**Supply Chain Last mile (SED)**

**Desarrollo**

#### **Selección de Libros**

1. Título: *Supply Chain Management: Strategy, Planning, and Operation* (7th Edition)

* Autor(es): Sunil Chopra.
* Justificación: Es considerado un texto fundamental y una referencia global en la gestión de la cadena de suministro. Aunque no se centra exclusivamente en la última milla, establece todas las bases teóricas sobre logística, gestión de inventarios, diseño de redes y transporte que son indispensables para entender la complejidad y los desafíos de la entrega final.

1. Título: *The Routledge Companion to Urban Logistics*

* Autor(es): Michael Browne, Stewart Allen, y Tom Cherrett.
* Justificación: Este libro se enfoca directamente en la logística urbana, el corazón de la última milla. Aborda temas contemporáneos como la sostenibilidad, las políticas públicas y las innovaciones tecnológicas (drones, vehículos eléctricos, puntos de conveniencia). Es perfecto para contextualizar los problemas específicos que se pueden modelar y simular.

1. Título: *Modeling the Supply Chain*

* Autor(es): W. David Kelton, Randall P. Sadowski, y Nancy B. Zupick.
* Justificación: Ofrece una base sólida en técnicas cuantitativas y de modelado matemático aplicadas a la cadena de suministro. Tiene un enfoque práctico permitiendo entender cómo estructurar y optimizar procesos logísticos complejos, como la entrega de última milla, utilizando herramientas como la simulación de eventos discretos. Además, integra aspectos estratégicos y operativos, lo que lo convierte en un recurso clave para diseñar modelos realistas y eficientes en entornos logísticos dinámicos.

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#### **Selección de Tutoriales/Presentaciones**

1. Titulo: Discrete Event Simulation for Supply Chain Optimization | Learning Sparks

* Canal: ASU Learning Enterprise
* Descripción: El video introduce la simulación de eventos discretos aplicada a cadenas de suministro complejas. Trata la creación de escenarios en tiempo real para analizar rendimiento logístico y permite experimentar con interrupciones, cuellos de botella y decisiones operativas.

1. Titulo: How To Use Simulation In Supply Chain? - The Friendly Statistician

* Canal: The Friendly Statistician
* Descripción: Un tutorial accesible que presenta los conceptos básicos de simulación en la cadena de suministro, incluyendo definición de eventos en DES, parametrización de modelos y casos de ejemplo sobre cómo mejorar flujos logísticos.

1. Titulo: Simulating a Multi-depot Omni-channel Last-mile Delivery Operation Using a VRP Solver and AnyLogic

* Canal: AnyLogic
* Descripción: muestra la construcción de un modelo en AnyLogic que simula un entorno omnicanal en la entrega de última milla desde múltiples depósitos. Incorpora un solver de VRP y rutas optimizadas, usando GIS y permite analizar eficiencia y cobertura.

#### **Selección de Artículos Generales**

#### *"Discrete-event simulation in logistics and supply chain management: a scientometric perspective"* – (2024) E.Bottani y G.Casella. Revisión del estado actual del paradigma de la simulación de eventos discretos

#### *"Last‑Mile Strategies for Urban Freight Delivery: A Systematic Review"* – (2022) T.Lyons y Noreen C. McDonald. Revisión de estrategias innovadoras en última milla urbana

#### *"A literature review of supply chain analyses integrating discrete event simulation and agent‑based simulation"* – (2023) C.Kogler. revisa integración de DES y ABS en SCM

#### *"Emerging Optimization Problems for Distribution in Same‑day Delivery"* – (2024) Y. Li, C.Archetti, Y.Ljubic. Aborda retos recientes en delivery inmediato, relevante para última milla y DES

1. "*Simulation of Last-Mile Delivery in E-commerce: A Review and Research Agenda*" – (2023) G. J. van der Veen y I. F. A. Vis. Revisión de la literatura sobre la simulación en la entrega de última milla en e-commerce y propone una agenda de investigación futura. <https://doi.org/10.1016/j.cie.2023.109279>

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#### **Selección de Artículos Específicos de la Temática**

1. *"Optimising Urban Freight Logistics Using Discrete‑Event Simulation"* – (2023) Z.Lyu, D.Pons, G.Palliparampil, Y.Zhang. Integra rutas y variables estocásticas en SED sobre entrega urbana.
2. *"Developing a Stochastic Two‑Tier Architecture for Modelling Last‑mile"* – (2023) Z.Lyu, D.Pons,J.Chen, Y.Zhang. Propone arquitectura SED‑GIS‑TSP para última milla; validada con datos de GPS.
3. *"Assessing sustainability of smart last mile delivery"* – (2025) M.Grazia, L.Rubrichi, F.Tornese. Herramienta SED para evaluar tecnologías inteligentes en entrega.
4. *"Full article: Last‑mile delivery performance of crowdsourced couriers"* – (2025) I.Celik, E.Aydemir, H.ibrahim, S.Guner. Analiza la performance de couriers crowdsourced, enfoque SED.
5. *"A Scalable Last‑Mile Delivery Service: From Simulation to Scaled Experiment"* – (2021) M.Ratnagiri, C.Dwyer, Logan E. Beaver, H.Bang, B.Chalaki, A. Malikopoulos. Muestra un DES junto a un experimento a escala con flota vehicular.

#### **Abstracts de los Artículos**

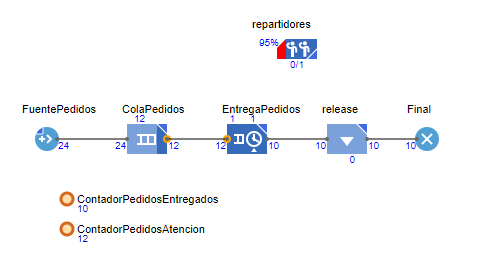
1. This paper has been designed in the form of a systematic literature review intended for evaluating the state-of-the-art of discrete-event simulation (DES) usage in the logistics and supply chain management fields under a scientometric perspective. With this primary aim in mind, 127 papers published between 2009 and 2022 are analysed, with the specific purposes of: 1) providing an overview of DES studies in logistics and supply chain management, map the main topics covered within this stream of literature and their evolution in time; 2) providing a robust ranking of the journals and authors in the field; 3) evaluating the rigor in the implementation of DES models in the logistics and supply chain management literature; and finally 4) correlating, through statistical elaborations, all the previous aspects to the success of these papers, measured as the citations received per year, taking inspiration from scientometric disciplines.
2. Trends in retail and e-commerce have led to greater demand for urban freight and last-mile deliveries. This is a concern for urban planners, parcel carriers, and citizens as they struggle to cope with the demands that increased freight flows create in an urban context. This topic has also seen a corresponding expansion in the academic literature as researchers propose solutions to the problem of last-mile delivery. We conduct a systematic review of the literature to identify innovative last-mile delivery strategies as well as ways that those strategies are evaluated by researchers. This study will help academics as they consider directing future research as well as practitioners as they assess how delivery patterns may shift. We identify 22 last-mile delivery strategies and group them into four categories: innovative vehicles, urban goods consolidation, technological and routing advances in city logistics, and emerging planning tools and policies. We find that urban consolidation centers, freight bicycles, and collaborative logistics are the strategies that have received the most attention to date. Analyses of these options has focused on operational, environmental, social, and economic impacts with operational efficiency, emissions, and congestion being the three evaluation criteria discussed most in the literature. We propose that safety has not been adequately considered as a means for evaluating last-mile delivery strategies and should be a higher-priority focus for urban freight research going forward.
3. Simulation and machine learning offer advanced methods to analyse complex flows, risks, and disruptions in supply chains. This literature review, based on a novel classification framework, traces the development of the research area from 2013 to 2025 and confirms intensified publication activities over the past 5 years. A majority of the analysed models merge discrete event simulation with reinforcement learning to cover an operational planning horizon and detailed to intermediate abstraction level. The comprehensive synthesis of 18 review articles, 72 research and conference papers, and 43 related studies explains integration approaches, discusses the current state of the art, and identifies research gaps. Existing individual limitations of discrete simulation and machine learning can be overcome by integrating those essential methods for supply chain analyses. This sets the stage for a new generation of models to plan, design, operate, control, and monitor supply chains in a sustainable, smart, and resilient way.
4. Same-day deliveries (SDD) have become a new standard to satisfy the "instant gratification" of online customers. Despite the existing powerful technologies deployed in last-mile delivery, SDD services face new decision-making challenges related to the trade-off between delivery cost and time. In addition, new challenges related to environmental issues, customer satisfaction, or fairness arise. Researchers have explored various approaches to face these challenges in the context of SDD, where stochastic and dynamic data uncertainty plays a fundamental role. In this paper, we carefully review the emerging routing problems and solutions proposed in the existing literature for SDD services. We survey papers related to how to deal with dynamic arrival times of orders, how to allocate time slots to deliveries, how to select the right delivery options, how to design pickup and delivery routes, or how to partition the delivery areas and decide the composition of the fleet. We also formulate and compare models for representative problems elaborating on the pros and cons that might guide practitioners in choosing the most appropriate objectives and constraints. Finally, we sketch challenges and identify future research directions.
5. The last-mile of a supply chain is considered the most expensive and polluting part of the delivery process. The rise of e-commerce has led to a significant increase in the number of last-mile deliveries, creating challenges for logistics service providers to organize the last-mile in a cost-efficient and sustainable way. Simulation is a powerful tool to design and evaluate new last-mile delivery concepts. This paper provides a systematic literature review on the use of simulation for last-mile delivery in an e-commerce setting. The review shows that the literature is fragmented and that there is a lack of generic simulation models and studies that provide managerial insights. Based on the review, we develop a research agenda that identifies key areas for future research, including the development of more realistic and integrated simulation models, the use of simulation to support decision-making in real-time, and the application of simulation to assess the impact of new technologies and business models on last-mile delivery performance.
6. The transport of freight involves numerous intermediate steps, such as freight consolidation, truck allocation, and routing, all of which exhibit high day-to-day variability. On the delivery side, drivers usually cover specific geographic regions, also known as clusters, to optimise operational efficiency. A crucial aspect of this process is the effective allocation of resources to match business requirements. The discrete-event simulation (DES) technique excels in replicating intricate real-world operations and can integrate a multitude of stochastic variables, thereby enhancing its utility for decision making. The objective of this study is to formulate a routing architecture that integrates with a DES model to capture the variability in freight operations. This integration is intended to provide robust support for informed decision-making processes. A two-tier hub-and-spoke (H&S) architecture was proposed to simulate stochastic routing for the truck fleet, which provided insights into travel distance and time for cluster-based delivery. Real industry data were employed in geographic information systems (GISs) to apply the density-based spatial clustering of applications with noise (DBSCAN) clustering method to identify customer clusters and establish a truck plan based on freight demand and truck capacity. This clustering analysis and simulation approach can serve as a planning tool for freight logistics companies and distributors to optimise their resource utilisation and operational efficiency, and the findings may be applied to develop plans for new regions with customer locations and freight demands. The original contribution of this study is the integration of variable last-mile routing and an operations model for freight decision making.

Keywords: [discrete-event simulation (DES)](https://www.mdpi.com/search?q=discrete-event+simulation+%28DES%29); [geographic information system (GIS)](https://www.mdpi.com/search?q=geographic+information+system+%28GIS%29); [freight logistics](https://www.mdpi.com/search?q=freight+logistics); [density-based clustering](https://www.mdpi.com/search?q=density-based+clustering)

1. Modelling freight logistics is challenging due to the variable consignments and diverse customers. Discrete-event Simulation (DES) is an approach that can model freight logistics and incorporate stochastic events. However, the flexible delivery routes of Pickup and Delivery (PUD) are still problematic to simulate. This research aims to develop last-mile delivery architecture in DES and evaluate the credibility of the model. A two-tier architecture was proposed and integrated with a DES model to simulate freight operations. The geographic foundation of the model was determined using Geographic Information Systems (GIS), including identifying customer locations, finding cluster centres, and implementing Travelling Salesman Problem (TSP) simulation. This complex model was simplified to the two-tier architecture with stochastic distances, which is more amenable to DES models. The model was validated with truck GPS data. The originality of the work is the development of a novel and simple methodology for developing a logistics model for highly variable last-mile delivery.
2. The increasing demand of e-commerce is forcing economic and environmental inefficiency in last mile logistics (LML). The adoption of smart and autonomous technologies, such as Unmanned Aerial Vehicles (UAVs) and Autonomous Delivery Robots (ADRs), is being evaluated in LML in order to increase its effectiveness. UAVs offer advantages such as faster delivery times and reduced traffic congestion, but face challenges like weather sensitivity and the need for dedicated take-off and landing infrastructure. ADRs can reduce emissions and operational costs compared to traditional LML systems, but their full application is limited mainly due to slower speeds and complex interactions with pedestrians. Despite their limitations, in future years these technologies could be fully applied for LML: thus, evaluating their environmental impact during LML service is necessary to plan their full-scale application. This study proposes a simulation-based decision support tool for assessing the performance of traditional and smart LML technologies according to economic and environmental points of view. By leveraging advanced simulation models, the proposed tool allows to estimate these impacts under varying operational conditions, providing a comprehensive framework for decision-making the LML field by comparing traditional versus innovative LML services. The tool was validated through a case study application in an urban context, demonstrating its ability to highlight the potential benefits and challenges of applying UAVs and ADRs into LML networks. Results indicate that unmanned delivery vehicles allow for a substantial reduction in carbon emissions in the operational phase, confirming their potential as a more environmentally sustainable solution for urban last mile logistics. In addition, the total cost associated with unmanned systems is found to be comparable to that of conventional vehicles, particularly when these latter operate under medium-to-high traffic conditions. Researchers and logistic companies can use this tool to evaluate and optimize the impact of their innovative LML services strategies and achieve improved economic and environmental sustainability levels.
3. This research examines the performance of crowdsourced couriers in last-mile delivery, focusing on user experiences, an aspect often overlooked in studies that rely on mathematical modelling and simulations. By analysing user reviews from online platforms in Turkey, the research compares crowdsourced couriers with traditional ones and explores how perceptions and service performance have evolved over time. User comments were extracted through web scraping, labelled for sentiment analysis, and analysed using topic modelling with machine learning algorithms. The results indicate that satisfaction levels in crowdsourced delivery are highly volatile, reflecting the variability and inconsistencies in service delivery. User satisfaction was quite high initially but has steadily declined. Traditional couriers, however, exhibit lower but more stable satisfaction levels. Turkish users prioritize accuracy, package safety, and convenience. Additionally, users now prioritize tracking capabilities over cost, signalling shifting preferences for service providers to address. These insights highlight areas for improvement in crowdsourced delivery practices.
4. In this paper, we investigate the problem of a last-mile delivery service that selects up to N available vehicles to deliver M packages from a centralized depot to M delivery locations. The objective of the last-mile delivery service is to jointly maximize customer satisfaction (minimize delivery time) and minimize operating cost (minimize total travel time) by selecting the optimal number of vehicles to perform the deliveries. We model this as an assignment (vehicles to packages) and path planning (determining the delivery order and route) problem, which is equivalent to the NP-hard multiple traveling salesperson problem. We propose a scalable heuristic algorithm, which sacrifices some optimality to achieve a reasonable computational cost for a high number of packages. The algorithm combines hierarchical clustering with a greedy search. To validate our approach, we compare the results of our simulation to experiments in a 1:25 scale robotic testbed for future mobility systems.

Prototipo Problema SED.

Para esta primera entrega generamos un modelo sencillo sobre una entrega de pedidos donde de primera mano generamos un proceso sencillo de entrega de pedidos, los clientes hacen cola para que los pedidos sean registrados por el repartidor y enviados a entrega, este proceso tiene un tiempo de minutos, nuestro propósito será mejorar este modelo para generar un modelo eficiente donde en este primero vemos que de 24 pedidos que llegaron, 12 salieron de la cola y solo 10 fueron procesados.Este modelo fue implementado utilizando un único resource pool (el repartidor) y únicamente con eventos, sin utilizar agentes ni entidades diferenciadas, como el tipo de pedido, su urgencia, ubicación o atributos específicos. No se incluyeron aspectos espaciales ni rutas de entrega, por lo que el modelo representa una aproximación básica al problema de la última milla.



Esta primera versión evidencia limitaciones operativas importantes, como cuellos de botella en el registro y procesamiento de pedidos. Esto deja la necesidad de rediseñar el modelo para incluir mayor complejidad y realismo, como por ejemplo:

* **Incorporación de agentes:** que representen los pedidos con características específicas (tipo de producto, destino, prioridad).
* **Segmentación de clientes:** y flujos diferenciados según tipo de servicio (urgente vs estándar).
* **Modelado de múltiples recursos:** (repartidores, vehículos, centros de consolidación).
* **Simular estrategias de despacho más complejas:** como rondas de reparto, agrupamiento de pedidos, o rutas por cercanía.
* **Incorporar ubicaciones espaciales simples**: ubicaciones en un mapa modelo 2d sencillo que permite al repartidor moverse entre puntos usando rutas básicas.
* **Evaluación de desempeño:** mediante indicadores como tiempo promedio de entrega, nivel de servicio, utilización de recursos, y satisfacción del cliente.

Este enfoque se inspira en trabajos recientes que promueven el uso combinado de simulación con inteligencia espacial y análisis operativo para optimizar el desempeño de servicios logísticos urbanos, incluyendo aspectos como la eficiencia, sostenibilidad, y satisfacción del cliente (Aljohani & Thompson, 2020; Noyan et al., 2024).