arrivals	0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%

Source: own compilation based on Heathrow. (2024)

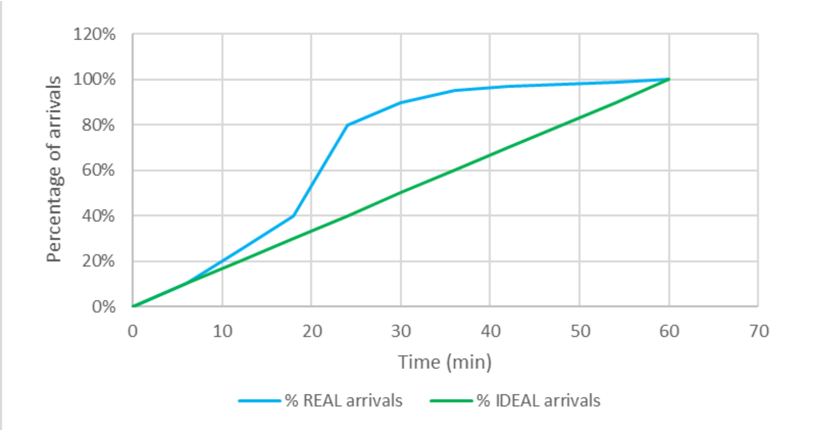

Figure 2. **Graphic comparison between an ideal distribution of arrivals and the real one**
Source: own compilation based on Heathrow. (2024)

There is a capacity problem when the slope of the real arrivals is higher than the slope of the ideal arrivals. This implies that an accumulation of passengers is occurring, and they will have to wait. For example, Figure 2 shows that between minutes 12 and 24, 65% of the total passengers arrive. While between minutes 48 and 60, just 2% of them.

The formulas used for the calculations are:

$$IS = \frac{PAX * tp}{60} \qquad (1)$$

where,

IS is the Initial Score, an initial approximation of the number of counters if the passenger's arrival was ideal,

PAX is the number of passengers,

tp is the time to process.

$$NC = \frac{(\boldsymbol{PAXf - PAXi}) * \boldsymbol{PAX} * \boldsymbol{tp}}{\boldsymbol{tf + ti - tmax}} \qquad (2)$$

where,

PAX_f is the final number of passengers of a certain period where the accumulation happens,

PAX_i is the initial number of passengers of a certain period where the accumulation happens,

PAX is the number of passengers,

t_p is the time to process,

t_f is the final moment where the accumulation ends,

t_i is the initial moment where the accumulation starts,

t_{max} is the maximum waiting time.

The final step will be to calculate the number of counters for each period (*Table 2*):

Table 2. **Counters for each period**

Period (min)	Counters
0–12	14
12–24	30
24–60	6

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** Please note that the dínamics of demand are different; therefore, a flexible number of security counters are open. That is the reason why the dynamics of opening are not equidistant.*

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3. Results and discussion

3.1 Arrivals study

The results for the basic scenario (ideal arrival) and realistic scenario (real arrival) are represented in (Table 1). The average number of counters for this example was 23 counters. However, let us analyse the real arrival distribution: Each period has a t_{max} of 13 min. These 30 counters of the (12–24) period cannot be closed on minute 24 because there are 13 extra minutes of queue and accumulated people.

So, this process concludes that starting with 14 counters will be enough. However, by minute 12, 30 counters should be opened to avoid the formation of an excessive queue. From minute 37, counters can progressively close until six remain open because the accumulation is decreasing.

3.1.1 Arrivals study: Waiting time depending on the type of flight

For this case, three different types of flights were taken into account: European Union and Schengen Area (UE SCH), International Short Range (INT SHRT), and International Long Range (INT LNG). At the same hour, the passengers of these three destinations will arrive with different waiting times.

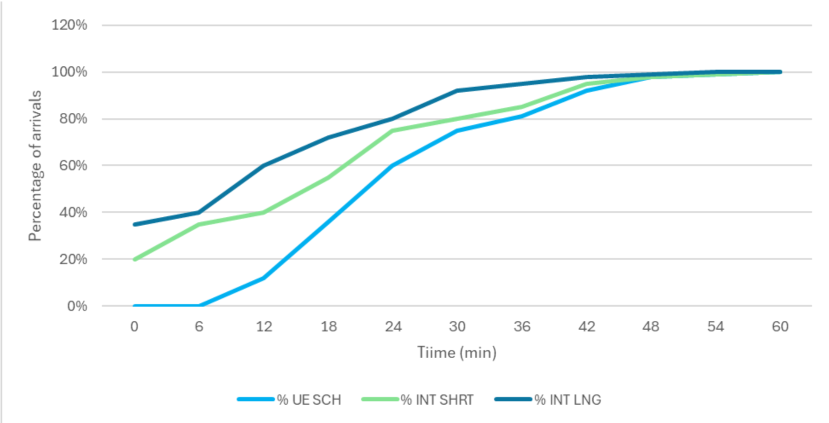

Figure 3. **Comparison of arrivals depending on the type of flight**
Source: own compilation based on NZ Pocket Guide (2024)

As shown in *Figure 3*, there is more waiting time for processing times in the case of International Short Range arrivals compared to the European Union Schengen flights, but the processing time for International Long Range arrivals is significantly higher than for the other categories. This data is representative and will differ depending on the circumstances in every airport.

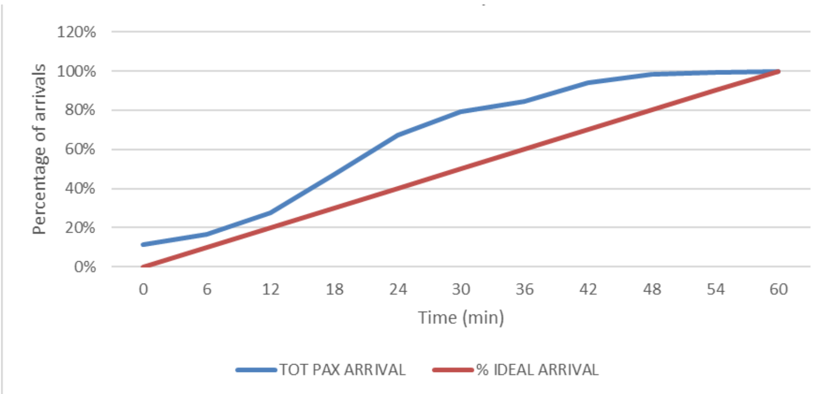

Figure 4. **Graphic comparison between an ideal distribution of arrivals and the real one**

The results were obtained using the following parameters.

- t_{max}: 13 minutes
- t_p: 40 seconds per passenger
- PAX (UE SCH): 2000 passengers
- PAX (INT Short Range): 1000 passengers

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- PAX (INT Long Range): 600 passengers

And the results:

Table 3. **Counters for each period**

Period (min)	Counters
0–6	20
6–30	41
30–60	17

** Please note that the dinamics of demand are different; therefore, a flexible number of security counters are open. That is the reason why the dynamics of opening are not equidistant.*

Due to the necessity of maximising capacity and the following necessity of more counters from minute six, the periods of (0–6) and (30–60) have been calculated for a maximum waiting time of zero ($t_{max} = 0$). That means initially, 20 counters must be opened to avoid a queue. Then, at minutes 6 and 21, more counters must be opened, and the maximum waiting time will be 13 minutes. Again, this number will be reduced to 17 counters for the last half an hour without waiting times. With this $t_{max} = 0$ decision, initial accumulation will be reduced to zero, concentrating the work on the following 24 minutes. Also, the passengers who are more impatient or hurried for the last 30 minutes will pass instantly. The decision to have the maximum number of counters from the beginning (41) is not feasible because most will be unexploited. This is a scenario where there is just one operation hour. In a real airport with a normal distribution of passengers, it will come and go, so these drastic opening and closing decisions should not be made. Now, we will study the case of a complete journey.

3.1.2 Arrivals study: Study of the arrival distribution in peak morning period

Airports are infrastructures that work most of the day, if not 24 hours. Thus, even if correct, the study of only one hour of operation is unrealistic. Figure 5 shows the different arrival distributions from 8 AM to 12 AM every hour. Also, as we have seen in previous examples, the real distribution of the total passengers will be compared to their ideal distribution.

Table 4. **Distribution of arrivals along a day and comparison of real and ideal distribution of arrivals**

TIME (min)	240	225	210	195	180	165	150	135	120	105	90	75	60	45	30	15	0
8 h - 9 h	5%	20%	65%	80%	100%												
9 h - 10 h					0%	35%	70%	85%	100%								
10 h - 11 h									0%	10%	45%	75%	100%				
11 h - 12 h													0%	40%	80%	100%	100%
IDEAL %	0%	6%	13%	19%	25%	31%	38%	44%	50%	56%	63%	69%	75%	81%	88%	94%	100%
REAL %	0,8%	3%	11%	13%	17%	32%	47%	53%	59%	62%	72%	80%	87%	92%	97%	100%	100%

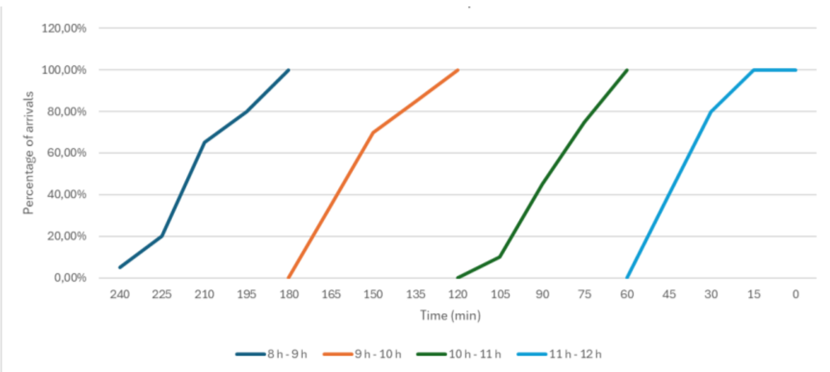

Figure 5. **Distribution of arrivals for each hour of operation**

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Following the previously explained procedure, and with these data:

- t_{max}: 5 minutes
- t_p: 40 seconds per passenger
- PAX (8 AM – 9 AM): 789 passengers
- PAX (9 AM – 10 AM): 2000 passengers
- PAX (10 AM – 11 AM): 1300 passengers
- PAX (11 AM – 12 AM): 600 passengers

The results obtained are:

Table 5. **Counters for each period**

Period (min)	Counters
240–210	2
210–135	10
135–0	5

3.1.3 Arrivals study: Study of the human factor and its consequences on processing times

For this part of the study, I assumed that passengers could have different cognitive attitudes and profiles that we could incorporate into the processing time (*Knol, Sharpanskykh, Janssen, 2019*), following *Table 6*. I focused on factors that influence the capacity of the security process, specifically human factors. Firstly, I divided each passenger profile according to the processing times. With a standard processing time of t_p = 30 s/pax, we will find:

Table 6. **Different processing times depend on the human factor**

Profile of the passenger	Processing time (s/pax)
Standard passenger	30
Passengers that increase the t_p	
First flight	75
Older than 60 years	60
Disabled	120
Passengers that decrease the t_p	
Business passenger	20

Now that every t_p is established, it is necessary to know which percentage of the total each profile of passenger supposes:

Table 7. **Proportion of each kind of passenger**

Human factors	% of the total PAX	Number of PAX
% Standard	48%	1440
% First flight	20%	500
% Older than 60	35%	875
% Disabled	0,4%	10
% Business	7%	175

To continue, it is important to know the distribution of the passengers by cognitive attitude. It is visible how the profile affects the processing times, the waiting time, and the distribution of arrivals.

Table 7. **Distribution of arrivals of every profile of passenger**

TIME (min)	0	6	12	18	24	30	36	42	48	54	60
% Disabled	0%	0%	50%	50%	50%	50%	50%	100%	100%	100%	100%
% First flight	0%	7%	25%	38%	60%	79%	95%	100%	100%	100%	100%
% Older than 60	1%	10%	22%	45%	53%	70%	89%	98%	100%	100%	100%
% Bussiness	0%	0%	4%	9%	16%	20%	37%	67%	85%	99%	100%
% Standard	1%	3%	15%	34%	48%	60%	67%	79%	88%	95%	100%

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In the next figure (Figure 6), Table 7 will be represented graphically. We can appreciate that, while first flight or older passengers seem to act with the same waiting time, business passengers, who are more experienced and usually carry less baggage, come with less waiting time.

This data is representative of creating a functional model. Every distribution of arrivals will depend on many factors and will be different for each airport.

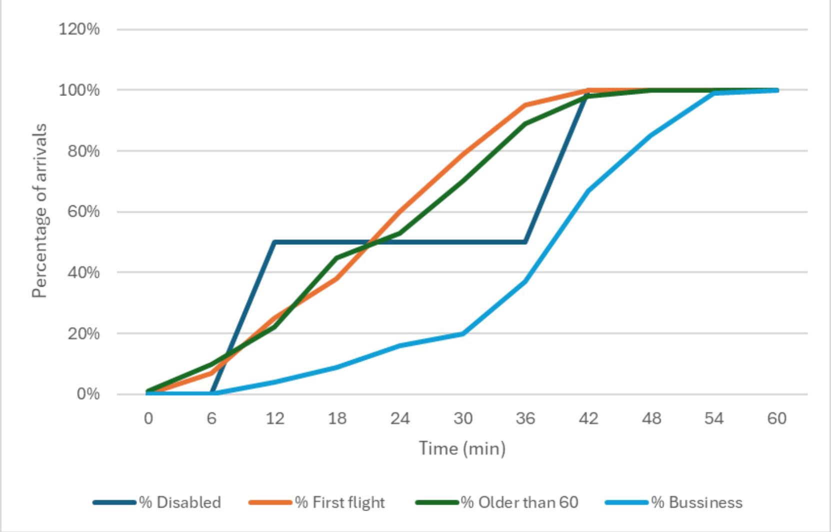

Figure 6. **Different waiting times depending on the cognitive attitude**

The following data was employed for this scenario:

- t_{max}: 10 minutes
- t_p: Table 14. Different processing times depend on the human factor
- PAX (total): 2500 passengers

The number of counters was calculated specifically for each passenger profile:

Table 8. **Number of counters on the period of 6–42 min for every type of passenger**

Human factors	**NC (6, 42)**
Standard	12
First flight	13
Older than 60	17
Disabled	1
Business	1

The number of counters is 43 if the above parameters are used.

This process was repeated for the last period, from minute 42 to 60:

Table 9. **Number of counters for 42–60 min for every type of passenger**

Human factors	**NC (42, 60)**
Standard	6
First flight	0
Older than 60	1
Disabled	0
Business	1

This gives us a total of 7 counters rather than eight because these values are approximations of the real ones, resulting in a final approximation of 7.

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3.2 Study of the new technologies applied in airports

In the following example, the size of the area is studied. The total space dedicated to the counters is taken to be 200 m^2. The area occupied by biometric counters is 3 m^2, and for standard counters: it is 6 m^2.

Table 9 compares the following values:

A) Maximum capacity of the process: where 100% of the counters are biometric, with space for 67 counters, and with the processing time of 30 seconds per passenger, the 8000 passengers processed in an hour.

B) Minimum capacity of the process: where 100 % of the counters are standard, with space for 33 counters, and with a processing time of 60 seconds per passenger, just 2000 passengers can be processed in an hour.

Table 10. **Capacity of the process**

	Number of counters	t_p (min/pax)	Capacity of the process (pax)
Max (all biometric)	67	0.5	8000
Min (all standard)	33	1	2000

In this example, we have 200 m^2 available for the counters. However, putting just biometric or standard counters is unrealistic; some passengers will not be compatible with technology, and the airport may not allow a complete reconstruction of the installations (*Hättenschwiler et al., 2018*). So, *Figure 7* shows the maximum coexistence that can exist in every case and the combination of standard and biometric counters (*Sánchez del Río et al., 2016*). The space relation is simple in this case: two biometric counters for every standard one.

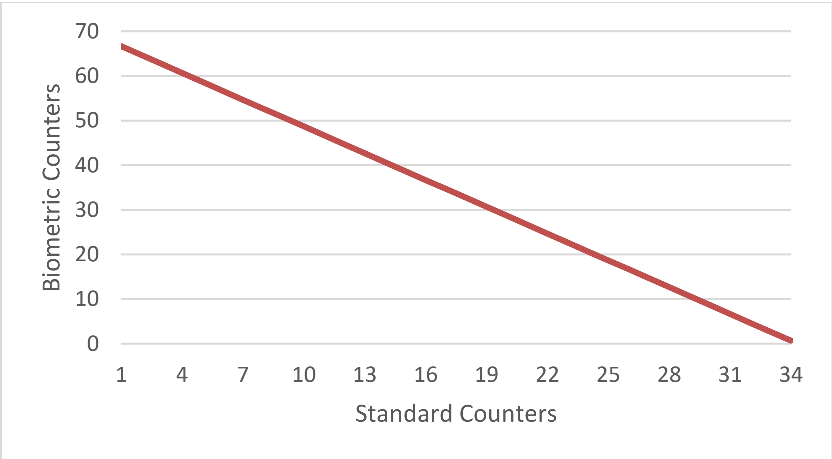

Figure 7. **Counters coexistence relation**

The next step for every combination of counters is calculating the number of passengers that can be processed. Every combination will have a specific number of passengers for biometric and standard counters to ensure maximum economic effectivity (*Kirschenbaum, 2013*).

In a specific case studied, 1800 passengers are compatible with biometric counters and 700 with the standard one:

Table 11. **Counters and areas occupied for the specific case**

	Number of pax	Number of counters	t_p	Area	
Biometric	1800	**15**	0,5	45 m^2	
Standard	700	**12**	1	72 m^2	
	TOT =	**27**		**117 m^2**	**< 200 m^2**

As a result, the optimal numbers of counters were considered a dynamic of arrival, the modification factor of the cognitive attitude, and the existing technologies.

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4. Conclusion

In this article, the aviation industry's security, especially the security counters, was investigated. On the one hand, governments are interested in globalising countries and protecting citizens and visitors when they enter and leave countries. In the aviation industry, however, the security of each process is vital. Aviation is known to be the safest mode of transportation, but accidents due to the possibility of passenger losses are the most criticised and scrutinised. Even if only one accident happens yearly, the impact on the public's eye will be fatal, and the aviation industry will not be the enormous transportation system it is today. In this study, security processes are analysed and studied by simulation. In addition to safety, there are also notable features of air transport, such as the number of passengers entering airports, using aircraft, travelling, working, and using the system daily. The study focuses on optimising processes without compromising safety standards. The main objective was to build a solid framework to optimise the number of security encounters focusing on the dynamic of arrival, the modification factor of the cognitive attitude, and the existing technologies. This paper examined factors such as flight priority, long-haul distribution, human factors, and technology and presented various design and optimisation issues for airport security processing. The study enables readers better to understand the importance of airport logistics and these parameters.

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