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A discrete event simulation model for analyzing the unloading of goods at a port

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Abstract. Today, maritime transport is responsible for moving approximately 80 percent of the volume of world trade, which has favored Colombia, which, due to its geographical position, has managed to become one of the most competitive and dynamic economies in the world. South America. For this reason, this investigation is carried out in a port of their country, with the aim of identifying and analyzing restrictions or critical points that may cause delays in the unloading of goods, these would also cause delays in the loading of vehicles. To do this, it began with a diagnosis of the current situation through interviews with the operational personnel of the port, then a simulated model was designed in the ARENA software, in which it was observed that the weighing activities are where the queues were formed, this will cause a delay in the download. As possible solutions, it is recommended to senior management that a proper verification of the operation of the weighing equipment be carried out in order to unload goods more quickly. In addition, a replacement weighing equipment must be purchased. With this change, it would be possible to reduce inefficiencies or cost overruns caused by download delays, which are reducing the fluidity of the goods and the competitiveness of the organization

Keywords. Discrete events simulation, Logistics port, Merchandise transports, Unloading of goods.

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1. Introduction

Aport is a group of installationson land, sea or on the shores of the ocean or rivers, which meet the basic physical, natural or artificial and organizational conditions for port traffic operations. For this reason, port operation is a broad process that includes administrative aspects prior to berthing, processes that are carried out at the time the ship arrives at the port, handling of the goods, services provided to passengers. All these activities involve a number of specialised actors whose mission will be to achieve maximum performance at the lowest cost.

At the end of the day, such organizations represent a considerable source of income for a country's economy. En foreign trade is expected that, by 2030, the time used for the import of goods in seaports will be reduced from the current 230 hours to 48, while for export it is projected to reduce it from the 156 hours required at this time to 48 hours, an achievement that will significantly favor Colombian producers. In contrast to the above, some of the conditions or limitations that affect ports and Colombians are no exception, that is, infrastructure, storage, connection to the outside, lack of equipment and administrative disorder, dredging in relation to shallow sea access due to sediments, insufficient security and administrative disorder some of the most representative. It has studied the case of a specific operation of an organization, belonging to the tertiary sector with the aim of determining possible causes that are causing delays in the operation times, which is why there are many disagreements on the part of the transporters (customers).

Based on the above it can be inferred that this type of organizations, the competitive market demands greater agility in their response times, which is guaranteed with more efficient processes for greater flexibility in times of constant change. Therefore, a small company belonging to this industry was selected, in which the investigation was carried out. This company has as its raison d'être is the mobilization of cargo, this is a reference point for the entry and exit of goods and is located in the city of Barranquilla-Atlántico. That said, this research was carried out with the aim of identifying and analyzing restrictions or critical points causing delay in port operation, which are causing delays in the arrival or loading of vehicles, through acritical analysis. For this reason simulationisused, since it allows the investigation of processes related to the application of scientific procedures to the recognition and definition of drawbacks, as well as to the developmentof methods for theirsolution.

2. Literature review

About the simulation of discrete events, its concept can be specified as the set of logical, mathematical and probabilistic relationships that integrate the behavior of a system under study when a given event occurs. The objective of the simulation model is precisely to understand, analyse and improve the relevant operating conditions ofthe system. [1, 2, 3]. The elements that are part of this definition are system, model and event. The basic definition of a system is that it is a set ofelements which are inrelationtofunction asawhole; from the point of viewof thesimulation, such elementsmust have a clearpicture. For example, it can talk about the customer service system in a bank, the inventory system of a company, or the emergency room care system of a hospital [4, 5, 6]. Each one can be divided into elements that are relevant to the construction of what will be your simulation model; among them are more entities, system state, current and future events, locations, resources, attributes, variables, and the simulation clock [7, 8, 9, 10] In short, a system is defined as the set of things that are neatly related to each other that contribute to a certain object.

It is also necessary to mention the components that make up a system that are the attributes, the entities, activities, the state, event. An entity is an object of interest in the system, as for attributes these are a property of an entity while activities refer to a specified lifetime. In contrast, an event is an instantaneous occurrence that could change the state of the system, the state refers to a collection of variables that describe the system at any time. Account should also be taken of the additional existence of two components, one of an endogenous nature and the other of an exogenous nature. The endogenous is concerning the activities and events that occur with the system; on the otherhand, the exogenous is in relation to theactividades and events that occur with the environment. [11, 12, 7].

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Now, the state of a system is the condition that keeps the system under study at a certain point in time; it's like a photograph of what's going on in the system at a certain instante. The state of the system is composedof variablesor characteristicsof specific operation (say the numberof parts in the system at thattime), and of variables or characteristics of operationaccumulated, or proaverage(such as the average time of permanencia of an entity in the system, in a row, warehouse or equipment). [13, 14, 15] That is, as the state of a system is defined as the set of variables necessary to describe the system at any time, in relation to the objectives of the study [16, 17, 18].

3. Methodology

The steps proposed for the development of this research are the following. Initially the collection of information was carried out through scheduled interviews with every one of those involved in the vehicle loading operation. After this the information obtained was tabulated and represented in an operational process flow diagram, using this diagram as a reference we proceeded to perform the simulation of the operation in the Arena version 16 software. Finally, based on the results of analysis the simulated, it was identified what the restrictions were to suggest alternatives as possible solutions. The graphical representation of the methodology is shown in Figure 1.

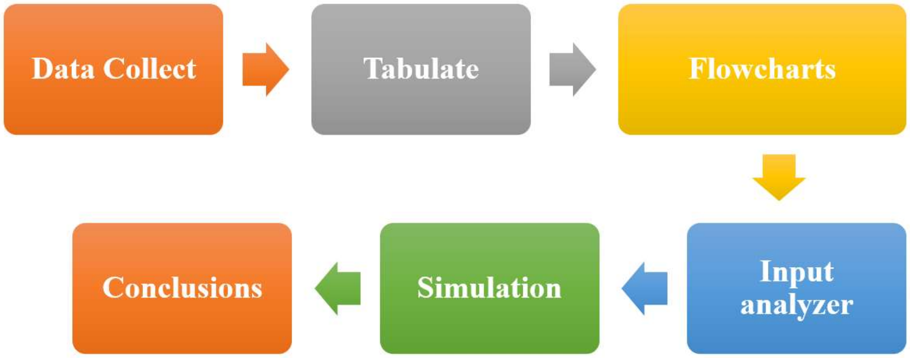

Figure 1. Methodology applied

4. Development of the simulation model

The real model from which it is based is the loading or stowage operation that is carried out in a port terminal in the city of Barranquilla. Only the corresponding activities will be modeled (see Figure 2) that is, once the cargo in this case bulk is already stored in the hold in port, once the vehicle is verified weight in cargo and documents will go to the exit of the port and leave the model. It should be clarified that this simulation only evaluates the behavior of the operation that is developed in a single winery.

The arrival of tractor-trailers is scheduled, so arrivals are considered to follow a known schedule. This schedule establishes the arrival of 4 vehicles per hour. Subsequently, an inspection of documentsis carried out, which properly approve 90% of the vehicles,to continue with their transfer to scale where the vehicle weight is initially determined without load and once the vehicle is weighed andoncethe vehicle is weighed and it is transferred to the cargo hold to load the bulk type cargo both the loading activity and the weighing activity follow a uniform distribution with a minimum time of 5 minutes and maximum 7 minutes. Luego is transferred to the carping area,the tenting has a uniform distribution with a maximum time of 2 minutes and minimum of 1 minute, then it is transferred to a scale or tothe second weighing and the weight in load is verified, this second weighing has a uniform time distribution of minimum 5 minutes and maximum 8 minutes. According to the result of the scale the vehicle will be moved to the loading area to remove or complete the net weight in load,In this verification *activity* 70% of the vehicles pass the load verification; then it goes to tilt again to validate the weight that corresponds to it consequently the net weight in load is verified and the system is entered then the load of the vehicle is verified again and the documents finally go to the exit. The entrance to the system has an even distribution of minimum 5 minutes and maximum 8 minutes.

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With regard to the resources involved in the loading or stowage operation are:
Personal:
1 supervisor
5 front loader operators
1 tilt auxiliary
1 vehicle driver
Equipment:
5 front loadersis
2 scales
Tracto trucks (vehicles)

Other aspects to take into account are that this process is simulated, thinking of a working day of 12 hours.

Finally,the information collected through the series of interviews was able to decompose the operation so that the development of this consists of 17 activities, corresponds to the bulk area and the data about the 17 activities can be seen in the diagram (see Figure 2).

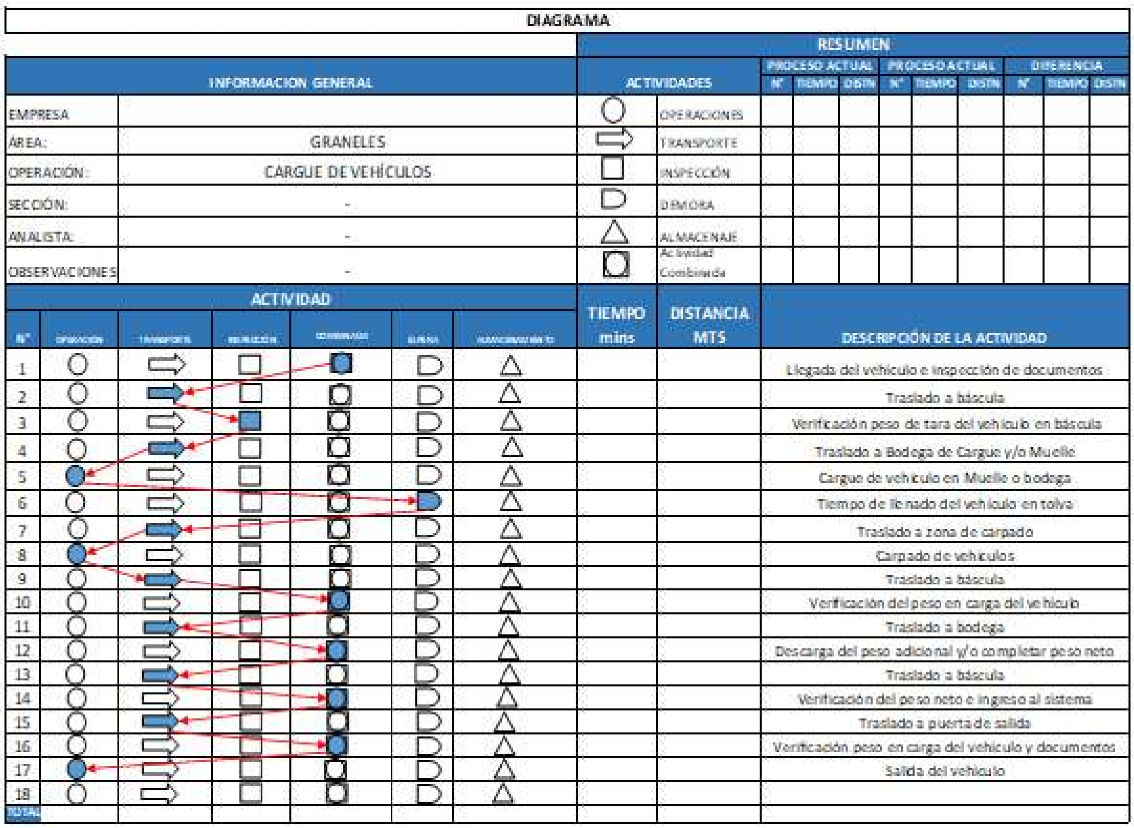

Figure 2. Operational process flowchart

According to the above, the information was chosen and simulation was used in the sand software for an analysis oriented exclusively towards the search for the causes of the problem with the greatest impact, expanding the vision of the causes of this problem in a more systemic and complete way, which can be seen in Figure 3.

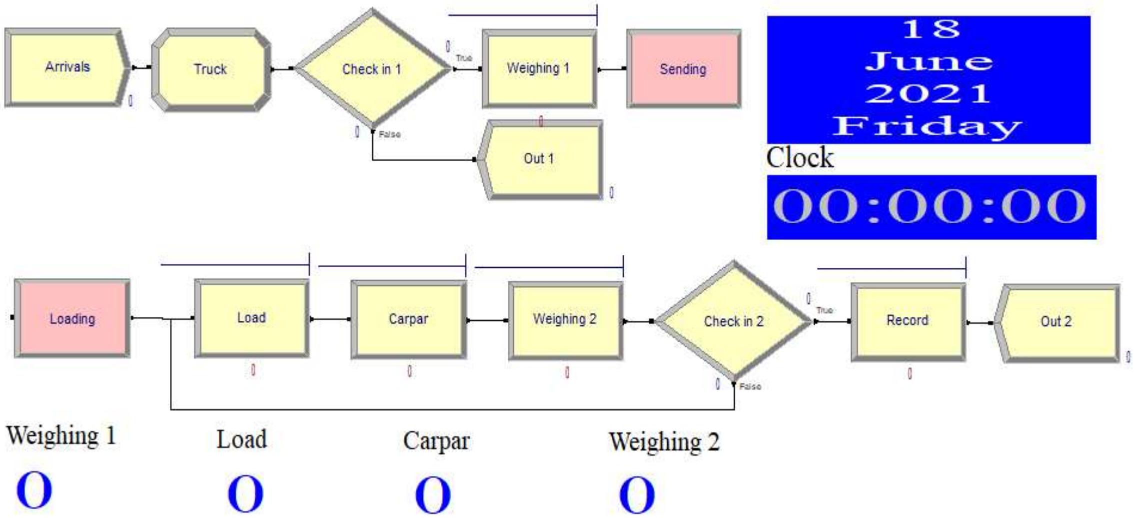

Figure 3. Simulation of the operational process in Arena software

5. Results

According to the results obtained from the digital twin of the loading process in the Arena software, it was identified that the activities where queues were presented were in the loading and in the second weighing. Likewise, I show that the activities with the highest number of cars waiting are, the second weighing the loading activity, on average the number of queues in the loading activity and the second weighing was 10. It was also evidenced that the number of vehicles that on average would receive the service, would be 50. In other words, for a 12-hour day, 50 tractor-trailers are being loaded into this warehouse.

Secondly, there are the results obtained in relation to the percentage of use or occupation of the system resources, since most of the resources have an occupancy percentage greater than 50% with the exception of the tenting assistant. For more details see Figure 4

	Inst Util	Num Busy	Num Sched	Num Seized	Sched Util
Aux.de Carpac	0,13	0,13	1,00	65,00	0,13
Bascula 1	0,39	0,39	1,00	48,00	0,39
Báscula 2	0,58	0,58	1,00	65,00	0,58
Oper.de cargac	0,54	0,54	1,00	66,00	0,54
Oper.de Carga	0,54	0,54	1,00	66,00	0,54
Oper.de Carga	0,54	0,54	1,00	66,00	0,54
Oper.de Carga	0,54	0,54	1,00	66,00	0,54
Oper.de Carga	0,54	0,54	1,00	66,00	0,54
Supervisor	0,41	0,41	1,00	46,00	0,41

Figua 4. Resource occupancy

Similarly, scale 2 compared to scale 1, doubles the occupancy percentage of the first, which reaffirms this as one of the causes of tail generation in the operation. The percentage of scale 1 is 39%, while that of scale 2 is 58%. Then we find the percentage of charging activity, considering the high percentages of shipper operators, is 58%. Which indicates that these operators are not yet so over workload, it is within a considerable range, but it is acceptable to the organization. However, it is evident that in contrast to the previous one the tenting assistant does not even reach 50% occupancy. Cabe high light that, for this first digital twin, is experimenting with a very basic model since it does not take into account all other aspects, such as lunchtime, but is developed to operate the 12 hours in a row.

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6. Conclusion

Finally, some of the recommendations suggested to combat these causes evidenced, regarding the conflict with weighing is to recondition the equipment ie the scales,ensure adequate maintenance and review focused more on the preventive character. Consider purchasing other scales to load balance scales on scale 2.

However, another option would be to review the loading activity more thoroughly to analyze the way in which the auxiliaries are operating in order to increase the percentage of vehicles that pass the weight verification, and thus prevent the same vehicle from passing several times on scale 2, given that 30% of tractor trucks are returned to load because they are underloaded or needed to load.

Likewise, the analysis of the situation in the loading activity serves to make decisions about the operator's load due to the direct relationship between these two activities. It is very important to intervene on scale 2 because these have a great responsibility for the proper development of the process.

Now, within the aspects to improve and take into account in the research have, in order to have a digital twin as real as possible support the use of quality control tools and methods and times to know more specific elements that affects the development of the operation in reference to one of the most important resources of the organization as it is the labor, which is so decisive when studying the processes.

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