

Adaption of HBEFA Emission Factors for Road Transport for Chinese Cities

Shengyang Sun
Sustainable Transport Programme, GIZ China

April, 2014



Outline

- **Background information for adaption of emission factors**
- Approach to adapt HBEFA to China
- Localized emission factors and comparison of the selected traffic situations
- Emission quantification tool - software package



Overview of worldwide existing models used for the calculation of traffic-related emissions

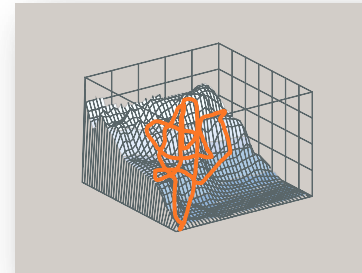
Motor Vehicle
Emission Simulator
(MOVES)



EMFAC



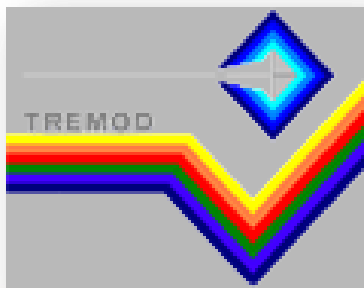
Passenger car and Heavy duty
Emission Model (PHEM)



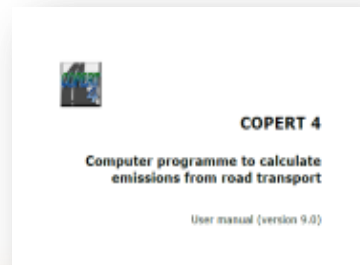
Handbook Emission
Factors of Road
Transport (HBEFA)



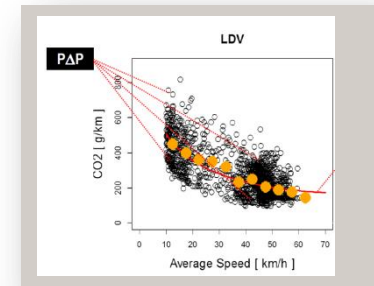
Transport Emission
Model (TREMOD)



Computer Programme
to calculate Emissions
from Road Transport
(COPERT)

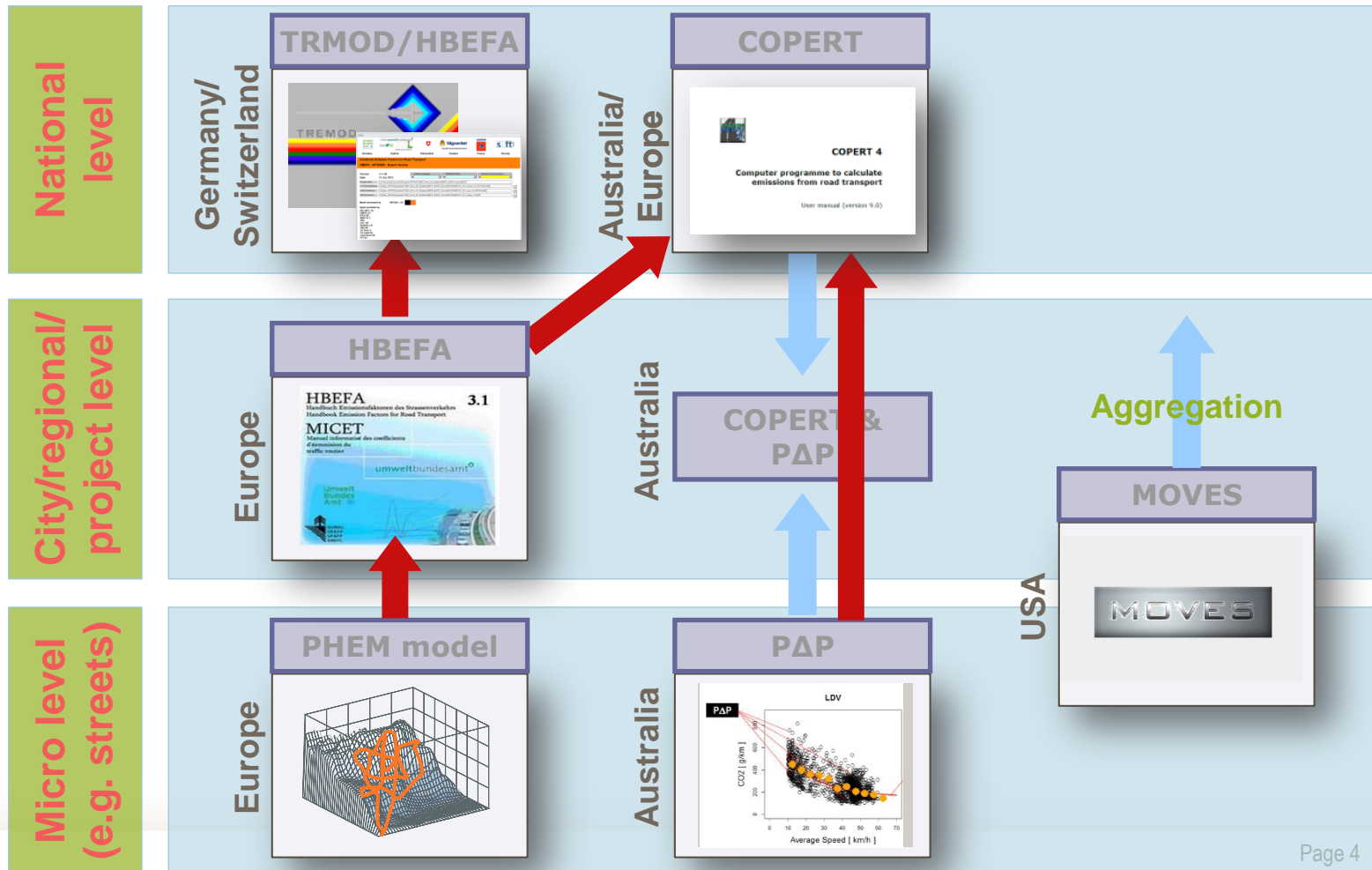


Power-Delta-Power
Model (PΔP)





Classification of different emission models used in Europe, Australia and USA





HandBook on Emission Factors for Road Transport (HBEFA)



- HBEFA is emission factor database for road transport which is developed on behalf of several European countries (e.g. Germany, Switzerland, Austria, Sweden, Norway, France)
- in 1995 the first version of HBEFA was published, since there it was continuously enhanced
- HBEFA provides emission factors (hot, cold start, evaporation) for all regulated and important non-regulated air pollutants as well as for fuel consumption and CO₂ emission



HBEFA provides emission factors for different sub-segments

Vehicle categories	Vehicle size	Fuel types	Emission Standards	Reduction technologies
Passenger Car	PC < 1.4 L	Gasoline	Pre Euro 1	Particle filter
Motorcycle	PC 1.4-2.0 L	Diesel	Euro 1	SCR
Urban bus	PC > 2.0 L	LPG	Euro 2	EGR
Coaches	Truck ≤ 7.5 t	CNG	Euro 3	...
Light duty veh.	Truck 7.5-12 t	FFV	Euro 4	
Single truck	Truck 12-14 t		Euro 5	
Truck trailer ¹⁾	...		Euro 6	

Abbreviations: PC = Passenger car; LPG = Liquefied Petroleum Gas; CNG = Compressed Natural Gas; FFV = Flexible Fuel Vehicles; SCR = Selective Catalytic Reduction; EGR = Exhaust Gas Recirculation

¹⁾ Including articulated vehicles.



Emission factors of HBEFA depends additionally on traffic situations

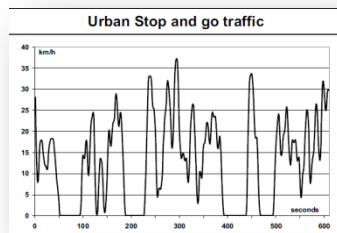
- **traffic situations** of HBEFA are categorised by:
 - › **areas:** urban/rural
 - › **road types:** e.g. motorway, trunk road
 - › **speed limits:** e.g. 50 km/h
 - › **levels of services:** free flow, heavy traffic, saturated, stop & go
- 276 different traffic situations (more than 120 for urban areas)

			Speed Limit [km/h]											
Area	Road type	Levels of service	30	40	50	60	70	80	90	100	110	120	130	>130
Rural	Motorway-Nat.	4 levels of service												
	Semi-Motorway	4 levels of service												
	TrunkRoad/Primary-Nat.	4 levels of service												
	Distributor/Secondary	4 levels of service												
	Distributor/Secondary(sinuous)	4 levels of service												
	Local/Collector	4 levels of service												
	Local/Collector(sinuous)	4 levels of service												
	Access-residential	4 levels of service												
Urban	Motorway-Nat.	4 levels of service												
	Motorway-City	4 levels of service												
	TrunkRoad/Primary-Nat.	4 levels of service												
	TrunkRoad/Primary-City	4 levels of service												
	Distributor/Secondary	4 levels of service												
	Local/Collector	4 levels of service												
	Access-residential	4 levels of service												

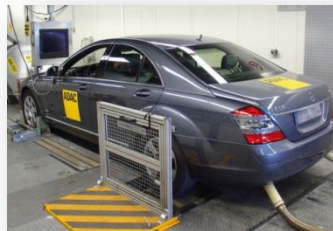


Ideal concept for measurement of real world emissions to generate reliable emission factors

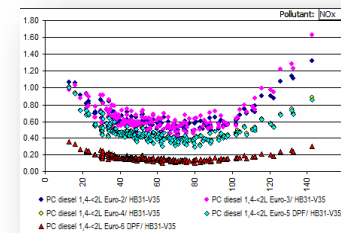
- › **Ideal concept:**
 - › emission measurement of each traffic situation



Traffic situations



Roller test bench

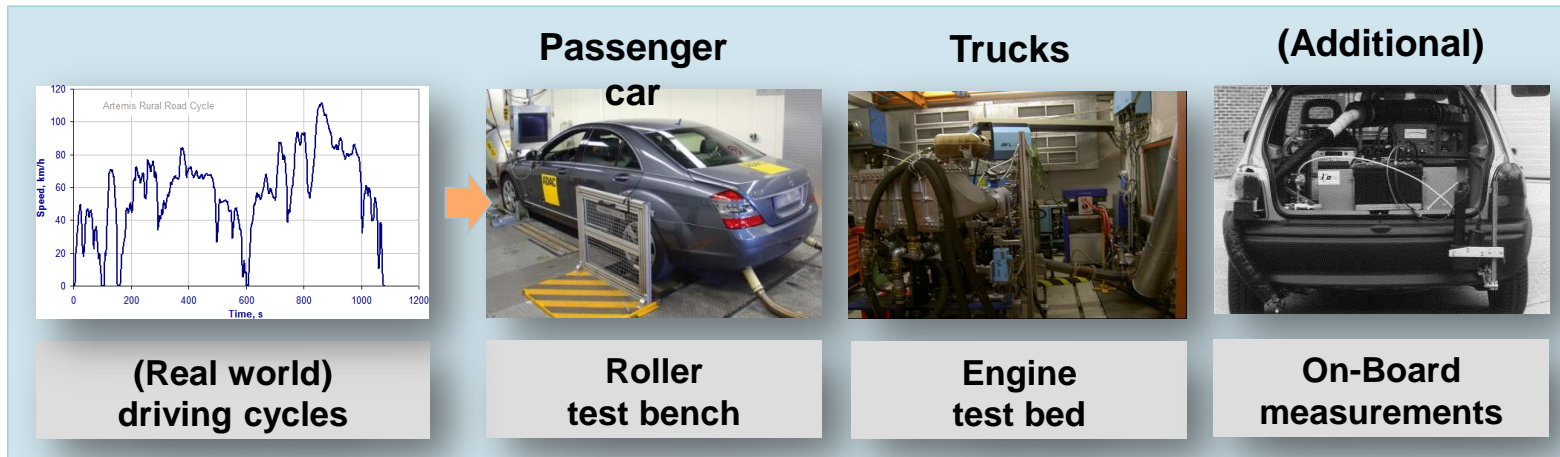


Emission factors

- › **Practical restrictions:**
 - › emission measurement of all 276 traffic situation is hardly feasible
 - › it is too costly and time-consuming
- › **HBEFA approach:**
 - › use of a computer model to derive emission factors for traffic situations
 - › emission calculation tool of the computer model is calibrated with emission measurements based on (real world) driving test cycles



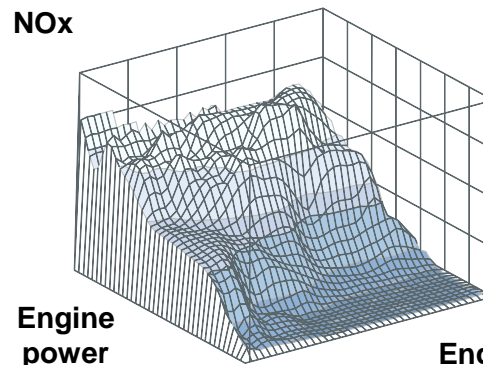
Measurement of real world emissions to generate engine maps



Engine maps

- › Engine maps are based on real world measurements data
- › Type approval cycles can't be used

NO_x



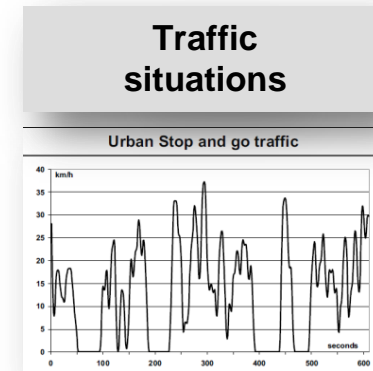
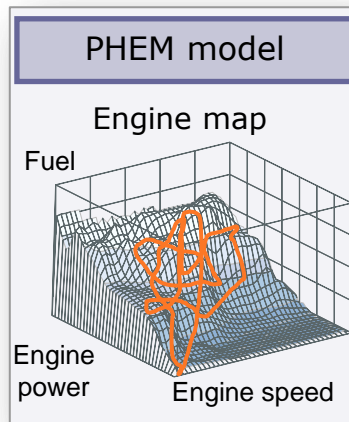
Engine power

Engine speed

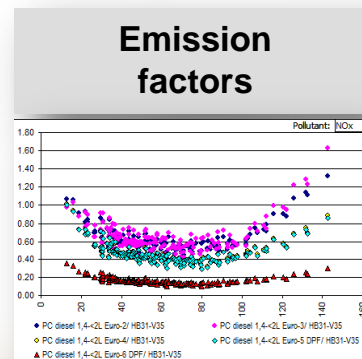
PHEM model



HBEFA approach: Calculation of emission factors for all traffic situations using the PHEM model



- approach is also feasible for other countries
- existing engine maps (particularly for CO₂) can be used for the calculation of emission factors based on local traffic situations



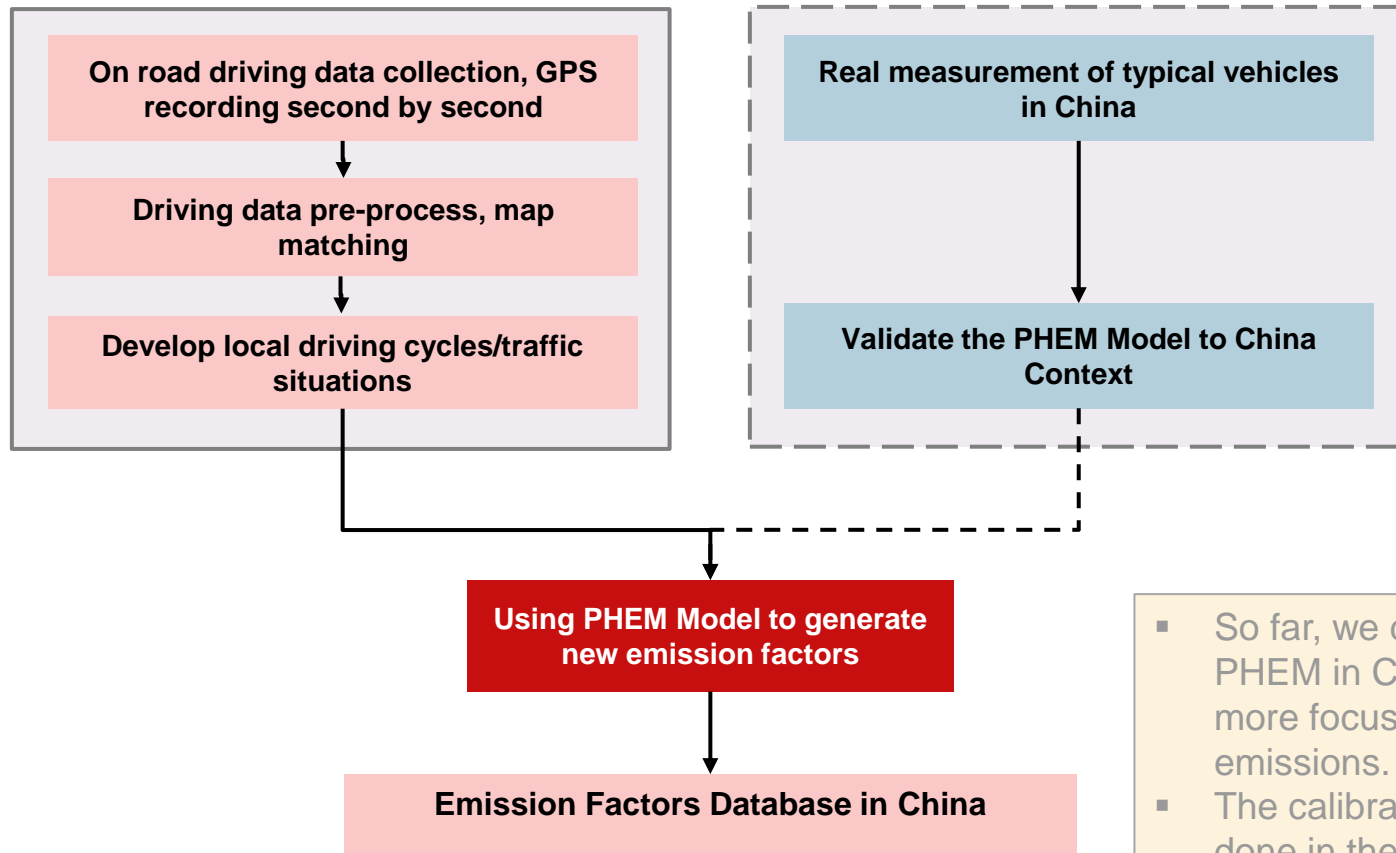


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Approach to Localize HBEFA



- So far, we did not calibrate PHEM in China since we are more focusing on carbon emissions.
- The calibration work will be done in the next step when focusing more on pollutants



Specification of Traffic Situations in China

Considering the on road traffic conditions and network performance in Beijing, traffic situations was specified as:

- 5 road type: Highway, Expressway, Major Arterial, Minor Arterial, and Branch Road
- Speed limit for each road type
- 5 Level of Service (comparing to 4 LOS in HBEFA)

Level of service	LOS 1: Free flow	LOS 2: Saturated traffic	LOS 3: Heavy traffic	LOS 4: Stop and go	LOS 5: Heavy stop and go
Congestion level	Unimpeded	Basically Unimpeded	Mild congestion	Moderate congestion	Severe congestion
Unit	km/h	km/h	km/h	km/h	km/h
Highway/Expressway	>55	40-55	30-40	20-30	≤20
Major arterial	>44	30-40	20-30	15-20	≤15
Minor arterial	>35	25-35	15-25	10-15	≤10
Branch	>35	25-35	15-25	10-15	≤10





On Road Driving Data Collection

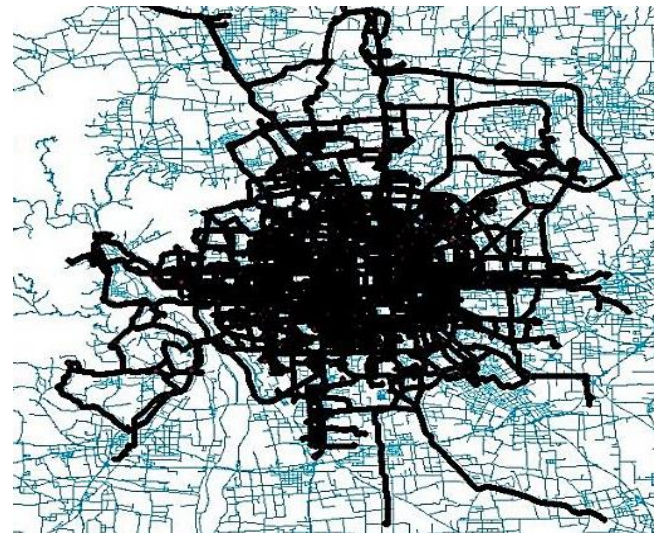
- GPS transmitters were applied to record real road vehicle movements.
- Measurements are made second by second (1 Hz)
- GPS data was collected in both Beijing and Shenzhen with a total of more than 2000 hours of driving data

GPS receiver





Map Matching to identify road type

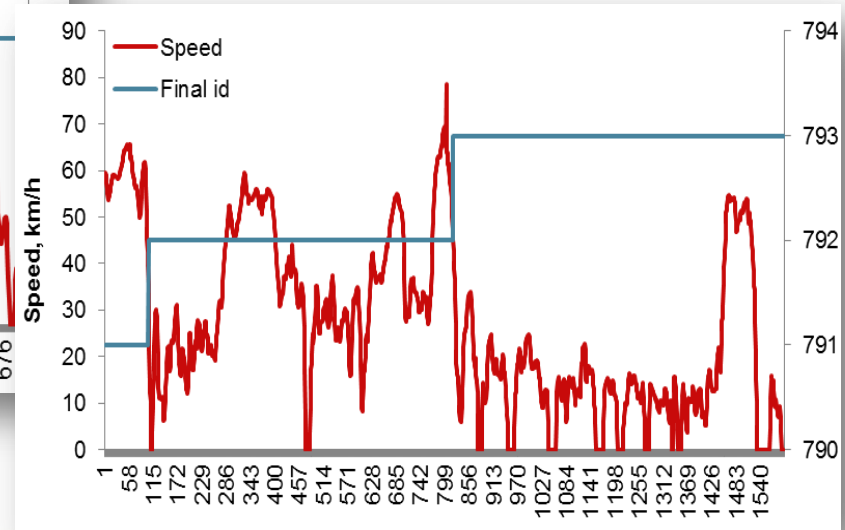
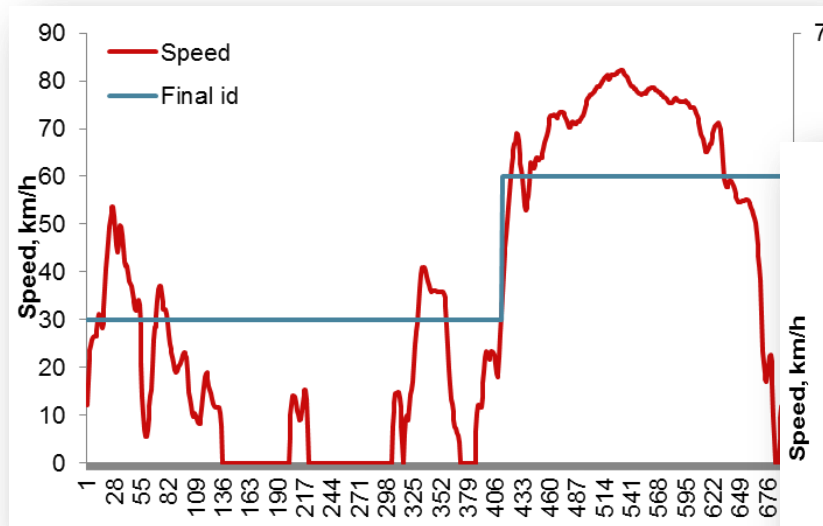


Beijing TRC floating car system was applied as a tool to conduct map matching



Separation of GPS data in so called cells for identification of typical traffic situations

- If the trip cell is longer than 120 seconds, then the cell was further reviewed to decide whether it will be subdivided based on the same LOS principle



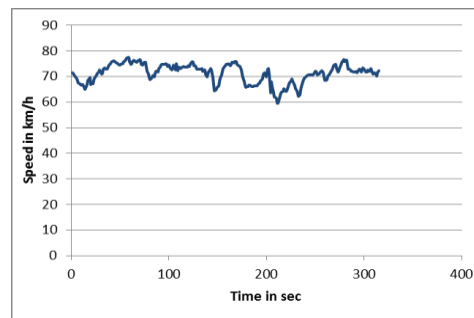


Selection of Chinese specific traffic situations *-Expressway/Highway*

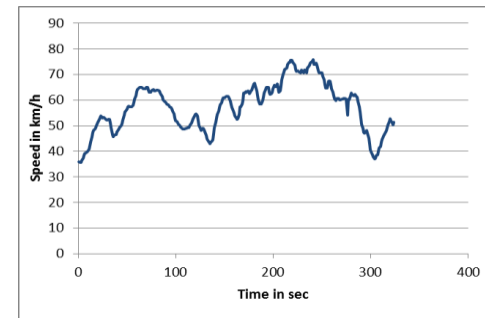
Key parameters:

	Average speed	RPA	% stop time
	km/h	m/s ³	%
LOS 1	71.2	0.09	0%
LOS 2	57.3	0.11	0%
LOS 3	42.3	0.13	1%
LOS 4	25.8	0.17	7%
LOS 5	12.0	0.17	26%

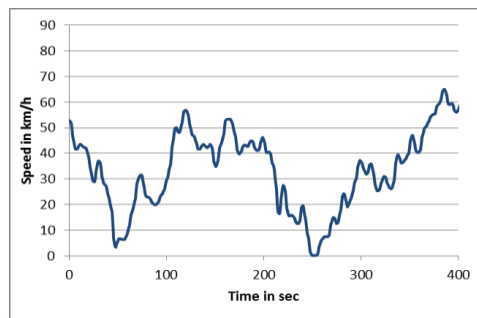
LOS 1: Free flow



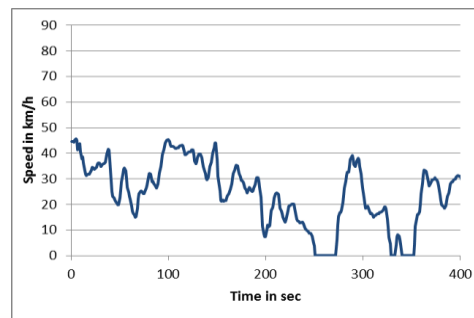
LOS 2: Heavy



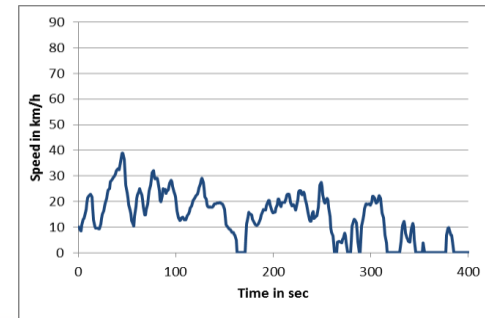
LOS 3: Saturated



LOS 4: Stop+go 1



LOS 5: Stop+go 2



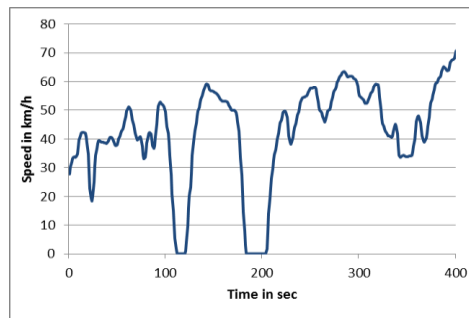


Selection of Chinese specific traffic situations *-Major Arterial*

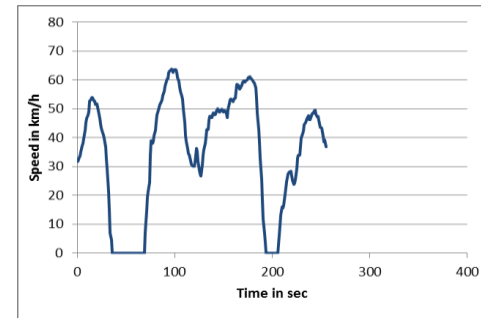
Key parameters:

	Average speed	RPA	% stop time
	km/h	m/s ³	%
LOS 1	49.8	0.17	5%
LOS 2	34.8	0.20	18%
LOS 3	24.2	0.20	28%
LOS 4	17.6	0.23	40%
LOS 5	8.4	0.21	62%

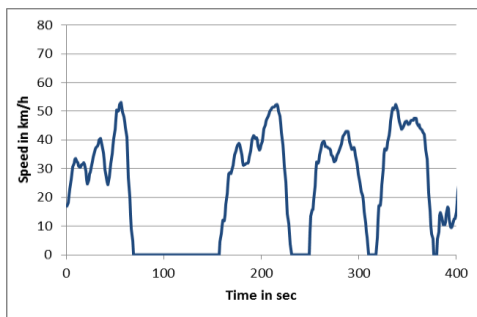
LOS 1: Free flow



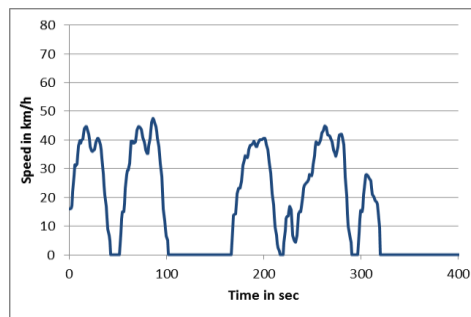
LOS 2: Heavy



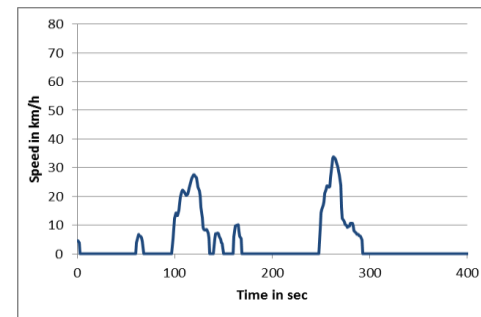
LOS 3: Saturated



LOS 4: Stop+go 1



LOS 5: Stop+go 2



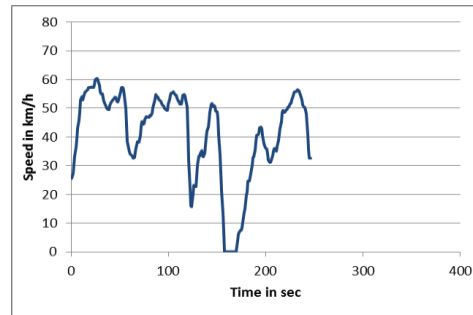


Selection of Chinese specific traffic situations *-Minor Arterial*

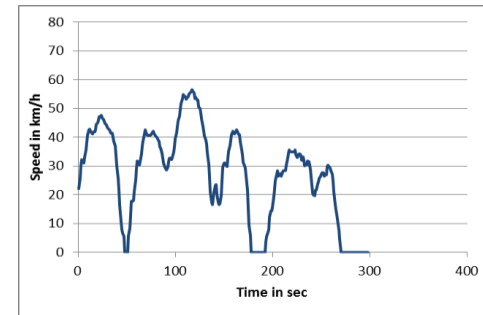
Key parameters:

	Average speed	RPA	% stop time
	km/h	m/s ³	%
LOS 1	41.0	0.19	5%
LOS 2	27.3	0.18	16%
LOS 3	18.8	0.19	27%
LOS 4	12.5	0.23	43%
LOS 5	5.3	0.20	65%

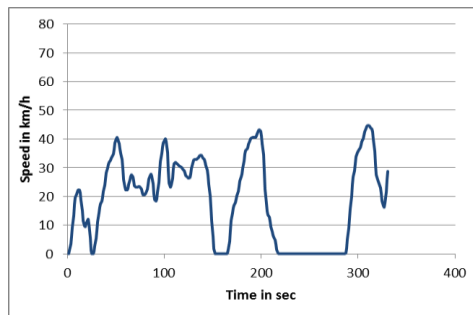
LOS 1: Free flow



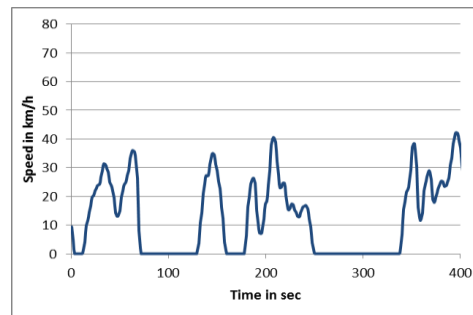
LOS 2: Heavy



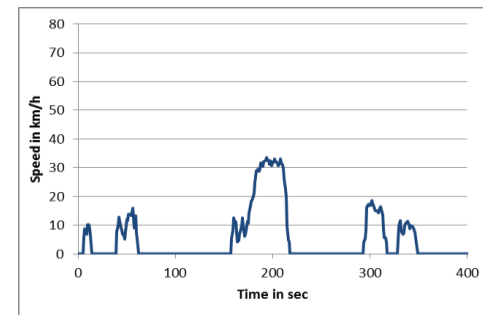
LOS 3: Saturated



LOS 4: Stop+go 1



LOS 5: Stop+go 2



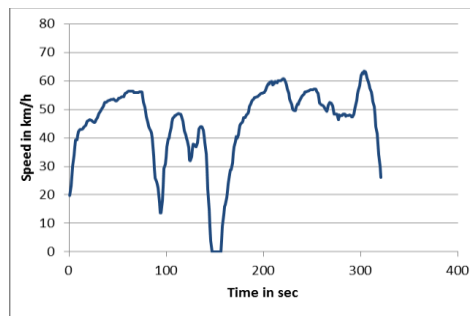


Selection of Chinese specific traffic situations *-Branch*

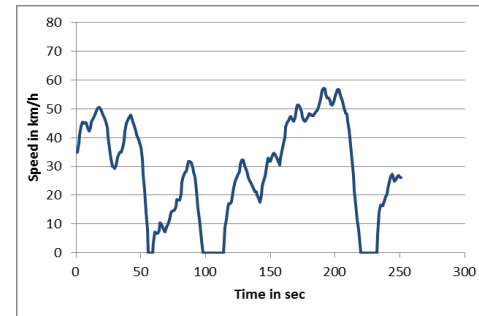
Key parameters:

	Average speed	RPA	% stop time
	km/h	m/s ³	%
LOS 1	45.7	0.12	3%
LOS 2	28.5	0.20	14%
LOS 3	19.6	0.19	21%
LOS 4	11.9	0.19	27%
LOS 5	4.5	0.18	60%

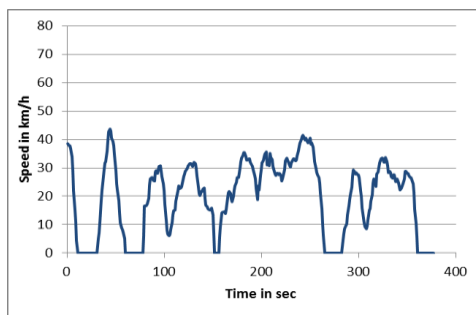
LOS 1: Free flow



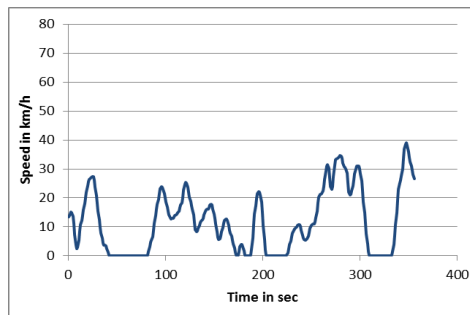
LOS 2: Heavy



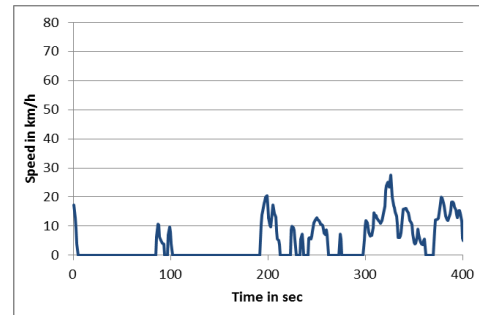
LOS 3: Saturated



LOS 4: Stop+go 1

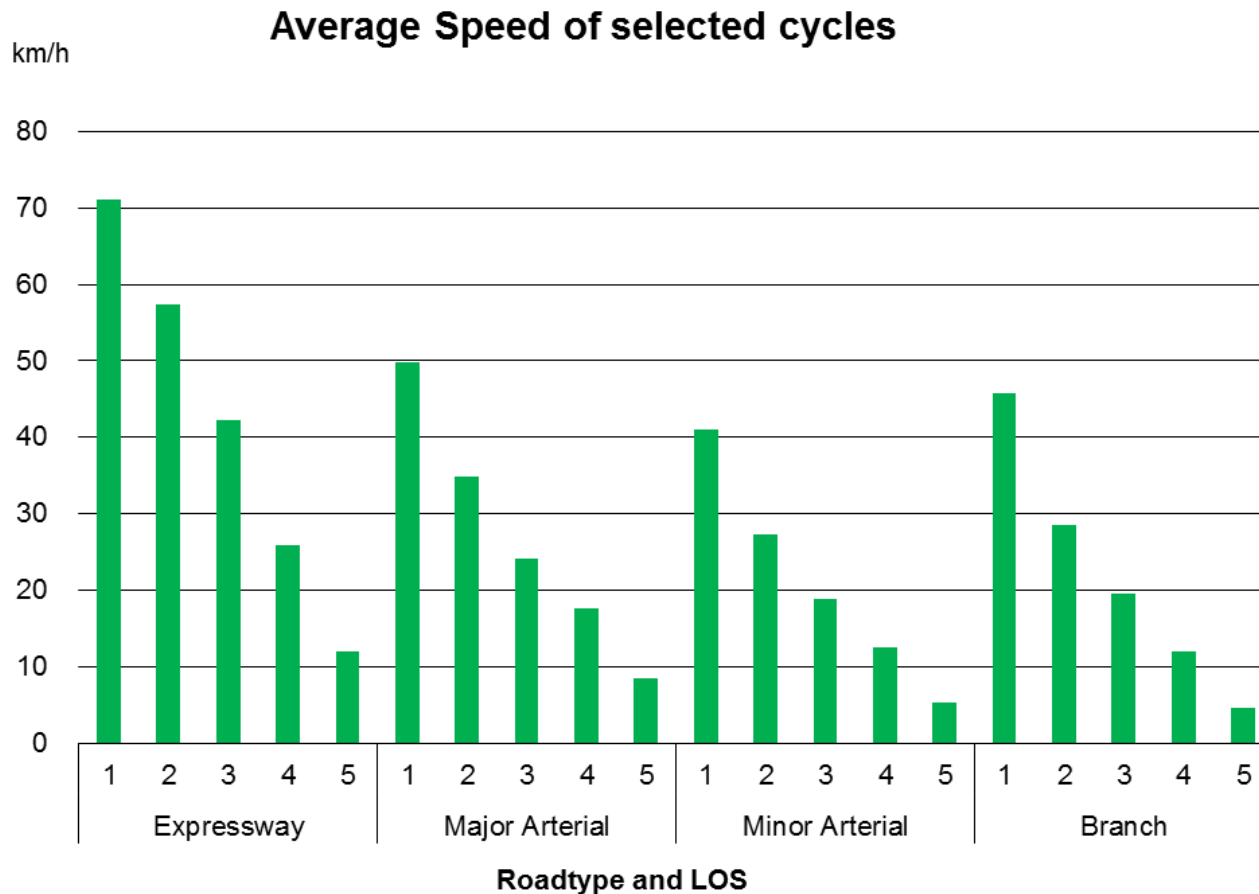


LOS 5: Stop+go 2



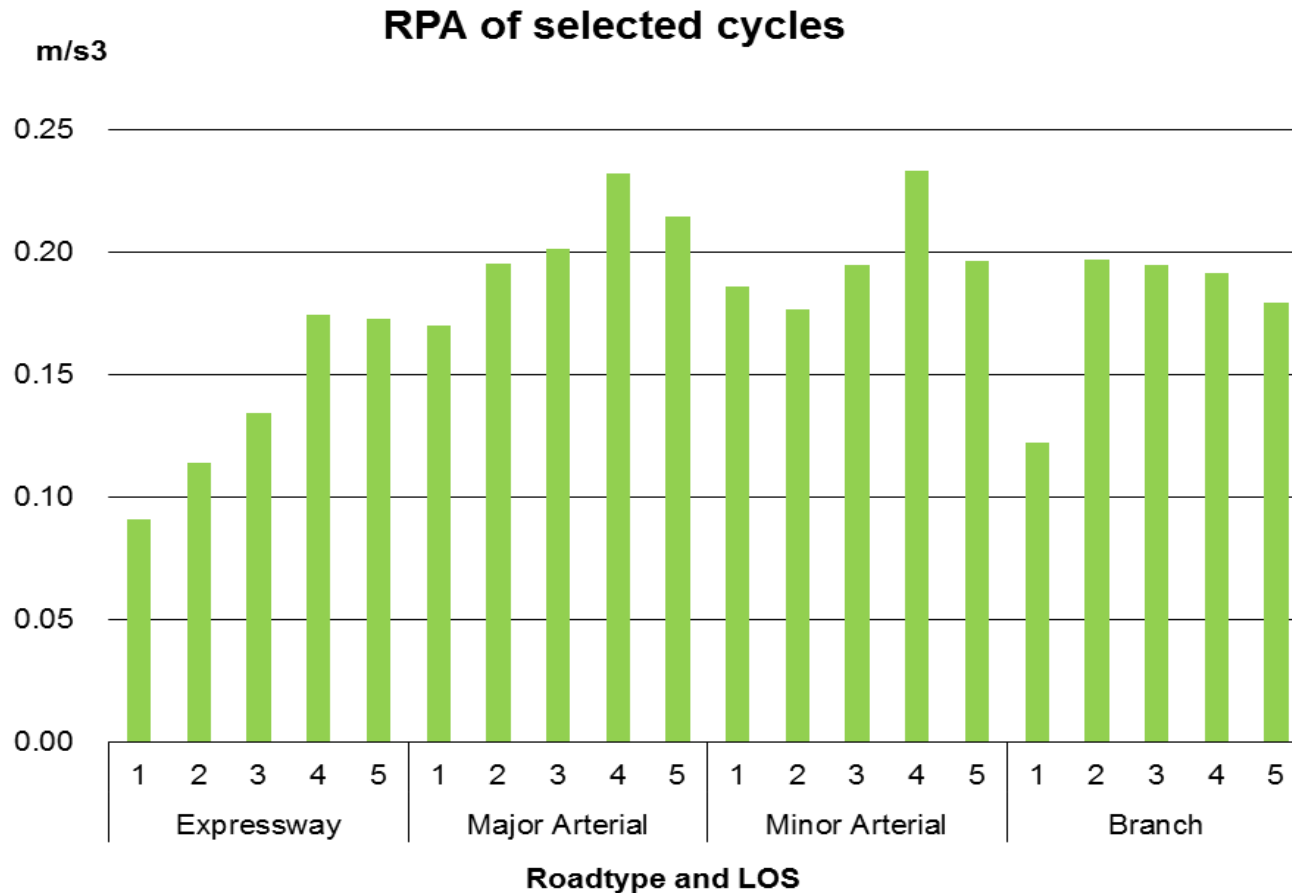


Average speed of the typical Chinese traffic situations





Relative positive acceleration (RPA) of the typical Chinese traffic situations





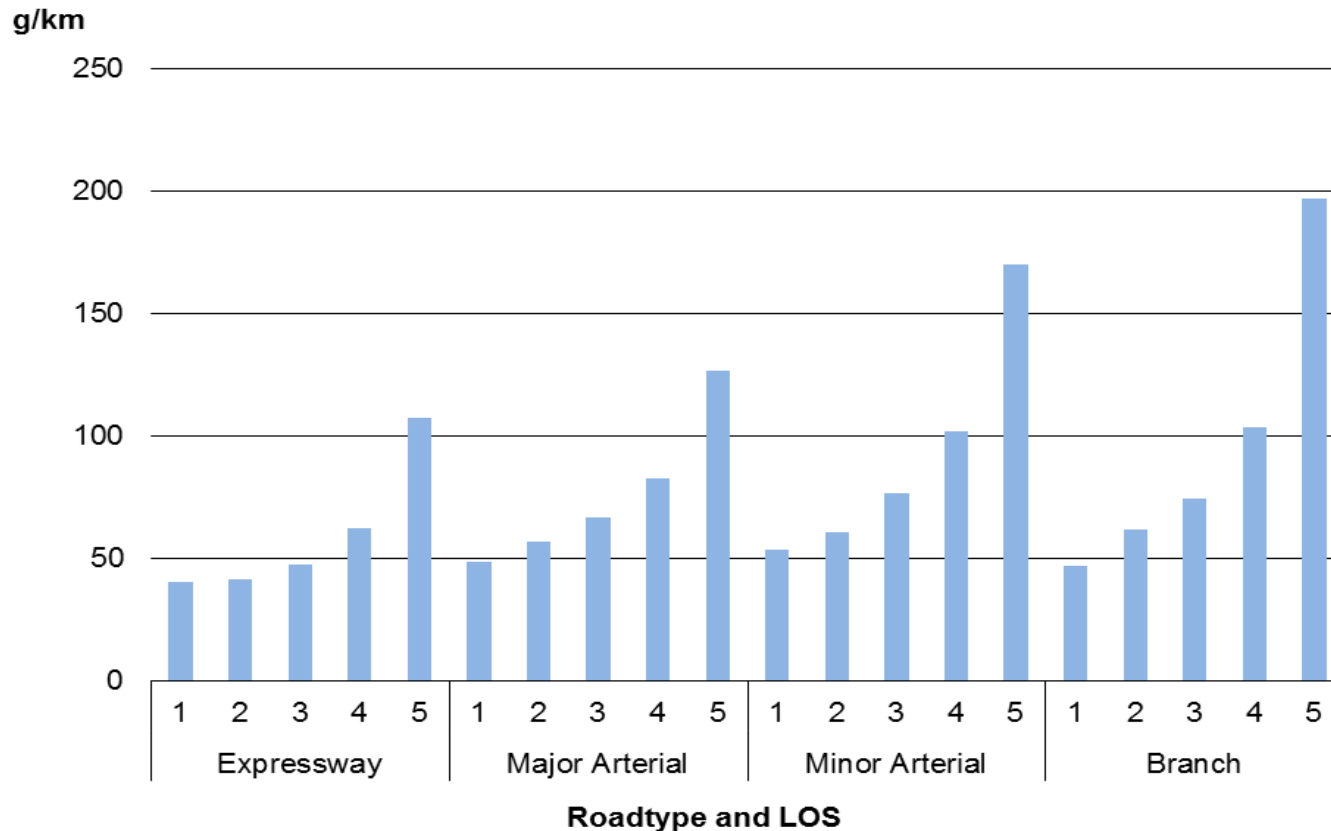
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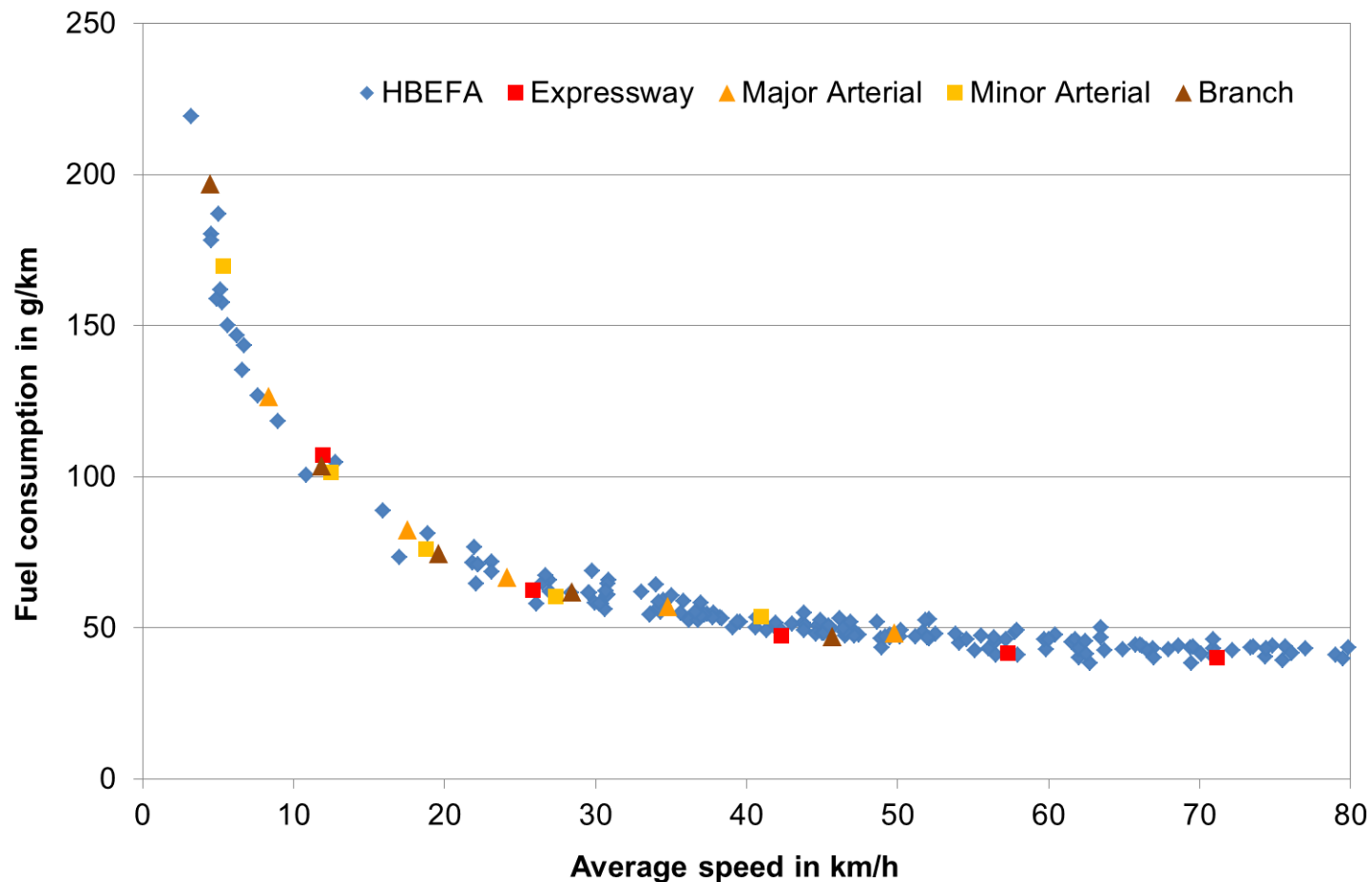
Fuel consumption of gasoline fueled passenger cars (Euro 3) for the Chinese traffic situations

Fuel consumption of selected cycles





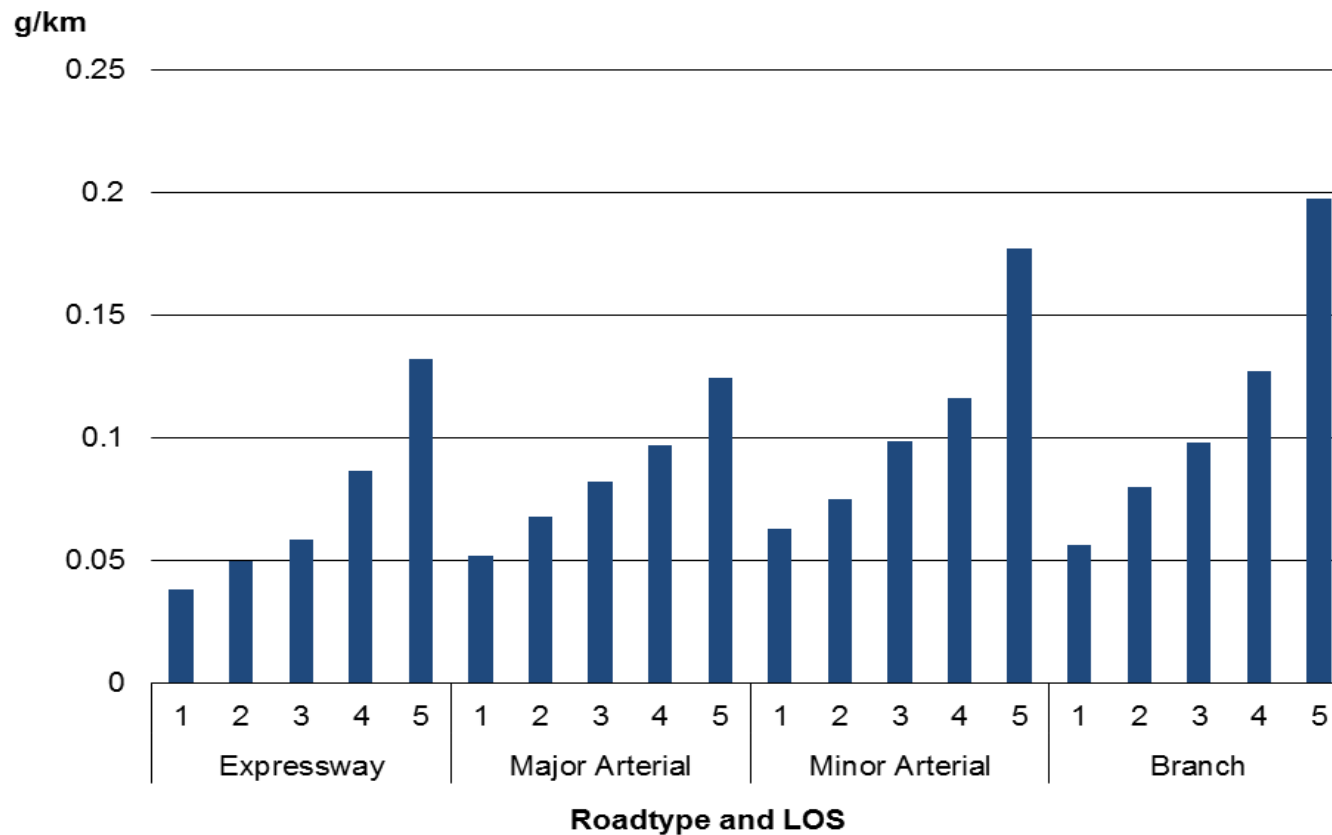
Fuel consumption of gasoline fueled passenger cars (2002): Chinese and HBEFA traffic situations





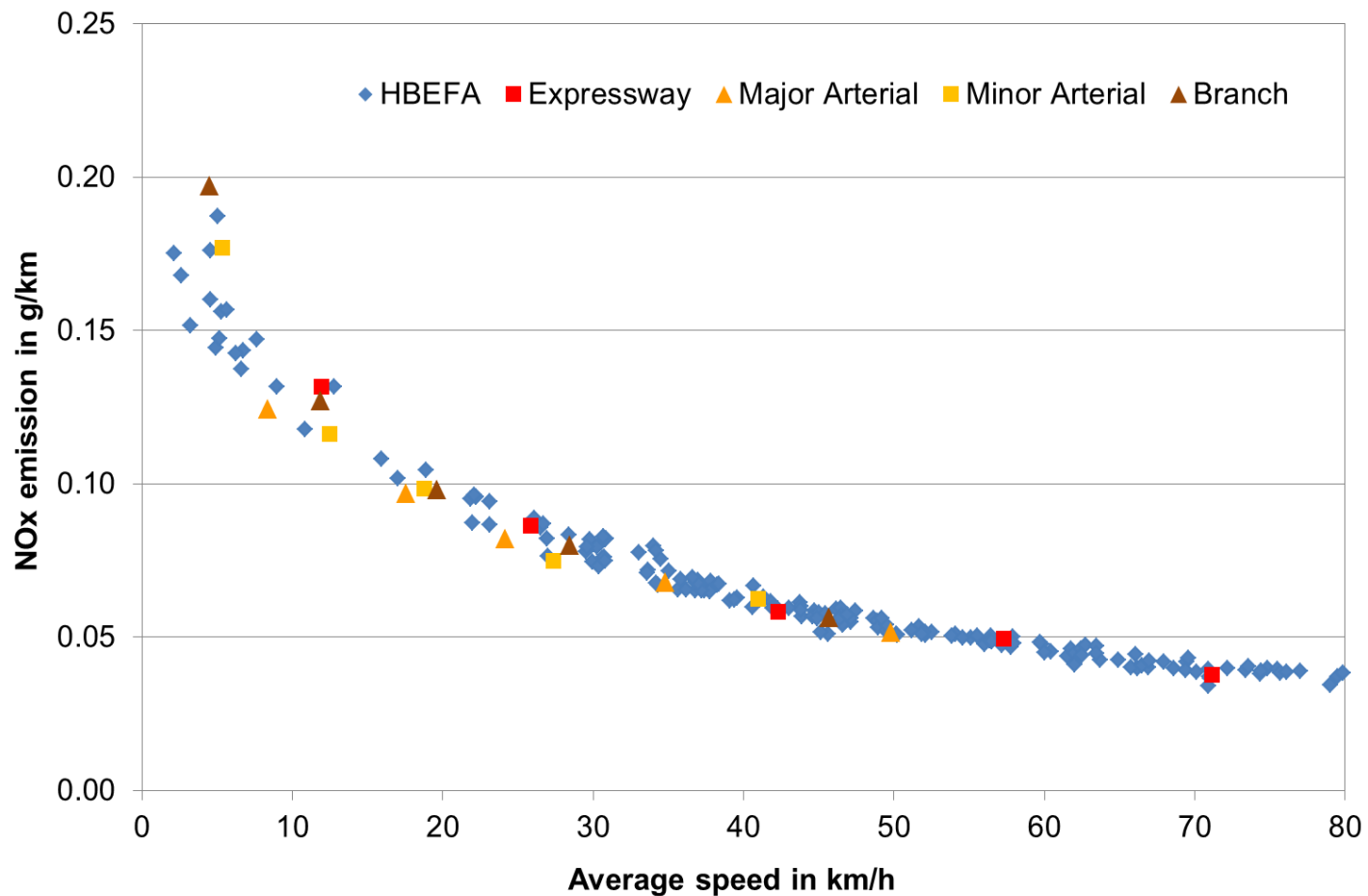
NOx emissions of gasoline fueled passenger cars (Euro 3) for the Chinese traffic situations

NOx emissions of selected cycles





NOx emissions of gasoline fueled passenger cars (Euro 3): Chinese and HBEFA traffic situations





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Handbook on Emission Factors for Road Transport for China developed by GIZ

The screenshot shows the HBEFA Wizard for Traffic Data Sets (TDS) interface. The window title is "HBEFA". The main content area is orange and contains the following text:

Welcome to the HBEFA-Wizard for Traffic Data Sets (TDS)!
It will guide you through the generation of a new TDS - step by step.

giz

Handbook

HBEFA - E

Version
Date

Model devel

1. Select aggregation level
2. **Fleet composition**
3. Traffic situation pattern
4. Ambient conditions pattern
5. Years in TDS
6. Vehicle categories in TDS
7. Create TDS

Which fleet composition do you want to use in your TDS?

Use an existing fleet composition
 Edit an existing fleet composition
 Create a new fleet composition (starts wizard for running the fleet model)

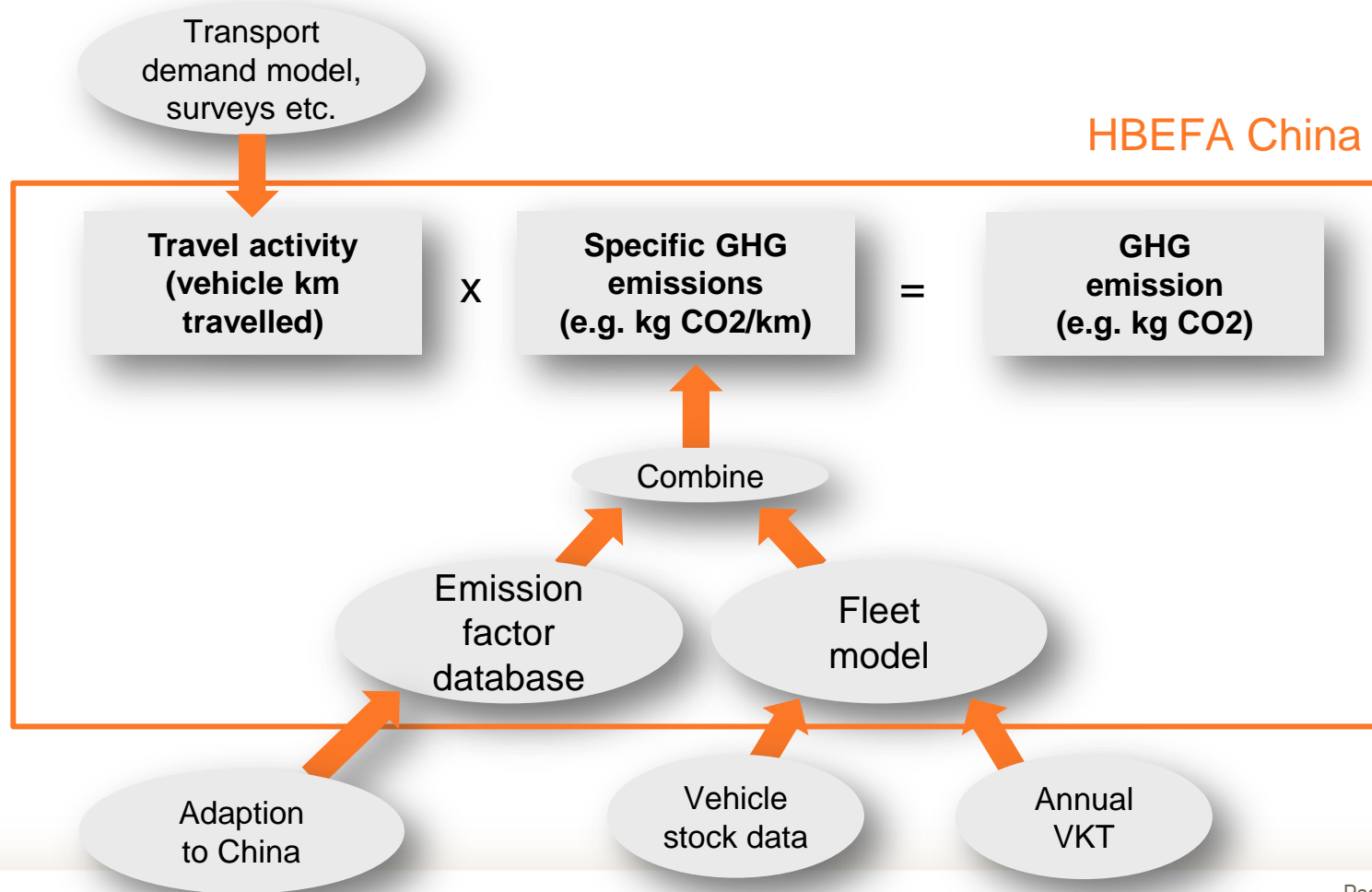
Select fleet composition:

Description	Tier 1 city	Tier 2 city	Tier 3 city
Passenger car fleet	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Taxi fleet	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Urban bus fleet	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Light duty truck fleet	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Heavy duty truck fleet	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Medium duty truck fleet	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Buttons: Cancel, Previous, Next



HBEFA Expert Version and interfaces to other external data sources



Thank you for your attention!

Shengyang Sun

Project Manager, Sustainable Transport Programme, GIZ China

Email: shengyang.sun@giz.de