Evaluation of multiple optimization scenarios for manual parcel handling cells with a focus on increasing productivity using FlexSim and Experimenter

Jonathan Sampaio Barreto[1*], Maíra Silva Andrade[1], Thiago Barros Murari[2].

[1]*SENAI CIMATEC, Núcleo de Modelagem e Simulação Computacional, Salvador, Bahia, Brazil*
[2]*SENAI CIMATEC, Modelagem Computacional, Salvador, Bahia, Brazil*
**Corresponding author: SENAI CIMATEC; Av. Orlando Gomes, 1845; jonathan.barreto@fbest.org.br*

Abstract: This article presents a systematic review of the literature on the use of simulation with FlexSim and Experimenter, focusing on manual parcel handling centers. The review aims to identify and analyze multiple simulation articles that address productivity improvement, idle time reduction, and process efficiency in manual operations. The methodology followed PRISMA guidelines, ensuring a structured process for study identification, screening, eligibility assessment and inclusion. The main literature findings indicate that simulation enables the evaluation of different scenarios and patterns, providing insights that, when combined with strategies such as Lean Manufacturing, lead to significant gains in productivity and efficiency. The studies reviewed reported productivity gains of up to 35% and reductions of up to 82% in operator travel time, demonstrating the potential impact of combining simulation with process improvement methodologies. It is concluded that the combined use of these tools not only allows the simulation of diverse scenarios but also facilitates decision-making and the development of innovative logistics solutions.
Keywords: FlexSim, Experimenter, scenarios, logistics solutions.

1. Introduction

In recent years, the demand for efficient logistics operations has grown exponentially, driven by the expansion of e-commerce and the need to optimize resources in a highly competitive market [1]. In the Brazilian context, the rapid growth of e-commerce has intensified the need for faster and more efficient logistics operations, creating pressure on parcel handling centers to adapt quickly.

In this scenario, where complex operations must be carried out quickly and accurately, the application of computer simulation techniques has emerged as a key approach to optimizing processes and increasing productivity. This context becomes even more relevant when operations involve manual parcel handling, which may present bottlenecks, time waste and resource allocation issues.

Simulation methodologies, particularly with FlexSim software and its Experimenter tool, allow the modeling and assessment of multiple scenarios without the interruptions and risks associated with real systems, offering valuable insights into operational performance and improvement feasibility [2].

FlexSim is a discrete-event simulation software designed for modeling, analyzing, and optimizing processes across various sectors, enabling a graphical representation of operational flows and the testing of different scenarios. The Experimenter, an integrated tool within FlexSim, allows for the automated execution of multiple simulations with varying

parameters, enabling comparative analyses and the identification of the most efficient configurations [3]. This combination facilitates the evaluation of alternatives prior to practical implementation, reducing operational costs and risks.

FlexSim stands out among simulation software for offering advanced functionalities for scenario modeling and performance analysis. It enables detailed mapping of workflow and cycle times, and, with Experimenter, facilitates sensitivity analyses and parameter tuning, providing a comprehensive view of potential improvements. In logistics centers, simulation is essential for managing systems with multiple variables and high complexity, enabling cost reductions and improved customer responsiveness [4].

Growing competitiveness also requires logistics centers to find ways to boost productivity and reduce waste [5]. The application of methodologies such as Lean has shown positive results, enabling the reduction of unnecessary movements and layout optimization [6]. These methods are even more effective when integrated with simplified computational modeling techniques, allowing for quicker and more efficient process analysis. This combination not only enhances performance but also supports faster decision-making, contributing to a more dynamic and responsive operational environment [7].

In this context, this article aims to conduct a systematic literature review on the use of FlexSim and Experimenter in optimizing manual parcel handling cells, focusing on productivity improvement scenarios. By analyzing multiple case studies and technical papers, the study seeks to synthesize evidence on the effectiveness of these tools in improving logistics flows and eliminating bottlenecks, contributing to the advancement of optimization practices in parcel handling centers.

Furthermore, the current evolution towards Logistics 4.0, characterized by the integration of advanced digital technologies, highlights the importance of simulation tools in strategic planning. FlexSim and Experimenter, when used in combination, not only enable virtual testing of operational strategies but also align with broader industry trends, such as predictive analytics, real-time monitoring, and data-driven decision-making.

2. Methodology

This study follows an initial approach based on PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) criteria as the foundation for the systematic review. The choice of PRISMA is justified by its ability to provide a structured guide for identifying, selecting, evaluating, and synthesizing studies. This methodology is widely used across research

areas due to its effectiveness in ensuring rigor and transparency for the validity of the findings.

In this work, adopting some PRISMA criteria allowed the systematic organization of information and the identification of consistent patterns across different studies. This was necessary given the analysis of multiple variables across scenarios related to modeling and simulating logistics processes.

During the selection process, it was observed that the number of studies focusing specifically on the optimization of manual parcel handling cells was limited. Studies applying FlexSim in logistics centers, focusing on productivity enhancement and idle time reduction, were considered. Studies without quantitative results or those applying simulation tools outside logistics contexts were excluded.

Data was collected from academic databases such as ScienceDirect and Google Scholar, as well as from university repositories and logistics/operations management conferences. The search included terms like “Parcel handling”, "FlexSim”, “Center logistics", "Simulation optimization", “Experimenter”, “Layout optimization”, and “Lean Manufacturing”.

Following PRISMA guidelines, the review followed four main phases: identification, screening, eligibility, and inclusion [8-9]. Searches were conducted in Scopus, Web of Science, and ScienceDirect using descriptors such as “discrete event simulation”, “parcel center”, “manual operations”, and “FlexSim”. A total of 138 records were initially identified, from which 32 duplicates were removed. After title and abstract screening, 76 articles were excluded for not fitting the thematic scope. Thirty studies were fully assessed, with 18 excluded due to lack of relevant data or for not addressing manual logistics contexts. Thus, 12 studies formed the final analysis base.

Effect measures were fundamental to assess the operational efficiency of the simulated scenarios. The effect measures included: percentage increase in productivity (based on processing capacity) and reduction in idle time. This approach allows identifying which changes generate the most positive impact, highlighting the importance of testing multiple configurations prior to implementation.

Variables such as performance increase, waste reduction, operator travel distance and machine utilization rate were analyzed. Specific FlexSim and Experimenter variables were also considered, such as the number of iterations required for optimization and the configuration time for experiments. These items were selected to ensure consistent comparisons across studies.

To synthesize results, some studies were compared using performance tables. The

synthesis method followed a qualitative meta-analysis approach, identifying common optimization patterns and improvements. Qualitative analysis was used to assess variable impacts across various logistics scenarios.

Following systematic review methods, a qualitative analysis was performed to identify patterns and discrepancies in simulation practices across studies. This method is consistent with similar reviews in logistics, particularly regarding logistics flow optimization using computer simulation.

3. Results and Discussion

The reviewed studies present a wide variety of logistics scenarios, ranging from fragile product distribution center operations to layout planning for workflow optimization. This diversity reflects the inherent complexity of logistics processes and the need to customize solutions according to each system's demands.

The analyzed variables are highly specific to the context of each study. For instance, while some emphasize worker utilization rate as a key indicator for manual processes [4], others highlight the importance of reducing operator travel distances in picking scenarios [10].

When analyzing the studies in a cross-comparative manner, it becomes evident that performance gains are often interdependent across metrics. This relationship suggests that layout optimization and workflow redesign, which directly impact operator movement, may serve as a primary driver for improvements in other performance indicators.

This specificity shows that although simulation with FlexSim and Experimenter tool are broadly applicable, result interpretation strongly depends on the logistics context. Therefore, it is essential to acknowledge that metrics from different studies are not directly comparable without considering their operational settings.

Another relevant aspect identified is the replicability of improvements across different logistics contexts. Even though each study had unique operational characteristics, certain strategies proved beneficial in multiple environments. While simulation outputs must be validated for each specific case, there is a repertoire of best practices that can serve as a starting point for optimization projects.

The studies analyzed in this review offer relevant insights for improving manual parcel handling processes, especially when using FlexSim and Experimenter for logistics optimization. The comparison of performance indicators extracted from the selected studies is summarized in Table 1.

Table 1. Summary of performance indicators in reviewed studies.

Title	Performance increase (%)	Machine utilization (%)	Operator distance reduction (%)	Travel time reduction (%)	Daily turnover increase (%)
Application of FlexSim in Handling Fragile and Unmachinable Items in a Logistics Center [1]	35	-	-	-	-
Resource Optimization via Discrete Event Simulation [2]	-	86.84	-	-	-
A Flexsim-based Optimization for the Operation Process of Cold-Chain Logistics Distribution Centre [4]	-	-	-	-	87
Lean Methodologies in a Distribution Center [6]	-	-	81.9	82	-
Development of a Continuous Improvement Program at the Logistics Center [10]	-	-	19	24	-

An important valuable finding relates to process movements and productivity improvement in picking. This study emphasizes the importance of mapping each step and using simulation to test scenarios that eliminate low-value activities [10].

Simulation enables precise control over material flows and better resource allocation, key benefits for logistics projects. Examples show that integrating tracking technologies with simulation can offer a comprehensive, detailed view, enabling real-time adjustments to layouts and operational routines.

The study demonstrated that it is possible to maximize the performance of a manual parcel handling cell by focusing on layout redesign and workflow configuration based on simulation. This is crucial, as even small changes can substantially impact capacity and productivity.

The Experimenter tool proved essential for testing scenarios, measuring performance, and optimizing processes, as simulation provides a practical way to visualize the effects of such changes [3]. This learning reinforces the importance of analyzing each process phase carefully to identify and reduce redundant activities, improving flow, response times, and removing non-value-added activities.

It was also observed that integrating simulation with emerging technologies can bring additional benefits, such as real-time process analysis and detailed resource availability and optimization [11]. These technologies include the Internet of Things (IoT), enabling remote monitoring and control of logistics equipment, and AI algorithms for demand forecasting and optimized resource allocation, which can significantly enhance operational performance.

This insight suggests that combining simulation with innovative technologies could be a future goal for this research, optimizing operator tracking and reducing process cycle time.

This learning process can guide continuous improvement practices, with simulation functioning not only as an analysis tool but also as a safe and economical experimentation mechanism.

The review also offers practical insights, such as the need for ongoing revision of simulation scenarios, as changes in operational parameters directly impact performance [12]. This continuous adaptation ensures that the simulation remains aligned with real conditions, maximizing its effectiveness as a decision-making tool.

4. Conclusion

The systematic review demonstrates that FlexSim and Experimenter can be powerful tools for optimizing operations in manual parcel handling centers. The analysis revealed that simulation not only facilitates testing of layout and resource allocation configurations but also offers valuable insights into process adjustments in response to demand variations and operational bottlenecks. The observed patterns, such as the effectiveness of Lean methodologies in reducing waste and optimizing processes, show that simulation can also be integrated with emerging technologies to maximize operational efficiency.

Although simulations using FlexSim and Experimenter are effective, it is important to recognize the limitations in generalizing results. Studies based solely on data from specific companies or logistics centers may not fully reflect other operational realities. Therefore, future studies should consider diverse operational contexts to enhance the external validity of their findings.

Additionally, future work should explore integrating FlexSim simulations with IoT systems, artificial intelligence algorithms, and predictive analytics in real-world scenarios. Including these elements could highlight the benefits of technological integration, contributing to innovation in logistics centers.

References

[1] Canipa, A.L.N., Cremonesi, F.C., Da Silva, M.M., Nascimento, R., Bueno, S. M., Gabriel, T.Q. and Da Silva, V.C.T., *Application of FlexSim in Handling Fragile and Unmachinable Items in a Logistics Center*. Jun. 2021. Available: https://prezi.com/p/npywhckx4bg5/flexsim-logistica/.

[2] Orozco-Crespo, E., Sablón-Cossio, N., Saraguro-Piarpuezán, R., Hermoso, D. and Rodríguez-Sánchez, Y., *Resource Optimization via Discrete Event Simulation*, Tecnology in Marcha, V. 32-2. Jun. 2019. 146-164.

[3] AUTODESK. *The Experimenter*. FlexSim Documentation, 2025. Available: https://docs.flexsim.com/en/25.1/Reference/Tools/Experimenter/Experimenter.html.

[4] Zhu, X., Zhang, R., Chu, F., He, Z. and Li, J., *A Flexsim-based Optimization for the Operation Process of Cold-Chain Logistics Distribution Centre*. Apr. 2014. DOI: https://doi.org/10.1016/S1665-6423(14)72343-0.

[5] Sartori, S., Ferreira, B.T., Merizio, M. and Gripa, S., *The use of FLEXSIM Software and its applicability for the continuous improvement of production systems*, Feb, 2020. Available: https://www.revistaespacios.com/a20v41n24/a20v41n24p08.pdf.

[6] Da Costa, Â.M.O., *Lean Methodologies in a Distribution Center*. Jul, 2021. Available: https://hdl.handle.net/1822/76140.

[7] Chwif, L., *Reducing discrete event simulation models in their conception: a causal approach,* São Paulo, 1999.

[8] Moher, D. et al. Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement. PLoS Medicine, v. 6, n. 7, p. e1000097, 2009. DOI: https://doi.org/10.1371/journal.pmed.1000097.

[9] Page, M.J., McKenzie, J.E., Bossuyt, P.M., Boutron I., Hoffmann, T. C., Mulrow, C.D. et al. *The PRISMA 2020 statement: an updated guideline for reporting systematic reviews*. BMJ 2021; 372: n71. DOI: https://doi.org/10.1136/bmj.n71.

[10] Rodrigues, M.I., "*Development of a Continuous Improvement Program at the Logistics Center*". Jan, 2024. Available: https://hdl.handle.net/10216/157285.

[11] Ljaskovska, S., et al. *Optimization of parameters of technological processes means of the flexsim simulation simulation program*. IEEE Third International Conference on Data Stream Mining & Processing (DSMP). IEEE, 2020. p. 391-397. DOI: 10.1109/DSMP47368.2020.9204029.

[12] Krynke, M., Personnel management on the production line using the FlexSim simulation environment, Manufacturing Technology, V. 21, n. 5, p. 657-667, 2021. DOI:10.21062/mft.2021.073.