HARMONY
SPATIAL & TRANSPORT PLANNING FOR A NEW MOBILITY ERA

Sebastiaan Thoen
thoen@significance.nl
(Significance)

Michiel de Bok
(Significance / TU Delft)

Larissa Eggers
(Significance)

Ioanna Kourounioti
(TU Delft)

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E-commerce in strategic freight models: an implementation in the province of the Zuid-Holland

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Contents

Parcel market – State of modelling practice

- Rapidly evolving market segment
  - Large growth in demand
  - New concepts and policies, such as:
    - Cargo bikes
    - Micro hubs
    - Zero emission zones
    - …
- Largely ignored segment in existing transport models
- A few first operational prototypes in the scientific literature
  - Karlsruhe (Reiffer et al., 2021)
  - Lyon (Hörl & Puchinger, 2021)
  - Berlin (Heldt et al., 2019)

Improving on current modelling practice

- We developed a parcel simulation model:
  - with a demand model estimated on real individual household data,
  - that distinguishes different parcel types,
  - represents parcel couriers explicitly,
  - and models all B2B, B2C and C2C parcel deliveries in region that includes both urban and rural areas (large scale and scope).

- Developed for the HARMONY project for the European Commission
  - As part of the Tactical Freight Simulator (TFS)
  - In collaboration with TU Delft

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https://harmony-h2020.eu/

Parcel segments

- Regular parcels
- E-groceries
- Meal deliveries

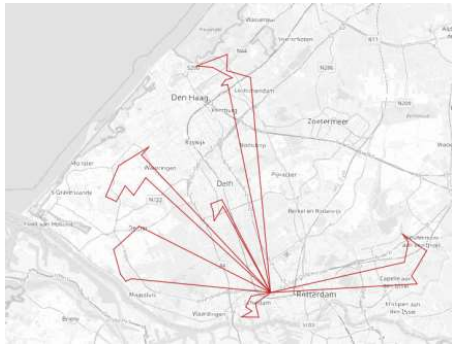
themanual.com

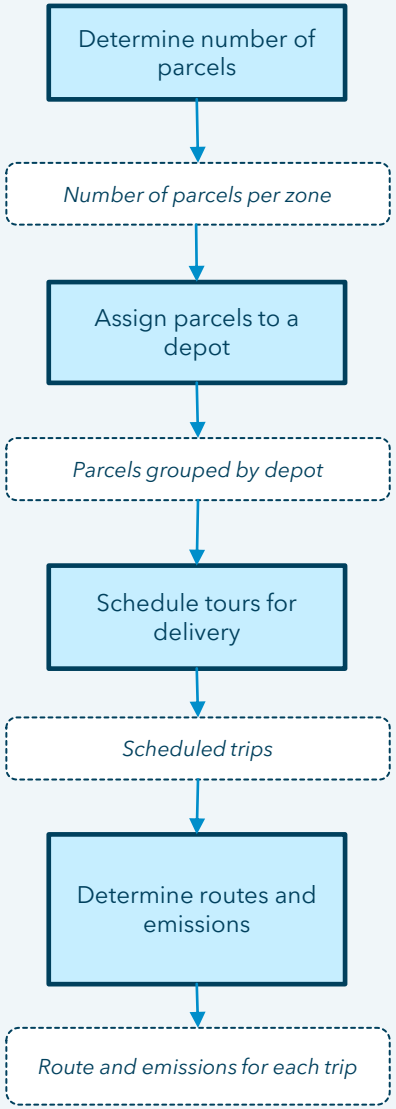
emerce.nl


careers.justeattakeaway.com

Overall structure of the simulation model
(for regular parcels)

1. Determine **number of parcels** delivered per household and business
2. Select the **depot** from the last-mile delivery is performed
3. Schedule the **tours** to deliver the parcels
4. Determine the **routes** and **emissions** on the road network





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Data collection – Zones and road network

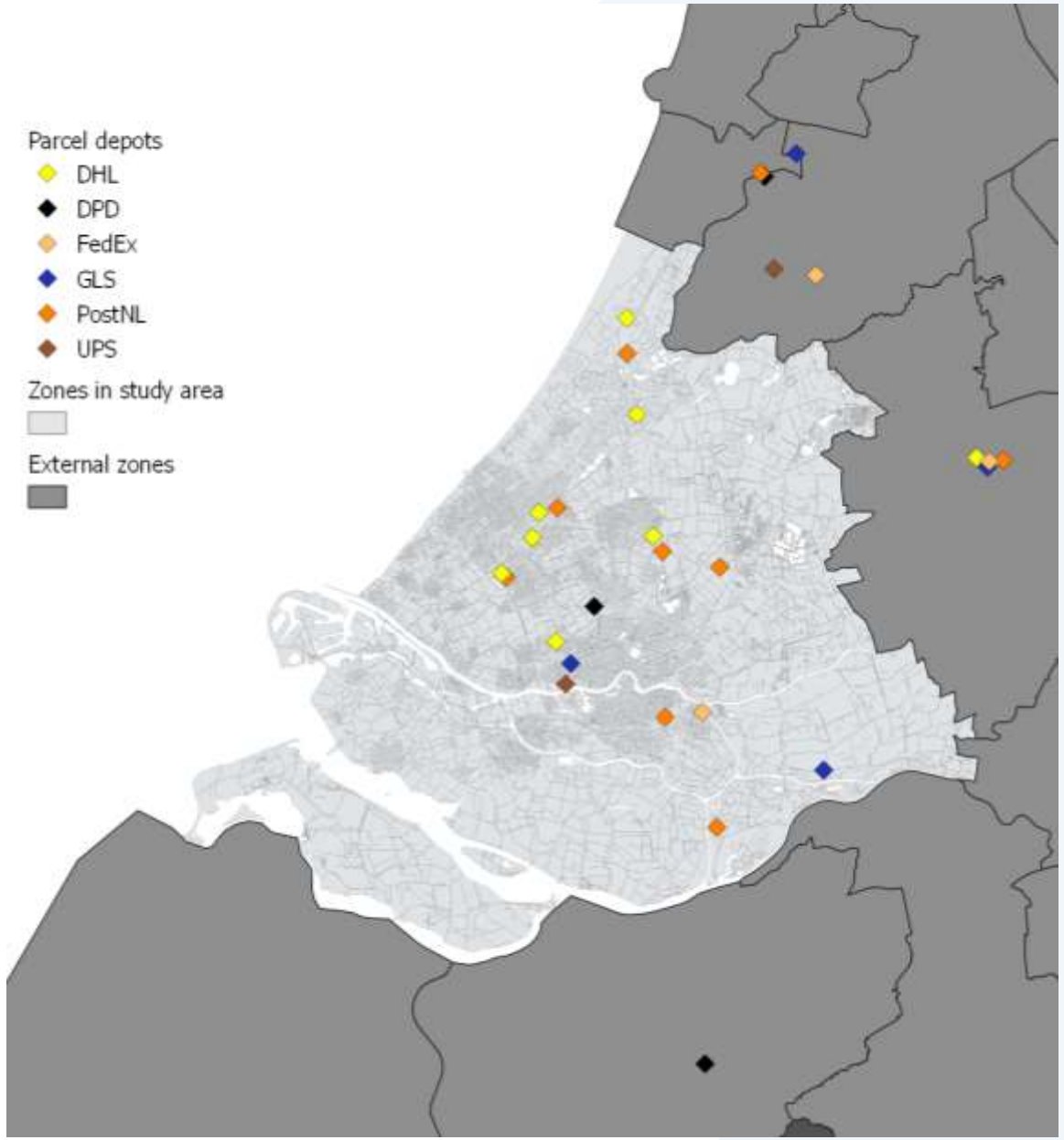
- Network and zones of the V-MRDH transport model, access granted by Gemeente Rotterdam
- About 7000 zones in the study area
  - Zuid-Holland, the Netherlands

Data collection – Couriers and depots

- Parcel depots
  - 29 depots in/near the Province of Zuid-Holland
  - For the 6 largest couriers in NL
  - Collected with OpenStreetMap API
  - Verified with Google Maps

- Courier market shares (ACM, 2018)

Courier	Share domestic	Share international
PostNL	62.5%	24.0%
DHL	27.5%	13.0%
DPD	2.5%	28.0%
GLS	2.5%	8.0%
UPS	2.5%	24.0%
FedEx	2.5%	3.0%



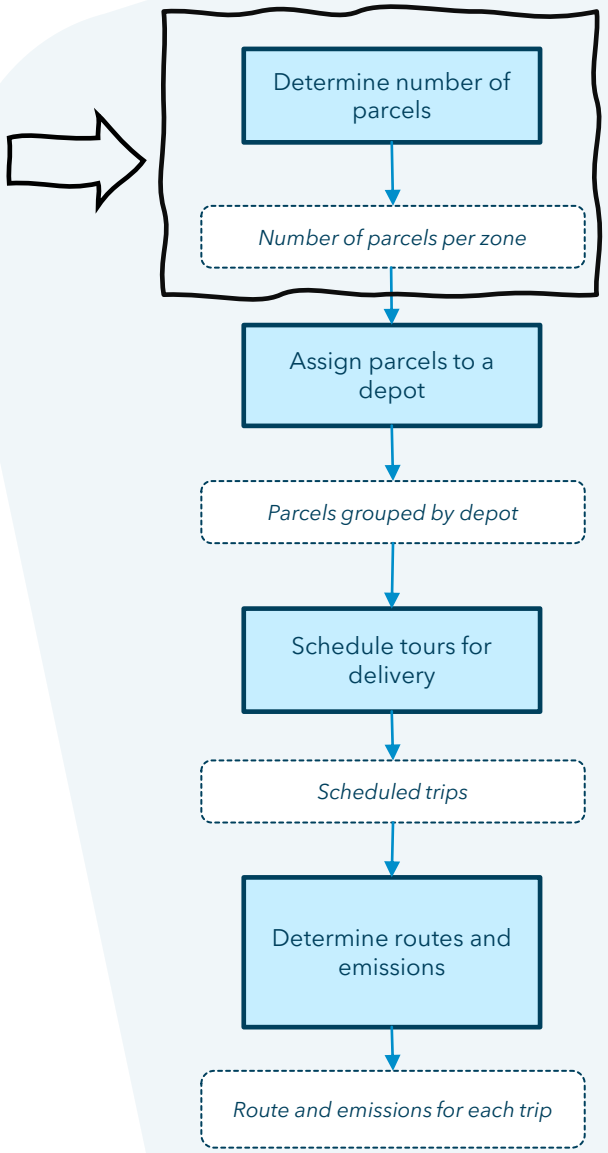
Data collection – Parcel demand

- Mobility Panel Netherlands (MPN)
  - Annual trip diary survey collected by the Kennisinstituut voor Mobiliteitsbeleid (KiM) amongst a panel of Dutch households
  - E-commerce questions in 2017 and 2021

Hoogendoorn-Lanser, S., Schaap, N. Olde Kalter, M.J. (2015).
The Netherlands Mobility Panel: An innovative design approach for web-based longitudinal travel data collection.
10th International Conference on Transport Survey Methods, Transportation Research Procedia 11 (2015) pp 311-329.
https://doi.org/10.1016/j.trpro.2015.12.027

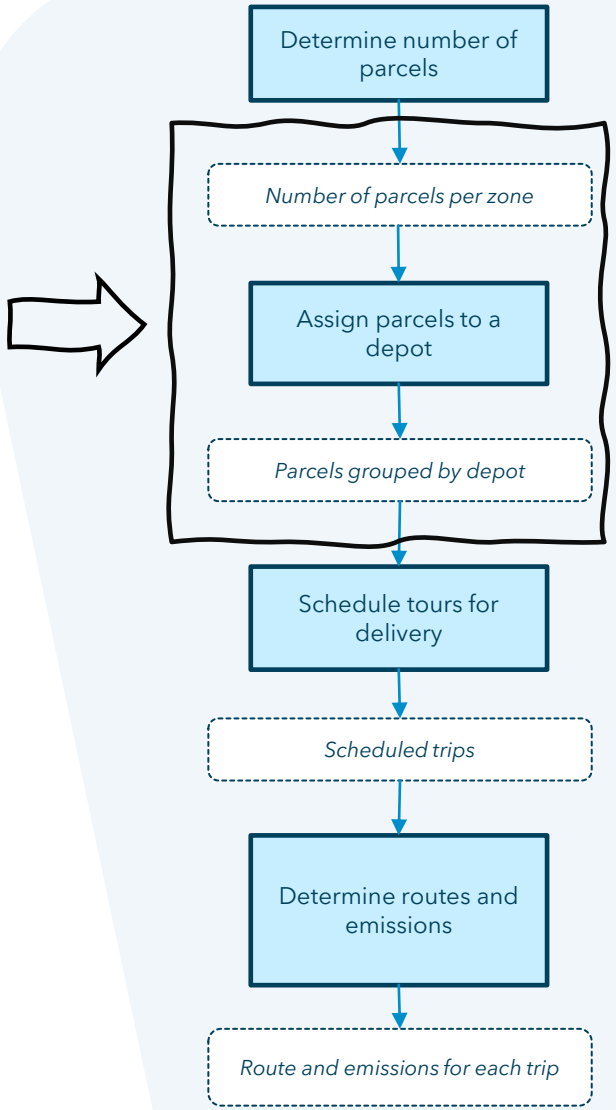
Step 1: Determining the parcel demand

- Parcel demand: Number of parcel deliveries per day in each zone
  - B2C/C2C (to households)
    - Ordered logit model estimated on MPN survey
    - Explanatory variables
      - Age
      - Income
      - Degree of urbanization
  - B2B/C2B (to businesses)
    - One generic parameter: parcels per employee
    - Deduced from report of ACM (Netherlands Authority for Consumers and Markets)



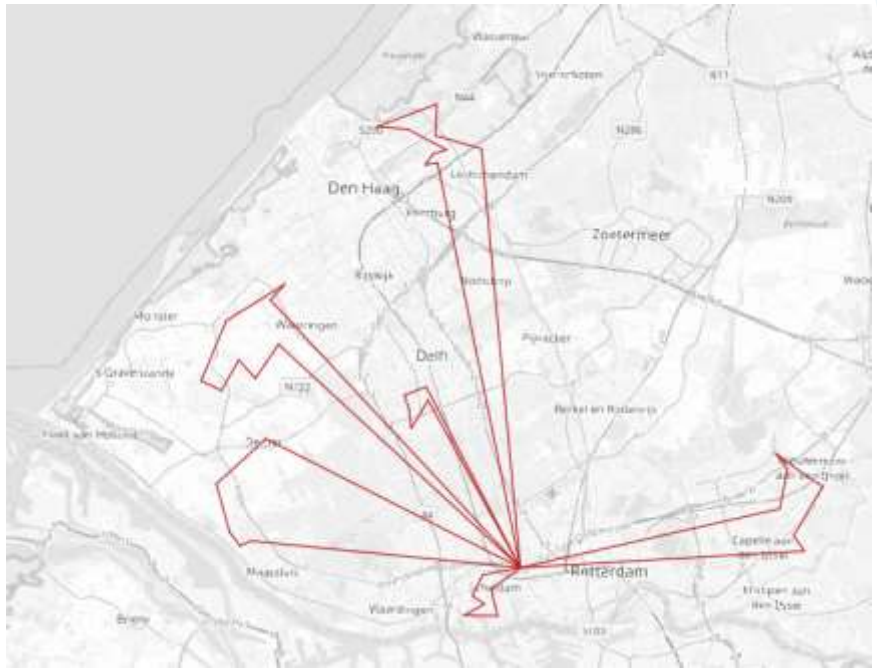
Step 2: Selecting the depot

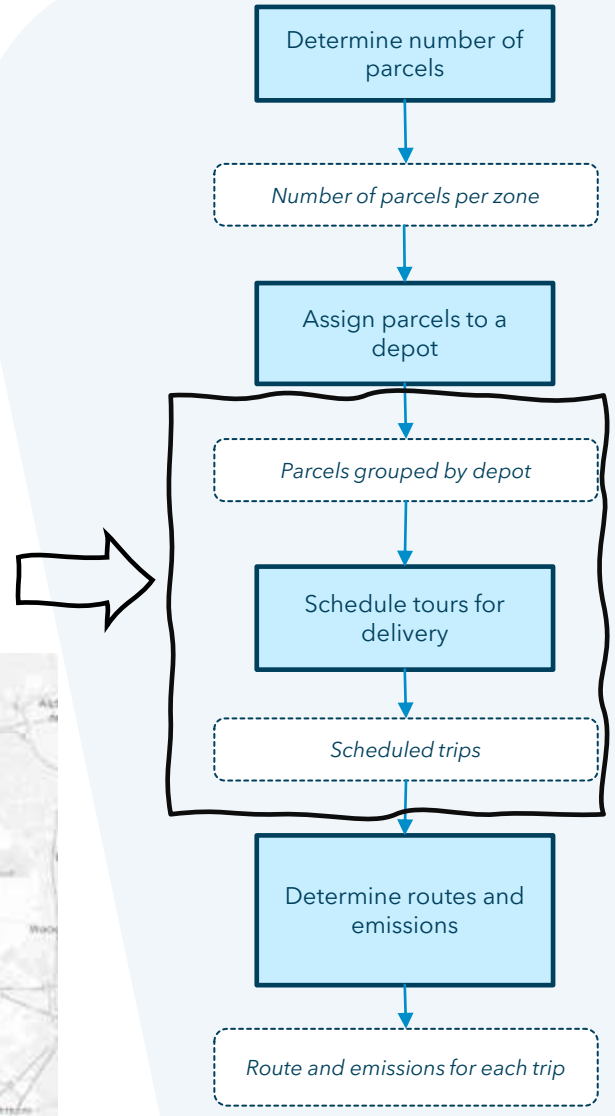
- Determine the parcel courier for each parcel, based on observed market shares
- Assign the parcel to the nearest depot of the courier



Step 3: Forming the tours

- For each depot:
  - Group parcels into clusters of max. 180 parcels, based on geographical proximity
  - Determine the order of visiting locations using a nearest-neighbor-search and a 2-opt posterior improvement
  - Maximum tour duration of 8 hours
- We’re not looking for the optimal set of tours, but for a sufficiently plausible set of tours



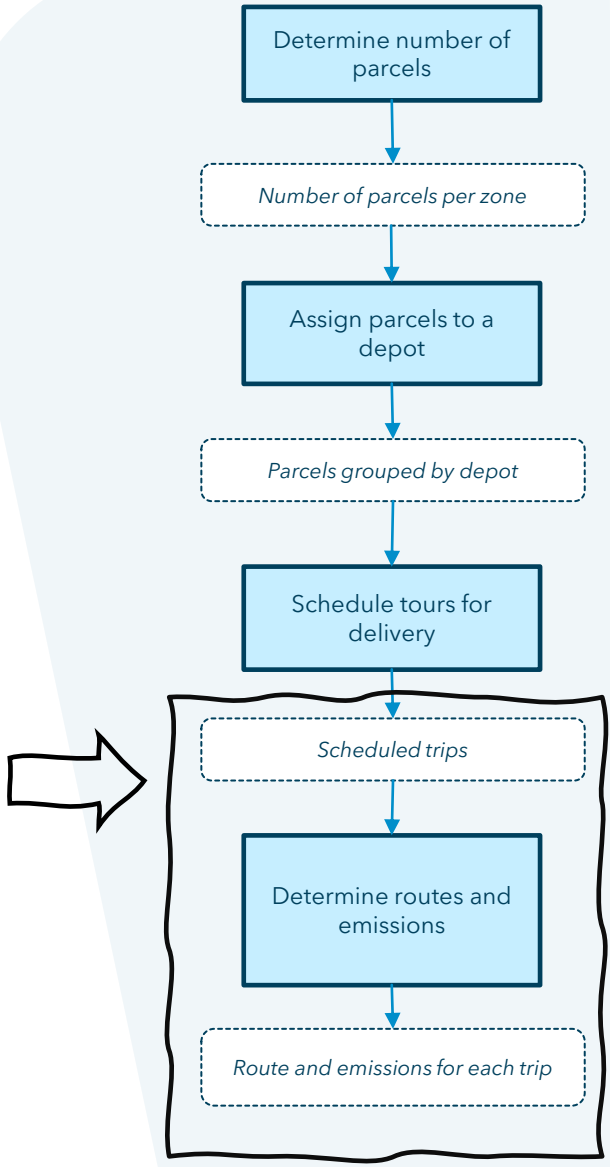


Step 4: Calculating the emissions

- For each scheduled trip:
  - Determine the route on the road network
  - For each link on the route, calculate the emissions:
    - Using emission factors (g/km)
      - For vans
      - Differing by road type (urban, rural, highway)
      - Source: CE Delft report “STREAM Goederenvervoer”

- Approach described in Thoen et al. (2020)

Thoen, S., de Bok, M., Tavasszy, L. (2020). *Shipment-Based Urban Freight Emission Calculation.* Proceedings Forum on Integrated and Sustainable Transportation Systems (FISTS), Delft, The Netherlands, November 2020. https://doi.org/10.1109/FISTS46898.2020.9264858



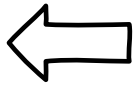
First model results

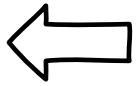
- Three scenarios
  - Reference forecast for 2030 → Large growth of parcel market
  - Zero-emission zones with consolidation hubs
  - Asset sharing of depots

First model results (Part 1 - Forecast run)

- Base year (2016) and future year (2030 – high economic growth scenario)
- Assumed: annual increase of 10% of number of parcels
- Key finding: Increase in vehicle kilometers (VKM) is not equal to increase in parcel demand
  - More efficient tour formation because of increased consolidation potential

KPI	2016	2030H	Growth
No. of parcels	356 197	1 562 064	+338.5%
No. of trips	36 466	54 187	+48.6%
No. of tours	1 994	8 693	+336.0%
VKM	123 673.0	356 605.4	+188.3%
CO2	22 937.3	69476.6	+202.9%



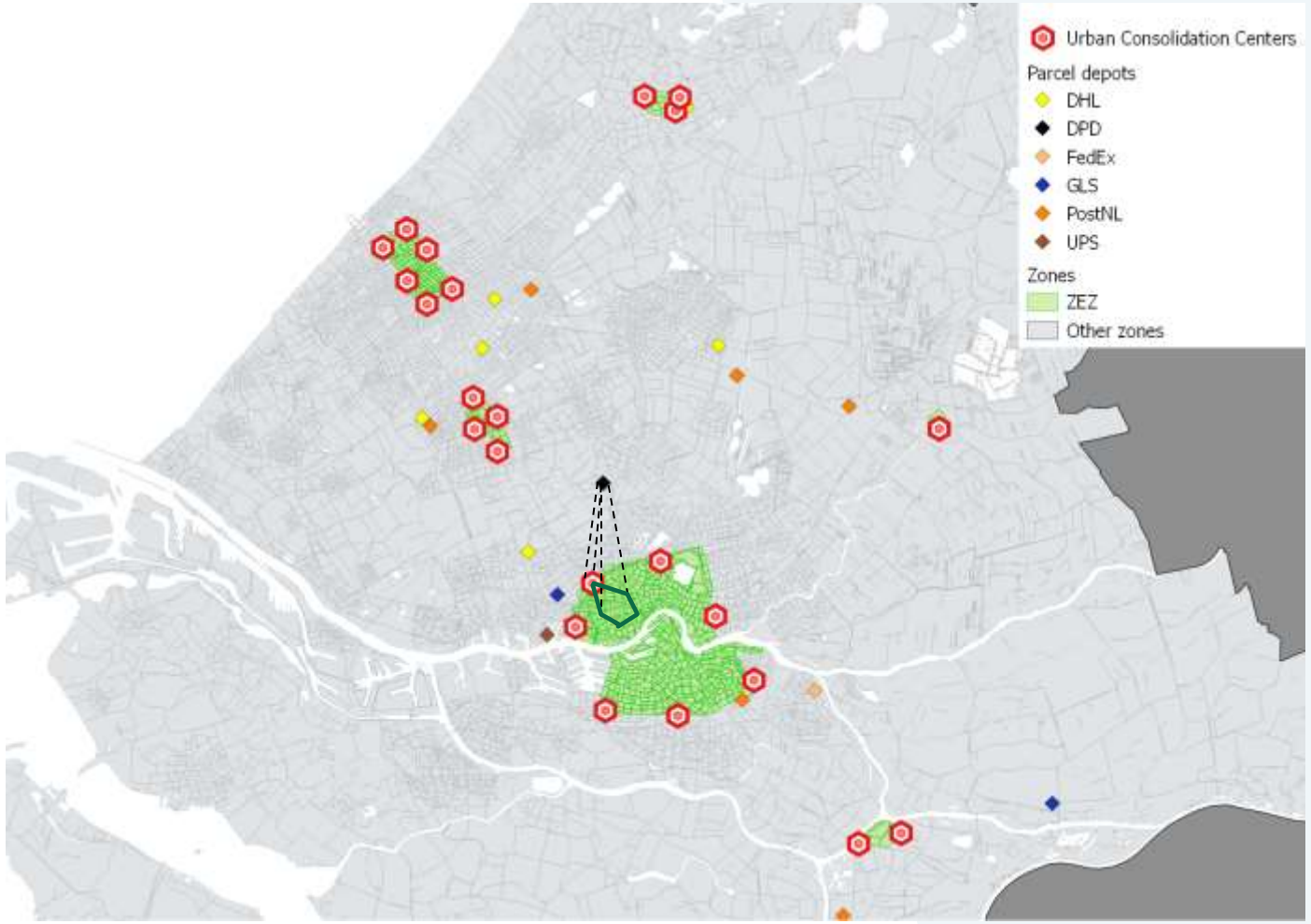


VKM (as % of freight)	2.0%	4.3%
CO2 (as % of freight)	0.6%	1.4%

First model results (Part 2 - Zero emission zones)

- Scenario with 6 zero emission zones (ZEZs)
  - Rotterdam, Den Haag, Delft, Gouda, Leiden, Dordrecht
  - Rotterdam is implementing this exact ZEZ for freight traffic in the upcoming years

- Each ZEZ is served by several Urban Consolidation Centers (UCCs)
  - Parcels are sent from depots to UCCs
  - Here delivery tours to the ZEZ are made with clean vehicles
    - electric van, LEVV, cargo bike



First model results (Part 2 - Zero emission zones)

- Result: more kilometers, because:
  - LEVV and cargo bikes have small capacity → more tours needed
  - Rerouting leads to detours for regular vans
- Minimal CO2 reduction, detours of regular vans compensate most savings made by the clean vehicles

KPI	2016 REF	2016 ZEZ	Growth
VKM	123 673.0	268 027.7	+116.72%
CO2	22 937.3	22 925.9	-0.05%

See also:
de Bok M., Tavasszy L., Kourounioti I., Thoen, S., Eggers, L., Nielsen, V. (2021) *Simulation of the Impacts of a Zero-Emission Zone on Freight Delivery Patterns in Rotterdam.* Transportation Research Record. https://doi.org/10.1177/03611981211012694

First model results (Part 3 – Asset sharing)

- All parcel couriers use each other's depots
  - Always the nearest depot for last-mile delivery
  - Very hypothetical scenario

- Result
  - Large reduction in VKM and CO2 of more than 50%
  - Do note: Not considering yet the feeder trips with trucks between the depots

KPI	2016 REF	2016 AS	Growth
VKM	123 673.0	516 53.0	-58.2 %
CO2	22 937.3	10 116.7	-55.7 %

Conclusions

- Successfully operationalized a parcel demand simulation model
- A large-scale simulation with this level of detail is necessary to be able to:
  - Consider complex non-linear effects, such as increased consolidation
  - Analyze the impacts of very detailed and fine-tuned scenarios and policies, such as zero-emission zones
  - Analyze the impacts of very extreme scenarios, such as full asset sharing

Next steps

- Modelling the whole transport chain of the parcel segment
  - Not just the last-mile, but also the first-mile and trips between distribution centers
- Operationalizing the models for the e-groceries and meal deliveries segments

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Significance

Grote Marktstraat 47

2511 BH

Den Haag

Nederland

info@significance.nl

+31 70 312 1530

thoen@significance.nl

www.linkedin.com/in/sebastiaan-thoen-70b22b157/
www.linkedin.com/company/significance/

www.harmony-h2020.eu