MODELING AND RESOURCES' OPTIMIZATION FOR PEOPLE PROCESSING IN SECURITY CHECKPOINTS OF BRAZILIAN AIRPORTS

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ABSTRACT

Using the theory of descriptive analysis of scenarios, the research aims to identify procedures, resources and layouts that should improve the screening checkpoints process. It was carried out at three Brazilian airports and was based on testing different configurations, observing the Brazilian regulations in force at the time of the study. These configurations evaluated, among other aspects: a) effects of: (i) making trays available for depositing items, still in the screening throughput; (ii) guidance to passengers on the removal of metallic items from the body to avoid the alarm of the walk-through-metal-detector (WTMD); (iii) the increase in the number of security checkpoints served by the security professional "flow controllers"; b) effects and reactions of passengers in face of pat down without the use of the hand-held metal detectors (HHMD); c) efficiency in allowing the passenger who "alarmed" the WTMD to return, on his own, to remove possible metallic objects that caused the "alarm", instead of being directly searched by the HHMD; d) composition of security checkpoints modules with varying numbers of WTMD, x-rays and professionals; e) reduction in the number of security professionals working in the employee security checkpoints; and f) expansion of the number of security checkpoints supervised by each professional who exercises the role of supervisor. The results were portrayed by: drawing each security checkpoint configuration scenario; the definition of operational processing capacity at the security checkpoints, which includes the evaluation of: the number of passengers who passed through the WTMD, the number of WTMD alarms activated, the number of passengers processed and the number of manual search carried out; and analysis of each established configuration efficiency.

Keywords: Security checkpoint configuration, Configuration, Modeling, Passenger processing; People processing.

1. INTRODUCTION

The security checkpoint is a component of the airport system that constitutes a crucial security point, being a contributory element of one of the national security levels, with international impact, depending on the nature of the airport operation. According to Tamasi & Demichela (2011), Aviation Security - AVSEC is not only a responsibility of the civil aviation industry, but it is also a matter of national security.

Regarding the analysis of the elements that make up the security checkpoint, Yoo, & Choi (2006) sought to explore factors and elements related to the security checkpoint that need improvement to increase the possibility of detecting prohibited items during the passenger screening process.

The effectiveness increase of a security control performance was also associated with the increase in the sensitivity of the WTMD and, after the adoption of this measure, the increase in the frequency of additional security measures, in addition to the selection of AVSEC professionals and the establishment of frequency of manual search (SKORUPSKI & UCHROŃSKI, 2016).

For the reasons set out above, the security checkpoint should be seen as one of the components that integrate the airport system and not as a specific system. Therefore, it must be structured and located so as not to hinder the flow of passengers at the airport and to facilitate the processing of users to air transport.

For Turner (2008), the use of scenarios makes the organization think systematically and strategically about the variety of potential results, without the influence of its own biases, opinions and prejudices. For this author, scenario planning allows the organization to reflect and rehearse several possible futures and avoid complacency or fear of changing a favorable present situation. This study is far from exhaustive the exploratory analysis of the possible configurations and compositions of security checkpoints at airports but represents a regulatory and operational advance in a strict sense.

This advance, as highlighted by Askew (2004), is fundamental and can make a difference to AVSEC and the performance of a security checkpoint. For the author, the review and changes, whenever necessary, in processes and procedures, as well as the implementation of principles relating to the search for high-tech and precise security equipment and the adequate design of a security checkpoint is essential to achieve the state of the art in aviation security.

In a study on the factors that influence airport security performance, Yoo (2009) highlighted that quality of service is one of the most important factors in the air transport industry and that security controls, which are also exercised in security checkpoints, are closely related to the perception of this quality by users of this mode.

Thus, the objective of this article is to identify configurations for security checkpoints capable to attend different operational realities of Brazilian airports and to increase the application of procedures, resources and layouts used in the security screening process.

2. METHOD

The initial proposal for data collection involved only one airport (Airport 1 – Arpt 1). However, during the execution of the search, it was verified the need for a broader sampling with varied profiles of airports for the intended evaluations. In this sense, other two airports were included in the research universe (Airports 2 and 3 – Arpt 2 and Arpt 3), all airports operated by the same airport operator during the study.

It is noteworthy that the choice of the selected airports considered the following aspects: availability of representatives of the aerodrome operators, proximity to the National Civil Aviation Agency – Brazil (ANAC) unit, availability of human resources, as well as the limited period for carrying out the study.

In total, 9,575 (nine thousand five hundred and seventy-five) passenger and employee screening procedures that went through the security checkpoints during the studies were evaluated at the three airports.

The research was initially structured with different modulations of passenger and employee security checkpoints. Furthermore, these modulations evaluated, among other aspects: (i) the effects of making trays available for passenger depositing items while still in the screening queue; (ii) effects of guidance to passengers on the removal of metallic items from the body, in order to avoid the alarm of walk-

through (WTMD); (iii) effects of the increase in the number of screening modules attended by professional “flow controllers”; (iv) passengers' effects and reactions to the manual search without the use of a handheld metal detectors (HHMD); (v) efficiency in allowing the passenger who “alarmed” the WTMD to return, on his own, to remove possible metallic objects that may have caused the “alarm”, instead of being subjected directly to the search with the HHMD; (vi) composition of security modules with varying numbers of WTMD, X-ray equipment and professionals; (vii) reduction in the number of professionals working in employee security checkpoints; and (viii) increase the number of security checkpoints supervised by each professional.

3. RESULTS

The scenarios presented were not analyzed at all airports, especially considering the results of the analyzes carried out at the first airport. Furthermore, throughout the study, new scenarios were identified to be analyzed, so some of them were not analyzed at the first airport. In this sense, it is also highlighted that, despite being indicated sequentially, the scenarios were not necessarily analyzed in the order presented, so that, for each analysis carried out, the airports where they were analyzed are indicated.

3.1 Analysis 1 – Passenger security checkpoint module without trays and without passenger guidance

The analysis was carried out at Airport 1 and Airport 2 (in two modules, indicated by the average result - Arpt 2 Avg.). In this analysis, the operational processing capacity of the passenger security checkpoint module was quantitatively verified, in a normal situation, respecting the provisions of ANAC Resolution nº 207 (ANAC, 2011) and IAC 107-1004A (DAC, 2005), without guidance to the passenger and without the availability of trays in the passenger formation area queue, so that the passenger could deposit the metallic objects. Table 1 presents the results obtained for the analysis.

Table 1 – Results – Analysis 1

	Arpt 1	**Arpt 2** Avg.	**Avg.**	**SD**
People through WTMD	191	209.5	203	10
WTMD Alarms	19	19	19	1
People processed	172	190.5	184	10
Manual searches	0	0	0	0

It is possible to conclude that there are no significant discrepancies (standard deviation - SD) between the number of passengers processed at different airports and checkpoint modules, with an average (avg. people processed) processing capacity of 184 passengers/hour in the domestic security checkpoint.

3.2 Analysis 2 – Passenger security checkpoint module with trays and without passenger guidance

The analysis was also carried out at Airports 1 and 2 (in two modules). In this analysis, the operational processing capacity of the passenger security checkpoint module was quantitatively verified, in a normal situation, respecting the provisions of ANAC Resolution nº 207 (ANAC, 2011) and IAC 107-1004A (DAC, 2005), with the provision of trays in the queue formation area, but without instructions for the passenger to place the metallic objects on it. Table 2 presents the results obtained for the analysis.

Table 2 – Results – Analysis 2

	Arpt 1	**Arpt 2** Avg.	**Avg.**	**SD**	**Dif. 1 and 2**
People through WTMD	187	201.5	197	11	6
WTMD Alarms	13	23	20	6	1
People processed	174	178.5	177	8	-4%
Manual searches	1	0	0	0,6	0

It is possible to conclude that there are no significant discrepancies between the number of passengers processed at different airports and checkpoint modules, with an average processing capacity of 177 passengers/hour. There is no gain in passenger processing efficiency when trays are made available for depositing metal objects in the queue formation area, with there even being a 4% reduction in the evaluations made, comparing the difference between analysis 1 and 2 (Dif. 1 and 2).

Even though the trays were available, it was found that most passengers did not use them to

arrange their metal objects. This fact may reflect the passenger's lack of knowledge about the purpose of the tray provided in the queue formation area.

3.3 Analysis 3 – Passenger security checkpoint module with trays and without passenger guidance

The analysis was also carried out at Airports 1 and 2 (in two modules). In this analysis, the operational processing capacity of the passenger security checkpoint module was quantitatively verified, in a normal situation, respecting the provisions of ANAC Resolution nº 207 (ANAC, 2011) and IAC 107-1004A (DAC, 2005), with the provision of trays and an advisor (APAC - civil aviation protection officer - with the function of guiding passengers) in the queue formation area so that the passenger could remove the metallic objects and place them on the tray. Table 3 presents the results obtained for the analysis.

Table 3 – Results – Analysis 3

	Arpt 1	**Arpt 2** Avg.	**Avg.**	**Dif. 3 and 2**
People through WTMD	222	254	243	43
WTMD Alarms	19	23.5	20	0
People processed	205	232	223	21%
Manual searches	0	0	0	0

It is possible to conclude that there is a discrepancy of approximately 12% between the processing of the two airports, and, on average, the processing capacity was 223 passengers/hour. There was a 21% efficiency gain in passenger processing capacity when trays are made available in the queue and there is a person instructing the passenger to remove metal objects from their bodies and place them on the tray or in their backpacks.

3.4 Analysis 4 – Passenger security checkpoint module without a flow controller per module

The analysis was carried out at Airport 1 (in two modules). In this analysis, the operational processing capacity of the passenger security checkpoint module was verified, quantitatively and qualitatively, using a flow controller at the beginning of the queue, so that it could serve two inspection modules. Table 4 presents the results obtained for the analysis.

Table 4 – Results – Analysis 4

	Arpt 1 Avg.	**Avg.**	**Dif. 6 and 4**
People through WTMD	175	175	105
WTMD Alarms	26	26	6
People processed	149	149	-42%
Manual searches	0.5	1	1

For this analysis, trays and OPI (pre-inspection guide) were used in the queue formation area, so the analysis in question represents an increase in relation to Analysis 3. Art. 3rd, IV of ANAC Resolution nº 207/2011 (ANAC, 2011) was not applied, considering the good results verified in Analysis 6, presented below.

It was found that the efficiency in passenger processing is greatly reduced when there is no flow controller next to the x-ray, losing efficiency of 42%, when compared to Analysis 6.

In addition to the low efficiency, the checkpoint module team reported:

- the passenger is lost in the module without knowing exactly how to proceed;
- the x-ray operator often had to stop his activity, as suitcases get stuck in the x-ray entrance due to poor placement of the luggage on the conveyor belt, which causes a loss of concentration for the x-ray operator;
- visualization of the luggage through x-ray is difficult due to the inadequate positioning of the luggage on the conveyor belt;
- when an agent has to be absent to carry out a manual search, for example, it creates turmoil, given the lack of an APAC to guide and control the flow of passengers through the gantry.
- difficulty in controlling the flow and at the same time correctly positioning the luggage on the x-ray conveyor of the two security checkpoint modules.

For the reasons explained, as well as the results, this evaluation was not carried out at Airports 2 and 3.

3.5 Analysis 5 – Passenger security checkpoint module with direct manual search without using HHMD

The purpose of this analysis was to verify the operational processing capacity of the passenger security checkpoint module, carrying out a manual search on the carpet, after triggering the WTMD alarm, without applying the HHMD, when consented by the passenger.

Considering the low number of passengers with unresolved alarms, especially due to the non-application of Art. 3rd, IV of ANAC Resolution nº 207/2011 (ANAC, 2011), the assessment was remodeled, so that passengers who had their luggage submitted to manual search were also manual searched on the security checkpoint module mat, with the passenger's consent. The analysis was carried out at Airports 1 (international security checkpoint) and 2 (in two modules). Table 5 presents the results obtained for the analysis.

Table 5 – Results – Analysis 5

	Arpt 1 Int	**Arpt 2** Avg.	**Avg.**	**Dif. 5 and 3**
People through WTMD	261	198.5	219	-24
WTMD Alarms	7	17	14	-6
People processed	254	181.5	206	-8%
Manual searches	12	6.5	12	12

There was a considerable difference (29%) in the number of passengers processed at Airport 1 compared to Airport 2. Furthermore, it was observed that a greater number of passengers were subjected to manual search of hand luggage and, consequently, to personal manual search, at Airport 1, compared to Airport 2. These results are different from the results verified in Analysis 3, in which a greater number of passengers processed in Airport 2 was observed compared to Airport 1. It is also noteworthy that the present analysis, carried out at Airport 1, was carried out in an international security checkpoint, that is subject to specific rules related to screening, especially considering the transport of liquids (rule in force at the time: Resolution ANAC nº 207/2011 – ANAC, 2011).

In an interview with passengers, regarding the location of the manual search, at Airport 2, 85% of passengers stated that they preferred to be manual searched outside the reserved room and only 15% felt embarrassed about being manual searched on the screening mat; at Airport 1, 8% of passengers declared themselves embarrassed by the manual search procedure on the screening mat and 92% were in favor of a manual search outside the reserved area.

When changing the screening procedure applied in this analysis, an 8% reduction in processing capacity was found, taking as a basis the module of Analysis 3 – Passenger security checkpoint module with trays and guidance, which, based on the results of the present study, it began to be considered as a standard module. In this sense, innovation stands out in relation to the regulations previously in force, so that a contribution to Brazilian civil aviation is observed, considering the identification of reliable and already tested alternatives.

3.6 Analysis 6 – Passenger security checkpoint module with non-application of Art. 3rd, IV of ANAC Resolution nº 207/2011

In this analysis, the operational processing capacity of the passenger security checkpoint module was quantitatively verified, without applying Art. 3rd, IV of ANAC Resolution nº 207/2011 (ANAC, 2011), that is, when the passenger passes through the WTMD and it is activated, and such passenger is not directly subjected to screening with a HHMD, having the possibility of returning to the WTMD to remove the objects causing the alarm. Furthermore, the analysis in question included the availability of trays and an advisor (APAC with the function of guiding passengers) in the queue formation area, so that the analysis in question represents an increase in relation to Analysis 3. Furthermore, the analysis in question was carried out at Airports 1 (in two modules) and 2 (in two modules). Table 6 presents the results obtained for the analysis.

Table 6 – Results – Analysis 6

	Arpt 1 Avg.	**Arpt 2** Avg.	**Avg.**	**Dif. 6 and 3**
People through WTMD	255	304.5	280	37
WTMD Alarms	17.5	27	20	0
People processed	237.5	277.5	258	16%
Manual searches	1	0	0,5	0,5

There is a discrepancy of approximately 17% between the processing of different airports

(Airport 2 had greater processing, as observed in Analysis 3), and, on the general average, they have a processing capacity of 258 passengers/hour.

It is possible to conclude that there is an average efficiency gain of 16% in passenger processing capacity when allowing the passenger to return to the WTMD without subjecting the passenger directly to search with DMM.

At Airport 2, it was found that, considering the average alarm level of the WTMD, 66% of passengers returned to the WTMD on their own, before the APAC approached to carry out the search with HHMD.

Analysis 6 was also applied at Airport 3. In the study at Airport 3, there was no availability of trays or OPI in the queue formation area and for this reason the comparative analyzes between applying or not article 3rd, IV of Resolution nº 207/2011 (ANAC, 2011), were carried out separately from the analyses for Airports 1 and 2. Table 7 presents the results obtained for the analysis carried out at Airport 3, with the application of article 3rd, IV of Res. 207 (ANAC, 2011) (Arpt 3 – 01), and without the application of the item (Arpt 3 – 02). The analyses were carried out at the same time in different modules, considering the application and non-application of the mentioned article.

Table 7 – Results – Analysis 6 – Arpt 3

	Arpt 3 01	**Arpt 3** 02	**Dif. 01 and 02**
People through WTMD	222	227	5
WTMD Alarms	38	15	-23
People processed	184	211	13%
Manual searches	1	0	-1

At Airport 3, the period with a minimum of 170 passengers per security checkpoint module were selected for comparison, for a continuous flow assessment to enable comparison. At Airport 3 there was an average efficiency gain (13%), comparing the application and non-application of art. 3rd, IV of Res. nº 207/2011 (ANAC, 2011), a value close to that one found at Airports 1 and 2, 16%.

It is also verified that the number of WTMD's alarms reduced considerably from 38 to 15, which may have been caused by a behavioral factor of the passenger who waited in line and observed the removal of metallic objects by the passenger who was being screened by WTMD, a factor not noticed by the passenger, when applying art. 3rd, IV of Res. nº 207/2011 (ANAC, 2011). In the case of Airports 1 and 2, it is believed that this difference did not exist, because the passenger was being guided by the OPI in both Analysis 3 and 6.

3.7 Analysis 7 – Passenger security checkpoint module with 2 WTMD and 1 x-ray

In this analysis, the operational processing capacity of the passenger security checkpoint module was quantitatively verified, using 2 WTMD, 1 x-ray and 5 APAC. Furthermore, the analysis included the availability of trays and an advisor (APAC with the function of guiding passengers) in the queue formation area and was carried out without the application of art. 3rd, IV of Res. nº 207/2011 (ANAC, 2011), so that the analysis represents an increase in relation to Analysis 6. Analysis 7 was carried out at Airport 1 and Table 8 presents the results obtained for the analysis.

Table 8 – Results – Analysis 7

	Arpt 1	**Dif. 7 and 3**
People through WTMD	173	70
WTMD Alarms	16	4
People processed	157	-42%
Manual searches	0	0

In this analysis, there was a reduction in processing capacity of 42%, demonstrating that the most impactful part of the screening process is related to the processing of hand luggage and not the passenger itself. Analysis 8 confirms this hypothesis, given that the use of 2 x-rays and 1 WTMD increased the process efficiency by 47%.

Due to the low performance demonstrated for this assessment at Airport 1, it was not carried out in the other airports.

3.8 Analysis 8 – Passenger security checkpoint module with 1 WTMD and 2 x-rays

In this analysis, the operational processing capacity of the passenger security checkpoint module was quantitatively verified, using 1 WTMD, 2 x-rays and 06 APAC. Furthermore, the analysis included the availability of trays and an advisor (APAC with the function of guiding passengers) in the queue formation area and was carried out without the application of art. 3rd, IV of Res. nº 207/2011 (ANAC, 2011), so this analysis represents an increase in relation to

Analysis 6. Furthermore, the analysis in question was carried out at Airports 1 and 2. Table 9 presents the results obtained for the analysis.

Table 9 – Results – Analysis 8

	Arpt 1	Arpt 2	Avg.	Dif. 8 and 3
People through WTMD	468	474	471	228
WTMD Alarms	60	40	50	30
People processed	408	434	421	88,7%
Manual searches	0	0	1	1

This analysis showed an increase in the indirect processing capacity of 88.7% of the security checkpoint module and a real gain of 25% in passenger processing, considering the proportionality of processing by APAC.

Furthermore, compared to two standard modules, this type of configuration for the security checkpoint module represents a 15.4% reduction in labor employment, as well as a reduction in the number of equipment required (1 HHMD and 1 WTMD) and, also, the reduction of physical space required to install screening equipment.

3.9 Analysis 9 – Passenger security checkpoint module with 2 WTMD and 2 x-rays

In this analysis, the operational processing capacity of the passenger security checkpoint module was quantitatively verified using two standard security checkpoint modules, allowing mutual assistance between teams. Furthermore, this analysis included the availability of trays and an advisor (APAC with the function of guiding passengers) in the queue formation area and was carried out without the application of art. 3rd, IV of Res. nº 207/2011 (ANAC, 2011), so that the analysis in question represents an increase in relation to Analysis 6. Furthermore, the analysis in question was carried out only at Airport 1, given the limited time available to carry out the study. Table 10 presents the results obtained for the analysis.

Table 10 – Results – Analysis 9

	Arpt 1	Dif. 9 and 3
People through WTMD	510	66
WTMD Alarms	35	1
People processed	475	-16%
Manual searches	2	2

There is a 16% gain in passenger processing efficiency in the inspection module. It can be seen from this analysis that mutual assistance between the teams prevents the processing of one of the security checkpoint modules from being interrupted when 2 APACs are doing manual search.

3.10 Analysis 10 – Passenger security checkpoint module with 2 WTMD and 2 x-rays and continuous hand luggage manual search

The purpose of this analysis was to verify the operational processing capacity of the passenger security checkpoint module, maintaining an APAC dedicated exclusively to the screening of hand luggage on a random and continuous basis. The module was configured with 2 WTMD, 2 x-rays and 7 APAC (2 flow controllers, 2 x-ray' screeners and 1 professional responsible for manual search) to analyze the impact with a reduction of 1 agent. Furthermore, the analysis in question included the availability of trays and an advisor (APAC with the function of guiding passengers) in the queue formation area and was carried out without the application of art. 3rd, IV of Res. nº 207/2011 (ANAC, 2011), so the analysis in question represents an increase in relation to Analysis 6. Furthermore, the analysis in question was carried out at Airports 1 and 2. Table 11 presents the results obtained for the analysis.

Table 11 – Results – Analysis 10

	Arpt 1	Arpt 2	Avg.	Dif. 10 and 6 (x2)
People through WTMD	385	503	444	-116
WTMD Alarms	34	36	35	-5
People processed	350	467	408	26%
Manual searches	1	0	1	0

Initially, it appears that there is a high difference in passenger processing at Airports 1 and 2. Airport 2 processed 33% more passengers. It was not possible to identify the reasons for this difference, however, it is noteworthy that Airport 2 processed a greater number of passengers, compared to Airport 1 also in Analyzes 3 and 6. On average, 408 passengers were processed, which corresponds to 204 passengers per security checkpoint module.

For comparison with the defined reference, evaluated in Analysis 6, the result of this

evaluation was multiplied by 2, which would correspond to the processing capacity of two modules and, in this case, there was an indirect reduction in processing rate capacity of 26%, when applied to random and continuous manual search. However, this reduction directly corresponds to 10.8%, given that in Analysis 6 a processing rate of 65 pax/APAC/hour is recorded, in Analysis 10, 58 pax/APAC/time are recorded. Given the discrepancy found between the results found at Airports 1 and 2, for the specific procedure, it is suggested that the evaluations be repeated at both airports.

3.11 Analysis 11 e 12 – Employee security checkpoint module with reduction in the number of APAC

The purpose of this analysis was to verify (qualitatively and quantitatively) the capacity to process people in the employee security checkpoint with a reduction in the standard configuration defined in IAC 107-1004A (DAC, 2005), from the removal of 2 APAC (Analysis 12), compared to the standard configuration defined in IAC 107-1004A (DAC, 2005) (Analysis 11).

This assessment was carried out only at Airport 1 during times of greatest demand. Table 12 presents the results obtained for the analysis.

Table 12 – Results – Analyses 11 and 12

	Arpt 1 (11)	**Arpt 1** (12)	**Dif. 12 and 11**
People through WTMD	229	226	3
WTMD Alarms	23	7	16
People processed	206	219	6%
Manual searches	5	1	4

In terms of people processing, there were no impacts on the security checkpoint with the reduction of the flow controller APAC. Tests were carried out on the people identification system and on the hand belongings screening system in the security checkpoint subject to the analysis, one in configuration of Analysis 11 and the other with configuration of Analysis 12 and, in both cases, the results were the same, therefore it is not possible to state that the reduction of an APAC and a Supervisor interfered with the quality of the screening and access control activities.

It is noted that Airport 1 had, at the time, a population of 4,736 authorized people with access to the ARS and that the analyses were carried out at times of greatest demand (shift change) in the security checkpoint.

3.12 Analysis 13 – Increase in the number of inspection modules per AVSEC supervisor

The purpose of this analysis was to qualitatively verify the ability of a supervisor to act effectively in three security checkpoint modules and not just two, in accordance with IAC 107-1004A (DAC, 2005) in force at the time. It is also noteworthy that no vulnerability, reduction in the processing capacity of the modules or difficulty in coordinating the teams was noticed with an increase in the number of inspection modules (2 to 3 modules). However, it is noteworthy that it was noticed that there were cases in which the supervisor did not intervene when he should have done so, for example, when the APAC was discarding items and it was necessary to stop the module, adding to the dispersion of the team.

4. DISCUSSION

The analyses carried out led to the following conclusions:

a) Passenger guidance in the queue formation area:

The placement of trays in the queue formation area without instructions for passengers to remove metal objects did not demonstrate an improvement in the efficiency of passenger processing, even causing a small reduction in efficiency. However, with the use of trays and passenger guidance through a dedicated APAC, a significant increase of 21% in the processing capacity of the modules can be seen, which reflects in gains in scale, considering all modules in the passenger security checkpoint.

b) Procedure of Resolution nº 207/2011 (ANAC, 2011) return to the WTMD after the first alarm:

Related to the non-application of item IV of art. 3rd, IV of Res. nº 207/2011 (ANAC, 2011), there was an approximate increase of 16% in the processing capacity of the security checkpoint modules. The repeal of this section does not create any type of AVSEC weakness, as the HHMD performs the same function as the WTMD, with the difference that the HHMD indicates the exact location of the object which caused the alarm and the WTMD indicates the position of where the largest quantity of metallic

mass is located. The analysis also found that frequent passengers have the habit of automatically returning to the WTMD when the alarm is triggered, a situation observed in the study for more than 50% of passengers. Another notable fact is the perception that using the HHMD is more uncomfortable for passengers, causing them inconvenience and delays in the screening process. These findings led to the recommendation to review this item in Resolution nº 207/2011.

c) Random and continuous manual search of hand luggage carried out by a specific APAC:

Regarding the random and continuous manual search of hand luggage carried out by a specific APAC, it was found that the procedure does not considerably impact the processing capacity of the passenger security checkpoint, denoting that such a configuration, in addition reducing the processing capacity of the module, did not bring any improvement in the application of the procedure. However, given the discrepancy found in passenger processing at Airports 1 and 2, it is suggested that the procedure be analyzed again.

d) Passenger x baggage processing time:

Regarding Analysis 7 and 8, it was demonstrated that the most impactful part of the screening process is related to the processing of hand luggage and not the passenger itself, it was observed that in a module configured with 1 WTMD, 2 x-rays and by 6 APAC the baggage processing time brings a real gain of 25% in passenger processing, without compromising AVSEC, in addition to reducing the number of equipment (1 HHMD and 1 WTMD) to be made available per module and require less physical space to install a checkpoint, therefore this is a possible layout solution to be adopted.

e) Random manual search of passengers and their luggage:

Regarding the manual search of those passengers who were selected for the manual search of hand luggage, it was found that the impact generated on processing efficiency is 8%, so that an 8% reduction in processing capacity was found, having the standard module as a basis. However, if the manual search were carried out in a private room, according to PNAVSEC - National Civil Aviation Security Programme (BRASIL, 2010), it is considered that the impact would be more significant, depending on the layout of the checkpoint and the distance from the security checkpoint module to the room.

As there was a considerable discrepancy between the results obtained at Airports 1 and 2, it is suggested that Analysis 5 be repeated at both airports.

f) Optimization of the Flow Controller for two security checkpoint modules:

The evaluation using only 1 flow controller for two security checkpoint modules reduced the processing capacity of the inspection module by 42%, based on the performance of a standard module, in addition to causing stress and a relative lack of control over APAC team. Therefore, the model is not suggested for application in international passenger security checkpoint, because of its specific requirements.

g) Employee security checkpoint:

In the evaluation carried out in the employee security checkpoint, it was found that the reduction of 1 APAC and 1 supervisor did not have any impact on the processing of people (queue or crowding). Regarding the effectiveness of access control and screening process, it cannot be concluded that the module configuration composed by 1 APAC x-ray operator and 1 APAC responsible for manual search is inferior to the standard configuration established in IAC 107-1004A RES (DAC, 2005). Therefore, further studies related to this item would be necessary.

It is also verified that the flow control agent has a fundamental role in verifying the airport authorization of an employee security checkpoint.

However, at times of lower flow of people, it is possible that the procedure can be adopted without impacting AVSEC. Another possibility for reducing the number of APACs is the adoption of an electronic authorization verification system, however these procedures would have to be better evaluated and with a larger sample.

h) Security checkpoint supervisors:

Despite the lack of definition, in legislation, of supervisors' duties, no vulnerability, reduction in module processing capacity or difficulty in coordinating teams with an increase in the number of security checkpoint modules per supervisor (from 2 to 3 modules) were perceived. Even so, it is suggested to carry out a mapping of

AVSEC activities that supervisors must carry out for a more realistic analysis of the number of modules they can supervise.

Finally, it is noteworthy that the legislation in force at the time of this study allowed little flexibility in the layout of the infrastructure and quantity of APAC in security checkpoints. Therefore, the procedures in the security checkpoint and the models that had good results in this study were considered in the regulations drawn up by ANAC, so that each airport administration can individually evaluate the configuration that best applies to their airports, considering the demand and operational specificity of each one and the current legislation.

Regarding the specificity of each scenario, it should be noted that the increase in efficiency allows for a gain in scale, as it affects all modules in the security checkpoint. Using the airports under study as a reference and comparing Analysis 3 and 2, the airport administration could reduce 1 security checkpoint module for every 5 modules installed, that is, a pre-screening advisor could reduce the labor force of 4 APAC, for every 5 modules installed.

Finally, it is worth noting that the savings in labor must be read with caution, since they are estimates, and there is no field study that considers the percentage of loss of security checkpoint capacity, which varies depending on its demand (passenger flow), due to the decrease in an APAC, not even a study that specifies the average increase in passenger inspection time in a random manual search compared to a common screening (passengers screened using metal detectors).

It is also worth emphasizing that the study did not aim to qualitatively evaluate the effectiveness of the procedures, this is a recommendation for the continuation and expansion of this pioneering study in the Brazilian reality.

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