Chapter 4
The Deployment of Automated Parcel Lockers in Urban Logistics:
Notions, Planning Principles, and Applications

Jorge Chicaiza Vaca
TU Dortmund, Germany

Markus Rabe
https://orcid.org/0000-0002-7190-9321
TU Dortmund, Germany

Jesus Gonzalez-Feliu
https://orcid.org/0000-0002-0056-7627
Excelia Business School, France

ABSTRACT

This chapter reviews the notion of automated parcel lockers (APL) and proposes a simulation-optimization methodology for APL adoption as last-mile delivery scheme, reducing the risk of failures in their implementations. After addressing the main issues in APL deployment and simulation and optimization related to them, a method combining a system dynamics simulation model (SDSM) with a facility location problem (FLP) optimization model is proposed. Then, it is applied to a case in the city of Dortmund (Germany) assessing three scenarios of customer demand. The three scenarios (pessimistic, realistic, and optimistic) are simulated through a planning horizon of 60 months. Results show functional indicators (number of parcel lockers used and their coverage in the territory) and economic ones, mainly the net present value (NPV). The NPV determines the investment required to implement each scenario. From these investments, third-party logistics providers can decide about implementing APLs as delivery scheme.

DOI: 10.4018/979-8-3693-1447-0.ch004

INTRODUCTION

Last-mile logistics (LML) are often characterized as the most expensive and complicated part of the supply chain, featuring negative impacts on pollution and congestion in densely populated areas (Gonzalez-Feliu, 2017). The arrival of e-commerce has accentuated the number of individual home deliveries, increasing the LML flows. Investigating how to improve the efficiency of LML in urban areas is a significant driver for the success of e-commerce and contributes to alleviating the negative externalities of urban logistics derived from it.

Concerning decision support in urban logistics, various methods can be used (Gonzalez-Feliu, 2017, 2019), such as empirical approaches, statistical analyses, or integrated computer models and algorithms, among others. Concerning the last category of methods, researchers use simulation and optimization techniques as separate or alternative approaches in the operational research fields to solve complex problems (Figueira & Almada-Lobo, 2014). On the one hand, exploring the behavior of systems and estimating their response to various environmental changes is a main purpose of the use of simulation (Crainic et al., 2018). On the other hand, the optimization tries to solve logistic problems, minimizing the total operational costs or maximizing profits.

Automated parcel locker (APL) systems such as packstations or locker boxes ar analyzed as one of the most promising initiatives to improve the UL activities (Boudouin et al., 2013). APLs have electronic locks with variable opening codes and can be used by different consumers, whenever it is convenient for them. APLs group several lockers, sited in apartment blocks, workplaces, or railway stations. The costs of delivery using APLs are lower than home deliveries, and the risk of missed deliveries is reduced. Some studies confirm that online shoppers will use APLs more frequently in the future (Moroz & Polkowski, 2016). Moreover, with the last years' context (mainly related to pandemics and demand uncertainty), the use of APLs has been generalized and showed a significant increase (Sulkowski et al., 2022; Jang et al., 2024).

The main factors that influence APL deployment are the system behavior and the possible locations (and layout) of this system, which are fundamental in understanding their potential impact (Bonomi et al., 2022). Moreover, tactical and operational logistics planning and management can lead to take into account the characteristics of cities and the dynamics of consumption, mainly when those APLs are modular or mobile. According to the literature, planning and optimization approaches can be static or take into account the city's dynamics (Crainic et al., 2023). To address this issue, a combination of simulation and optimization methods seems the most suitable option (Rabe et al., 2021).

This chapter presents the main issues of simulation-optimization for mobile APL planning and management in urban logistics. First, the major background related to simulation and optimization methods for the targeted problem class is presented. Second, the general methodology, i.e., the global procedural model is explained. Third, each step of the procedure model is implemented in a case study for the city of Dortmund. Finally, the conclusions address the potential future research and applications.