System Behavior for Automated Parcel Lockers as an Urban Logistics Delivery Scheme

Markus Rabe
Department of IT in Production and Logistics
Technical University Dortmund
Leonhard-Euler-Str. 5
Dortmund, 44227, GERMANY
markus.rabe@tu-dortmund.de

Jorge Chicaiza-Vaca
Department of IT in Production and Logistics
Technical University Dortmund
Leonhard-Euler-Str. 5
Dortmund, 44227, GERMANY
jorge.chicaiza@tu-dortmund.de

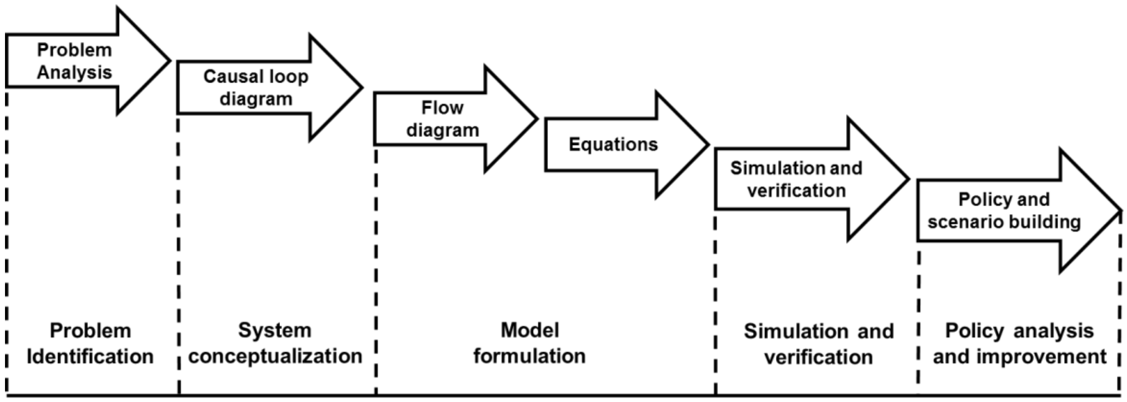
Jesús González-Feliu
Department of Supply Chain and Project Management
La Rochelle Business School
102 Rue de Coureilles
La Rochelle, 17000, FRANCE
gonzalezfeliuj@excelia-group.com

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 (UL) derived from it. An automated parcel locker (APL) is a valuable solution for these challenges. In our current work, we analyze the use of APLs such as packstations or locker boxes as one of the most promising initiatives to improve the UL activities (Boudoin et al., 2013). The APL has electronic locks with variable opening codes and can be used by different consumers, whenever it is convenient for them. Some studies confirm that online shoppers will use APLs more frequently in the future (Moroz and Polkowski, 2016).

APLs can be found around the world and receive increasing interest from a research viewpoint. Boudoin et al. (2013) and Zurel et al. (2018) presented general overviews of different experiences. For example, German 'Packstations' have been in action since 2001, with Deutsche Post DHL Group starting this business 20 years ago. The company now runs more than 3.700 APLs in Germany alone. Similarly, the Posten Norge has started a pilot project in Oslo with 100 APLs known as Pakkeboks (E-commerce News, 2020). The pilot project is carried out over six months and is operating in cooperation with SwipBox. The test is meant to provide insight for the further rollout of a new APL network in Norway. The Posten Norgen company stated that it will soon be possible for consumers to use the APL to return parcels to online shops or to send parcels to other individuals. APLs offer the possibility of conducting a non-attended delivery (i.e., delivering parcels without a receiver being present), thereby reducing the number of failed deliveries (Iwan et al., 2016; Vakulenko et al., 2018; Zurel et al., 2018). They consolidate the demand of different customers at one single point, increasing the ratio of deliveries per stop. Moreover, the customers use them as both delivery and collect points, where they can return unsatisfactory items.

On the one hand, the scientific literature has been devoted to analyzing the potential savings of APL usage (Morganti et al., 2014; Iwan et al., 2016). Most authors agree that the benefits of APLs will vanish if they require private car trips from the customers. Guerrero and Díaz-Ramírez (2017) remark that the APL strategy has not been discussed in the scientific field. In consequence, the actual urban parcel delivery market remains understudied. Jlassi et al. (2017) highlight the almost absence of system dynamics (SD) simulation applied in the UL field. In those works, local visions are adopted, but the systemic (or holistic) viewpoint is not taken into account (stakeholders, processes, interactions, and others). On the other hand, one of the most critical expectations of APL users is their location. These include the close location from customers' homes, on the way to work, and the availability of parking spaces. Many studies did not look at network design issues such as the APL installation costs as well as the required capacity for seasonal peaks in e-commerce. For those reasons, a systemic approach taking into account those network components is not only an insufficiently considered concept but also a challenging and suitable approach to analyze and plan APL networks.

In this paper, we propose an SD simulation model (SDSM) for the APL as an UL delivery scheme. The SDSM serves to understand the APL system components' behavior, and it will be used as a decision support tool for future APL implementations. For developing an SD model, Sterman (2000) presents a modeling process with the following steps: (i) problem analysis, (ii) dynamic hypothesis, (iii) model formulation, (iv) simulation and verification, and (v) policy analysis. Figure illustrates the SDSM process.



In the logistics context, Villa et al. (2015) presented an SD model that already analyzed the decisions and interdependencies between customers, retailers, and suppliers from an economic research perspective. Thaller et al. (2017) presented a specific application of SD in UL operations, and La Torre et al. (2018) showed an SD model that studied the customer behavior from a last-mile context perspective.

For our model, we have considered three scenarios to cover pessimistic (S1), realistic (S2), and optimistic (S3) developments. The planning horizon has always been 60 months. The results for the number of deliveries (units) after 60 months show a wide spread from around 220,000 in the pessimistic case to more than a million in the optimistic case. Obviously, there is a strong impact on the number of APLs that the city needs. In the first month, this figure varies from 8 (pessimistic) to 41 (optimistic). After 60 months, the numbers grow to 37 and 186, respectively. Interestingly, the "realistic" scenario leads to a number of APLs required that lies just in the middle of the other two scenarios, i.e., the effect on the APLs appears linear with respect to the e-consumers without obvious scale effects.

We conclude that using an SDSM for understanding the APL components' behavior is a suitable tool to help service companies for future APL implementations. The first approximation of the SDSM presented in this paper could be applied for any city around the world, adapting the model components to their specific characteristics. Especially in cities in emerging markets, the applications of the model could be very useful, considering the few APL adaptations as a delivery scheme in these kinds of markets.

References

Beemelmanns L. 2016. DHL-Packstation an der Prämienstraße wird erweitert. Available: https://www.aachener-nachrichten.de/lokales/stolberg/dhl-packstation-an-der-praemienstrasse-wird-erweitert_aid-25082967 [30 January 2020].

Boudoin D, Morel C, Gardat M. 2013. Supply Chains and Urban Logistics Platforms. In Gonzalez-Feliu J, Semet F, Routhier J (eds) *Sustainable Urban Logistics: Concepts, Methods and Information Systems*. Springer: New York; 1–20.

Durand B, Gonzalez-Feliu J. 2012. Urban Logistics and E-Grocery: Have Proximity Delivery Services a Positive Impact on Shopping Trips? *Procedia - Social and Behavioral Sciences* **39**: 510–520.

E-commerce News. 2020. Posten Norge Tests Parcel Lockers in Norway. Available: https://ecommercenews.eu/posten-norge-tests-parcel-lockers-in-norway/ [30 January 2020].

Forrester JW. 1968. Industrial Dynamics after the First Decade. *Management Science* **14**(7): 398–415.

Gonzalez-Feliu J. 2017. *Sustainable Urban Logistics: Planning and Evaluation*. ISTE Ltd / John Wiley and Sons Inc: Hoboken NJ.

Guerrero J, Díaz-Ramírez J. 2017. A Review on Transportation Last-Mile Network Design and Urban Freight Vehicles. In *Proceedings of the 2017 International Conference on Industrial Engineering and Operations Management*. Bristol, UK; 533–552.

Hernández B, Jiménez J, Martín MJ. 2010. Customer Behavior in Electronic Commerce: The Moderating Effect of E-Purchasing Experience. *Journal of Business Research* **63**(9-10): 964–971.

Iwan S, Kijewska K, Lemke J. 2016. Analysis of Parcel Lockers' Efficiency as the Last Mile Delivery Solution – The Results of the Research in Poland. *Transportation Research Procedia* **12**: 644–655.

Jlassi S, Tamayo S, Gaudron A. 2017. Simulation Applied to Urban Logistics: A State of the Art. In *Proceedings of 10th International Conference on City Logistics*. Phuket, Thailand.

La Torre G de, Gruchmann T, Kamath V, Melkonyan A, Krumme K. 2018. A System Dynamics-Based Simulation Model to Analyze Consumers' Behavior Based on Participatory Systems Mapping – A "Last Mile" Perspective. In Melkonyan A, Krumme K (eds) *Innovative Logistics Services and Sustainable Lifestyles*. Springer Science and Business Media: New York NY; 165–194.

Morganti E, Dablanc L, Fortin F. 2014. Final Deliveries for Online Shopping: The Deployment of Pickup Point Networks in Urban and Suburban Areas. *Research in Transportation Business & Management* **11**: 23–31.

Moroz M, Polkowski Z. 2016. The Last Mile Issue and Urban Logistics: Choosing Parcel Machines in the Context of the Ecological Attitudes of the Y Generation Consumers Purchasing Online. *Transportation Research Procedia* **16**: 378–393.

Sterman J. 2000. *Business Dynamics*. Irwin/McGraw-Hill: Boston.

Taniguchi E, Thompson R, Yamada T. 2012. Emerging Techniques for Enhancing the Practical Application of City Logistics Models. *Procedia - Social and Behavioral Sciences* **39**: 3–18.

Thaller C, Niemann F, Dahmen B, Clausen U, Leerkamp B. 2017. Describing and Explaining Urban Freight Transport by System Dynamics. *Transportation Research Procedia* **25**: 1075–1094.

Vakulenko Y, Hellström D, Hjort K. 2018. What's in the Parcel Locker? Exploring Customer Value in E-commerce Last-Mile Delivery. *Journal of Business Research* **88**: 421–427.

Villa S, Gonçalves P, Arango S. 2015. Exploring Retailers' Ordering Decisions Under Delays. *System Dynamics Review* **31**(1-2): 1–27.

Zurel Ö, van Hoyweghen L, Braes S, Seghers A. 2018. Parcel Lockers, an Answer to the Pressure on the Last Mile Delivery? In Parcu PL, Brennan TJ, Glass V (eds) *New Business and Regulatory Strategies in the Postal Sector*. Springer International Publishing: Cham; 299–312.