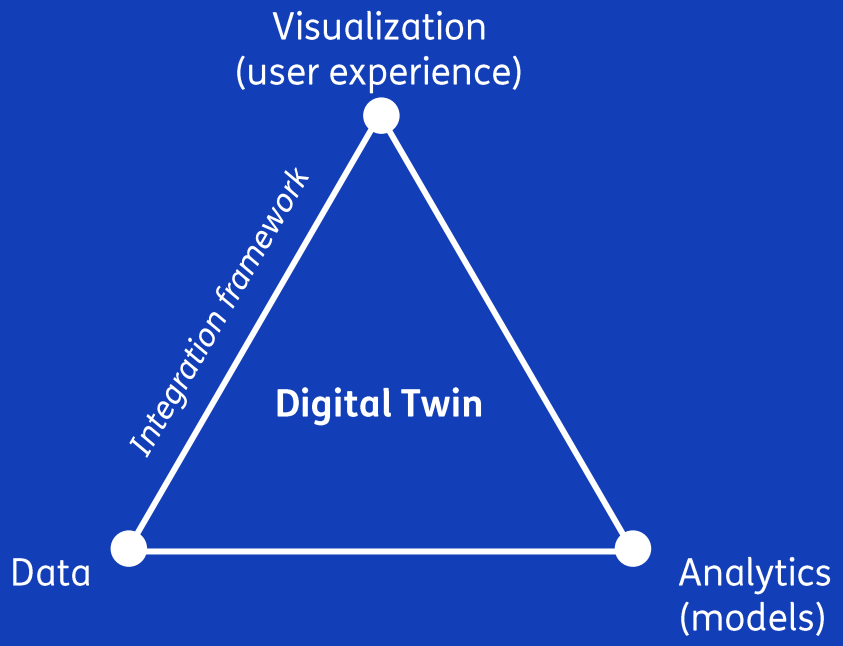
Move21
Oslo Digital Twin

Predictive digital city replica with TNO Urban Strategy for simulating shared modes and logistics.

September 19th 2023

Digital Twins: making complexity manageable

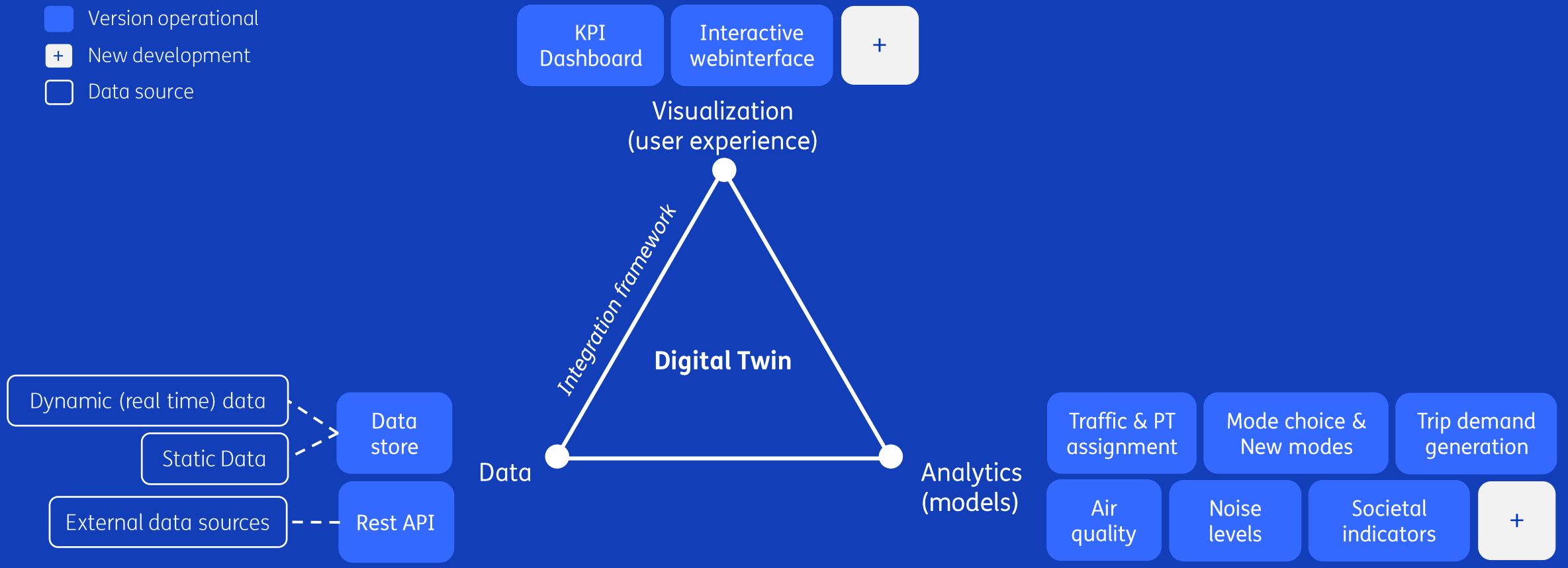
- Digital Twins are realistic digital replica's of the real world, consisting of the integration of data, analytics and visualization.



- Integral overview on multiple domains by visualization of the current situation or future situations
- Possibility to interact with data with analytics (models) to form exploratory 'what-if' analysis
- Cooperation of multiple stakeholders and decision making processes based on multiple KPI's.

Walter Lohman, Hans Cornelissen, Jeroen Borst, Ralph Klerkx, Yashar Araghi, Erwin Walraven,
Building digital twins of cities using the Inter Model Broker framework, Future Generation Computer Systems, Volume 148, 2023, Pages 501-513, ISSN 0167-739X,
https://doi.org/10.1016/j.future.2023.06.024.

Digital Twins: making complexity manageable



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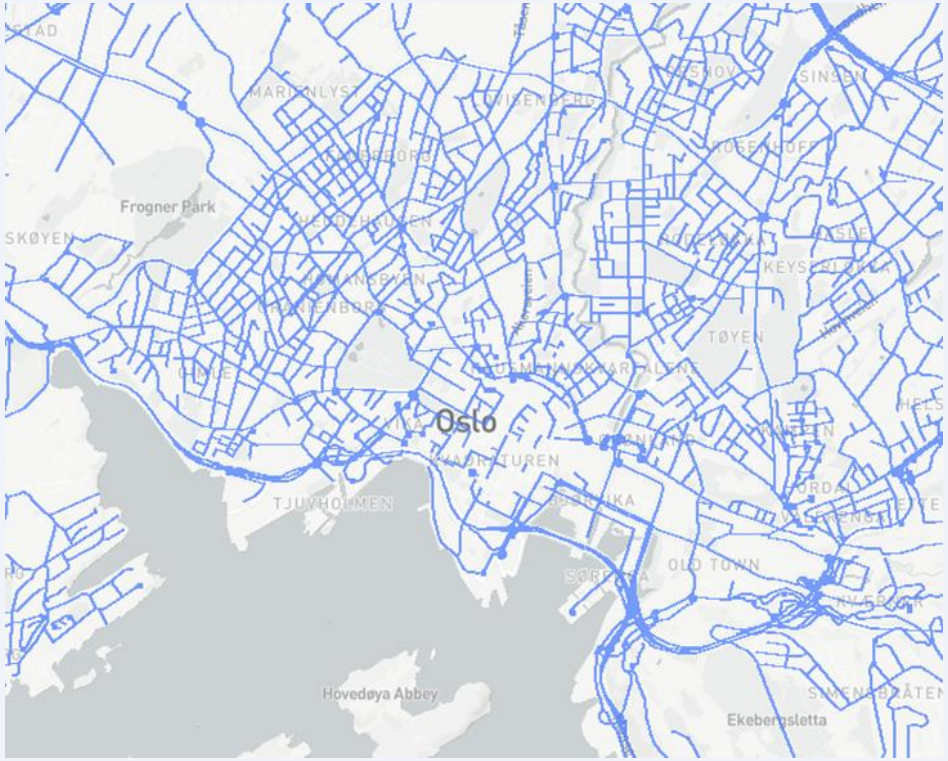
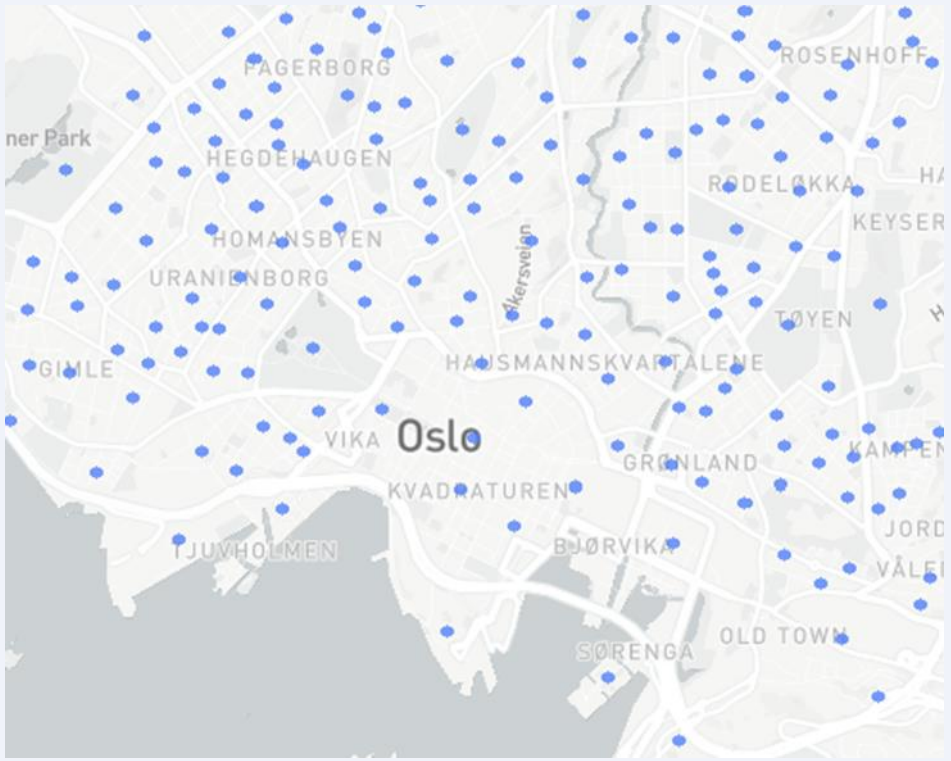
Building digital twins of cities using the Inter Model Broker framework, Future Generation Computer Systems, Volume 148, 2023, Pages 501-513, ISSN 0167-739X,
https://doi.org/10.1016/j.future.2023.06.024.

Simulating shared modes in Urban Strategy

Input data from Emme

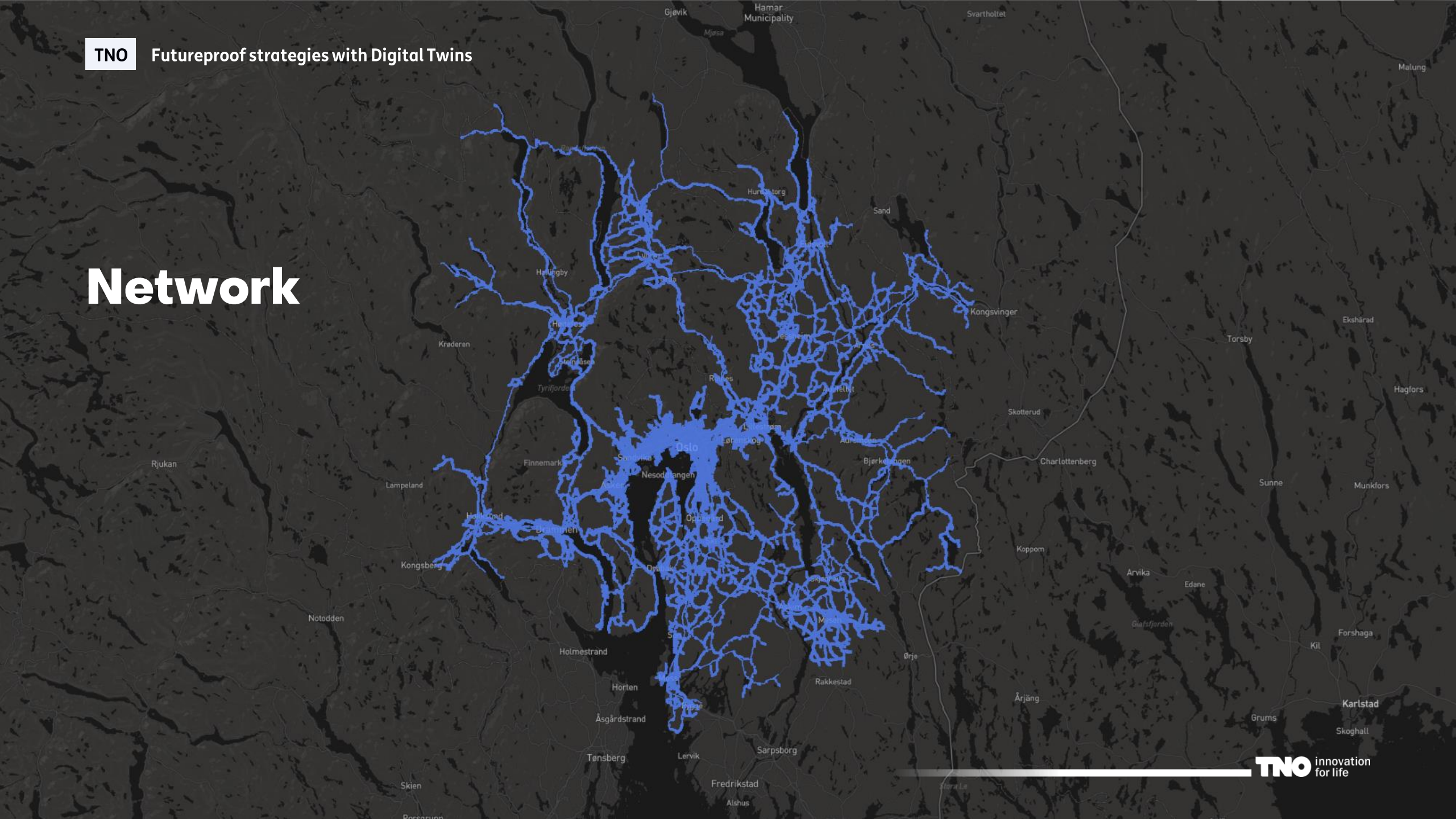
Network | Zones | OD-matrices



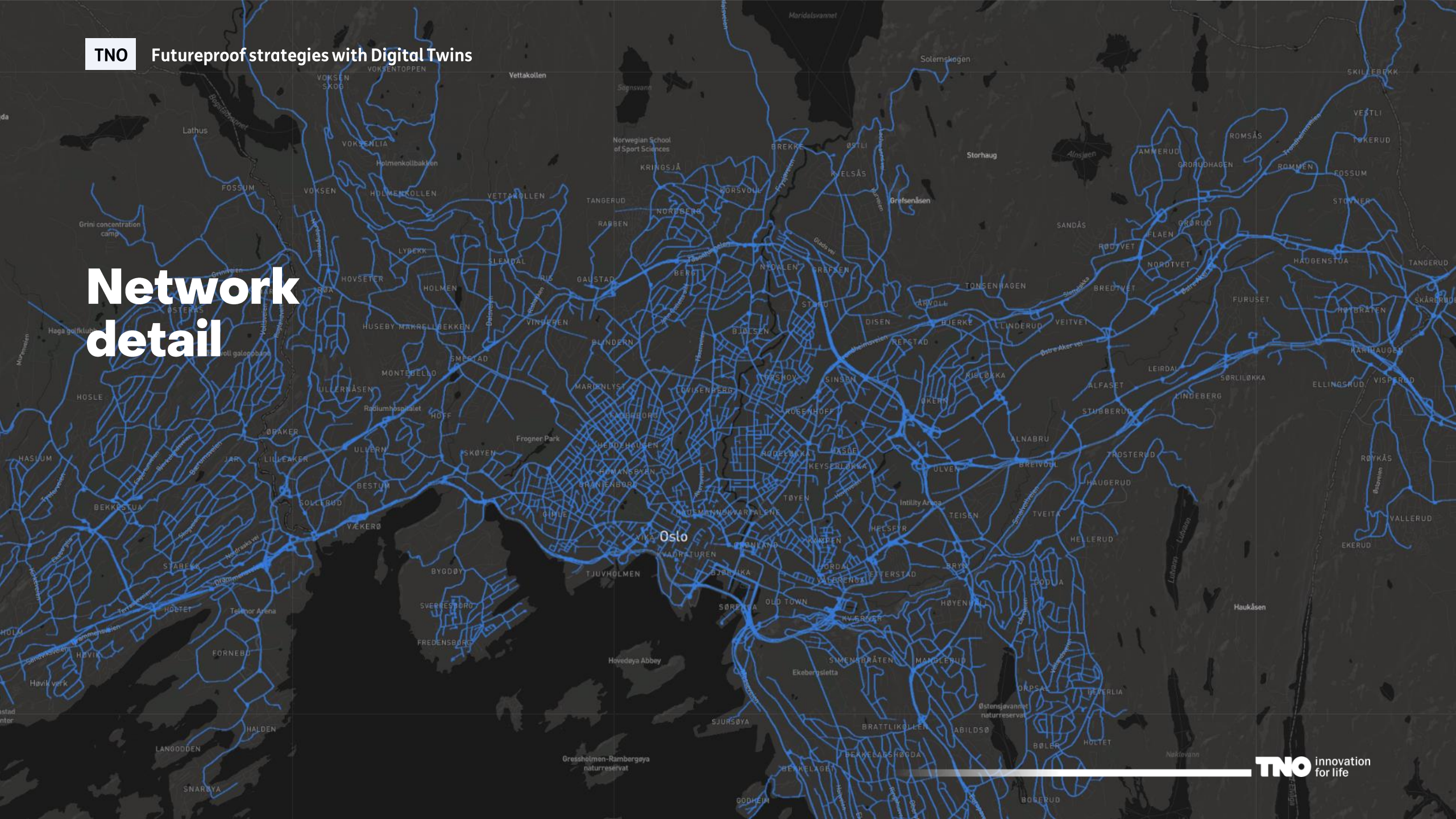


Data | Simulation | → Data exchange

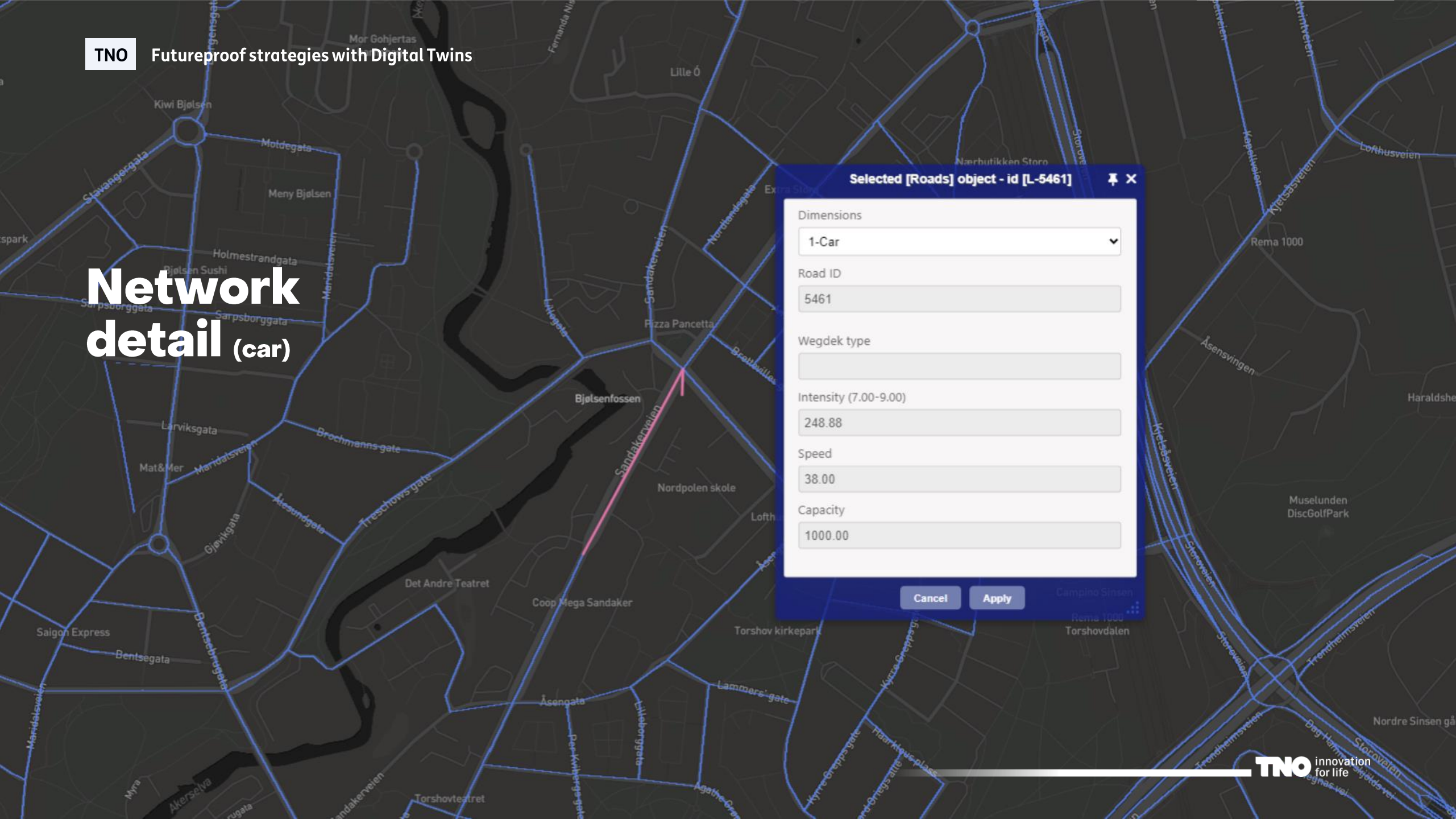
Network


Gjøvik
Hamar Municipality
Svartholtet
Malung
Sand
Kongsvinger
Ekshärad
Torsby
Hagfors
Krøderen
Skotterud
Oslo
Charlottenberg
Rjukan
Lampeland
Finnemark
Sunne
Munkfors
Kongsberg
Koppom
Arvika
Edane
Notodden
Holmestrand
Forshaga
Kil
Ørje
Rakkestad
Horten
Årjäng
Karlstad
Grums
Skoghall
Åsgårdstrand
Tønsberg
Lervik
Sarpsborg
Fredrikstad
Skien
Alshus

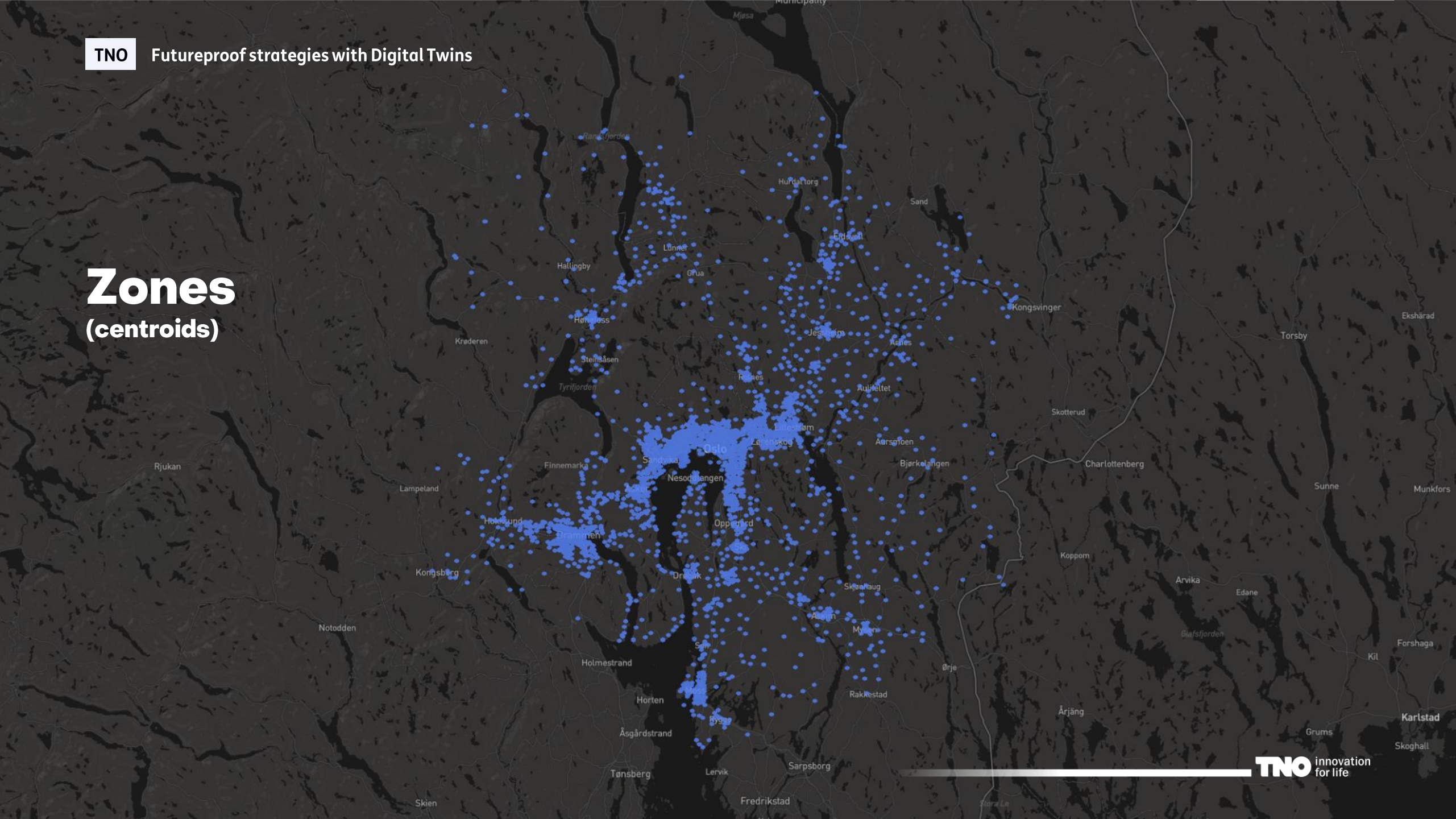
Network detail



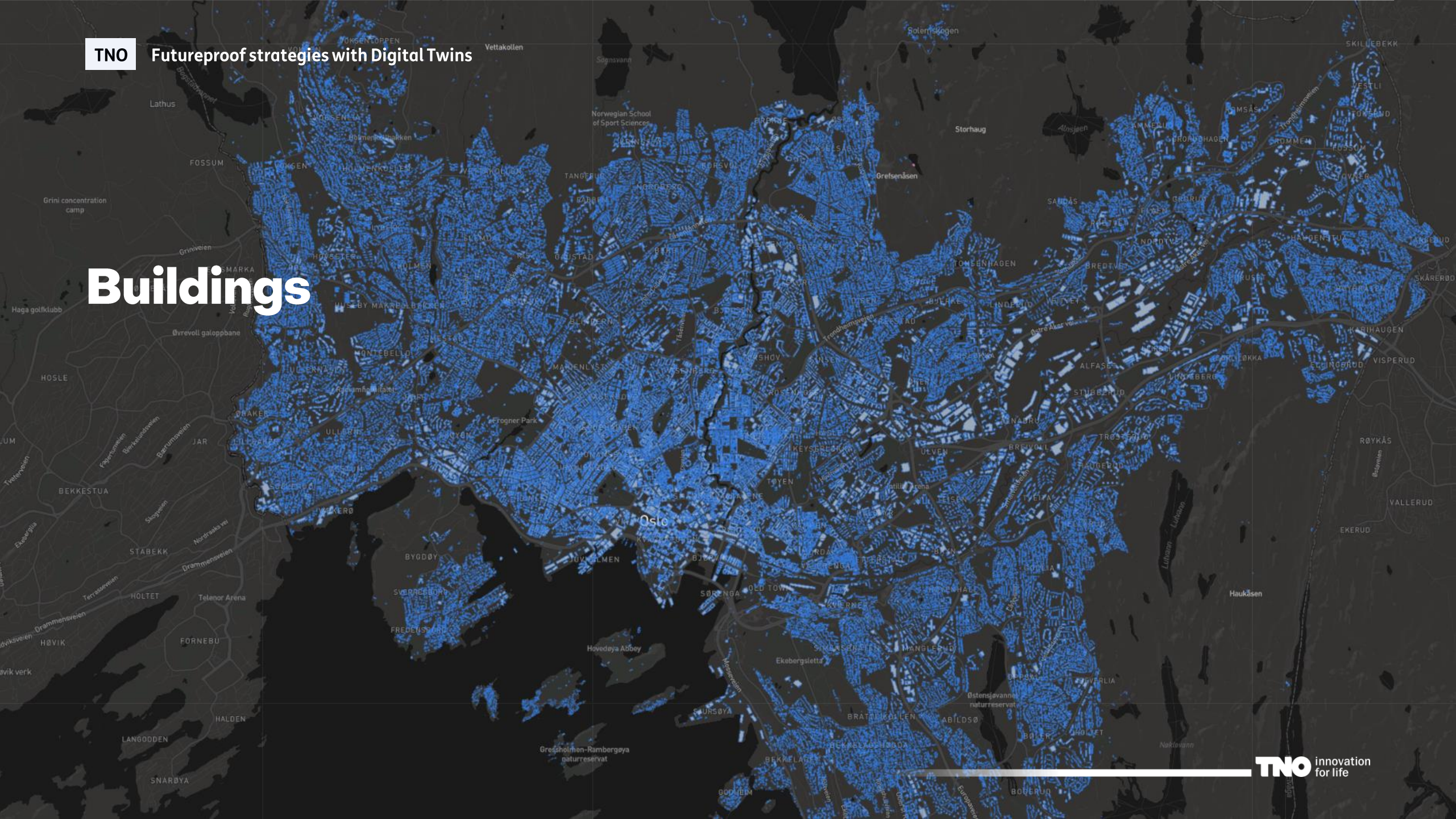
Network detail (car)



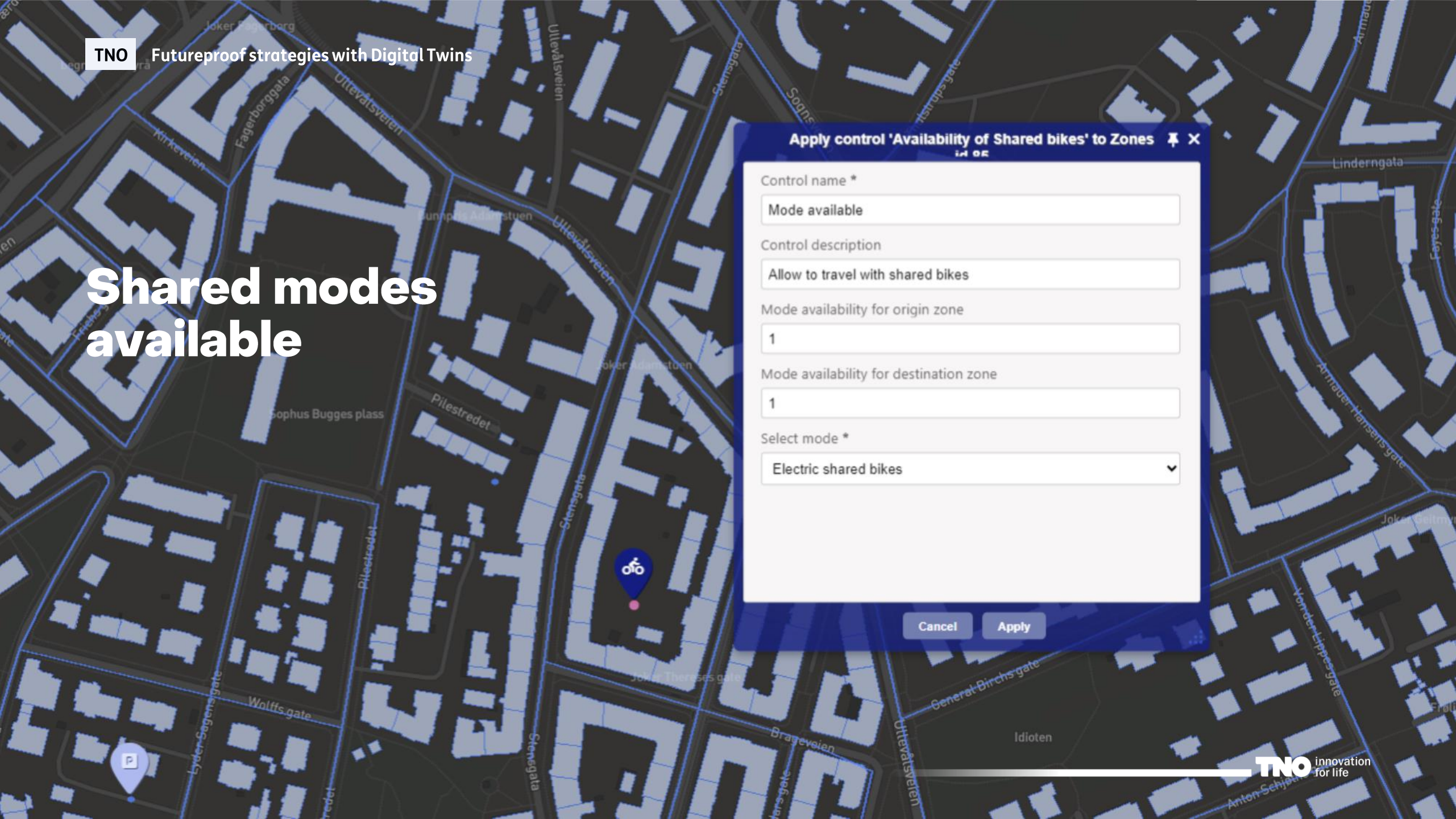
Zones
(centroids)



Buildings


Oslo
Vettakollen
Solemskogen
Lathus
Norwegian School of Sport Sciences
Storhaug
Grefsenåsen
FOSSUM
Grini concentration camp
Haga golfklubb
Øvrevoll galoppbane
HOSLE
BEKKESTUA
STABEKK
HØVIK
FORNEBU
HALDEN
LANGODDEN
SNARØYA
HOLTET
Telenor Arena
BYGDØY
Frogner Park
Hovedøya Abbey
Ekebergsletta
Gressholmen-Rambergøya naturreservat
Østensjøvannet naturreservat
Haukåsen
RØYKÅS
VALLERUD
EKERUD
VISPERUD
SKÅRERUD
BOGERUD

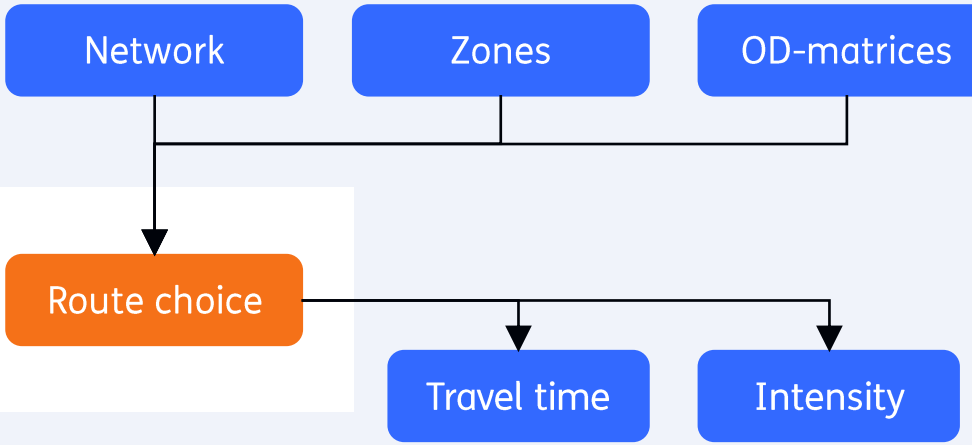
Shared modes available

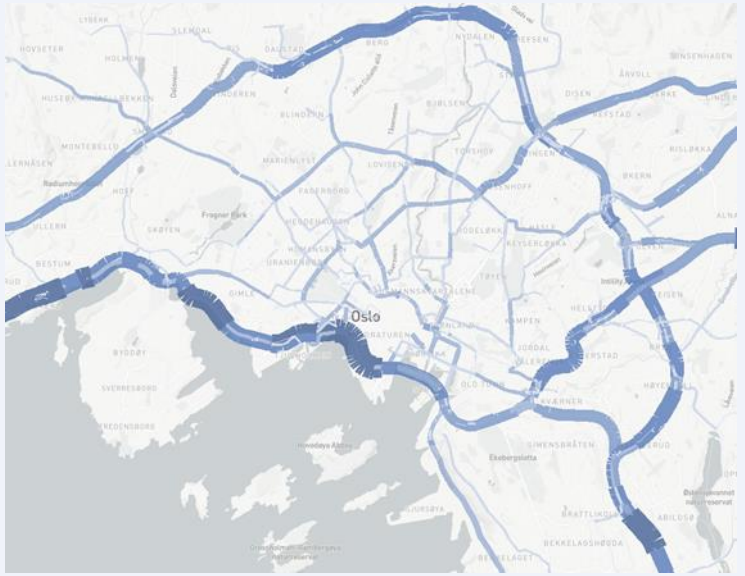


Simulating shared modes in Urban Strategy

Input data from Emme

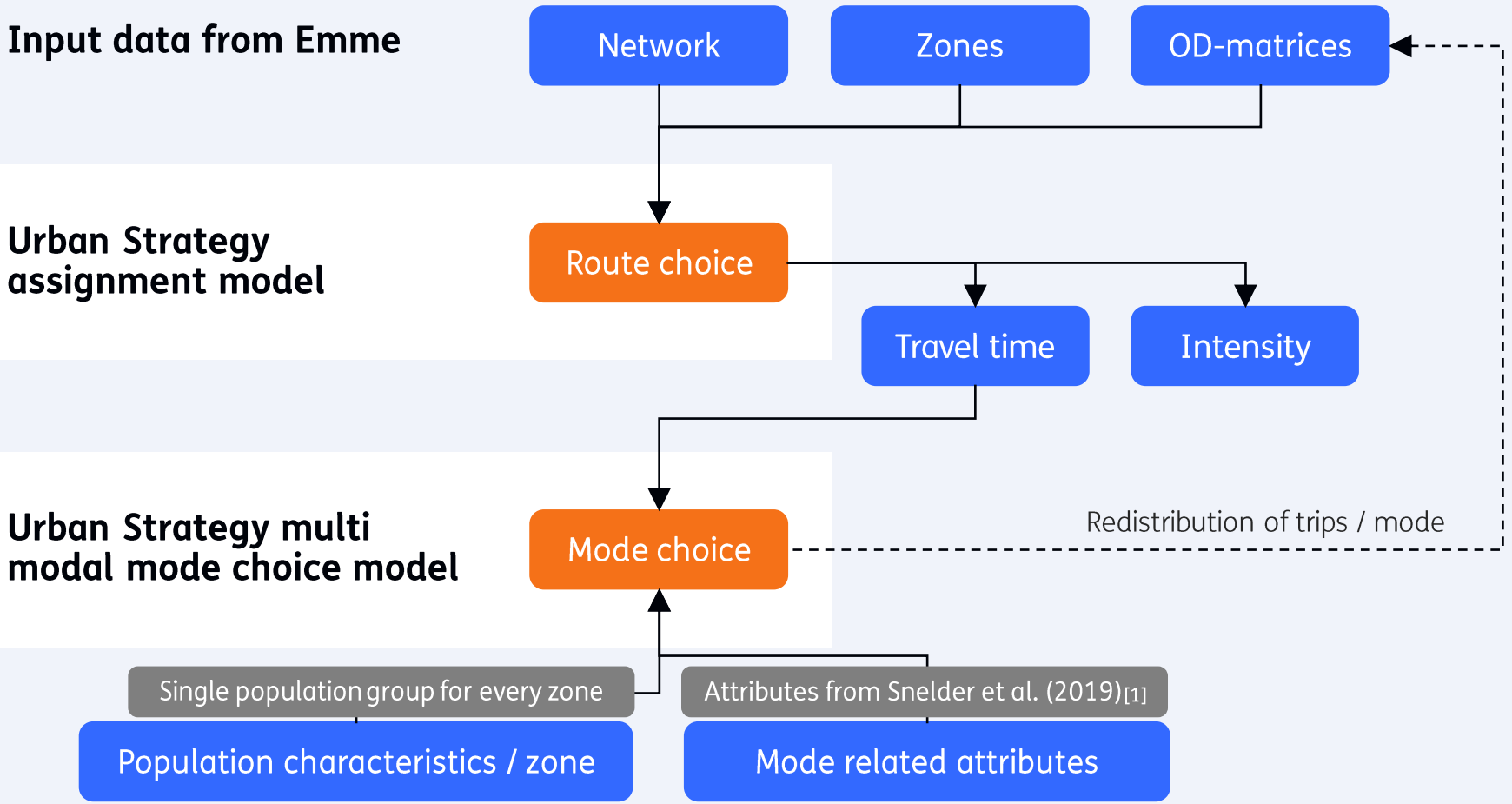
Urban Strategy assignment model





Data Simulation → Data exchange

Simulating shared modes in Urban Strategy

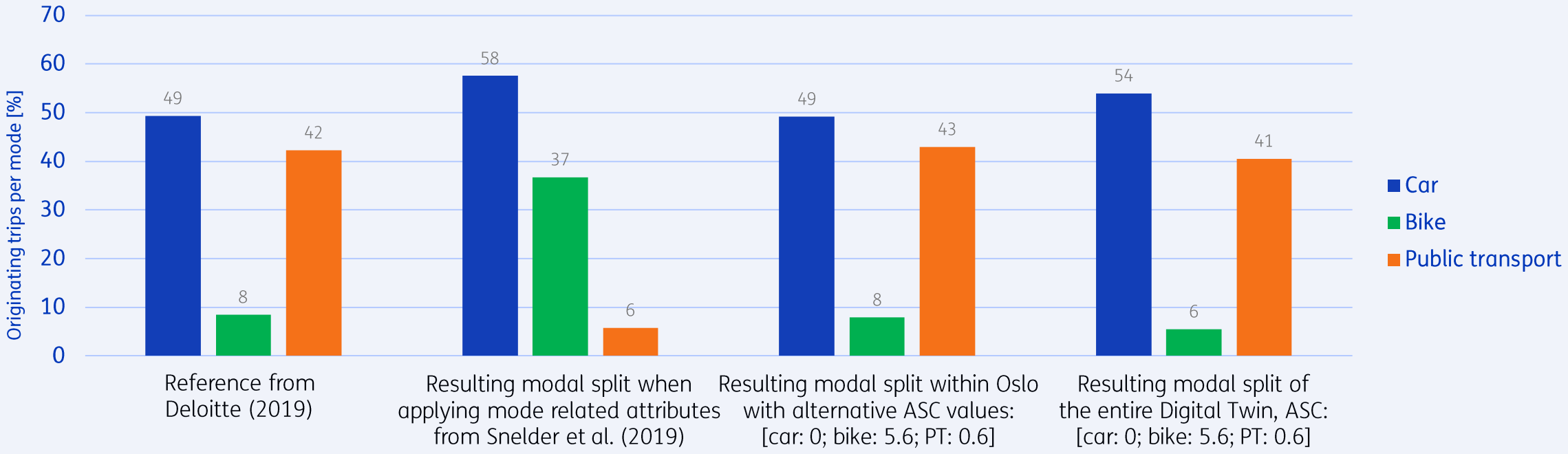


[1] Snelder, M., Wilmink, I., van der Gun, J., Bergveld, H. J., Hoseini, P., & van Arem, B. (2019). Mobility impacts of automated driving and shared mobility: explorative model and case study of the province of north Holland. European Journal of Transport and Infrastructure Research, 19(4). https://doi.org/10.18757/ejtir.2019.19.4.4282

Calibration of modal split

Calibrating modal split with alternative mode specific constants (ASC)

Due to the absence of mode related attributes, parameter values from the study of Snelder et al. (2019) are used. To fit the resulting modal split to the reference based on Deloitte (2019) the ASC values are adjusted. This results in a matching modal split for the study area, results for the entire Digital Twin area are therefore slightly different.



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Deloitte (2019). City Mobility Index Oslo
https://www2.deloitte.com/content/dam/insights/us/articles/4331_Deloitte-City-Mobility-Index/Oslo_GlobalCityMobility_WEB.pdf

Calibration of modal split

Single population group per zone

Due to the absence of demographic data, it is assumed that every zone (centroid) in the Digital Twin contains the same population characteristics. As such, influence of demographic differences to mode choice is not a component of this simulation session.

Mode related attributes

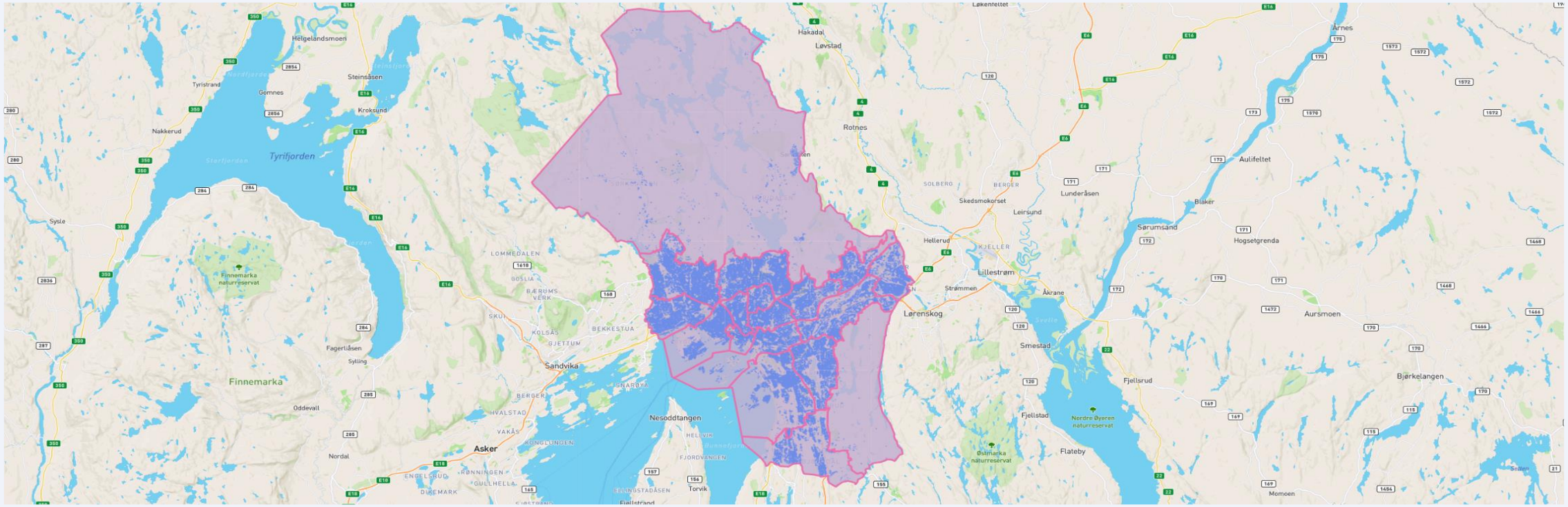
ID	Mode name	Cost start [€]	Cost user [€/km]	Mode specific constant	Max distance [km]	Max speed [km/h]	Parking considered	Passenger Car Unit	Search time [min]
1	Car	0.00	0.17	0.0	9999	120	Yes	1	0
2	Freight	-	-	-	-	-	-	-	-
4	Bike	0.00	0.00	5.6	20	14	No	1	0
7	Public transport	0.78	0.17	0.6	9999	160	No	-	-
11	Shared car	0.00	0.17	0	9999	120	Yes	1	20
12	Zero emission freight vehicle	-	-	-	-	-	-	-	-
13	Electric shared bike	0.00	0.05	5.6	20	25	No	1	0
14	Electric shared scooter	1.00	0.22	5.6	20	40	No	1	0

Shared mode simulations

Study area

Oslo

Including districts Alna, Bjerke, Frogner, Gamle Oslo, Grorud, Grünerløkka, Marka, Nordre Aker, Nordstrand, Østensjø, Sagene, Sentrum, Søndre Nordstrand, St. Hanshaugen, Stovner, Ullern and Vestre Aker



Shared mode scenarios

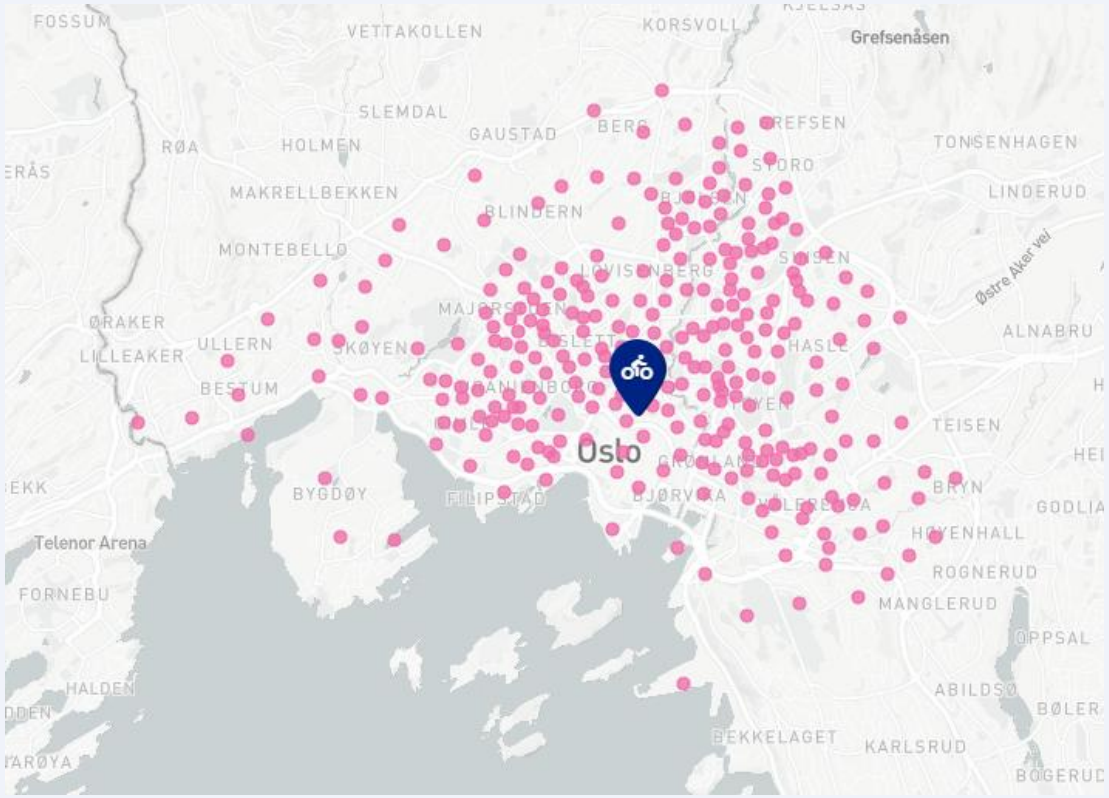
Overview of scenarios

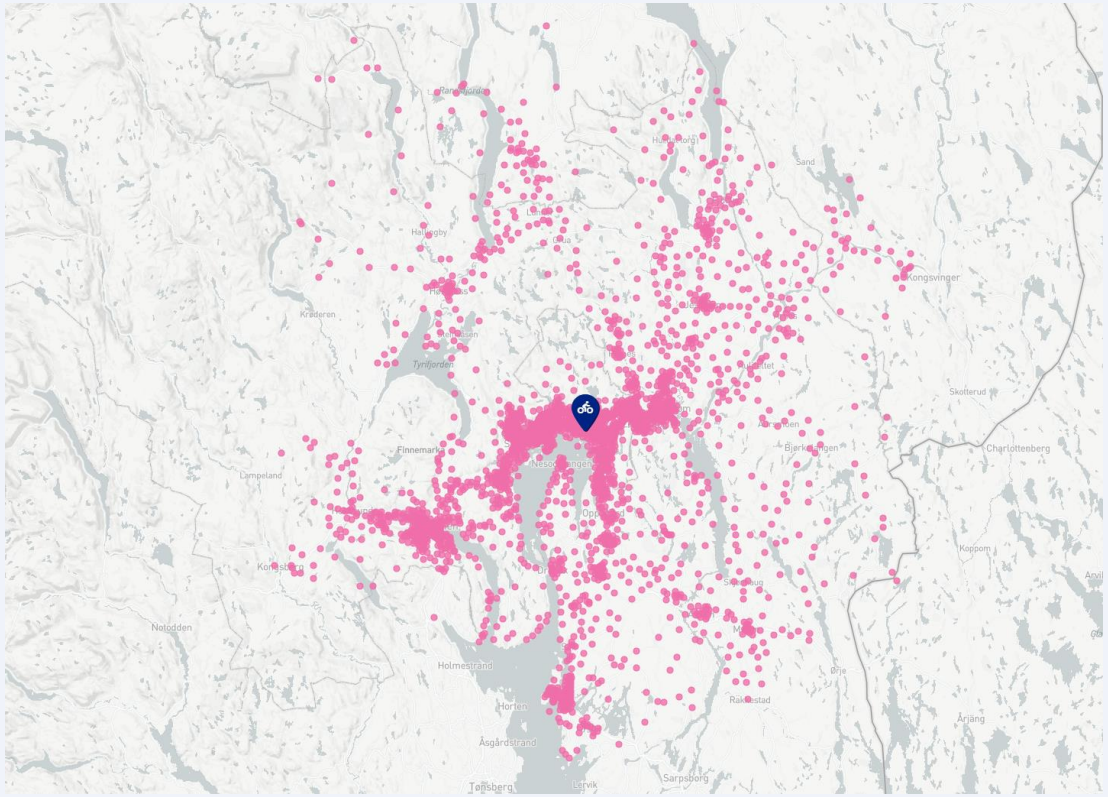
1. No shared modes available
2. Shared bikes and shared scooters available
3. Shared bikes, shared scooters and shared cars available
4. Additional locations for shared bikes and shared scooters

Shared mode scenarios

Scenario 2: Shared bikes and shared scooters available

Only for a selected number of zones shared bikes and shared scooters are available as travel mode for originating trips (image on the left). All zones can be reached with these modes (image on the right).

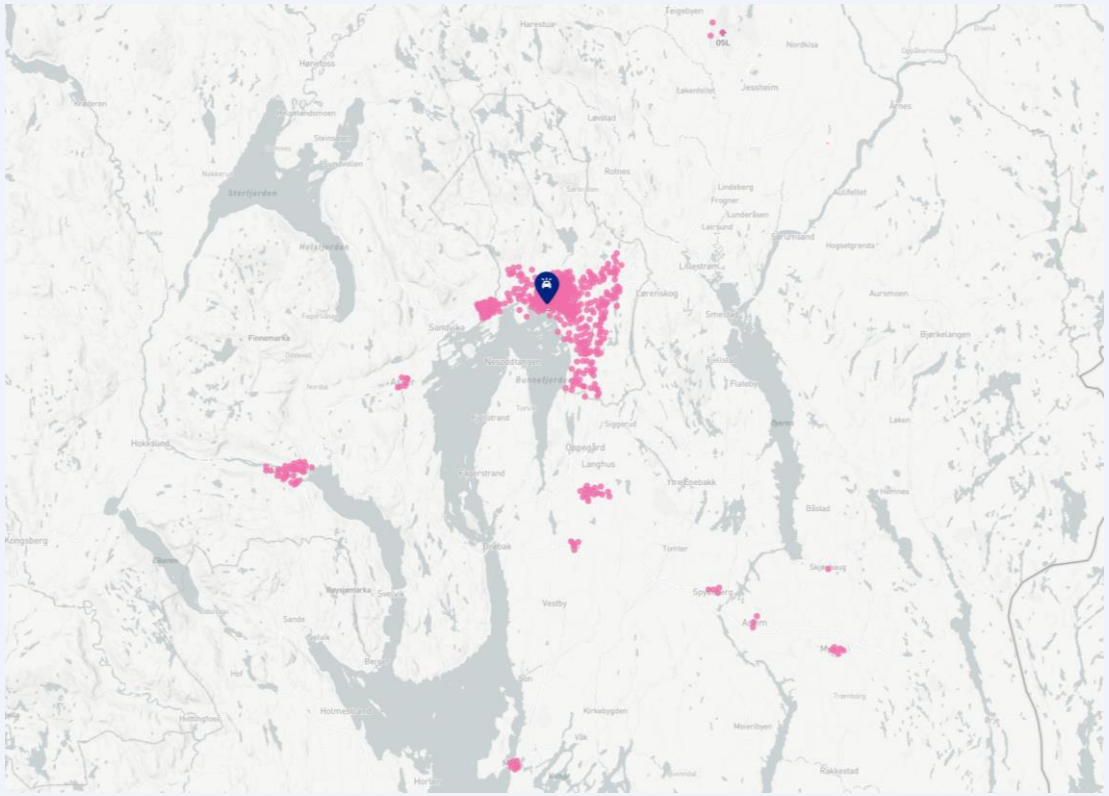


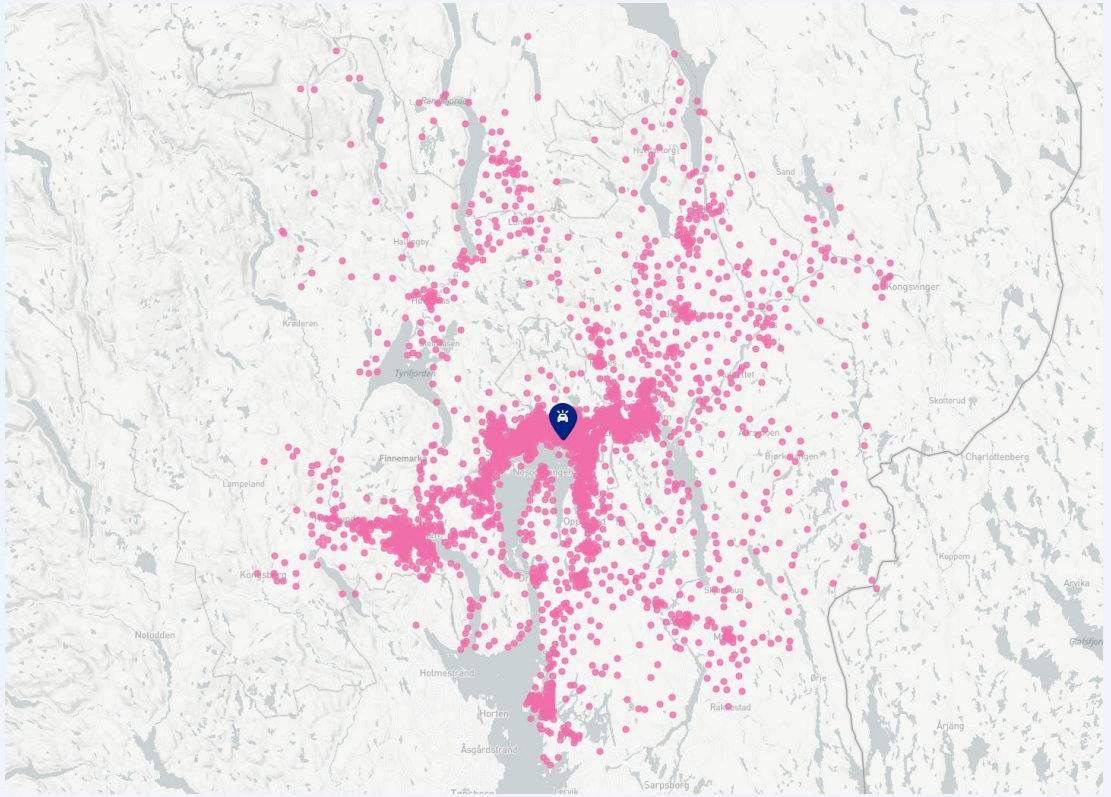


Shared mode scenarios

Scenario 3: Shared bikes, shared scooters and shared cars available

In addition to scenario 2, shared cars can be used for a selected number of zones as travel mode for originating trips (image on the left). All zones can be reached with these modes (image on the right).

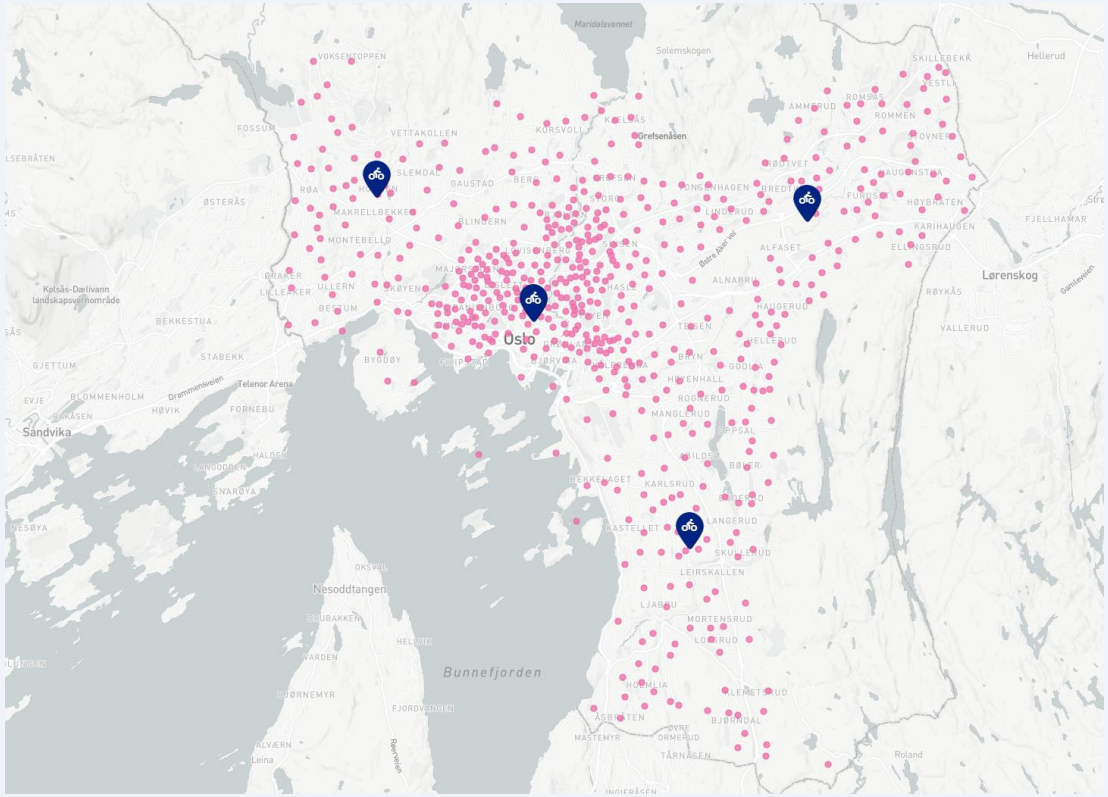


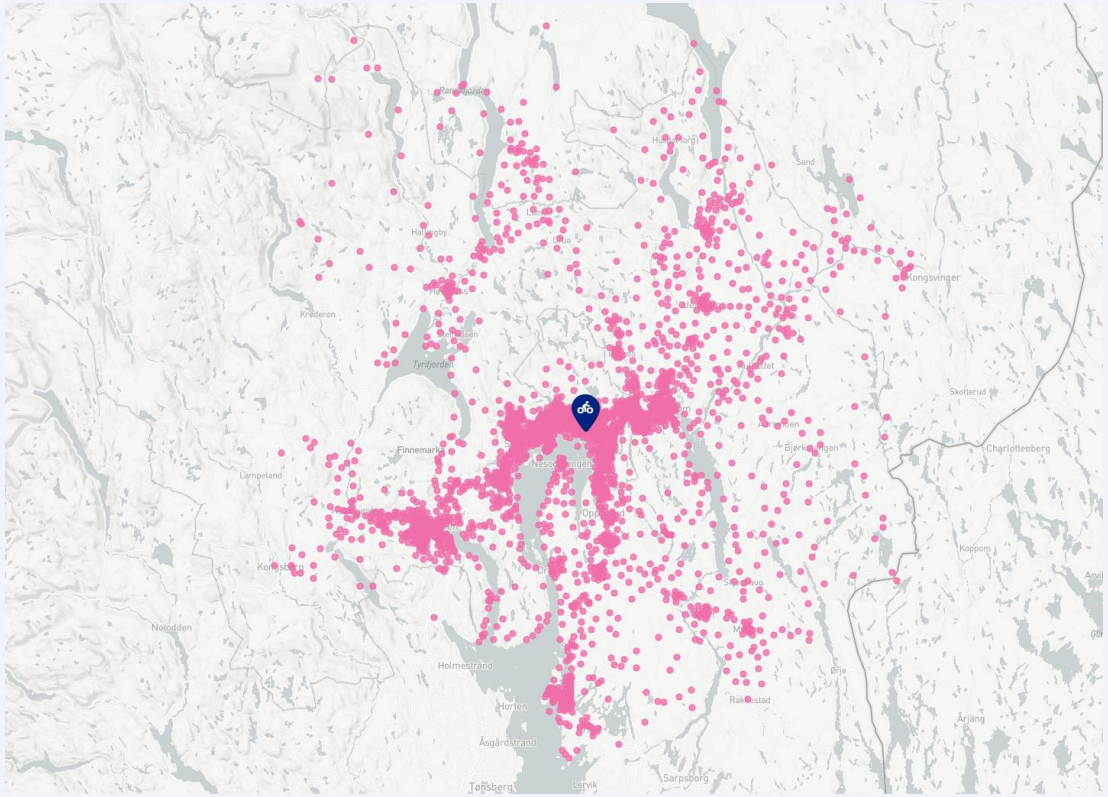


Shared mode scenarios

Scenario 4: Additional locations for shared bikes and shared scooters

In addition to scenario 3, shared bikes and shared scooters are available in additional zones as travel mode for originating trips (image on the left). All zones can be reached with these modes (image on the right).





About the results

Quality of simulation results

Given the limited data provided by the city, the results of the simulations should be used merely to provide the (relative) sensitivity of policy measures. This means that results can be used to identify potential effective measures to be explored in future studies or with more detailed input data. Given these restrictions and associated assumptions the results are presented relatively to a reference scenario in stead of absolute values provided by the simulations.

Recommended data to improve simulation results

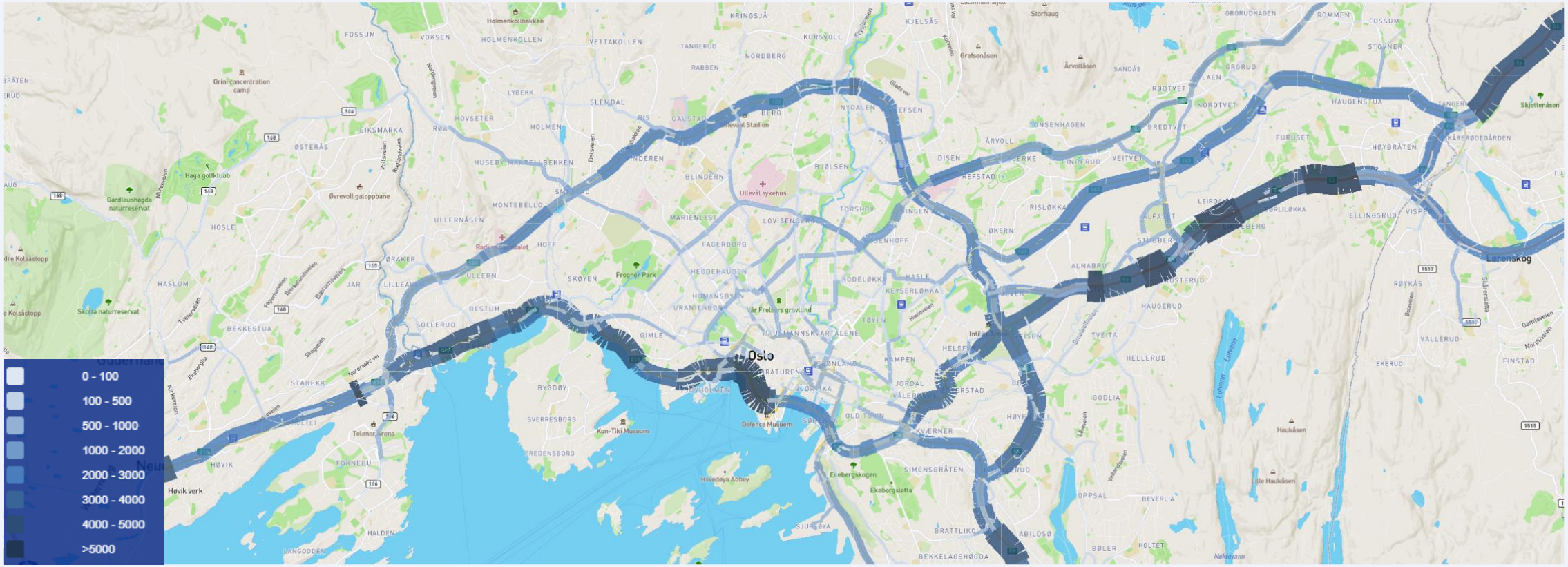
- Preprocessed traffic model data and outcomes (roads, OD-pairs and intensities);
- Population distribution data per zone to improve accuracy of mode choice simulation;
- Population data (#inhabitants) per building to further differentiate noise and air indicators;
- Distribution of vehicles and associated emission values of the fleet;
- Background concentration and meteo data;
- Noise barrier data.

Please note that depended on the research question or intended application of the Digital Twin (use case) there may be additional data sources required.

Reference scenario

Traffic intensities: Car + Freight

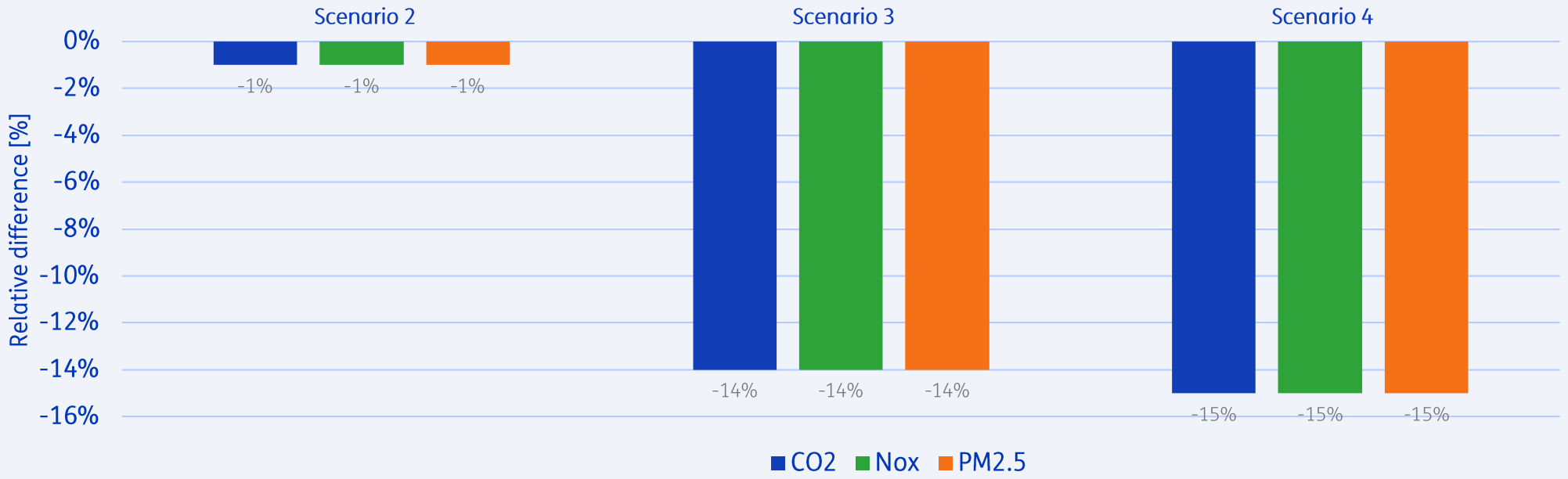
Traffic assignment results based on origin and destination matrices and network as provided by the city.



Results: Air emissions

Relative difference of traffic emissions per scenario compared to scenario 1

Due to data limitations these results are based on Dutch emission factors for Dutch fleet composition.

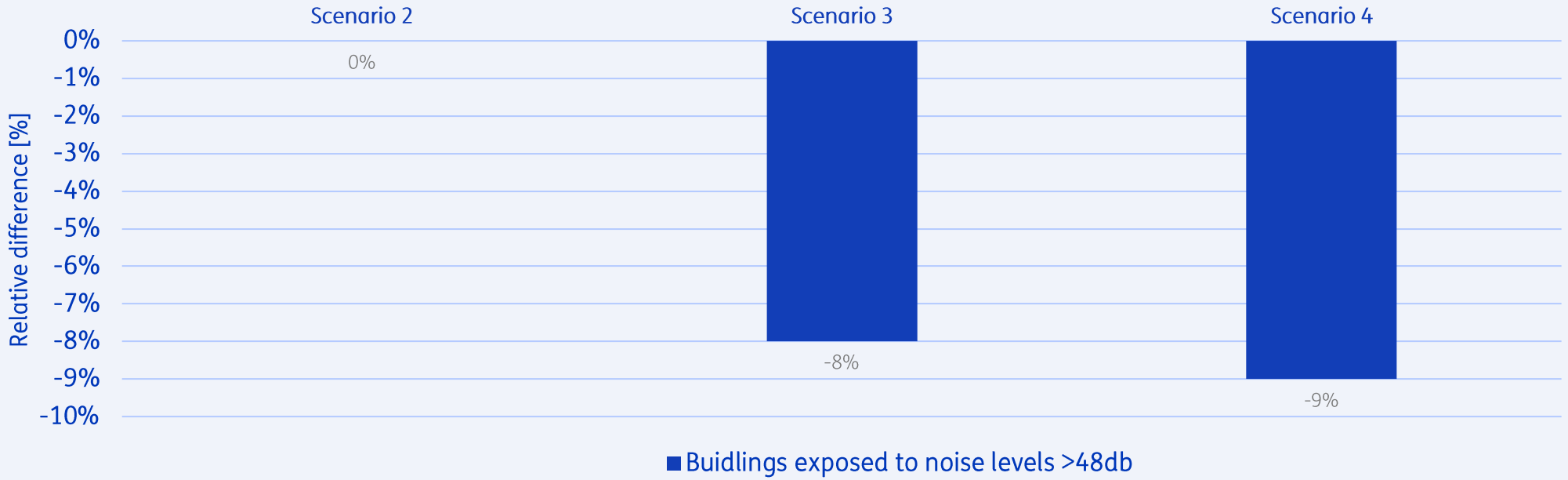


Scenario 1: No shared modes available
Scenario 2: Shared bikes and shared scooters available
Scenario 3: Shared bikes, shared scooters and shared cars available
Scenario 4: Additional locations for shared bikes and shared scooters

Results: Noise emissions

Relative difference of traffic emissions per scenario compared to scenario 1

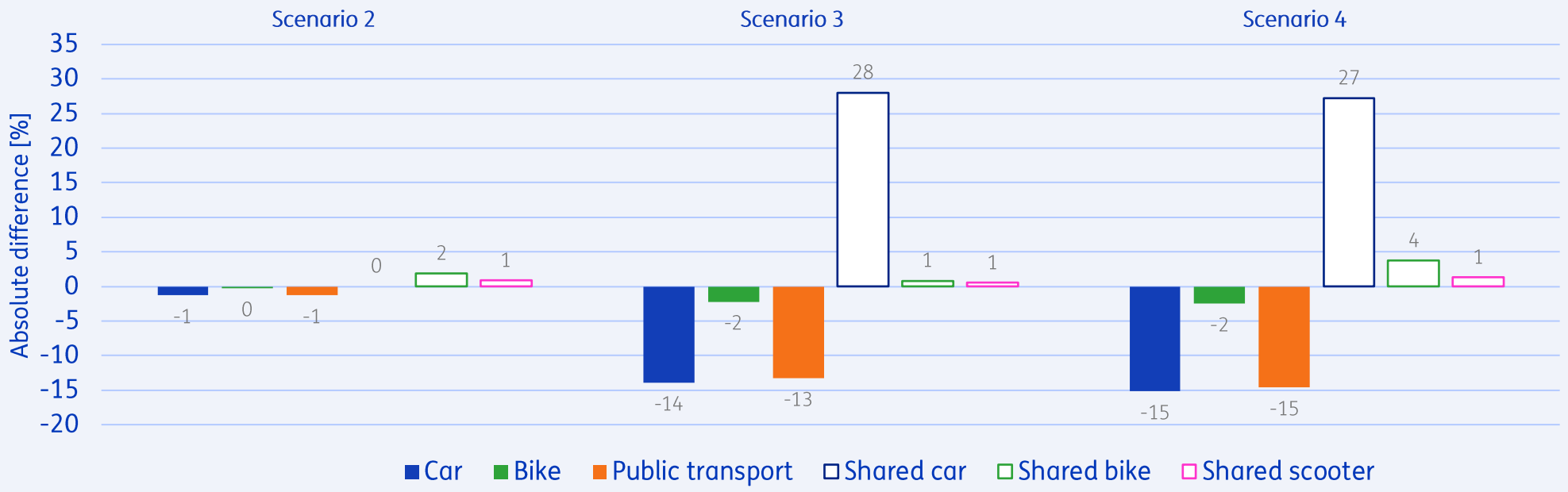
Due to data limitations these results are based on Dutch emission factors for Dutch fleet composition. Excluding noise emissions by shared cars.



Scenario 1: No shared modes available
Scenario 2: Shared bikes and shared scooters available
Scenario 3: Shared bikes, shared scooters and shared cars available
Scenario 4: Additional locations for shared bikes and shared scooters

Results: Modal split

Absolute difference of modal split per scenario compared to scenario 1



Scenario 1: No shared modes available
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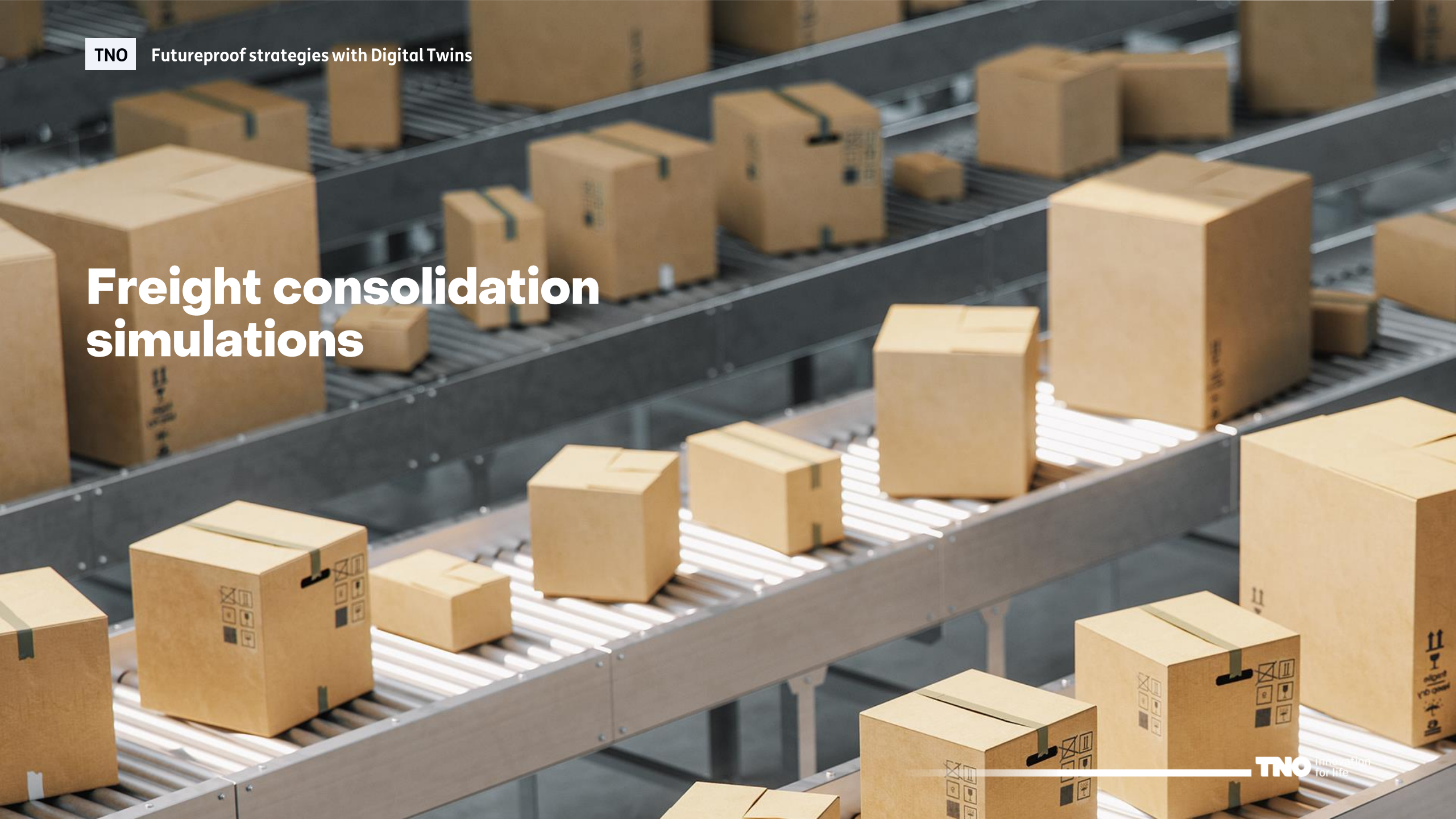
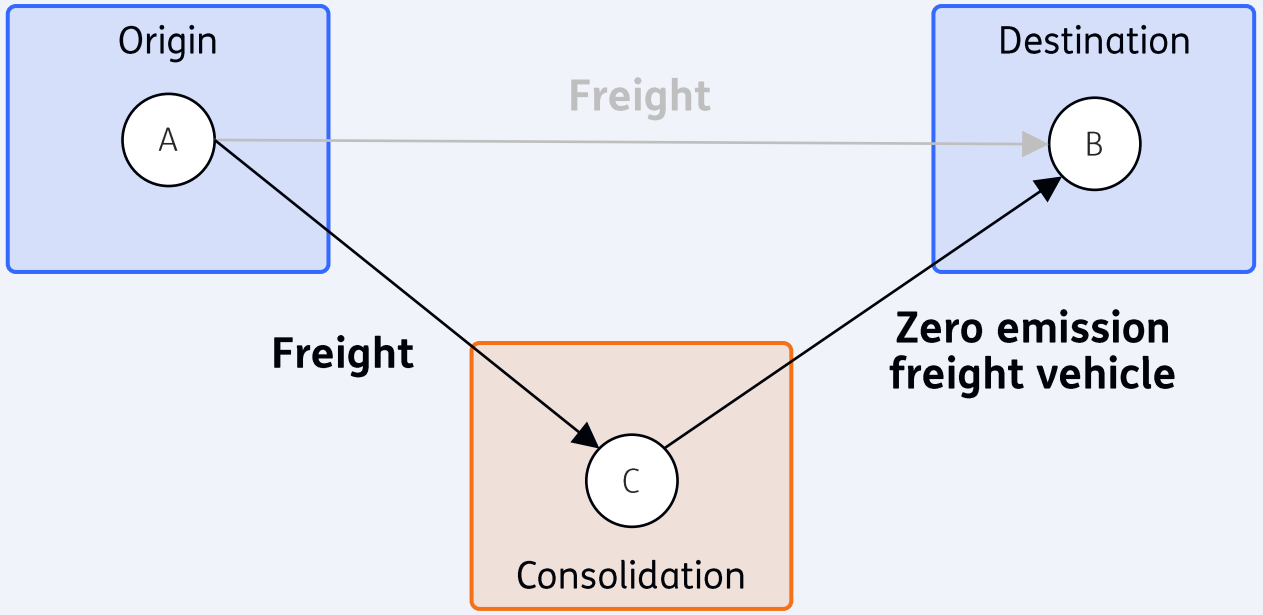
Freight consolidation simulations



Consolidating freight in Urban Strategy



Model parameters

From mode:	Freight
To mode:	Zero emission freight vehicle
Exchange factor:	100%

Freight consolidation scenarios

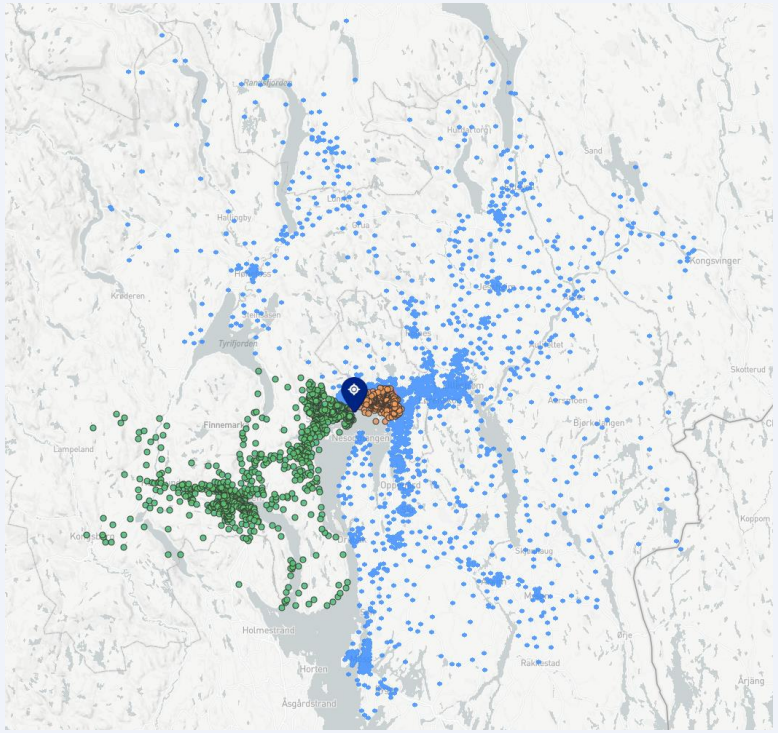
Overview of scenarios

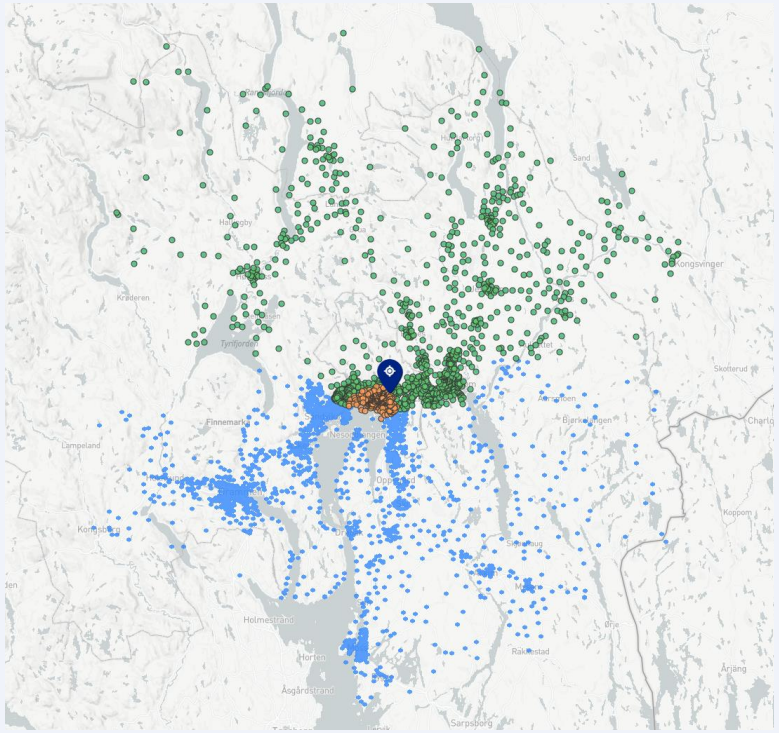
1. No consolidation hub
2. Consolidation centre West
3. Consolidation centre North
4. Consolidation centre South
5. All consolidation centres
6. Limited access within Ring 3

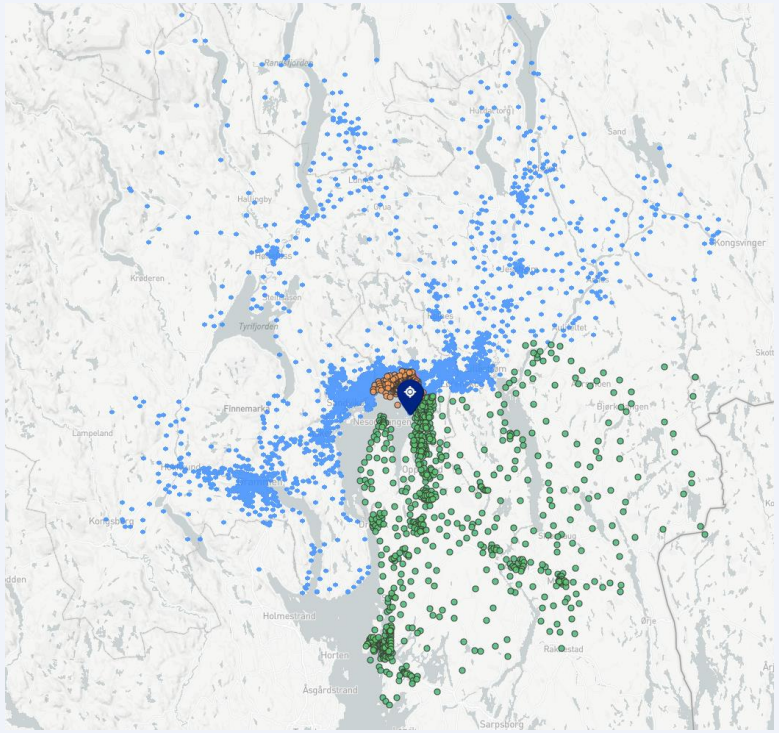
Freight consolidation scenarios

Overview of hub locations

From left to right: Hub West, Hub North and Hub South. Blue zones are unaffected, freight trips for which the green zones are the origin and the orange zones are the destination will be transferred to zero emission freight vehicle.



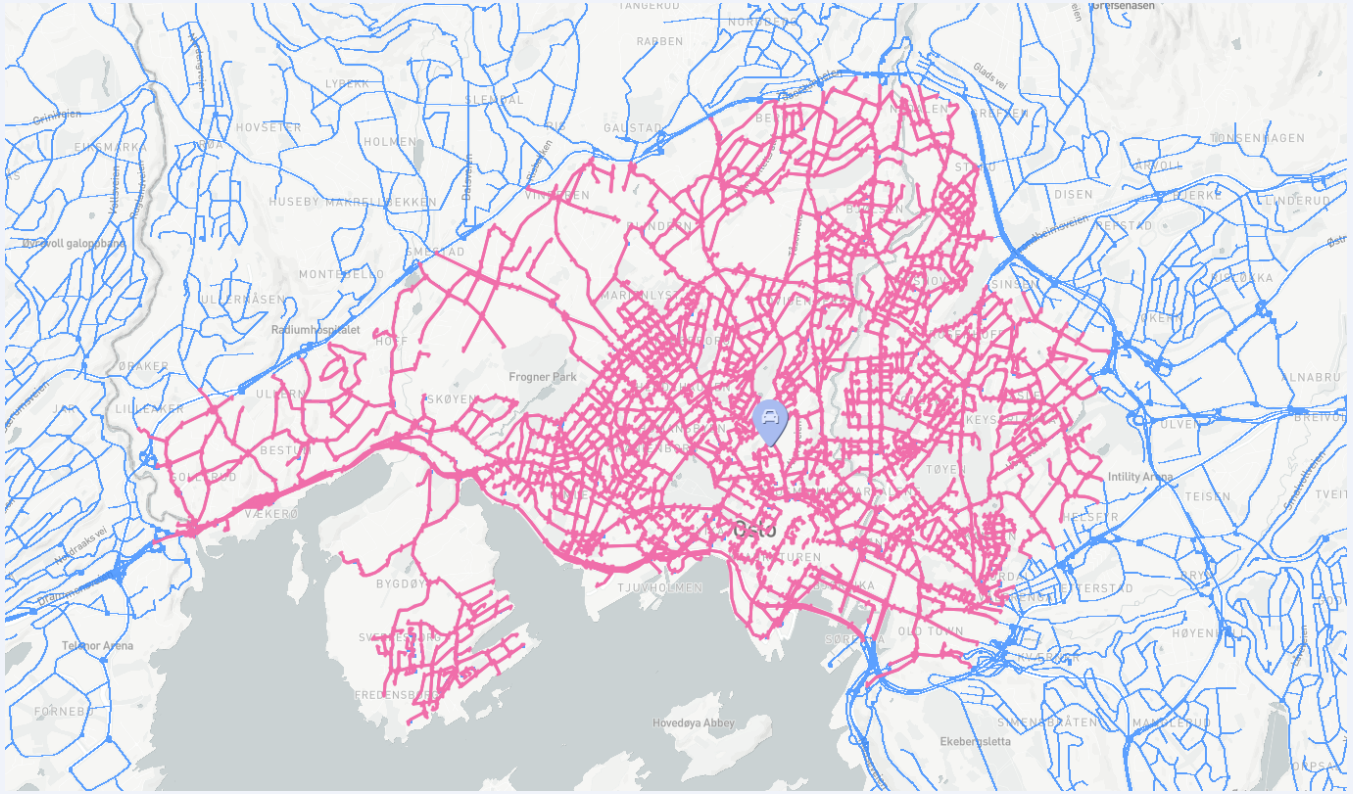




Freight consolidation scenarios

Limited access of freight vehicles

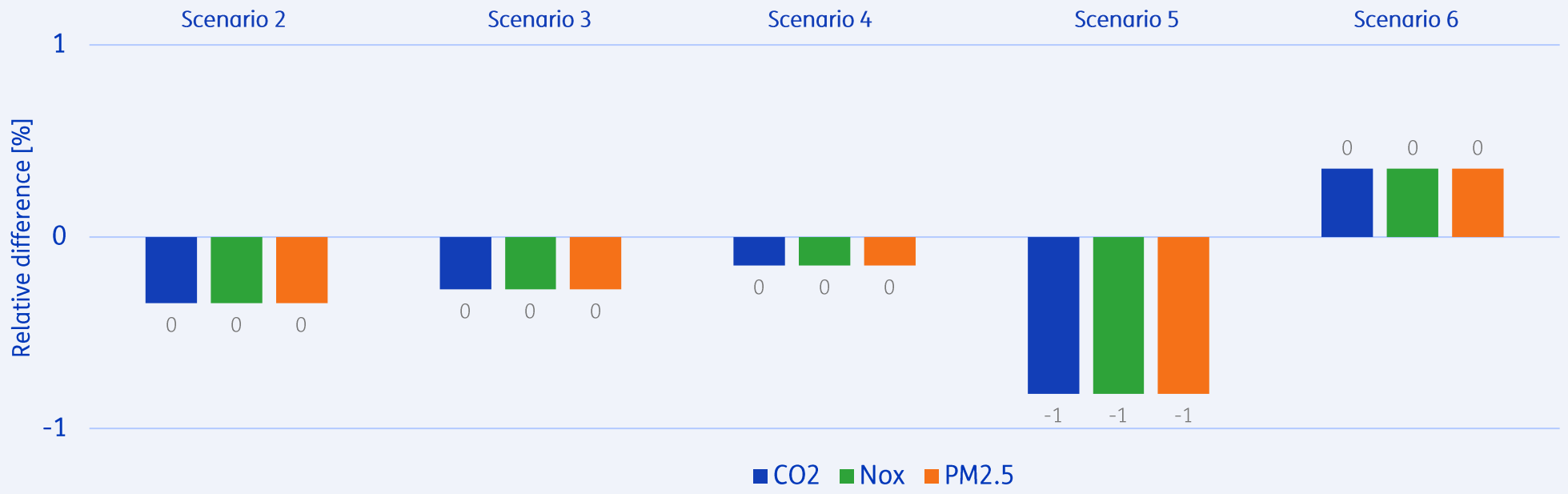
In addition to the consolidation centre scenarios, roads within Ring 3 are made extremely unattractive for the route choice of freight trips. Speed for the pink roads in the image are reduced to 1 km/h for freight vehicles.



Results: Air emissions

Relative difference of traffic emissions per scenario compared to scenario 1

Due to data limitations these results are based on Dutch emission factors for Dutch fleet composition.

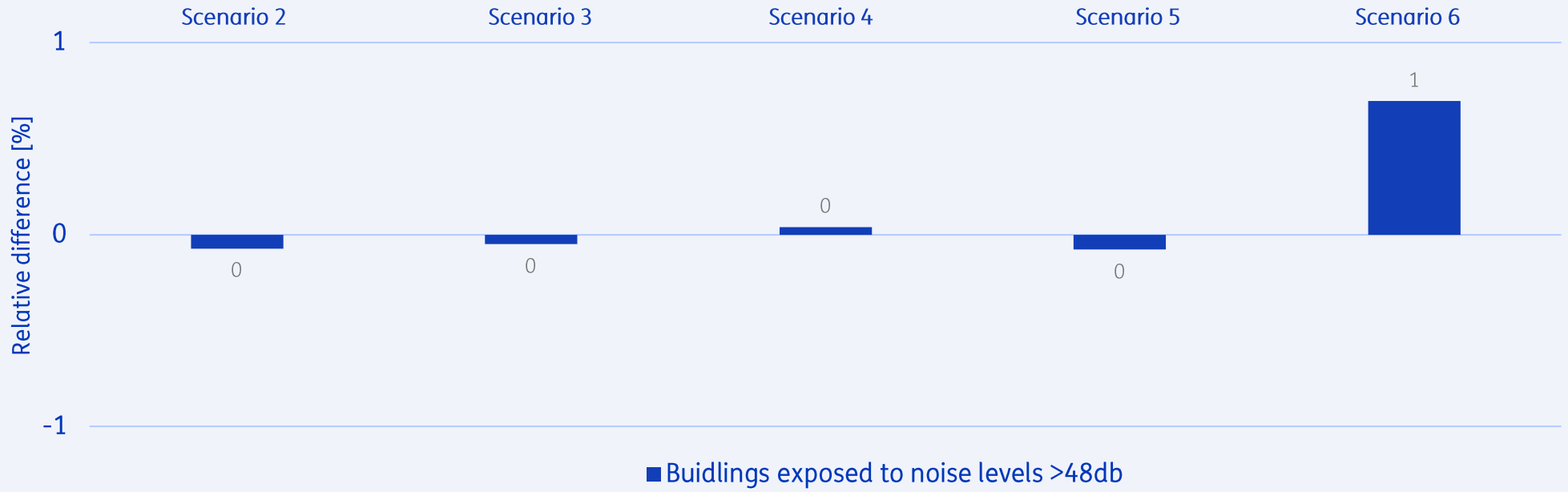


Scenario 1: Reference scenario (No consolidation hub)
Scenario 2: Consolidation centre West
Scenario 3: Consolidation centre North
Scenario 4: Consolidation centre South
Scenario 5: All consolidation centres
Scenario 6: Limited access within Ring 3

Results: Noise emissions

Relative difference of traffic emissions per scenario compared to scenario 1

Due to data limitations these results are based on Dutch emission factors for Dutch fleet composition. Excluding noise emissions by zero emission freight vehicles.



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