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D3.6 LL The Hague Value Case

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Contents

Executive Summary 9
1. Introduction 10
1.1 Scope and objectives 10
1.2 How does this deliverable relate to other deliverables? 11
1.3 Structure of the document 11
2 The Hague Living Lab pilots 12
2.1 Living Lab vision 12
2.2 Description of Minimum Viable Products 13
2.2 Pilot activities 14
2.1.1 MVP 1: Crowdshipping Logistics 14
2.1.2 MVP 2: Public Parcel Locker Network 17
2.1.3 MVP 3: Integrated Crowdshipping Locker Network 19
2.2.3 General conclusions 23
2.2.4 Workshops and events 24
2.4 Pilot validation and user acceptance 26
2.5 Digital twin validation and user acceptance 26
3 Digital twin: Scenarios modelling 27
3.1 Models used in the Digital Twin 28
3.1.1 Configuration of the DT 28
3.1.2 LL Data collection and anonymisation 28
3.1.3 LL2 definition of the modelling conditions 28
3.2 LL2 Digital twin: user interface and data ingestion 29
3.3 Digital twin: verification process 30
3.4 Digital twin: Value case scenario definition 30
3.5 Digital twin: “What if” scenarios simulation and results 31
3.5.1 Scenario 1: Crowdshipping simulations 31
3.5.2 Scenario 2: Parcel lockers 33
3.5.3 Scenario 3: Parcel lockers and Crowdshipping results 34
4 KPIs measurements 35
5 Learnings and recommendations 39
6 Summary and outlook 40

References 41
Annex 1: Further pilot details 42
Annex 3: Configuration of DTs 46
Annex 4: Simulation scenarios details 50
Annex 5: Workshops' details 55

Table of Figures

Figure 1. Hyperconnected City Logistics (Crainic & Montreuil, 2016)....12
Figure 2. Living Lab development path....13
Figure 3. Living Lab implementation....14
Figure 4. Stated preference for trip based crowdshipping....15
Figure 5. Stated preference for home based crowdshipping....15
Figure 6. Remuneration per km....16
Figure 7. MyPup app and platform....17
Figure 8. Stadsboerderij De Kakelhof, The Hague....18
Figure 9. Location of the Stadsboerderij in Den Haag....18
Figure 10. Parcel locker and crowdshipping concept....19
Figure 11. Description of package delivery scenarios tested in MVP 3....20
Figure 12. Splitting Crowd Shipping flows....21
Figure 13. Architecture integrated platform....22
Figure 14. Models for LL2 DT....27
Figure 15. LL2 DT dashboard....29
Figure 16. LL2 DT scenario builder....29
Figure 17. Parcel remuneration and platform revenue in scenario 1....31
Figure 18. Parcel fulfilment in scenario 1 for all deliveries (left) and L2L (right)....32
Figure 19. The Hague with the depots and parcel locker locations....33
Figure 20. The Kakelhof in the DT map....34
Annex Figure 1. Nimber dashboard....42
Annex Figure 2. Nimber task example....42
Annex Figure 3. Parcel locker plans....43
Annex Figure 4. MVP3 design session....43

Table of Tables

Table 1. Deliverable’s adherence to LEAD objectives and Work Plan 10
Table 2. Value case definition 30
Table 3. Sustainability Impact Assessment Indicators 35
Table 4. LL2 The Hague: Specific stakeholders' objectives and KPIs (D3.1, 2021) 37
Annex Table 1. LEAD Environmental KPIs 44
Annex Table 2. LEAD Social KPIs: 44
Annex Table 3. LEAD Economic KPIs 45
Annex Table 4. Configuration of the DT for LL2 46
Annex Table 5. Complete KPI list from simulations 50

Acronyms

Acronyms	Explanation
ABM	Agent based model
API	Application Programming Interface
B2B	Business to business
B2C	Business to consumer
C2B	Consumer to business
C2C	Consumer to consumer
CoP	Communities of Practice
COPERT	EU standard vehicle emissions calculator
DDDAS	Dynamic Data-Driven Application System
DT	Digital Twin
GDP	Gross domestic product
GitHUB	Web-based hosting service for software development projects
INLE	Inlecom (Project partner)
KPIs	Key performance indicators
LL	Living Lab
LL2	Living Lab 2, The Hague
LSP	Logistic Service Provider
MVP	Minimum Viable Product
VoT	Value of Time
WP	Work Package

Executive Summary

The city of The Hague is one of the largest cities in the Netherlands and the Dutch political centre. Although equipped with a large number of public transport connections, only 10% of the population use public transportation as their main transportation mode. The huge amount of 3.500.000 vehicle kilometres per year creates a problem for the city that leads to congestion, especially during rush hours. Moreover, the high demand for parcel deliveries that was accelerated during Covid-19 is expected to continue. These deliveries have several negative effects, such as more traffic congestion, increases in energy consumption and air pollution.

To deal with these effects the city is looking into developing hyperconnected city logistics. The aim of the Hague Living Lab (LL) is to integrate physical logistic facilities and capabilities, and the digital integration of independent logistic networks via the development of two parallel Minimum Viable Product (MVP) tracks that converge to the final product of a city logistic platform that envisions the hyperconnected city.

The objective of this deliverable is to report modelling activities and data sources used in The Hague Living Lab. It includes a description of the MVPs of The Hague: (1) ‘Crowdshipping Logistics’ (MVP1) and (2) ‘Public Parcel Locker Network (MVP2). Both result in (3) Integrated Crowdshipping Locker Network (MVP3). In parallel, to scale up the effects of the various physical pilots, a simulation environment has been developed that applies and connects various models into The Hague Digital Twin (DT).

In the DT, a parcel generator model simulates the demand for parcels that are fed to the Parcel Market Model, where the integration of the delivery networks and the fulfilment of the generated parcels is done either by passengers (crowdshippers) or by couriers. For each of the parcels delivered by each of the couriers, the Parcel Tour Formation Model generates an approximation to the tours needed. The results are fed into the Network Assignment Model that loads the streets of the city. Finally, the loaded network results are used by COPERT to estimate the emission impact of the scenarios. The data used to estimate and calibrate the models are derived either from already existing models and databases in the city of the Hague or are collected from the physical pilots.

From the pilot and simulations, crowdshipping looks like a feasible way to reduce emissions as long as the remuneration is not high enough to attract existing or new car users. Moreover, from the simulations we concluded that parcel lockers have potential to reduce congestion and emissions as well, which is encouraging towards the vision of an open platform for urban logistic implementation. The DT has proven to be an important tool for testing these kinds of innovations before a full-scale implementation.

Besides the MVPs developments, the deliverable the descriptions of the specific models developed by the LL and the models configured from the Digital Twin Model Library. It also includes the verification process for validating the simulation scenarios and validating the KPIs baseline measurements, as well as the insights from the workshops with the community of practice, feedback from participants and partners and a further implementation plan for the continuation and scale up of the physical pilots with our project partners.

1. Introduction

1.1 Scope and objectives

This report provides an updated and final version of the activities and results presented in D3.5 (Tapia et al. 2022) with the objective to report the final release of the demonstrator including user acceptance, recommendations and lesson learned, present the final artifacts/ models of the LL2 Digital Twin, and set of explanatory simulation scenarios demonstrating the efficiencies achieved.

The modelling part describes the LL2 specific model built. It includes conceptual diagrams of the agent-based models for representing the stakeholders involved in the LL2 use case.

Table 1 contains the deliverable adherence to LEAD LL objectives covered during the modelling phase, the baseline KPI measurements and the verification and validation process, including the assumptions, data sources and data ingestion used.

Table 1. Deliverable's adherence to LEAD objectives and Work Plan

LEAD GA Requirements	Section(s) of present deliverable addressing LEAD GA	Description
ST3.6.1 Preparation. MVP Specification and Modelling.	Chapter 2.1 (Living lab vision) and 2.2 (Description of Minimum Viable Product)	This section covers the conceptualization of The Hague's pilot. Specifically, chapter 2.1 provides the vision of the LL and chapter 2.2 provides the actual definition of the MVP.
	Chapter 3.1 Scenarios Modelling and chapter 3.2 configuration of the DT	These sections show the models and configurations used in the DT (not changed since D3.5) and the user interface from the current LEAD platform.
ST3.6.2. Digital Twin Verification.	Chapter 4. Baseline KPIs measurements	This Chapter reports the results of the KPIs described in D3.1 baseline measurement.
	Chapter 2.5. Digital Twin validation and user acceptance	This section describes the verification process for validating DT by the LL CoP.
ST3.6.3. Real-life implementation.	Chapter 3. Simulation environment.	This Chapter reports the modelling conditions/ assumptions; the data sources and data ingested used for calculating the baseline KPIs measurements, key results of the simulation exercises and verifying and validating the DT.
	Chapter 2.3. Pilot activities	This section reports the execution and results from the physical pilots to configure the DT.

ST3.6.4. Evaluation impact assessment	Chapter 2.4 Pilot validation and user acceptance, 2.5 Digital twin validation and user acceptance	These sections show the results from the validation survey done after the workshops
	Section 2.2.5 General conclusions	This sub section describes the main lessons from the pilot activities
	Chapter 4 KPIs measurements	This chapter describes the KPIs estimated in the LL
	Chapter 5 Learnings and recommendations and Chapter 6 Summary and outlook	This chapter summarises the lessons learnt and proposed the outlook for the next steps.

1.2 How does this deliverable relate to other deliverables?

This report is the updated version of the D3.5 and contributes to the D3.2 and D3.15. It is based on the results of T1.4 and ST3.1.1. KPIs results will be communicated to the responsible of T3.8

1.3 Structure of the document

- Chapter 1: Introduction
- Chapter 2: The Hague pilots
- Chapter 3: Simulation environment
- Chapter 4: Baseline KPIs measurement
- Chapter 5: Digital twin verification and validation
- Chapter 6: Implementation timeline
- Chapter 7: Learnings and recommendations
- Chapter 8: Summary and outlook

2 The Hague Living Lab pilots

In this chapter we describe the pilot and validation activities since the D3.5 report (Tapia et al. 2022). It begins with a description of the overall goals and the two different pilots. Hereafter, the architecture of the city logistics platform is discussed.

2.1 Living Lab vision

As described in Deliverable 3.5 (Tapia et al. 2022), the LL2 aims to implement the concept of hyperconnected city (Crainic & Montreuil, 2016). The concept of the hyperconnected city is based on numerous multi-modal logistics and transportation service providers which could cooperate by smart consolidation and synchronization of service. Cooperation can occur vertically and horizontally. In the first case, services have been connected at their end points to create a new door-to-door transport chain. In the second, services share capacity to increase the utilization of assets.

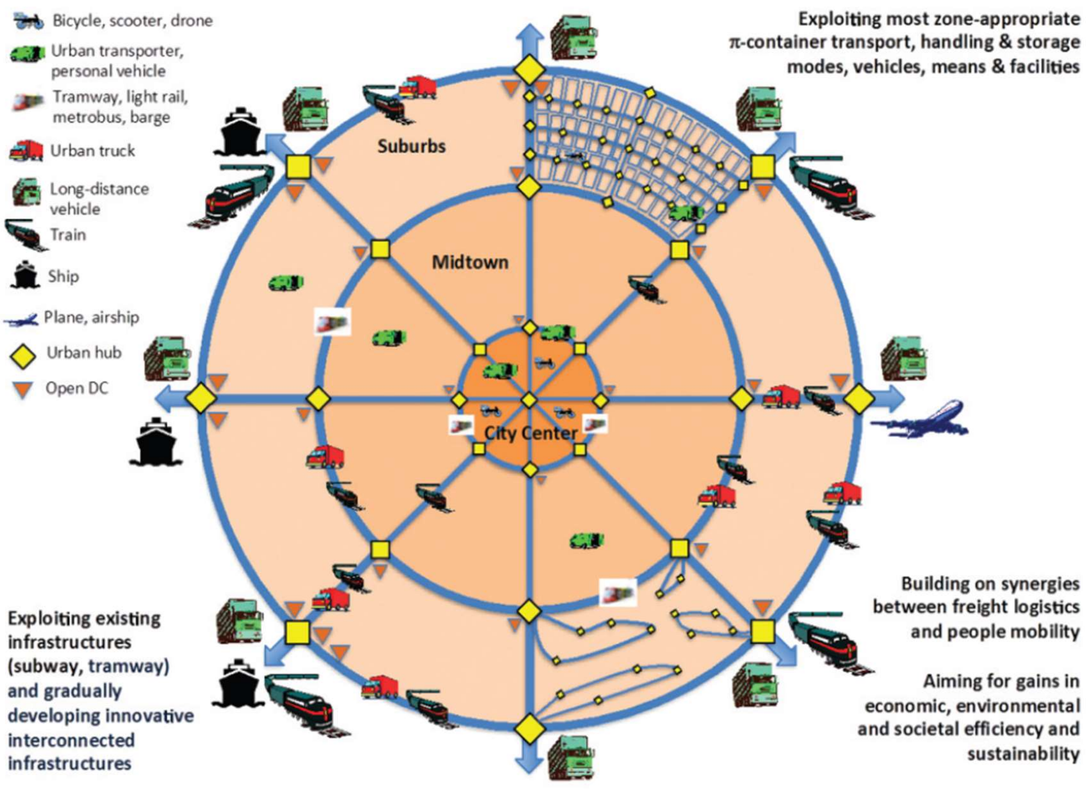


Figure 1. **Hyperconnected City Logistics (Crainic & Montreuil, 2016)**

The experiments in the living lab had the overarching aim to accelerate the co-operation of different modal service providers to create a more efficient and sustainable urban delivery system, sharing resources for carriers and improving their offerings for customers. For a full description of the pilots, see D.3.5 (Tapia et al. 2022).

As the current project focusses on last-mile urban logistic solutions, the intercity movements of packages will not be described in detail. It is assumed that most packages are consolidated in distribution centres per collection of cities in a region, and that transport happens between those on a larger scale. Although it would be beneficial to effectiveness to include this in the design, it is outside the current scope. Providing a template on a city-scale can prove the concept and give a basis upon which to scale up.

2.2 Description of Minimum Viable Products

As described in D3.5 (Tapia et al. 2022), the 'Living Lab the Hague' has used three separate MVPs (see Figure 2):

1. Crowdshipping Logistics (Blue)
2. Public Parcel Locker Network (Red)
3. Integrated Crowdshipping Network (Green)

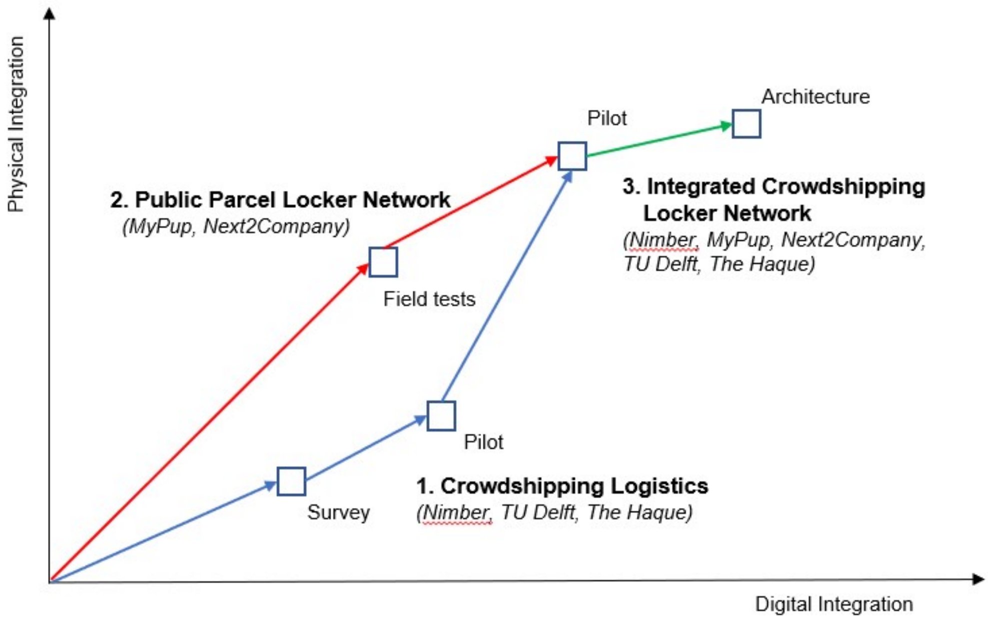


Figure 2. Living Lab development path

The figure above illustrates how the living lab roadmap is achieved via several tracks: MVP1 and MVP2 that come together at MVP3. This was done to reduce the risk of incompletion and to obtain intermediate insights that can be included in the designs. The activities of each MVP are shown in Figure 3.

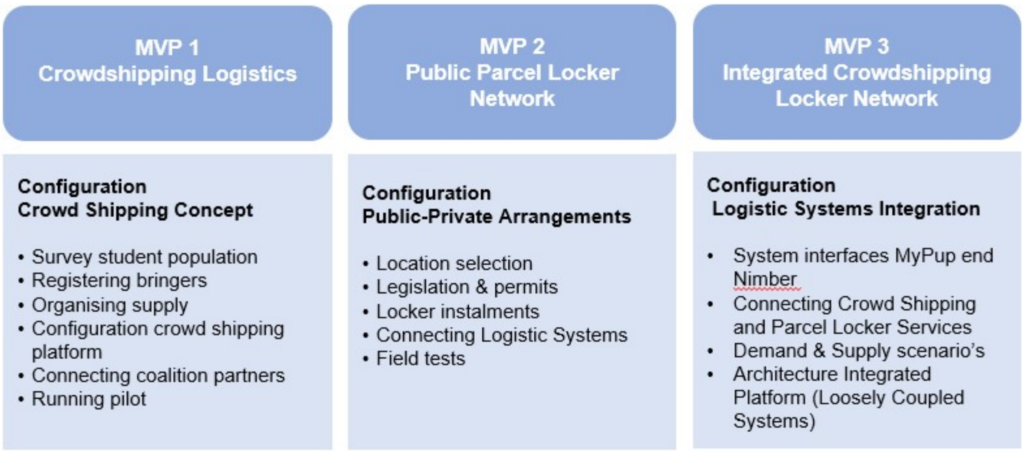


Figure 3. Living Lab implementation

As stated in D3.5, MVP1 focuses on crowdshipping. Their platform enables bringers to connect to senders, to move packages from one point to another. MVP2 uses parcel lockers from MyPup in a public location. In MVP3, the architecture brings the networks together, connecting crowdshipping and the parcel locker network, altogether forming a City Logistics Platform.

2.2 Pilot activities

The current chapter discusses the MVPs, the corresponding pilots, the workshop activities, and the findings since the D3.5 report (Tapia et al. 2022). Each pilot is discussed, the pilot goals are evaluated, and several learnings are discussed.

2.1.1 MVP 1: Crowdshipping Logistics

This MVP focused on the introduction of a crowdshipping service for the City of The Hague. Allowing for both business to consumer (B2C) and consumer to consumer (C2C) parcel deliveries to be made by local pool of bringers (i.e., crowdshippers).

The challenge in this scenario was encouraging the actual use of the platform. Nimber did not have an established userbase in The Hague, so it had to be built. This would include mobilising both bringers that want to deliver packages and mobilising senders that are willing to ship their parcels by the crowdshipping arrangements.

Between 19/05/2022 and 5/10/2022 a survey was done with two objectives and distributed through social media and flyers on TU Delft campus and in the municipality building of The Hague:

1. Obtain preference parameters for the decision of picking a parcel or not in their commute
2. Recruit bringers for the field test

The survey consisted in two sets of stated preference questions that aimed to obtain the preference of the respondent when there are commuting, where an example of this choice activity is shown in Figure 4. The second set of questions refer to the possibility of having new trips generated due to crowdshipping while at home (Figure 5). Although this is off the scope of the Living Lab activities, it was considered as one of the concerns respect platforms that could generate new trips that could increase congestion.

	Normal trip	Pick up BEFORE activity	Pick up AFTER activity
Number of Parcels		1	2
Total Travel Time (minutes)	10	15	30
Delivery point			
Total Remuneration (euros)		5	20

Which of the alternatives above you would choose?

- Do not pick up any parcels
- Pick up and deliver the parcels before the activity
- Pick up and deliver the parcels after the activity

Figure 4. Stated preference for trip based crowdshipping

a

	Deliver parcels by Car	Deliver parcels by Bike
Number of Parcels	1	1
Mode		
Total Travel Time (minutes)	15	30
Delivery point		
Total Cost (euros)	1	0
Total Renumeration (euros)	3	3

Would you:

- Stay home and do not pick up any parcels
- Pick up and deliver the parcels by bike
- Pick up and deliver the parcels by car

b

	Deliver parcels
Number of Parcels	3
Total Travel Time (by bike, in minutes)	40
Delivery point	
Total Renumeration (euros)	45

Would you:

- Stay home and do not pick up any parcels
- Pick up and deliver the parcels

Figure 5. Stated preference for home based crowdshipping

132 answers were obtained, of which 98 participants noted that they were interested in the field test. The results of the modelling of this phase are calibration parameters for the DT of The Hague. The results of this survey were reported in TRB meeting in 2023 (Cebeci et al, 2023a, Tavasszy, 2023). The data has been uploaded to an open repository to be accessed freely (Cebeci et al, 2023 b).

The main results from the survey and the subsequent model are that the value of time (VoT) for commuting trips is similar to what was found for business trips and not for commuting. This is a surprising finding that suggests that crowdshippers consider taking a parcel as the trade-off between working time and money and not personal time, as commuting VoT is normally interpreted. Another finding is that, at least in the survey, crowdshippers seem to be encouraged by the presence of parcel lockers, probably because of the additional flexibility it can provide.

The crowdshipping physical pilot started in October 2022 and ran for 6 weeks, where during each week 5 parcels were uploaded. Among the bidders for one parcel, the bringer will be allocated randomly in order reduce selection biases and be fairer in the assignments. The 98 respondents from the first phase were contacted in two opportunities for them to register in Nimber's app. From those, 30 successfully downloaded and registered in Nimber app. The remuneration per km travelled by the parcel ranged between 0.3 eur/km to 3.2 euro/km. Figure 6 shows the remuneration per trip for all posted tasks.

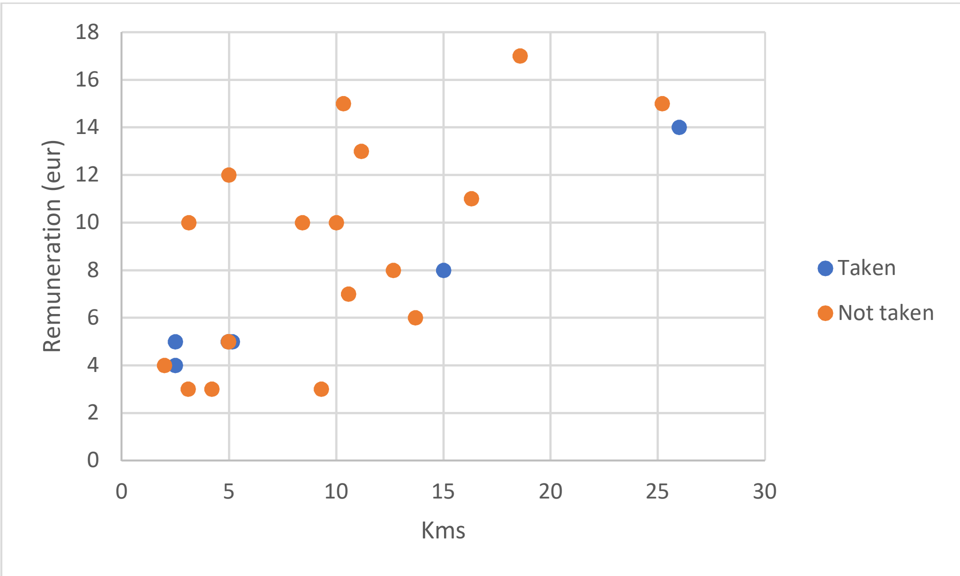


Figure 6. Remuneration per km

It can be seen from the above that parcels from all the distance ranges and remuneration levels were picked up. The overall acceptance rate was 20%.Regarding the effective remuneration per km, the ranges are between 0.5 and 2 eur/km. Considering that the parcels that were picked up had origin and destinations in areas that had multiple bringers and that there were effective picks up at 0.5 eur/km and not with 3.2 eur/km, suggests that the coverage of bringers is a key aspect for successful implementation of crowdshipping.

Key results and lessons learned:

- Crowdshippers consider the time spent becoming bringers as 'working' time
- Crowdshipping could potentially produce more trips
- Parcel lockers can have a positive impact in crowdshipping

- Identified several bugs of the Nimber app:
    - Some untranslated communications with the bringers
    - Some bringer and sender authentication issues
- The coverage of bringers is a very strong factor that distinguishes acceptability, more than the actual remuneration (within reasonable limits).
- A remuneration of 1 eur/km looks like a good starting point of remuneration, although a fixed component of the remuneration can be considered.

2.1.2 MVP 2: Public Parcel Locker Network

The focus of this second track of the LL2 was on providing parcel lockers in public spaces. Our external partner in the LEAD project, MyPup, is the provider of the parcel lockers that are used in the pilots. They have an existing platform with live use cases but had thus far only provided their services to businesses at indoor locations that were not open to the public. There is an interest from MyPup to test the implementation of parcel lockers in public spaces.

Figure 7. MyPup app and platform

The selection of the locations for the parcel lockers considered neighbourhood demographic, geographic location within the city, existing nearby freight infrastructure, location accessibility and the willingness of local parties to cooperate and invest. From the public locations considered, the Stadsboerderij (city farms) were chosen as the most promising. There are ten locations throughout the city in total. These are open to the public every day of the week, but not during evenings. As such, it was decided to build outside shelters for the parcel lockers so that they could be accessed without time restrictions. The Stadsboerderij is managed by a department within the Municipality of The Hague, and they showed interest in introducing the parcel lockers to increase flow through the city farms and make them more attractive. The parcel locker installation is funded by the Stadsboerderij and the experimentation, conceptualisation, setting of objectives and implementation is done by The Hague LL.

Two locations were selected together with the Stadsboerderij collective for continuing our implementation plan: *Stadsboerderij De Schildershoeve* in the city centre and *Stadsboerderij De Kakelhof* in a suburb neighbourhood with a demographic of young couples with children and older couples between 50-60. The De Schildershoeve location was later discarded due to vandalism concerns in the area from the Municipality of The Hague. De Kakelhof location was judged as to have enough potential parcel traffic due to the neighbourhood not having a pick-up-point from another company yet (PostNL, etc.). The process to obtain the permit to build the shelter is ongoing.

Figure 8. Stadsboerderij De Kakelhof, The Hague

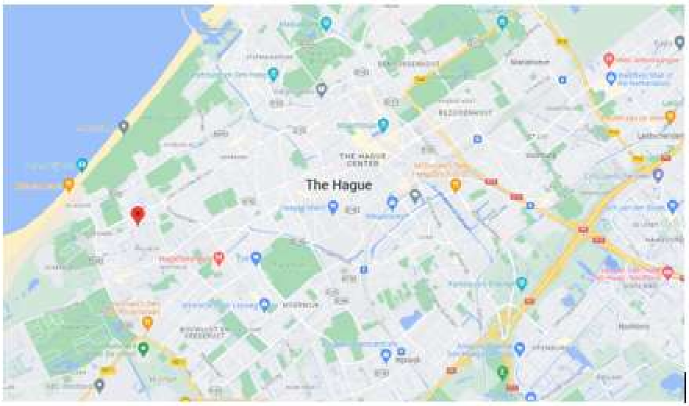


Figure 9. Location of the Stadsboerderij in Den Haag

Key results and lessons learnt:

- Mapping public authority processes and awareness of all the relevant (departments that give approval) areas can reduce delay risks.
- The Living Lab worked as a catalyser and a forum where different interested parties managed to provide a framework for experimentation of new logistic solutions under the hyperconnectivity concept, including deciding to invest own time and budget (besides LEAD participation).

2.1.3 MVP 3: Integrated Crowdshipping Locker Network

Crowdshipping and Parcel locker connection

The third MVP is the merging of MVP 1 and MPV 2. It is about connecting different actors for maximum efficiency through an urban logistic platform that can realise the hyperconnectivity vision. The first application will be done by connecting crowdshipping activities with the connected pick-up-delivery-locker network. Learnings from this combination will be used in the design of the architecture of the platform such that in the future, other logistical services can be added to the platform. The goal is to find the most efficient fulfilment trajectory for specific package streams.

The pilot builds upon the insights from MVP 1 and MVP 2. In MVP 1, the crowdshipping pilot showed that parcels are more likely to be picked up by crowdshippers on shorter distances. MVP 2 showed that it is interesting for the partners to install parcel lockers in public areas. This implies that introducing parcel lockers in last mile urban deliveries could increase the likelihood that crowdshippers are willing to pick up parcels. As such, the MVP3 investigates how to split up deliveries in two legs, posting orders for the last mile delivery to be picked up by crowdshippers. The parcel locker is thus used as a transhipment point. Figure 10 illustrates the concept.

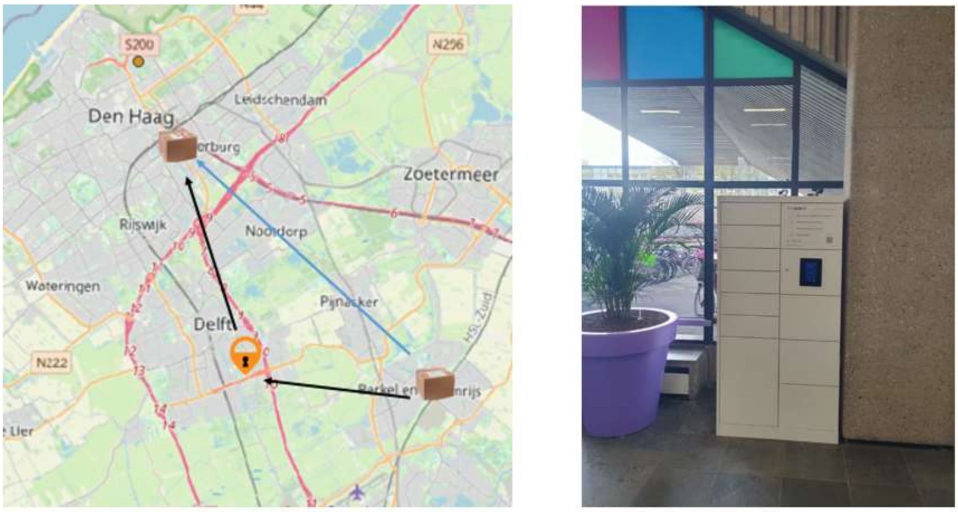


Figure 10. Parcel locker and crowdshipping concept

The potential benefits of introducing parcel lockers in the crowdshipper logistics are: 1) reducing the average kilometres travelled per package due to increasing potential consolidation, and 2) reducing congestion and pollution due to substituting traditional (van-based) deliveries with crowdshipping deliveries, which use cargo bikes, foot traffic or public transport.

The main research question is *how can parcel lockers become transhipment points for crowdshipping.* By answering this question, we can design a pricing strategy for this and have insights on how to connect crowdshipping and the parcel lockers into one system.

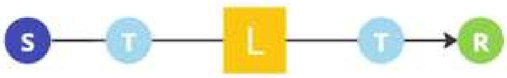
To answer the research question, a MyPup locker has been installed at the TU Delft and a restricted admin access to the MyPup system has been provided to the LL. An internal design workshop has been done in order to define the point of interactions between the systems from MyPup and Nimber. Figure 11 describes the various scenarios where the parcel locker can provide value in crowdshipping: as an intermediate location for longer trips (indirect delivery), consolidation of multiple deliveries to a single location (consolidated sender delivery) and as a consolidation point to multiple receivers (consolidated receiver delivery).

1. Point-to-Point delivery (sender, transport, receiver)

This is a standard fulfillment job with one leg, which is handled within the systsem of one service provider. This doesn't use any form of cross-platform matching.

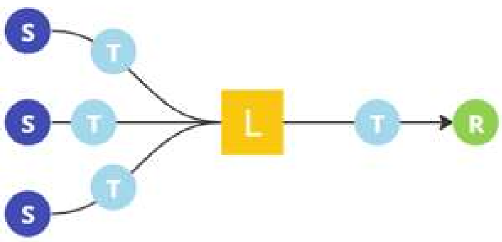
2. Indirect delivery (sender, transport, locker, transport, receiver)

This fulfillment job is split up into two or more legs. The legs can be fulfilled by one or more transporters. For each leg sperate pick-up and delivery assignments are generated.



3. Consolidated sender delivery (multiple senders, transport, locker, transport, receiver)

The fulfillment job is split into two or more legs. In the first leg, multiple packages are gathered by two or more transporters for consolidation purposes at the locker. The second leg then consists of a delivery at one adress.



4. Consolidated receiver delivery (sender, transport, locker, transport, multiple recievers)

The fulfillment job is split into two or more legs. In the first leg, multiple packages are transported to a locker. Then, in the second leg, one transport provider fulfills multiple deliveries to a postal code area.

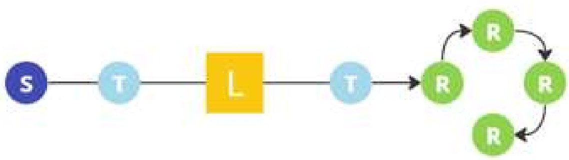


Figure 11. Description of package delivery scenarios tested in MVP 3

From testing the interactions between the systems and considering the current interfaces between the platform provided by MyPup and by Nimber, the procedure from Figure 12 has been developed.

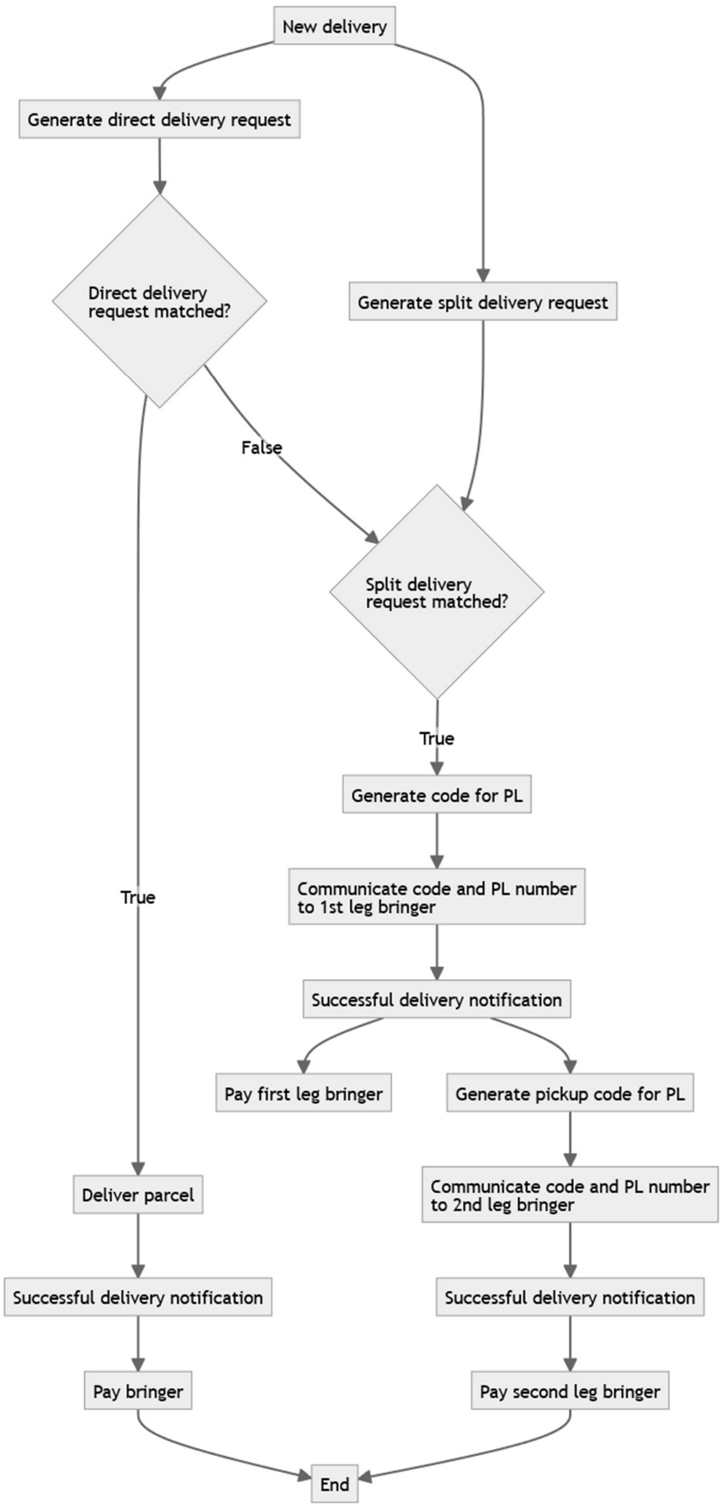


Figure 12. Splitting Crowd Shipping flows

The insights from gained from the technical combinations of the parcel locker- and crowdshipping systems are the main result of this MVP. However, it focuses on the technical side and are not able to capture the behavioural nuances of the effect of having shorter crowdshipping trips with a parcel locker as an interface. It has been identified during the development process and posterior discussions that it is an interest of the LL to investigate further the implications of the use of parcel lockers in a crowdshipping trip and how that affects the adoption of the system.

Key results and lessons learnt:

- Insights on how parcel lockers can be implemented within the flow of crowdshipping.
- Configurations of the interactions between parcel lockers and crowdshipping have been identified, together with the key information elements between the platforms.
- Further testing of the behavioural implications of using parcel lockers as an intermediate stage of crowdshipping is needed.

Shared Logistic Network

1. Integrated platform

In operational terms the hyperconnected city requires numerous multi-modal logistics and transportation service providers to co-operate to ensure consolidation and synchronization.

In a completely hyperconnected city, all logistical services are linked to each other, in both routing and infrastructure, via an integrated logistic platform. Such a platform would link the service providers (i.e. transport and lockers) to senders and receivers. Service providers can then use each other's capacities to store and consolidate packages, while customers can make use of multiple service providers at once to send and receive deliveries. Figure 13 shows the system concept of such an integrated platform.

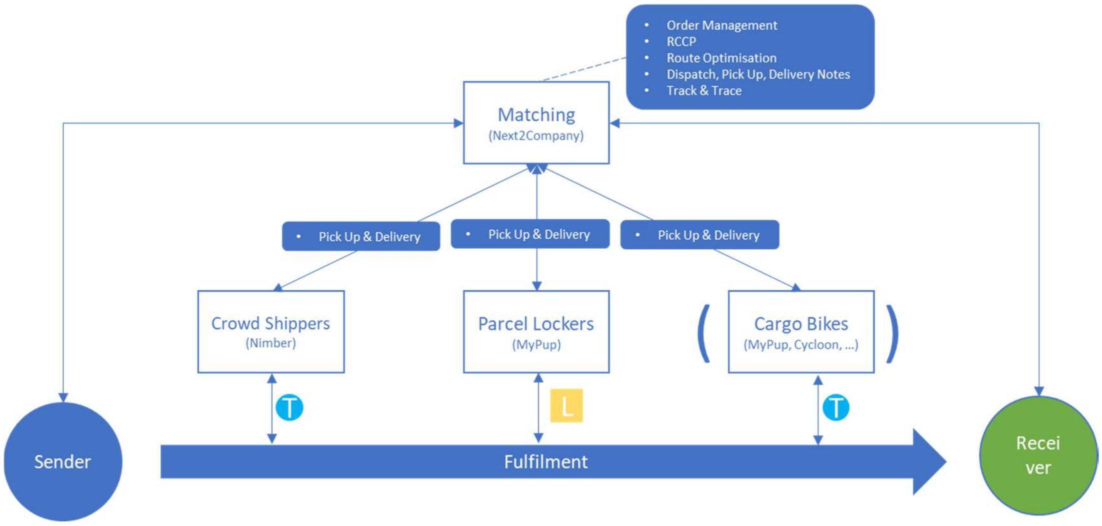


Figure 13. Architecture integrated platform

This process needs to be managed by a 'matching function' that orchestrates all (API) data-exchange between the service providers' systems. The matching functions conists of order management (order entry, price setting, delivery confirmation), service level management (delivery window), rough cut capacity planning (crowdshippers, parcel lockers and optional cargo bikes), route optimalization, dispatch of pick-up & delivery notes and track & trace. After the launch of Nimber's new platform, an API interface can be established with their system as well.

2. <u>Loosely coupled systems</u>

A step that can be made before a fully integrated platform is achieved is a network of loosely coupled systems. In The Hague Living Lab the connection between the separate logistic applications is managed manually, by posting and forwarding delivery requests, confirmations, and cutting up requests to test the consolidation of packages in different scenarios. The different secenarios cover most of the interactions that would happen within an actual platform (this is described in more detail in the MVP 3a section).

2.2.3 General conclusions

The LL The Hague has a strong innovation and business model driven focus. This means that the interest of the stakeholders and the value that the LEAD project gave to the community of practice are testing and providing insights about the operational feasibility and business model sustainability of the pilot scenarios.

This has a double effect. The first effect is that KPIs measurement is less direct (and need a DT for that) meaning that the impact of the field tests cannot be measured in field but provides insights for the twinning process. The other effect it has is that it provides stronger business evidence and higher commitment for the parties involved. Consequently, the likelihood that the partners continue working together after the end of the LEAD project is higher, due to the compatibility of their interests. The last item is particularly true for LL The Hague, as there are parties that have decided to join the LL without funding of the LEAD initiative but are participating out of their own volitions, carrying both risk and benefit.

Regarding the implementations, important lessons have been obtained regarding crowdshipping. First, that crowdshipping has the risk of creating new trips that can increase negative externalities if the conditions (e.g., remuneration) is large enough to attract car users. However, this could potentially be minimized by a targeting the correct sociodemographic segments, by having a relatively low cost and introducing parcel lockers to split the trips into smaller segments. This way bicycle and/or foot traffic trips are more likely to occur and at a competitive price.

The insights from MVP1 and MVP2 resulted in the design of MVP3. In MVP3 the interaction between Nimber and MyPup has been designed by defining the key interaction points between the systems. With this input and, considering the different use cases of a shared logistic network, and architecture for such platform has been designed.

2.2.4 Workshops and events

Workshop 1

On the 3rd and 4th of March 2022 a workshop was held about the Hyperconnected city of the Hague. It was discussed how to mix logistic services across platforms to create a more efficient and sustainable urban freight system, by sharing resources for carriers and improve offerings for customers.

The goals of the workshop were to inspire potential partners, exchange information and lay the basis for future cooperation. Besides that, the event aimed at establishing a vision of a greener and cleaner the Hague, by introducing hyperconnectivity solutions.

23 people attended in person and 64 attended online for a total of 87 people, spread out over project team members, partners, and other interested parties. There were several speakers covering various topics. The workshop was organised by: Polis, TU Delft, Municipality of The Hague, Next2Company, MyPup, HubKlup and Cycloon.

In short, the LEAD project was introduced, each partner introduced themselves and the LEAD value cases were discussed. Thereafter, an open discussion took place between all participants. After the break, various speakers spoke about Urban Strategy, Digital Twins and Urban Logistics. Another work session was done for further ideas to be exchanged, and overall, the day had a very positive demeanour. The main conclusion of the workshop is that trust is the key element for generating connections between logistic agents. Transparency has an important role here, for the participants to generate the trust in the platform and between the other parties. Customer experience must be coordinated and uniformized across the different participants. Annex 5 provides more details of the workshops.



Workshop 2

On the 17th of April 2023 a workshop was held about the activities and insights of the LEAD project. 17 people attended the workshop (14 in person and 3 online). From the municipality, the participants came from the following departments: Urban Planning (2), Innovation and Experiments (2), Mobility (4), Mobility Policy (2), Management (1), City Farms (1). The other participants came from Nimber (1), from TU Delft (2) and from Next2Company (2). Several other parties expressed interest but were unable to attend, including Q-Park (the parking management from The Hague), Shell and other municipality officials from the data team, logistics & the urban parking department.

The goal of the workshop was to validate the pilot's user acceptance with the CoP, local stakeholders, potential local users. This was done by reintroducing the LEAD project, discussing the progress and insights of The Hague Living Lab and looking towards the future to see how we can use the LEAD insights for the improvement of city logistics in The Hague the coming years.

The workshop was started by Next2Company introducing of all partners and outside stakeholders present. Hereafter, the hyperconnected city concept and the activities of MVP 1 were discussed. Following this, TU Delft then continued to speak about the LEAD project activities in MVP 2 and MVP 3, showcasing the pilot results and the Digital Twin.

After lunch, two brainstorming sessions were done, led by Next2Company and TU Delft, to gather more ideas of what other ideas can be tested or worked out to improve city logistics in The Hague. This sparked a lively debate about the goal of city logistics from the perspective of the municipality and the insights from LEAD could add to that.

Furthermore, we got some wonderful results of how the LEAD activities could fit into the future of city logistics in The Hague. Some insights were gathered, both bringing in new ideas for solution areas, further research areas and constructive criticisms. Below a shortlist of gathered ideas.

New solution areas:

- Gamification in combination with health challenges to promote (bike) crowdshipping.
- Coupling freight delivery with existing transport services such as special needs transport.
- Package delivery windows during the week similar to waste retrieval (e.g. deliveries every Tuesday).
- Stricter policy making by the municipality to enforce what is currently 'advice', such as only allowing zero-emission delivery for certain areas.
- The Hague Freight Quality Partnership (similar to Rotterdam) to bring together logistic companies and the municipality.
- Maximum package size for highly congested locations.

Further research areas:

- A whitepaper with insights, solution areas and further research to create and communicate the vision for city logistics in The Hague.
- Varying payment systems based on delivery urgency.
- Locker storage as intermediate consolidation points.
- Investigate alternative motivation for becoming a crowdshipper besides monetary incentives.
- Testing the social context of hyperconnectivity solutions including the Municipality's social KPIs

- Create local Freight demand partnerships such as sector partnerships (e.g. hospitality delivery partnerships).

Constructive criticisms:

- Possible downside to hyperconnectivity is an increase in movements in the long term because of the lower transport costs, which might lead to a net-increase (rebound effect).
- Using parcel lockers as logistical hubs might take away business from local business owners of pick-up points, which currently perform a function in social cohesion within neighbourhoods.

2.4 Pilot validation and user acceptance

Besides the overall good reception during the workshop, a survey was sent to request some of the participants to rate and validate the results from the workshop. For this, respondents were asked a series of questions about the implementation, business models, KPIs and effect of large-scale implementations where they had to rank between 1 (lowest) and 5 (highest).

Regarding the implementation of crowdshipping, there was an overall agreement that it was a success (average 3.7), although not very high, no respondent answered lower than 3. However, results about the success of the business model were more mixed, with values ranging from 2 to 5 and an average of 3.17. The open platform had a better reception regarding its business model, with a 3.5 of average.

Large scale implementation of the pilots had relatively good acceptance. Large scale implementation of crowdshipping was judged to be relatively feasible (3.5 average) and that it can have a positive impact in the quality of life of the inhabitants (4.0 average) and a positive impact on the logistic operators (4.17 average). Similarly, the open platform was judged feasible at a large scale (4.17 average) and with positive impacts on inhabitants (3.83 average) and logistic operators (4.0 average)

Regarding KPIs, it was judged that the LEAD implementation had positive impacts when compared with the objectives (3.5 average)

2.5 Digital twin validation and user acceptance

During the second workshop, the basics on what is a DT and how it can be used in the urban freight context were explained. To obtain further validation, a survey was sent to the participants. For this, respondents were asked a series of questions about the understanding and uses of DTs where they had to rank between 1 (lowest) and 5 (highest).

The explanation of a DT from a non-technical perspective was deemed as understandable (average of 3.67 average), however the outputs and KPIs that it conveyed were positive but not as high (3.17 average). Regarding the potential for use, it was considered that the DT had most of the information needed for policy makers (3.33 average) and for logistic companies (3.33 average).

It is worth noting that the lowest scores given in this part were from a participant that only attended the online version of the workshop, thus having less opportunity to interact and see the benefits of DTs. However, they have subscribed to the DT training that will happen later in the year.

3 Digital twin: Scenarios modelling

As reported in D3.5 (Tapia et al. 2022), most of the modelling from our DT is based on the MASS-GT related modules developed by TU Delft. These are Pa*rcel Generator, Parcel Market, Parcel Tour formation*, *Shipment Model* and *Network Assignment*. Additionally, we use COPERT for some KPIs estimation that were contributed by UPM. Originally, there was the intention of including MATSim from IRTX and noise model. Eventually, the model was not used because of the availability of passenger data from a Dutch Activity based model (Albatross) and the other MATSim outputs have been mostly covered by the other models. Regarding the noise model, the KPI was not in the expected impacts of the interventions, so the connection was not developed. Figure 13 shows the models used in this DT. All the models have been described in D2.2 (Tapia and Kourounioti, 2022) and are hosted in GITHub.

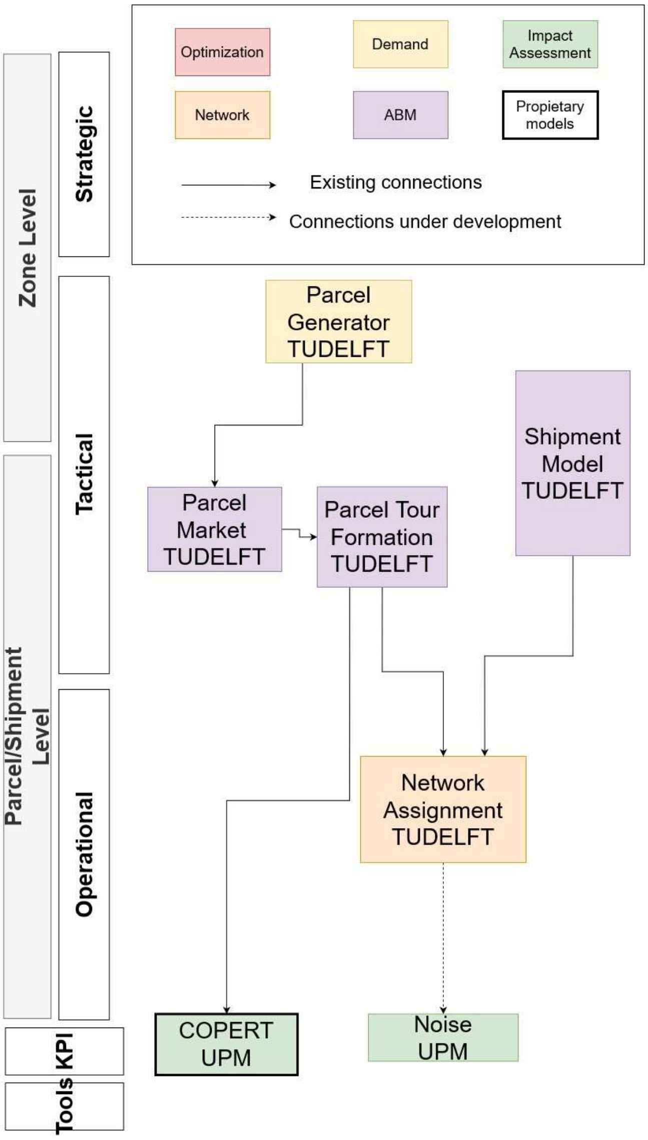


Figure 14. Models for LL2 DT

3.1 Models used in the Digital Twin

The models used in the DT are described in D3.5 (Tapia et al. 2022) and D2.2 (Tapia and Kourounioti, 2022). In this sub-section, the names of the models and connectors are mentioned.

Developed in the framework of LL2:

- Parcel Generation
- Parcel Market
- Parcel Scheduling
- Network assignment
- Shipment Model

Developed in the framework on other LLs:

- COPERT

Connectors:

- Gen2Market
- Market2Sched
- Sched2Netw
- Sched2COPERT

Noticeably, the latest crowdshipping matching algorithm and some preliminary modelling results have been published in a scientific journal (Tapia et al. 2023).

3.1.1 Configuration of the DT

The basic configuration of the LL2 DT is explained in the D3.5 (Tapia et al. 2022), no large configuration differences were done since then.

3.1.2 LL Data collection and anonymisation

The basic configuration of the LL2 DT is explained in the D3.5 (Tapia et al. 2022). The new data sources from surveys have been anonymised and uploaded to an open repository (Cebeci et al., 2023b).

3.1.3 LL2 definition of the modelling conditions

The model conditions for the base model have not been essentially changed since D3.5 (Tapia et al. 2022). For the different value cases, the model definitions are given in section 3.4.

3.2 LL2 Digital twin: user interface and data ingestion

The LL2 DT has been configured in the LEAD platform. Figure 16 and Figure 17 show some screenshots of the platform's dashboard and scenario builder. Figure 17 represents a models' workflow, including the connectors developed for the Hague Living Lab, that facilitate the sequential execution of models, with the outputs of one being fed to the other.

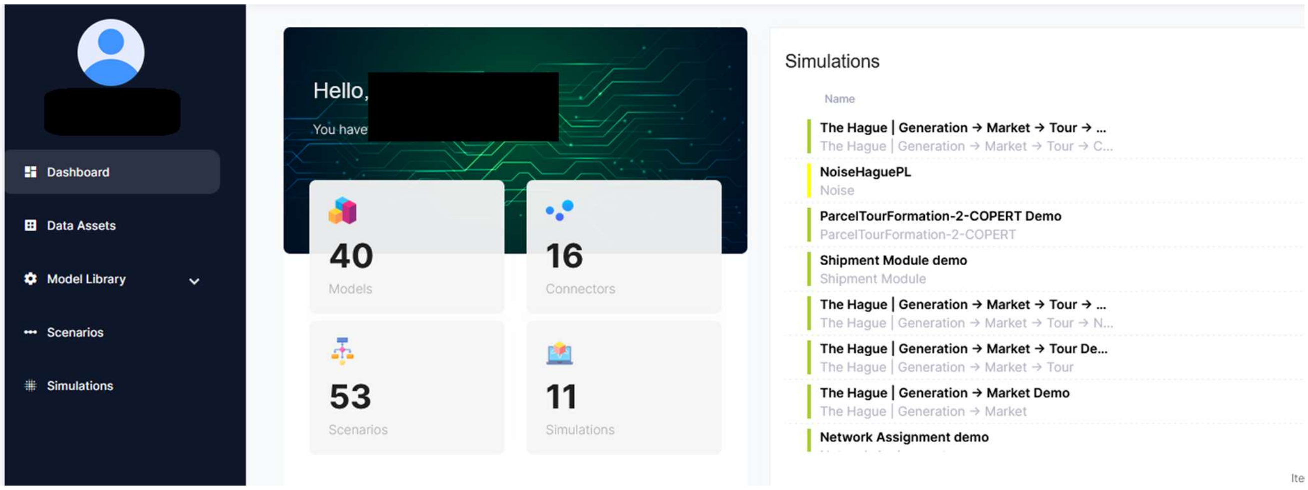


Figure 15. LL2 DT dashboard

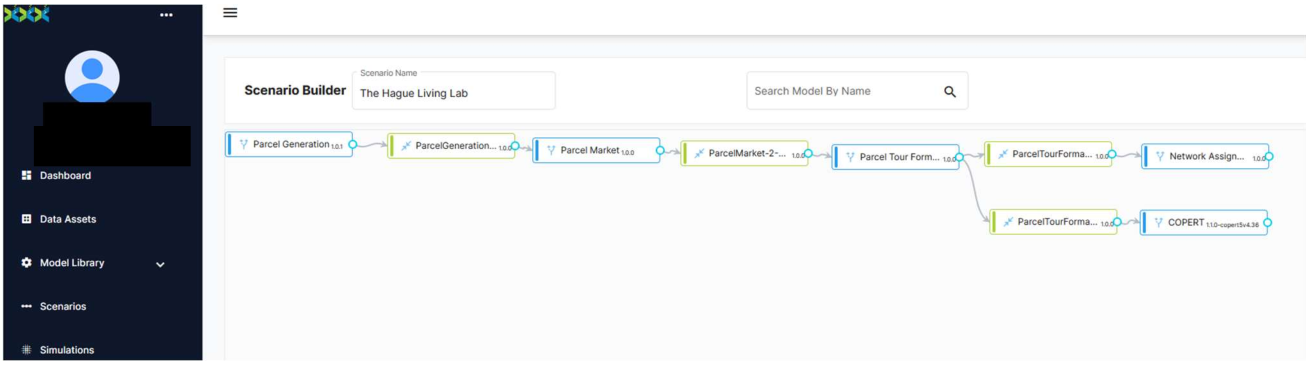


Figure 16. LL2 DT scenario builder

The LEAD DT platform, apart from integrating the Hague LLs models, integrate the respective data assets required for the execution of the models.

3.3 Digital twin: verification process

The verification of the KPIs of the DT has not been done directly in the pilots due to the difference in scope between the DT (city scale implementation) and the pilot implementation (small scale). The verification and validation were done qualitatively by consulting constantly with the logistical parties and the municipality the plausibility of the results and in Workshop 2.

In the workshop the DT approach was shown, together with the main results (see section 2.5). After the workshop a survey was presented to the participants to validate the DT.

3.4 Digital twin: Value case scenario definition

The scenarios to be modelled are linked to the MVPs that are described in this scenario and were not detailed in D3.5 (Tapia et al. 2022). Table 2: Value case definition shows the main assumptions and objectives of each value case.

Table 2. Value case definition

Scenario	Value case	Concept/ research question?	Main elements
1	Crowdshipping	a) What is the potential effect of maximizing platform profit under a fixed fare model? b) What is the effect of implementing the pilot remuneration findings?	Effects of crowdshipping in the city with different remunerations
2	New parcel lockers	What is the effect of the new parcel lockers and the bike fulfilment?	Effect of new parcel lockers Effect of changing delivery vehicle
3	Parcel lockers and Crowdshipping	Are there any complementarity between these two cases?	Combination effect of two scenarios above

The complete configuration can be found in Annex 3, together with the raw outputs of the scenarios in Annex 4.

3.5 Digital twin: “What if” scenarios simulation and results

3.5.1 Scenario 1: Crowdshipping simulations

The LEAD DT has first been used to test the effect of crowdshipping in the urban environment. The model used the modes described in Section 3.1. The main question asked in this simulation is the effect of pricing in the total emissions and congestion. The KPIs obtained are Green House Gas (GHG) emissions by car and vans, total kms travelled by cars and vans and the expected revenue by the crowdshipping company.

The first set of simulations changed the remuneration given to the crowdshipping, assuming a flat rate (i.e. not depending on parcel distance). From all the simulations we registered the crowdshipping platform remuneration (Figure *18*) and selected the one with the maximum (7 euros) for a more in-depth analysis. In this case it was assumed that the platform would set the prices that maximize their revenue.

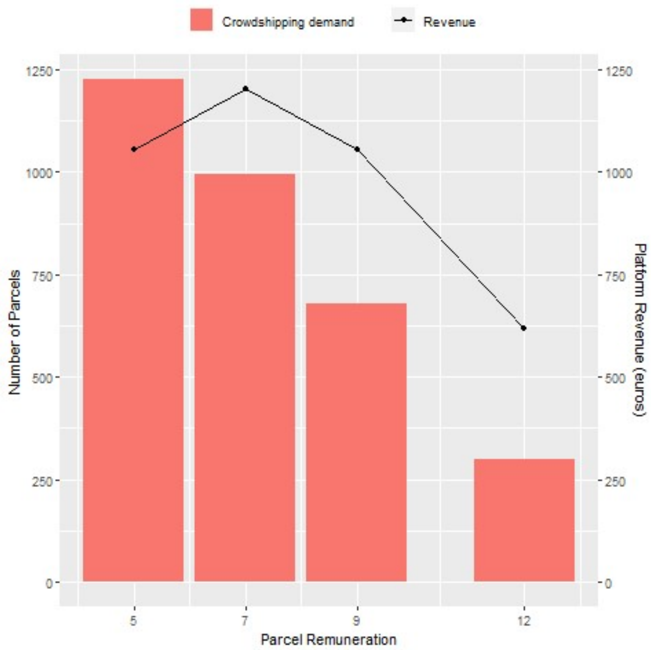
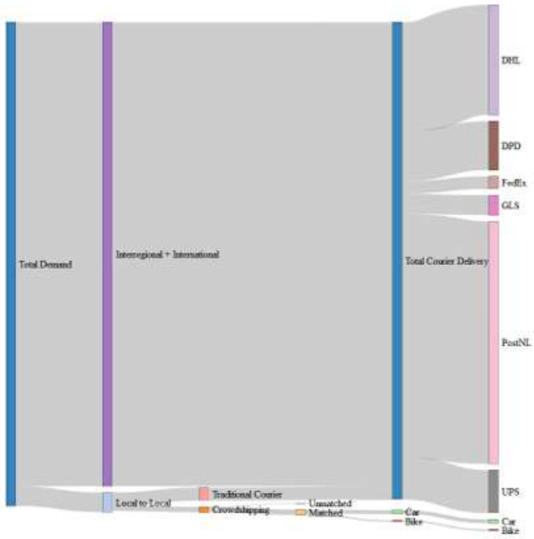


Figure 17. Parcel remuneration and platform revenue in scenario 1

For the case where the tariff is 7 euros, the flows were simulated for all the parcels in The Hague. It can be seen in Figure 17 how these parcels are fulfilled across the multiple carriers and, for the case of crowdshipping, which mode they take. Since crowdshipping is only available for Local-to-Local flows (i.e., flows that start and end in the area), they are restricted to these flows that represent around 4% of the total demand. From these, it can be seen that circa two-third of the crowdshipping is done by car.



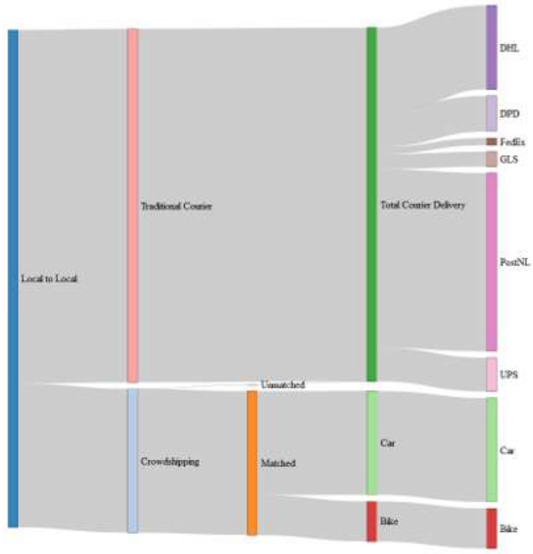


Figure 18. Parcel fulfilment in scenario 1 for all deliveries (left) and L2L (right)

The detours made by the car trips cause an increase in the total km travelled by vehicles of 27%. This figure includes the lower van-km via traditional carriers. Another relevant result is that the average remuneration for the crowdshipper was 9.15 euro/hour, on par with the Dutch minimum wage of 9.96 euro/hour, which indicates a relatively fair remuneration.

Two relevant publications arose from this work and are used in the simulations. The first one regards the demand for crowdshipping (Cebeci, 2023c), where insights are collected about how consumers choose between crowdshipping and traditional delivery. The results of this model were used as a parameter in the DT. The second relevant publication (Tapia et al., 2023) details the method for the matching between travellers (bringers) and parcels and analyses the case with a fixed tariff (Crowdshipping a). Both papers were published in one of the most relevant journals for these kinds of projects, which is *Transportation Research part A: Policy and Practice*.

The second simulation is based on the key insights presented in section 1.6.1. The remuneration tested was of 1 euro/km. In this case, the structure of the parcel fulfilment is the same, except that now it is completely fulfilled by bicycles. This results in around a 9% decrease in emissions and van-km. However, the expected remuneration of the platform was reduced 51% to 539 euros/day.

However, the hourly remuneration went up to 10.98 euro/hour. This is a result of detours of approximately 5,67 km (please note that this is different from the parcel distance, that is the basis for calculation) and an average remuneration of 5.19 euros/parcel. This average parcel cost implies a 5.97 euro/parcel effective price for consumers, which is a 35% decrease regarding the reference parcel cost.

The main conclusions of these two simulations were that the pricing policy and, consequently, the mode of the trips travelled have a huge impact in the sustainability output of crowdshipping. By simply changing the remuneration style, crowdshipping goes from a potential detrimental proposal to one that reduces the output of GHG emissions and vehicles kms. As a downside, the revenue for the platform is not as high as it could, so it has no incentives to keep it this way without public regulation.

3.5.2 Scenario 2: Parcel lockers

The parcel locker simulation focuses on two interventions. The first of which are two new parcel lockers (one at the TU Delft and the other at the Kakelhof Stadsboerderij). The second intervention was that all the parcel lockers of MyPup would be fulfilled by cargobikes. The environmental and congestion KPIs were relatively stable when measured at a city level (1% reduction), which is expected due to the limited extent of the interventions simulated. The congestion as well, with a negligible 0.4% reduction. Figure *20* shows the location of the depots and parcel lockers in the study area.

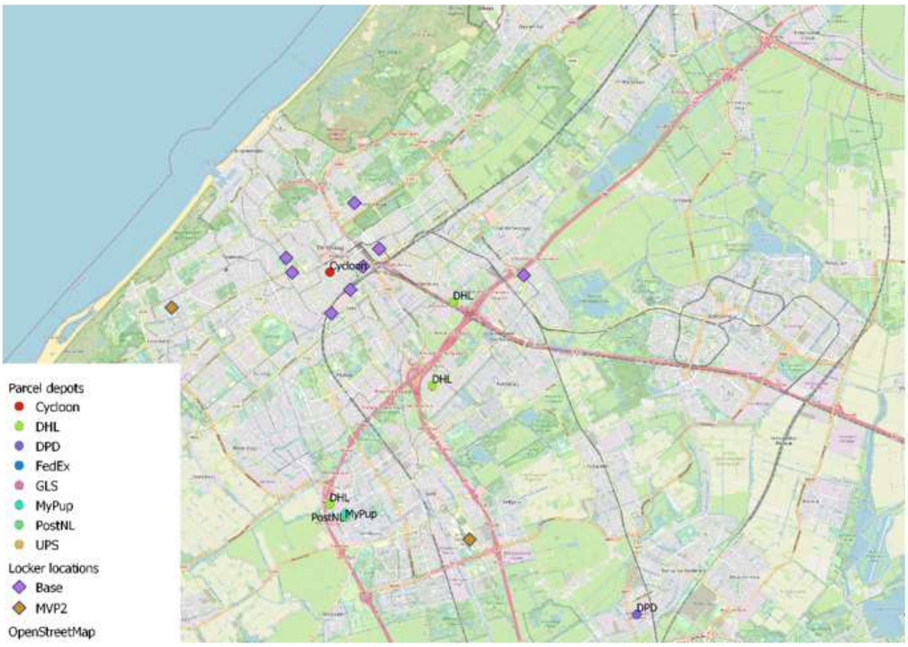


Figure 19. The Hague with the depots and parcel locker locations

However, in the zone around the new parcel lockers, the situation is different. The Kakelhof surrounding streets (Figure 19) saw a reduction of 9.14% of the vans that circulated. This result is relatively large in comparison to the size of the intervention and would result in a noticeable change for the neighbourhood. It is worth noting that there might be a large inertia in the congestion levels, since a lot of traffic can be through traffic.

Figure 20. The Kakelhof in the DT map

The main conclusion here is that the parcel lockers have a positive effect in the neighbourhood, but it is very limited when analysing the big picture at a city level. This means that to scale up the effects, a wider implementation of lockers is needed.

3.5.3 Scenario 3: Parcel lockers and Crowdshipping results

The last simulation was done by considering crowdshipping with a remuneration of 1 euro/km, the parcel lockers at TU Delft and the Stadsboerderij, and the fulfilment of the parcel lockers by cargo-bikes. The combination of both interventions did not have a large effect on the emissions or congestion or a particular complementary effect.

Part of this not noticeable effect is due to the relatively large bringer population simulated, because a more mature crowdshipping scenario was simulated. Splitting the shipment with a parcel locker in the middle might increase the likelihood of a successful crowdshipping task in the case of low market penetration of the crowdshipping platform. However, these results might change once new behavioural inputs that can provide some light into the complementarity of these interventions.

The main conclusions of the simulations are that the effect in the larger network might be very difficult to obtain for targeted pilots. However, via digital twins, these effects can be measured (even though small) and that localized effects can also be quantified. This highlights the role that DT can have for experimenting and pre-piloting for public authorities and companies.

4 KPIs measurements

LEAD LL The Hague develops innovative business cases for city logistics services in the city. Therefore, existing base line values and intervention for some of the KPIs from D3.1 could not be measured. In addition, the pilots were implemented in parts of the city and the DT models were applied to extrapolate the impacts of hyperconnected services citywide and in an open system (i.e., in interaction with the whole of the parcel demand and not just a subset of it). This means that some of the KPIs were estimated by applying the models in the The Hague DT (as reported in section 3) and others, when possible, by the direct measurement in the pilots.

Moreover, some of the measurements of the baseline presented in D3.5 (Tapia et al. 2022) were changed due to the introduction of new models into The Hague DT (such as COPERT). Table 3 presents the KPIs applied in the LEAD projects to evaluate the impact of the proposed interventions as described in MVP3 and scenario 3.

Table 3. Sustainability Impact Assessment Indicators

Impact area	KPI	Definition	Target	Actual
Environment	Energy consumption	Energy savings compared to the "do-nothing" scenario	30% decrease	9.26%
	Noise impact			No change
	GHG emissions	CO_2 equivalent emissions savings compared to the "do-nothing" scenario.	50% decrease	9.26%
	Air pollution	Savings of [PM; NOx; VoC] compared to the "do-nothing" scenario	50% decrease	9.26%
Social	Jobs created	Jobs compared to the "do-nothing" scenario	In the DT level 5% increase in jobs.	309 working hours (baseline =0)
	Quality of jobs	Qualitative evaluation of the types of jobs created by the LL according to the opinion of the CoP.	A general increase in the number the quality of jobs.	3 (no change in the quality of jobs)
	Quality of life	People satisfied with the value case scenario compared with the "do-nothing" scenario in terms of quality of life.	A general improvement in the neighbourhood quality of life is expected.	4.1 (high improvement)
	Sustainable	Ideas suggested to	>3 ideas should be	4 new

Impact area	KPI	Definition	Target	Actual
	behaviour	promote a more sustainable behaviour	generated in the LL.	proposals
	Solutions & incentives	Cooperative solutions and incentive measures promoted within the framework of the LL and approved by the CoP	In the LL >2 solutions > 4 measures	6 new solution areas
Economic	Delivery costs	Average delivery cost savings of the business model compared to the “do-nothing” scenario.	-5%	-35.11% (crowdshipping average price)
	Congestion 1	Changes in the share of shipments that are carried out within the congested hours of the day.	NA	
	Congestion 2	Congestion contribution of delivery vehicles: Changes in the occupation time of the road.	reduction of 15%	-10.14%
	Urban storage and parking space	Urban space required for last mile deliveries (storage and parking) in comparison with the “do-nothing” scenario.	reduction of 15%	Surface of 6.5 m2
	Internal rate of return	Financial internal rate of return of the investment conducted to implement the value case scenario.	>6%	>6%[1]
	Shop/retail benefits	Retail benefits compared to the “do-nothing” scenario	Benefits are expected to be generated in the DT.	3.8 (slight benefits to local retailers)
	Delivery time	Average delivery time compared to the “do-nothing” scenario.	In total 5% in the simulation environment.	No change
	Delivery reliability	On-time deliveries within the time window compared to the “do-nothing” scenario	In total 10% improvement	No change

[1] *The actual number not reported due to business strategy privacy concerns.*

The KPIs presented above are somewhat lower than the expected. However, there are some nuances in the numbers reported. The values were generally calculated in the DT at a city level (or at a neighbourhood in the case of congestion). This means that the baseline for calculation is the whole city and this makes that the percentual changes are very low.

For example, if the computed baseline would be the specific externalities of a set of parcels that were before carried by van and now are carried by bikes (being cargo bikes in the case of parcel locker fulfilment or regular commuter bikes for crowdshipping), the emissions would be 0, having a reduction of 100% (and meeting the expected values). However, we believe that this value would be misleading and not provide an adequate level of comparison of the interventions across multiple cities (objective of task 3.8) and would generate problems in the transferability of the solution to new places. This affects mainly the environmental KPIs and the congestion (under economic category). It can also be seen that some of the KPIs have been successfully achieved, such as Jobs created, sustainable behaviour, job quality and delivery costs.

There were some KPIs that were considered not to have a measurable change because it was not the objective of the interventions, or the models used from the DT were not sensitive to them. Such is the case for noise, delivery time and delivery reliability. Table 4 shows additional objectives and KPIs from the stakeholders of the LL.

Table 4. LL2 The Hague: Specific stakeholders' objectives and KPIs (D3.1, 2021)

Stakeholder	Objective	KPI	Base value	Target	Actual
Next2Company	Collaborate with last-mile urban delivery companies	Connect company systems in the platform	0	>3 companies	2 companies
	Develop platform links and participate in the connection between them	Number of platforms linked	NA	>=3 number of platforms	Results to follow 2 connected platforms
	Improve understanding on the freight behaviour of different segments in The Hague	Number of new segments targeted	NA	>=2 number of segments	Yes, C2C and B2C.
	Enable valid business cases to the combined fulfilment	# Of innovative solutions for specific segments	0	>=2 number of solutions	1

Nimber	Test platform in new markets	Number of Deliveries	0	30 deliveries	5
	Market share in the Netherlands	Crowdshipping successful implementation (Yes/No)	No	Yes	No
	Increase participants in the platform	Number of commuters/bringers	0	20 number of participants	30 new bringers
MyPup	Test different business models	Number of business models	0	2 new business models	1 new business model
	Increase use of assets	Construction site pilot (yes/no)	No	Yes	No

Regarding the stakeholder KPIs, there are also some deviations from the objectives. The original aim of the LEAD project was to have various freight transport companies collaborate, both regular and last-mile delivery. This has been done by connecting crowdshipping and parcel lockers. Further extensions and new partners are also considered in the design of the city logistic platform.

Concerning the validity of the business cases for the companies involved, for Nimber, even though there were enough signings to the platform as bringers, it is still not a standalone operation because no new clients are posting parcels in the platform. Moreover, the effective number of parcels carried was relatively low due to the scale and specific scope of the pilots (i.e., the objective was to understand the behaviour and not necessarily to make a lot of deliveries).

For Mypup, the original objective was to target construction logistics and to propose new business models besides the current one where the owner of the location pays for the installation and running costs of the lockers. This has not been achieved during the LEAD project, but their continuation within the LL and the CoP more broadly reflects that they are willing to continue working on this.

Moreover, the concept of the MVP pilot showcases a potential business case using MyPup's parcel locker network as transhipment points for C2C, C2B, B2C & B2B. In the instance if the pilot this is done by using Nimber's crowdshipping pilot, but this could also be achieved by integrating other last mile urban delivery solutions, such as bike couriers, existing municipality logistics and larger companies like DHL and PostNL (For more on this, see section: Workshop 2).

5 Learnings and recommendations

The main lesson learned is that resilience is key for success in Living Labs. Whenever you are dealing with actual people and organizations, there are a lot of variables and things might not go according to plan. As such, it is important to remain flexible and seize the opportunities that are presented. During the first stage of the Living Lab, the consortium lost a partner and the CoP's resilience was tested. However, the LL managed to reinvent itself by restructuring and obtaining a different value case that was satisfactory for the stakeholders. This was managed because of well-established communication channels and a thorough understanding of the needs of each of the stakeholders of the CoP (Tapia et al., 2022; Snoeijenbos, 2021).

Regarding the physical implementation phases, it is advisable to start as soon as possible, not only because of the difficulties in finding a suitable space, but also because of the administrative management that makes its use possible since these are time-consuming procedures. When public authorities are involved, the matching of the local administration and the logistic operational requirements is one of the main challenges from the conceptual side. The business model must be sustainable over time, which implies not only environmental sustainability, but also financial and social sustainability. In this sense, one of the recommendations is to take advantage of the policies established in the city (regulatory framework, strategies, etc.) to promote these types of activities.

The hyperconnected vision of the city has shown some potential to contribute to city logistics. This Living Lab has focused on the establishment and testing of business models that combine the interests of different parties showing that there is a viable way to connect logistic partners and obtain a more sustainable last mile delivery system. Each individual platform might be too small to make a relevant change, but by connecting them, a more efficient and promising movement towards more sustainable urban logistics can be achieved.

Even though there are some promising elements, the hyperconnected vision of the city needs to be explored further. The asset sharing between the logistic service providers was not tested in a large scale, and the involvement of the municipality as a central agent to boost this collaboration has not been implanted yet.

The DT approach has also been proven as a positive asset throughout the LL activities. Some of the KPIs were not possible to be measured in the physical implementation, since the pilots were done in an open system (i.e., not in a controlled environment). By using data collected from the pilots and the DT approaches, the DT was able to simulate large scale implementations. Through the DT the possible effects of crowdshipping were measured and signaled a warning regarding the potential detrimental effects it can have if it attracts car travelers. This procedure can become a key in the future, when public authorities are able to simulate the effects of a new logistic innovation and be aware of the potential impacts before they happen and be able to avoid possible negative externalities.

6 Summary and outlook

This deliverable shows the LL2 pilots' implementation and DTs. The objective of the LL was to implement an instance of the hyperconnected city. Hyperconnectivity is part of the physical internet vision, where the different urban logistics networks connect between each other in order to create a larger and more efficient delivery network. To achieve this, a 3-step MVP is designed. The first MVP is to test crowdshipping in the Netherlands; the second MVP is to implement parcel lockers in public spaces, and the third one is to combine crowdshipping with parcel lockers in order to build an open city logistics platform.

Crowdshipping was tested by simulating parcels with different remunerations and origin-destination pairs. To recruit bringers, a survey to collect their preferences and invite them to Nimber's app was done. The main conclusion is that a remuneration of 1 euro/km might be feasible to attract bike bringers (as opposite of car bringers), although having coverage of multiple origin and destinations might be the key for a high level of service.

The implementation of parcel lockers in public spaces is waiting for building permit approval. However, this implementation has enough interest across the living lab that will continue to be implemented due to the interest developed by the CoP during the design phases of the Living Lab.

The third MVP combines the other two MVPs. This MVP analysed and defined how can the parcel locker and crowdshipping platform can interact by defining the key information elements to be shared and later included the open logistic platform architecture. The living lab further considered that it would be interesting to understand the behavioural implications of the interactions between crowdshippers and parcel lockers, which will be investigated outside the scope of this project.

The main result of the LL is the architecture of a new open urban logistics platform has been developed with the hyperconnected vision in mind. This integrated platform links service providers providers (e.g., delivery companies, couriers), shared infrastructure (e.g., warehouses, pickup/dropoff locations) and customers (e.g., businesses, individuals) to each other. Service providers can then use each other's infrastructure to store and consolidate packages, while customers can make use of multiple service providers at once to send and receive deliveries.

The DT is built with basis of the MASS-GT model, allowing the LL to used agent-based simulations to estimate KPIs in city-level implementations. Key insights were obtained, such as the importance of remuneration balance in order not to attract car users for crowdshipping and the large-scale effects of implementing parcel lockers.

Regarding the future, the CoP of the LL is expected to continue working together due to the shared vision that considers the multiple objectives of the stakeholder, being the implementation of the Stadsboerderij the first continuation of this, together with the implementation of the open city logistic platform. The DT and models can continuously be refined to include ore behavioural insights and extend the use cases to more connection across logistic service providers.

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Annex 1: Further pilot details

Annex Figure 1 and Annex Figure 2 show the layout of the parcels sent in Pilot 1.

Tasks (up to 10 latest)

View all Tasks (Old) | View all Tasks

Creator

#	Title	Price	Locations
289168	Book_W6_05	4 (Fee: 1) EUR	BM Delft — ED Delft
289167	Book_W6_04	12 (Fee: 2) EUR	TP Den Haag — AE Voorburg
289166	Book_W6_03	19 (Fee: 4) EUR	BT Den Haag — AL Rotterdam
289165	Book_W6_02	15 (Fee: 3) EUR	BB Den Haag — JV Den Haag
289164	Book_W6_01	6 (Fee: 1) EUR	ZE Delft — CS Delft
289015	Book_W5_05	16 (Fee: 3) EUR	LB Delft — BB Den Haag
289014	Book_W5_04	19 (Fee: 4) EUR	ZE Delft — AE Voorburg
289013	Book_W5_03	10 (Fee: 2) EUR	CN Delft — AL Rotterdam
289012	Book_W5_02	5 (Fee: 1) EUR	BM Delft — EX Delft
289011	Book_W5_01	21 (Fee: 4) EUR	CN Delft — AN Maassluis

Annex Figure 1. Nimber dashboard

Example of a task with multiple bidders

Offers

Amount	Deliverd Until	User	State	Created At	Action
6 EUR	27.10.2022	[redacted]	Open	20.10.2022 - 07:43 UTC	
6 EUR	26.10.2022		Accepted	22.10.2022 - 21:39 UTC	

Transactions

Authorized

#	User	Price	Cancel	Refund	Created At
30047682-b2dc-449b-bc0c-e6bcac87dc73	LEAD PILOT	6.0 EUR	Refund		20.10.2022 - 06:55 UTC

Annex Figure 2. Nimber task example

Annex Figure 3 show the designs and layout of the locker and shelter for Pilot N2. These drawings have been submitted as part of the permit application.

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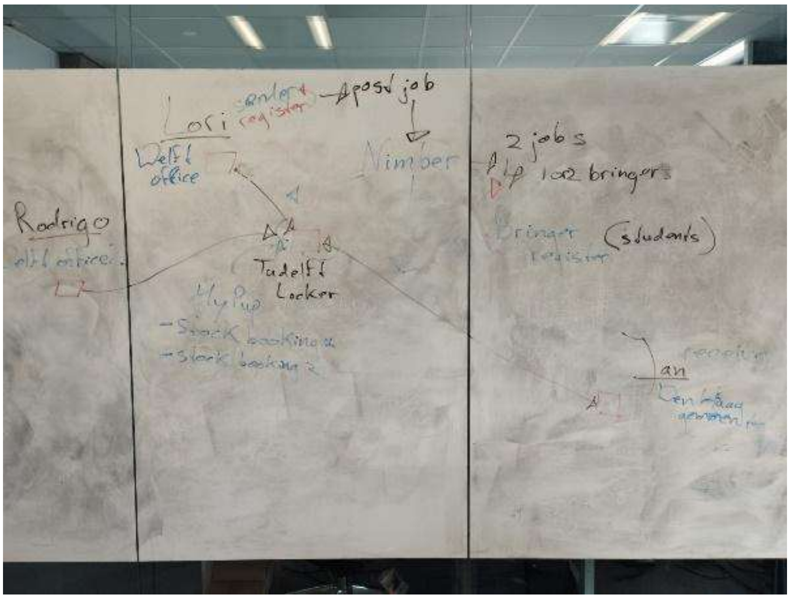
Annex Figure 3. Parcel locker plans

Annex Figure 4 shows the MVP3 pilot design session.



Annex Figure 4. MVP3 design session

Annex 2: KPIs calculation methodologies

Below the LEAD estimation calculation method, shown in Annex Table 1, Annex Table 2 and Annex Table 3.

Annex Table 1. LEAD Environmental KPIs

KPI	Calculation Method	Measurement units
Energy consumption	COPERT using the average activity data from the month of January 2022 (number of vehicles,total kilometres, average speed) calculated by the route optimization model.	Average energy consumption per delivery (MJ/delivery)
GHG emission		Average CO_2 per delivery (gCO2/delivery)
Air quality		Average $PM_{2.5}$ per delivery ($gPM_{2.5}$/delivery)
		Average NO_2 per delivery (gNO2/delivery)
		Average VoC per delivery (gVOC/delivery)
~~**Noise impact**~~		

Annex Table 2. LEAD Social KPIs:

KPI	Calculation Method	Measurement units
Jobs created	Data from operator	Number of employees
Quality of the jobs	Quality of the jobs (local survey involving the CoP)	Not applied: surveys will be conducted during the pilot testing phase to compare before and after situations.
Neighborhoods quality of life	Neighborhoods quality of life (local survey involving the CoP)	Not applied: surveys will be conducted during the pilot testing phase to compare before and after situations
Users sustainable behaviour	Users sustainable behaviour (local survey involving the CoP)	Not applied: surveys will be conducted during the pilot testing phase to compare before and after situations
Cooperative solutions & incentive measures	Cooperative solutions & incentive measures (number of solutions implemented during the pilot development)	Not applied: surveys will be conducted during the pilot testing phase to compare before and after situations

Annex Table 3. LEAD Economic KPIs

KPI	Calculation Method	Baseline scenario value
Average delivery cost of the business model	Data from operator	Annual average cost per delivery (€/delivery) [2]
Congestion 1 (Congested Shipments)	Data from operator	Not applied
Congestion 2 (Congestion from vehicles)[3]	Data from operator	Number of trucks circulating in an area
Urban storage and parking space[4]	Data from operator	Urban storage and parking area required depending on the type and ownership of the area (m^2)
Financial internal rate of return of the investment conducted	Data from operator	Not applied: surveys will be conducted during the pilot testing phase to compare before and after situations
Shop/retail benefits (shippers)	Local survey	
Delivery time	Data from operator	Average time required to make a delivery (minutes/delivery)
Delivery reliability within the time window	Data from operator	Daily average percentage of deliveries made on time within the time window and in good conditions (%)

[2] *A: sensitive data. We provide and arbitrary value A.*
[3] *Assuming that the vehicle does not influence congestión when propertly parked*
[4] *Assuming that the vehicle does not influence congestión when propertly parked*

Annex 3: Configuration of DTs

Annex Table 4 shows the list of parameters that were used to configure the LL2 DT.

Annex Table 4. Configuration of the DT for LL2

	Baseline	MVP1	MVP2	MVP3
Gemeenten_studyarea	['Delft', 'Midden_Delfland', 'Rijswijk','sGravenhage','Leidschendam_Voorburg',]	['Delft', 'Midden_Delfland', 'Rijswijk','sGravenhage','Leidschendam_Voorburg',]	['Delft', 'Midden_Delfland', 'Rijswijk','sGravenhage','Leidschendam_Voorburg',]	['Delft', 'Midden_Delfland', 'Rijswijk','sGravenhage','Leidschendam_Voorburg',]
PARCELS_PER_HH_C2C	20.8 / 250 / 8.0	20.8 / 250 / 8.0	20.8 / 250 / 8.0	20.8 / 250 / 8.0
PARCELS_PER_HH_B2C	0.195	0.195	0.195	0.195
PARCELS_PER_EMPL	0.000	0.000	0.000	0.000
Local2Local	0.04	0.04	0.04	0.04
CS_cust_willingness	0.50	0.50	0.50	0.50
PARCELS_MAXLOAD	180	180	180	180
PARCELS_DROPTIME	120	120	120	120
PARCELS_SUCCESS_B2C	0.90	0.90	0.90	0.90
PARCELS_SUCCESS_B2B	0.95	0.95	0.95	0.95
PARCELS_GROWTHFREIGHT	1.0	1.0	1.0	1.0
RUN_DEMAND_MODULE	True	True	True	True
CROWDSHIPPING_NETWORK	False	True	False	True

	Baseline	MVP1	MVP2	MVP3
COMBINE_DELIVERY_PICKUP_TOUR	True	True	True	True
HYPERCONNECTED_NETWORK	False	False	False	False
printKPI	True	True	True	True
PL_ZonalDemand	0.7	0.7	0.7	0.7
parcelLockers_zones	[212,612,161,610,151,978,252,299]	[212,612,161,610,151,978,252,299]	[212,612,161,610,151,978,252,299,2359,800]	[212,612,161,610,151,978,252,299,2359,17]
CROWDSHIPPING_NETWORK	False	False	False	False
COMBINE_DELIVERY_PICKUP_TOUR	True	True	True	True
HYPERCONNECTED_NETWORK	False	False	False	False
TESTRUN	False	False	False	False
Gemeenten_CS	["sGravenhage", "Zoetermeer", "Midden_Delfland"]	["sGravenhage", "Zoetermeer", "Midden_Delfland"]	["sGravenhage", "Zoetermeer", "Midden_Delfland"]	["sGravenhage", "Zoetermeer", "Midden_Delfland"]
SCORE_ALPHAS	[0,0,1,1]	[0,0,1,1]	[0,0,1,1]	[0,0,1,1]
SCORE_COSTS	[2, .2, .2, 0 , 0, 999999999990]	[2, .2, .2, 0 , 0, 999999999990]	[2, .2, .2, 0 , 0, 999999999990]	[2, .2, .2, 0 , 0, 999999999990]
CONSOLIDATED_MAXLOAD	500	500	500	500
HyperConect	{"DHL": [] , "DPD": [] , "FedEx": [] , "GLS": [] ,"PostNL": [] , "UPS": [] , "Cycloon": [],"MyPup":[]}	{"DHL": [] , "DPD": [] , "FedEx": [] , "GLS": [] ,"PostNL": [] , "UPS": [] , "Cycloon": [],"MyPup":[]}	{"DHL": [] , "DPD": [] , "FedEx": [] , "GLS": [] ,"PostNL": [] , "UPS": [] , "Cycloon": [],"MyPup":[]}	{"DHL": [] , "DPD": [] , "FedEx": [] , "GLS": [] ,"PostNL": [] , "UPS": [] , "Cycloon": [],"MyPup":[]}
ParcelLockersfulfilment	["MyPup"]	["MyPup"]	["Cycloon"]	["Cycloon"]
CS_Willingess2Send	0.05 + (Cost-TradCost) * (-0.329)	0.05 + (Cost-TradCost) * (-0.329)	0.05 + (Cost-TradCost) * (-0.329)	0.05 + (Cost-TradCost) * (-0.329)

	Baseline	MVP1	MVP2	MVP3
CS_BaseBringerWillingess	-1.4 + 0.1 * np.random.normal(0,1)	-1.4 + 0.1 * np.random.normal(0,1)	-1.4 + 0.1 * np.random.normal(0,1)	-1.4 + 0.1 * np.random.normal(0,1)
CS_BringerFilter	{'age' : ['<35','35-55'] , 'income' : ['low','average','aboveAverage'] , 'following_purpose' :['Home', 'Business', 'Leisure', 'Other', 'Groceries', 'Services', 'Social', 'BringGet', 'NonGroc', 'Touring'],'Mode' : ['Car','Walking or Biking']}	{'age' : ['<35','35-55'] , 'income' : ['low','average','aboveAverage'] , 'following_purpose' :['Home', 'Business', 'Leisure', 'Other', 'Groceries', 'Services', 'Social', 'BringGet', 'NonGroc', 'Touring'],'Mode' : ['Car','Walking or Biking']}	{'age' : ['<35','35-55'] , 'income' : ['low','average','aboveAverage'] , 'following_purpose' :['Home', 'Business', 'Leisure', 'Other', 'Groceries', 'Services', 'Social', 'BringGet', 'NonGroc', 'Touring'],'Mode' : ['Car','Walking or Biking']}	{'age' : ['<35','35-55'] , 'income' : ['low','average','aboveAverage'] , 'following_purpose' :['Home', 'Business', 'Leisure', 'Other', 'Groceries', 'Services', 'Social', 'BringGet', 'NonGroc', 'Touring'],'Mode' : ['Car','Walking or Biking']}
CS_BringerUtility	0.1 + (-0.052) * Cost + (-0.069) * Time	0.3 + (-0.1) * Cost + (-0.062) * Time	0.1 + (-0.052) * Cost + (-0.069) * Time	#REF!
Car_CostKM	0.19	0.19	0.19	0.19
VOT	9.00	9.00	9.00	9.00
PARCELS_DROPTIME_CAR	120	120	120	120
PARCELS_DROPTIME_BIKE	60	60	60	60
PARCELS_DROPTIME_PT	0	0	0	0
CS_BringerScore	Min_Detour	Min_Detour	Min_Detour	Min_Detour
CS_COMPENSATION	6	8	6	6
CS_ALLOCATION	best2best	best2best	best2best	best2best
CS_UtilDiscount	SecondBest	SecondBest	SecondBest	SecondBest
PlatformComission	0.15	0.15	0.15	0.15
CS_Costs	0.00	0.00	0.00	0.00
CarSpeed	30.00	30.00	30.00	30.00
WalkBikeSpeed	12.00	12.00	12.00	12.00
CarCO2	160.00	160.00	160.00	160.00

	Baseline	MVP1	MVP2	MVP3
TradCost	9.20	10.20	9.20	9.20
CS_MaxParcelDistance	10.00	10.00	10.00	10.00
CONSOLIDATED_TRIPS	True	True	True	True
DEDICATED_CONSOLIDATED_TRIPS	False	False	False	False
#PARCELS_MAXLOAD	180	180	180	180
PARCELS_DROPTIME	120	120	120	120
PARCELS_MAXLOAD_Hub2Hub	500	500	500	500
PARCELS_DROPTIME_Hub2Hub	90	90	90	90
VEHICLES	{"DHL": ['Van','Van'] , "DPD":['Van','Van'] , "FedEx":['Van','Van'] , "GLS":['Van','Van'] ,"PostNL":['Van','Van'] , "UPS":['Van','Van'] , "Cycloon":['CargoBike','Van']," MyPup":['Van','Van'] }	{"DHL": ['Van','Van'] , "DPD":['Van','Van'] , "FedEx":['Van','Van'] , "GLS":['Van','Van'] ,"PostNL":['Van','Van'] , "UPS":['Van','Van'] , "Cycloon":['CargoBike','Van']," MyPup":['Van','Van'] }	{"DHL": ['Van','Van'] , "DPD":['Van','Van'] , "FedEx":['Van','Van'] , "GLS":['Van','Van'] ,"PostNL":['Van','Van'] , "UPS":['Van','Van'] , "Cycloon":['CargoBike','Van'] , "MyPup" : ['Van','Van'] }	{"DHL": ['Van','Van'] , "DPD":['Van','Van'] , "FedEx":['Van','Van'] , "GLS":['Van','Van'] ,"PostNL":['Van','Van'] , "UPS":['Van','Van'] , "Cycloon":['CargoBike','Van']," MyPup":['Van','Van'] }
CAPACITY	{'Van': [180,120], 'ConsoldVan': [180,60], 'CargoBike' : [50,120] }	{'Van': [180,120], 'ConsoldVan': [180,60], 'CargoBike' : [50,120] }	{'Van': [180,120], 'ConsoldVan': [180,60], 'CargoBike' : [50,120] }	{'Van': [180,120], 'ConsoldVan': [180,60], 'CargoBike' : [50,120] }

Annex 4: Simulation scenarios details

Below, in Annex Table 5, the results of the simulations for baseline and MVPs.

Annex Table 5. Complete KPI list from simulations

			Baseline	MVP1	MVP2	MVP3
Parcel generation	**Parcel demand aggregates**	Number Of Parcels to be delivered per day (with redelivery)	89,934	89,934	89,924	89,924
		New parcel daily demand	81,347	81,347	81,347	81,347
		Redelivered parcels	8,587	8,587	8,577	8,577
		Number Of Parcels to Parcel lockers	426	426	511	511
		ParcelDemand_Cycloon	827	827	827	827
		ParcelDemand_DHL	20,824	20,824	20,821	20,821
		ParcelDemand_DPD	9,258	9,258	9,258	9,258
		ParcelDemand_FedEx	2,383	2,383	2,383	2,383
		ParcelDemand_GLS	3,769	3,769	3,768	3,768
		ParcelDemand_PostNL	44,748	44,748	44,743	44,743
		ParcelDemand_UPS	8,125	8,125	8,124	8,124
Parcel Market	**L2L demand**	Local2Local	3558	3558	3559	3559
		Local2Local_Percentage	3.96	3.96	3.96	3.96
		L2L_Cycloon	488	44	51	36
		L2L_DHL	1195	606	1204	587
		L2L_DPD	573	267	567	284
		L2L_FedEx	160	89	138	83
		L2L_GLS	276	137	223	138

			Baseline	MVP1	MVP2	MVP3
		L2L_PostNL	2668	1343	2798	1379
		L2L_UPS	488	248	462	245
	Crowdshipping	parcels_eligibleforCS	0	740	0	654
		parcels_ChooseCS	0	740	0	654
		parcels_DidntChooseCS	0	0	0	0
		PoolOfTrips	0	3152	0	3145
		PoolOfTravellers	0	2592	0	2545
		parcels_matched	0	740	0	654
		match_percentage	0	100	0	100
		detour_sum	0	4740	0	3709
		detour_avg	0	6.41	0	5.67
		compensation_avg	0	4.23	0	5.19
		PlatformComission	0	539.43	0	585.64
		car detour	0	0	0	0
		car extraTime	0	0	0	0
		car Compensation	0	0	0	0
		car CompPerHour	0	0	0	0
		car Count	0	0	0	0
		car Share	0	0	0	0
		car detour_average	0	0	0	0
		bike detour	0	4740.67	0	3709.64
		bike extraTime	0	395.06	0	309.14
		bike Compensation	0	3127.12	0	3395.02
		bike CompPerHour	0	7.92	0	10.98
		bikeCount	0	740	0	654

			Baseline	MVP1	MVP2	MVP3
		bike Share	0	100	0	100
		bike tour_av	0	6.4	0	5.66
		crowdshipping_ExtraCO2	0	0	0	0
Parcel scheduling	**General**	conventional_direct_return	176.77	119.89	215.2	221.23
		conventional_parcels_delivered	90386	88363	93101	89998
		conventional_parcels_picked-up	3547	1511	3861	3861
		conventional_parcels_total	89967	88146	89904	89904
		conventional_distance	27496	25459	28379	27774
		conventional_trips	13006	11685	13200	12982
		conventional_tours	548	531	614	580
		conventional_distance_avg	0.3	0.29	0.31	0.31
		Cycloon Depot 1 parcels	827	1230	3895	2595
		Cycloon total parcels	827	1230	3895	2595
		DHL Depot 1 parcels	3512	3278	3394	3214
		DHL Depot 2 parcels	468	467	469	469
		DHL Depot 3 parcels	12166	11885	12048	11913
		DHL Depot 4 parcels	5084	4910	5025	4895
		DHL Depot 5 parcels	0	0	0	0
		DHL Depot 6 parcels	10	9	10	8
		DHL total parcels	21240	20549	20946	20499
		DPD Depot 1 parcels	9260	9009	9255	9065
		DPD total parcels	9260	9009	9255	9065
		Fedex Depot 1 parcels	2382	2327	2382	2343
		Fedex total parcels	2382	2327	2382	2343
		GLS Depot 1 parcels	3771	3664	3766	3706

			Baseline	MVP1	MVP2	MVP3
		GLS Depot 2 parcels	0	0	0	0
		GLS total parcels	3771	3664	3766	3706
		PostNL Depot 1 parcels	44688	43578	44650	43745
		PostNL Depot 2 parcels	0	0	0	0
		PostNL Depot 3 parcels	0	0	0	0
		PostNL Depot 4 parcels	89	87	83	83
		PostNL total parcels	44777	43665	44733	43828
		UPS Depot 1	8129	7919	8124	7962
		UPS total parcels	8129	7919	8124	7962
		Cycloon Depot 1 parcels	41	22	370	370
		Cycloon total parcels	41	22	370	370
		DHL Depot 1 parcels	295	139	303	303
		DHL Depot 2 parcels	3	1	1	1
		DHL Depot 3 parcels	272	128	249	249
		DHL Depot 4 parcels	225	68	215	215
		DHL Depot 5 parcels	0	0	0	0
		DHL Depot 6 parcels	2	0	1	1
		DHL total parcels	797	336	769	769
		DPD Depot 1 parcels	375	147	372	372
		DPD total parcels	375	147	372	372
		Fedex Depot 1 parcels	95	50	94	94
		Fedex total parcels	95	50	94	94
		GLS Depot 1 parcels	140	74	143	143
		GLS Depot 2 parcels	0	0	0	0
		GLS total parcels	140	74	143	143

			Baseline	MVP1	MVP2	MVP3
		PostNL Depot 1 parcels	1759	750	1793	1793
		PostNL Depot 2 parcels	0	0	0	0
		PostNL Depot 3 parcels	0	0	0	0
		PostNL Depot 4 parcels	3	1	2	2
		PostNL total parcels	1762	751	1795	1795
		UPS Depot 1	337	131	318	318
		UPS total parcels	337	131	318	318
	LastMile distances	Cycloon	1221.79	1235.3	2220.69	1851.38
		DHL	4437.5	3800.88	4195.79	4171.84
		DPD	4251.94	3904.34	4259.05	4183.3
		FedEx	2894.35	2709.13	2805.97	2789.47
		GLS	2666.53	2585.94	2701.22	2698.76
		MyPup	0	0	0	0
		PostNL	7650.38	7241.44	7807.52	7656.25
		UPS	4197.21	3862.84	4173.62	4202.48
		total	27319.7	25339.86	28163.84	27553.48
	Kms per vehicle type	Van	53417.61	49444.44	54107.03	53255.58
		CargoBike	1221.79	1235.3	2220.69	1851.38
COPERT		TJ	0.088998	0.0816495	0.0884839	0.0877211
		COPERT CO2	6.6330806	6.0853951	6.5947652	7
		Nox	0.0024429	0.0022412	0.0024287	0.0024078
		PM	0.0010855	0.0009959	0.0010792	0.0010699
Network		Total Vehicles	3129682.4	3116374.2	3128518	3117030.1
		Vehicles in kakelhof	343.5	310.5	308.3	309.3

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Annex 5: Workshops' details

One pager of the conclusions of the workshop:

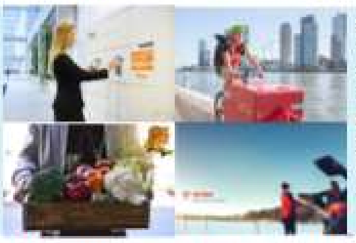
TUDelft Next2Company

LEAD Futureshop 3-4 March 2022

Hyperconnected City the Hague

Context: The Central Innovation District (CID). Economic heart where:
90,000 people earn their money
>**30,000 study** towards a better, safer and fairer world in a digital age
25,000 new homes will be added for
50,000 new residents.
500,000 square meters of office space expected addition
Commuters will **double** to more than **400,000** per day.

Problem statement: How to **mix logistic services across platforms** to create a more efficient and sustainable **urban freight system,** by **sharing resources** for carriers and improve offerings for customers?



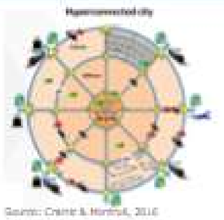
Participating partners

City of The Hague – Access to infrastructure
MyPup - Consolidation and locker deliveries
Cycloon - Largest bike courier in NL
Hubklup - Consolidated fresh delivery to restaurants
Nimber - Crowdshipping platform

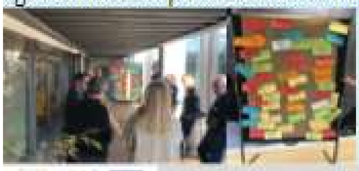
Two-step goal towards Hyperconnected City

The hyperconnected city is a city where actors in multiple segments are connected, both physically and digitally, to ensure efficient logistics.
We work towards this goal in two steps:

1. Collaborate: Loosely coupling logistical partners for efficient fulfilment
2. Integration: An open city logistics platform



Workshop insights and design questions to answer for the coming period:
Hard factors like tech are no bottleneck: What factors are needed for standardization and harmonization? **The key is flexible and connected business models:** How do we build trustful business relationships between LSPs?
Information is value: What information needs to be shared in order to have the costs and benefits clear and transparent? How do we measure them?
It is hard to "lend" hard-fought clients to competitors. What type of customer experience is needed? How do we allow different parties to retain competitive advantages and, at the same time, how do we provide a general customer experience?
The right governance helps hyperconnectivity: How do we make a *fair* governance structure?
Municipality and other governments can help: What regulations and rewards could the government impose to make connecting more attractive for LSPs?

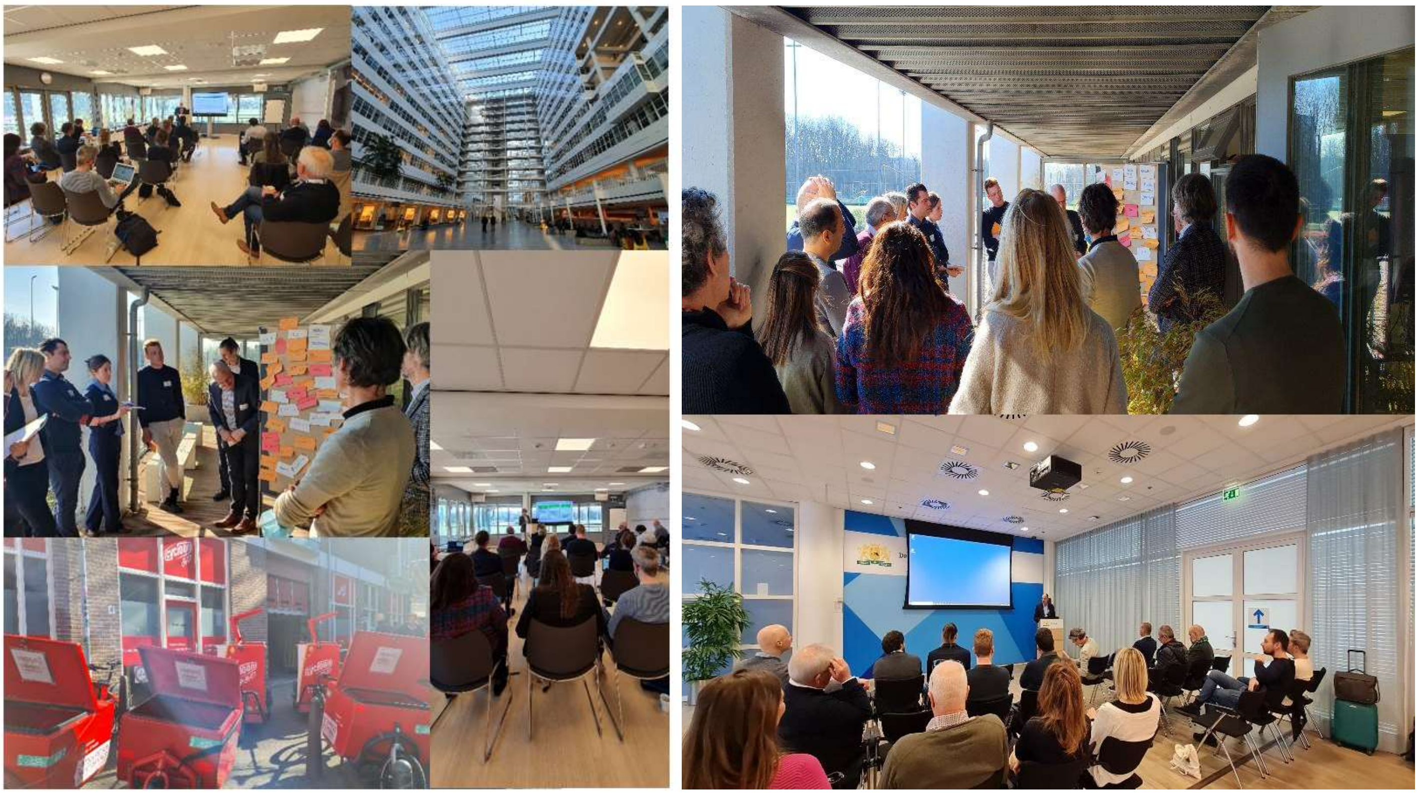


***Digital Twins** as a tool for decision making*
DTs add value by representing current and future scenarios from the multiple stakeholders.
Logistical DT should have interaction with other urban DT and accommodate different time horizons.

CIVITAS

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 861598

Participants during the presentations:



Boards of the first workshop:

Communication of results of the second workshop:

Workshop summary

On the 17th of April a workshop was held about the activities and insights of the LEAD project. The goal of the workshop was to introduce the LEAD project to the different departments of the municipality of The Hague, to discuss the progress and insights of The Hague Living Lab and to look towards to future and discuss how we can use the LEAD insights for the improvement of city logistics in The Hague the coming years.

Below you see the agenda of the workshop. We started with a brief introduction of all partners and outside stakeholders present. Hereafter we discussed the hyperconnected city concept and the activities of the LEAD project to test different parts of this concept.

Time	Subject	By...
10:00 – 10:10	**Welcome**	**Next2Company**
10:10 – 10:25	Vision of the The hyperconnected city	Next2Company
10:25 - 11:20	1. What is the LEAD project? 2. LEAD MVPs physical with results 3. Digital Twin with results	TU Delft & Next2Company
11:20 – 12:00	Reactions to LEAD - Discussion	All
12:00 – 12:30	Lunch	
12:30 – 13:15	Brainstorm: future possibilities	All
13:15 – 14:00	Brainstorm: practical implications	All
14:00	Closing & Networking	All

After lunch we went in to two brainstorming sessions to gather more ideas of what other ideas can be tested or worked out to improve city logistics in The Hague. This sparked a debate about the goal of city logistics from the perspective of the municipality and the insights from LEAD could add to that.

Furthermore, ideas were exchanged about how the LEAD activities could fit into the future of city logistics in The Hague and new ideas for solution areas, further research areas and constructive criticisms were brought up. Below a shortlist of gathered ideas.

New solution areas:

- Gamification in combination with health challenges to promote (bike) crowdshipping
- Coupling freight delivery with existing transport services such as special needs transport.
- Package delivery windows during the week similar to waste retrieval (e.g. deliveries every Tuesday).
- Stricter policy making by the municipality to enforce what is currently ‘advice’, such as only allowing zero-emission delivery for certain areas.
- The Hague Freight Quality Partnership (similar to Rotterdam) to bring together logistic companies and the municipality.
- Maximum package size for highly congested locations.

Further research areas:

- A whitepaper with insights, solution areas and further research to create and communicate the vision for city logistics in The Hague.
- Varying payment systems based on delivery urgency.
- Locker storage as intermediate consolidation points.
- Investigate alternative motivation for becoming a crowdshipper besides monetary incentives.
- Testing the social context of hyperconnectivity solutions including the Municipality's social KPIs
- Create local Freight demand partnerships such as sector partnerships (e.g. hospitality delivery partnerships).

Constructive criticisms:

- Possible downside to hyperconnectivity is an increase in movements in the long term because of the lower transport costs, which might lead to a net-increase (rebound effect).
- Using parcel lockers as logistical hubs might take away business from local business owners of pick-up points, which currently perform a function in social cohesion within neighbourhoods.