Chapter 16
Drone Integration in Vehicle Routing: Advancements, Challenges, and E-Commerce Urban Applications

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ABSTRACT

This chapter examines the integration of drones into Vehicle Routing Problems (VRPs) and their impact on e-commerce and urban logistics. It highlights the benefits of drone delivery, focusing on last-mile logistics, with advantages such as reduced delivery times, cost-effectiveness, and expanded regional coverage. Drones also support environmental sustainability by lowering carbon emissions and promoting energy-efficient operations, aligning with ecological goals. The chapter reviews advancements in technology, optimization models, and routing techniques that enhance drone utility in congested urban areas. However, successful adoption faces challenges, including technical issues, security risks, public acceptance, and legal constraints. By analyzing these limitations, the chapter provides an overview of the current state of drone delivery in VRPs and offers practical recommendations to address these barriers, enabling improved integration of drones into urban logistics while advancing sustainability and reducing environmental impacts.

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1. INTRODUCTION

1.1 Background

Drone delivery is also an evolving and efficient opportunity for solving logistics problems experienced in conventional delivery systems, especially in relation to urban logistics. Certain challenges, such as traffic jams and time-sensitive delivery, have advanced the use of drones, which have certain advantages, including shorter delivery times, increased cost-effectiveness, and increased accessibility (She & Ouyang, 2021). Public interest in using drones for product delivery has been demonstrated by the largest companies, including Amazon, Google, DHL, and Walmart (Katochkov et al., 2020). Advancements in technology, such as batteries, improvements in load-bearing capability and changes in policy makers, have increased the viability of drone deliveries (Nonami, 2016). These changes have contributed to the development of more studies on the use of drones in VRPs, as these studies address the different forms of vehicle routing and scheduling to improve delayed deliveries. Companies such as Amazon have developed and implemented the use of drones for logistics through projects such as Prime Air; other companies such as Zookal and Royal Mail have used drones to increase their delivery service to reach and minimize operational costs (Welch, 2013; DroneLife, 2024). Hence, the delivery of goods via drones by incorporating VRPs has the potential to improve delivery routes, minimize impacts on the environment, and eliminate the constraints of traditional delivery methods (Moadab et al., 2022). In addition, the environmental impacts achieved by allowing delivery by drones eliminate the need for enormous conventional delivery automobiles, particularly in the extensive areas of dense populations, thus enhancing sustainable delivery methods (Smith et al., 2022). Drones have emerged as transformative tools in addressing global challenges at the intersection of technology, ecology, and human health. By minimizing emissions and enhancing last-mile delivery efficiency, drones are not only revolutionizing logistics but also supporting sustainable development goals. Their ability to deliver critical medical supplies to remote or underserved regions underscores their significance in healthcare innovation. Nevertheless, the actual usage of drones in logistics is mostly dependent on consumers. Perceptions of privacy infringements, safety concerns, and noise pollution among the public are additional obstacles to the widespread use of drone delivery services (Johnson et al., 2021). These challenges and advantages demonstrate that technology, the environment, and market reception are crucial determinants of success in contemporary logistics using drones. To provide an understanding of these areas and issues discussed in the integration of drones in VRPs, **Figure. 1** presents an interrelated map of the VRP with drone logistics, legal concerns, technology, and public perception.

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