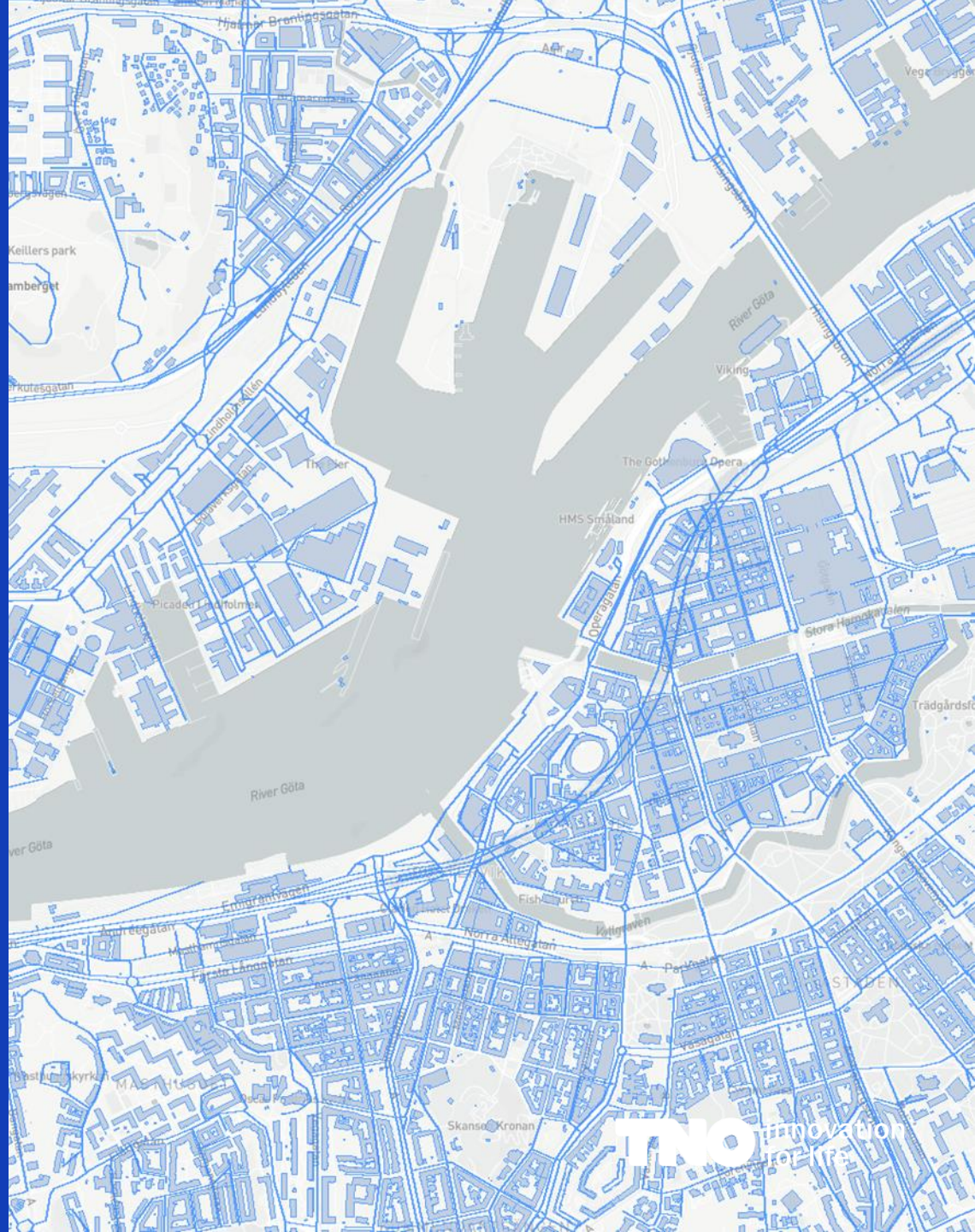
Move21 Gothenburg Digital Twin

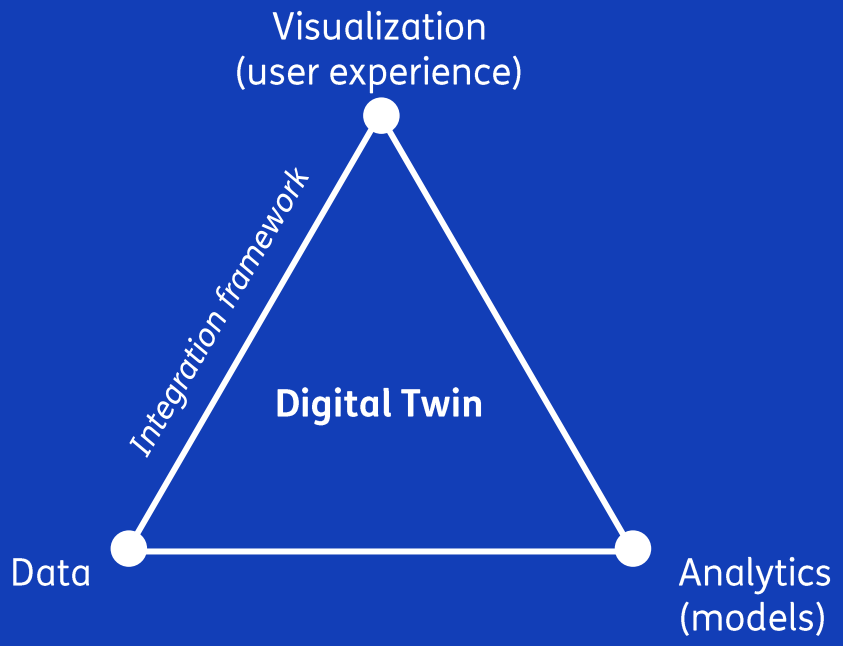
Predictive digital city replica with TNO Urban Strategy for simulating shared modes and logistics.



September 19th 2023

Digital Twins: making complexity manageable

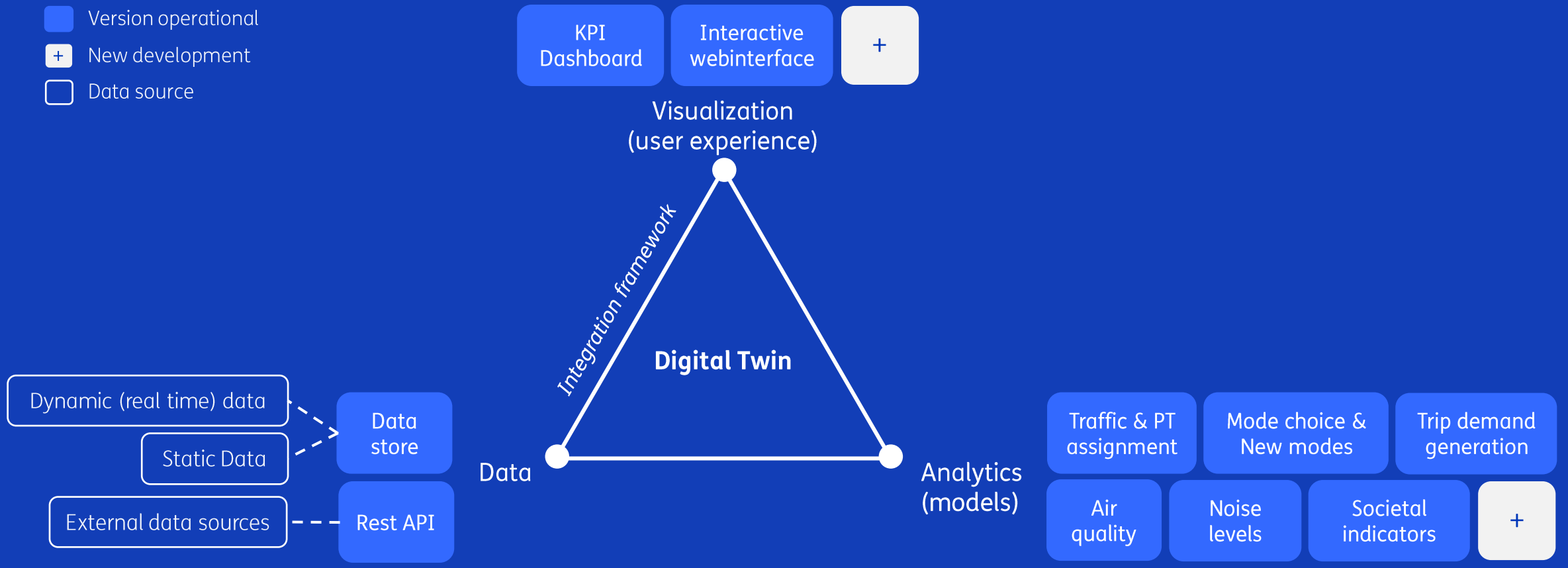
- Digital Twins are realistic digital replica's of the real world, consisting of the integration of data, analytics and visualization.



- 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.

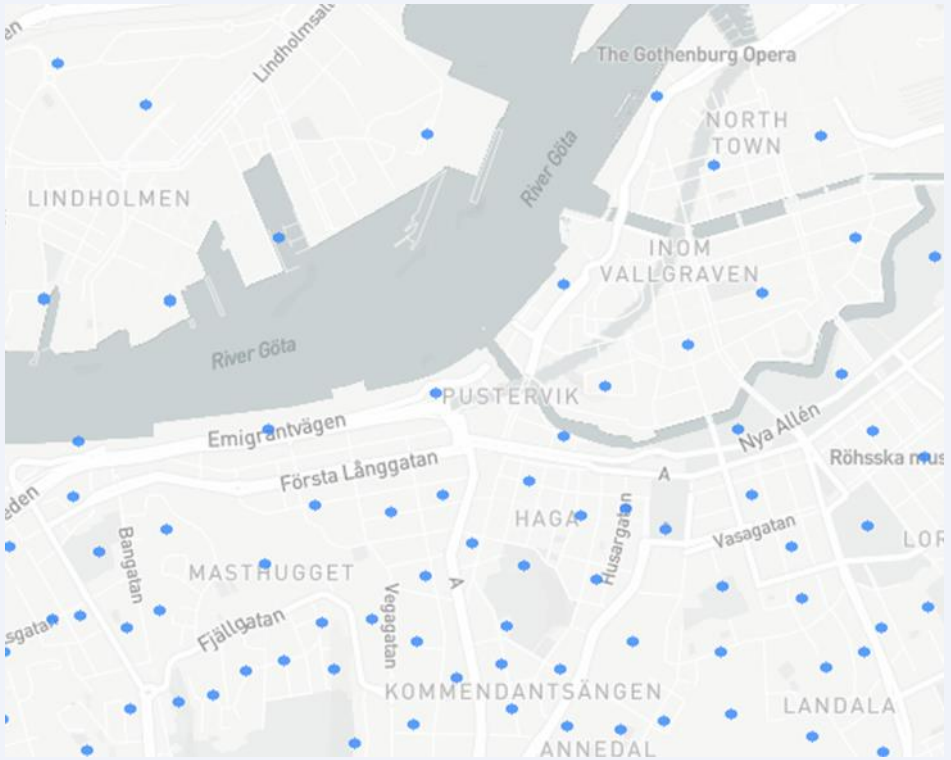
Simulating shared modes in Urban Strategy

Input data from Visum

Network

Zones

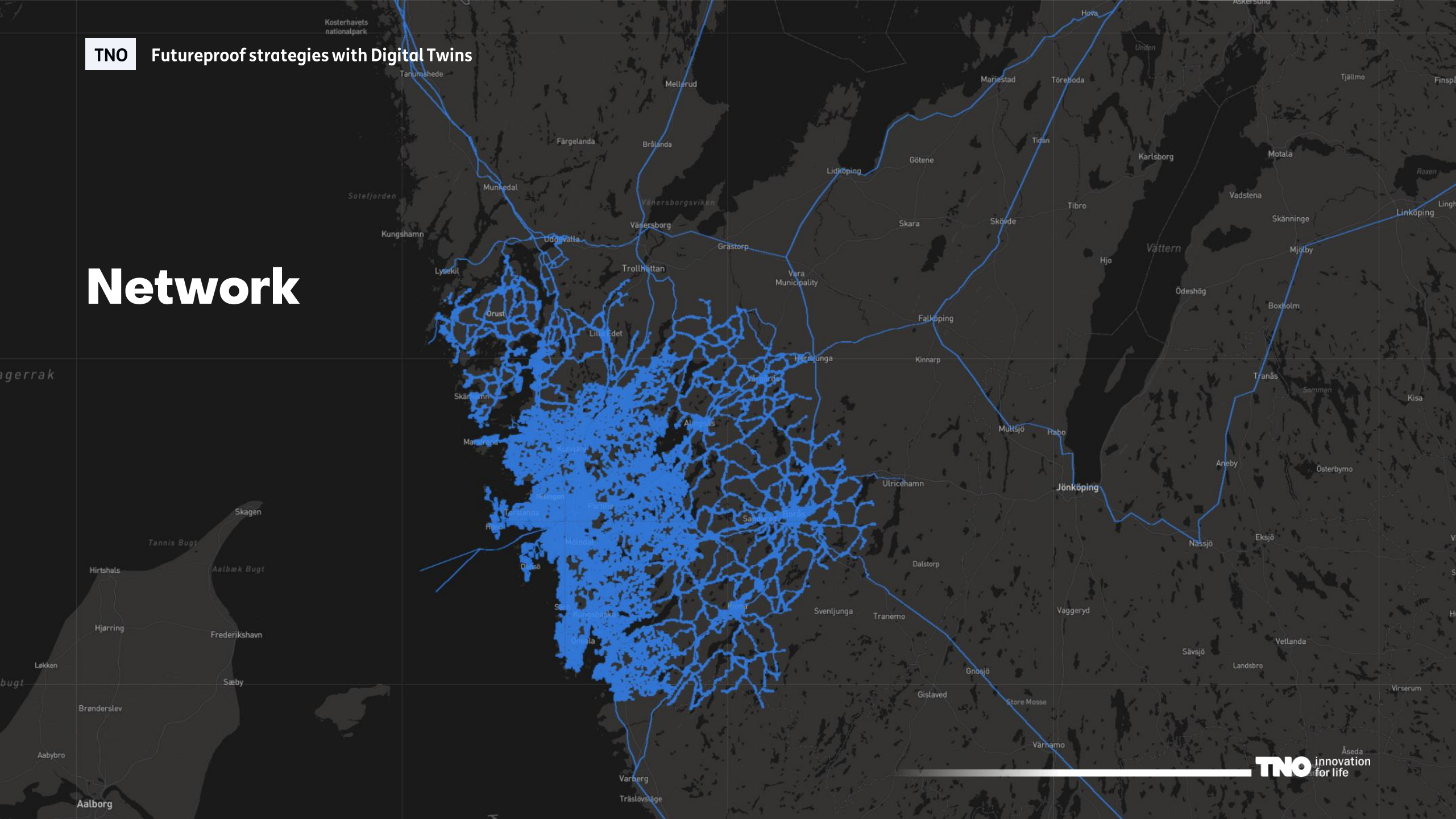
OD-matrices



Data Simulation → Data exchange

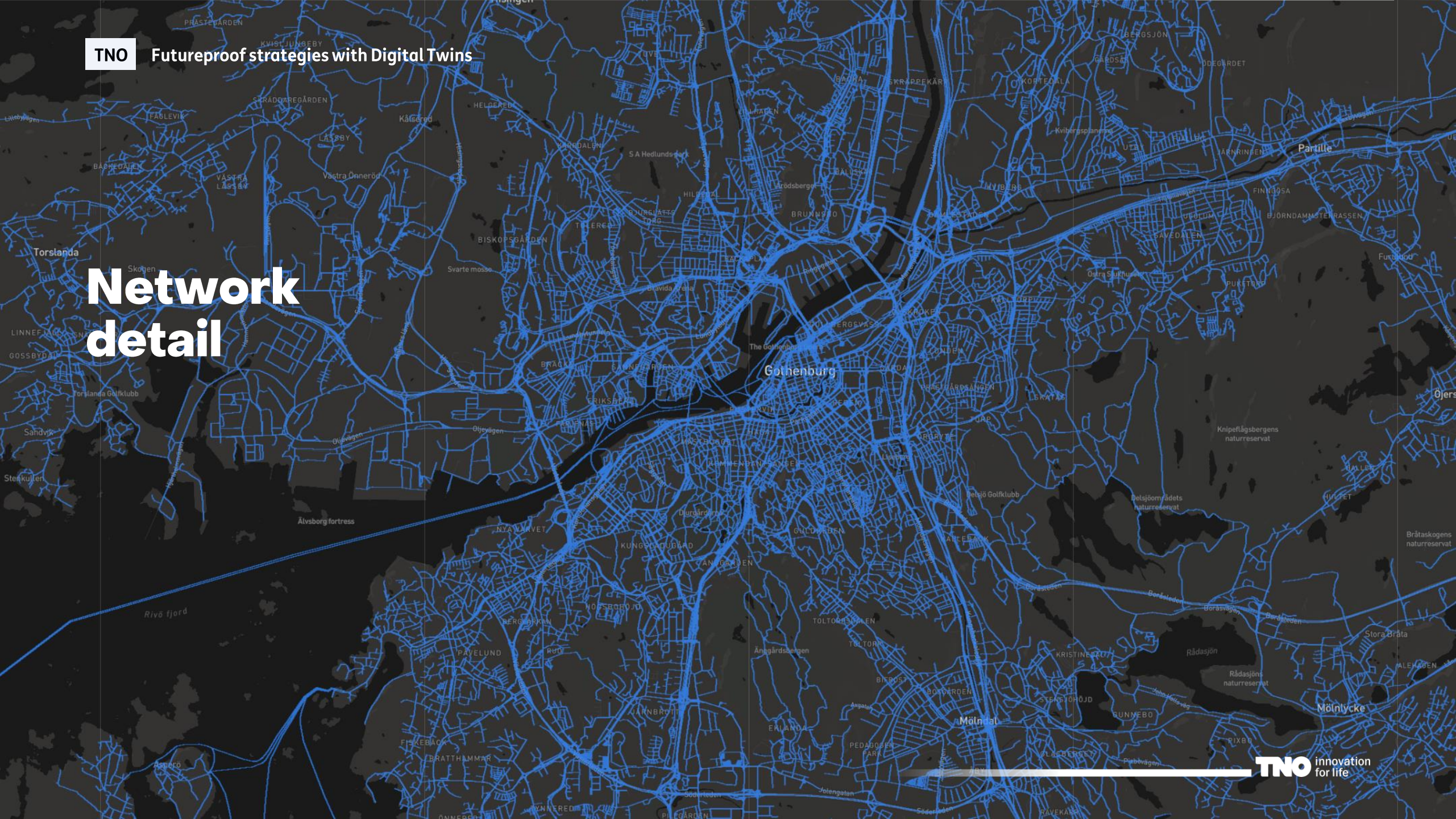
TNO Futureproof strategies with Digital Twins

Network

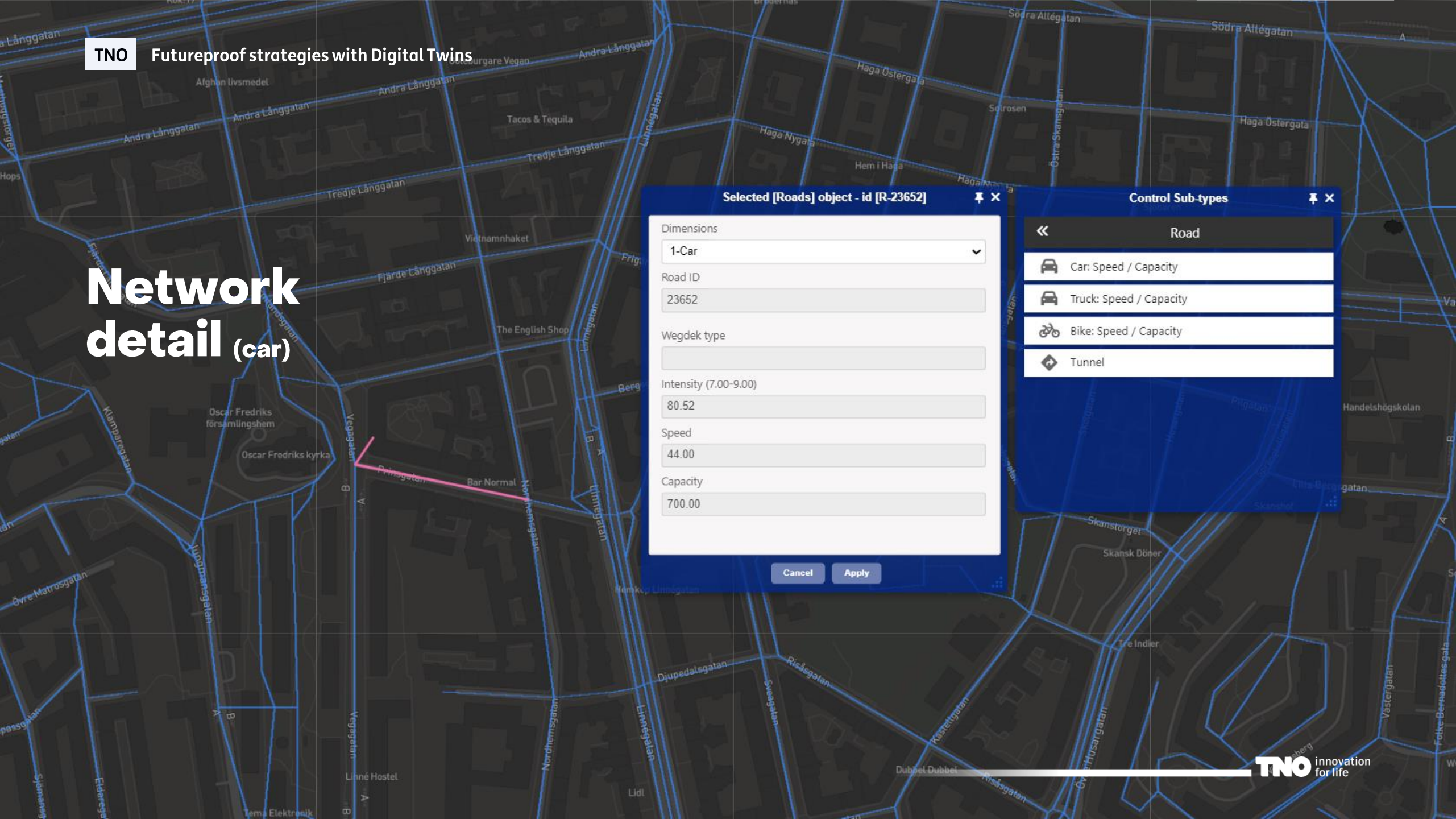


TNO innovation for life

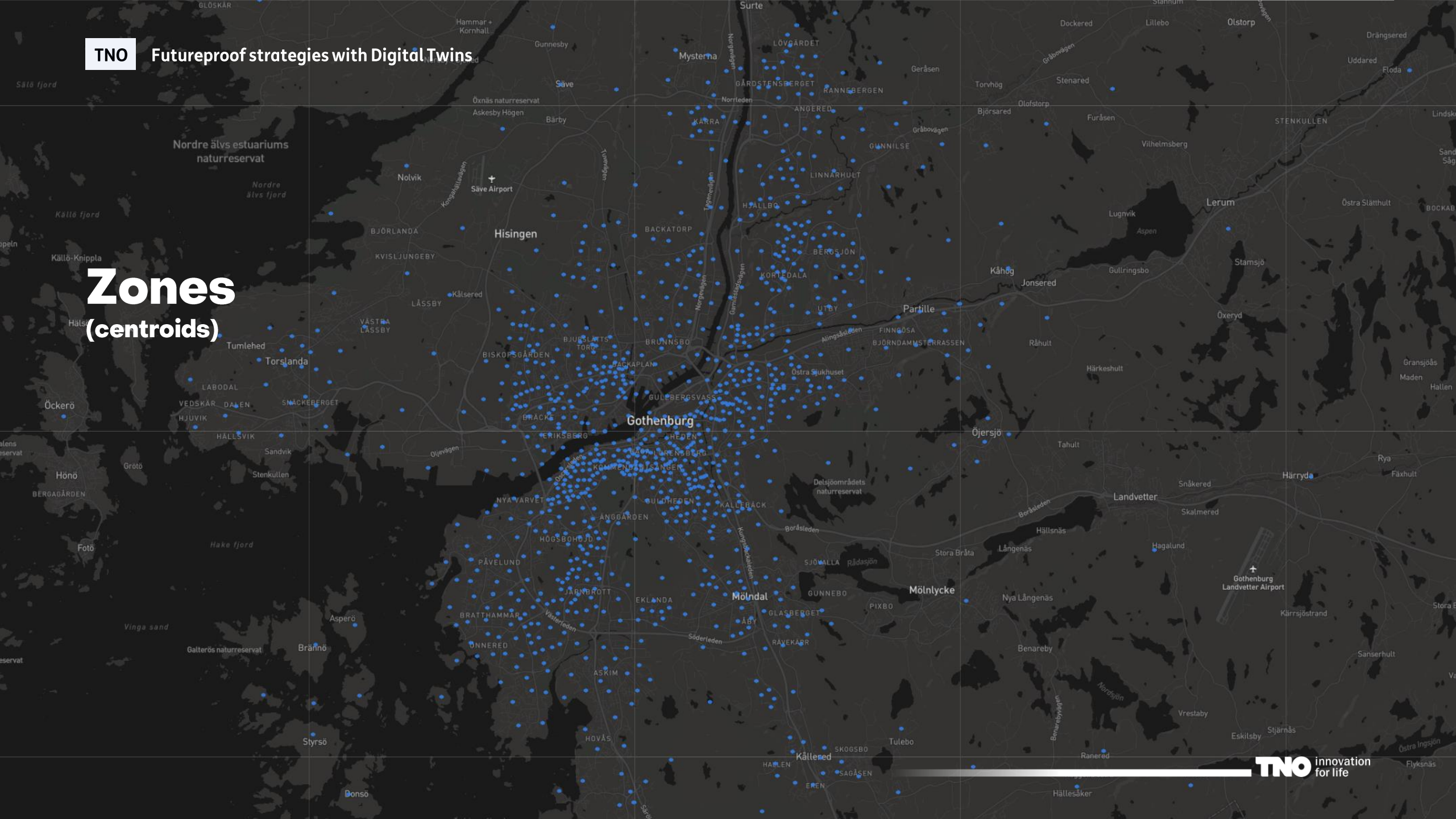
Network detail



Network detail (car)

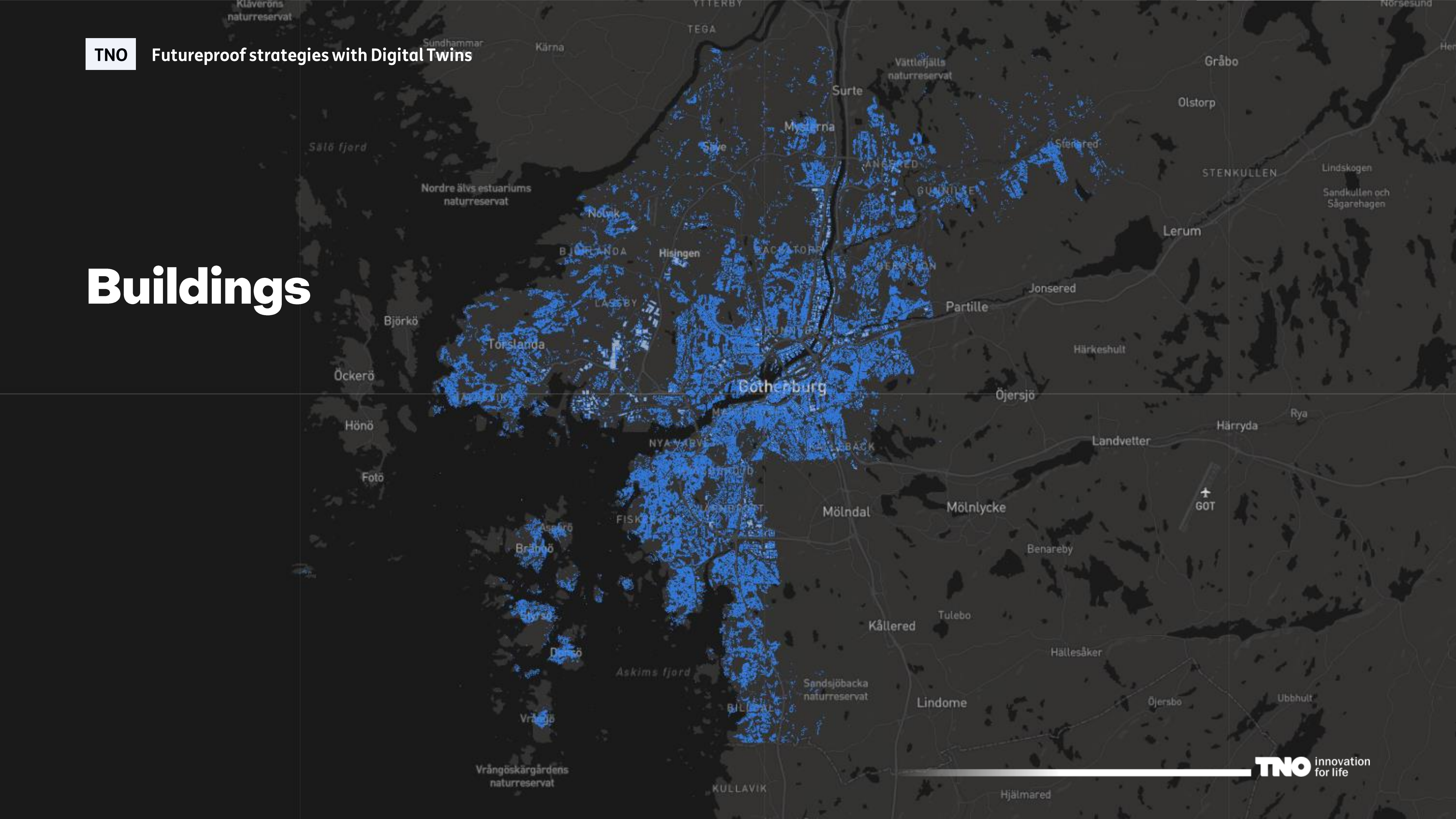


Zones
(centroids)

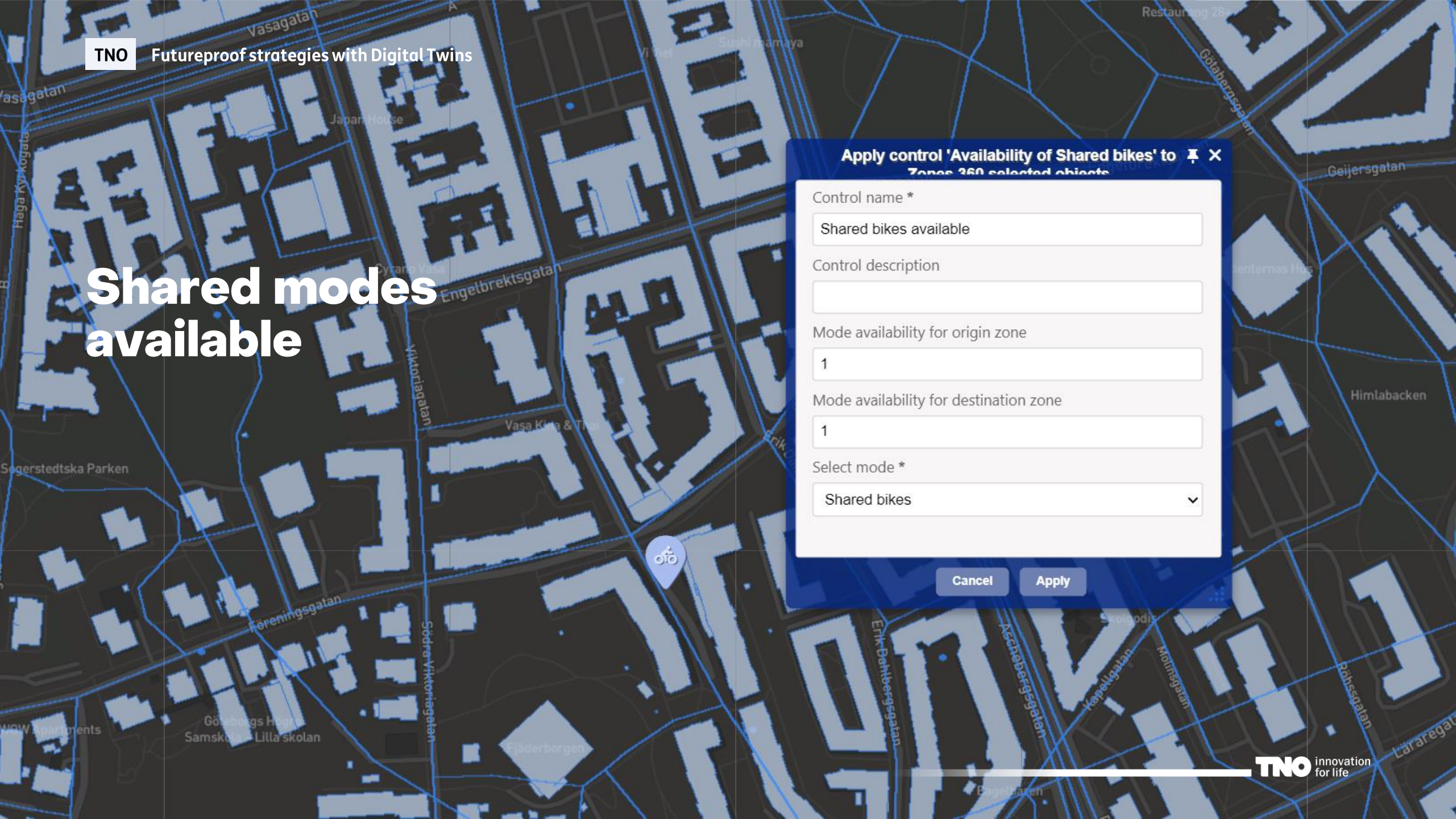


TNO innovation for life

Buildings


Kläverons naturreservat
Ytterby
Tega
Sundhammar
Kärna
Vättlefjälls naturreservat
Gråbo
Surte
Olstorp
Sälö fjord
Stenkullen
Lindskogen
Sandkullen och Sågarehagen
Nordre älvs estuariums naturreservat
Lerum
Hisingen
Jonsered
Partille
Björkö
Torslanda
Härkeshult
Öckerö
Gothenburg
Öjersjö
Hönö
Rya
Härryda
Landvetter
Fotö
GOT
Mölndal
Mölnlycke
Benareby
Tulebo
Kållered
Hällesåker
Askims fjord
Sandsjöbacka naturreservat
Lindome
Öjersbo
Ubbhult
Vrångöskärgårdens naturreservat
Kullavik
Hjälmared

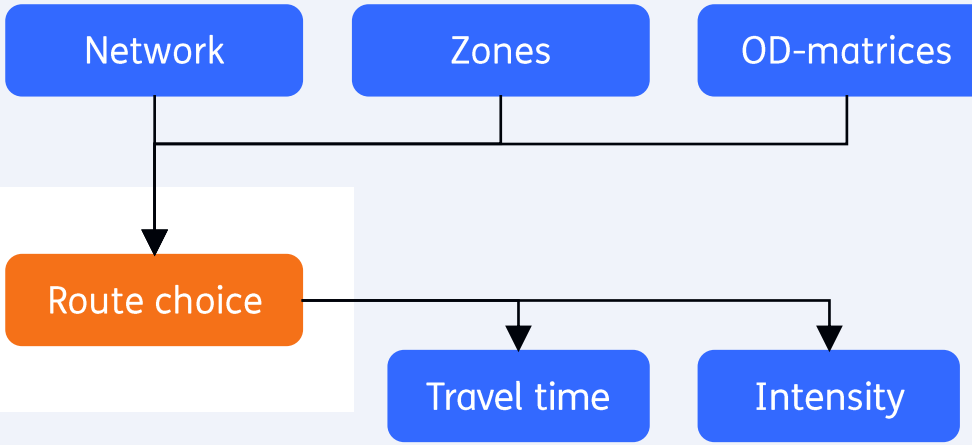
Shared modes available



Simulating shared modes in Urban Strategy

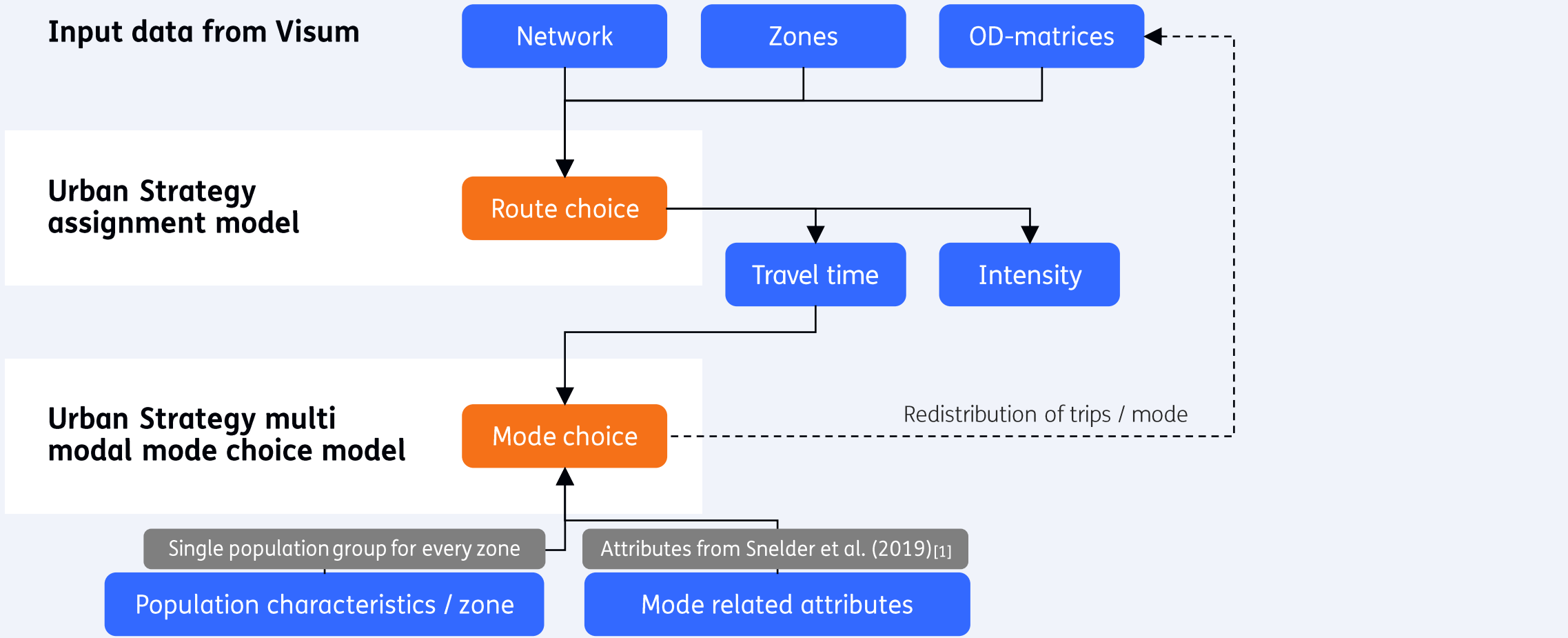
Input data from Visum

Urban Strategy assignment model



Data Simulation → Data exchange

Simulating shared modes in Urban Strategy

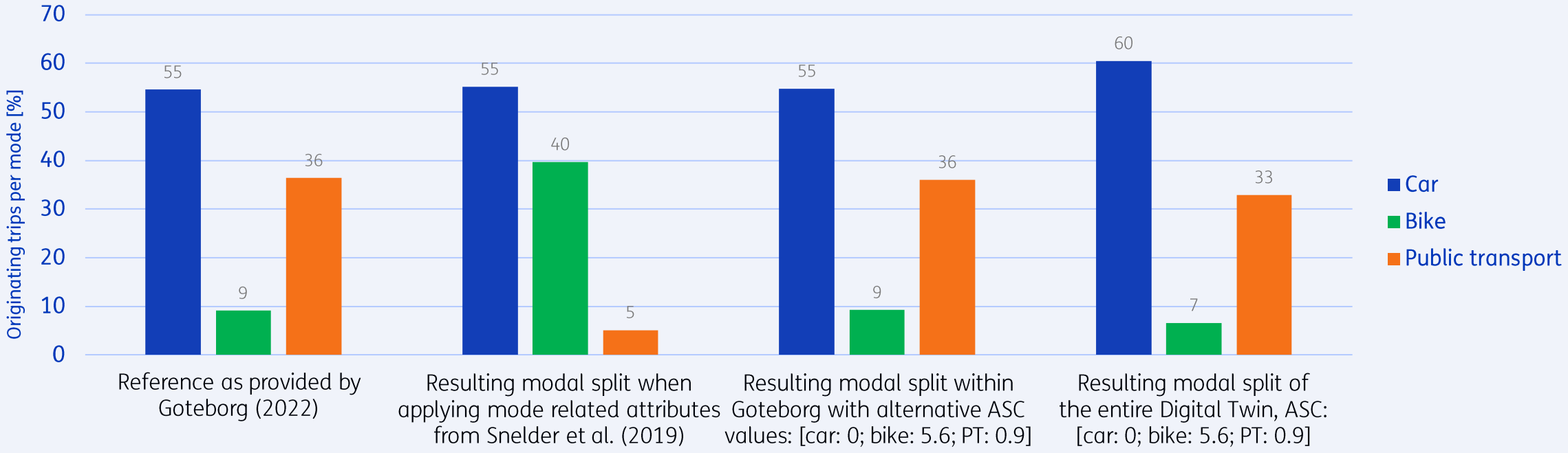


[1] Snelder, M., Wilmink, I., van der Gun, J., Bergveld, H. J., Hoseini, P., & van Arem, B. (2019). Mobility impacts of automated driving and shared mobility: explorative model and case study of the province of north Holland. European Journal of Transport and Infrastructure Research, 19(4). https://doi.org/10.18757/ejtir.2019.19.4.4282

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 provided by Goteborg (2022) the ASC values are adjusted. This results in a matching modal split for the district Goteborg, results for the entire Digital Twin are therefore slightly different.



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

Goteborg (2022, July 3). Trafik- och resandeutveckling 2022. https://goteborg.se/wps/wcm/connect/a16af15a-1d65-4bc9-88c0-4d222c2b3732/TRU_2022_slutversion.pdf?MOD=AJPERES

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.

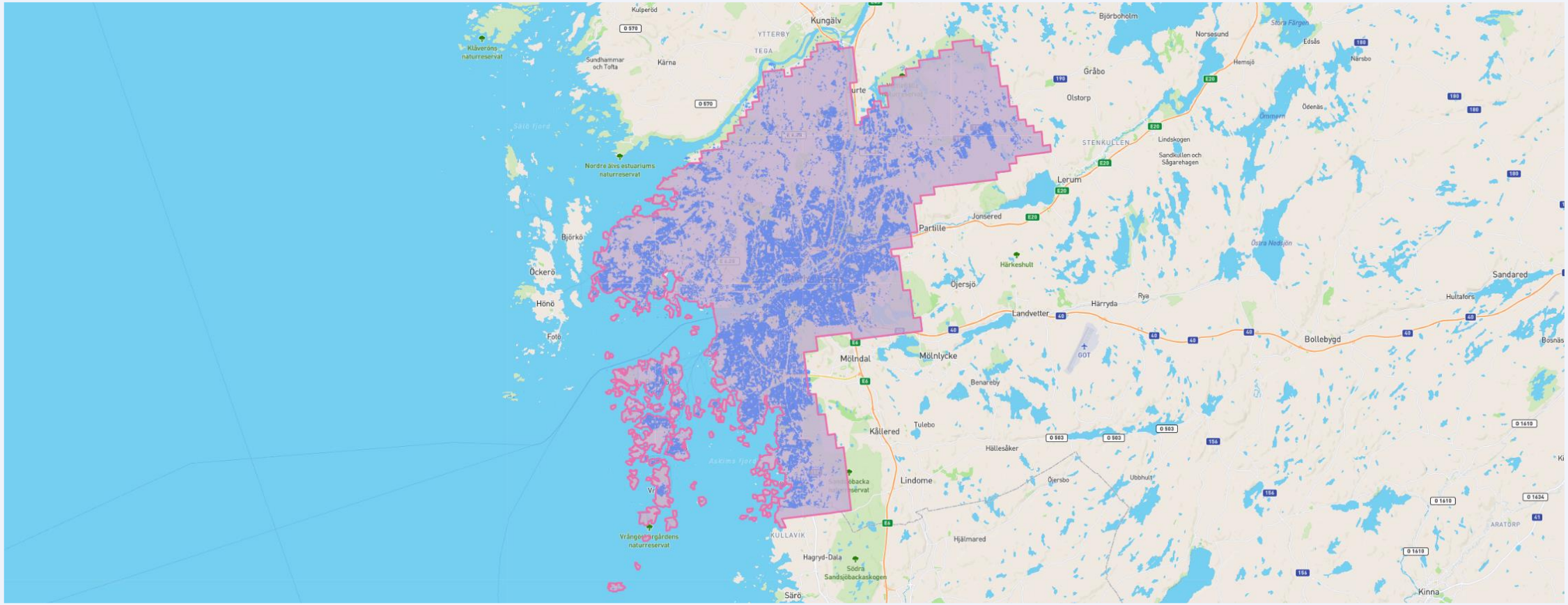
Mode related attributes

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	0.9	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

Goteborg



Shared mode scenarios

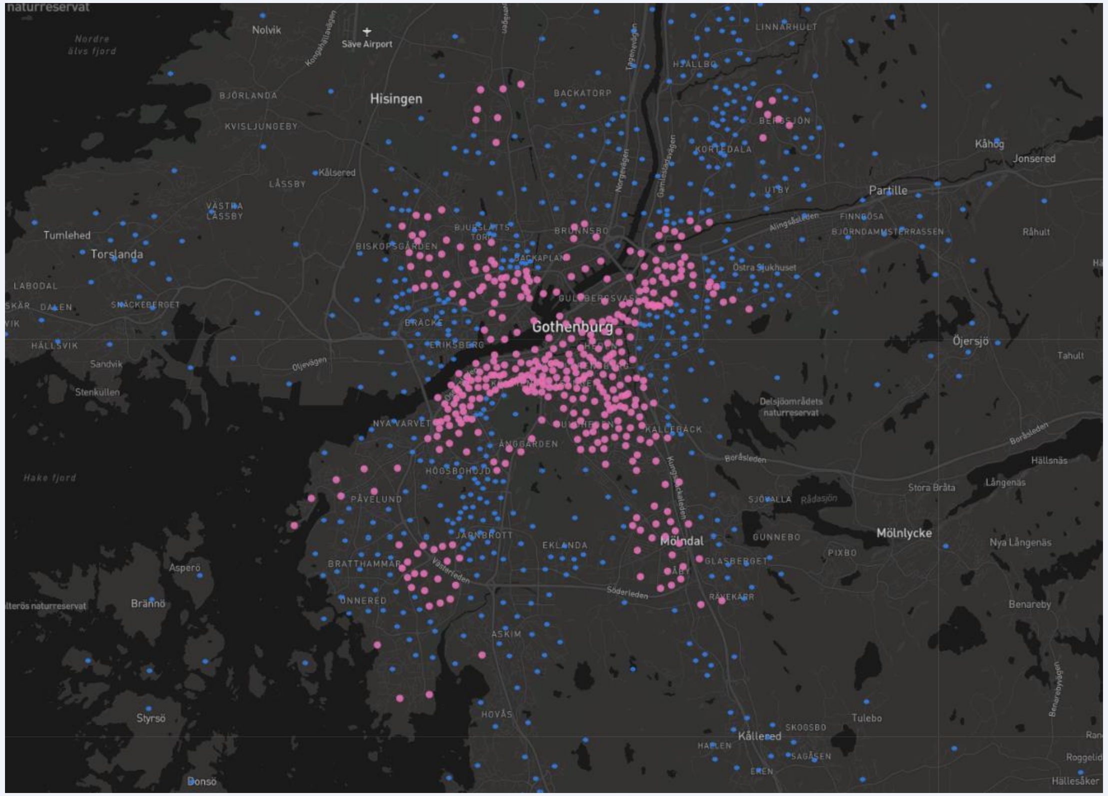
Overview of scenarios

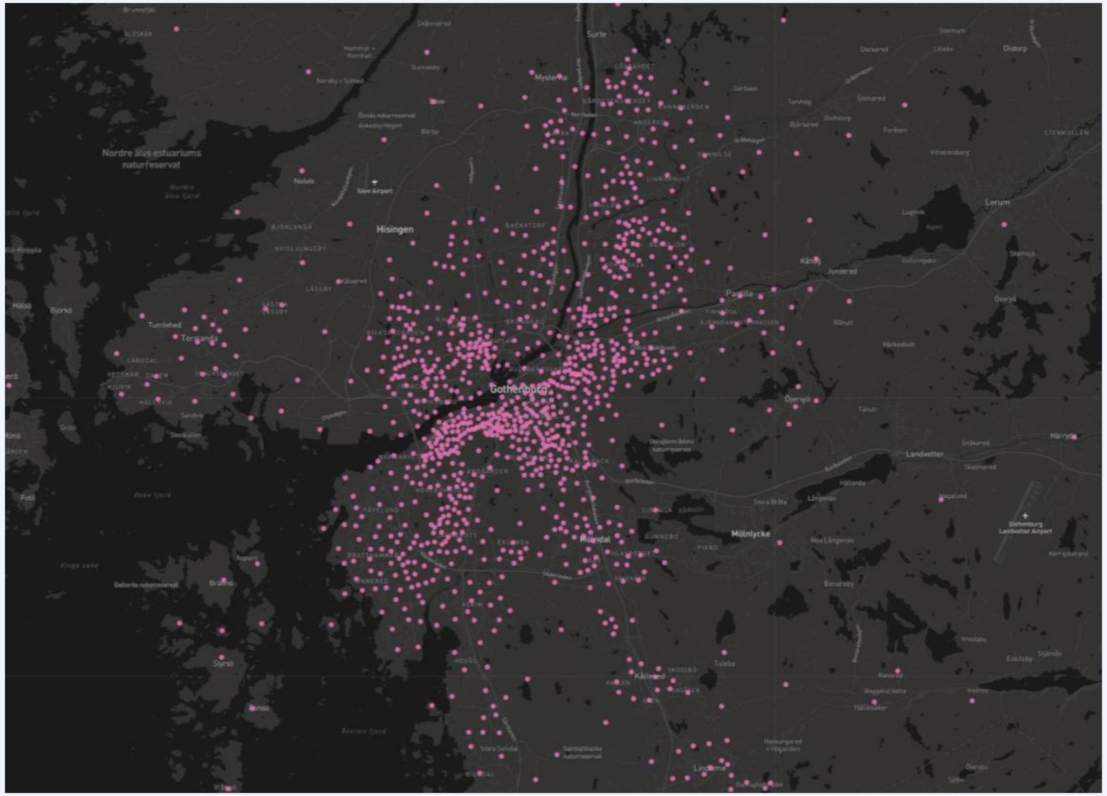
1. No shared modes available (reference scenario)
2. Shared bikes available at Styr & Ställ locations
3. Shared bikes available at MOVE21 hub locations
4. Shared bikes and shared scooters available at MOVE21 hub locations
5. Shared bikes, scooters and cars available at MOVE21 hub locations.
6. Combination of scenario 2 (Styr & Ställ) and 5 (MOVE21 hubs).

Shared mode scenarios

Scenario 2: Shared bikes available at Styr & Ställ locations

Only for zones within the service area shared bikes and shared scooters are available as travel mode for originating trips (image left). All zones in the entire Digital Twin can be reached as destination with these modes (image right).

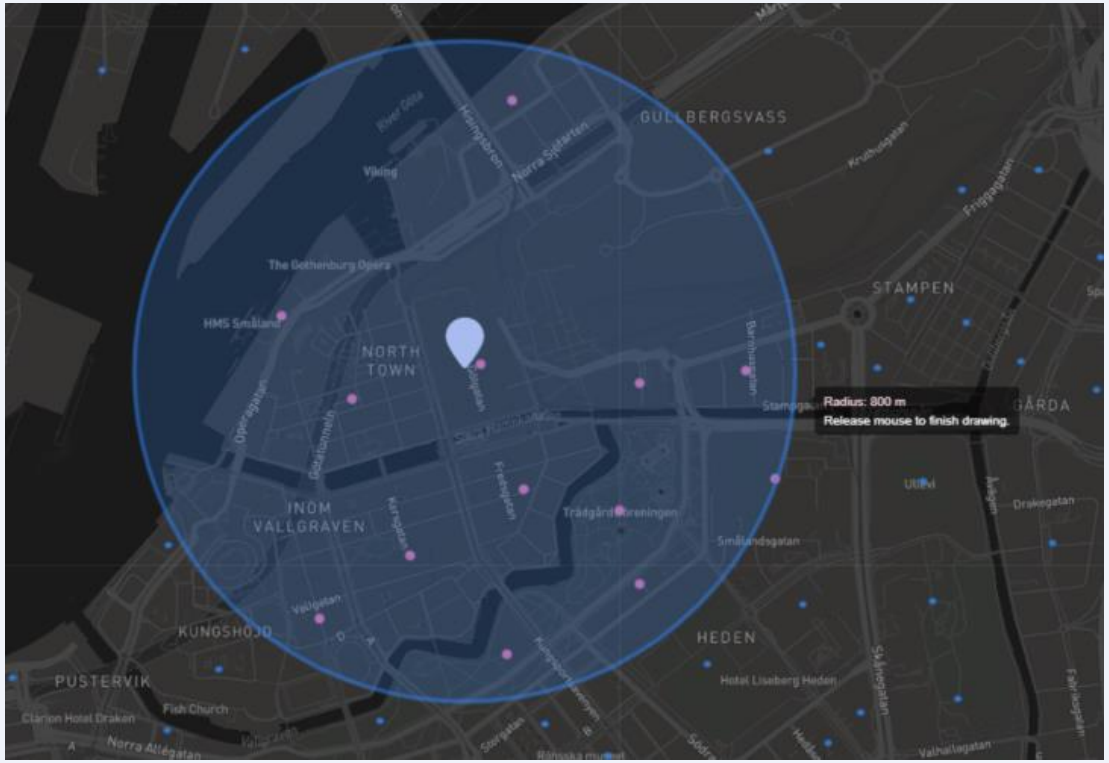


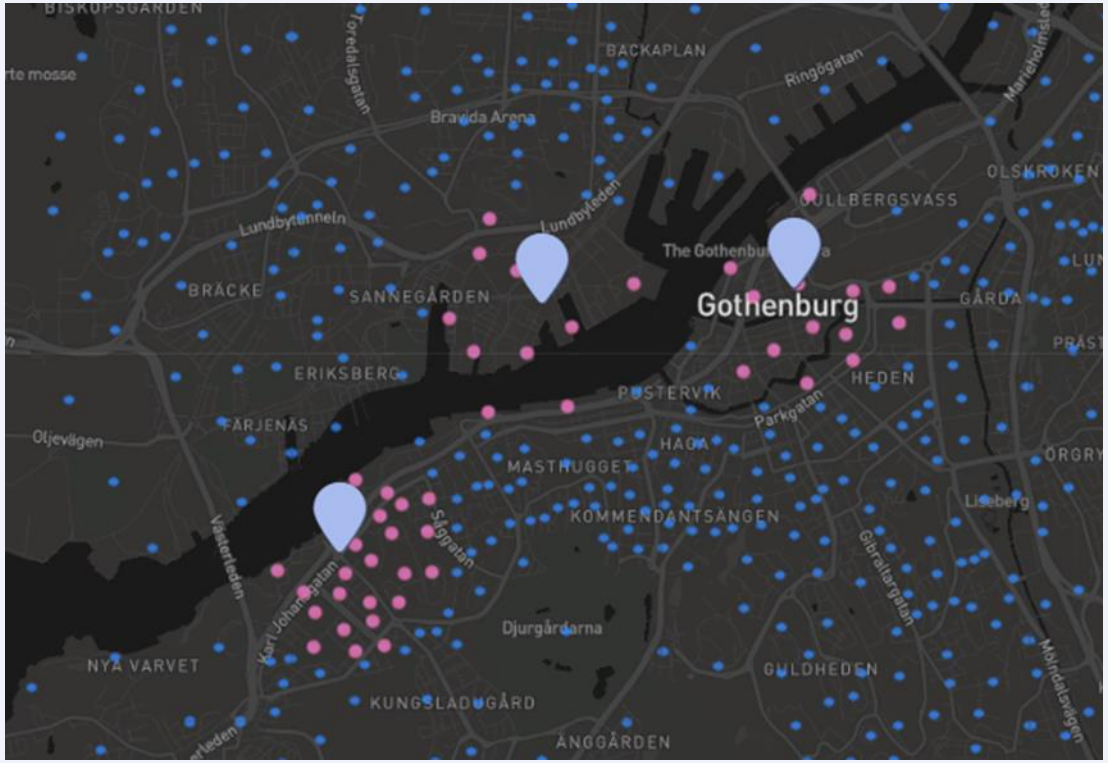


Shared mode scenarios

Scenario 3: Shared bikes available at MOVE21 hub locations

Only for zones within a 800 meter radius of the MOVE21 hublocations Nordstan (image left), Lindholmen and Kippan shared bikes are available as travel mode for originating trips (image right). All zones in the entire Digital Twin can be reached as destination with these modes.





Shared mode scenarios

Scenario 4: Shared bikes and shared scooters available at MOVE21 hub locations

In addition to scenario 3, also shared scooters can be used for originating trips from the hub location. All zones in the entire Digital Twin can be reached as destination with these modes.

Scenario 5: Shared bikes, scooters and cars available at MOVE21 hub locations.

In addition to scenario 4, also shared cars can be used for originating trips from the hub location. All zones in the entire Digital Twin can be reached as destination with these modes.

Scenario 6: Combination of scenario 2 (Styr & Ställ) and 5 (MOVE21 hubs).

In addition to scenario 5, also zones corresponding to the Styr & Ställ service area can be used for originating trips with shared bikes. Shared scooters and shared cars can only be used originating from the MOVE21 hub locations. All zones in the entire Digital Twin can be reached as destination with these modes.

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

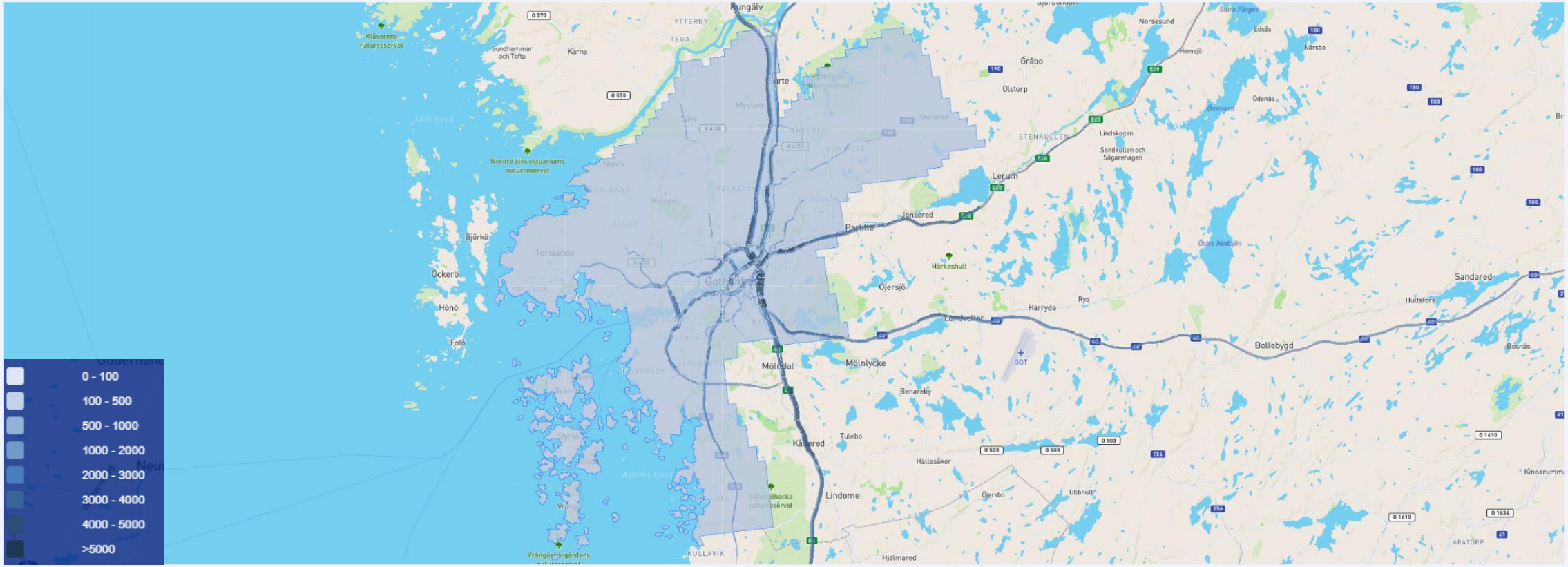
- Preprocessed traffic model data and outcomes (roads, OD-pairs and intensities);
- Population distribution data per zone to improve accuracy of mode choice simulation;
- Population data (#inhabitants) per building to further differentiate noise and air indicators;
- Distribution of vehicles and associated 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

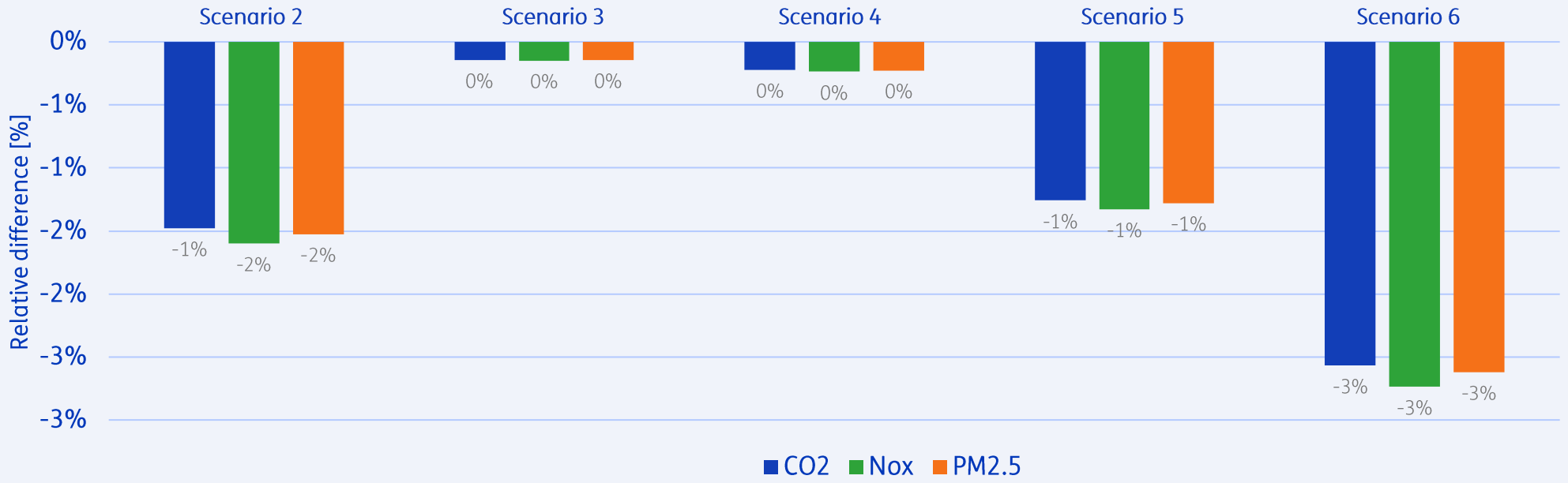
Traffic assignment results based on origin and destination matrices and network as provided by the city.



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.



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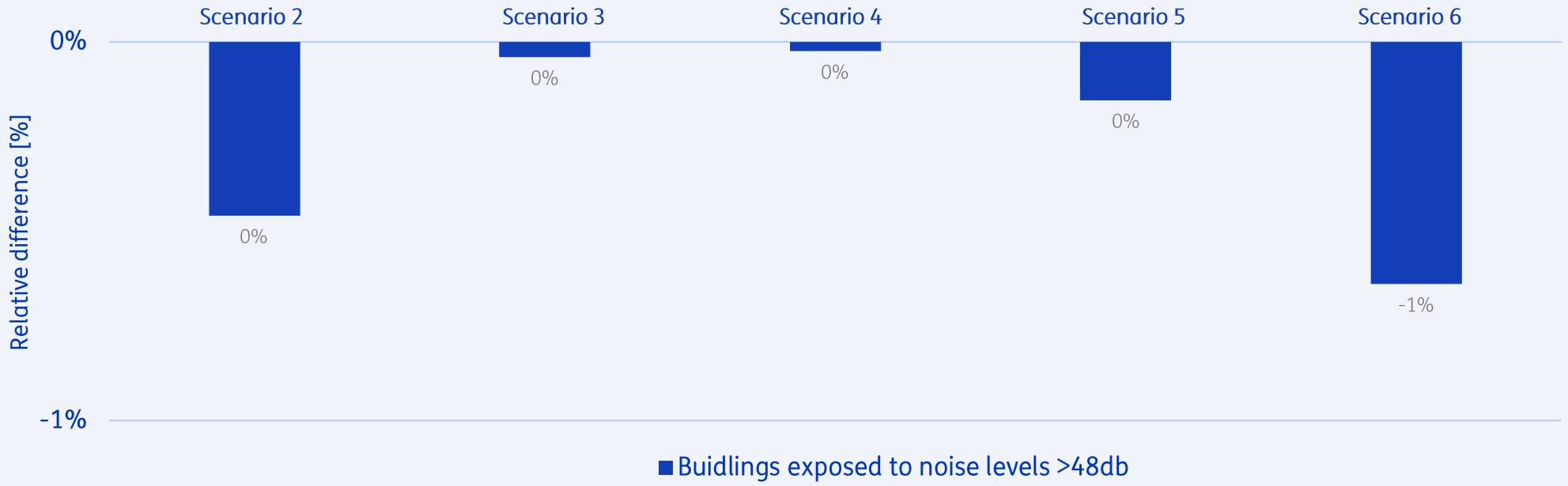
Scenario 4: Shared bikes and shared scooters available at MOVE21 hub locations
Scenario 5: Shared bikes, scooters and cars available at MOVE21 hub locations.
Scenario 6: Combination of scenario 2 (Styr & Ställ) and 5 (MOVE21 hubs).

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.



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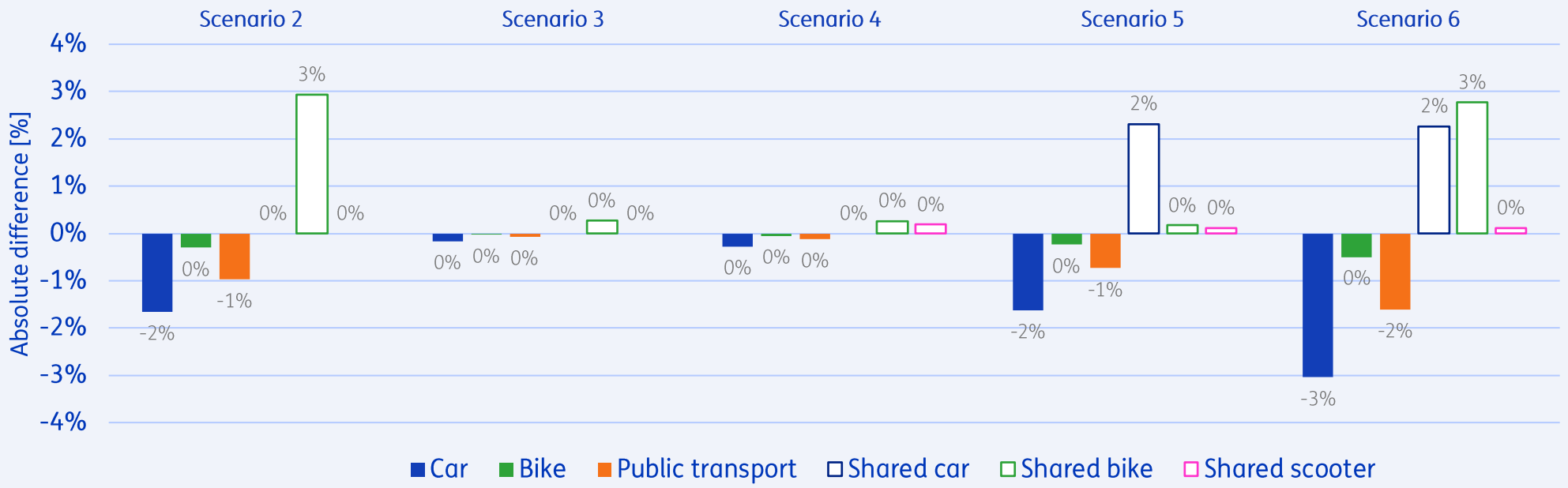
Scenario 6: Combination of scenario 2 (Styr & Ställ) and 5 (MOVE21 hubs).

Results: Modal split

Absolute difference of modal split per scenario compared to scenario 1



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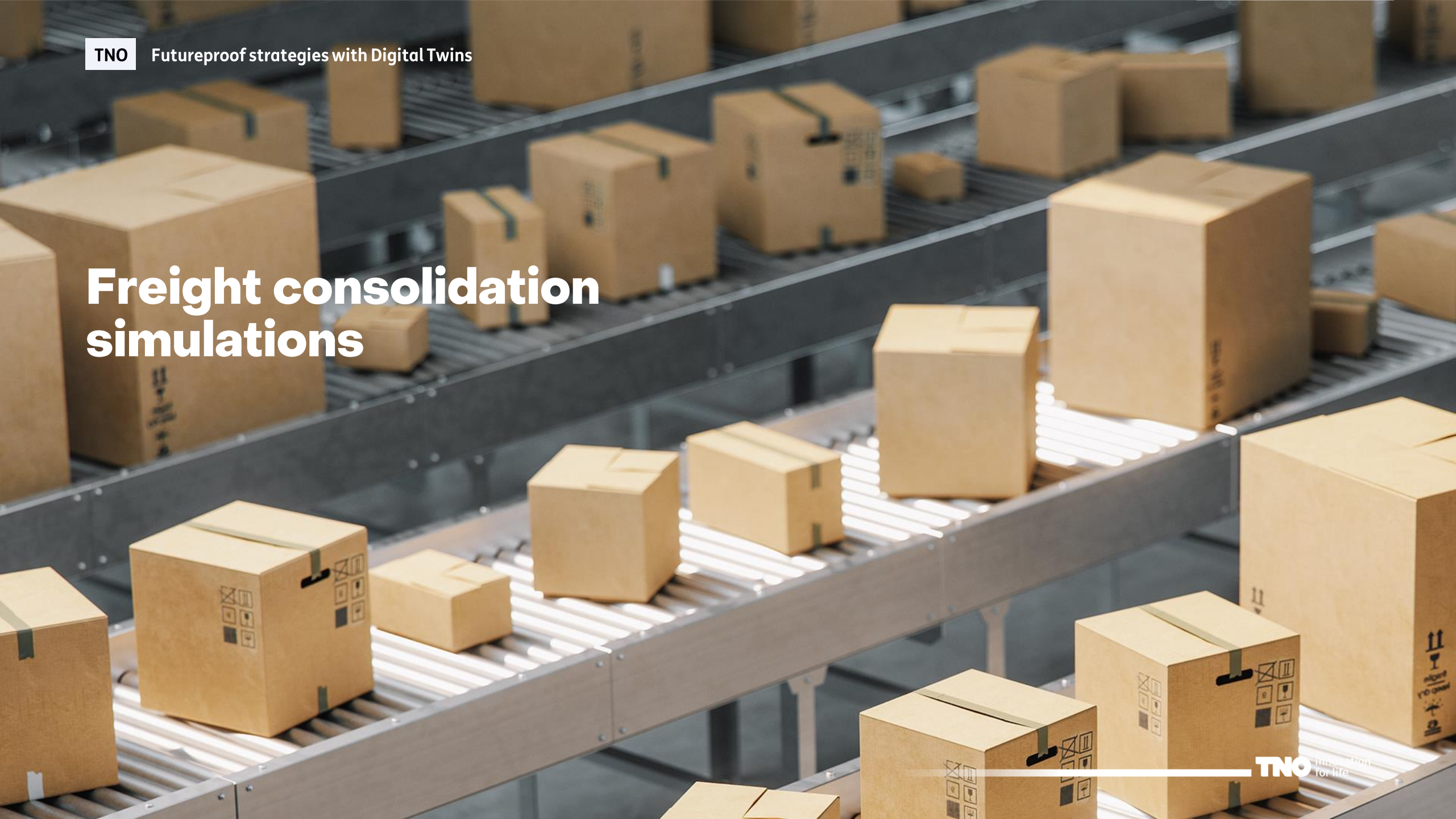
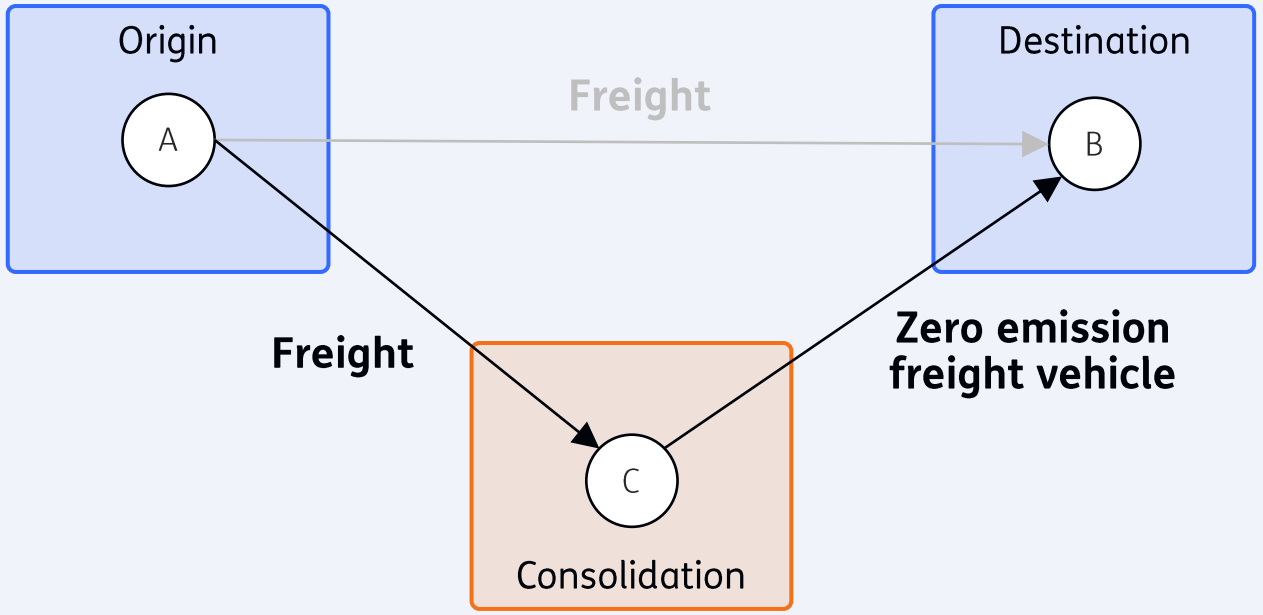
Freight consolidation simulations



Consolidating freight in Urban Strategy



Model parameters

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

Freight consolidation scenarios

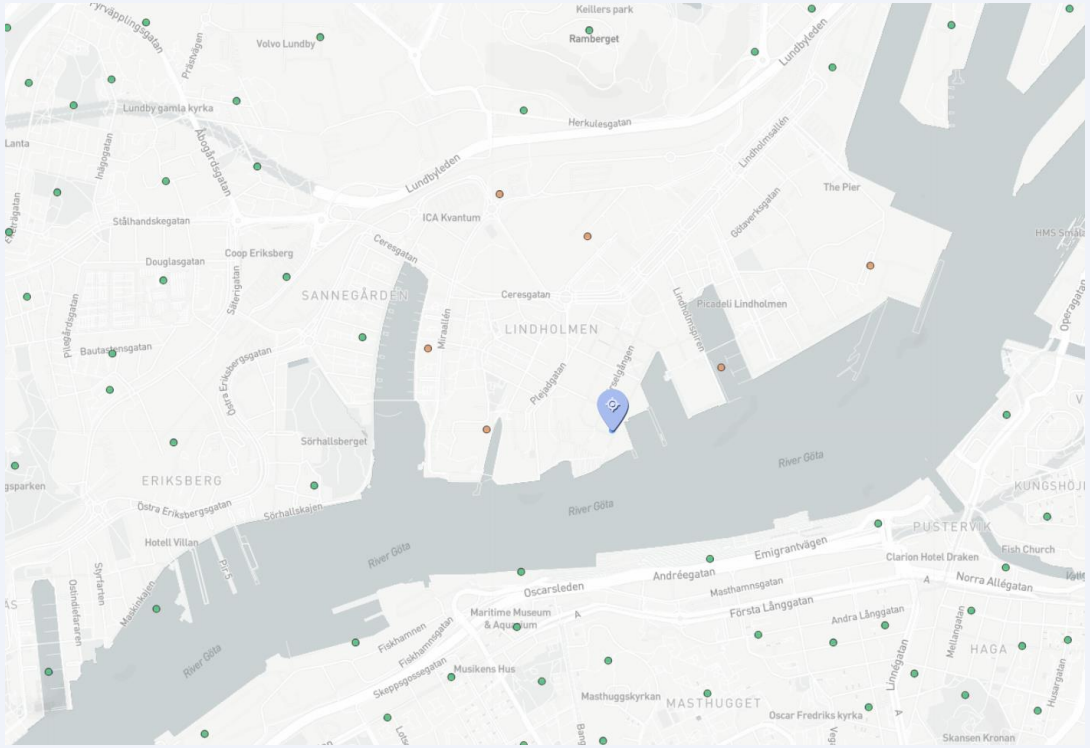
Overview of scenarios

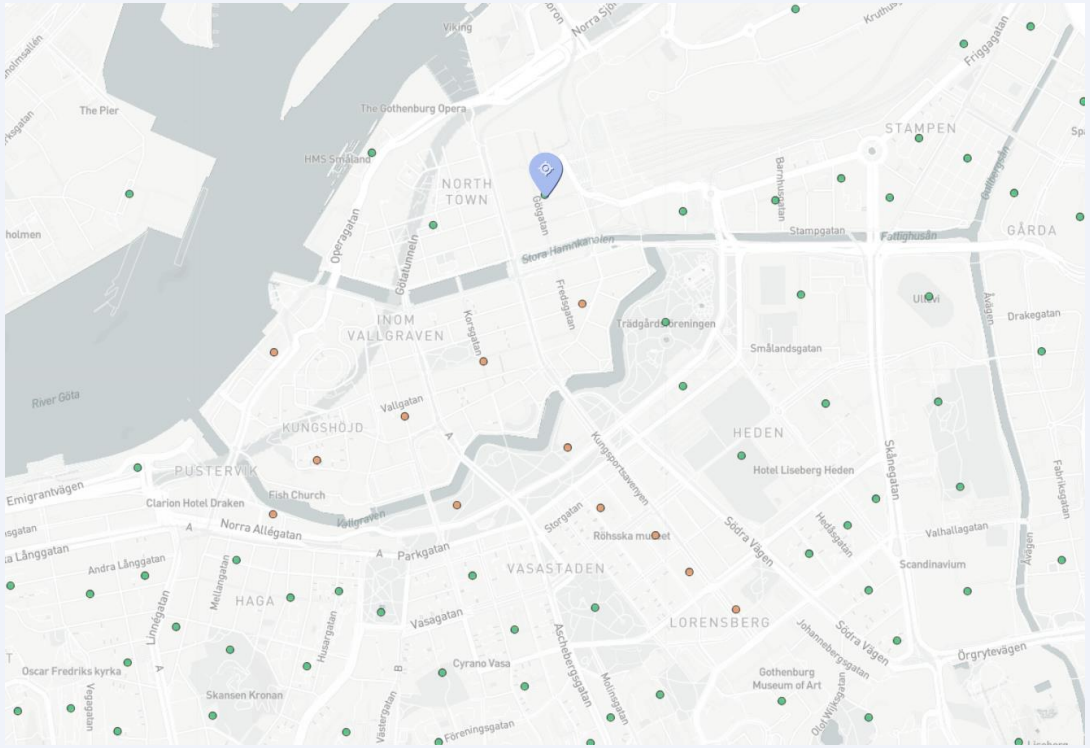
1. No consolidation hub
2. Consolidation centre Lindholmen
3. Consolidation centre Mall North Town
4. Both consolidation centres active
5. Both consolidation centres active and limited access to Inom Vallgraven for freight

Freight consolidation scenarios

Overview of hub locations

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 at Lindholmen (image left) and Mall North Town (image right).

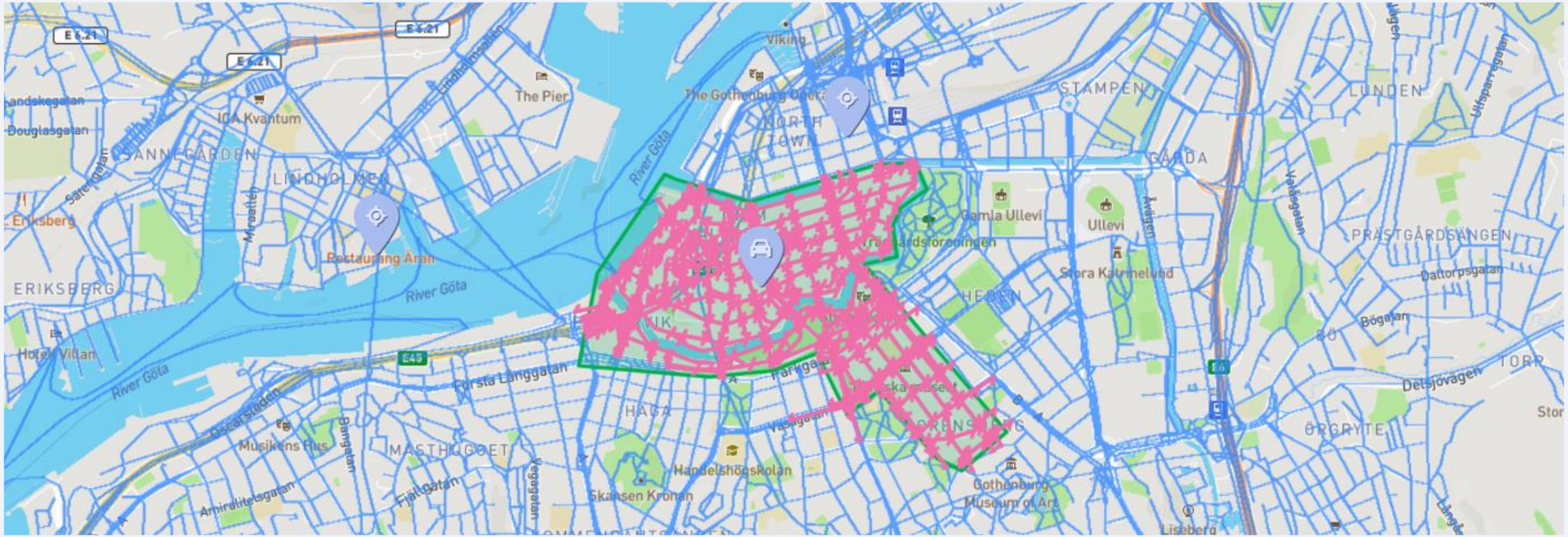




Freight consolidation scenarios

Limited access of freight vehicles

In addition to the consolidation centre scenarios, roads within the Inom Vallgraven area 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.



Reference scenario

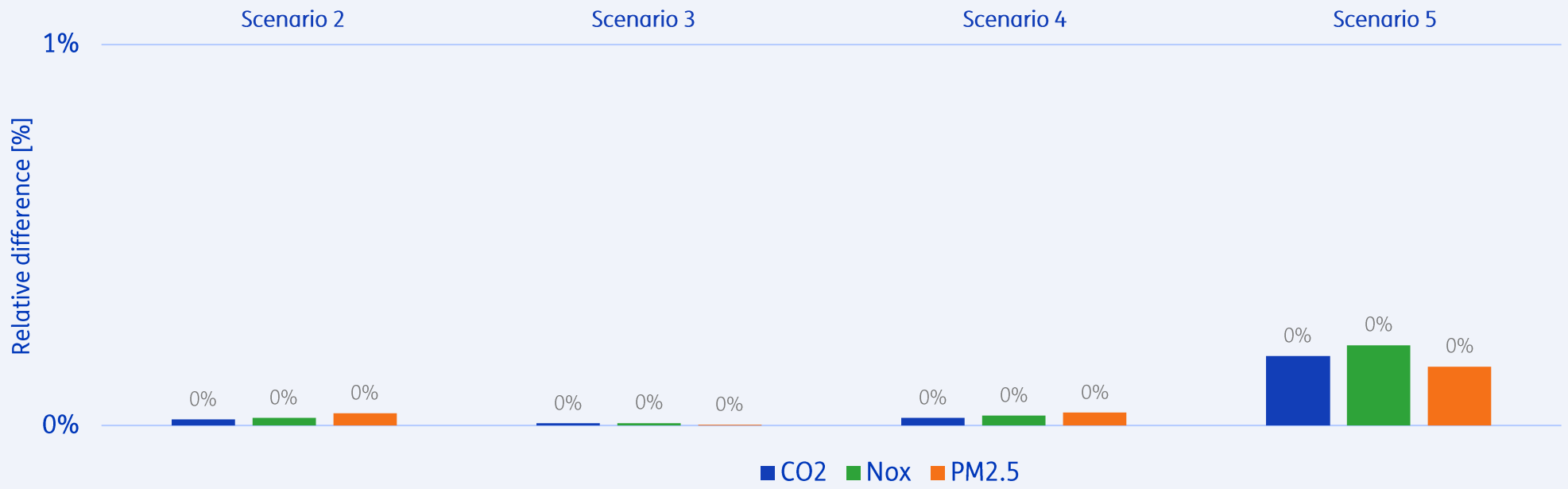
Traffic intensities: Freight

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.



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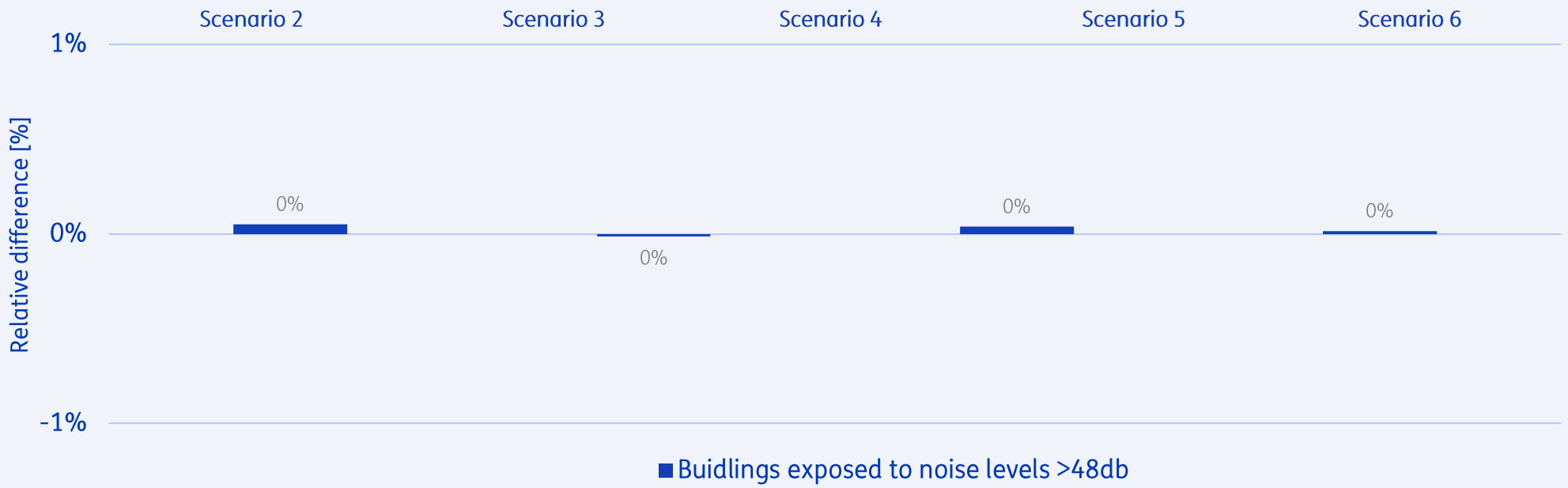
Scenario 2: Consolidation centre Lindholmen
Scenario 3: Consolidation centre Mall North Town
Scenario 4: Both consolidation centres active
Scenario 5: Both consolidation centres active and limited access to Inom Vallgraven for freight

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.



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