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Discrete Events Simulation Method for Analyze Cycle Time: A Case Study in the Plastics Industry Sector

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Abstract. This work shows the potential of the Discrete-Event Simulation -DES- in a software modeling process applied to business decision making, using a descriptive methodology in a productive process of a manufacturing plastic bags company. The analysis identified the process characteristics and built a simulated model in Arena® software. Simulation shown variability in the process greater than 50% in the cycle time, which negatively affects the economic interests of the company, impacting opportunities to supply the market risking its position with other companies in the sector. The method implemented in the present work allows to know the critical points of the process, evaluate them and project a path to obtain the optimal or most viable solution, and propose modifications rising up the probability of success of any improvement plan. This makes any economic investment or locative change a desition-making quantitative supported.

1. Introduction

Globally, the growing scientific and technological development and Free Trade Agreements (FTA) changes, allowed the entry of multinational companies to developing countries. This new scenario generated in some cases absorption of local companies due to a lack of competitive capacity, others closed, and others remain and undergo the transformation, adapting to the new challenges and demands of this increasingly competitive environment. This is why improvements should have, besides technological updates and innovation strategies, but assertive decision making that allows companies to accelerate their processes to become increasingly competitive. In the case of Colombia, according to [1] the increase in companies' productivity, must be one of the fundamental goals of competitiveness and productive development policies. As can be seen in [2], the manufacturing industry at least in Colombia can lose ground against other countries industry, showing the necessity to continue advancing in the strengthening of capacities in innovation and process improvement [3] even more due to events like gross domestic product (GDP) growing 2.2% in the second quarter of the first period of 2018 [4], which shows an alerts that should be attended. According to [5], the plastic sector has been negatively impacted in recent years. This sector has made specific requests to the Colombian government in tax, labor, and energy matters, due to the fierce competition with multinational companies, which have greater financial-economic muscle, better technology, and high-performance processes. These caused that the

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national companies have been acquired or absorbed by various multinationals, which makes the improvement in the productive and logistic systems of the national companies, a pressing need.

It's important to be aware, that companies must make strategic decisions to address the new market dynamics. This paper shows a case for process improvement decision making data-supported. For this, the production process of a company dedicated to the manufacture of plastic bags (polypropylene) was analyzed. Scientific literature shows that the simulation of discrete events (DES) is widely used quantitative processes in decision making. Works such as those carried out by [6], where a two-level remanufacturing system is modeled; or the one carried out by [7], which through simulation predicts the behavior of inputs and outputs of the material to designing a new warehouse. [8] Used simulation of discrete events to optimize resources in the emergency department in a hospital of the city of Cartagena. Also [9] used simulation of discrete events to assist supply chain managers in making decisions in the analysis of the inventory order history information for three different time periods. In accordance with [10], to carry out the simulation of discrete events it is necessary to perform a series of statistical tests, to establish confidence intervals so that the similarity between the simulated model and reality is identifiable.

2. Methodology

This work was developed following a three-phase methodology. The first phase documented the process, characterizing it and building a database with the results of the process. Second phase designed and evaluated the plastic bag production process through discrete events simulation, taking as a response variable the cycle time of three batches of different sizes. The third phase analyses and process the results for desition making related to raw material supply and resource allocation. An overview of the methodology is presented in Figure 1.

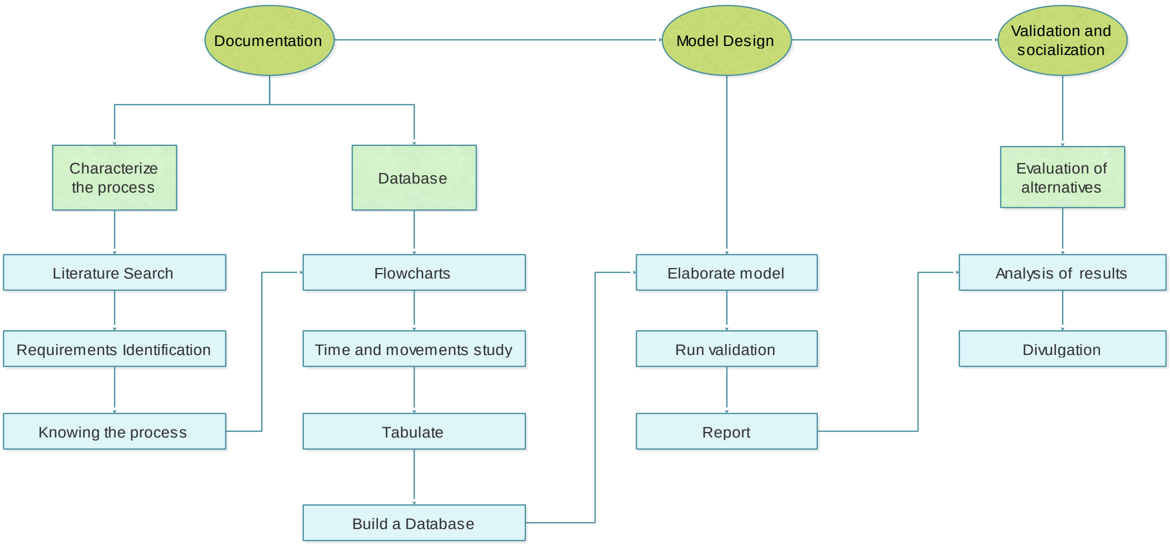

Figure 1. Applied methodology.

Phase 1 (Documentation) described the manufacturing process of plastic bags, in order to be able to characterize the process obtaining accurate and direct information from the personnel responsible for the production. Identifying at the same time the cost parameters for providing the financial analysis that complements the performance diagnosis. Also, data collected related to the variables and parameters in a company database helped to incorporate high-quality information into the simulated model. This information turned in flowcharts and SIPOC (Vendor-Entry-Process-Exit-Client) to perform the detailed model of the real system, following the methodology of [11].

Phase 2 (Model design) examined the data behavior by means of a series of statistical analyses, to determine if these present or don't abnormal system behavior. Then performed a heterogeneity test to check if data was homogeneous or not. In the event that the data is homogeneous, they should be represented by an existing probability distribution, and if not, each data set should be modeled separately. Then, the distribution parameters that should be entered in the simulation model should be calculated. This phase used a process simulation software for a virtual representation of the plastic bag manufacturing process.

Phase 3 (Validation and socialization) verify the reliability of the model. During this phase it performed 10 runs to estimate the size of the computational sample required. Once completed, a hypothesis testing is performed to determine if the simulated model is statistically equivalent to the actual manufacturing system. Finally, identified the critical points, bottlenecks or the rows and delays in each simulated station or process for strategies proposal that give solution to each specific point.

2.1. Case study analize approach

The problem approach selected to this work (Figure 2) was according to the contributions made by [12, 13]. Researchers selected 9 typical steps to analyze the problem through simulation of discrete events, described as next:

1. Problem formulation: includes the definition of the problem and set the objectives of the project.
2. Project planning: includes simulation programming tasks, assignment of roles and responsibilities.
3. System definition: identification of system components, input data, system processes, results, and performance measures.
4. Collection and analysis of input data: a collection of original data, use of existing data and statistical analysis.
5. Translation model: selection of the appropriate simulation, Software and model construction.
6. Verification & validation: Verification ensures that the model, works as intended and validation, determines whether the model represents reality.
7. Experimental design: determines which model alternatives will be beneficial to investigate.
8. Analysis: statistical comparisons between alternatives.
9. Presentation of conclusions and results.

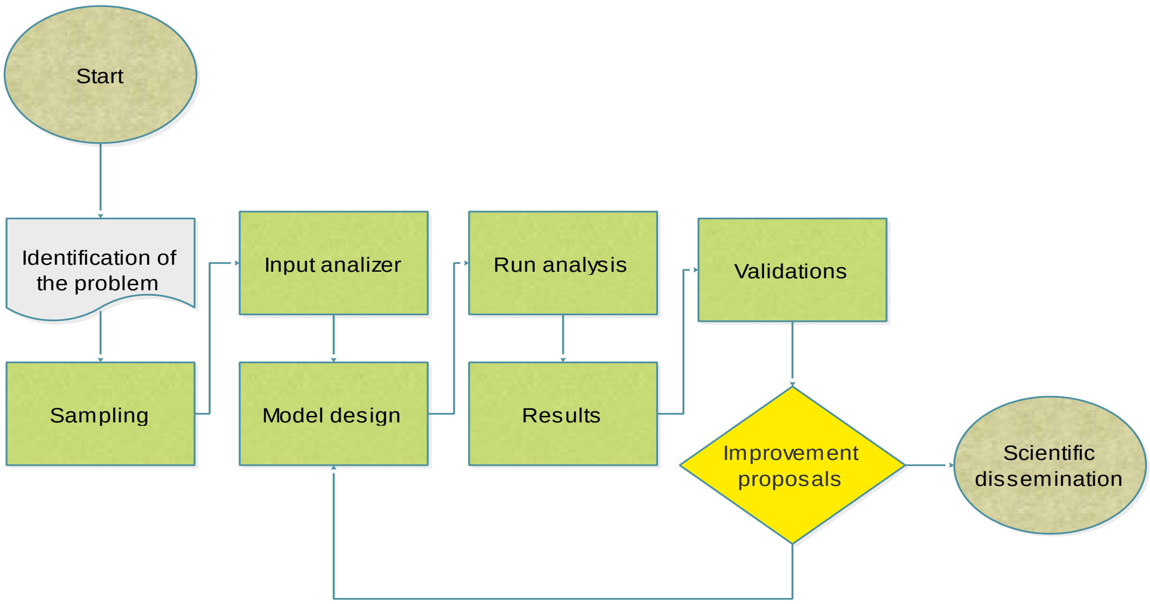

Figure 2. Steps for the development of the simulation model.

3. Case Study

The plastic bag manufacturing process for three types of bags consists of six main stages, namely:

1. Raw material supply process (High-density polyethylene and dyes)

2. Raw material processing
3. Extrusion (4 extruders of equal capacity 50-600 kg are used)
4. Sealing (1 sealer is used for each type of cut (3))
5. Coloration (an operator is used for product design)
6. Storage and dispatch

To identify the parties involved in this Process, researchers used the SIPOC diagram tool to identified input providers to the process, and what are the outputs of the process for customers (Figure 3) After that, the process diagram is carried out (Figure 4).

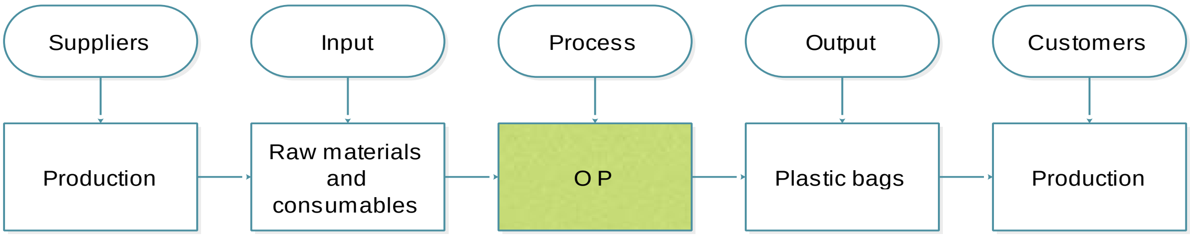

Figure 3. Application of the SIPOC tool

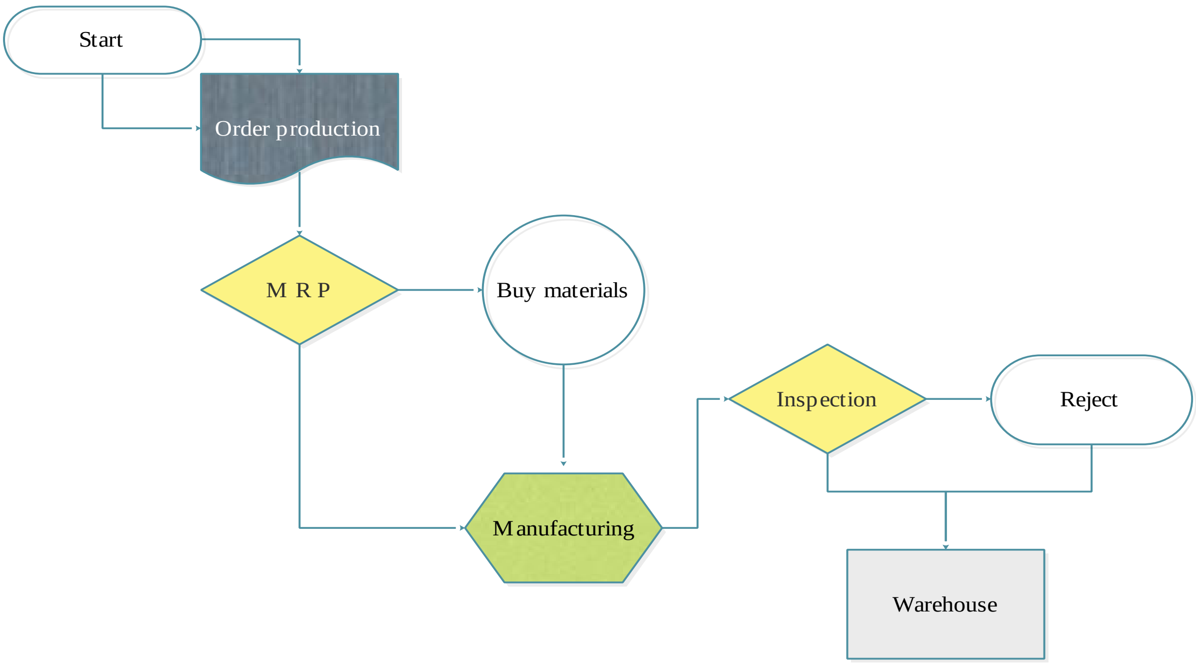

Figure 4. Diagram of the manufacturing process of plastic bags

The construction of the simulation model took into account the steps shown in the previous section: problem identification, data collection, model creation, validation, experimentation, and results. The plastic bag manufacturing process constructed in the Arena® software can be seen in Figure 5. On this, through statistical analysis determine which of the distributions of known probabilities resembles the process inputs associated with each activity. Once the distribution is identified and selected, a simulation of discrete events carried allowed the analysis of the cycle time of manufacturing plastic bags, to infer over it, and thus propose actions in order to improve the performance of the process.

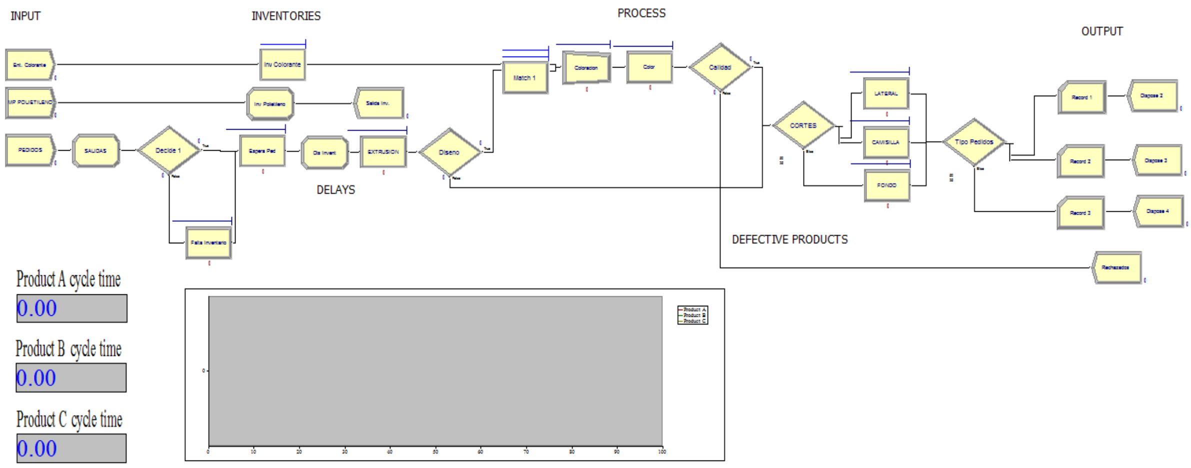

Figure 5. Simulation models of the manufacturing process of plastic bags, in Arena® software.

4. Results and discussions

Once the simulation was carried out, the resources that are critical within the process and the impact on the cycle times were identified, for example, in the manufacturing, the bottom cut activity has an average delay of 1.04 hours, while the shortage impacts on average 7.62 hours the cycle time. The results of the cycle times according to the order types are described below in Table 1:

Table 1. Cycle time by product type

Item	Average	Minimum value	Maximum value
Cycle time Product A	34,1263	33,0682	35,1844
Cycle time Product B	24,900	19,495	41,451
Cycle time Product C	10,961	7,267	14,861

At the same time, the statistic report yielded results about used resources in the process (Figure 6).

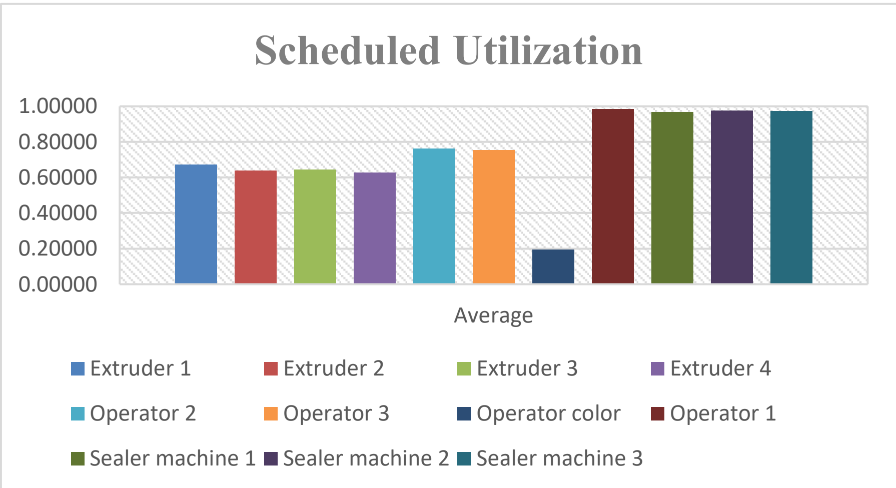

Figure 6. Resource utilization times

Homogeneity of cycle times can be observed in a pie chart shown in Figure 7.

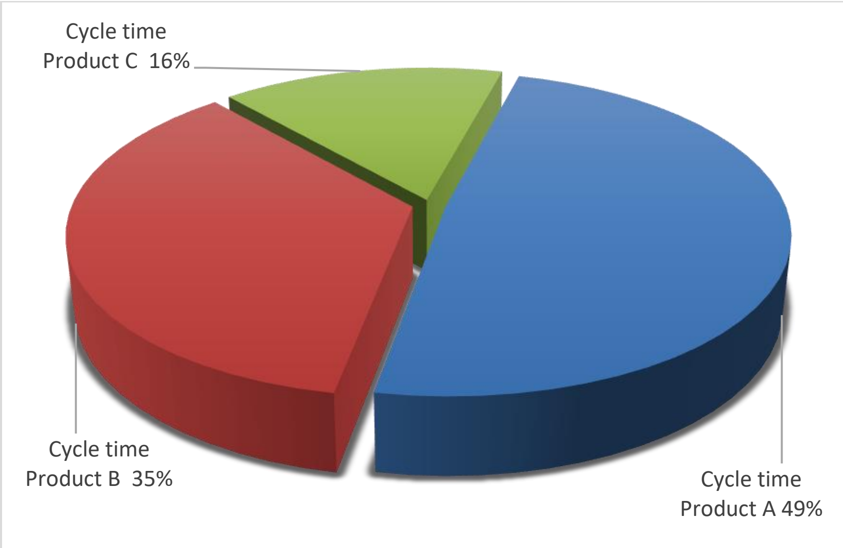

Figure 7. Percentage of time used for each product.

A deep homogeneity test is performed in Minitab® software using a box and whisker graph, to clearly visualize where the average of the data is, and check if the data follows the same sequence.

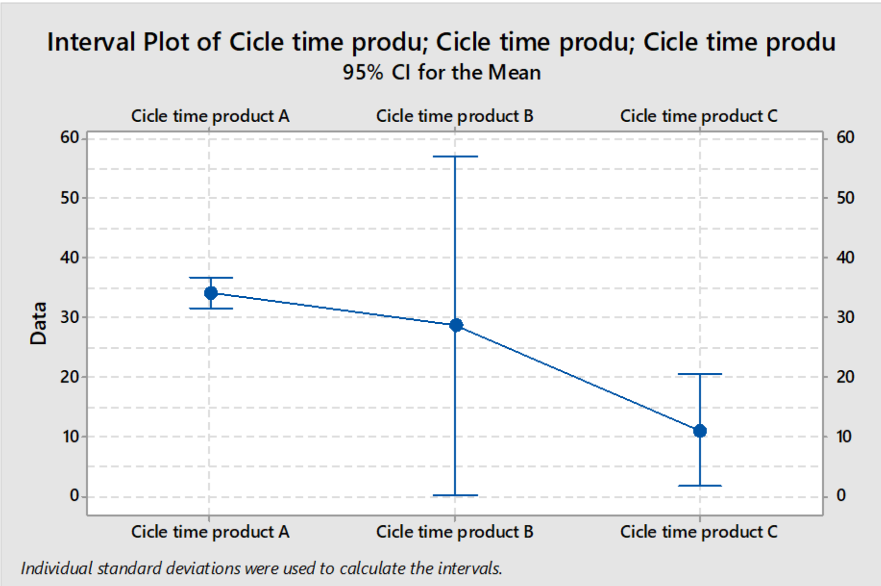

Figure 8. Homogeneity Test

The results are visible in Figure 8 where the high variability of the cycle time of product B is clearly evidenced, which is why this process should be intervened as soon as possible with the intention of reducing the cycle time. As can be seen, Discrete Event Simulation –DES in the Arena ® software, allows complex models analysis, due to its approach to processes with a flowchart type description, providing at the same time statistics data reports output based on different types of distribution, which is great for agile validations, [14, 15, 16]. Mixing a tool and techniques as made in the present work, show how useful is make quantitative process analysis before making any economic investment or location change into a process. Implementing tools for process analyzes techniques like DES allowed to make virtual adjustments and reevaluate it in order to find best or optimal strategies or improvement

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actions, that allow processes to generate true value to final clients and achieving productivity goals, improving company competitiveness, contributing business sustainability.

5. Conclusions

This case study demonstrated that there is the high potential of Discrete Events Simulation -DES- technique for process improvement decisions, but it should be noted that it is essential to have the truthful set of input data to make process modeling, which will give robustness to support desition making. Once this requirement is met, the descriptive methodology proposed in this article can be followed, using any process modeling tool. In this case study, the Arena® software.

The tool and methodology implemented for DES, allowed to detect in the case study a high variability in the process greater than 50% in the time cycle, which negatively affects the process performance and productivity goals of the company, cutting opportunity to supply the local market or compete with other companies in the sector. Also detected a high variability in the cycle time of one of the three different product of the process. Other advantages of using this technique were: observe the interactions between the units of the system, to know the behavior of the process at a certain moment of time, and estimate the probability of success and the percentage of occupation of the resources involved in the Process. Other advantages of using this technique are the observation of the interaction between the units of the System and gather knowledge of the behavior of the process in a certain moment of time.

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References

[1] Fedesarrollo 2014 Productividad y competitividad del Sistema de Ciudades (Bogotá).

[2] ANDI 2015. [En línea]. Available: http://www.andi.com.co/Uploads/Estrategia%20para%20una%20nueva%20industrializacion.pdf.

[3] ANDI 2017. [En línea]. Available: http://www.andi.com.co/Uploads/estrategia-para-una-nueva-industrializacion-ii.pdf.

[4] DANE 2018 dane.gov.co, Junio 2018. [En línea]. Available: http://www.dane.gov.co/files/investigaciones/boletines/pib/bol_PIB_IItrim18_producion_y_gasto.pdf.

[5] Revista Dinero 2018 Las reformas que pide el sector plástico al presidente Duque, *Industria,* 13 08 2018.

[6] Niranjan S 2017 A study of remanufacturing system in presence of unreliable supply of new products (*Las Vegas, NV, USA: Winter Simulation Conference WSC)* pp. 3459-3470

[7] Alvarez Rangel M A 2017 Simulación de un Sistema de Rollos para el Área de Corte (Lerma, Edo.de México)

[8] Medina P and Arrieta K Simulación de eventos discretos para optimizar recursos restrictivos del servicio de urgencias de un hospital (*Cartagena, Colombia Revista Científica Teknos,* vol. 13, nº 1) pp. 55-66, 2013

[9] Raznick E and Chatfield D C 2017 Information blackout in a multi-echelon supply chain simulation (*Las Vegas, NV, USA: Winter Simulation Conference WSC)*

[10] Herrera O J and Becerra L A 2014 Diseño General de las Etapas de Simulación de Procesos con Énfasis en el análisis de Entrada (Guayaquil Ecuador).

[11] Ortiz Barrios M.A., Escorcia Caballero J., Sánchez Sánchez F. 2015 A Methodology for the Creation of Integrated Service Networks in Outpatient Internal Medicine. In: Bravo J., Hervás R., Villarreal V. (eds) Ambient Intelligence for Health. AmIHEALTH 2015. Lecture Notes in Computer Science, vol 9456. Springer, Cham (Puerto Varas, Chile) pp. 247-257

[12] Shawki K, Kilani K and Gomaa M Analysis of earth-moving systems using discrete-event simulation (*Alexandria Engineering Journal)* pp. 533-540

[13] Troncoso-Palacio A, Neira-Rodado D, Ortíz-Barrios M, Jiménez-Delgado G, Hernández-Palma H 2018 Using Discrete-Event-Simulation for Improving Operational Efficiency in Laboratories: A Case Study in Pharmaceutical Industry. (Shangai China Advances in Swarm Intelligence. ICSI 2018. Lecture Notes in Computer Science, vol 10942. Springer, Cham) pp. 440-451

[14] Kelton W D, Sadowski R P and Sturrock D T 2008 Simulation with Arena (Nueva York: Editorial McGrawHill)

[15] Rabe M and Scheidler A A 2014 An approach for increasing the level of accuracy in Supply Chain simulation by using patterns on input data *(Savannah, GA Winter Simulation Conference WSC)*

[16] Kotachi M 2016 A Modeling and Simulation Platform for Evaluating Optimization Methods in Container Terminals *(Arlington, VA, USA: Winter Simulation Conference)*