# EMFAC-HK

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# Vehicle Emission Inventory

- The methodology used to estimate vehicle emission inventories in Hong Kong

- Making use of traffic data from TD, HyD and EPD's surveys

# Real-world vehicle emission measurements using Portable Emission Measurement System (PEMS)

# Various PEMS being used in HK

| Analyzers | Measurement |
|---|---|
| SEMTECH-DS (7 units) | CO, CO2, NO, NO2, THC |
| SEMTECH-ECOSTAR (1 unit) | CO, CO2, NO, NO2, THC & PM2.5 on filter |
| A&D portable FTIR (2 units) | N2O, NH3, CO, CO2, NO, NO2 & various hydrocarbon species |
| SECTECH-Low CO (2 units) | CO in low conc. |
| A&D THC/Low CO analyzer (1 unit) | CO in low conc. and THC |
| AVL M.O.V.E. GAS PEMS (4 units) | CO, CO2, NO, NO2, THC |
| SEMTECH-SAMPS (5 units) & SEMTECH-Filter System (3 units) | PM2.5 on filter |
| AVL M.O.V.E. PM PEMS (3 units) | Real time PM & PM on filter |

AVL PM PEMS

AVL GAS PEMS

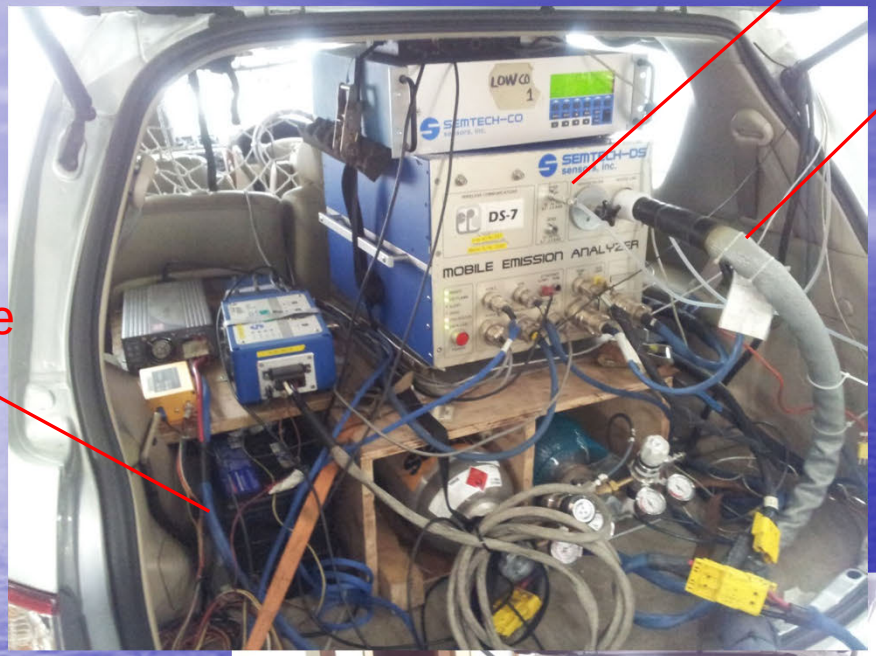
# Installation

Low CO/THC

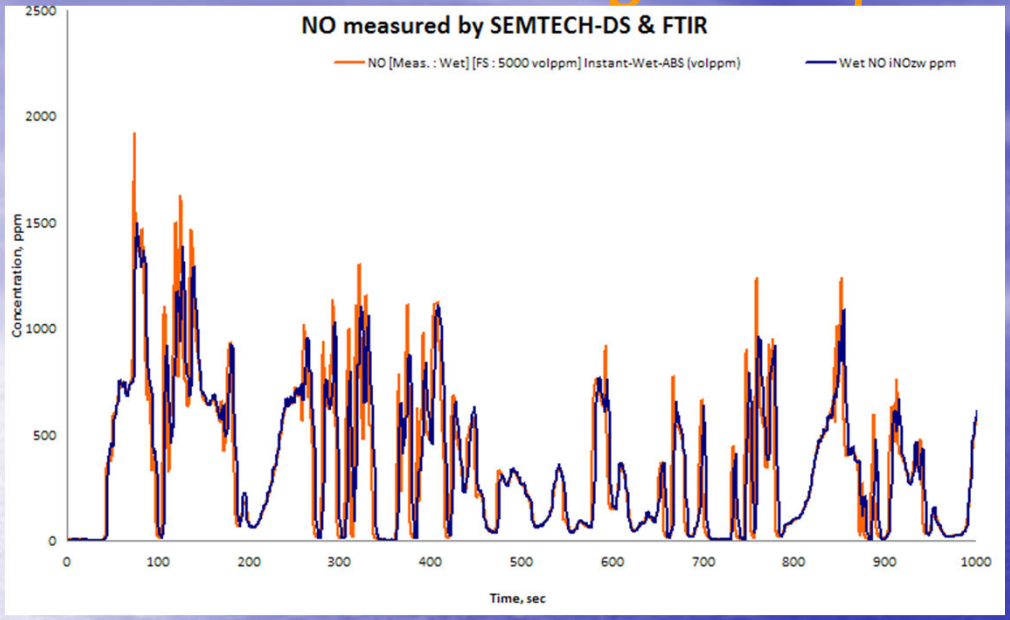
SEMTECH-DS

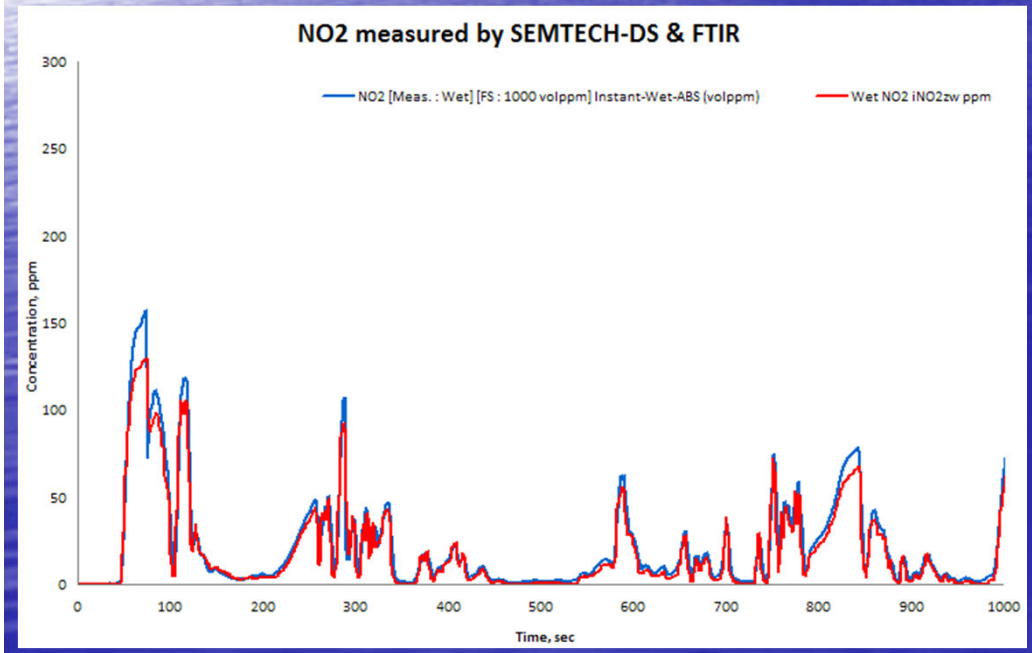
Trimble GPS

Exhaust flow meter



# On-Road Testing Example: SCR coach




- On-road testing of an EURO IV coach (w/ SCR)
  - Professional bus drivers
  - Driving on a pre-determined routes as well as following a similar vehicle
  - 50-60 % of maximum payload
  - Traffic are captured by video camera mounted in front of the bus
- Both gaseous pollutants and PM are collected
  - PEMS used – SEMTECH-DS, SAMPS, Filter System, FTIR, and M.O.V.E. PM PEMS

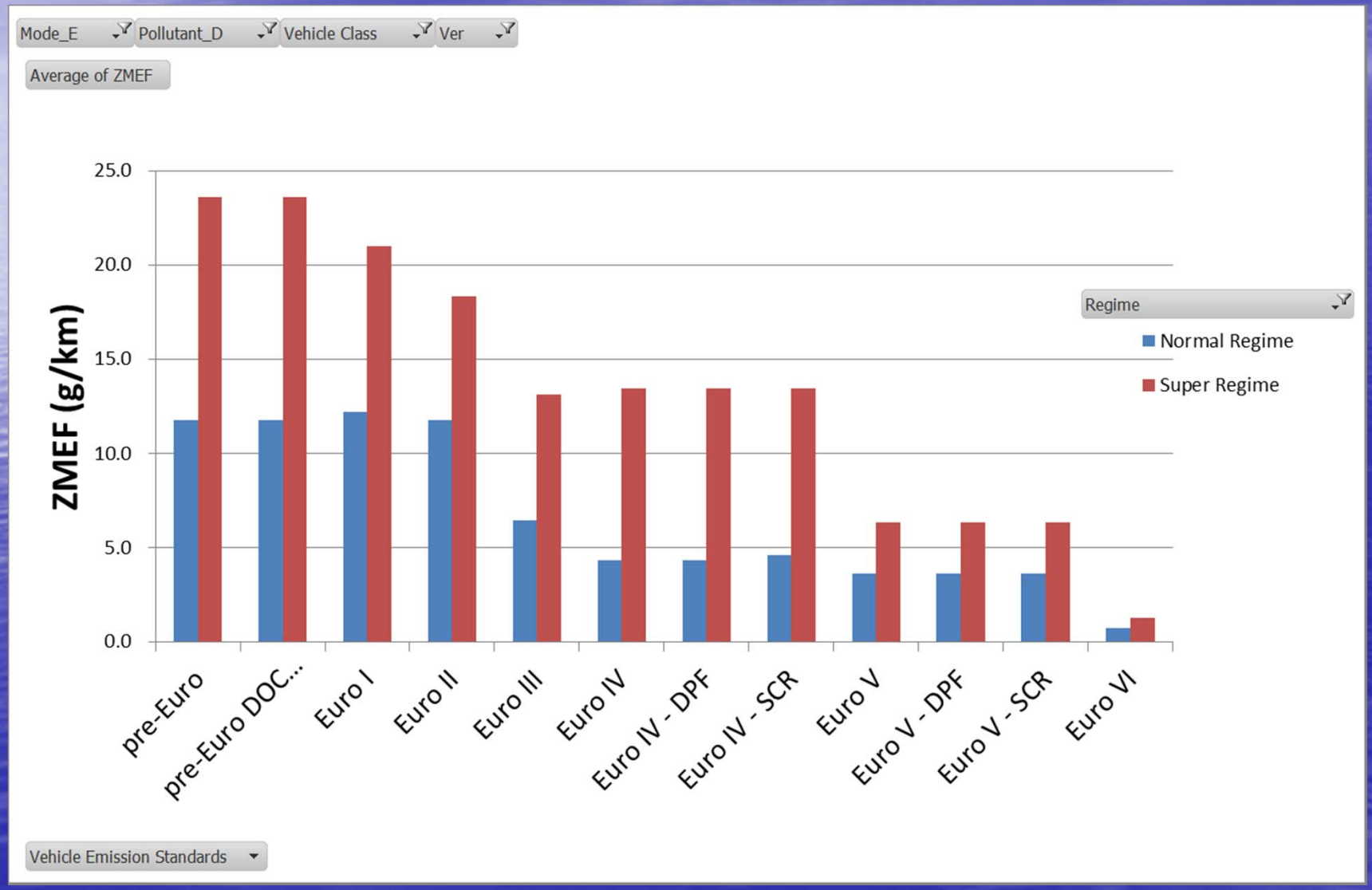
# QA/QC for PEMS

- Follow international standards:
  - ISO16183/Euro VI
  - US CFR 1065 Subpart J

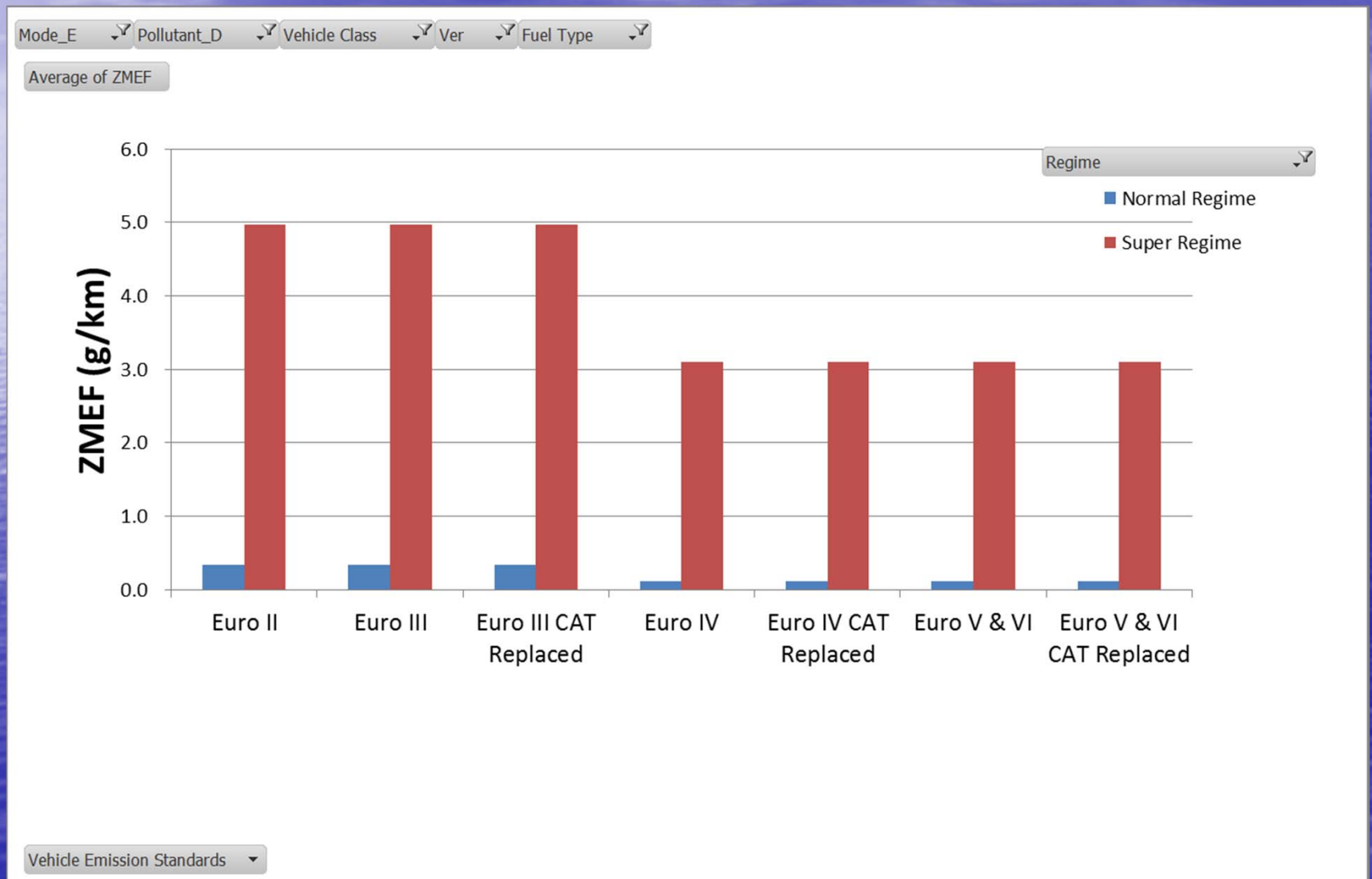
  Including
  - calibrate at least once a day for all the gas analyzers, zero check every hour & audit every three hours
  - linearity check for all gas analyzers every 35 days
  - flow meter calibration every six months
  - cross-interference tests for various gas analyzers every six months

# Estimation of Zero Mile Emission Factors (ZMEF) and Deterioration Rates (DR)

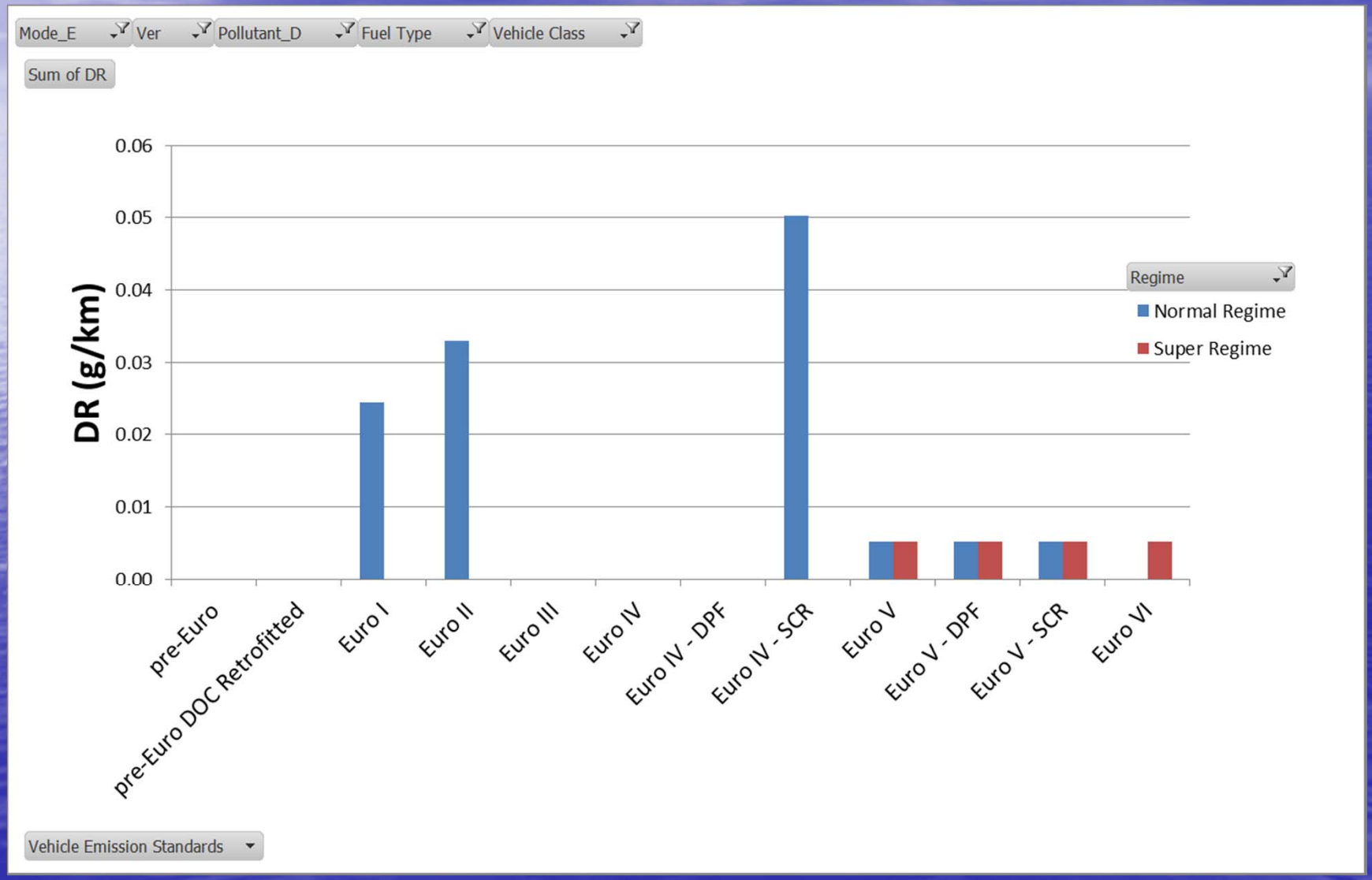
# NOx ZMEF for Diesel Heavy Goods Vehicles > 15t (HGV8)



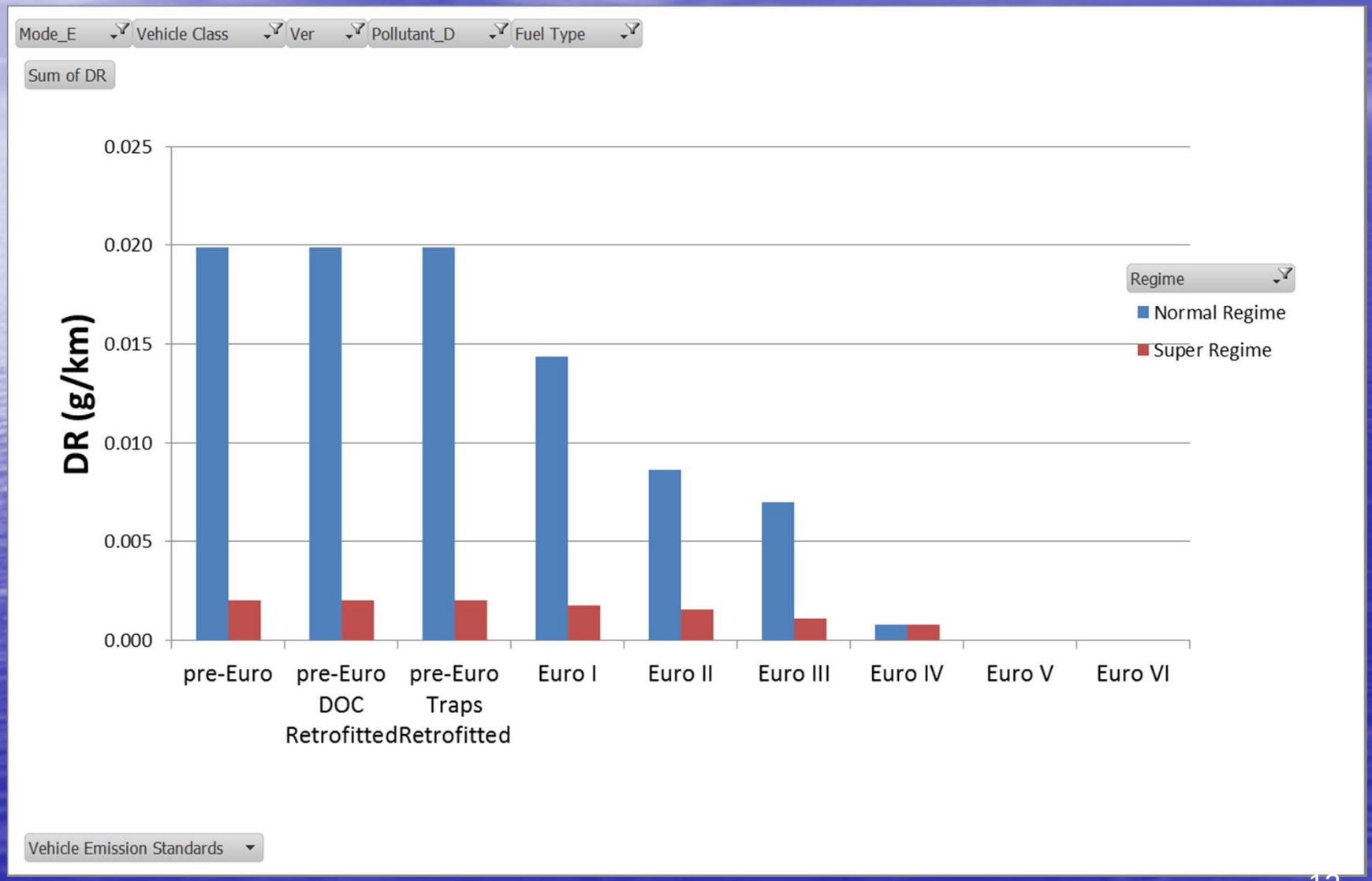
# NOx ZMEF for Taxis



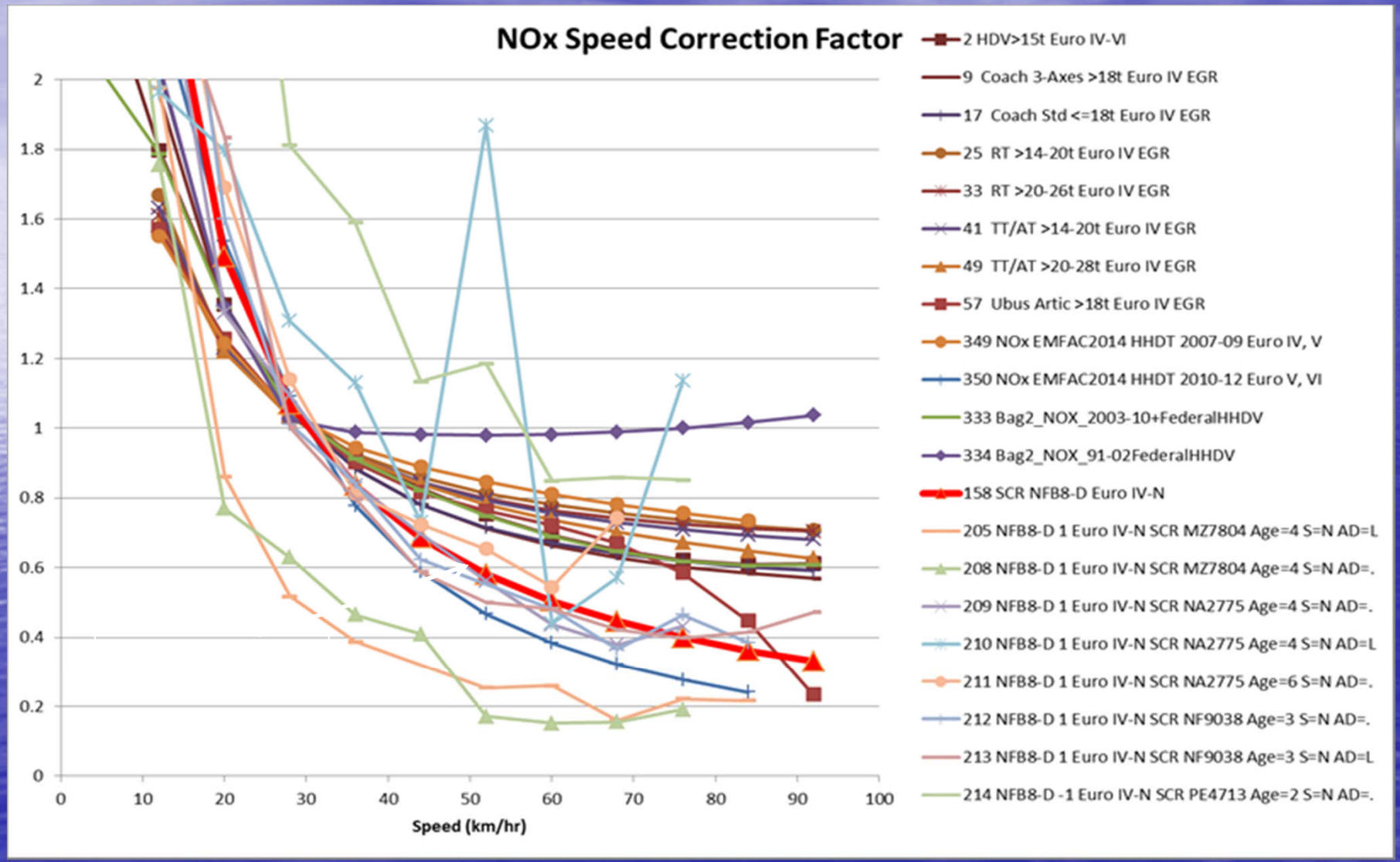
# NOx DR for Diesel Heavy Goods Vehicles > 15t (HGV8)



# NOx DR for Diesel Public Light Bus (PLB)



# NOx Speed Correction Factor for Euro IV Heavy Goods Vehicles and Non-Franchised Bus >15t with SCR



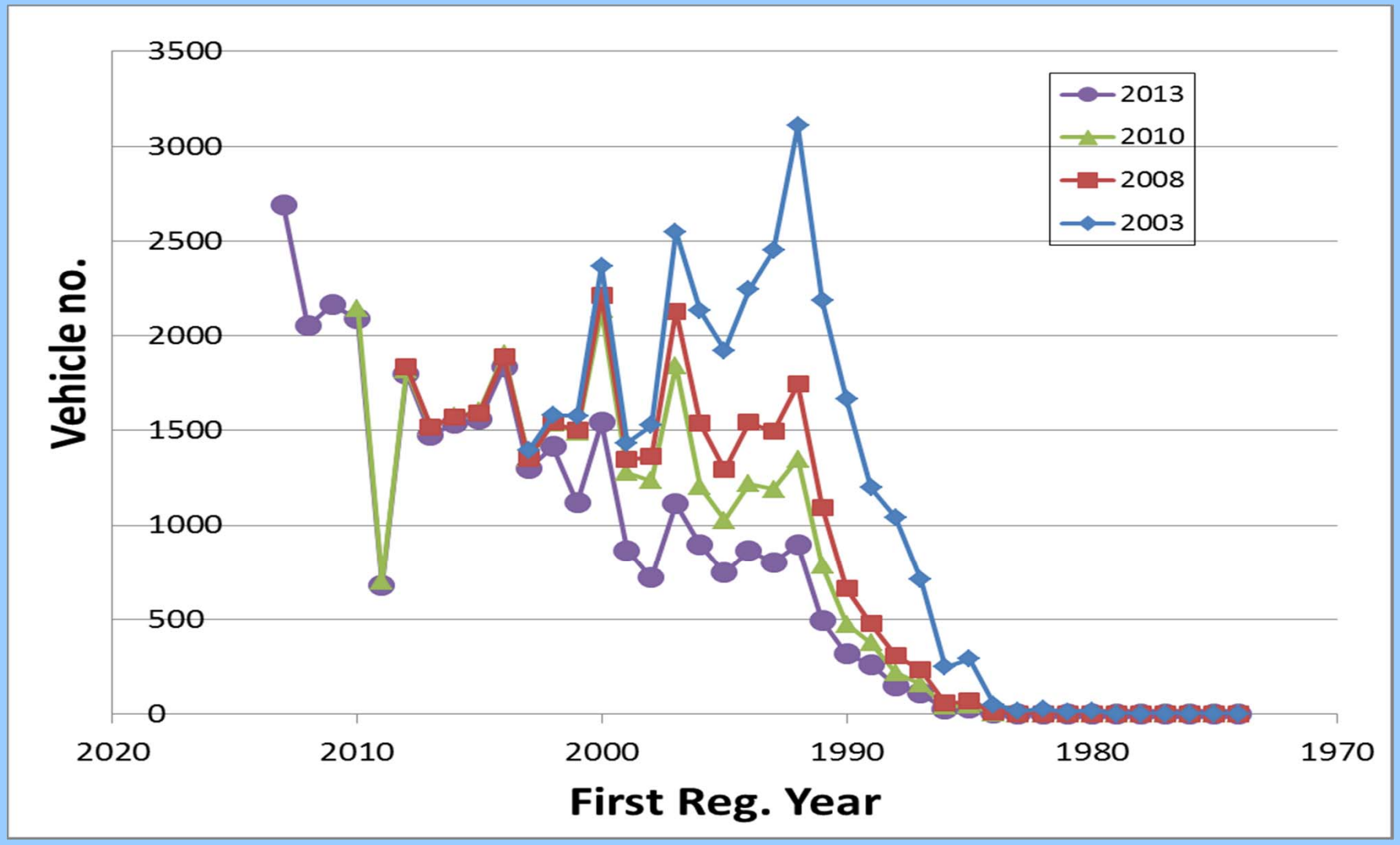
# Vehicle Activities

# Vehicular Activities

- Vehicle population - Local vehicle licensed data was used
- VKT - methodology in ATC was adopted with modification
- VKT by class - TD's methodology was adopted with modification
- speed fractions – VKT fractions by speed bins

# Vehicle Population Distribution

# Distribution of Goods Vehicles > 15 t
# Population vs. 1st Reg. Year



# Estimation of VKT

# Counter Installation System in ATC

| Type of Station | Frequency | Type of Counter Used | Duration of Measurement | Data Obtained |
|---|---|---|---|---|
| Core | Once a year | Recording | 1 week in each of any 3 month | Daily & hourly directional flows |
| | | | 1 week in each of the remaining 9 months | Daily & hourly non-directional flows |
| Coverage at cordon/ screenline | Once a year | Recording | 1 week | Daily & hourly directional flows |
| Coverage not at Cordon/ Screenline | Surveyed twice in 5 years | Recording or non-recording | 1 weekday (Mon-to-Fri) | Daily non-directional flows |

# Distribution of Counting Stations in 2013 ATC

| District | Type of Station | Road Network | | Total |
|---|---|---|---|---|
| | | Major | Minor | |
| Hong Kong Island | Core | 30 | 8 | 38 |
| | Coverage | 127 | 54 | 181 |
| | Total | 157 | 62 | 219 |
| Kowloon | Core | 27 | 6 | 33 |
| | Coverage | 218 | 53 | 271 |
| | Total | 245 | 59 | 304 |
| New Territories | Core | 37 | 6 | 43 |
| | Coverage | 242 | 45 | 287 |
| | Total | 279 | 51 | 330 |
| Total | | 681 | 172 | 853 |

# Road Types (1)

- Expressway (EX) and Urban (UT) / Rural (RT) Trunk Road
- Primary Distributor (PD)
  - form urban area's major network
- District Distributor (DD)
  - links districts to the PD

# Road Types (2)

- Local Distributor (LD)
  - Roads within districts linking developments to DD
- Rural Road
  - Connects the smaller population centres/recreation areas with major road networks

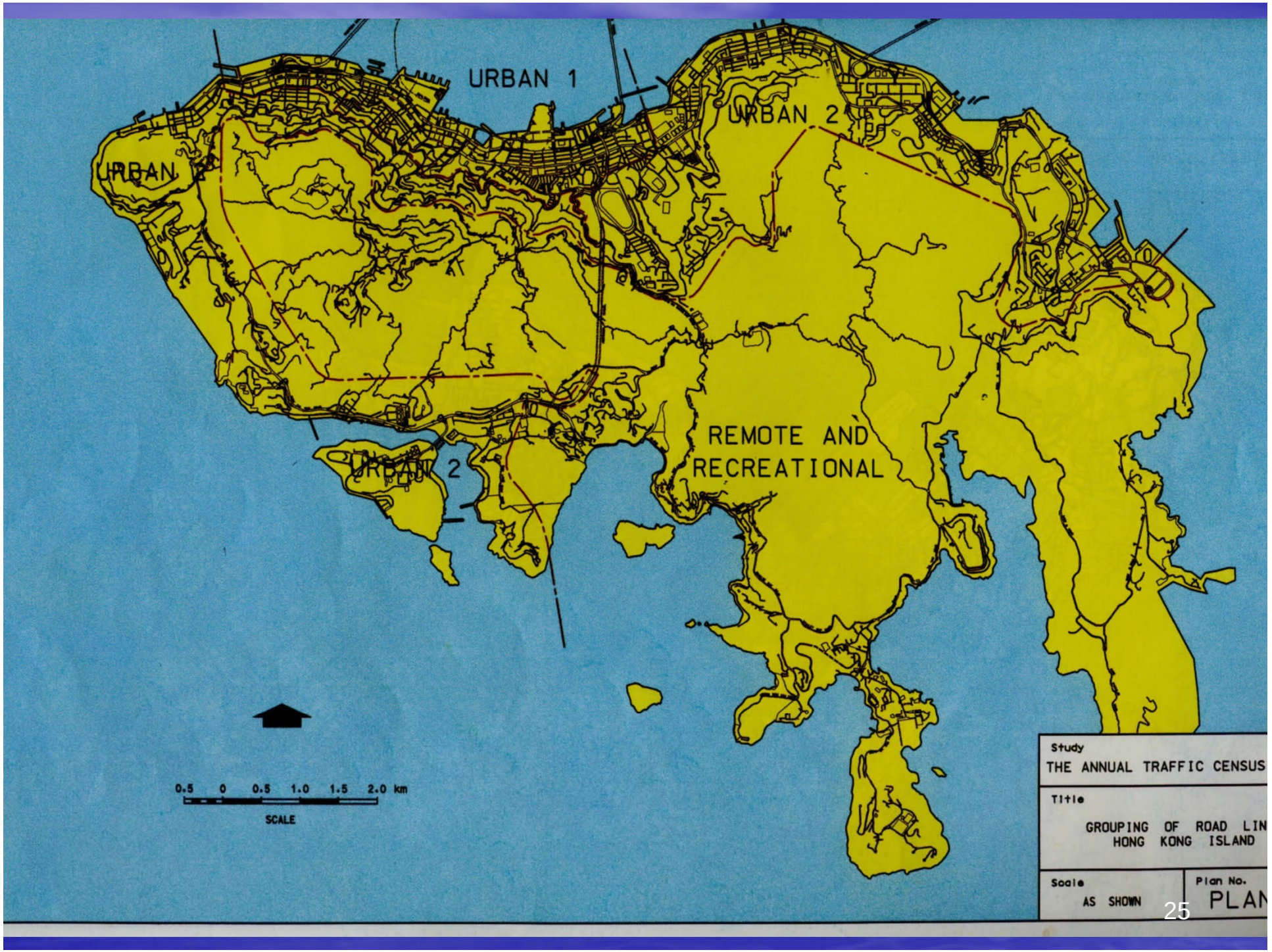
# Road Link Groups (1)

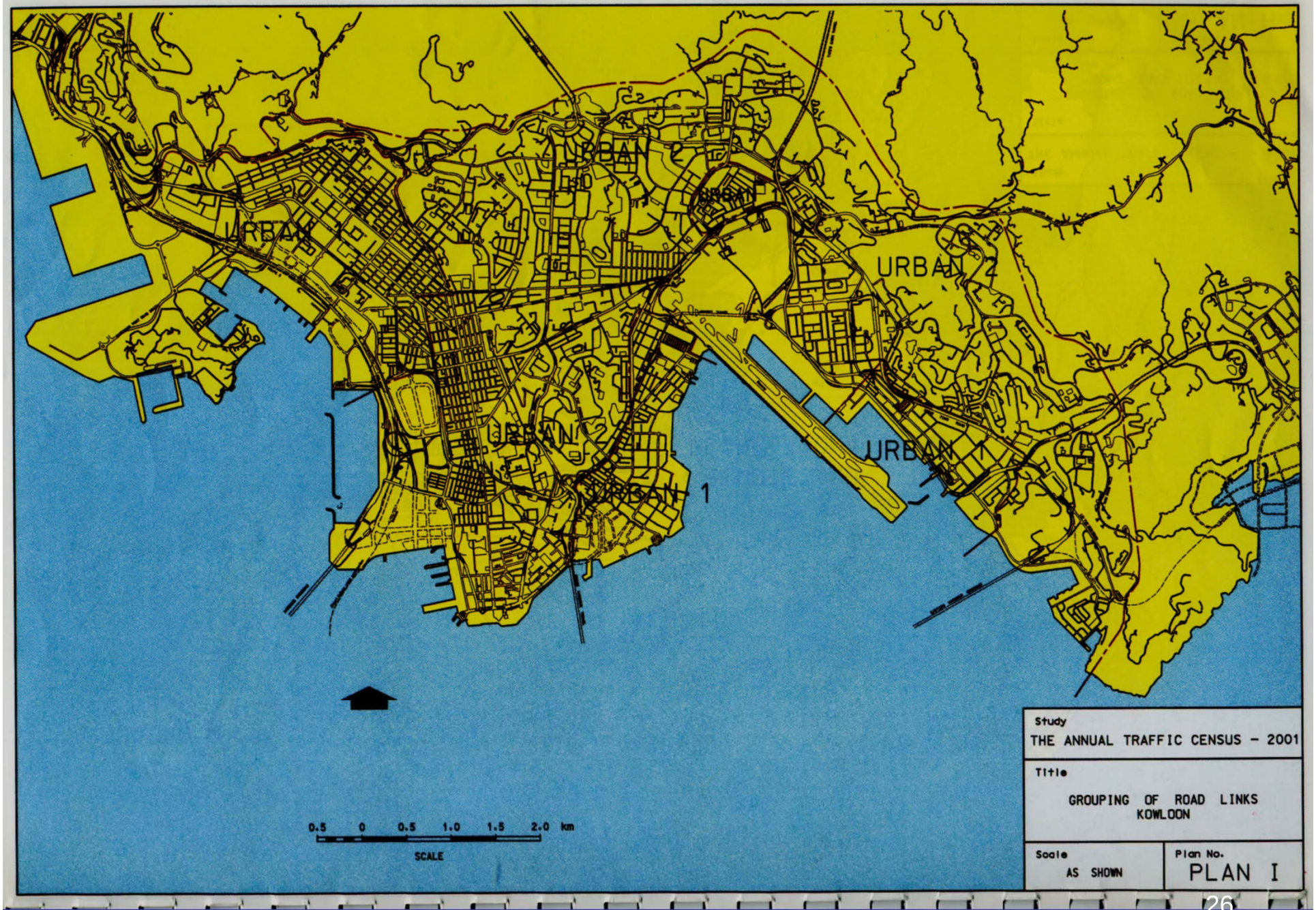
- For coverage stations, AADT estimated by making use of the available information for the core stations.

- The core stations are clustered into groups based on the daily traffic pattern exhibited at each counting stations, called **road link groups**.

# Road Link Groups (2)

| Region | Road Link Group |
|---|---|
| Hong Kong | Urban 1 |
| | Urban 2 (Major Road Network) |
| | Urban 2 (Minor Road Network) |
| Kowloon | Urban 1 |
| | Urban 2 (Trunk Roads and Primary Distributors) |
| | Urban 2 (District Distributors and Local Distributors) |


URBAN 1
URBAN 2
URBAN
URBAN 2
REMOTE AND
RECREATIONAL
0.5 0 0.5 1.0 1.5 2.0 km
SCALE
Study
THE ANNUAL TRAFFIC CENSUS
Title
GROUPING OF ROAD LIN
HONG KONG ISLAND
Scale
AS SHOWN
Plan No.
PLAN


URBAN
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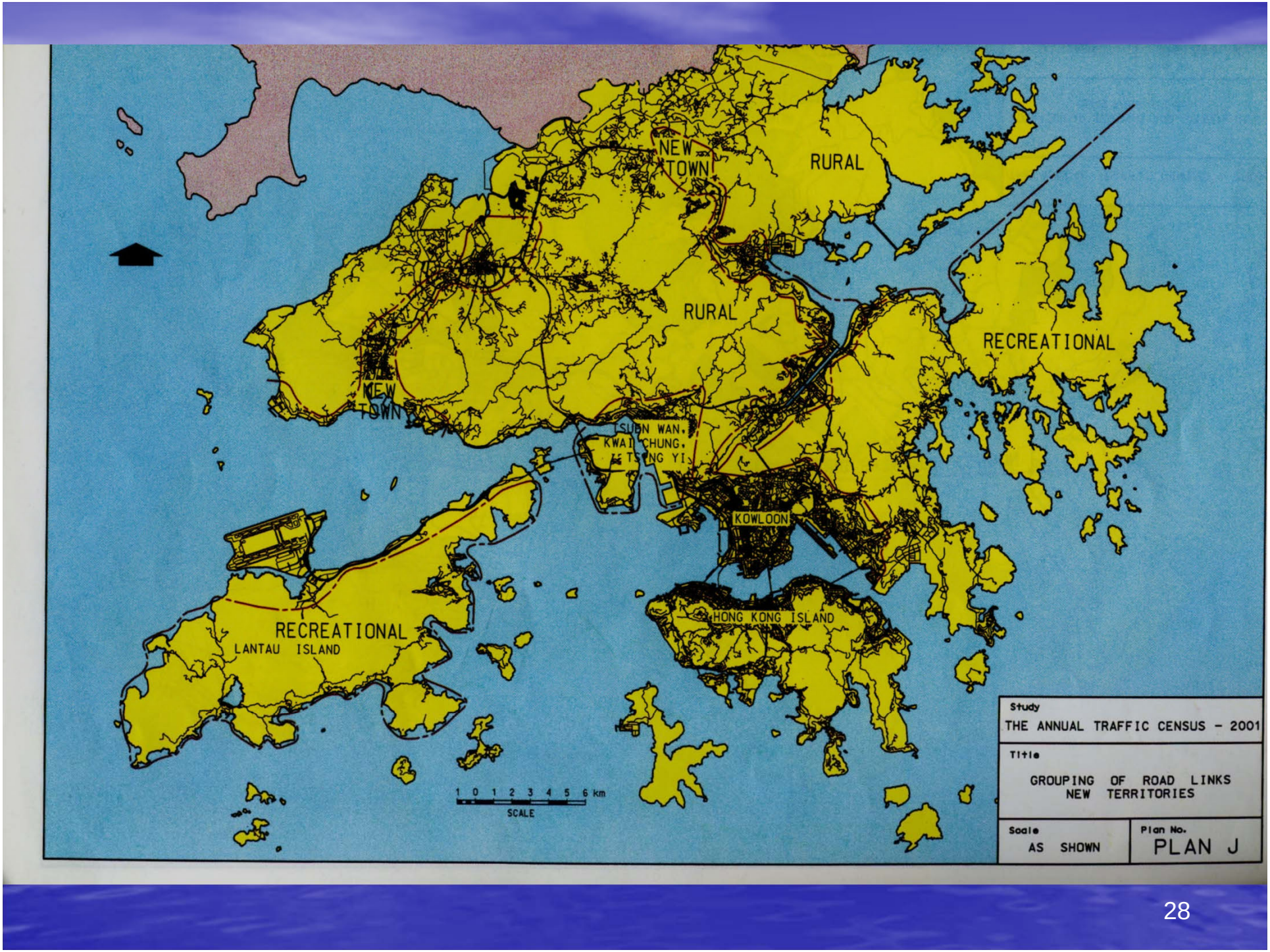
1
0.5 0 0.5 1.0 1.5 2.0 km
SCALE
Study
THE ANNUAL TRAFFIC CENSUS - 2001
Title
GROUPING OF ROAD LINKS
KOWLOON
Scale
AS SHOWN
Plan No.
PLAN I

# Road Link Groups (3)

| Region | Road Link Group |
|---|---|
| Hong Kong | Remote & Recreational |
| New Territories | New Towns |
| | Tsuen Wan, Kwai Chung & Tsing Yi |
| | Recreational |
| | Rural |


NEW TOWN
RURAL
RURAL
RECREATIONAL
NEW TOWN
SHUN WAN,
KWAI CHUNG,
TSING YI
KOWLOON
HONG KONG ISLAND
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Study
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GROUPING OF ROAD LINKS
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Scale
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Plan No.
PLAN J

# Estimation of VKT (1)

- Major Road Network

  The vehicle-kilometrage (VK) for each road link group *(r)* for each major road type *(t)* is

$$VK_{r,t} = \{\Sigma L_{i,core,r,t} * AADT_{i,core,r,t}\}$$

$$\text{all core}$$

$$+ L_{coverage,r,t} * \frac{}{AADT_{coverage,r,t}}$$

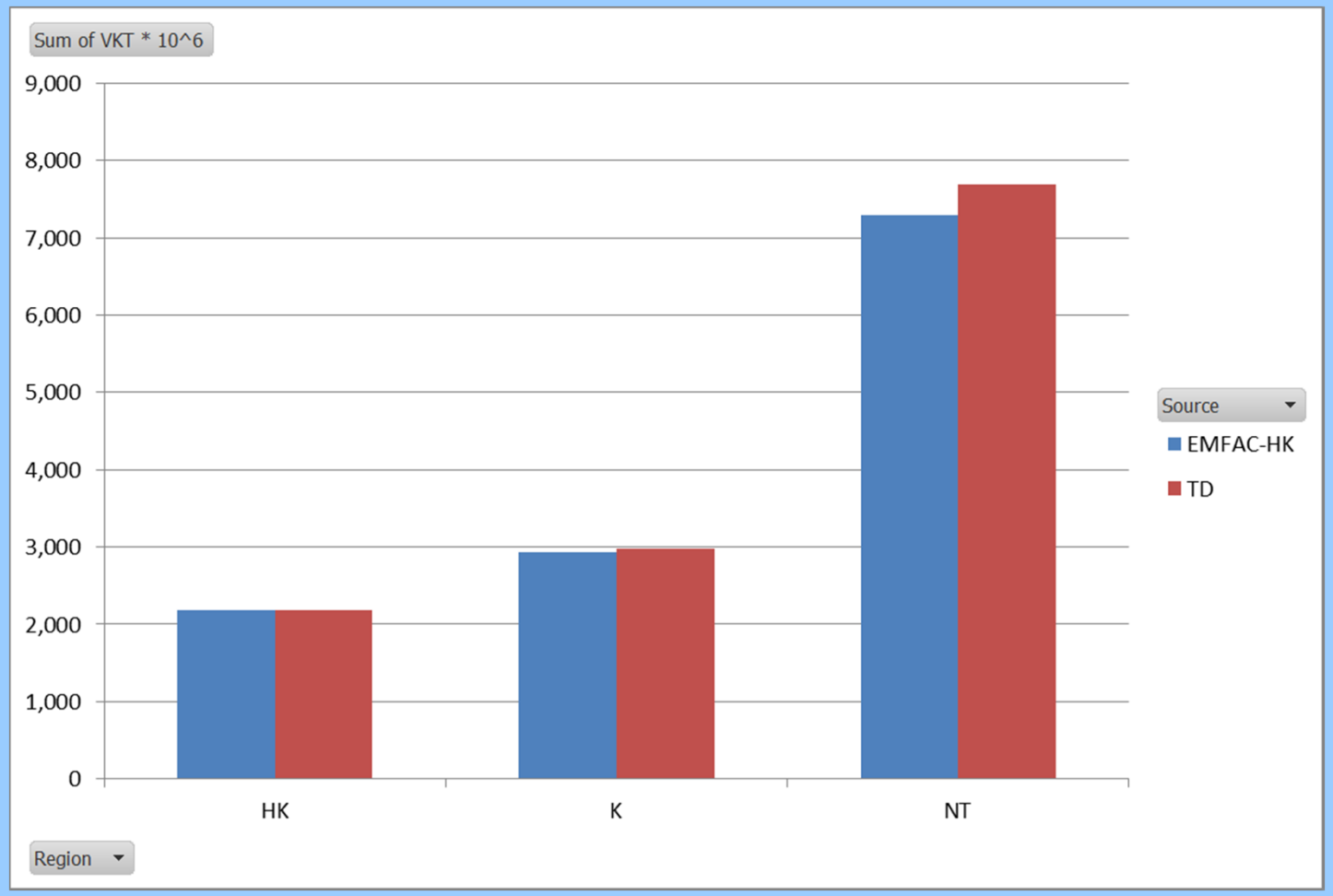
# Estimation of VKT (2)

- Minor Road Network

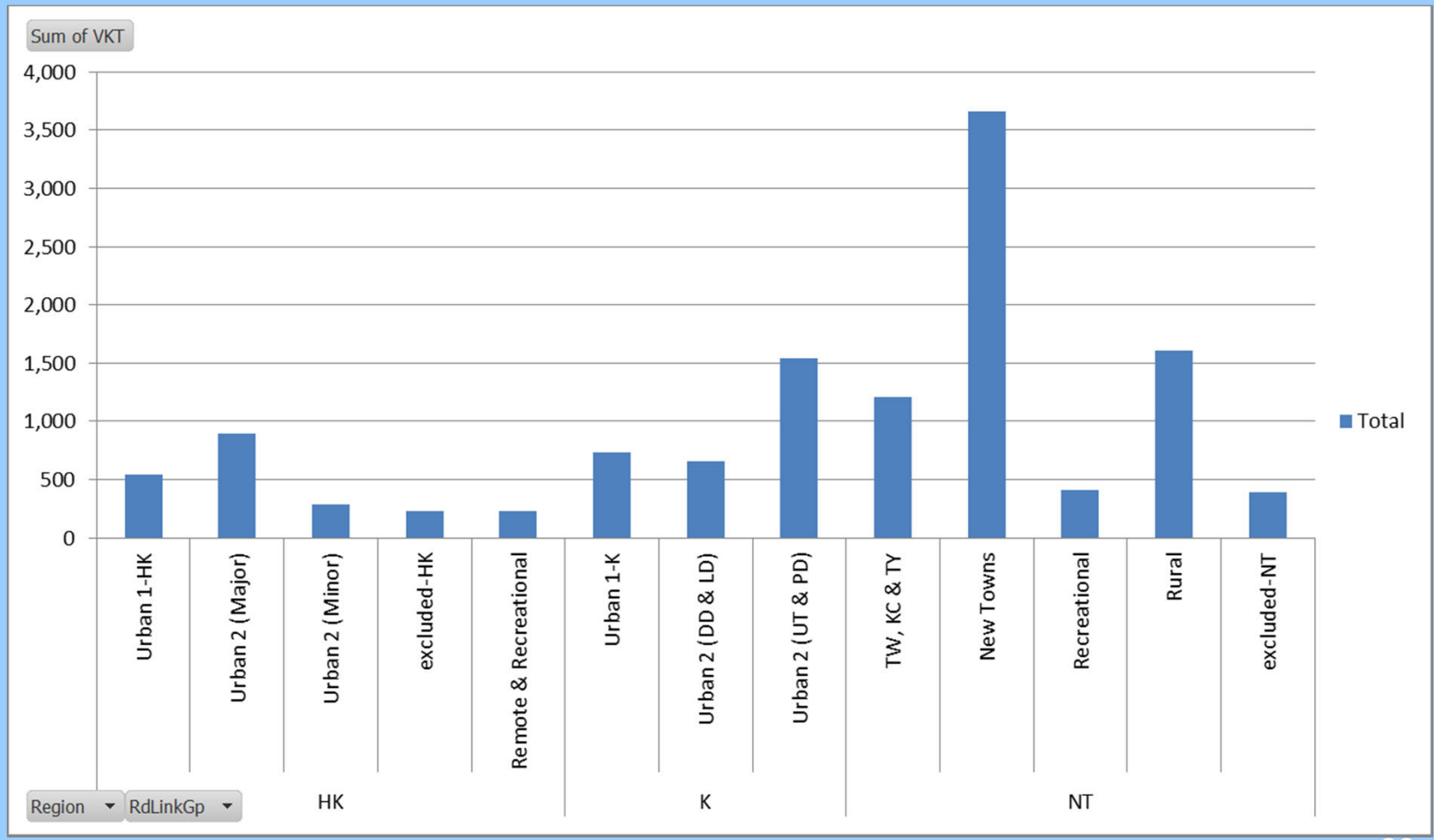
  The vehicle-kilometrage (VK) for each road link group *(r)* for each minor road type *(t)* is

$$VK_{r,t} = L_{r,t} * \overline{AADT}_{r,t}$$

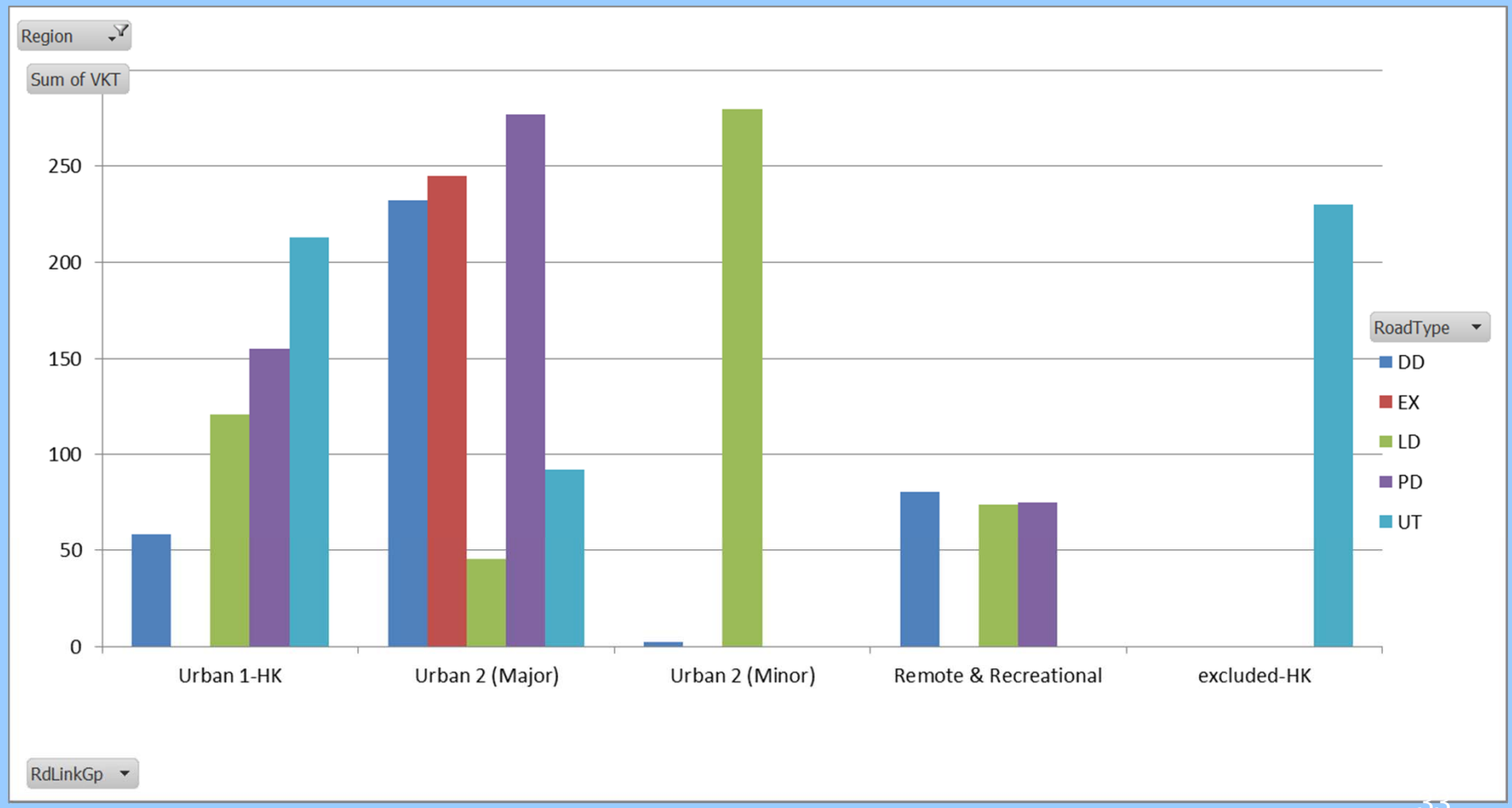
# Comparison of VKT in 2013



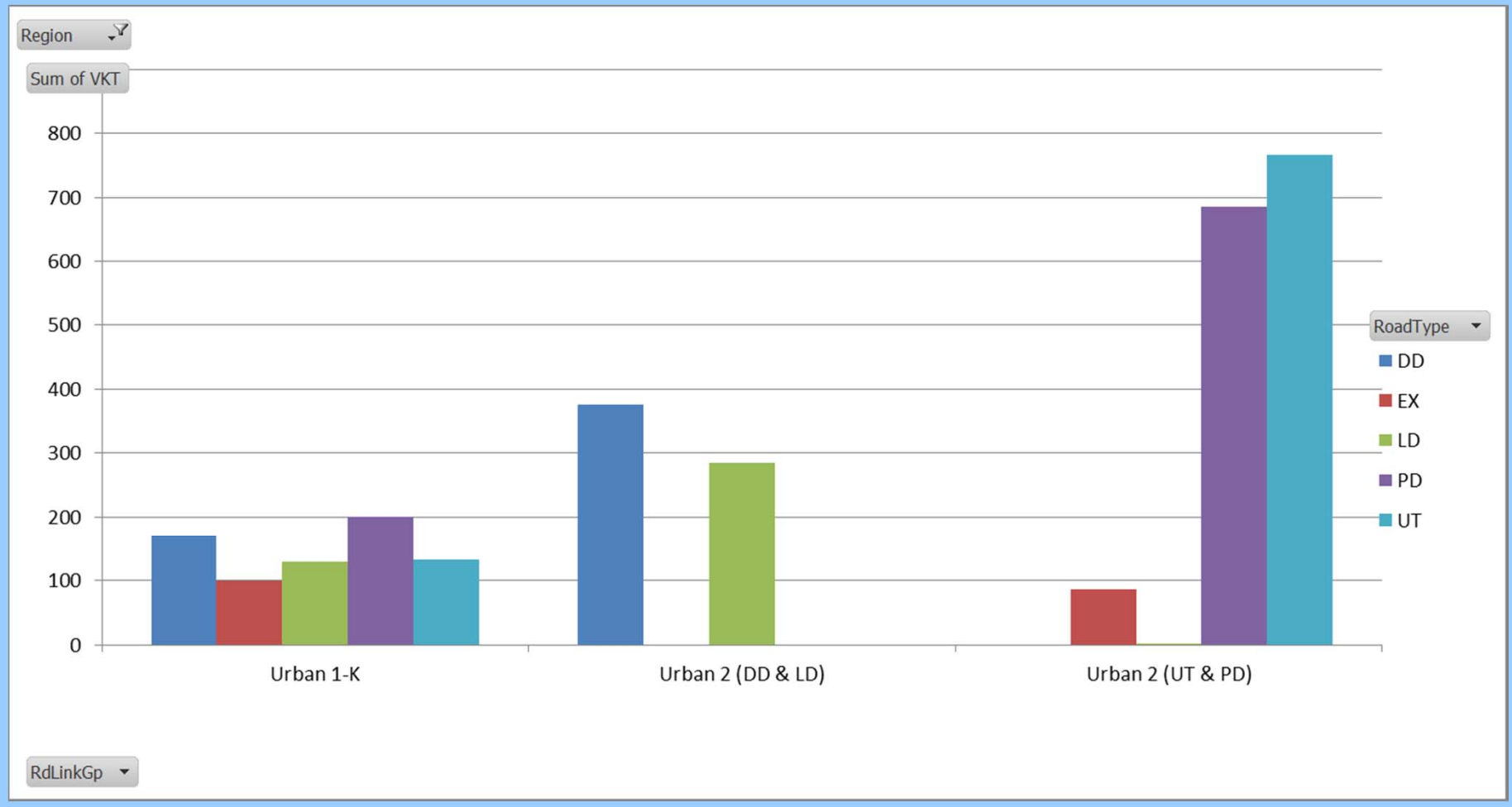
# VKT Distribution by Road Link Group in 2013



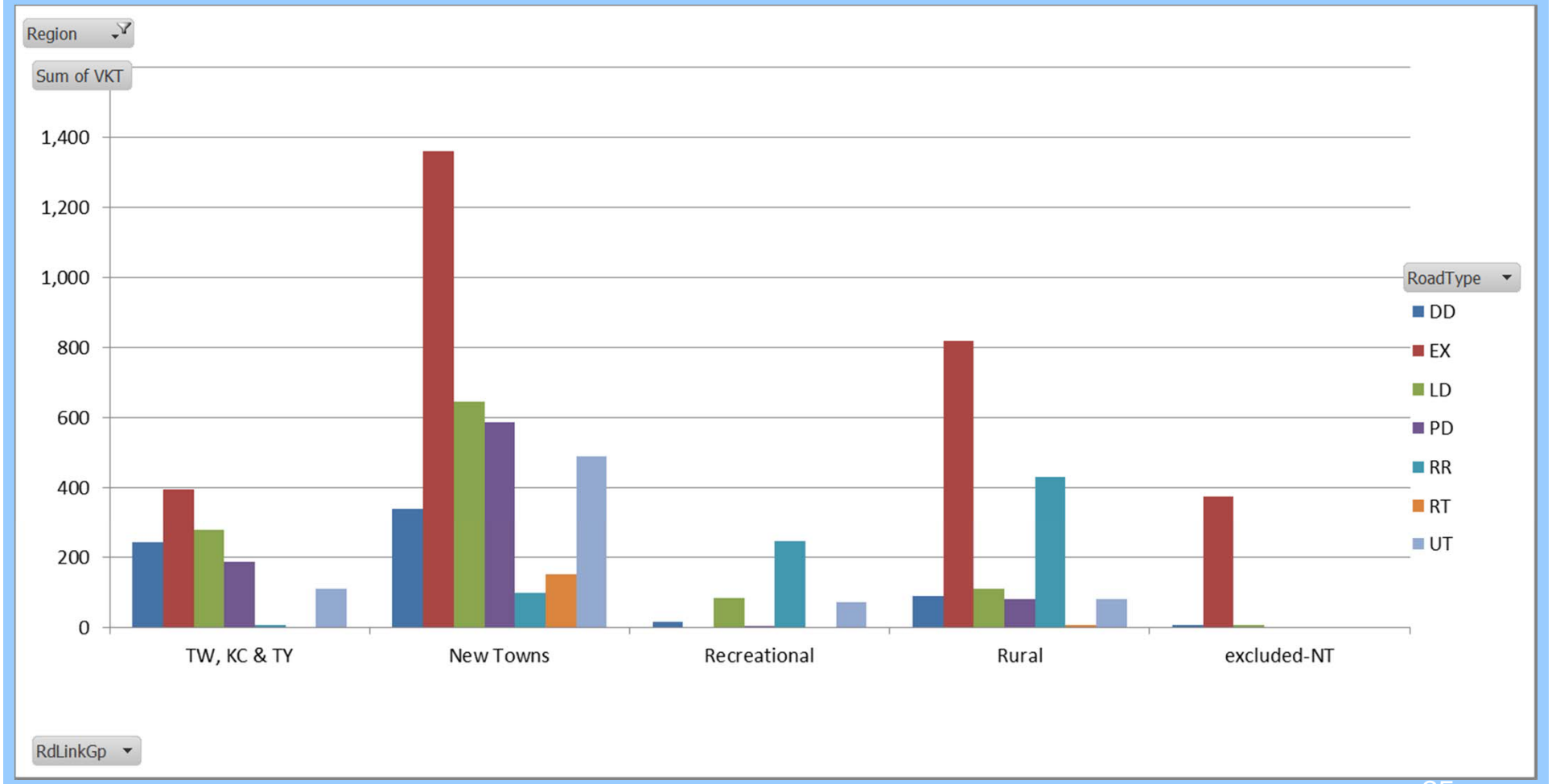
# VKT Distribution by Road Link Group & Road Type in HKI in 2013



# VKT Distribution by Road Link Group & Road Type in Kln in 2013



# VKT Distribution by Road Link Group & Road Type in NT in 2013



# Estimation of VKT by Vehicle Class

# Vehicle Classification

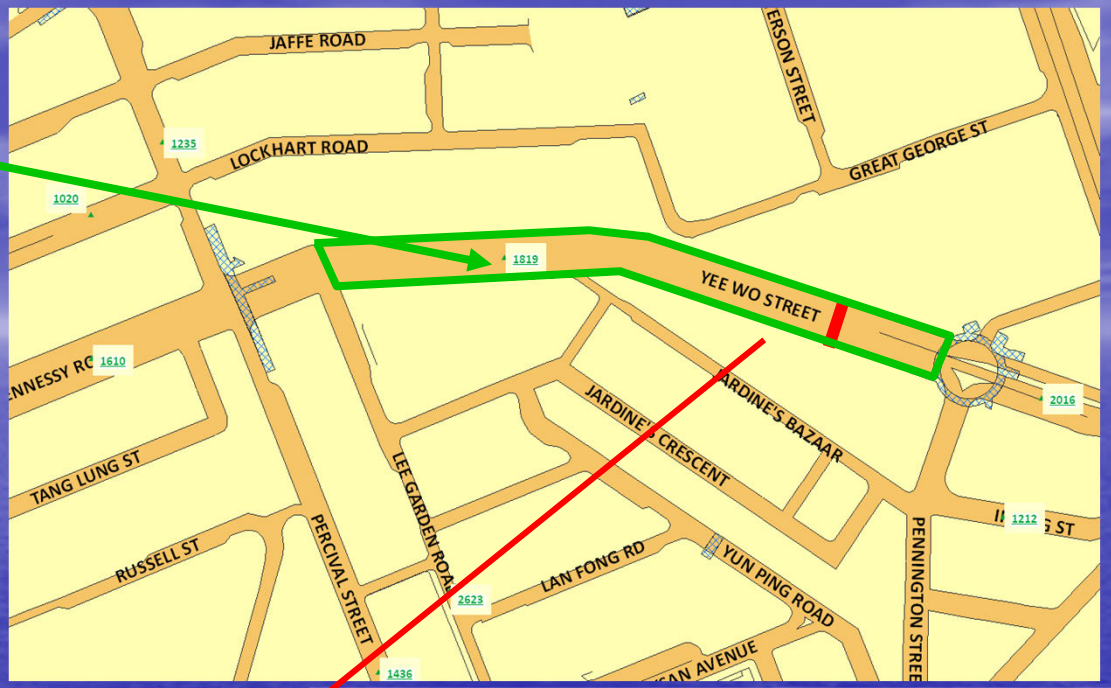
Percentage of Vehicles by class

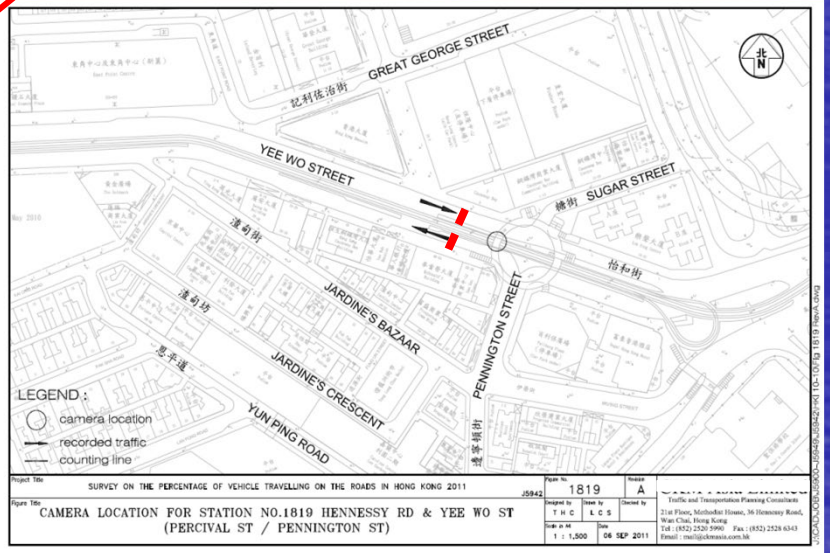
- obtained by manual counts for ~ 170 count stations (TD & EPD surveys)
- 24 hours
- one typical weekday each year
- at core stations and coverage stations falling on a cordon or screenline

Traffic Counting Station locating on one of our proposed Low Emission Zones

(Yee Wo Street, Causeway Bay)

-Traffic flow before the implementation of low emission zone can then be monitored and evaluated.





# Estimation of VKT by Class (e.g. taxi)

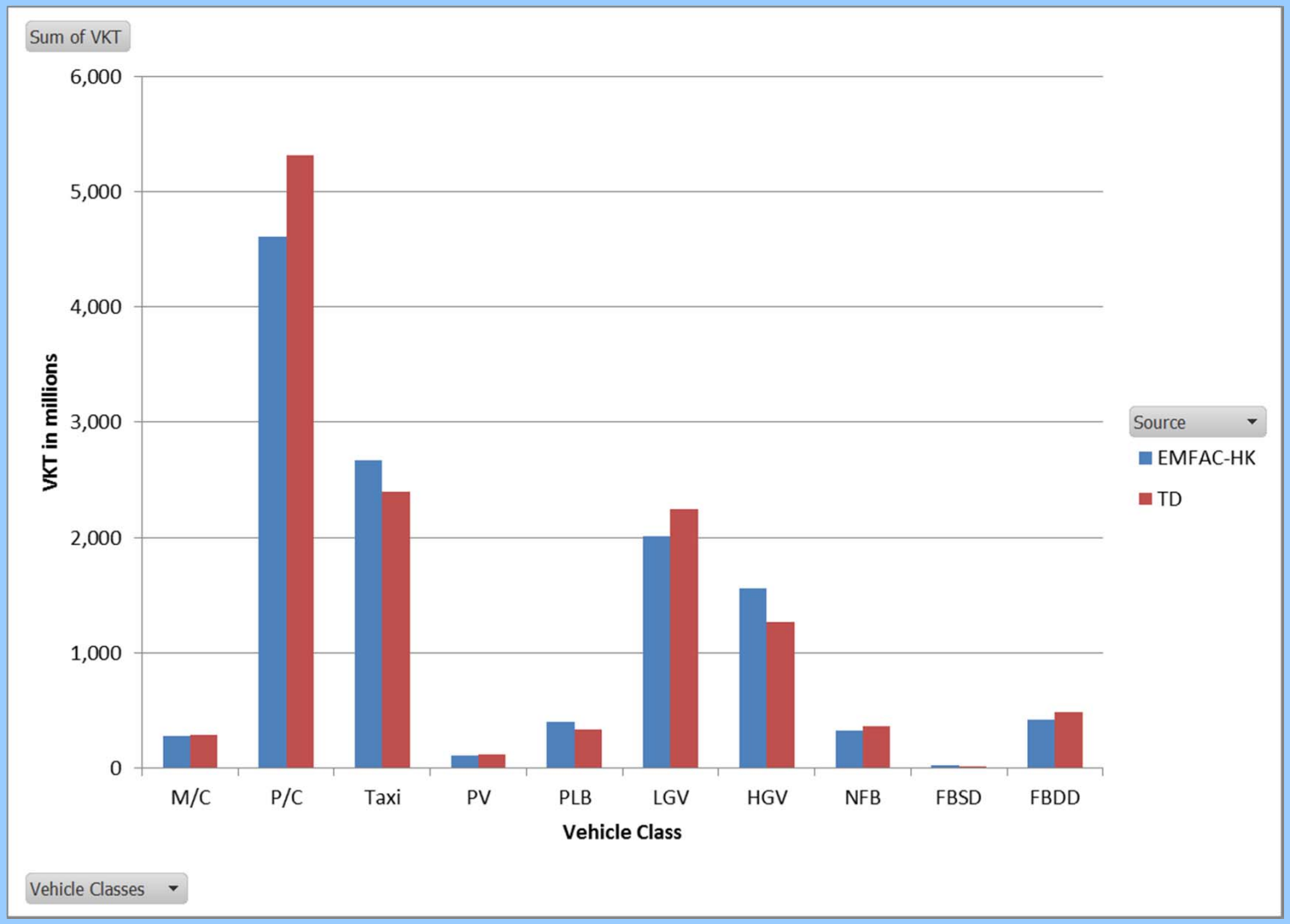
Traffic flow of $taxi_{r,t,i,m}$ at $hr_i$ at road $type_t$ at $stn_m$ in $link\ group_r$

= (AADT * % of taxi at $hr_i$

* % of diurnal variation of traffic flow at $hr_i$)

- lump together to give VKT by class
- provide diurnal variations of VKT

# Comparison of VKT in 2013



# Estimation of Speed Fractions

# Data Sources

- congested speeds at 0800-0930 from TD's Car Journey Time Surveys
- Speed limits (Highway Dept or TD)
- Speed vs. volume/capacity ratio from CTS-3

# Peak Hour (1)

Source –TD

AADT is not null at a station,
Traffic volume in one direction, TV
= segment Length x AADT / no of dirns

AADT is null at a station,
Traffic volume in one direction, TV
= segment Length x $\overline{\text{AADT}}$ / no of dirns

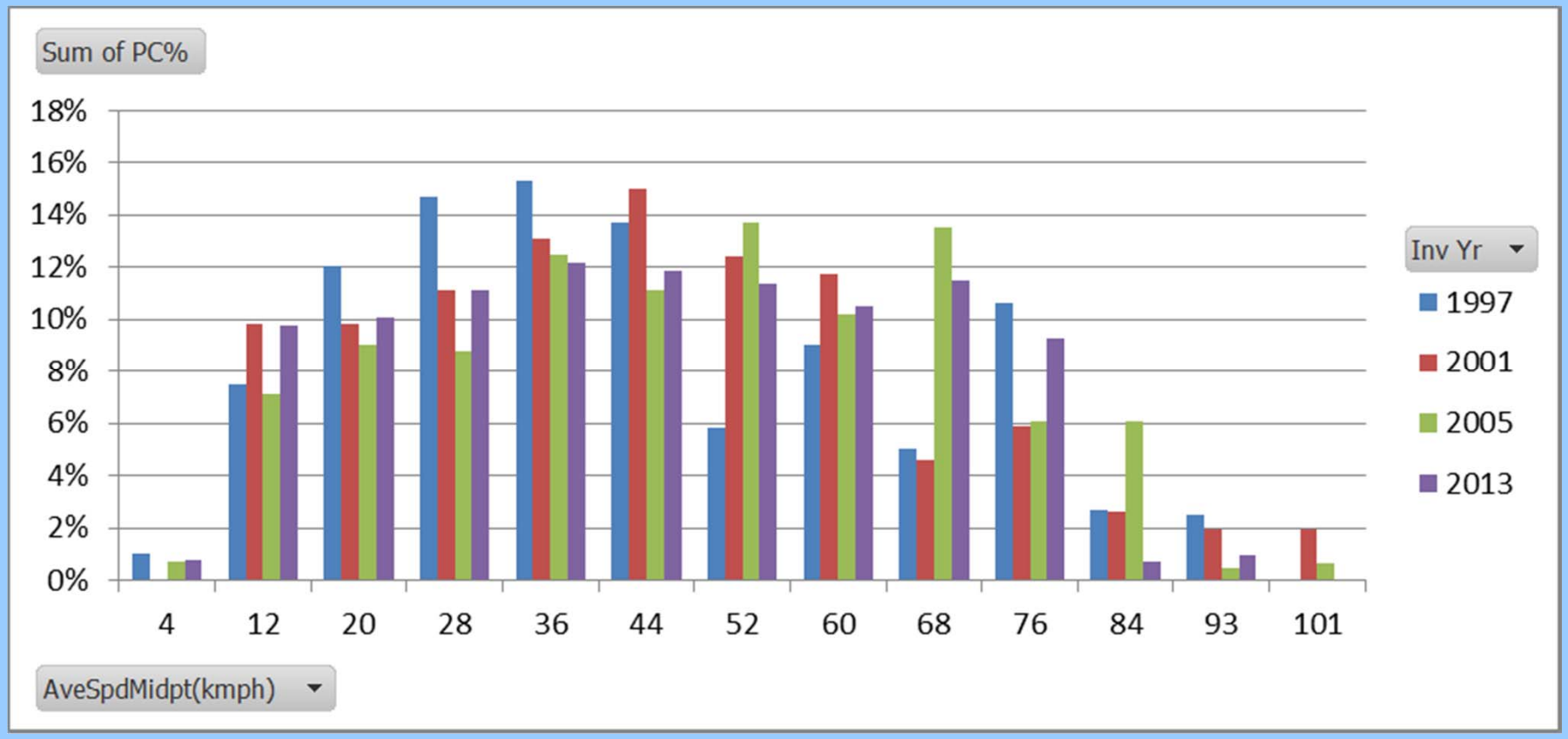
# Peak Hour (2)

VKT by class, region, linkgroup$_r$, rdtype$_t$ and survey speed$_k$, VKMx

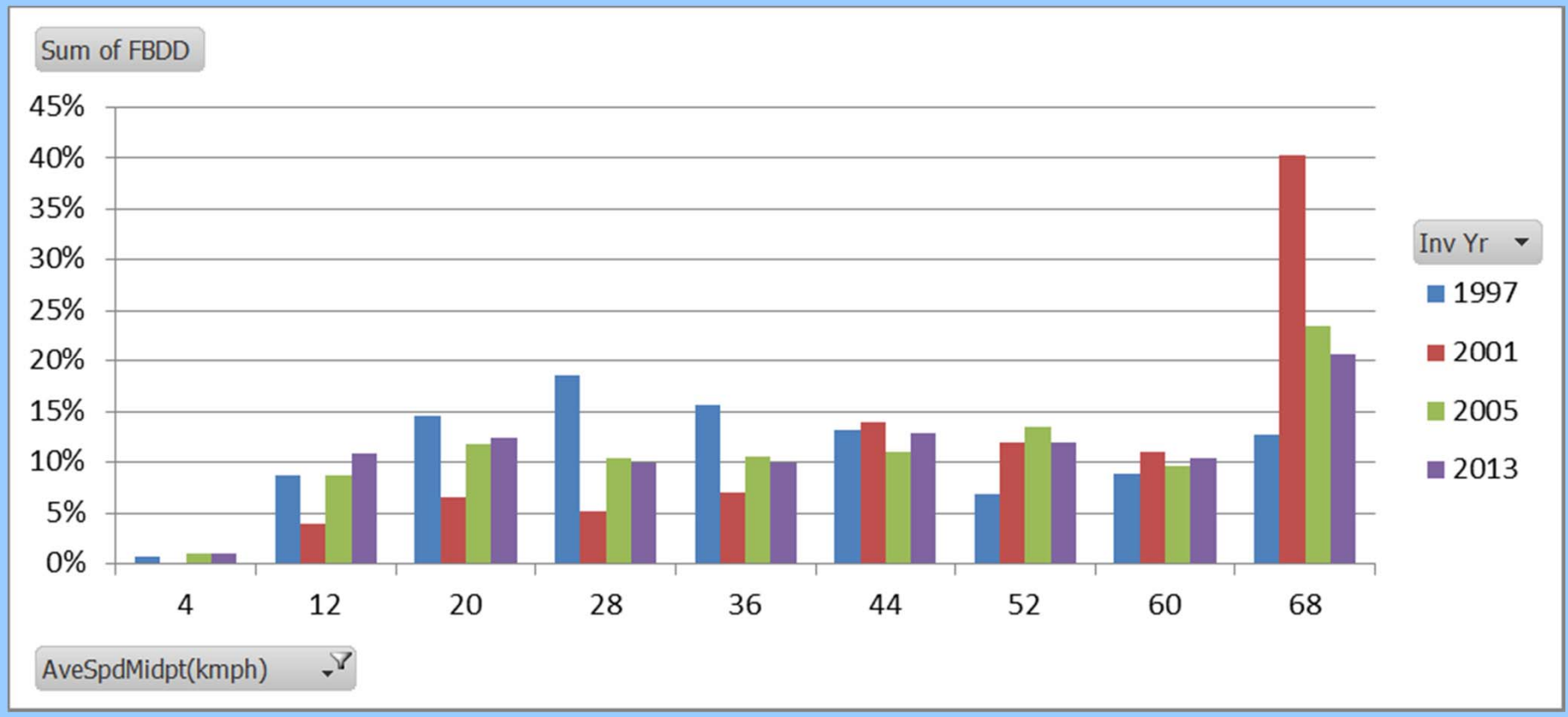
=VKT by class * % Traffic volume in one direction at spd$_k$

VKMx within a region then lump together to give speed fractions.

# Speed Fractions for Private Cars at Peak Hours



# Speed Fractions for Franchised Buses at Peak Hours

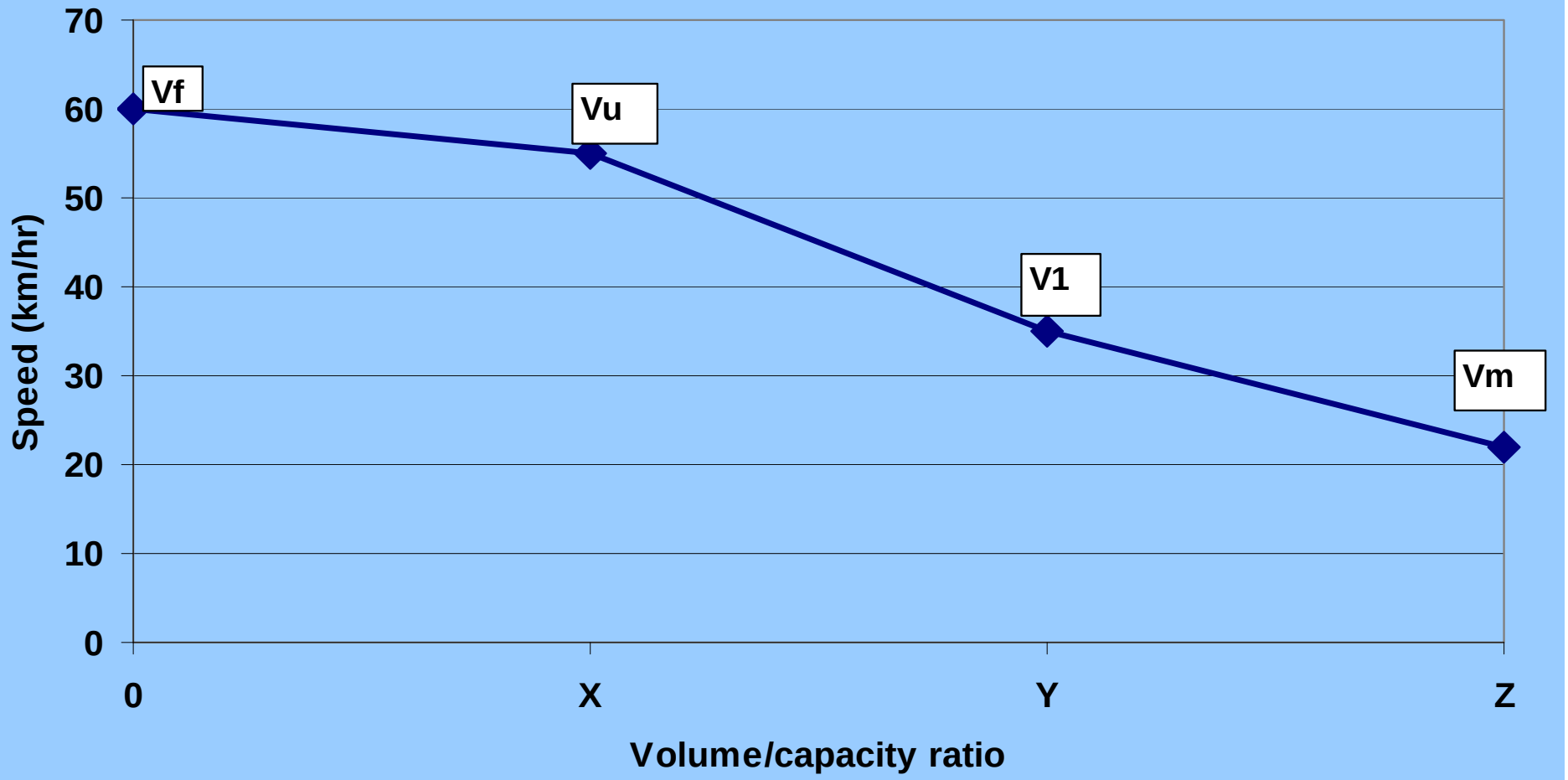


# Non Peak (1)

Data Sources

- Speed limits (Highway Dept)
- Speed vs. volume/capacity ratio from CTS-3

# Link Speed Flow Curves



# Link Speed Flow Curves

| Road Type | Vf | Vu | V1 | Vm | X | Y | Z |
|---|---|---|---|---|---|---|---|
| Rural Road A | 60 | 55 | 35 | 22 | 0.4 | 1.0 | 1.2 |
| Rural Trunk Road | 75 | 70 | 45 | 30 | 0.4 | 1.0 | 1.2 |
| Urban Local Distributer | 30 | 30 | 12 | 5 | 0.1 | 1.0 | 1.2 |
| Urban District Distributer | 40 | 40 | 22 | 11 | 0.1 | 1.0 | 1.2 |
| Urban Primary Distributer | 50 | 50 | 27 | 16 | 0.2 | 1.0 | 1.2 |
| Urban Trunk Road | 70 | 70 | 45 | 30 | 0.4 | 1.0 | 1.2 |
| Expressway | 90 | 85 | 65 | 40 | 0.4 | 1.0 | 1.2 |

# Passenger Car Unit Conversion Factors

| Vehicle Type | PCU Conversion Factors |
|---|---|
| Car | 1 |
| Taxi | 1 |
| Bus | 3 |
| PLB | 1.5 |
| Light Van | 1.25 |
| Light Goods Vehicle | 1.5 |
| Medium Goods Vehicle | 2 |
| Heavy Goods Vehicle | 2.5 |

# Non-Peak Hour (1)

- [avgMF] – average of traffic% in passenger car unit over each period by station
- [avgMF]=veh%* [MF]*PCU/100
- [maxMF] = veh% * a.m. peak hour traffic flow in passenger car unit / AADT

[MF] is found in TD's ATC

# Non-Peak Hour (2)

If speed limit = 50 km/hr, use congested speed to find volume/capacity ratio, VC ratio

- Congested speed > 50km/hr, use congested speed

- Congested speed ≤ 50km/hr:
  - Congested speed > free flow speed: use spd limit
  - Congested speed ≤ free flow speed

  use VCnonPH / VCcongested

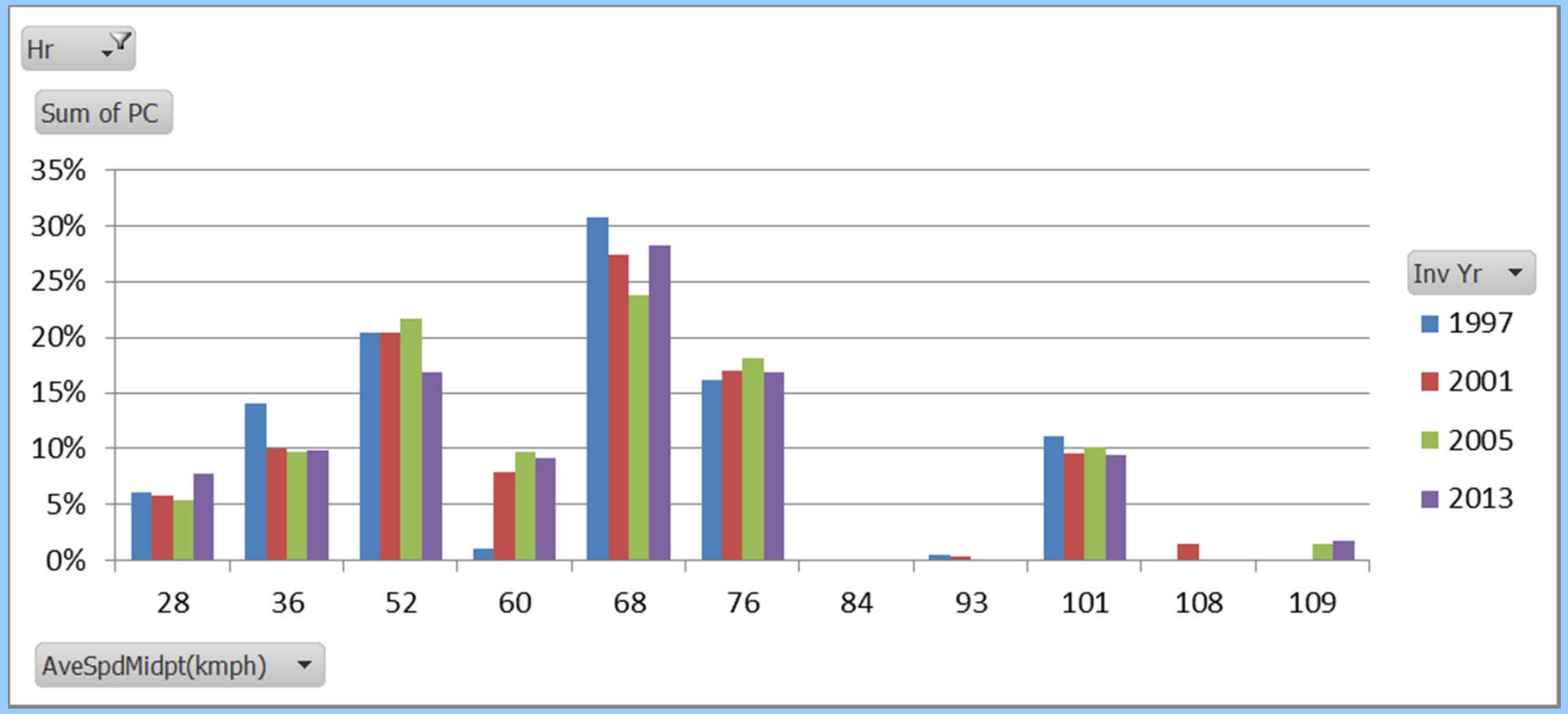
  =[avgMF] / [maxMF]

  to calculate corresponding speed for non-PH

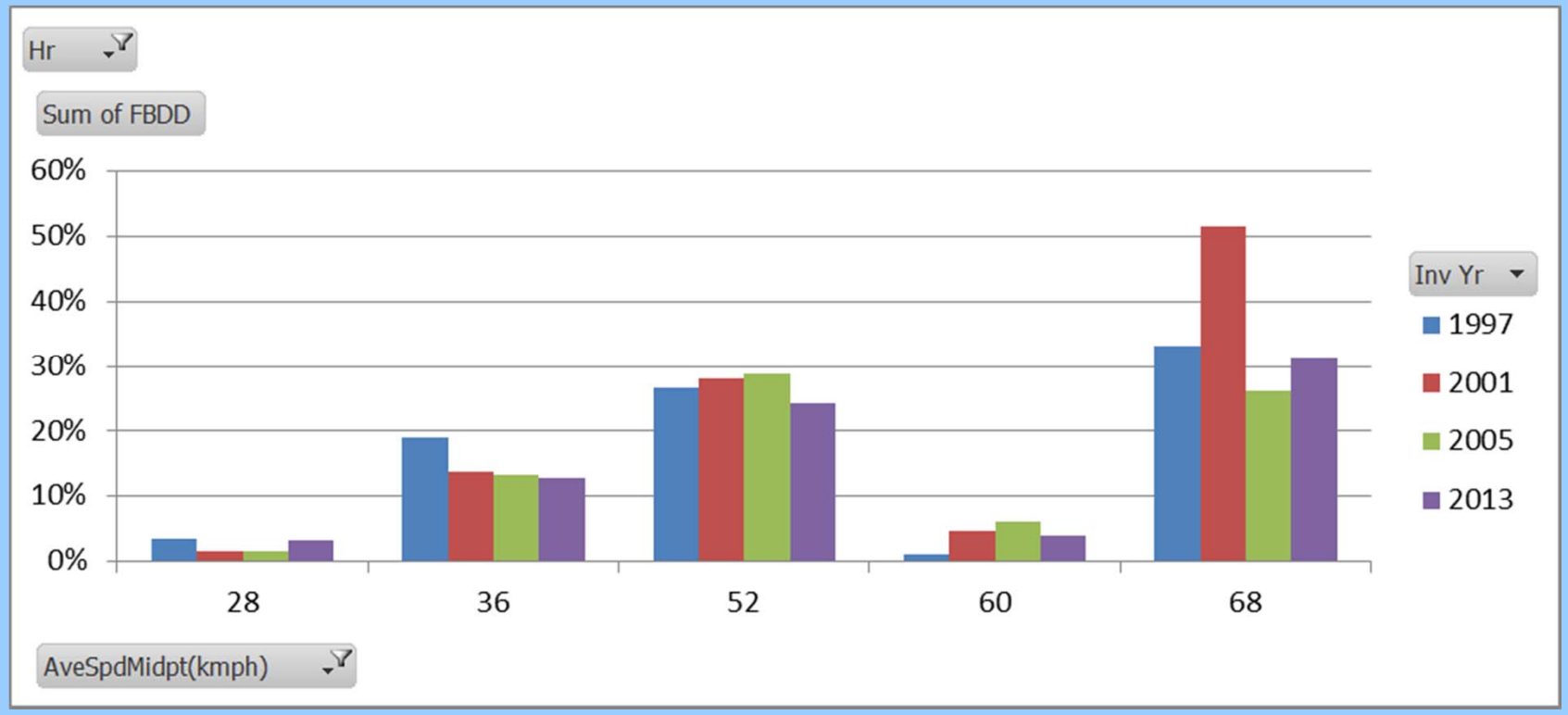
# Non-Peak Hour (3)

- If speed limit > 50 km/hr, use speed limit.
- Calculation of speed fractions for non-peak daytime and non-peak nighttime was then similar to speed fractions at peak hour
- Will use the data obtained during vehicle emission measurements using PEMS

# Speed Fractions for Petrol Cars at Daytime non-peak Hours (using speed limit)



# Speed Fractions for Franchised Buses at Daytime non-peak Hours (using speed limit)



Thank you.