

Capacity planning in a synergized passenger and freight urban delivery network

Cécile DUPOUY^{1,2}, François CLAUTIAUX², Walid KLIBI¹, Olivier LABARTHE¹

¹ CESIT, Kedge Business School, Bordeaux, France

`cecile.dupouy@kedgebs.com, walid.klibi@kedgebs.com, olivier.labarthe@kedgebs.com`

² Univ. Bordeaux, CNRS, Inria, IMB, UMR 5251, F-33400 Talence, France

`francois.clautiaux@math.u-bordeaux.fr`

Keywords : *tactical planning, capacity and resource deployment, two-stage stochastic programming, shared passenger–freight systems, autonomous vehicle, public transportation.*

1 Problem description

In this work, we introduce a new tactical capacity and resource deployment problem for an urban logistics orchestrator operating over a shared multimodal network of public transport (PT) and autonomous vehicles (AV). Urban parcel delivery systems are under increasing pressure due to the rapid growth of e-commerce and the demand for fast, reliable services, and pressure to reduce congestion and emissions [3]. At the same time, cities offer many mobility options for passengers: buses, tramways, metro systems, and now emerging autonomous shuttles. However, freight flows using the same streets and roads cannot access most of these mobility services. They remain almost entirely restricted to dedicated delivery vehicles. Passenger transport services generate substantial spare capacity during off-peak periods. Using part of this capacity for freight is a promising way to reduce the need for dedicated urban delivery fleets [2].

Building on this observation, we consider a shared passenger–freight urban mobility system. The city is divided into unit zones connected through a multimodal network of scheduled PT lines and AV shuttle lines. Each line follows a fixed route and timetable, and the planning horizon is divided into operational periods reflecting variations in passenger flows and in the freight capacity available in PT vehicles. Parcels are consolidated into standardized containers. Containerization is widely used in freight systems, as it achieves economies of scale and improves resource utilization [1]. Containers are loaded inside a secure compartment within PT vehicles or AV shuttles, and cannot be accessed by the passengers. While passengers naturally move through the network to access public transport, freight does not move by itself. Human operators are deployed in specific urban zones to perform loading, unloading, and transfer operations. Their presence is essential: zones without operators cannot use the shared network and must rely on private vehicles instead.

The capacity and resource deployment problem consists of deciding, at a tactical weekly horizon, how much freight capacity to reserve on the multimodal network and how to deploy the resources required to use it. The orchestrator must choose in advance which PT vehicles will carry freight, how many autonomous shuttles will operate on each line, how many standardized containers will be activated, and where human operators will be assigned across urban zones. These decisions must be made before the actual parcel demand and the availability of transport services are known. Once uncertainty is revealed, the orchestrator determines how parcels can move through the shared network, how containers can be routed, and when private vehicles must be used as a fallback.

2 Modeling approach

To address the problem of capacity planning in a synergized passenger and freight urban delivery network, we use a two-stage stochastic program. This approach is commonly used for tactical planning under uncertainty [4]. Uncertainty affects both parcel demand and the availability of transport services. For each scenario $\omega \in \Omega$, we specify a realization of origin-destination parcel volumes and the operational state of each PT and AV line, which may be disrupted or unavailable due to delays, incidents, or other exceptional events. In the first stage, the orchestrator makes all tactical anticipatory decisions: the amount of freight capacity reserved on PT vehicles, the number of AV shuttles deployed on each line, the number of containers activated, and the workforce allocated across zones and periods. These tactical choices must be fixed before demand volumes and service availability are known. In the second stage, once a scenario is revealed, operational recourse decisions determine how parcels are assigned to containers, how containers are routed through the scheduled multimodal network, and when private vehicles must be used as a fallback. Feasible flows depend on the capacities reserved in the first stage and on the scenario-dependent availability of PT and AV lines.

The planning horizon spans one week and is divided into operational periods of two hours. This temporal structure captures the daily fluctuations of passenger flows and, consequently, the freight capacity available in PT vehicles.

The model aims to maximize the expected profit of the shared delivery system for the orchestrator. Logistics Service Providers pay the orchestrator for the transport of their parcels through the multimodal network, and the revenue generated depends on the volumes successfully carried on PT and AV services. Against these revenues, the orchestrator must account for tactical reservation costs for PT and AV capacity, container activation costs, and workforce allocation costs. Once demand and service availability are revealed, additional operational costs arise, especially when part of the flow must be handled through private fallback vehicles in case of insufficient reserved capacity or line disruptions.

This extended abstract introduces the problem setting and modeling framework. Ongoing work includes the development of algorithms and a numerical study based on a real multimodal network and demand data from the city of Bordeaux, France.

References

- [1] Teodor Gabriel Crainic and Walter Rei. 50 years of operations research for the tactical planning of consolidation-based freight transportation. *EURO Journal on Transportation and Logistics*, page 100157, 2025.
- [2] Ezzeddine Fatnassi, Jouhaina Chaouachi, and Walid Klibi. Planning and operating a shared goods and passengers on-demand rapid transit system for sustainable city-logistics. *Transportation Research Part B: Methodological*, 81:440–460, 2015.
- [3] Louis Faugère, Walid Klibi, Chelsea White III, and Benoit Montreuil. Dynamic pooled capacity deployment for urban parcel logistics. *European Journal of Operational Research*, 303(2):650–667, 2022.
- [4] Mike Hewitt, Teodor Gabriel Crainic, Maciek Nowak, and Walter Rei. Scheduled service network design with resource acquisition and management under uncertainty. *Transportation Research Part B: Methodological*, 128:324–343, 2019.