PTV GROUP

the mind of movement

SPECIFICATION OF A STRATEGIC TRANSPORT MODEL FOR THE CITY OF GÖTEBORG – PART II

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CONTENT

1. Demand segmentation
2. PrT Network
3. Link Types and v/d curves
4. Demand Model
5. Congestion Charging
6. Future Year Scenarios

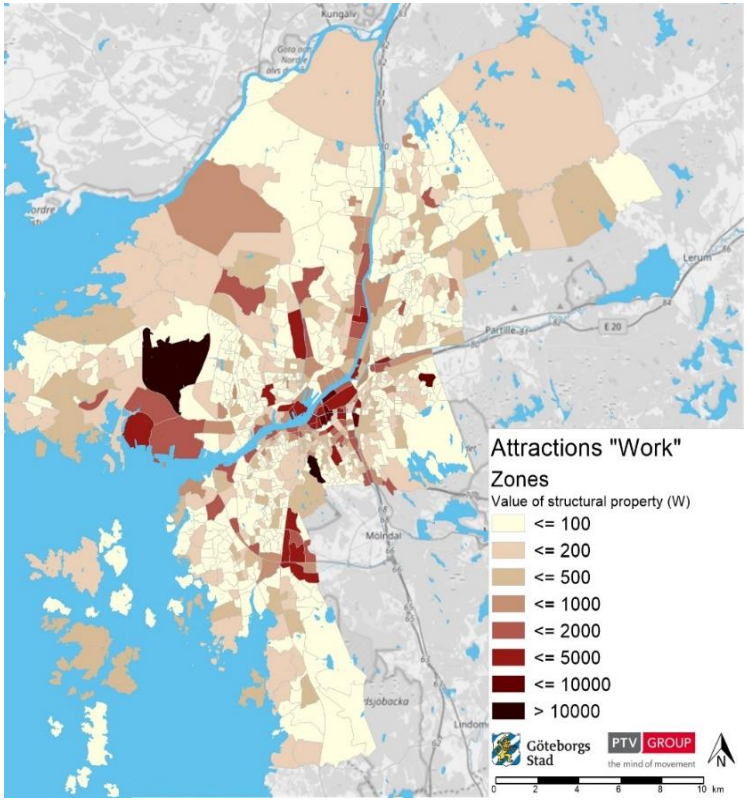
1. DEMAND SEGMENTATION

Definition

- Modelling area :
  - Göteborg (detailed) + 18 municipalities
  - Divided in more than 1,000 zones
  - 1 M inhabitants between 11 and 84 years
  - 2.7 million daily trips

- Demand segmentation is essential for modelling :
  - **who** travels **when** from **where** to **where** with **what mode** for **what purpose** ?

- Main data source : hhsurvey

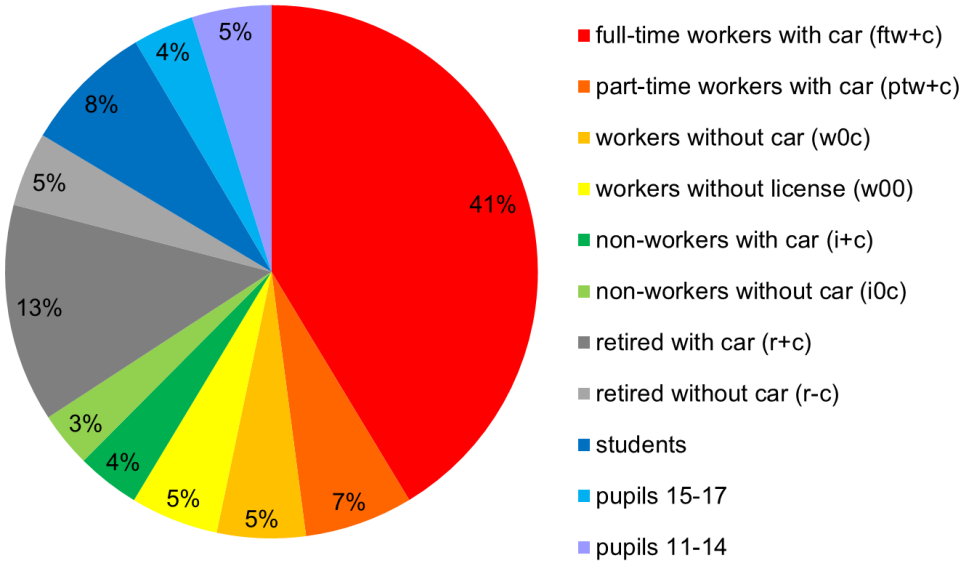


- For models to be useful
  - Simplifying assumptions must be made
  - Boundary conditions or initial conditions must be identified
  - The range of applicability of the model must be defined

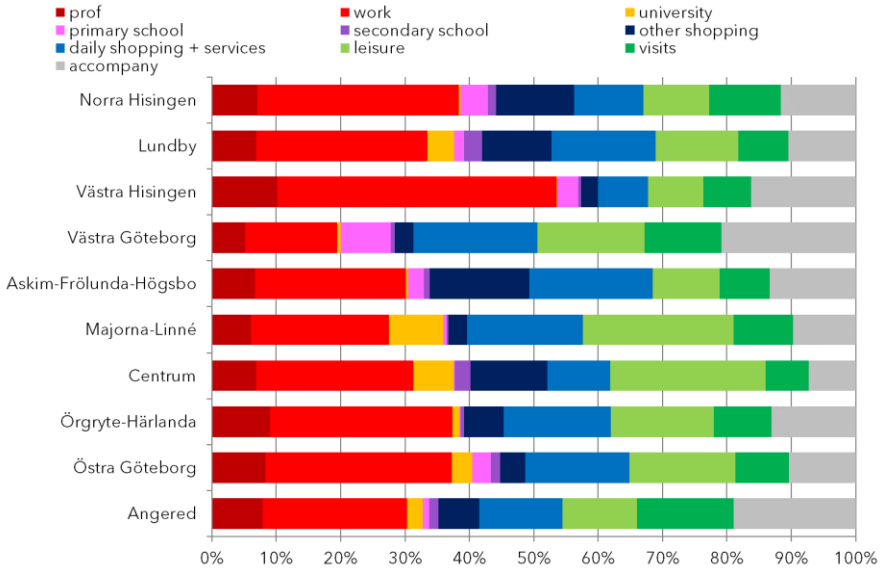
1. DEMAND SEGMENTATION

Demand segmentation

- Person Groups (who?)
  - 6 main groups
  - Further split by car availability



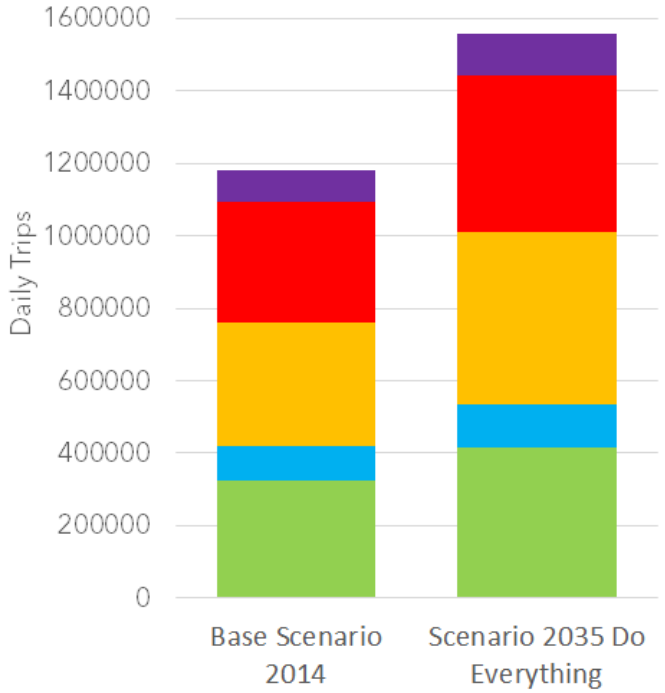
- Trip Purposes and trip chains
  - 11 trip purposes
  - 175 different trip chains
  - Each trip purpose needs attraction potentials



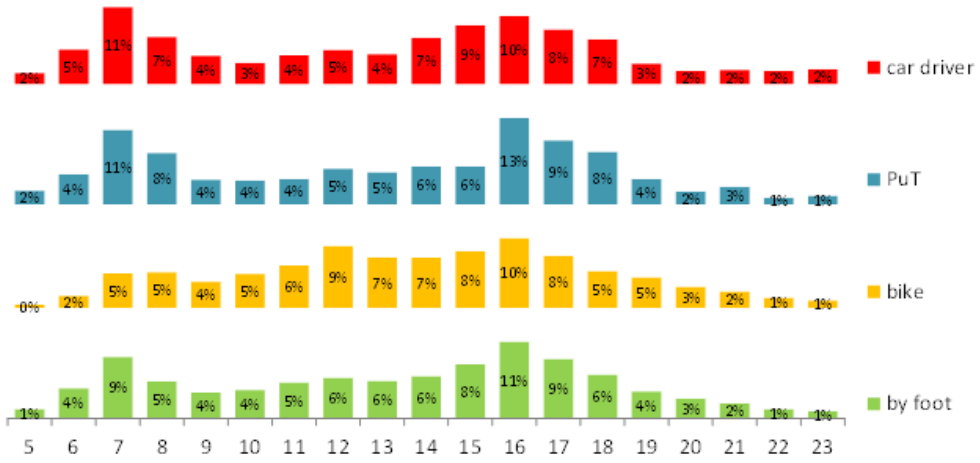
1. DEMAND SEGMENTATION

Demand segmentation

- Modes
  - Foot
  - Bike
  - Public Transport
  - Car driver
  - Car passenger



- Peak hours (when?)
  - Morning peak (7-8)
  - Evening peak (4-5)
  - Day (24h)



1. DEMAND SEGMENTATION

	nb of chains		nb of trips	
2 trips	3289	68%	5981	49%
3 trips	762	16%	2286	19%
4 trips	387	8%	1548	13%
5 trips	186	4%	930	8%
6 trips	86	2%	516	4%
7+ trips	114	2%	942	8%
total	4824		12203	

Trip chains

- Advantages
  - Trip chains provide a more realistic picture of travel patterns
    - Roughly one third of trip chains have more than one out-of-home activity (for example Home – Work – Shopping – Home)
  - Integrated modelling of non-home-based trips

- Method
  - The number of different trip chains found in the hhsurvey is very high (roughly 800), but most of them are statistically insignificant, for example Home-Accompany-Work-Shopping-Work-Home ➔ merging process
  - In the model, for each couple of group and trip chain a frequency is provided

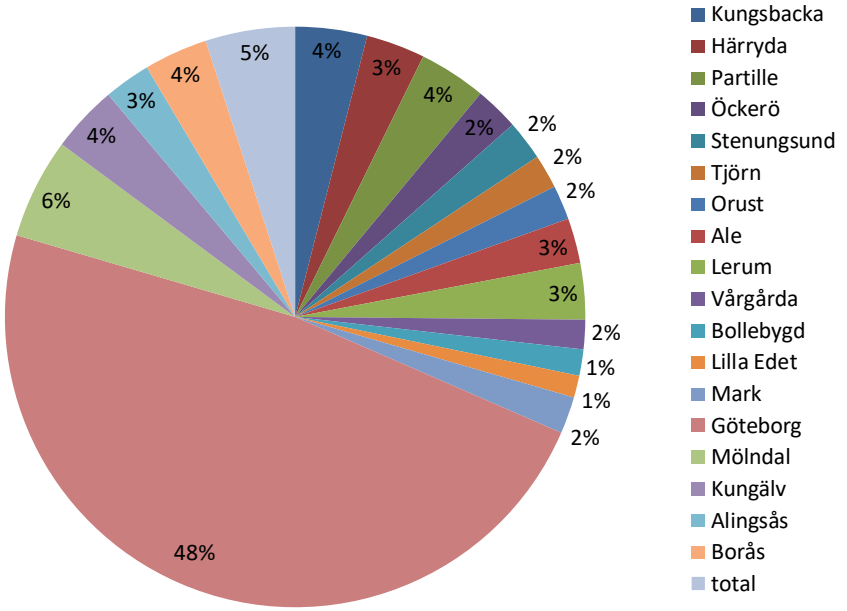
- Example : full-time workers with car availability (140 different trip chains)
  - 27% probability to carry out Home – Work – Home
  - 15% probability to carry out Home – Leisure – Home
  - …
  - 0,1% probability to carry out Home-Accompany-Work-Shopping-Work-Home

1. DEMAND SEGMENTATION

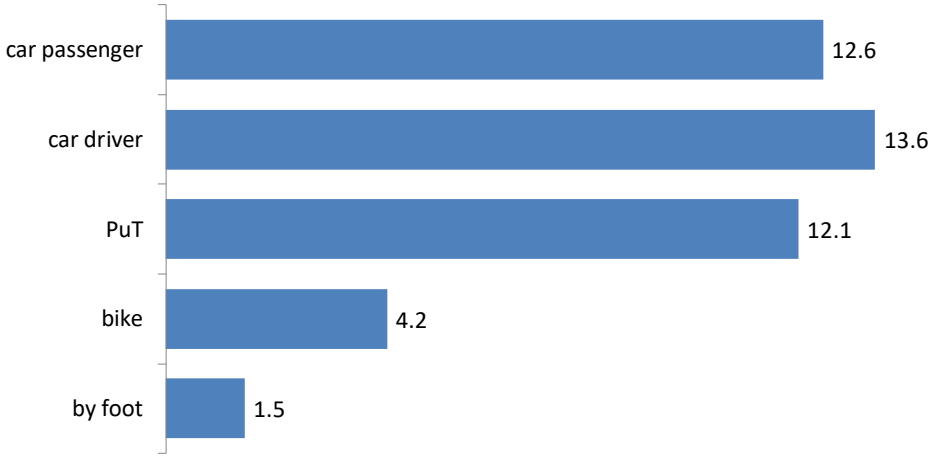
Model calibration

- Trip generation
  - Number of trips per person group and per purpose
- Trip distribution
  - Mean trip lengths, per person group, per purpose and per mode
  - OD-matrices (several scales o resolution)
- Mode choice
  - Shares for each mode
  - O-D matrices for each mode

Trip distribution (municipality)



Mean distance [km] per mode

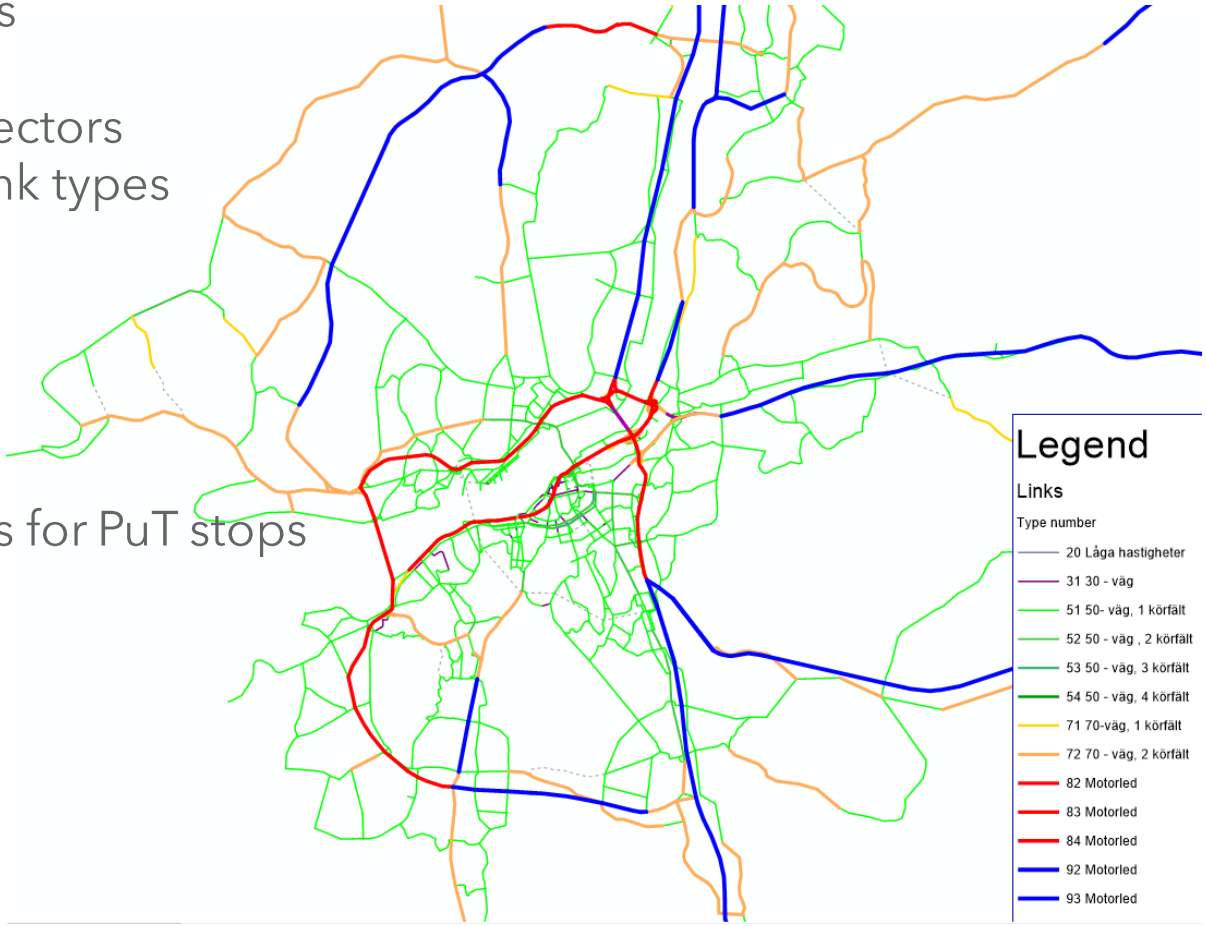


2. PRT NETWORK

PrT Network of previous models

- Previous models offered less details than multimodal model
  - 2800 – 4000 links
  - 1000 – 1500 nodes
  - 1070 zones
  - 2400 – 2800 connectors
  - 10 – 40 different link types
  - 2 v/d functions

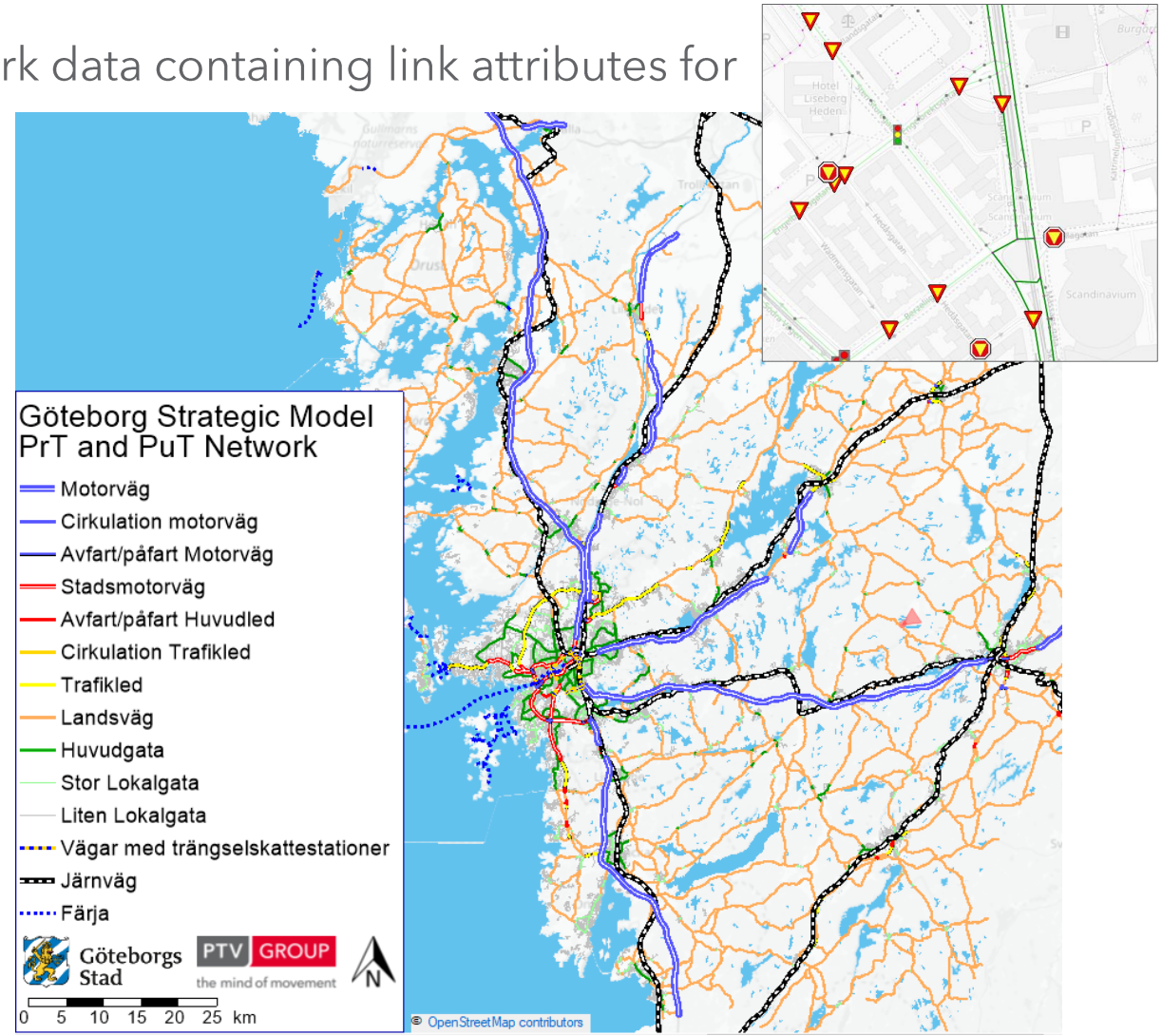
- Not detailed enough
  - Not enough nodes for PuT stops



2. PRT NETWORK

Current PrT Network

- Import from HERE network data containing link attributes for
  - v0
  - No of lanes
  - Transport Systems
  - Turn Movements
  - Node heights
  - Road Categories
- To be thinned out
  - Forest Lanes
  - Rural roads
- Remaining network
  - 235,000 links
  - 100,000 nodes
  - 105 link types
  - 18 v/d functions
  - 11 node types

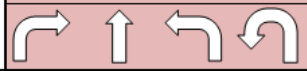


2. PRT NETWORK

Current PrT Network - Nodes

- Control types for nodes implemented
  - Used for turn penalties
  - Major junctions represented by Main Nodes

Legend:	
P	Priority Road
S	Secondary Road
r	right turn
s	straight ahead
l	left turn
u	u-turn

		S->S				S->P				P->S				P->P			
		1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
																	
Node Type	Description	r	s	l	u	r	s	l	u	r	s	l	u	r	s	l	u
0	Unknown	10	7	20	45	15	7	20	45	10	5	15	45	10	5	15	45
5	Intermediate node	0	0	0	45	0	0	0	45	0	0	0	45	0	0	0	45
10	Signalized junction	5	15	20	45	5	10	15	45	5	10	15	45	5	5	5	45
11	Signalized junction with PuT priority	15	35	45	45	15	25	35	45	15	25	35	45	15	15	15	45
20	Give Way/Yield	10	20	25	45	20	20	25	45	10	15	20	45	0	0	0	45
30	Stop	12	22	27	45	22	22	27	45	12	17	22	45	0	0	0	45
40	Roundabout	15	15	15	45	10	10	10	45	5	5	5	45	0	0	0	45
41	Roundabout with PuT priority	20	20	20	45	20	20	20	45	20	20	20	45	10	10	10	45
50	Priority to the right	10	10	10	45	10	10	10	45	10	10	10	45	10	10	10	45
51	Motorway entry	5	5	5	45	5	5	5	45	5	5	5	45	5	5	5	45
52	Motorway exit	0	0	0	45	0	0	0	45	0	0	0	45	0	0	0	45
60	Main Node Signalized junction	5	17	25	45	5	12	20	45	5	12	20	45	5	7	10	45
61	Main Node Signalized junction with PuT priority	15	37	50	45	15	27	40	45	15	27	40	45	15	17	20	45
70	Main Node Give way	10	20	25	45	20	20	25	45	10	15	20	45	0	0	0	45
80	Main Node Stop	12	22	27	45	22	22	27	45	12	17	22	45	0	0	0	45
90	Main Node Roundabout	15	15	15	45	10	10	10	45	5	5	5	45	0	0	0	45
91	Main Node Roundabout with PuT priority	20	20	20	45	20	20	20	45	20	20	20	45	10	10	10	45

3. LINK TYPES AND V/D CURVES

Link Types

- Developed using HERE road classification attributes, SAMPERS types as orientation
- 9 Main groups, further split by speed limits, number of lanes, ramps, rbt…
  - Motorväg (link types 1-9)
  - Stadsmotorväg (link types 10-19)
  - Trafikled (link types 20-29)
  - Landsväg (link types 30-39)
  - Huvudgata (link types 40-49)
  - Stor Lokalgata (link types 50-59)
  - Liten Lokalgata (link types 60-69)
  - Links of the Göteborg Congestion Charge System (75-87, 101-127)
  - Public Transport Links (90-98)

- Link Types for Congestion Charge System
  - Links for 2014 CC System: closed for Car/Truck not paying CC
  - Backa Exemption: no CC for traffic into and out of Backa, through-traffic pays CC
    - CC Stations East of Backa at E6N interchanges: open only for Backa traffic
    - CC Control Stations West of Backa: open only for Backa traffic

3. LINK TYPES AND V/D CURVES

V/D curves

- 18 v/d curves based on SAMPERS model, but modified to fit needs
- From SAMPERS:
  - Saturation flow
  - vCur values depending on flow
  - 4 or 5 values to define curve

							Brytpunkt 0		Brytpunkt 1		Brytpunkt 2		Brytpunkt 3		Brytpunkt 4		Brytpunkt 5	
Löpnummer		Vägfunktion	Vägmiljö	Hastighet	Körfält	Körfält/riktnin	Flöde	Km/h	Flöde	Km/h	Flöde	Km/h	Flöde	Km/h	Flöde	Km/h	Flöde	Km/h
0							0	0	0	0	0	0	0	0	0	0	0	0
1	Tätort	GIF	Ytter	70	2	1	0	71	400	71	800	62	1100	53	1500	42	1800	10
2	Tätort	GIF	Ytter	60	2	1	0	61.5	400	61.5	750	55	1000	48	1400	40	1680	10
3	Tätort	GIF	Ytter	50	2	1	0	52	400	52	700	48	950	44	1300	39	1560	10
4	Tätort	GIF	Mellan	70	2	1	0	67	400	67	700	58	950	49	1300	39	1560	10
5	Tätort	GIF	Mellan	60	2	1	0	57.5	400	57.5	650	51.5	850	45	1200	38	1440	10
6	Tätort	GIF	Mellan	50	2	1	0	48	400	48	600	45	800	41.5	1100	37	1320	10
7	Tätort	GIF	Mellan	40	2	1	0	42	400	42	600	39	800	36	1100	33	1320	10
8	Tätort	GIF	Centrum	50	2	1	0	48	400	48	600	45	800	41.5	1100	37	1320	10
9	Tätort	GIF	Centrum	40	2	1	0	42	400	42	600	39	800	36	1100	33	1320	10
10	Tätort	Tangent	Ytter	70	2	1	0	69	400	69	750	59	1000	49	1400	39	1680	10
11	Tätort	Tangent	Ytter	60	2	1	0	60	400	60	700	53	900	46	1300	38	1560	10
12	Tätort	Tangent	Ytter	50	2	1	0	51	400	51	650	46.5	850	42	1200	37	1440	10
13	Tätort	Tangent	Mellan	70	2	1	0	66	350	66	600	57	850	48	1200	38	1440	10
14	Tätort	Tangent	Mellan	60	2	1	0	56.5	350	56.5	600	50.5	800	44	1100	36	1320	10
15	Tätort	Tangent	Mellan	50	2	1	0	47	350	47	550	44	700	40	1000	35	1200	10
16	Tätort	Tangent	Mellan	40	2	1	0	41	350	41	550	38	700	35	1000	31	1200	10
17	Tätort	Tangent	Centrum	50	2	1	0	44	350	44	550	41	700	37	950	33	1140	10
18	Tätort	Tangent	Centrum	40	2	1	0	39	350	39	550	36	700	33	950	30	1140	10
19	Tätort	Citygata	Mellan	50	2	1	0	43	350	43	550	40	700	37	950	33	1140	10

3. LINK TYPES AND V/D CURVES

V/D curves

- SAMPERS values served as starting point
- BPR3 for 17 out of 18 v/d curves

$$t_{cur} = t_0 \cdot \left(1 + a \cdot sat^b\right) \qquad for\ sat \leq sat_{crit}$$

$$t_{cur} = t_0 \cdot \left(1 + a \cdot sat^b\right) + (q - q_{max}) \cdot d \qquad for\ sat > sat_{crit}$$

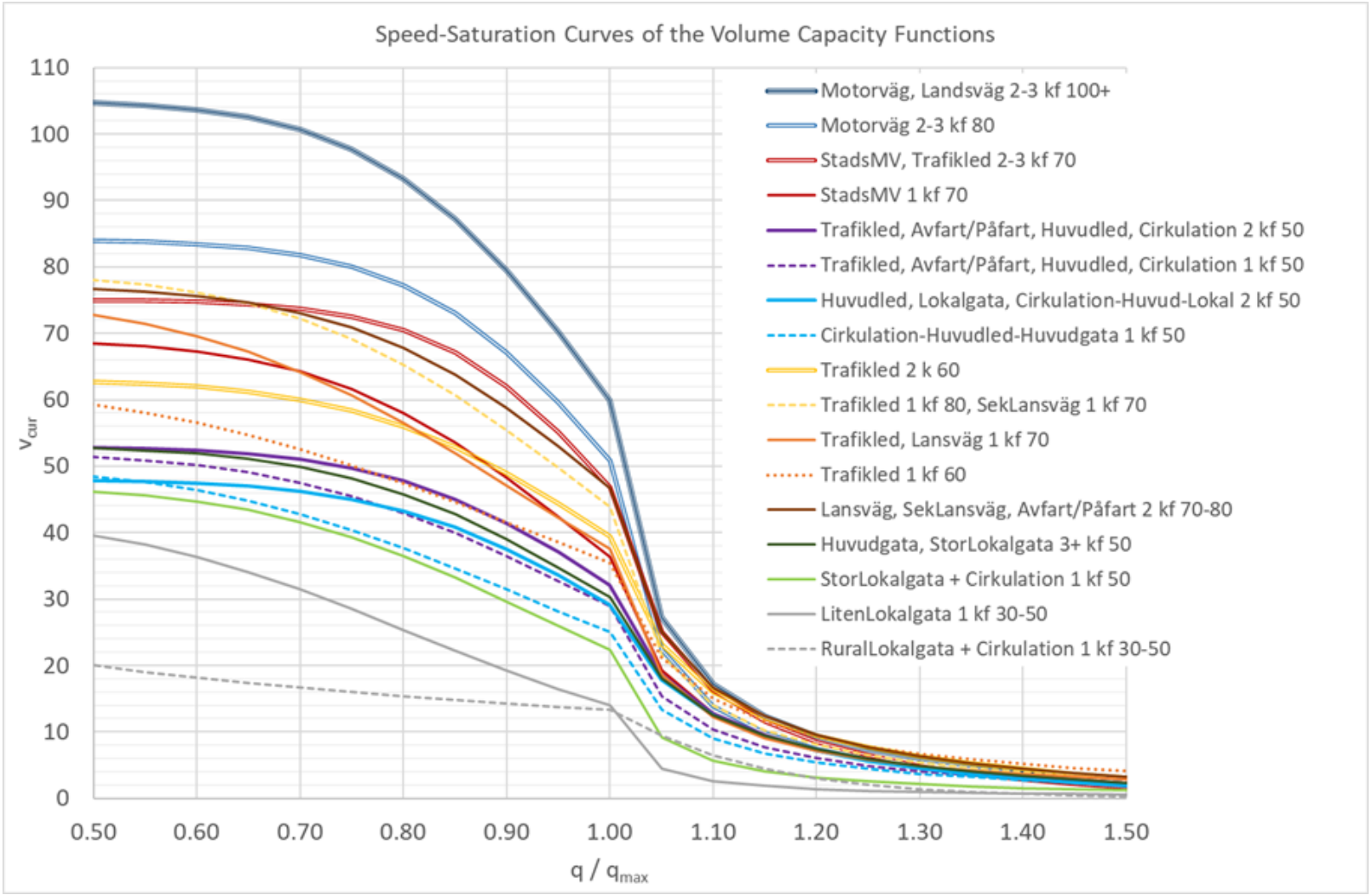
  - BPR3 identical to BPR2 below critical saturation level
  - Above critical saturation level: steeper increase of travel time

- Capacity, v0 and parameters a, b, d adapted in calibration process, as original values to lenient (to much oversaturation)

- Different v/d functions depending on main link type and number of lanes

3. LINK TYPES AND V/D CURVES

V/D curves

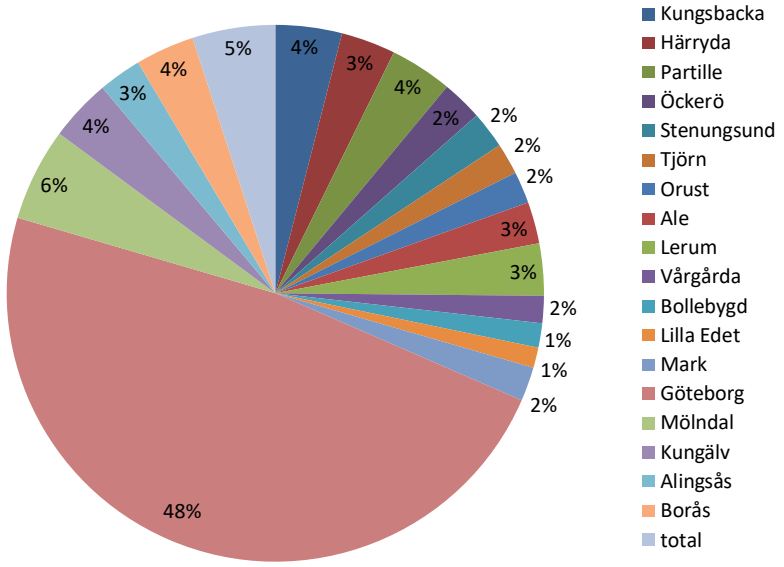


4. DEMAND MODEL

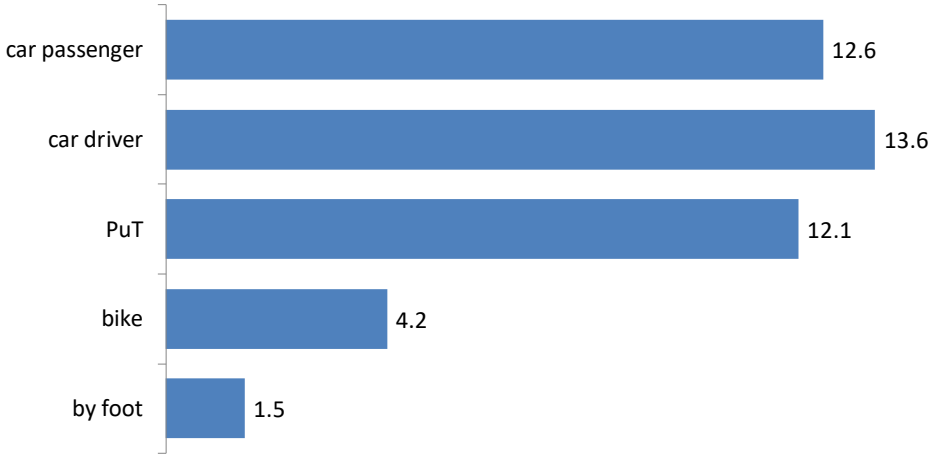
Model calibration

- Trip generation
  - "Generation rates"
  - Number of trips per person group and per purpose
- Trip distribution
  - "Impedance functions"
  - Mean trip lengths, per person group, per purpose and per mode
  - OD-matrices (several scales of resolution)
- Mode choice
  - "Utility functions"
  - Shares for each mode
  - O-D matrices for each mode

Trip distribution (municipality)



Mean distance [km] per mode



4. DEMAND MODEL

Logsum

- Destination and mode choice is realised by a nested logit approach. The general cost function for destination choice is a logsum function of the utilities of the modelled modes.

$$D_{ij} = E_i \cdot \frac{A_j * e^{-\alpha * w_{ij} + \gamma * d_{ij}}}{\sum_k A_k * e^{-\alpha * w_{ik} + \gamma * d_{ik}}} \qquad w_{ij} = \log\left\{\sum_m e^{U_{i,j,m}}\right\}$$

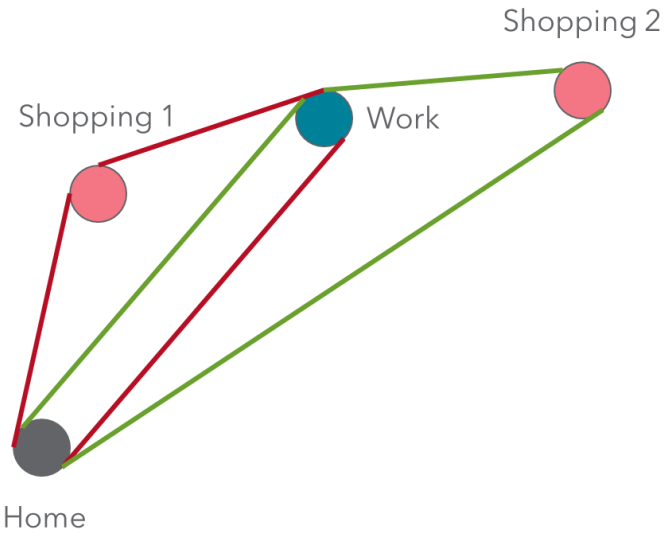
- Logsum approach :
  - directly available in PTV Visum
  - $U_{i,j,m}$ = utility of mode m for the relation i,j
  - distribution and mode choice are simultaneous steps (in a classical four steps model, distribution and mode choice are sequential steps).

- The use of an invariant distance term (γ * d) is a calibration tool :
  - define the right level of sensitivity to distance
  - Balance distribution and mode choice effects

4. DEMAND MODEL

Rubberbanding

- Better destination choice modelling for secondary activities (eg shopping), carried out before or after a primary activity (eg work)
- Without rubberbanding destination choice of shopping is only a function of distance from activity Work: Shop 1 and shop 2 have the same attraction
- In Real life, shop 1 is far more attractive, since it is roughly in between home and work
- Three variables must be defined
  - Hierarchy of purposes
  - Trip chains to be rubberbanded
  - Weights (defining the elasticity of the rubberband)



4. DEMAND MODEL

Parking restrictions

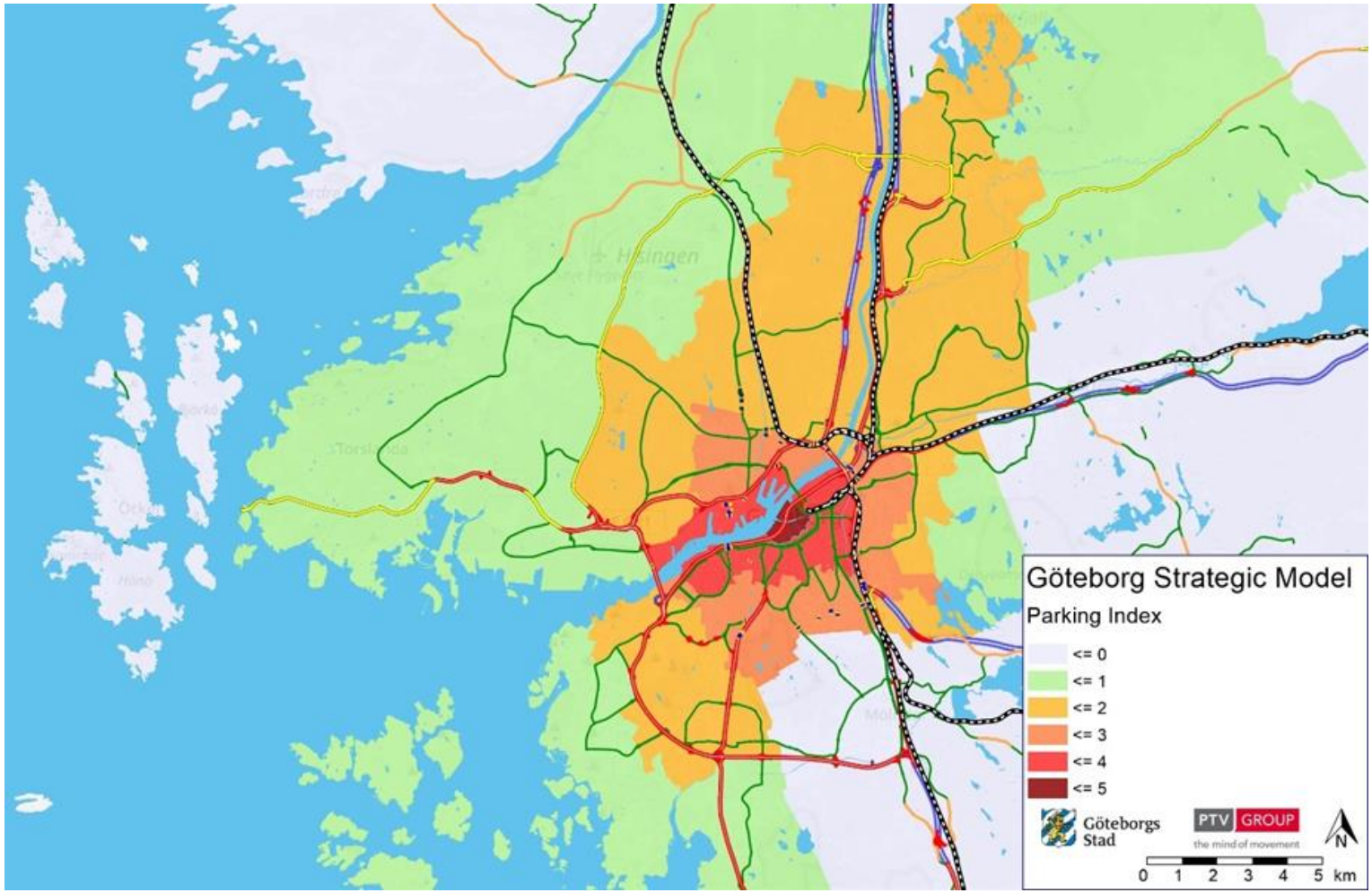
- In an urban context, parking restrictions have a very high impact on distribution and mode choice
  - Price
  - Limited availability of public parking lots / resident parking

- Modelling of parking restrictions is not straight forward
  - No standard procedure – also due to often inconsistent availability of data
  - Price is (more or less) proportional to parking time (distribution of parking depends on purposes and lots of other criteria)
  - Availability of parking lots differ for different people (residents, workers, clients of shops…)

- Methodology
  - A penalty is introduced to make trips into the zone of restrictions less attractive
  - Penalty is ranging from 0 to 5 (see map next page)
  - Parking restrictions outside Core Model Area are not explicitly modelled
  - The penalty of a car trip to the highly restricted zone equals up to 35 minutes of travel time (calibration result)

4. DEMAND MODEL

Parking restrictions



4. DEMAND MODEL

Public Transport

- Transport system "Public Transport" consists of 4 different modes : bus, tram, rail, ferry (base scenario)

- These modes serve different purposes and different distances :
  - Bus, Tram, Ferry: Urban traffic & Suburban traffic
  - Rail: Suburban traffic & Regional traffic

- We distinguish between road traffic (bus) and railbound traffic (tram and train)
  - The latter are more reliable, especially in peak hours, and more comfortable, due to longer distance between stops, less traffic related stop-and-go and absence of lateral acceleration (all other things being equal, people generally prefer tramways to busses and trains to coaches)
  - This is taken into account by means of different weighting of travel times (calibration results)

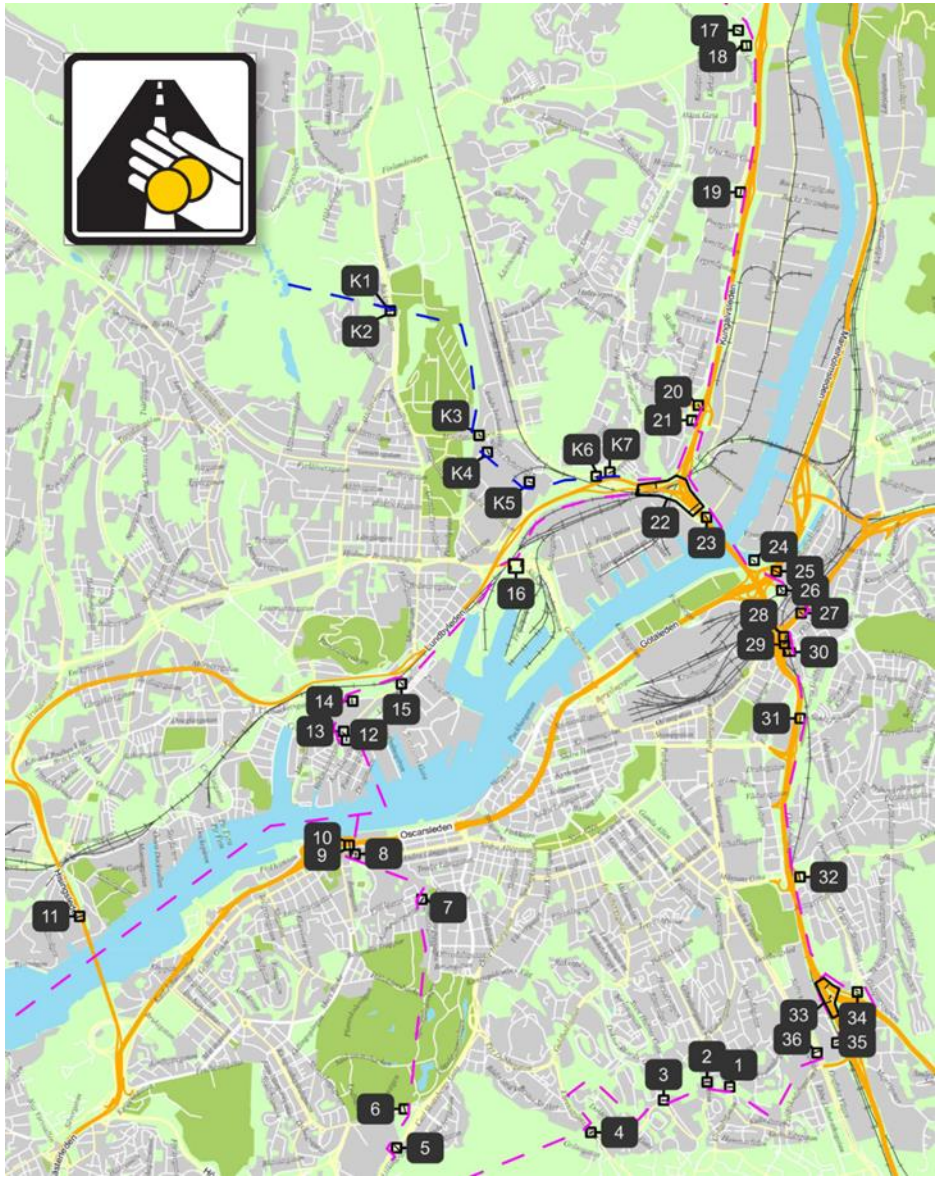
TrSys	coefficient
Bus	1,2
Tram	0,6
Train	0,8
Ferry	1,4

  - Explication : all other things being equal a 12 minutes tramway ride is as attractive than a 6 minutes bus ride

5. CONGESTION CHARGING

Key Facts

- 36 Toll Stations on strategic entry points
- From 2018 onwards, 7 control points for Backa Exemption (trips starting or ending in Backa do not pay CC)
- Single charge rule: pay only once in 60 min
- Vehicles staying inside CC zone (not crossing toll station) do not pay



5. CONGESTION CHARGING

Implementation - Approach

- CC taken into account in Demand Model and in Assignment Model

- 3 Steps to calculate CC cost for demand model:
  - Identify ODs passing CC stations → PrT Skims using link type UDAs
  - Verification of ODs passing/in/out Backa → Skim Matrix 0 (no CC) /1 (CC)
  - Application of CC Toll Value to 0/1 skim → OD Skim Matrix with CC Value for demand model

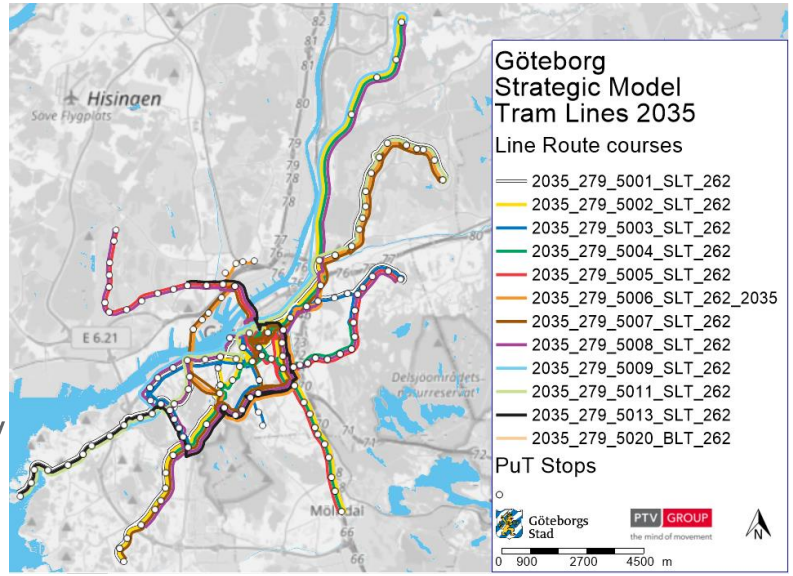
- Demand Model uses CC skim as one of the factors influencing mode choice and distribution

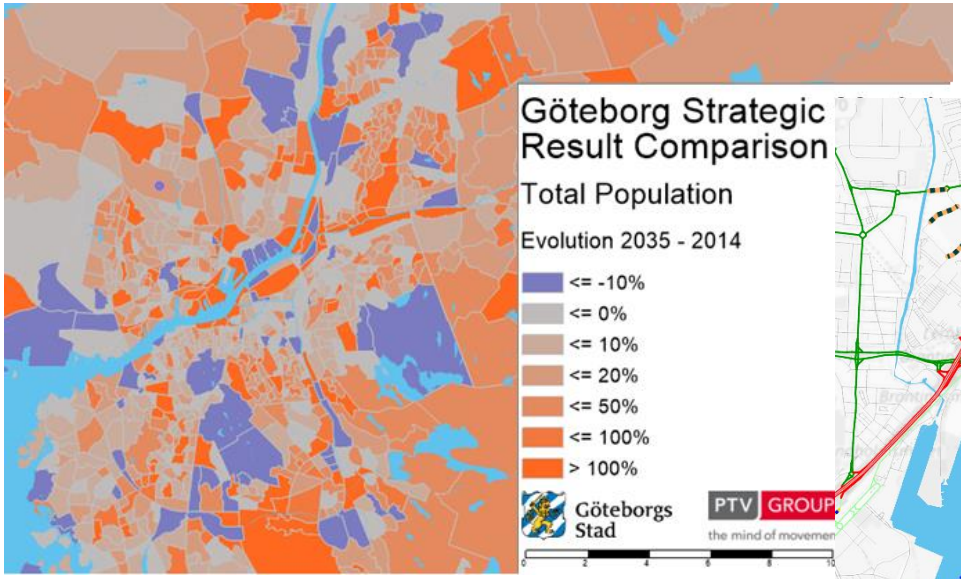
- Assignment Model
  - Calculation of threshold value between routes passing CC Toll stations and routes not passing CC Toll stations
  - Using Value of time and the threshold value in a lognormal function, the share between paying and not-paying demand for each OD is calculated
    - → Split of car demand according to share paying/not paying
  - Assignment of paying and not-paying demand segments

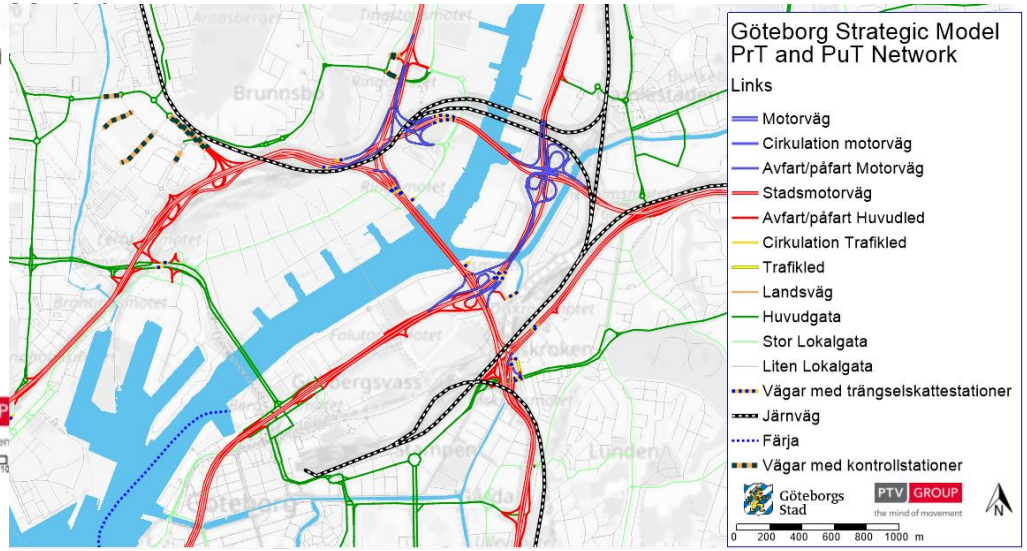
6. FUTURE YEAR SCENARIOS

Necessary elements for future year scenarios

- Socio-economics
  - Sourced by TK, implemented by PTV
- PrT projects
  - Sourced and implemented by TK
- PuT projects
  - Sourced by TK, implemented by TK and PTV







6. FUTURE YEAR SCENARIOS

Socio-Economic Data

- Based on SAMS Database also used in Sampers
  - Excel File used to update person groups based on future population
  - Characteristics taken into account:
    - Age class (per zone)
    - Employment status (per zone)
    - Car and driver licence availability (per SDEL/Municipality)

    ➔Every additional person = around 3.5 - 4 additional trips

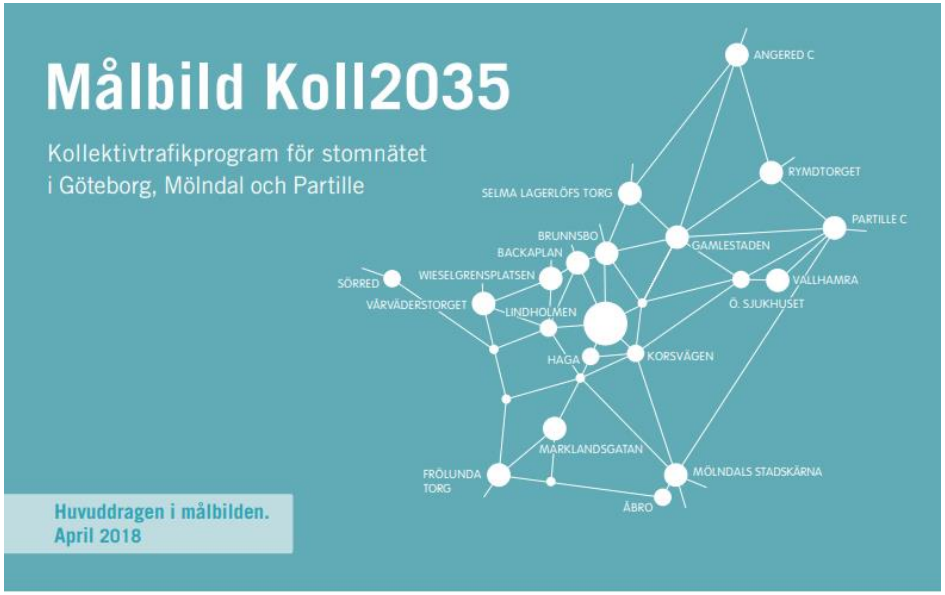
  - Workplaces 2035

  - 23% increase in population
  - 22% increase in available cars
  - 26% increase in number of workplaces

6. FUTURE YEAR SCENARIOS

Infrastructure Projects

- PrT: 12 PrT projects included
- Backa Exemption included
- PuT: projects imported from Visum model Målbild Koll 2035



Edit project

Basic settings | Scenarios | Modifications | Procedure parameter sets | Gl

Number: 26	Number	Code
13	13	PuT Offer 2035 Activation - Train
14	14	PuT Offer 2035 Activation - Ferry
15	15	PrT Project - Kallebäcksmotet
16	16	PrT Project - Sörredsmotet
17	17	PrT Project - Halvors Länk
18	18	PrT Project - Hisingsleden, södra delen
19	19	PrT Project - Eriksbergsmotet
20	20	PrT Project - Marieholmstunneln
21	21	PrT Project - Breddning E6
22	22	PrT Project - Lundbyleden
23	23	PrT Project - Sisjömotet
24	24	PrT Project - Gamlestan
25	25	PrT Project - Hisingsbron
26	26	PrT Project - Nedsänkning E45

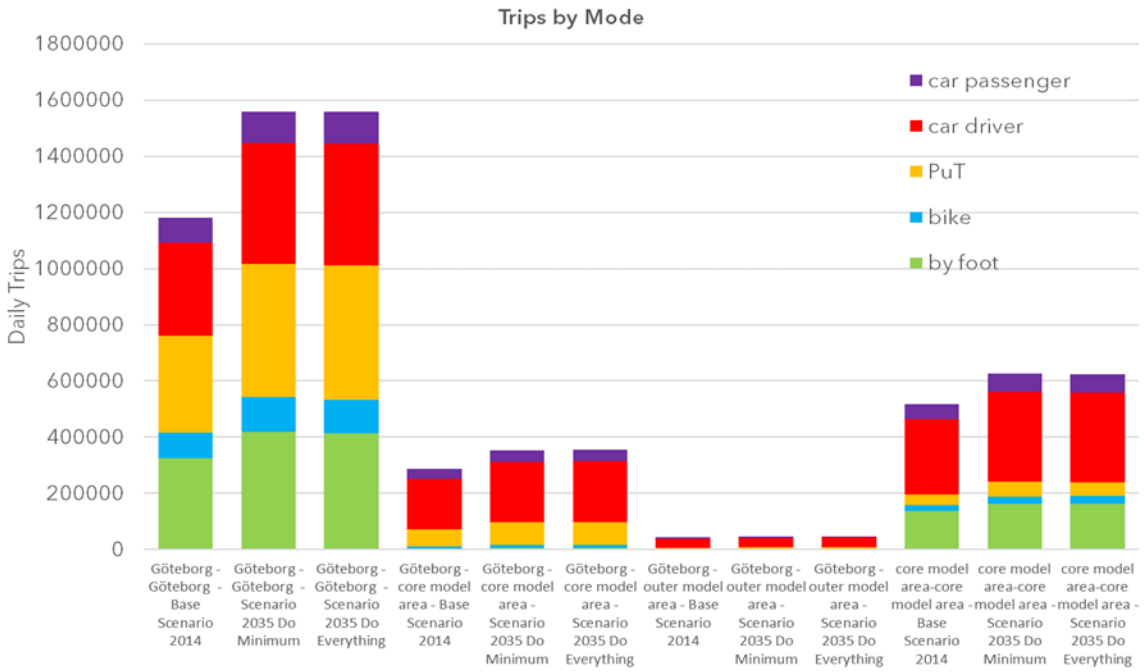
6. FUTURE YEAR SCENARIOS

Future Year Results

- Mode Share of Göteborg trips (to, from, internal)
  - 2% increase of PuT
  - Due to population increase

Scenario	by foot	bike	PuT	car driver	car passenger
Base Scenario 2014	21.7%	6.8%	27.0%	36.1%	8.5%
Scenario 2035 Minimum	21.7%	6.8%	28.8%	34.8%	8.0%
Scenario 2035 Maximum	21.4%	6.6%	29.0%	34.8%	8.2%

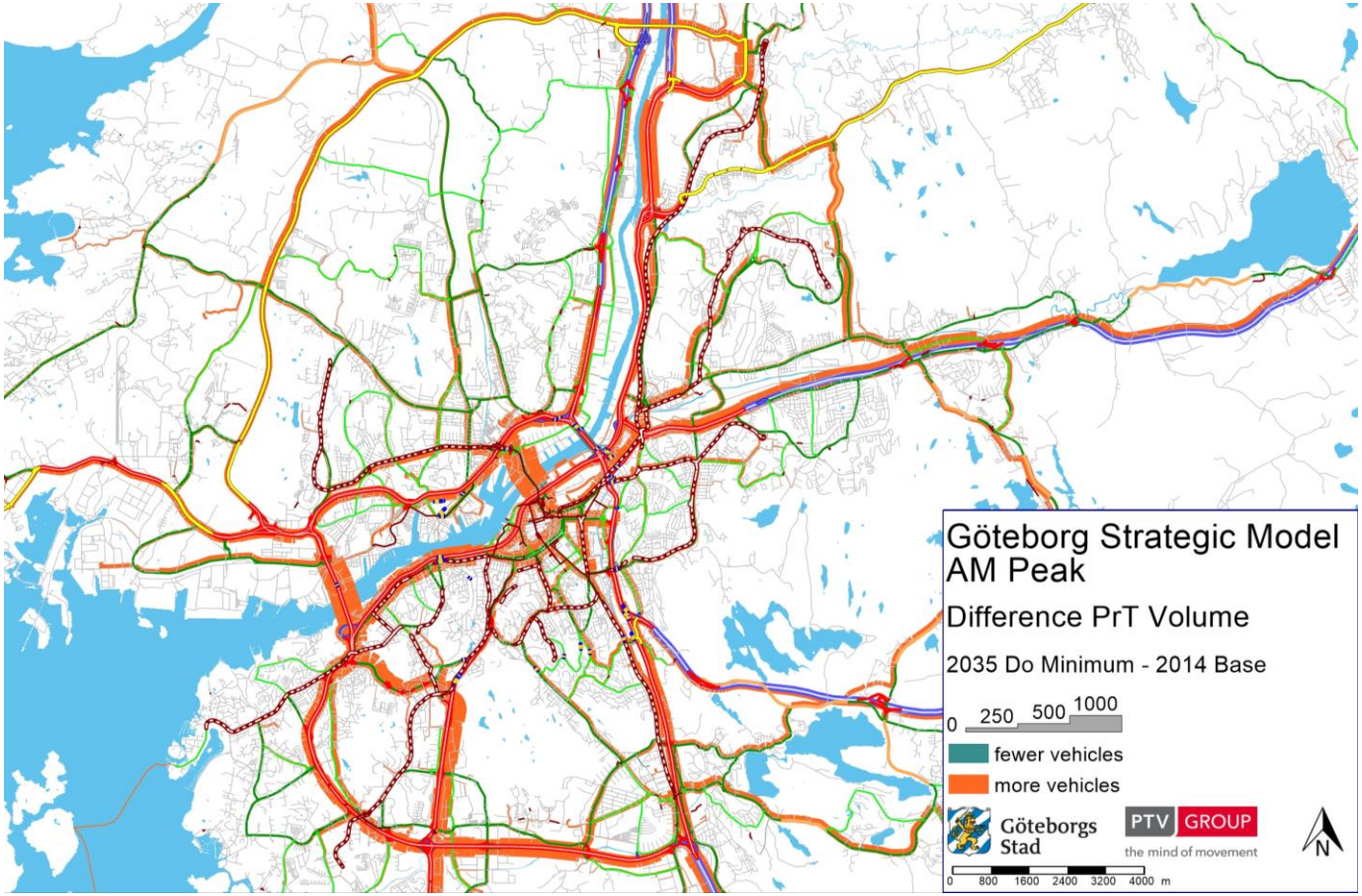
- No of Trips by mode



6. FUTURE YEAR SCENARIOS

Results

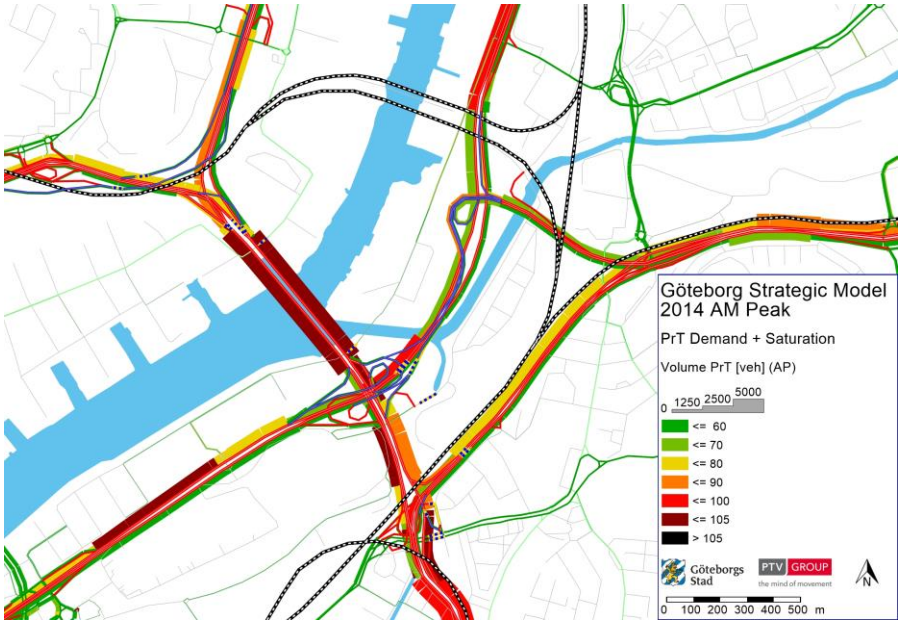
- PrT Assignment: 2014 Base vs 2035 Minimum

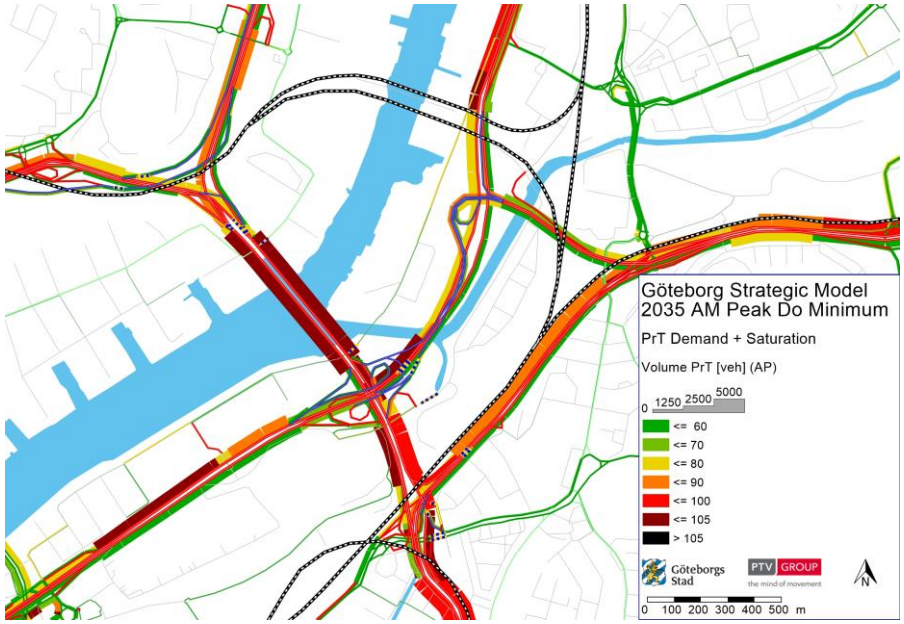


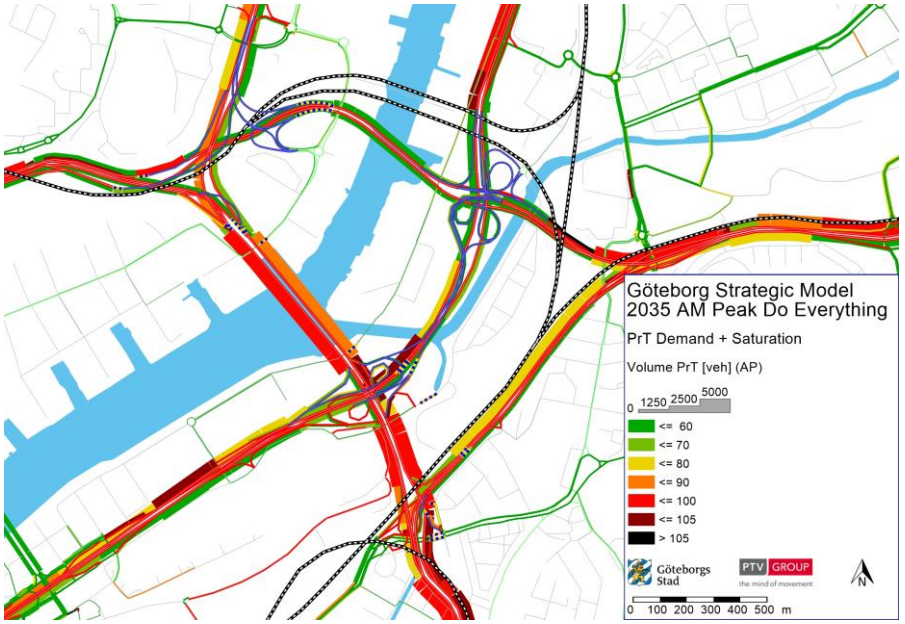
6. FUTURE YEAR SCENARIOS

Results

- PrT Assignment: 2014 Base vs 2035 Minimum vs 2035 Maximum



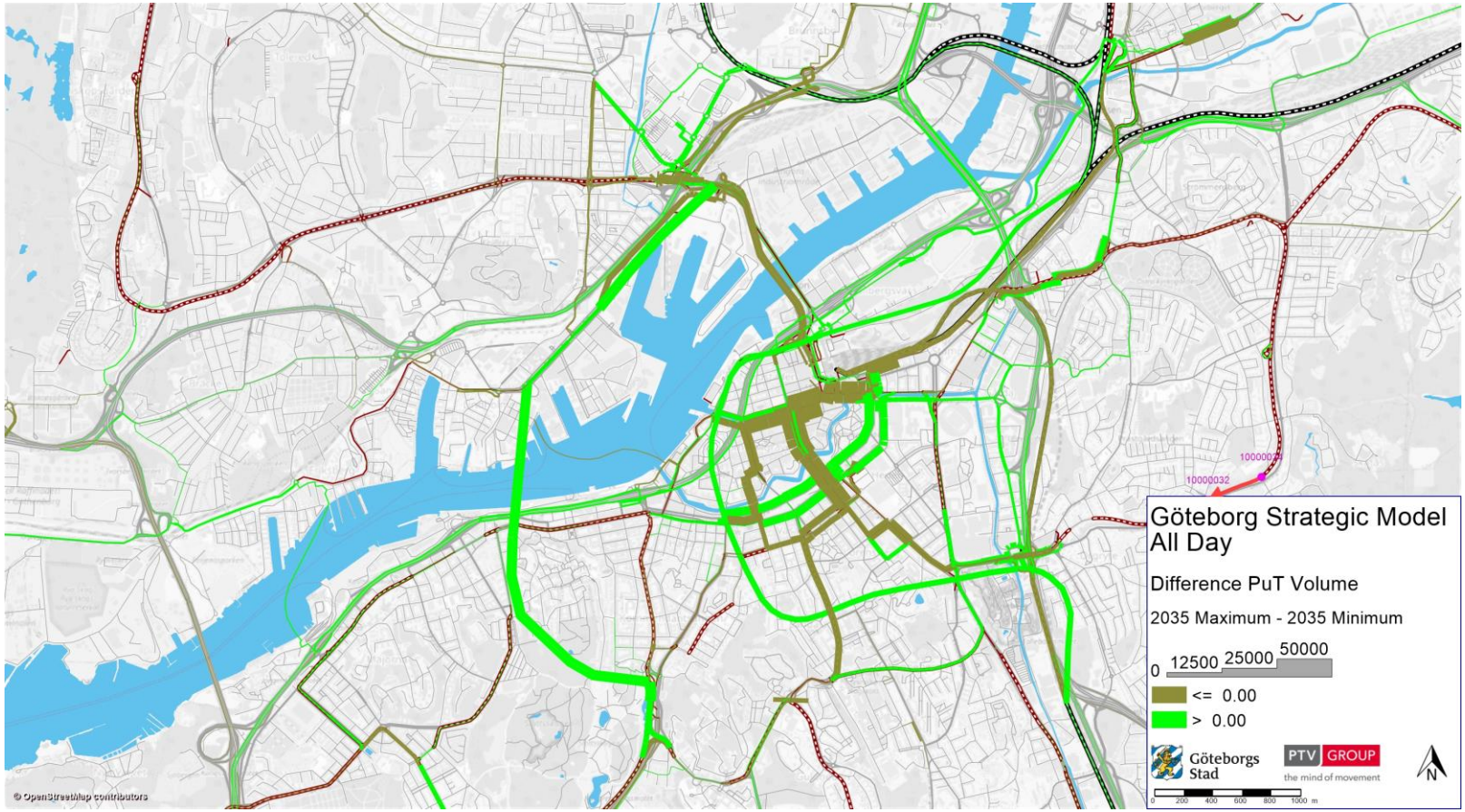




6. FUTURE YEAR SCENARIOS

Results

- PuT: 2035 Maximum vs 2035 Minimum



THANKS !

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