Optimizing Process of Airport Passengers Flow. The Case of Madeira International Airport Cristiano Ronaldo

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Abstract

The increased demand for air transportation has enlarged congestion problems in the areas of Passenger Terminals. This study proposes how to optimize the flows of passengers at the airport of Madeira to increase airport efficiency.

There are two specific approaches to achieve this study objective. Firstly, we analyse the flow of passengers at the airport terminal to detect where are the most critical congestion points. Secondly, using simulation software (MassMotion) we analyse different layouts of the airport terminal, including ramp area, considering passengers flows of different typologies, to find the most efficient layout configuration.

This study optimizes the flow of passengers in the terminal area of the International Airport of Madeira, making it more efficient in routing passengers and thus maintaining control over congestion levels. Thus, the proposed configurations for Check-in, Security, Border Control, Boarding Gates, Embark, Disembark, and Luggage Claim areas allow to considerably reduce (or even eliminate) passenger congestion at these critical points.

An airport is a complex transport infrastructure, and therefore any change in its physical structure must be made during its period of operation. Structural modifications must be simulated in software to be validated before being implemented; this was the option of Madeira International Airport, which thus seeks solutions to keep congestion levels under control, increase the efficiency of the terminal, and raise the level of passenger satisfaction.

Keywords

Airport Congestion; Optimizing Passengers Flow; Simulation; MassMotion

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Introduction

Air transport has grown in the last decades at a very fast pace, and the prediction according to a EUROCONTROL study [1] is that it continues to grow.
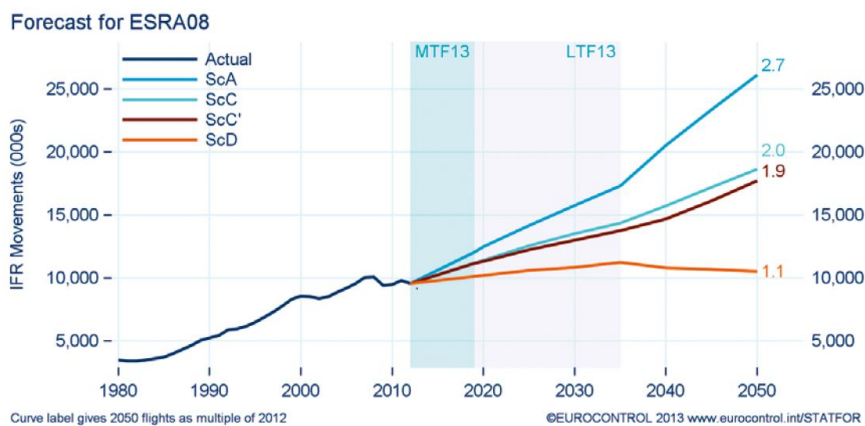

Figure 1 – Prediction of the number of aircraft movements until 2050 [1].

In Figure 1, we can see that according to the most probable scenario, in 2035 there will be approximately 50% more flights than those that currently exist, and the forecast for 2050 indicates that this number will double compared to the current one. Regarding the number of passengers flying, we can see that according to a forecast made by ICAO in 2016 [2], this number will also grow strongly in the coming years.
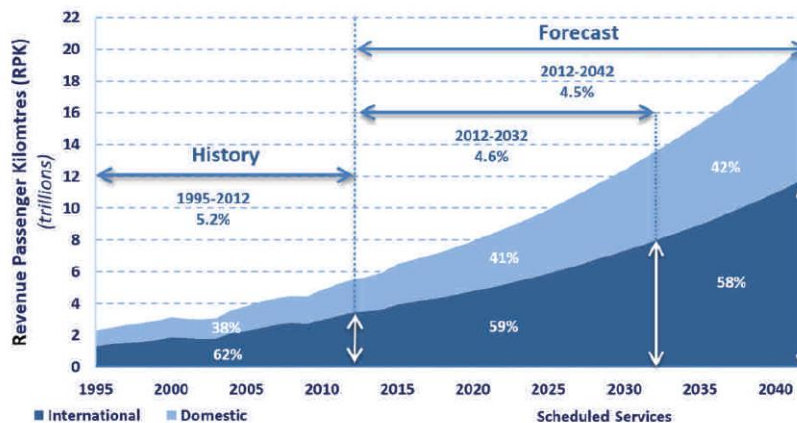

Figure 2 - Total passenger traffic: history and forecasts [2].

Figure 2 shows the expected annual growth rates over the next 20 and 30 years. We can see that in the period from 2012 to 2032 the forecast is that the number of passengers has a growth of 4.6% per year and in the period from 2012 to 2042 this growth is 4.5%.
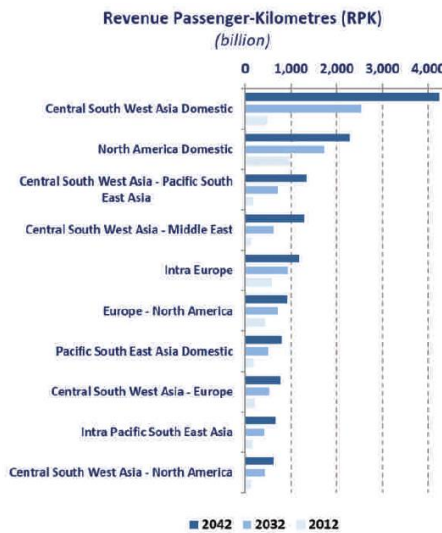
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Figure 3 – World top 10 passenger traffic by route group: 2012 vs. 2032 and 2012 vs. 2042 [2].

Figure 3 shows the 10 main world routes and the growth projection for each one. The biggest growth will be in the Asian continent, more precisely in South Asia, where growth around 10% per year is expected. In Europe, the volume of passengers will also grow, but at a rate of 2.1% per year. However, this growth is not parallel to the increase of the airport capacity, which leads to congestion being a major issue. The EUROCONTROL study [1] estimates that by 2030, 1.9 million flights will not be able to be accommodated. By 2035, within the plans that the airports reported, it is estimated that 120 million passengers will not be able to travel. By 2035, more than 20 airports will be operating at 80% or more of their total capacity, in 2012 they were only 3. This entails delaying the airport which was about 1 minute per flight in 2012, to 5 to 6 minutes in 2035, making it switch from a minor or intermittent problem to a permanent problem in the delay of flights.

To respond to this growth, airports need to act, as more flights will bring more passengers to airports with airports where expansion is very limited; one of the solutions is to increase the efficiency of the airport.

Framework

At Madeira airport, growth follows the world trend, reaching a record of more than 3 million passengers in 2017 [3].
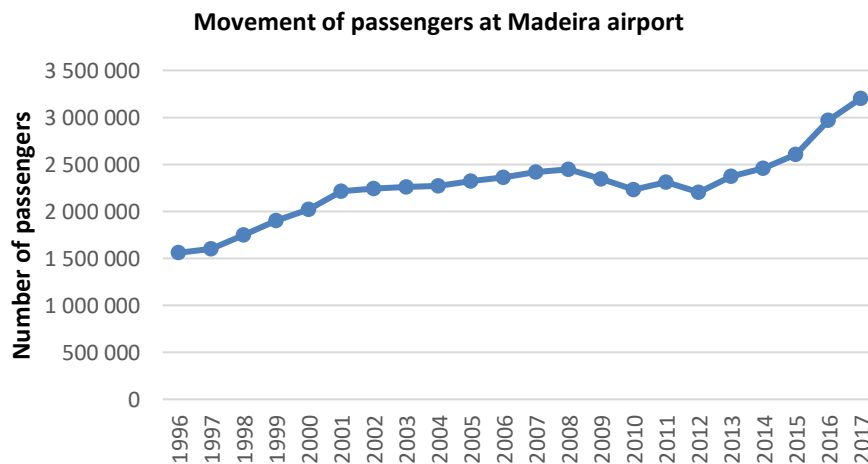

Figure 4 – Movement of passengers at the airport of Madeira between 1996 and 2017. Source: Own elaboration based on [4].

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As we can see in Figure 4, growth in recent years was accentuated, with only a decline between 2008 and 2012, which can be explained by the global crisis that was felt during this period. The growth forecast for Europe by 2042 will be 2.1% each year, which will make the number of passengers by that time double compared to 2012. Figure 5 shows in more detail the growth of European routes by 2032 and 2042.
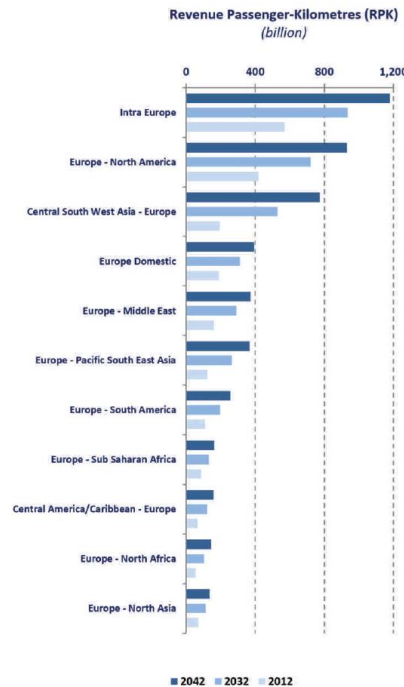

Figure 5 – Europe Passenger traffic forecast: 2012 vs. 2032 and 2012 vs. 2042 [2].

Case study

With the number of passengers increasing at the airport and considering that projections for the coming years will be continuously growing, it will be likely that there will be more congestion at the airport terminal. After observing the normal operation of the airport of Madeira, some points were observed in the terminal where the flow of passengers sometimes tends to congestion. Time measurements were taken where the passenger takes at all distinct phases of their route to the aircraft, as well as the observation of the procedures to which they are subject. In the context of this article, we will show only two of these phases, Check-in and Security, and we will compare the layout used in 2017 with a new layout, the latter with the aim of reducing or even eliminating the congestion observed in the layout of 2017.

Actual configuration

Check-in

Check-in at Madeira Airport is done on floor 1, where some points were found where the flow of passengers is not done smoothly. There are 40 check-in counters available, however, 38 are used to check-in, and two of the counters do not have a belt to dispatch a basement suitcase, so it is not very common to use them. To exemplify and analyse the current situation, we use the crowd simulation software: MassMotion is a very versatile program that shows us how crowds behave in certain spaces. For the cases that we will analyse in this article, we have the second busiest day at the airport in Madeira in the year 2017, which according to IATA should be considered the peak day [5]. A total of 53 flights corresponding to 7886 passengers were inserted into MassMotion, the times used for check-layouts analysed correspond to those used in 2017.
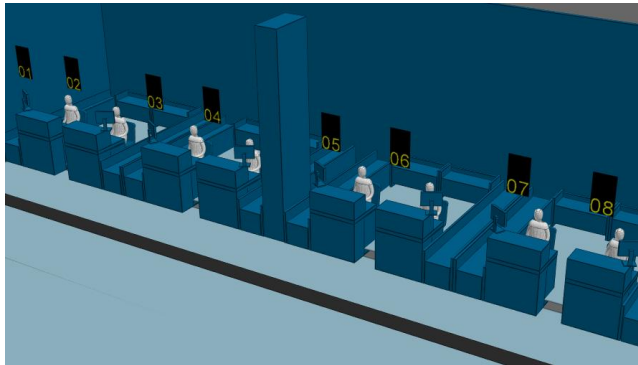
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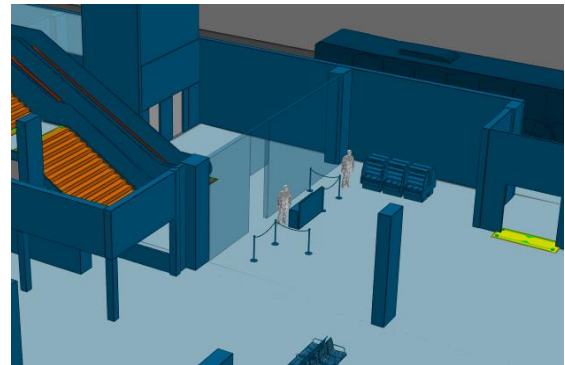Figure 6 – Check-in counters. Source: Own elaboration.

Figure 7 – Entrance to access floor 3. Source: Own elaboration.

In Figure 6 we have an example of what the check-in counters are like. One of the problems with the passenger's arrangement at the check-in is that when more than 2 consecutive counters are used, passengers at the middle counter have some difficulty getting out of the counter toward the access door to floor 3 (Figure 7). This happens because the distance between the passenger who is at the check-in counter and the passenger immediately behind him is short and also the distance between queues are reduced, since the queues are individual at each counter, although it is the same flight, which means that the passenger has to try to arrange a passage between the passengers who are queuing for the check-in. In this configuration what happens is that the passenger immediately behind the passenger who has already checked-in, takes a few more seconds to reach the counter, this is because the passenger in queue is prevented by the passenger who has already checked-in and wants to go to the floor of the access door 3. This problem is represented in Figures 8 and 9, where passengers represented with the grey colour already have checked-in, and the coloured passengers are those who are queuing waiting for their turn to check-in. The different colours represent passengers on different flights.

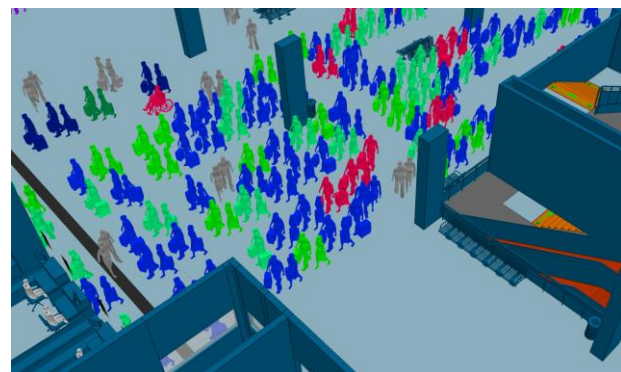Figure 8 - Arrangement of queues at check-in counters. Source: Own elaboration

Figure 9 - Example of queue arrangement and exit of passengers from check-in counters. Source: Own elaboration

In order to analyse how these queues behave and how they are arranged in the terminal, we will use simulation software, MassMotion. With the experienced density map, which is shown in Figure 10, we can see where the passengers were in line until they were answered on the counter. This map is made considering the average density that was measured with the particularity of accenting the peaks of density. The colours shown on the maps represent the IATA level of service the passenger experienced. The scale of 0 to 1 represents the number of people per square meter at a given time.

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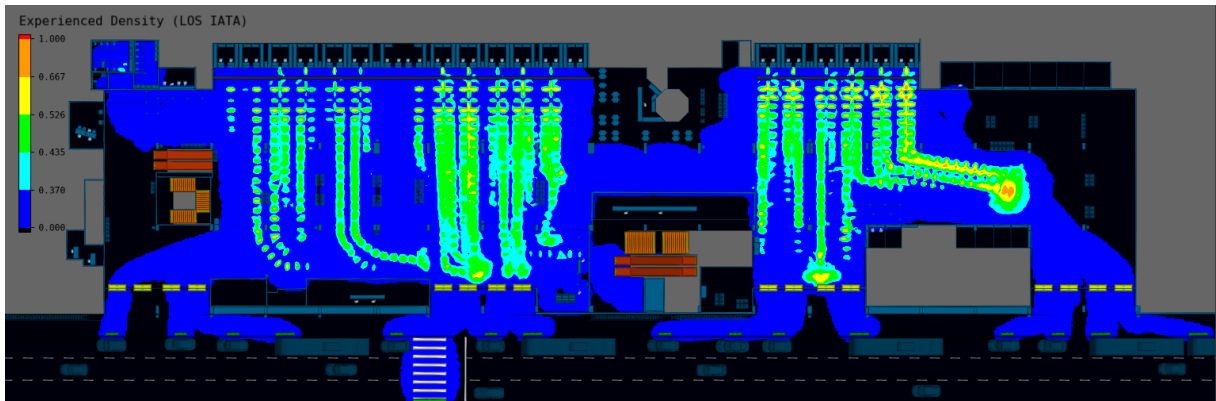
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Figure 10 - Experienced density observed on the 1st floor on the busiest day of the high season. Source: Own elaboration.

In Figure 11 we have the map of maximum density from the arrival of the first passenger until the moment the last passenger climbs to the third floor.
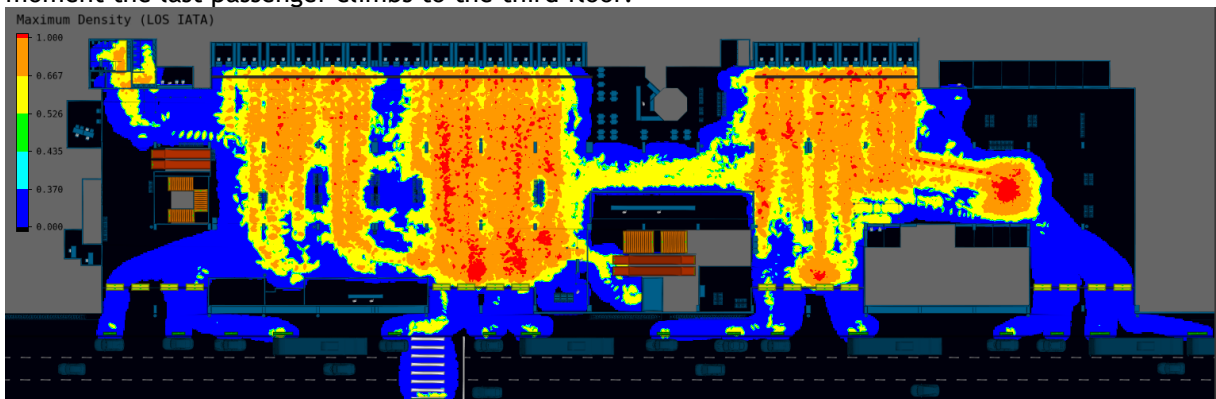

Figure 11 - Maximum density observed on the 1st floor on the busiest day of the high season. Source: Own elaboration.

When analysing the density maps we can see that there are areas where the flow of passengers is not fluid; considering the characteristics of the layout used and the area available for passengers to queue, we find some situations that lead to areas with some congestion. In Figures 12 and 13 we have two examples of congestion. Queues are organized in front of the counters and behave independently of each other; sometimes we have 2 queues of different sizes, depending on the speed of attendance of the employee at the check-in counter. As shown in Figure 12, passengers in purple are making it difficult for passengers to enter the terminal due to the length of the queue. In Figure 13 we have another example where we can see the passengers in line near the entrance doors and obstructing the passage that gives access to the floor 3, so the passengers who already checked-in have some difficulty in going through the access control and sometimes even in finding the access door. This makes the experience less pleasant for the passenger.
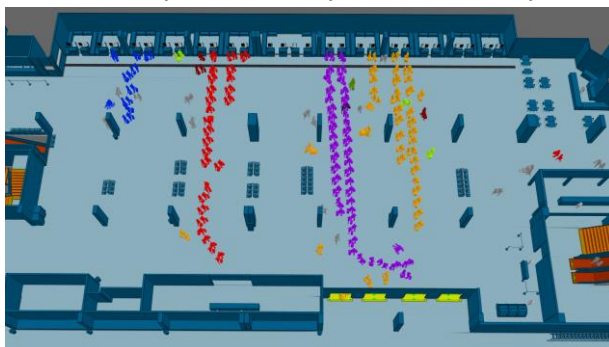

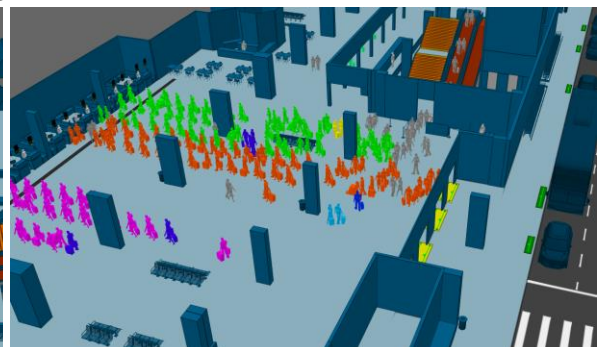Figure 12 - Passenger queues in front of entry doors. Source: Own elaboration.

Figure 13 - Passenger queues in front of the access door to the 3rd floor. Source: Own elaboration.

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Security

The security screening at Madeira Airport is located on floor 3 and is where all passengers with valid boarding ticket should be directed to move to the airside. As is a very sensitive topic, in this article we will approach this theme more loosely. We will essentially analyse the queues until we reach the trace line, where we found some points that can be improved. Tracking line 1 is where passengers with reduced mobility and fast track should go; as it is only a line for these two situations sometimes creates some conflict. We can see exemplified the situation in Figure 14, where we also see how it is waiting time for passengers with an economic ticket. Another case is in access control, in peak hours: this control is done by two agents, as we can see in Figure 15. In this case, two agents are not enough to give discharge to the number of people that are verified at the peak hour.
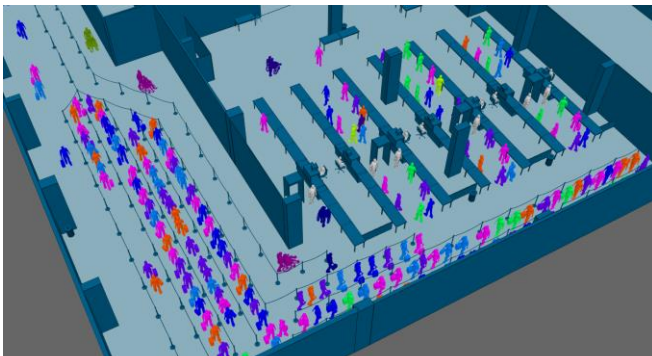

Figure 14 - Waiting queues for security. Source: Own elaboration.

Figure 15 - Access control. Source: Own elaboration.

The current layout is shown in Figure 16. The marked areas represent the different queues, the area where the letter A is marked are for priority passengers, the areas with the letters B and C are for passengers with an economic ticket, zone C is only used when there is a large number of passengers. Row 1 is used only by passengers with reduced mobility, row 2 for passengers with an executive ticket or equivalent and for fast track, finally row 3 is for the remaining passengers.
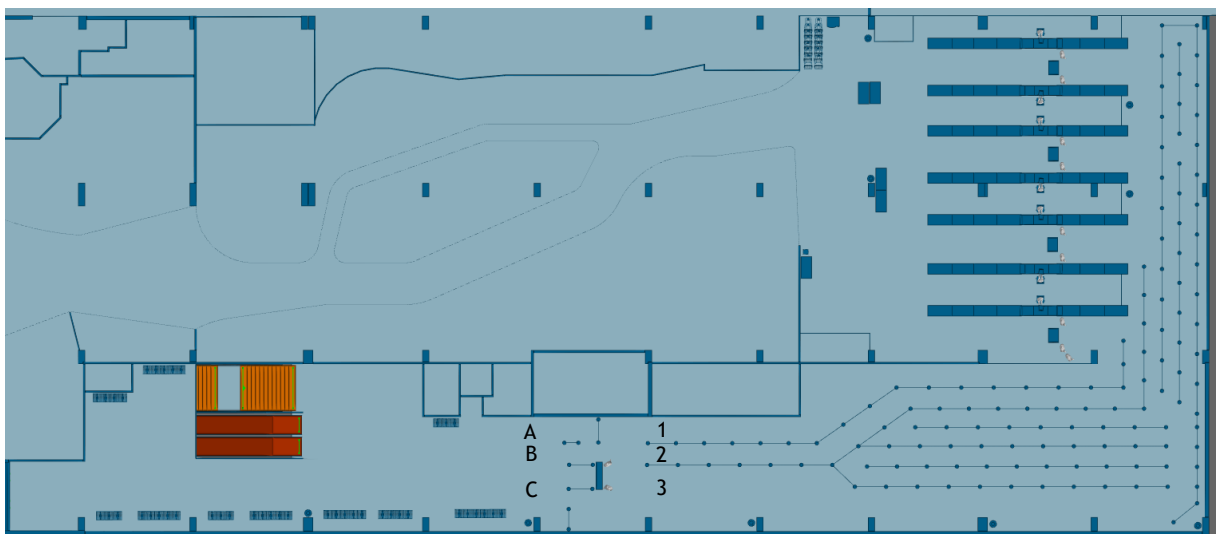

Figure 16 - Current layout of the security zone. Source: Own elaboration.

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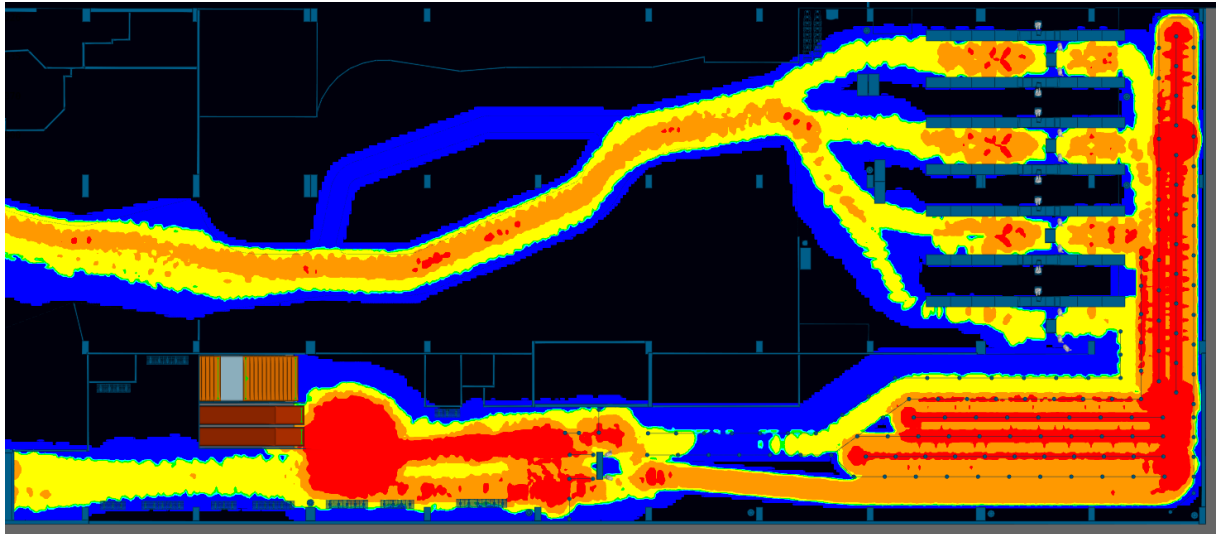To better understand how the current layout behaves we will analyse the maximum density map.

Figure 17 - Density map on floor 3. Source: Own elaboration.

As we can see in Figure 17, we have some congestion in the second access control: the first access control, as we saw at check-in, is done on floor 1, is essentially due to a peak. The layout for the queues is also oversized, according to the level of service recommended by IATA, which is 1 square meter per person [5], so space is not fully harnessed and optimized. In the tracing zone, we also find that it does not comply with the measures recommended by IATA, which is slightly lower than expected [6].

Optimized configuration

Check-in

Considering that the distance between the entrance doors and the check-in counters at the Madeira airport is reduced, some solutions have been found to try to solve this problem. The first change implemented was to retreat all check-in counters 1 meter, as exemplified in Figure 18, to create a check-in zone marked in green, between the pillars, and a movement corridor marked in red, as we can see in Figure 19.
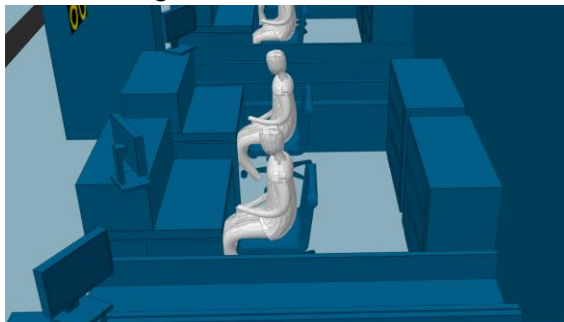

Figure 18 - Change of check-in counters. Source: Own elaboration.
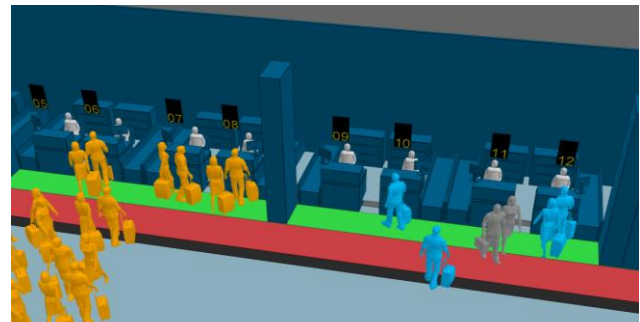

Figure 19 - Check-in area and corridor of movement. Source: Own elaboration.

The next change was in the construction of the layouts: the solution found was to distribute the passengers in parallel queues to the check-in counters, with zig-zag layouts, where they were preferably made within the area marked in green (zone A) in Figure 20. The yellow area (zone B) was only used on days of high affluence.

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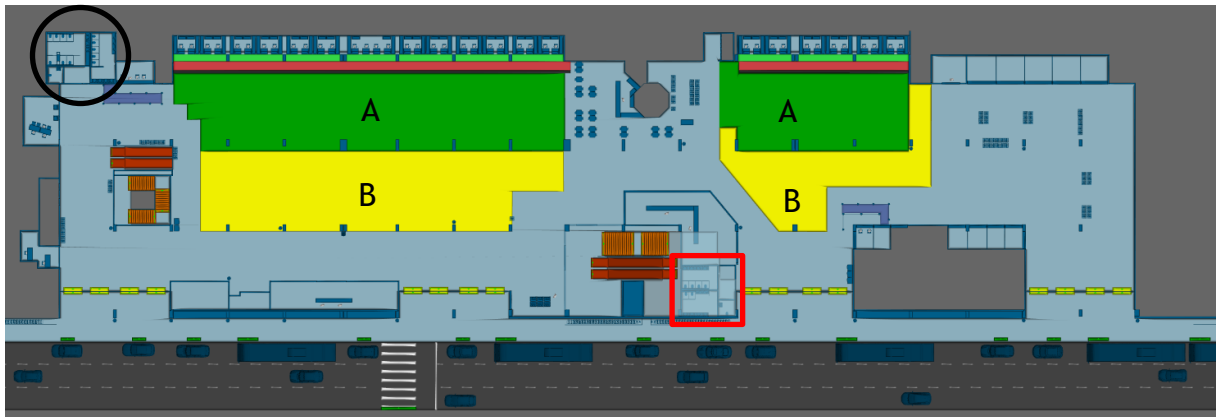
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Figure 20 - Check-in areas. Source: Own elaboration.

The next change concerns the fact that there is only one bathroom on floor 1, which is marked with a black circle in Figure 20. A passenger checking-in on the opposite side of the terminal and having to move to the bathroom will have to go through the entire extension of the terminal and then go back to climb to the third floor. The solution found was to build another bathroom in the central area of the terminal; the location of this bathroom is marked in Figure 20 with a red square.
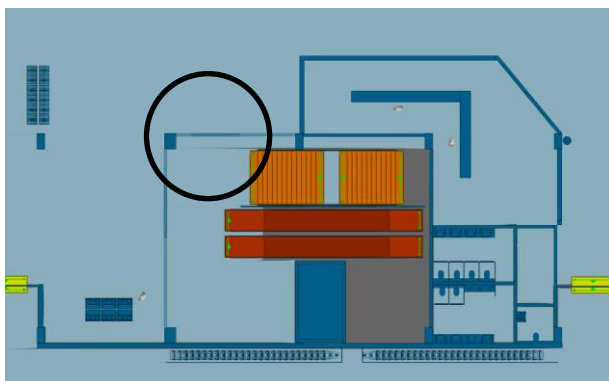

Figure 21 - Detail of the bathroom and access to the 3rd floor. Source: Own elaboration.
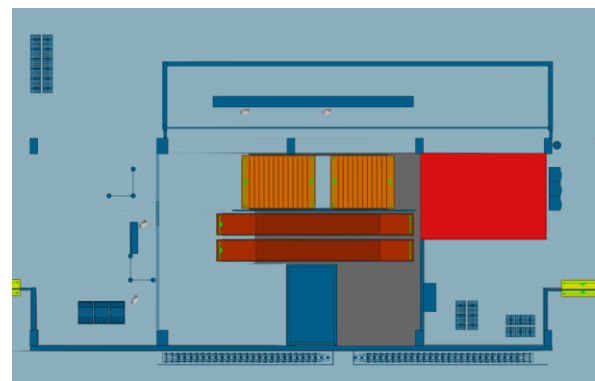

Figure 22 - Current layout of the zone to be changed. Source: Own elaboration.

In Figure 21 we see the bathroom in more detail and also a change in access to floor 3. Comparing with Figure 22 which is the current situation, we noticed that we have another door that is marked with a black circle in Figure 21; at this stage, there will be no preliminary access control for floor 3, since it will be done mainly on floor 3 itself, as it is currently done. For the store shown in Figure 22 to have the same area, it was necessary to close the floor in the area marked by a red filled rectangle in Figure 22, once the floor in that zone is opened.

Layout constructions were previously studied with the help of MassMotion software so that we could get the most efficient possible layout. These simulations considered the number of passengers on each flight so that we can comfortably accommodate all passengers throughout the length of the check-in zone. The counters to be assigned to each flight were also analysed in detail, to be able to assign the counters required by each company, but also to make the layout viable.

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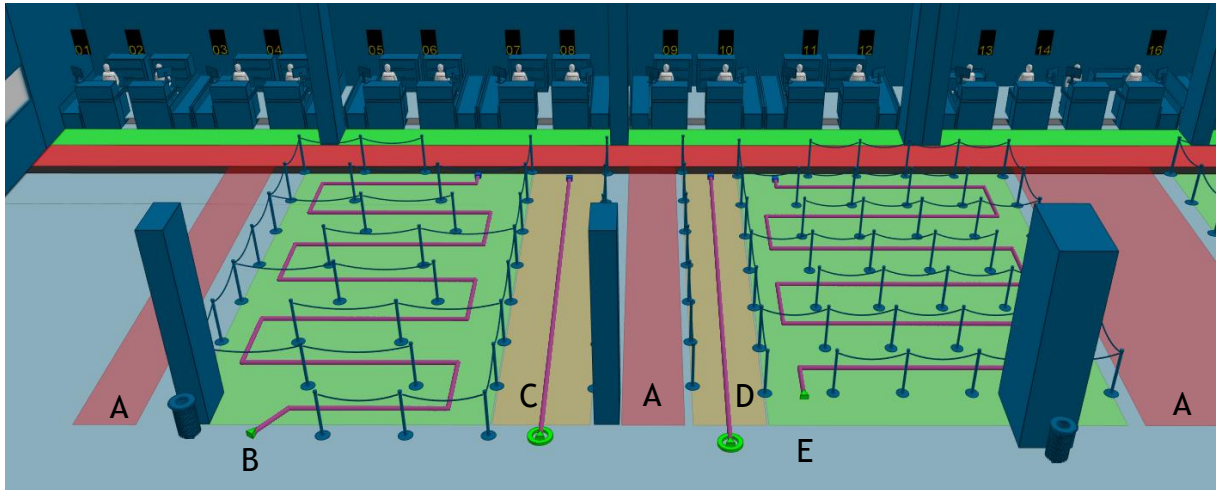
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Figure 23 - New layout example. Source: Own elaboration.

In Figure 23 we also have four distinct single rows, the letters B and E are two single rows of economy class, which occupy the area marked in green, the letters C and D are single rows of business class, executive class and passengers with priority, occupying the area marked in yellow, the letters A represent exit corridors for passengers who have already checked-in and are marked in red. In Figure 24 we have the new layouts used for the same day analysed in the current situation.
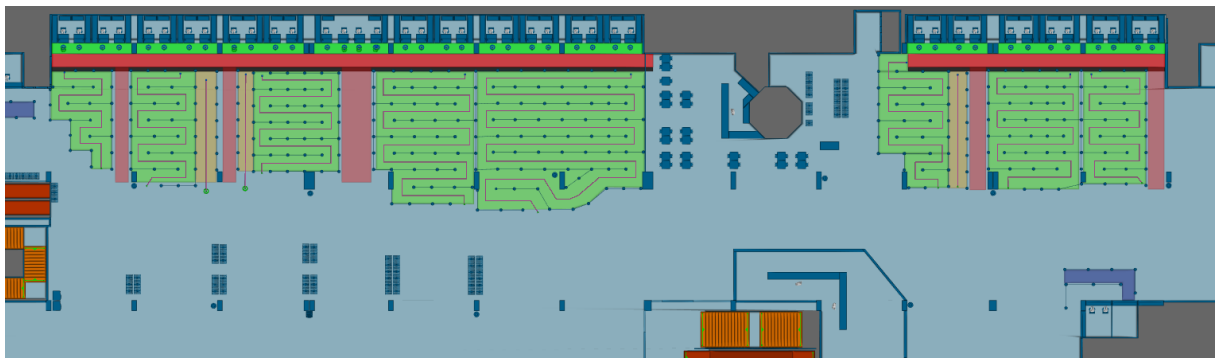

Figure 24 - New layouts for the 2nd busiest day. Source: Own elaboration.
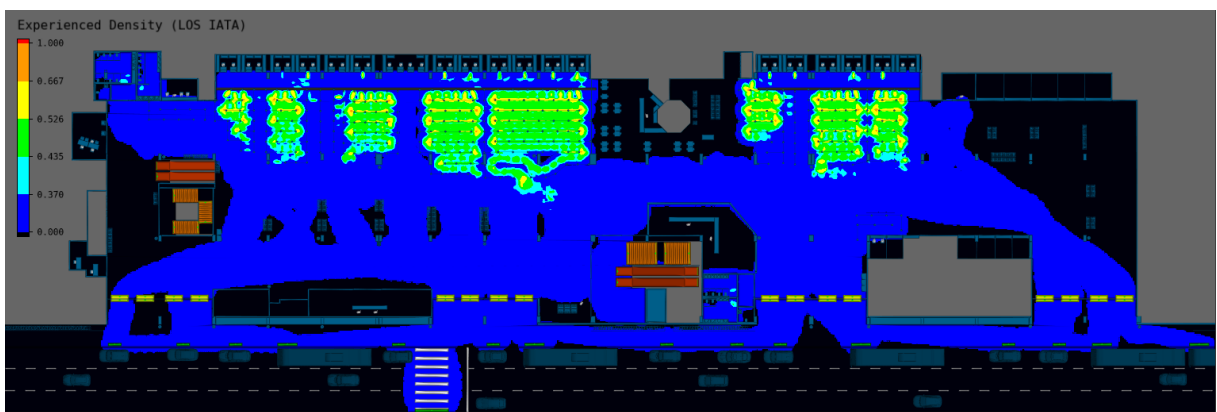

Figure 25 - Experienced density observed on the 1st floor on the busiest day of the high season. Source: Own elaboration.

In Figure 25 we have represented the experienced density map; with this map we were able to observe where the passengers are in queue, as expected: in all the flights it was possible to distribute the passengers so that they remained in the area closest to the counters, the green area (zone A) represented in Figure 20.

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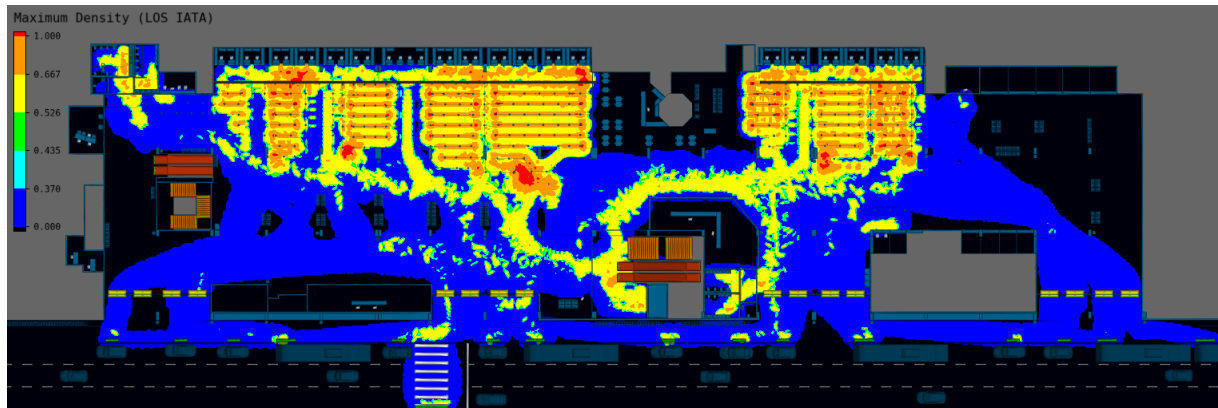
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Figure 26 - Maximum density observed on the 1st floor on the busiest day of the high season. Source: Own elaboration.

In Figure 26 we have represented the maximum density map. As we can see, the areas where the density was the most critical was at the entrance to the layouts. In general, the level of service that the passenger experienced was better than the current layout. The entrance doors and also the access doors to the floor 3 are completely free of queues and also the passageway to the bathroom is completely unobstructed.

Security

On the third floor, the layout shown in Figure 27 was studied to comply with the measures recommended by IATA between the security lines and the level of service.
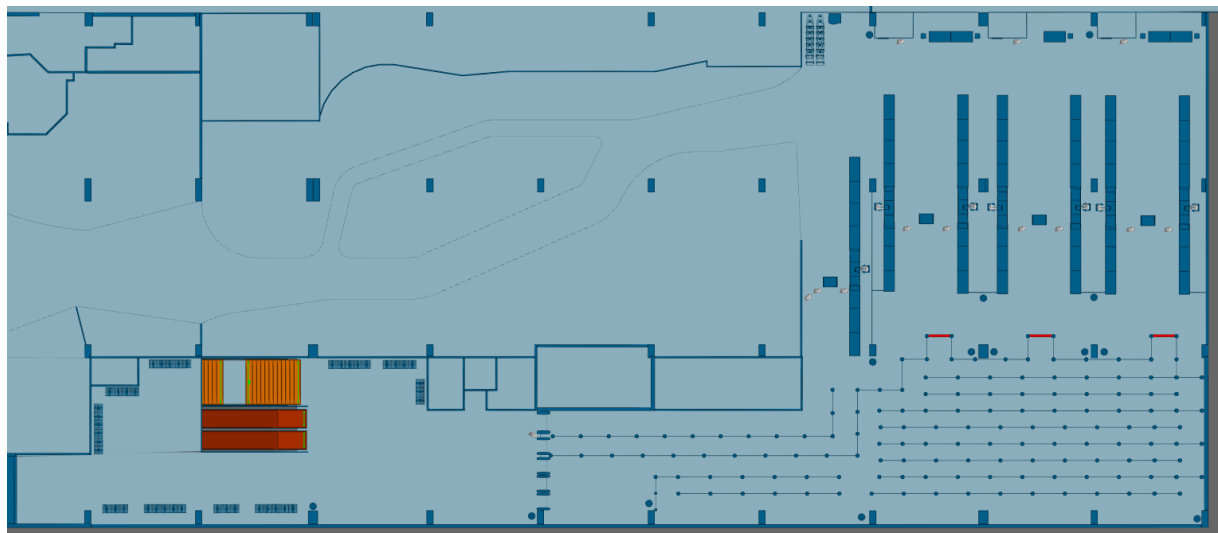

Figure 27 - New layout for security lines and queues. Source: Own elaboration.

In Figure 28 we can see that we have line 1 dedicated to passengers with reduced mobility. When there are no passengers with reduced mobility, passengers with fast track and an executive ticket can use this line; when it is not free, line 2 will be dedicated to these passengers. The remaining passengers use the remaining lines and when lines 1 and 2 are free, they can also use them. In access control, automatic access machines were implemented, 3 for the economy, 1 for fast track and executive, and 1 for passengers with reduced mobility, as we can see in Figure 29.
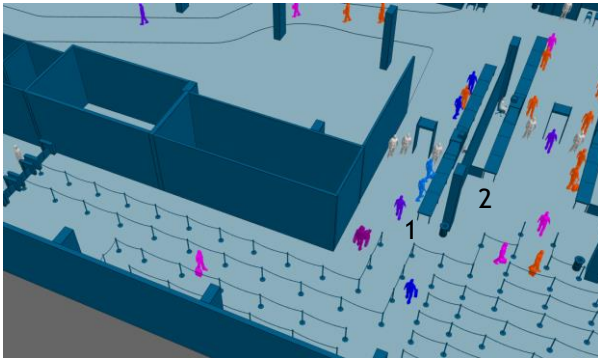
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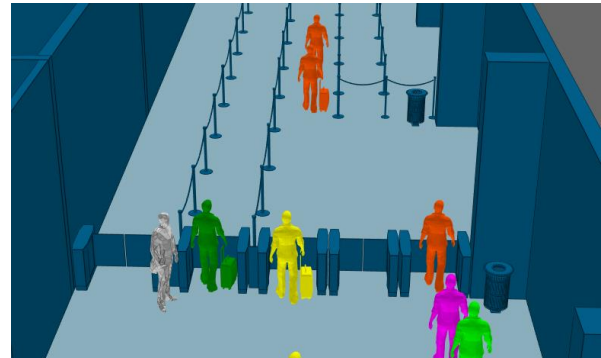Figure 28 - Specific security lines. Source: Own elaboration.

Figure 29 – Automated access machines. Source: Own elaboration.

In Figure 30 we have the maximum density map. We can see that there was a reducing in congestion in the queues for access control. In the queues for security, we have the level of service recommended by IATA, 1 square meter per person [5], which makes the area optimized to the maximum. Also the distance between the security lines has been increased, which has improved the level of service experienced by passengers in this area.

Figure 30 - Density map on floor 3. Source: Own elaboration.
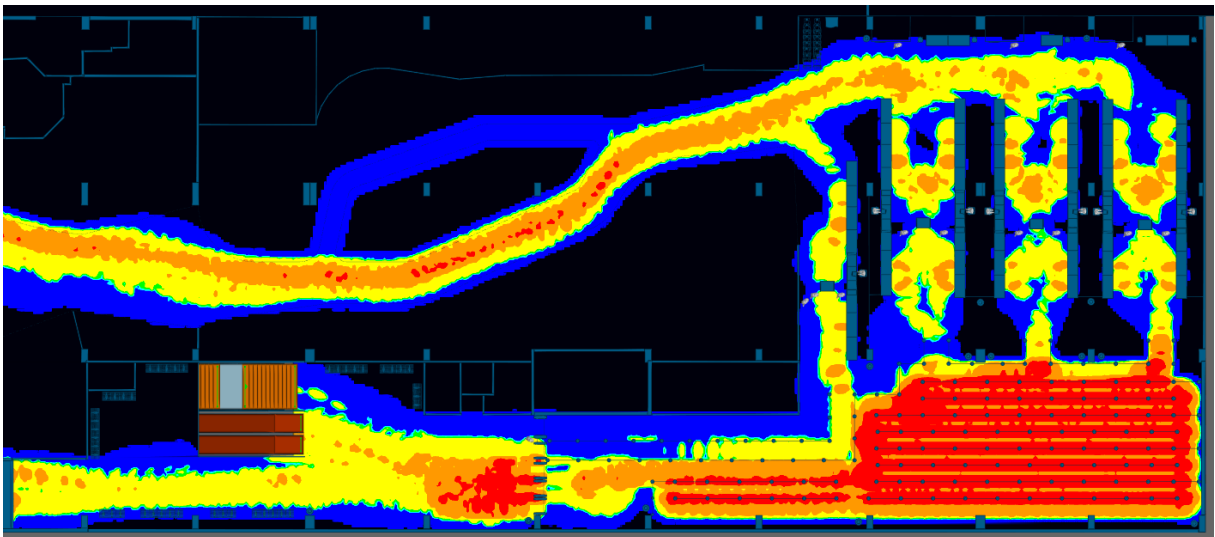
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Conclusions and Future Work

Air transport remains one of the most popular worldwide. Several sectors of air transport will continue to be pressured to accommodate more and more passengers and airports are one of them. In this regard, to solve the problem of airport congestion, it is necessary either to implement restrictive measures to accept passengers or to improve the layout of the premises. This paper analyses the problem of passenger congestion at Madeira Airport, and in two specific areas: Check-in and Security According to the obtained results, we realized that with more detailed planning for the check-in, we were able to make the area more comfortable for the passengers, and a little bit faster. We achieved a 62% reduction in waiting time in a row with the new layout, going from a maximum waiting time of about 49 minutes and 49 seconds to 18 minutes and 40 seconds. This reduction is mainly due to the implementation of a single queue. In the old layout, the queues for the same flight were independent of each other, if one passenger had a problem at check-in, that passenger made the whole queue stand still waiting until the problem was solved. With a single queue, the passengers immediately after that passenger whit the problem, can go to another available counter. Most of the proposed changes do not entail financial costs or imply relatively low costs for the airport, such as the organization of queues. Other changes already involve slightly higher costs, which would imply a cost-benefit analysis by the competent authorities. Regarding security we have a significant improvement, especially in the access queues, with the implementation of automatic machines, the average waiting time in this phase was reduced by 84%, going from 44 seconds in the current layout to only 7 seconds in the new layout and we could achieve a reduction in personnel costs. The improvements in the screening area were mainly in the distances between the lines, considering the measures recommended by IATA, making the passenger experience more comfortable. Regarding the time it takes from access control until the passenger reaches security screening lines, we went from 3 minutes and 29 seconds in the current layout to 2 minutes and 3 seconds in the new layout, which means a reduction of 41%. The proposed layout for the security lines would already involve some more significant changes and therefore would have to be analysed by the competent authorities. This work will extend to all areas at Madeira Airport and, we believe, to all major airports in the country.

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