30/03/2021
UCL MaaSLab's Guest Lecture Series

Application of the HARMONY tactical freight simulator to a case study for zero emission zones in Rotterdam

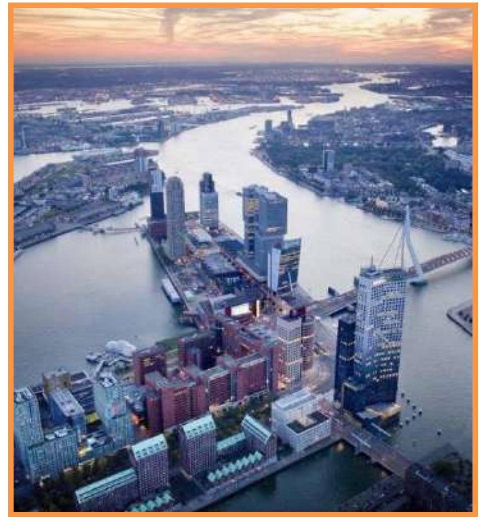
Michiel de Bok(*,θ), Lórant Tavasszy(*), Ioanna Kourounioti (*), Sebastiaan Thoen(θ), Larissa Eggers(θ), Victor Nielsen(θ), Jos Streng (#)

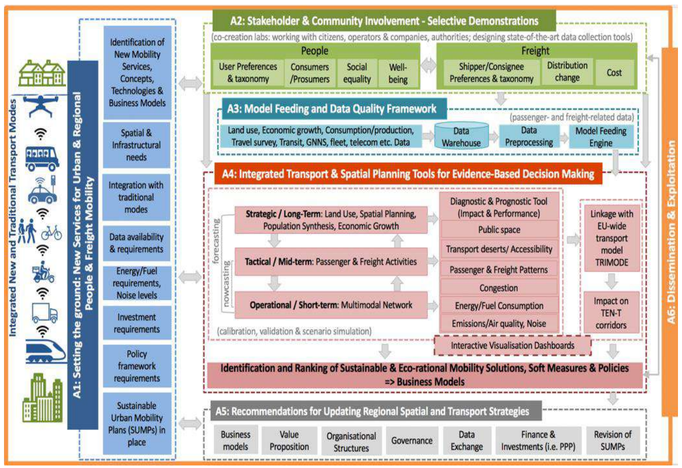
(*) Delft University of Technology, (θ) Significance Quantitative Research, (#) City of Rotterdam

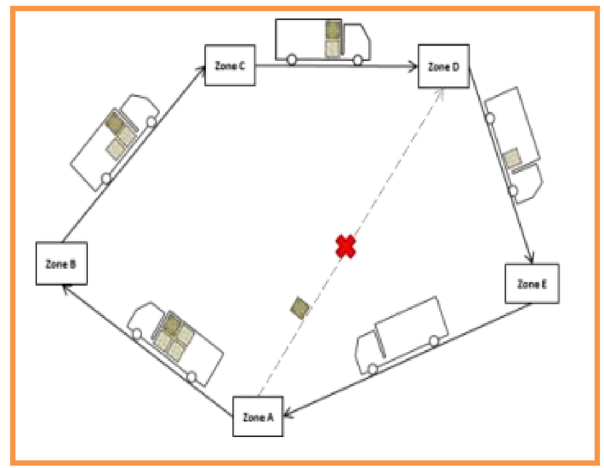
TU Delft significance quantitative research City of Rotterdam

Content

- HARMONY
- Tactical Freight Simulator
- Case study ZE-zone Rotterdam
- Q&A







THE HARMONY PROJECT

HARMONY consortium

21 partners from 9 European countries

HARMONY's Vision

Develop **a new generation of harmonised spatial and multimodal transport planning tools** which comprehensively model the dynamics of the changing transport sector and spatial organisation, enabling **metropolitan area authorities** to lead the transition to a low carbon new mobility era in a sustainable manner.

HARMONY Metropolitan Areas' Activities

Trailblazing

Rotterdam
- Electric AV demonstration - freight
- HARMONY MS - Freight

Oxfordshire
- Electric AV demonstration - Passenger & freight
- Drones demonstration - Freight
- HARMONY MS - Passenger

Aspiring

Athens
- HARMONY MS - Freight

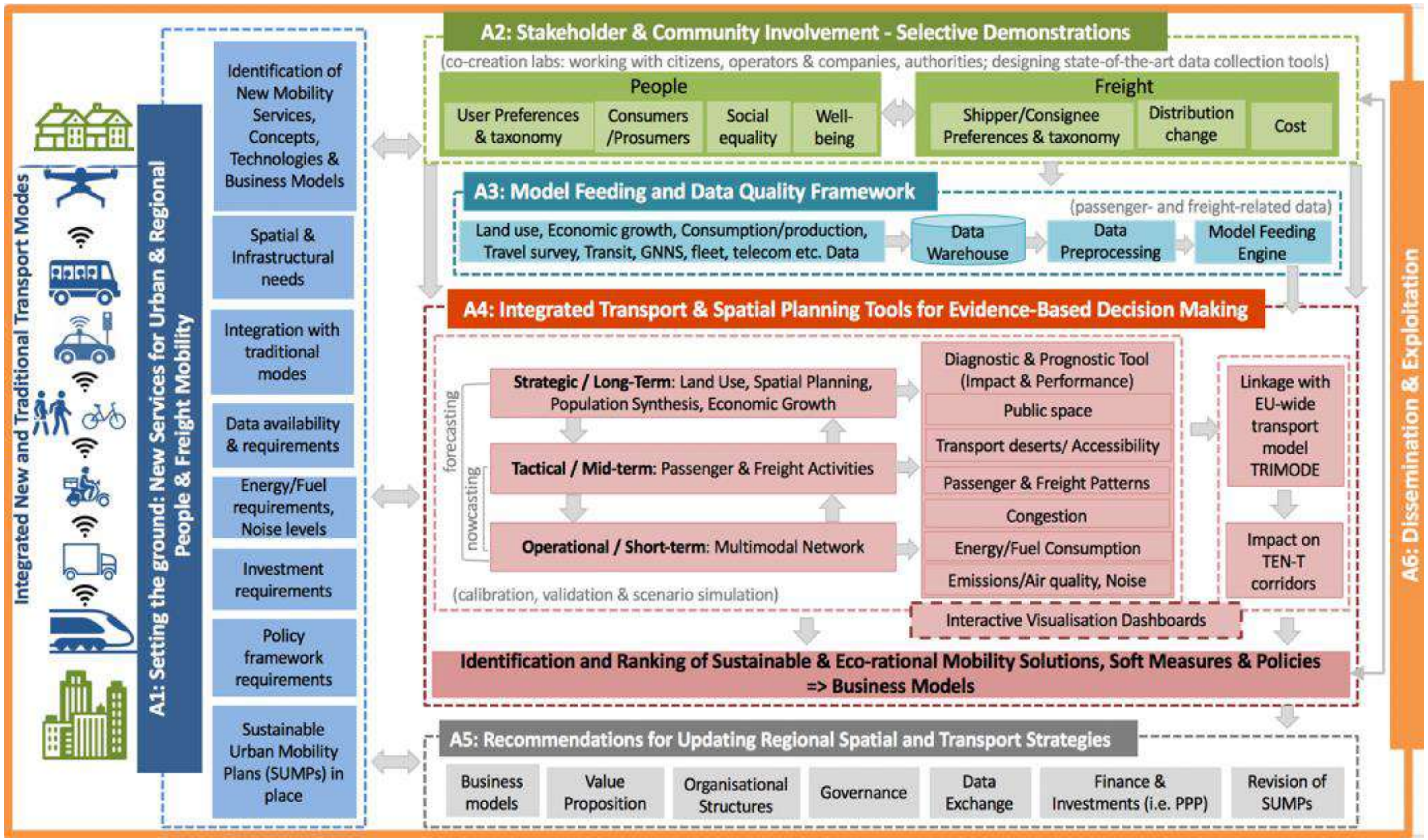
Turin
- HARMONY MS - Passenger

Follower

Trikala
- HARMONY MS - Passenger

GZM
- HARMONY MS - Passenger

HARMONY conceptual architecture



THE TACTICAL FREIGHT SIMULATOR

- Scope and Structure
- Data requirements
- Calibration
- Illustrate outputs

The story of Jos..

E commerce

Road user charges

Globalisation

Internet of Things

Logistic developments

Logistic hub's

ZE vehicles

Truckplatooning

Emission zones

'Urban transport planner'

Keep the city accessible

Reduce CO2 emissions

Policy objectives

Keep the city livable

Use land efficiently

transport planning tool

Scope of the TFS

Simulation of logistic decision making behind urban freight transport demand.

<u>Key design principles:</u>

- ❖ Evidence based (data!)
- ❖ Agent-based: to represent the heterogeneity in city logistics: producers, consumers, carriers, public administrators
- ❖ Shipment-based: more behavioural realism
- ❖ Long-term and daily logistic decisions are simulated separately

Shipment & parcel demand

- Producer/supplier choice
- Shipment size & vehicle type

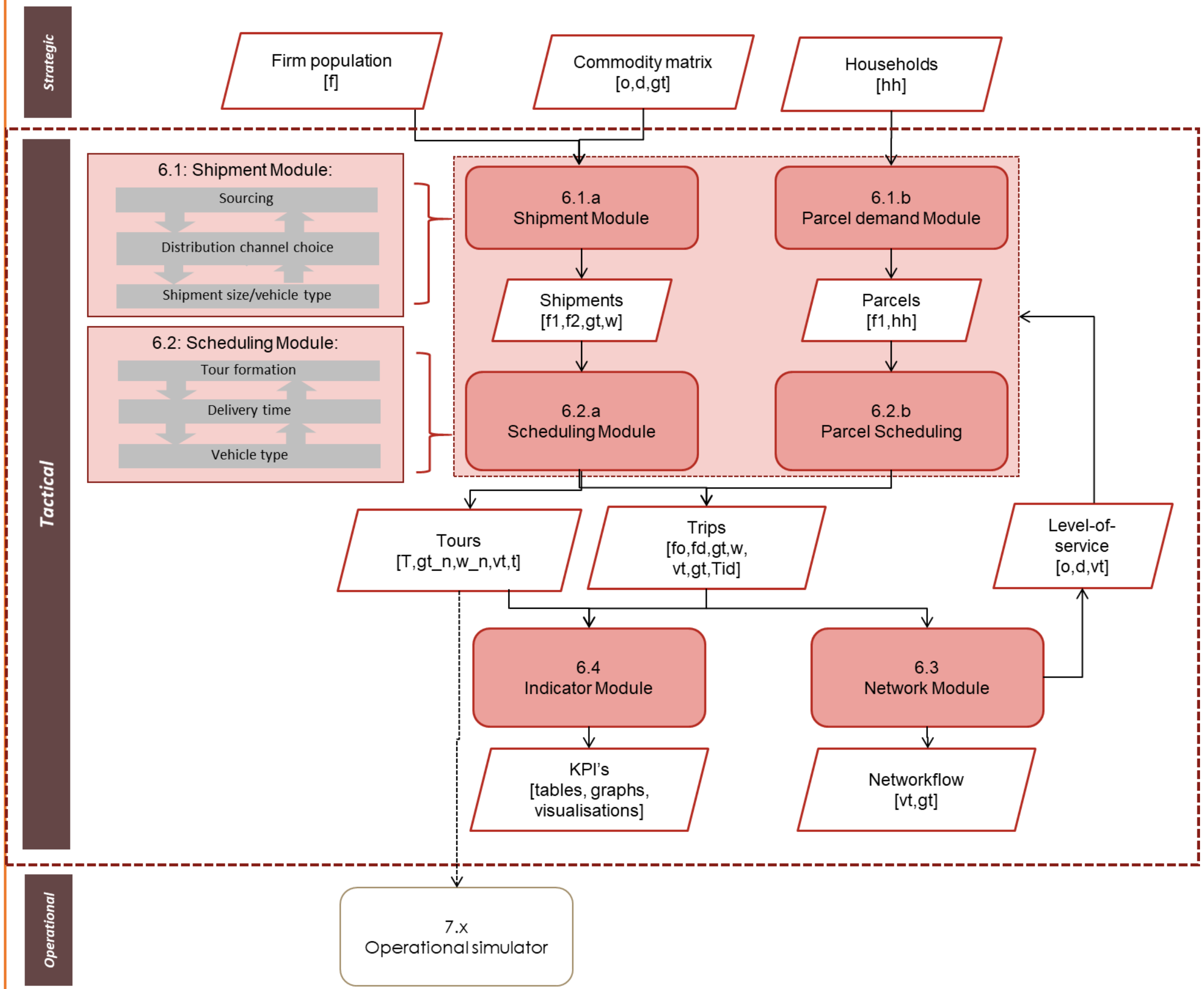
Scheduling

- Tourformation
- Time-of-delivery choice

Networkmodule

- Routechoice
- Emissions

Technical architecture



MASS-GT prototype v3

Shipment module: simulates long-term decisions:

- Sourcing/Producer choice
- Distribution channel choice
- Shipment size & vehicle type (simultaneous)

Scheduling module: simulates daily decisions:

- Tourformation
- Time-of-day

Two auxiliary modules:

- Network Module (skim & routechoice)
- Indicator Module

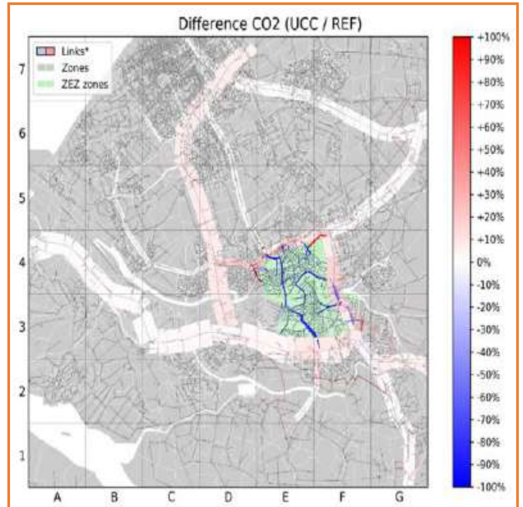
Use cases

The TFS is aimed at city logistic analysis in general. In HARMONY several relevant use cases are developed and tested during the project:

- ❑ Zero –emission zone
- ❑ Crowd-shipping
- ❑ Micro-hubs and cargo bikes
- ❑ Autonomous services

City logistic outlook

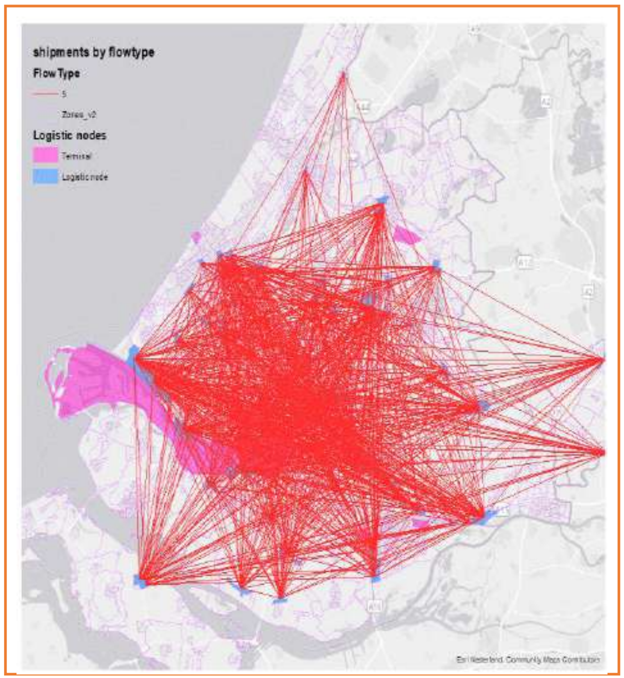
New logistic services



Impact assessment

Data requirements

The TFS has been designed in such a way that it uses generally available transport modelling data and statistics as primary inputs. Behavioural parameters can be calibrated, either validated, depending on local available data.



Summary of basis input data:

- Local transport model (networks, zones with socio economic data)
- Location of logistic nodes (distribution centers/transshipment terminals)
- Global firm statistics (size distribution)
- Aggregate commodity demand

Optional data:

- Detailed freight trip diaries
- Establishment surveys
- Truck counts

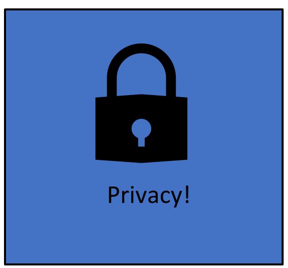
The use of secondary data for Calibration

- Main source for calibration is the automated truck trip diary collected from Transport Management System (TMS) of freight carriers
- +2M individual trips in raw **XML-data**
- Offers huge potential for development of microscopic freight demand models

opgaveId (Truck)
License plate
Year & week
In BasGoed sample [yes/no]
Transporting company
Ownership type *Owned, hired, leased, or not owned anymore*
Fuel consumption [L per 100 km]
Home base *Country* *ZIP* *Town* *LatLon*
Carrying capacity [kg]
Vehicle type

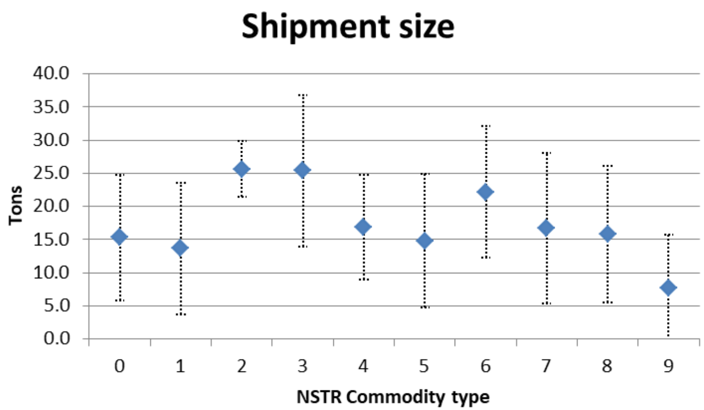
ritId (Tour)
Serial tour number *Describes order of tours for a truck*
Distance [km] *From origin to destination of tour*
Date & time *Start* *End*
Origin & destination *Country* *ZIP* *Town* *LatLon*
Operator type *Hired carrier or own-account*
Capacity utilization *% m2* *% m3*
Border crossing *Country* *LatLon*

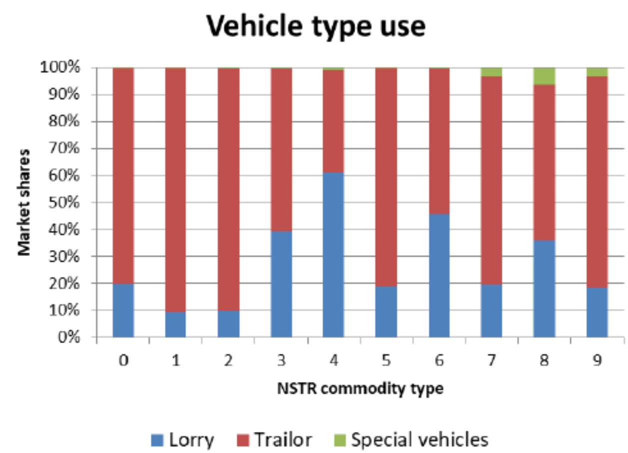
zendingId (Shipment)
Serial shipment number *Describes order of shipments for a tour*
Distance [km] *From loading to unloading point*
Gross weight [kg]
Shape *Fluid, solid bulk, sea containers, other containers, pallets, hanging goods, goods in ropes, mobile units with own power, or other mobile units.*
Loading and unloading location *Country* *ZIP* *Town* *LatLon*
Loading and unloading location type *Production, consumption/processing, retail, seaport, inner port, rail terminal, airport, distribution/wholesale, or home base.*
Goods type *Description* *NSTR* *NST2007* *Hazardous [yes/no]*
Invoice value [€]
Volume [L or m3]

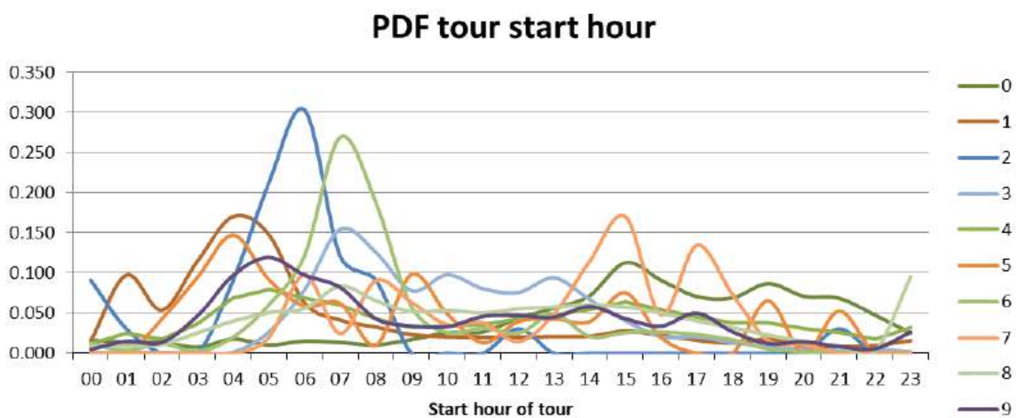


Data: illustration

Descriptive stats freight data:







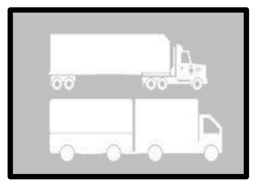
Vehicle and shipment size choice model

EOQ theory

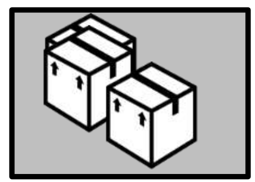
The shipment module includes a **logistic choice model** for **vehicle type** and **shipment size**. Both logistic choice are explained by a logistic cost function that includes **transport costs** and **inventory holding cost**:

Random Utility Theory

Vehicle and shipment size choice is simulated in a discrete-discrete MNL choice model:



Vehicle type



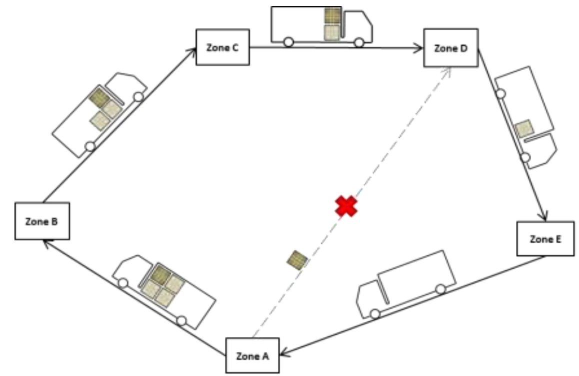
Shipment size

Case study with this model was published in Case Studies in Transport Policy

Tour formation choice model

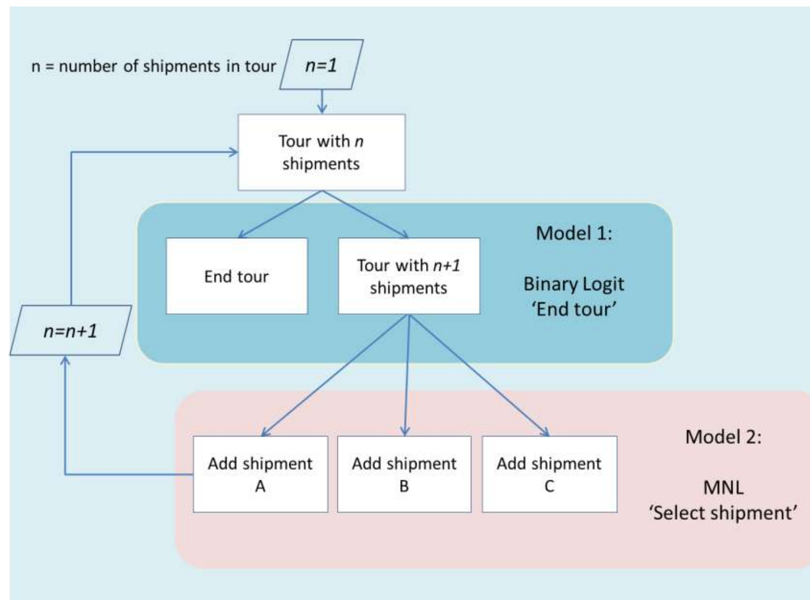
Purpose:

Choice model for the formation of roundtours making one or multiple stops



Approach:

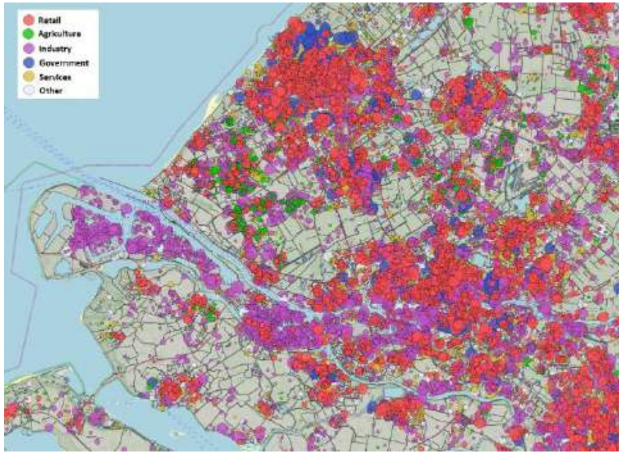
- Shipment based
- Step-wise discrete choice models
- Constraints: capacity, tour duration, distance
- Attributes in utility function: transport costs, commodity types, vehicle type, location type



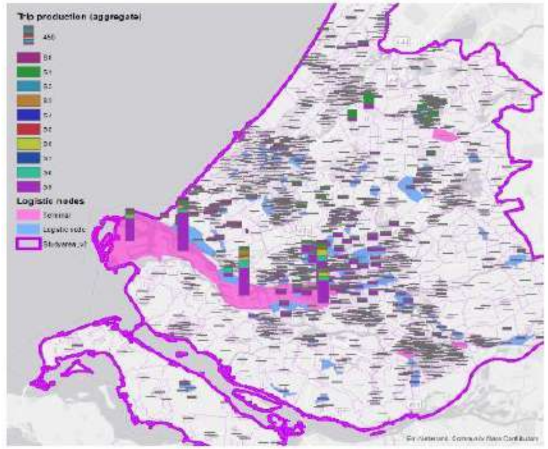
Detailed description of approach is published in:

Thoen, S, L Tavasszy, M de Bok, G Correia, R van Duin (2020) Descriptive modeling of freight tour formation: A shipment-based approach, *Transportation Research Part E*, Volume 140, Pages XX – XX

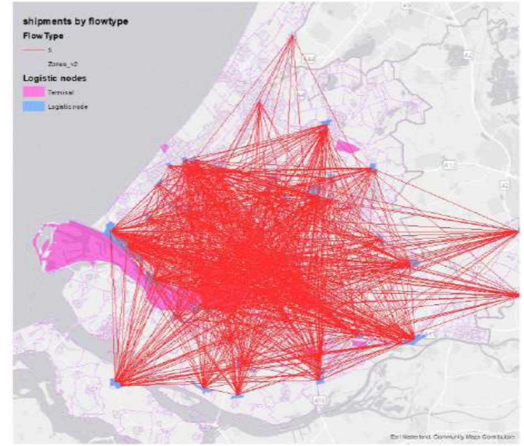
Tactical Freight Simulator in 6 figures



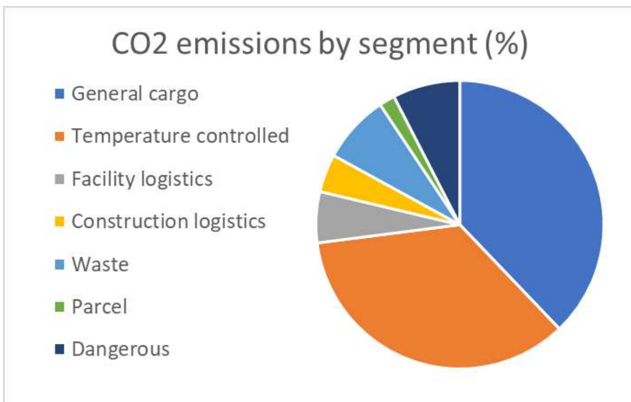
Firms (Synthetic)



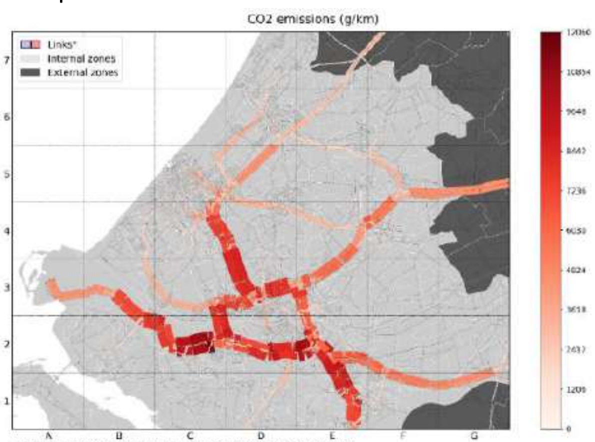
Shipment demand



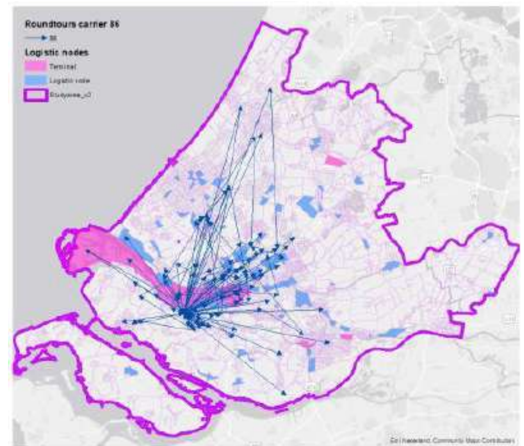
Demand via distribution channels



Aggregated output indicators (KPI's)



Emissions



Logistic planning of roundtours

www.harmony-h2020.eu

Harmony-H2020

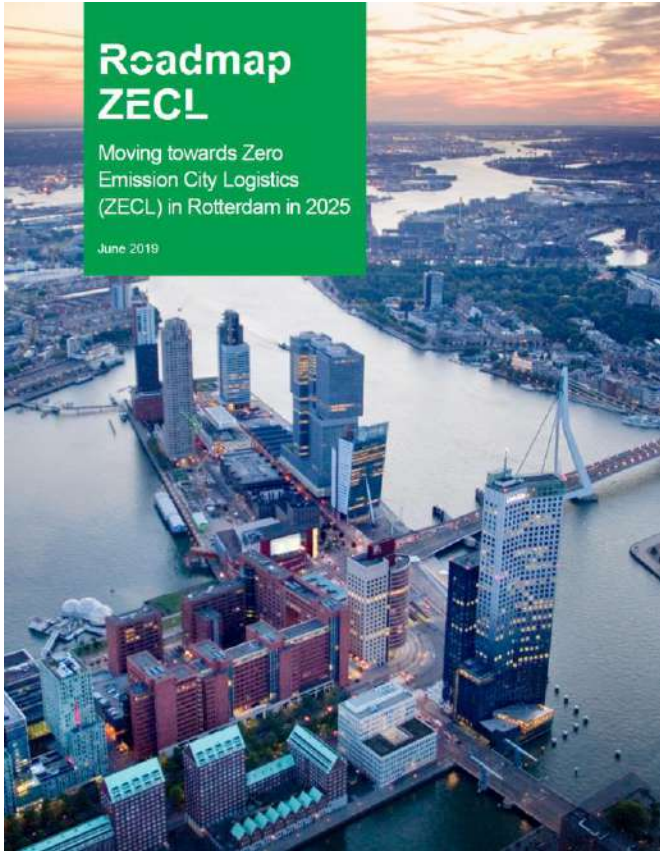
Harmony_H2020

HARMONY

Impacts of a zero- emission zone

- Background
- Scenario
- Simulation results

Zero emission zone for Rotterdam



Jan Boeve, Director of TLN:

"As soon as possible, the City of Rotterdam must communicate where the zero emission zone for city logistics will be from 2025, so that transport business owners know where they stand and can prepare their business model accordingly."

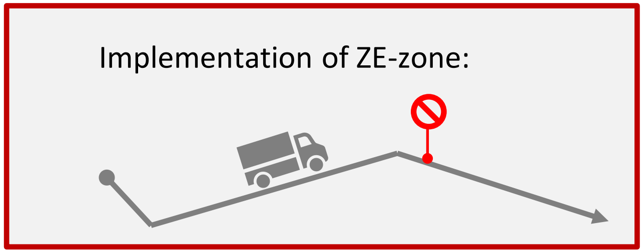
Zero emission scenario: geography

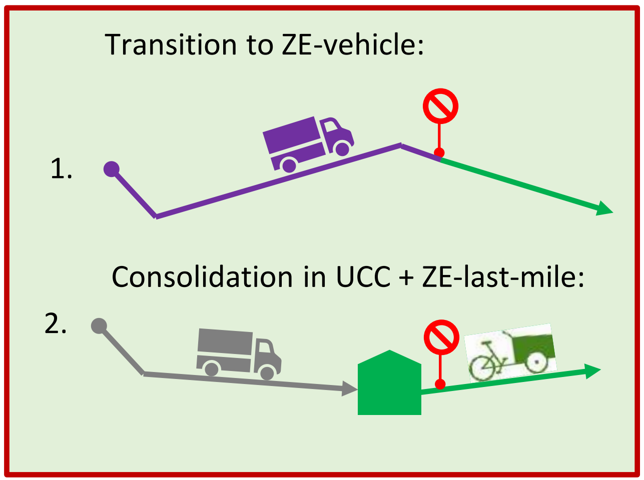
Assumptions:

- Only ZE vehicles may enter the zero emission zone
- A proportion of shipments are redistributed via 7 UCC's
- Delivery and collection from the UCC takes place with dedicated ZE vehicles
- Analysis based on transitions scenario's for each logistic segment

Possible configuration of the zero-emission zone, and 7 Urban Consolidation Centers

Zero emission transition scenarios





The Roadmap ZECL provides transition scenarios for each logistic segment with the expected **use of UCC** and **ZE-vehicle types**.

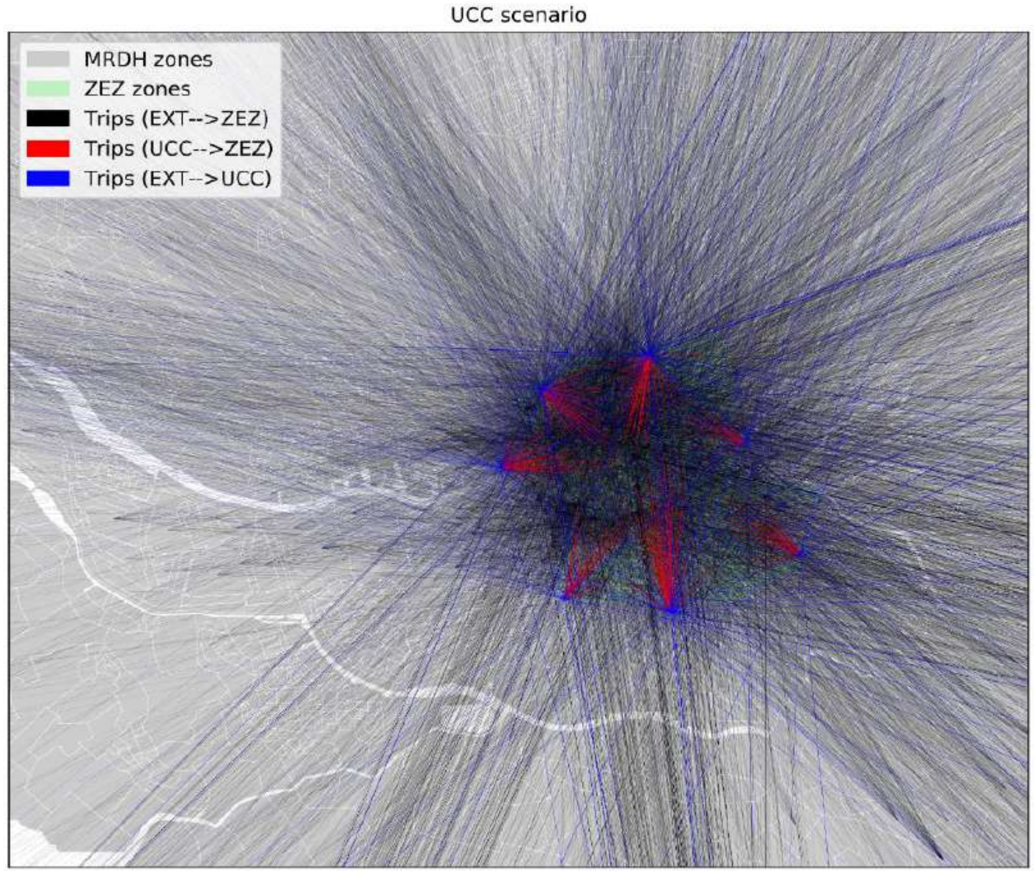
Two possible responses from the introduction of the ZE-zone on urban distribution:

1. Shift from conventional to ZE-vehicle (electric, Hybrid)
2. Consolidation in a dedicated hub (UCC), and last-mile using ZE-vehicles.

The last-mile distribution to/from the UCC is operated with ZE-vehicles: the composition of types (electric truck, van, LEVV) is assumed by segment.

Impact on shipment patterns

- Part of the shipments to/from the ZE-zone are consolidated in 7 urban consolidation hubs
- The collection and distribution patterns of these shipments are redirected through these hubs (see map).
- This leads to a small increase in vehicle kms in the study area (+0.25%)

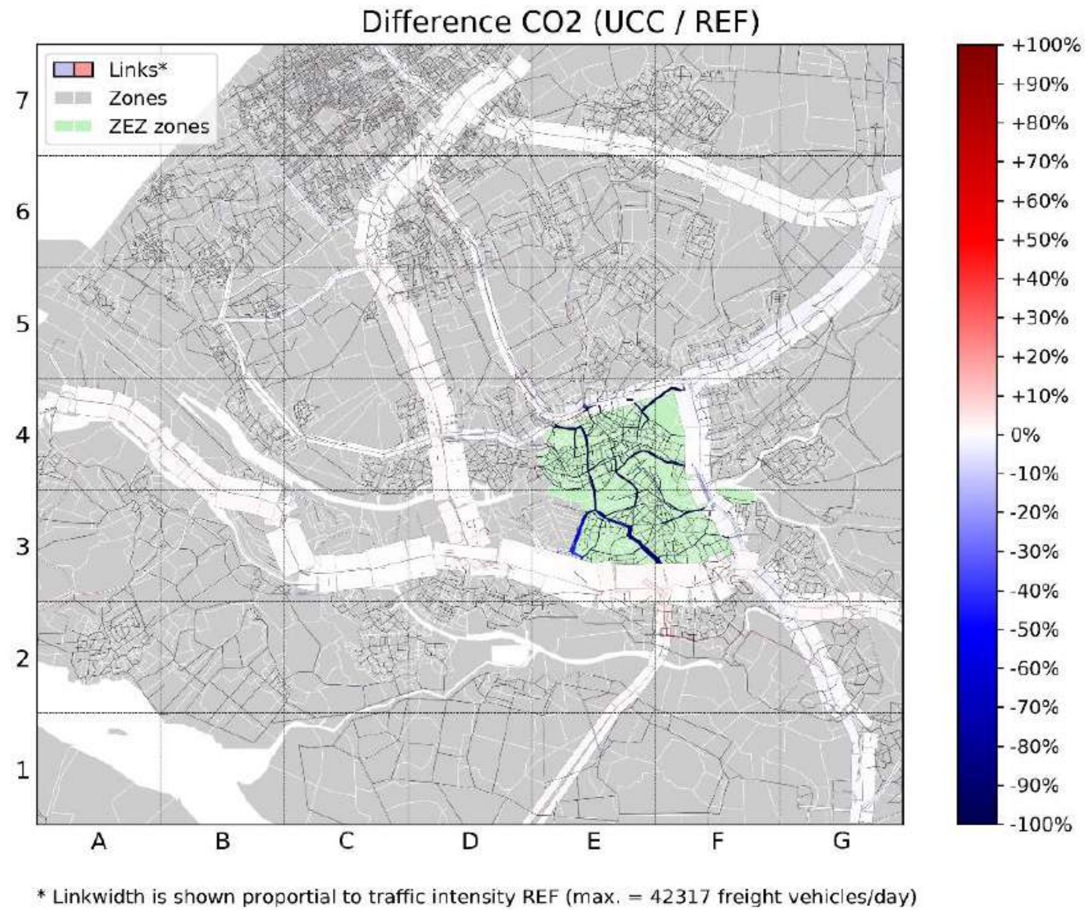


Impact on emissions at network level

- Emissions of all vehicle movements are calculated using the vehicle type, link speeds, and load of the vehicles.
- Reduction in total emissions within the municipality of Rotterdam: ca. 8%. This includes all the freight traffic to and from the port area.

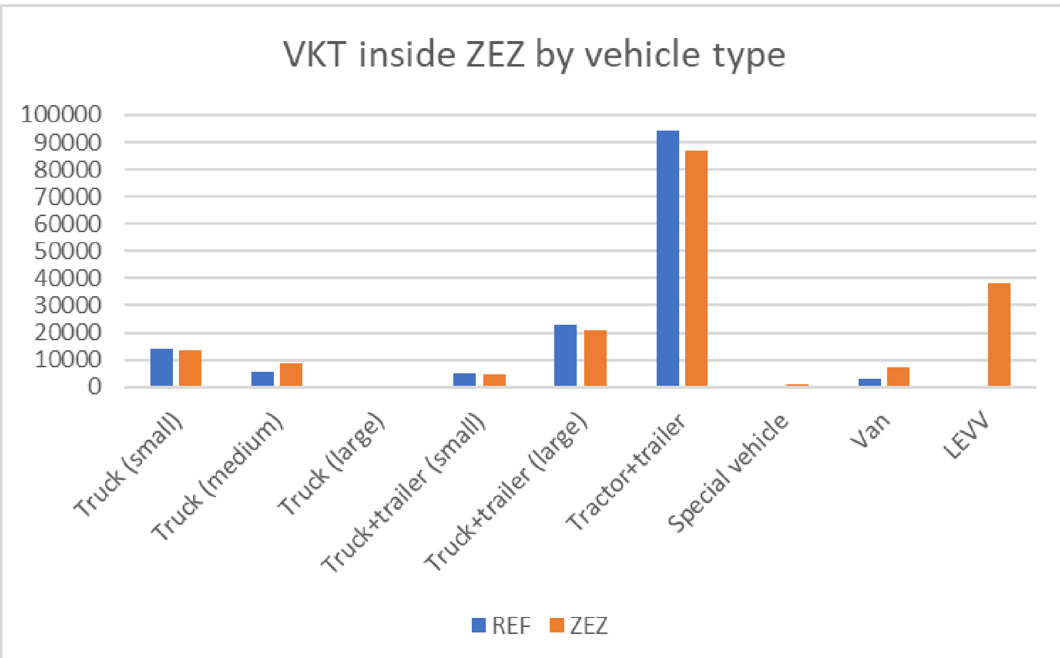
Type	Inside the ZEZ	City of Rotterdam	Study area (prov. South Holland)
CO2	-91%	-8%	-1%
SO2	-91%	-8%	-1%
PM	-89%	-8%	-1%
NOX	-91%	-9%	-1%

- Rerouting of shipments to the hubs also leads to small increases of emissions in the surrounding area.



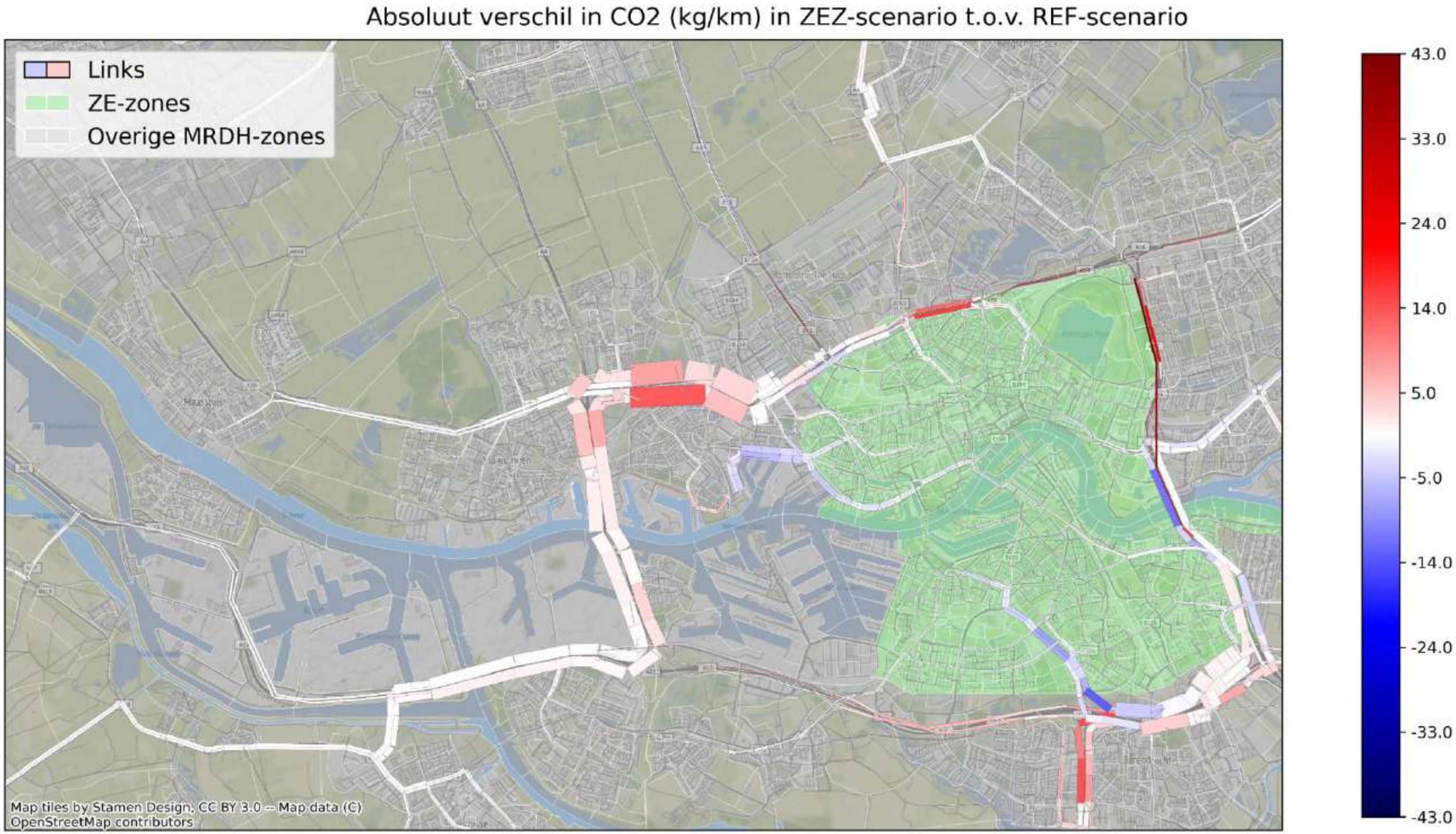
Impact on vehicle use inside the ZEZ

The composition of vehicle kilometers inside the ZE-zone will change in the Zero-emission scenario (ZEZ):



- Decrease in use of Tractor+trailer combinations (or with hybrid driveline)
- The share of new ZE-vehicles (LEVV and e-moped) is expected to be 10% in total vkms
- A large share of the reduction of emission will be the result of a shift to cleaner combustion types (electric, hybrid, hydrogen, biofuel)

Impact on emissions for parcel delivery

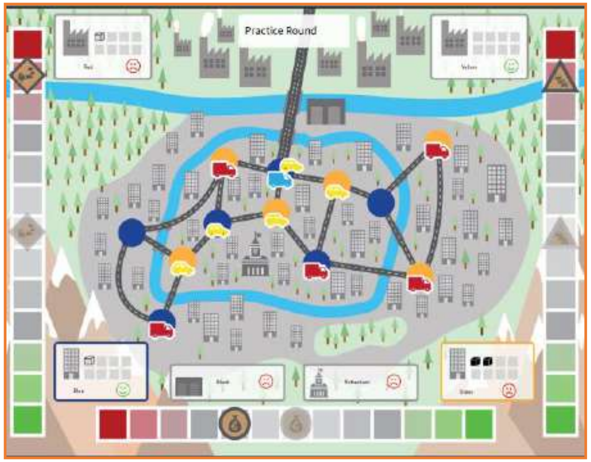


Conclusions on the zero-emission zone

- ❖ Impacts are not trivial: emissions within the ZEZ are reduced, but vehicle kilometers (VKT) outside the zone increase slightly as a result of the rerouting of shipments through the UCCs.
- ❖ Emissions are reduced by 90% inside the ZEZ; at the city scale by 10%, considered a significant impact at city level.
- ❖ ZE zone is a good step towards the ambition to reduce CO2 emissions by 49% by 2030, but more measures are needed to further decarbonize long-haul freight transportation.

Conclusion and discussion

Further work in HARMONY

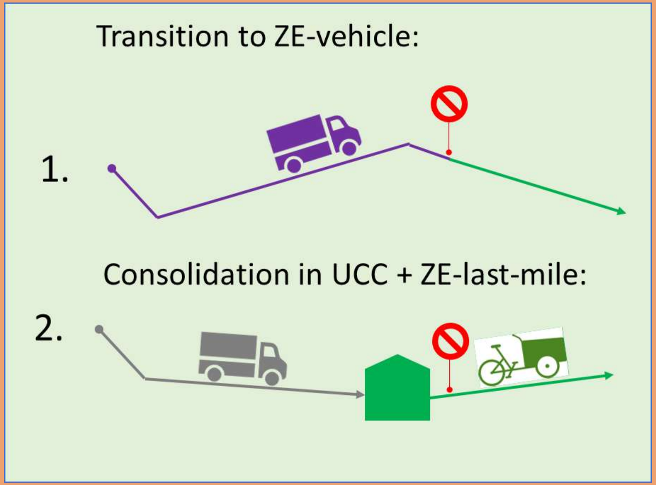


Tactical Freight Simulator next steps :

- Data collection: serious games with City Logistic stakeholders (carriers, retailers, administrators)
- Implement new logistic choice models for Delivery time choice, Distribution channel choice
- Validation: traffic counts, sensitivity analyses
- Integration with the HARMONY-MS

Final observations

- Emerging sources of 'big data' allow the development of a new generation of empirical multi-agent simulation models for urban freight planning.
- Multi-agent simulation models allow a better representation of stakeholders (e.g. logistic segments), and implementation of scenarios for city logistics.
- Presented scenario-based analysis shows how the model is used for system wide impact assessment.
- Validation of the assumptions behind the new technology and services scenarios is key challenge.



Thank you!

Michiel de Bok

m.a.debok@tudelft.nl /
debok@significance.nl

HARMONY

SPATIAL & TRANSPORT PLANNING FOR A NEW MOBILITY ERA

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 815269

Part of:

CIVITAS