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Improvement of the procedures performed during theTurnaround time of an airline in theairport of Bogota

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Abstract :*In the aviation industry there are multiple processes that are part of a flight, one of them is the turnaround time which is the time from the moment an aircraft enters its parking position andTurns off the engines until it leaves for the next destination. This is known as "pre-takeoff". Most airlines have it set in 30 minutes, however, with the ABC airline there is something very particular and that is that although all its bases handle the same 30 minutes, at its base in theBogota at El Dorado Airport, it's 35 minutes. In a matter of costs, this makes a big difference.The purpose of this project is to identify the processes that affect the turnaround time. Engineering tools such as the DMAIC were used in order to generate strategies that helpminimize processes to complete them in a maximum of 30 minutes. Once the investigation was completed, it was shown that if it ispossible to carry out this procedure in less time, which would generate an optimization of economic resourcesbecause the aircraft would remain less time on the ground generating greater use and therefore greater profitability.*

Keywords: *Aerolínea,procesos, vuelo, rentabilidad,*

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I. INTRODUCTION

According to the PRNewswire magazine from New York, global airlines grew 7.4% between 2012 and 2016 expecting a more accelerated increase by 2022 [1]. One of the main reasons for this improvement is the safety, ease, and fast movement from a place to another that is offered by aviation today, thus becoming one of the most efficient means of transport around the world. The client that uses this service seeks to find efficiency in all the processes that happen before boarding a flight so that it leaves on time, at the same time, the smooth course of the entire operation benefits the airlines economically.

During the operations of an airline, as explained by Midkiff, A., Hansman, J., Reynolds, T. in 2004 [2], there are many factors that can influence the normal development of the activities to be performed before the departure of a flight; these can be internal or external as they appear in Figure 1. Within the internal elements that are most relevant are those processes that are carried out during the turnaround time, these determinethat a flight begins at the established departure time. External factors include the airport infrastructure, air traffic (ATC) and damage to the aircraft caused by lightning strikes or birds' impact and the weather conditions that affect the operation.

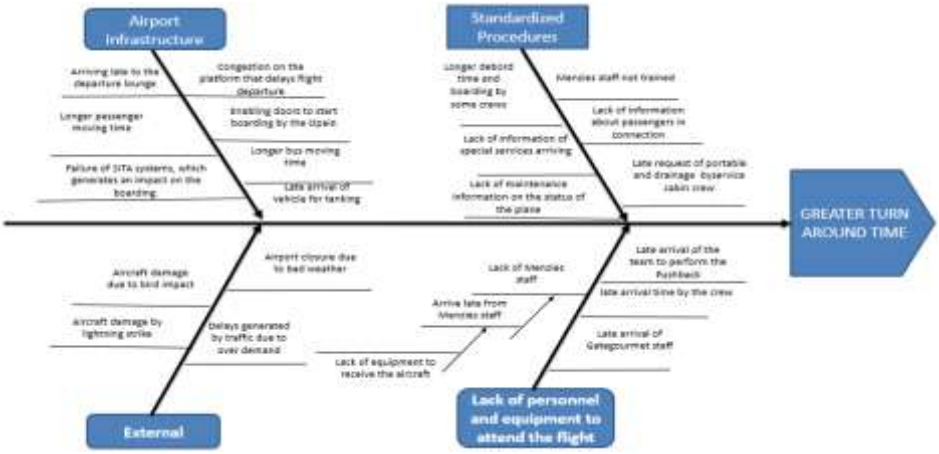


Figure 1. Causes that affect the turnaround time

The turnaround time is the one that occurs from when an aircraft enters a parking position, turns off engines until it starts the pushback to start the next flight [3]. For this process, each airline uses a Gantt chart that establishes the times of each process as shown in figure 2: The first column numbers the processes to be executed; in total there are 28 processes. In the second column the processes are named. The third, shows the times that each of these processes takes. At the top, under the title, you can find the timeline. This line goes from three minutes before the plane that just finished its flight opens its doors, up to thirty-seven minutes (37) which is the ending of the turnaround time. Within the graph, you can see with a blue or red line the time it takes to make a certain process.

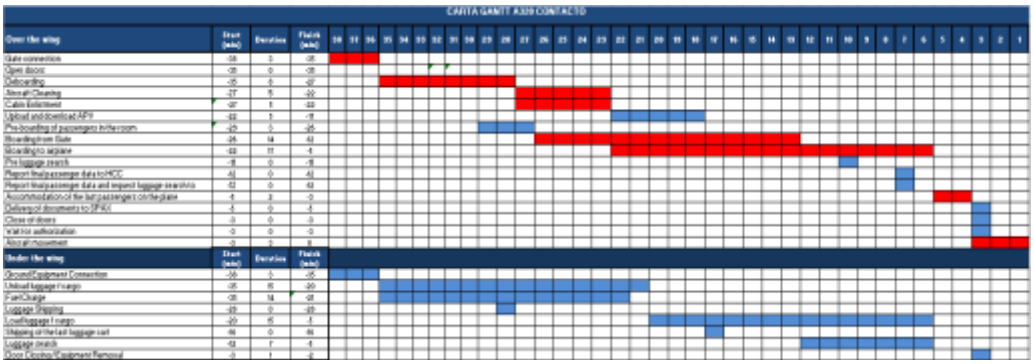


Figura 2. Gantt chart for ABC airline

As Schmidt mentions in his 2017 review [4], multiple studies have been done that indicate that in order to make a good impact on the reduction of transit time, the changes must happen on the internal factors already mentioned. That is why, with the development of this project, what is sought is to diagnose and correct all those controllable variables of the company that are made during the turnaround time of the aircraft in order to reduce the time to only 30 minutes and achieve better profitability for the company.

II. METHODOLOGY

For this studythe DMAIC (Define, Measure, Analyze, Improve, and Control) methodology of Six Sigma [5] was used. Taking into account its acronyms and methods, it began by making a diagnosis of the current situation of the turnaround processes ofABC airline. Following this, time-taking was carried out in order to identify procedures that were outside the established times. With this information the analysis was prepared in order to find recommendations that would help reduce times of such procedures thus creating a new Gantt chart with a 30 minute maximum. .

2.1 Diagnosis

To develop the diagnosis of the processes that are carried out within the turnaround time of the flights of the ABC airline, 4 research tools were used: First the SWOT Matrix [6] was implemented to identify the strengths and weaknesses of the company. Following this, the Vester Matrix [7] was used to determine which the weaknesses that most affect the procedure are. Also, Asurvey of ten questions was done to forty-six workers in the area in charge of all the processes that are carried out during the turnaround time in order to know their opinion on what is it that affect this time the most. Finally, a competitive profile matrix was used [8] to know how the ABC airline is at the competition level.

In the case of the survey, to determine the sample that was required according to the target population, the following formula (formula 1) was used:

$$n = \frac{z^2 PQN}{E^2(N-1) + Z^2 PQ}$$

Formula 1: Sampleneeded

n: It's the sample size, it is determined by the result of the formula
Z: Normal deviation, this is determined by the level of confidence, in this case it's 90%. With this information, the value of the deviation is 1.28
Q: The success portion, taking into account the level of trust, a value of 0.5 will be used
Q: It is the portion of failure, taking into account the level of confidence, a value of 0.5 will be used
E: It is the error shown, for this case, a maximum error of 5% is being used

$$n = \frac{1.28^2 * 0.5 * 0.5 * 62}{5\%^2(62-1) + 1.287^2 * 0.5 * 0.5} = 45.8 = 46$$

2.2 Measurement

In order to do the measurement of all the processes of the actual Gantt chart (figure 2), a field work was carried out tracking the transit time of sixty flights of theABC airline. These were flights that made national routes departing from a contact positionin Bogotá, excluding the routes Bogotá to Leticia and Bogotá to San Andrés since these require more than 35 minutes of turnaround timedue to the large volume of cargo they handle. Thirty turnaround times of aircraft Airbus 320 with a maximum configuration of 174 passengers and thirty of Airbus 319 with a maximum configuration of 144 passengers, were monitored. Measurements were made from June 10 to 20, 2019, on random days, several different routes.

2.3 Analysis

For the analysis, a comparative chart of the most important activities that should be carried out during the turnaround time of the flights was developed. To do this, themanuals of ABC airline were consulted to see how each of these processes are established and the times determined for them. Once the verification was completed, the measured times were compared with those established in order to identify the discrepancies.

2.4 Improvement

With the results obtained in the measurement and analysis, two new Gantt charts were made, one for Airbus 319 aircrafts and another for the Airbus 320. The Monte Carlo Simulation and control limits were used to determine what would be the optimum times of each process taking into account the variability of each one of them.

2.5 Control

With the information obtained from the surveys and the observations made during the 60 flights, the most important processes were established. This in order to make a more detailed follow-up through the control to have a more precise monitoring of the traffic progress.

III. Results

After applying each of the phases of the methodology of DMAIC, these are the results:

3.1 Survey

To do the survey, a total of forty-six employees were taken into account, of which 45.8% considered that to improve punctuality it is necessary to have greater clarity in the procedures, 39.6% indicated that better strategies are required in the teamwork. 81.3% agreed that the areas that generate the most delays and therefore affect the turnaround time are those related with passenger service. These include the boarding / unboarding time of an aircraft. A Pareto chart was made (figure 3) where it can be seen that eight areas of theABC airline that interfere with the turnaround time were taken into account, in which about 80% of the delays are being generated from the two areas already mentioned by respondents.

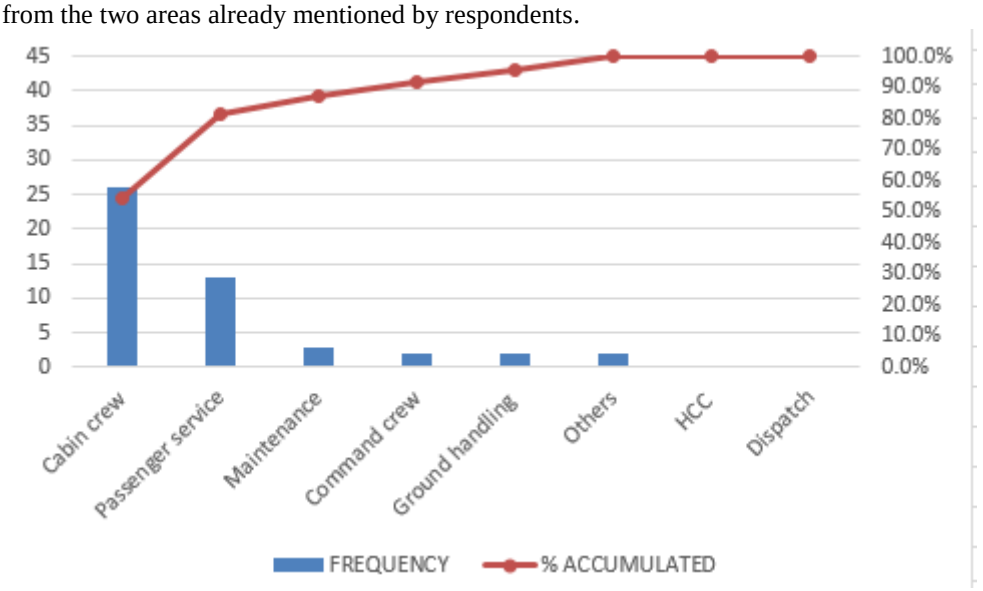


Figure 3. Pareto chart

3.2 SWOT Matrix

To perform the analysis of the ABC airline, a SWOT matrix was made with the information of the respondents. Weaknesses, strengths, threats and opportunities of the company were establishedas shown in figure 4.

INTERNAL FACTORS OF THE COMPANY	EXTERNAL COMPANY FACTORS
WEAKNESSES	**Threats**
Difference between the luggage you have per system, with respect to what is physical for the plane	Shorter time in turn around of competition flights
Lack of standardization of some HCC processes that help to execute the tasks in the best way.	Increase in competition frequencies
Follow-up and solution of the problems that occur day by day, these are always repeated	Competition Prices
There is no established communication flow to transmit the messages	The Dorado airport infrastructure
Communication equipment failure, since these are unsuitable for operation	Weather condiccions
There are staggering of important issues and there is no response from management	Delay generated by traffic flow
When delays are generated, the areas do not accept responsibility and the root cause is not analyzed	High dollar price, which increases the operational cost
The process for coding delays is not standardized	High turnover of company personnel providing ground handling service
Long waiting time to serve customers at the counter	
There is no unity between the different areas of the	
When an area modifies a procedure, it does not socialize with everyone involved, generated errors	
Aircraft with technical events	
Strengths	**OPPORTUNITIES**
Trajectory in the market at national and international level	Reduction of turn around to optimize the use of aircraft through best practices or by benchmarking companies that achieve transits in less time
Staff with trajectory	Increase in airport frequencies, given the improvement of the national economy
Qualified personnel to perform their duties	Improve the travel experience of passengers, through the fulfillment of itineraries and low prices
Security in each of the processes that are performed	Negotiation with Opain to increase the number of flights in contact
	Standardization and socialization of processes

Figure 4. SWOT Matrix

3.3 Vester's Matrix

From the SWOT matrix, weaknesses that may affect the normal development of the processes of the turnaround time were selected. As shown in Figure 5, the most critical mistakes occur when "Monitoring and solving the problems that occur day by day" and "When delays are generated, the areas do not accept responsibility and neither is the root cause analyzed. " These are the ones that have more influence over the others and generate more dependence to complete all the tasks under 30 minutes.

Vester's Matrix

	DESCRIPTION	A	B	C	D	E	F	G	H	I	J	K	L	TOTAL INFLUENCE
A	Difference between the luggage you have per system, with respect to what is physical for the plane		0	0	0	1	0	3	0	0	0	0	0	4
B	Lack of standardization of some HCC processes that help to execute the tasks in the best way.	3		3	3	1	2	3	3	2	2	2	1	25
C	Follow-up and solution of the problems that occur day by day, these are always repeated	3	3		3	2	3	2	3	3	2	1	2	27
D	There is no established communication flow to transmit the messages	2	0	2		1	2	2	0	2	0	0	0	11
E	Communication equipment failure, since these are unsuitable for operation	0	0	0	0		0	0	0	0	2	1	0	3
F	There are staggering of important issues and there is no response from management	3	3	3	2	2		2	3	2	3	3	2	28
G	When delays are generated, the areas do not accept responsibility and the root cause is not analyzed	3	3	3	2	1	2		3	0	2	2	1	22
H	The process for coding delays is not standardized	0	0	1	0	0	0	3		0	1	0	0	5
I	Long waiting time to serve customers at the counter	0	0	2	0	0	2	0	0		0	0	0	4
J	There is no unity between the different areas of the company	3	0	3	0	0	1	3	0	0		3	0	13
K	When an area modifies a procedure, it does not socialize with everyone involved, generated errors	3	1	2	0	0	0	0	0	0	3		0	9
L	Aircraft with technical events	0	0	0	0	0	0	0	0	0	0	0		0
	TOTAL DEPENDENCE	20	10	19	10	8	12	18	12	9	15	12	6	

Figure 5. Vester's Matrix

3.4 Competitive Profile Matrix

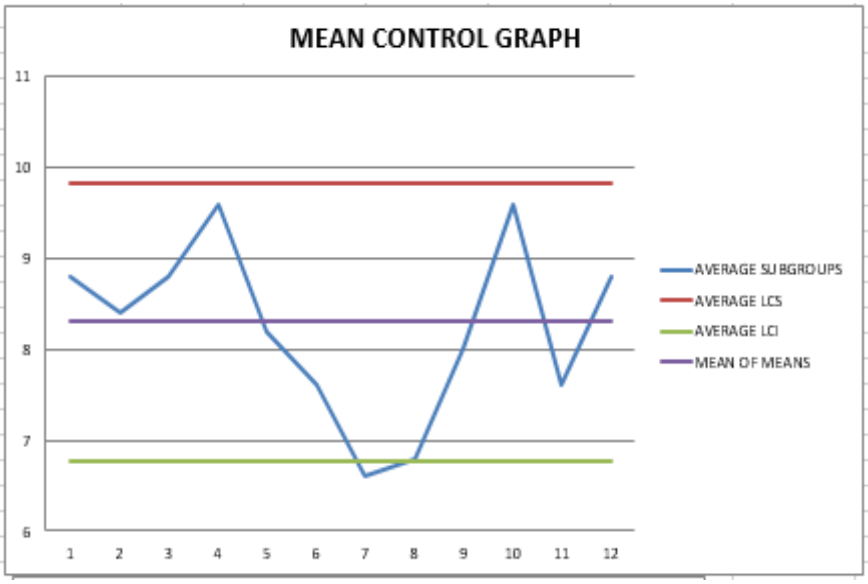
To determine the strength of the company against the competition, a competitive profile matrix was developed where the five factors listed in the first column of Figure 6 were evaluated. To determine the qualification of each of them, the financial statements of companies, internet surveys and databases on market share, were investigated. After performing the analysis of each of the factors of the matrix of the competitive profile, the following results were obtained: Competition 1 obtained the highest score with a rating of 9.4, followed by ABC Airline with 8.7 and finally the Competition 2 with a 7.2 score of a maximum of 10 points. In this case, the airline is not in a bad position especially considering that it has been in the Colombian market for 7 years.

Critical Factors for Success	weight	Airline ABC		COMPETITION 1		COMPETITION 2	
		Qualification	Weighted Rating	Qualification	Weighted Rating	Qualification	Weighted Rating
Market share	0.1	7	0.7	10	1	6	0.6
Price Competitiveness	0.1	5	0.5	6	0.6	10	1
Financial Position	0.1	8	0.8	8	0.8	10	1
Product quality	0.3	10	3	10	3	5	1.5
Customer loyalty	0.2	8.5	1.7	10	2	5.5	1.1
Staff Qualification	0.2	10	2	10	2	10	2
TOTAL	1	48.5	8.7	54	9.4	46.5	7.2

Figure 6. Competitive Profile Matrix

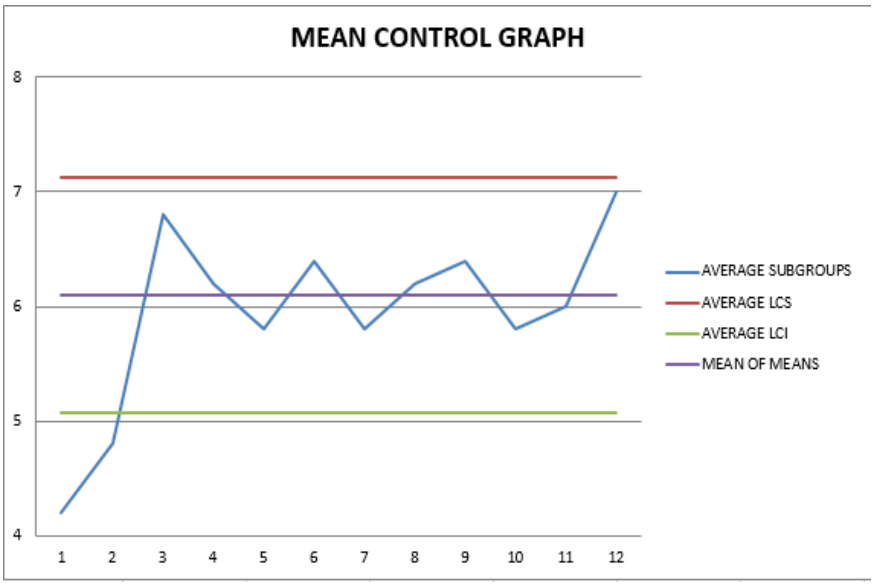
3.5 Field measurements

After performing the field measurements, the critical route of the entire transit process was established. It could be seen that there are processes that have slack time and that if they are delayed, they will not affect the flight departure since according to the Gantt chart they can be done simultaneously with others. On the other hand, there are some that directly affect the total time, so they will be taken into account for this analysis. These processes are: Deboarding, security check by the crew or briefing, boarding passengers from thegate and boarding the aircraft.



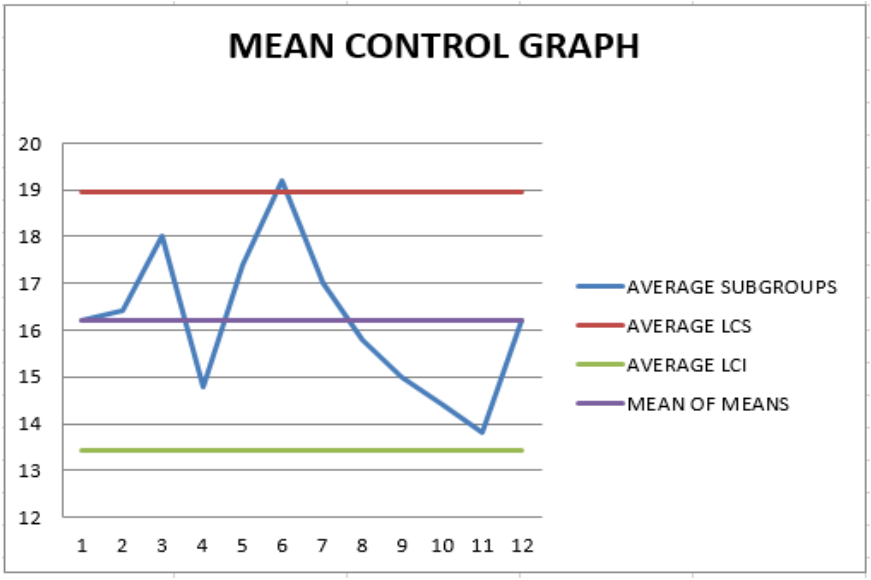
Graph 1. Deboarding time

After the time taking, it was possible to establish that the average deboarding time (graph 1) is 8.3 minutes versus the 8 minutes established in the Gantt chart. Taking into account the total sum of passengers of the 60 flights and the landing times of the same, it was determined that for each minute there is an overflow of 18 passengers which would generate a total of 9.5 minutes for an Airbus 320 of 174 passengers and 8 minutes for an Airbus 319 of 144 passengers. With the database, a MonteCarlo model with 10,000 interactions was made, where the intervals were established for each minute of time from 10 to 30 minutes, where more than 80% of the data were between 12 and 20 minutes, with an average of 18.3 passengers per minute.



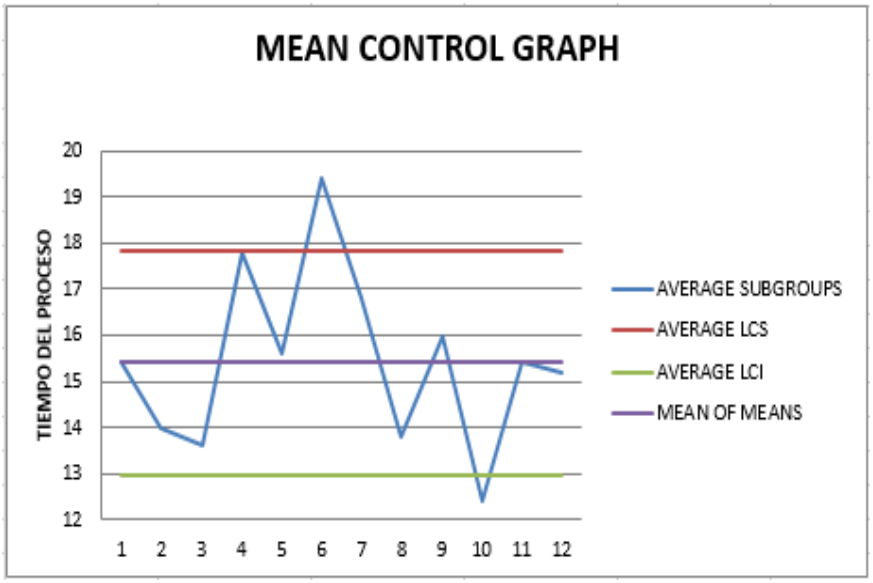
Graph 2. Crew Briefing

In addition, an average briefing time (graph 2) of 6 minutes was obtained, 1 more minute compared to the 5 established in the Gantt chart currently operated by the ABC airline. After running the Monte Carlo model with the same characteristics mentioned above, an average time of 5.5 minutes was achieved and 80% of the data were located between 3 and 6 minutes.



Graph 3: Boarding from the gate

The average passenger boarding time from de gate (graph 3) was 15.9 minutes compared to the 15 minutes shown on the Gantt chart. This time was averaged for all flights resulting in 9 passengers per minute, which would be equal to a total of 19.3 minutes for the Airbus 320 and 16 minutes for the Airbus A319. With the Monte Carlo model, a decrease in boarding time per passenger was observed from 9 to 8.7 passengers per minute.



Graph 4. Boarding to the aircraft

Regarding the boarding to the aircraft (graph 4), an average of 15 minutes was found against the 17 minutes that were established, which generated an average per passenger of 9.3 passengers per minute and a total of 18.71 minutes for the A320 and 15.4 minutes for A320. After running the 10,000 interactions of the Monte Carlo model, an average of 8.7 passengers per minute was achieved.

The result of this investigation showed it is possible to reduce the time currently operated by the ABC airline. After the survey of the workers, field time takin and generating the Monte Carlo Simulation, it was possible to establish two new Gantt cards with a new time of 30 minutes to carry out the turnaround processes (Fig. 7 and 8). This is not without first making a series of recommendations based on previously conducted studies and observations of the workers surveyed:

- The aircraft deboarding should not only be done through the front door but also through the rear door. According to the Fuchte study in 2014 [9], this decreases the total time by 3 minutes or up to 30%. However, to avoid delaying the start of the cleaning of the aircraft, it is recommended to only deboard a total of 60 passengers through the back door, filling a single mobile (who is responsible for taking passengers to the area of luggage) this so that the cleaning staff to enter promptly
- Crew Briefing: To improve this process and achieve it in 3 minutes, the crew that starts anew flight could enter during the deboarding so that the crew that is finishing personally delivers the safety equipment and thus avoid having to check one by one
- Boarding passengers from the gateThis should start when the flight is still deboarding. By company regulations, passengers can be up to 7 minutes on the boarding bridge, if this time is used to start boarding, the process could be accelerated thus reducing their time
- Boarding: Besides using multiple doors for boarding as already mentioned, Schmidt [4] says that one of the factors that has affected the time of the process is the amount of luggage that is entering the cabins since the beginning oflow cost airlines where most passengers carry hand luggage. Milne [10] indicates that with better strategies, the negative effects of this could decrease by up to 28%. It is recommended therefore that the airline offers that the hand luggageis also checked in at no additional cost and thus speed up the time of entry to the aircraft. Regarding the boarding mode, Jaehn and Neumann [11] suggest that the optimal boarding is the one currently operated by the company, where first passengers with special needs (Wheelchairs, people with special assistance, recommended children, families of children arm and passengers who have a special category for being frequent) are boarded, then the passengers who have assigned window, after the central rows and finally the aisle

Taking into account these recommendations, some changes were made to the Gantt Chart:

- The deboarding time was set at 7 minutes compared to previous 8 minutes
- Crew briefing was set to 3 minutes
- Cleaning will be done in 3 minutes and not 5
- Boarding time from the gate will be done in 13 minutes since it will star 7 minutes ahead of previous schedule.
- Boarding to the aircraft will be done in 16 minutes, 1 less than the actual Gantt.
- Door closing will be done at minute -2 not at -3

Figure 7. Proposed Gantt chart for Airbus 320

For the Airbus 319 aircraft, the changes done are the following:

- Deboarding will be done in 5 minutes since this aircraft has less passengers
- Crew briefing time will be 3 minutes
- Cleaning will also be done in 3 minutes
- Boarding from the gate will be done in 12 minutes considering it will start 4 minutes before finishing the deboarding.
- Boarding the aircraft will take 15 minutes, 2 less than previously established.
- Door closing will be done at minute -2 not at -3

Figura 8. Proposed Gantt chart for Airbus 319

IV. DISCUSION

In his 2017 study, Rico [12] determined that a cost of 90.8 euros is generated for every minute that an aircraft is on the ground. The profits of an airline then depend mostly on the amount of time they keep their aircraft in the air so it becomes a priority to seek to reduce the turnaround time, especially if this is greater than that of the competition as it happens in the case of the ABC airline.

After the diagnosis process of this study, it was possible to determine that the processes that most affect the total time of an aircraft on the ground, are those that involve the descent and entry of passengers to the plane. These results are not very different from those found in the literature. Schmidt [4] mentions that since the 70s with the appearance of aircraft with new configurations to accommodate more passengers, most studies have focused on making recommendations and strategies to reduce boarding and deboarding times.

According to Ozmec et al in their 2018 study, the change to low-cost airlines, as the ABC airline is doing, implies not only a greater number of passengers, but also of hand luggage. Both causing more delays in the movement of passengers in and out of the plane. To counteract this, changes in boarding and deboarding strategies must be generated that increase the number of passengers that can be moved per minute [13]. In the case of the ABC airline and as suggested by the respondents of the survey, although many times the strategies are those indicated internationally, there might be lack of clarity in the realization of these by the staff that must of carrying them out.

However, this study also served to review boarding strategies that are used in other airlines and that can be applied to this one. It was demonstrated through the new Gantt charts (figures 7 and 8) and the Monte Carlo

Simulation that following the recommendations would reduce the transit time to 30 minutes like the rest of Colombian airlines

V. CONCLUSION

With the study it can be shown that although the turnaround time has established a 35 minute time for all its procedures, there are many internal factors that can increase it. In this study the diagnosis allow to determine that the most important thing is to improve theprocedures that are performed during boarding and deboarding since they generate the most delays. Based on this, recommendations were made that will help you betterpractices that affect the process. It was also determined that there are tasks that can be done simultaneously, this along with making some changes on how the boarding/deboarding processes are being done would decrease the total time to 30minutes, thus giving more flying time to the aircraft and decreasing the extra cost for keeping it on ground.

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