The Acoustical Society of New Zealand

NZ TRANSPORT AGENCY WAKA KOTAHI

MÜLLER-BBM

Transport Acoustics Forum, Auckland, 2019-05-08

CPX road surface noise monitoring in Germany and Switzerland

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Agenda

- a short history
- road surface monitoring in Switzerland
- road surface monitoring in Germany
- minimization of uncertainties

Short history

- Germany — 1992
  - experimental device
  - no serious intents

- The Netherlands — 1998
  - lucky division of budgets:
    the ministry for transport has to pay for the road pavements, the ministry for environment has to pay for noise protection. Everyone shouts: „Save my budget!“
  - the Netherlands were the political driver for ISO standard 11819-2

- Austria — 1997
  - approval tool for cement concrete road surfaces (RVS 11.06.64)

Current situation

- Germany
  - road building that is oriented towards road building regulations without acoustic requirements
  - preventive noise protection strategy
  - no legal duties for road administrations to monitor the acoustic state of their road networks
  - therefore, no reason for road administrations to conduct CPX measurements within their road networks
  - however, in recent years, regional and local road administrations initiated CPX data collection projects to
    - find out which types of road surfaces perform better than others in terms of tyre/road noise
    - assess actions taken to improve the structural quality of road pavements

Current situation

- Germany
  terms and definitions

  tyre/road noise reference values, passenger cars

	50 km/h	80 km/h	120 km/h
SPB, dB(A)	72.7	78.8	85.2
CPX, dB(A)	-	101.0	-

  tyre/road noise level correction is determined
  3 years after construction (new considerations: 6 years)

  no acoustic life-span considerations

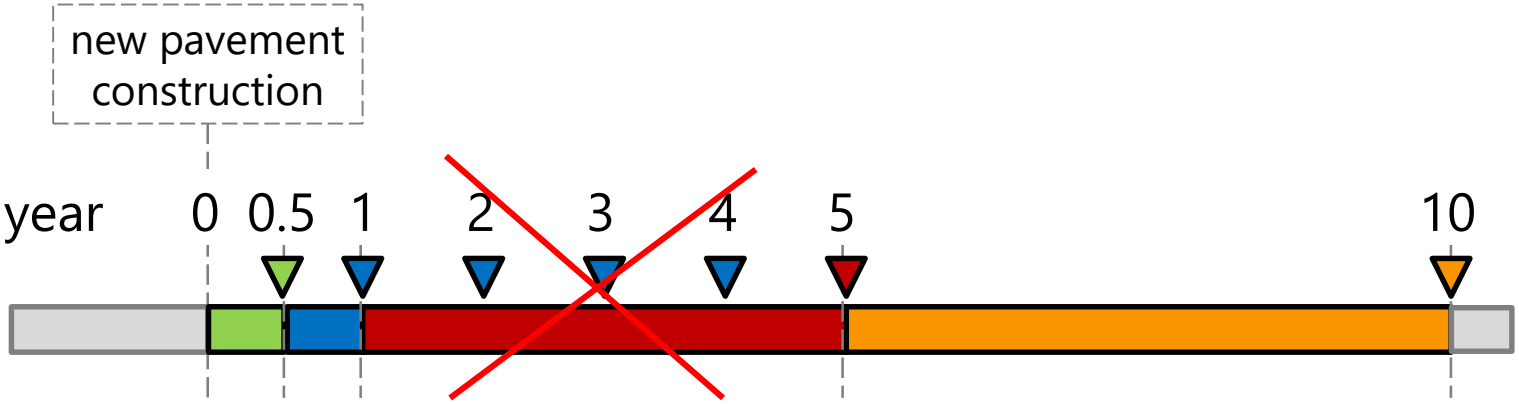
Current situation

- Germany
  facts and figures

  - 83 Mio. people
  - 357,000 km²
  - 830,000 road km
    - Autobahnen 13,000 km no speed limit
    - federal roads 38,000 km speed limit 100/120 km/h
    - state roads 87,000 km speed limit 100 km/h
    - district roads 92,000 km speed limit 100 km/h
    - rest (estim.) 230,000 km speed limit 50/80/100 km/h

Current situation

- Switzerland
  - road building that is oriented towards roads building regulations without acoustic requirements
  - both preventive noise protection and periodic revision of noise protection measures is obligatory
  - therefore, there is a legal duty to monitor the quality of the road network in terms of tyre/road noise
  - ∇ measurement schedule

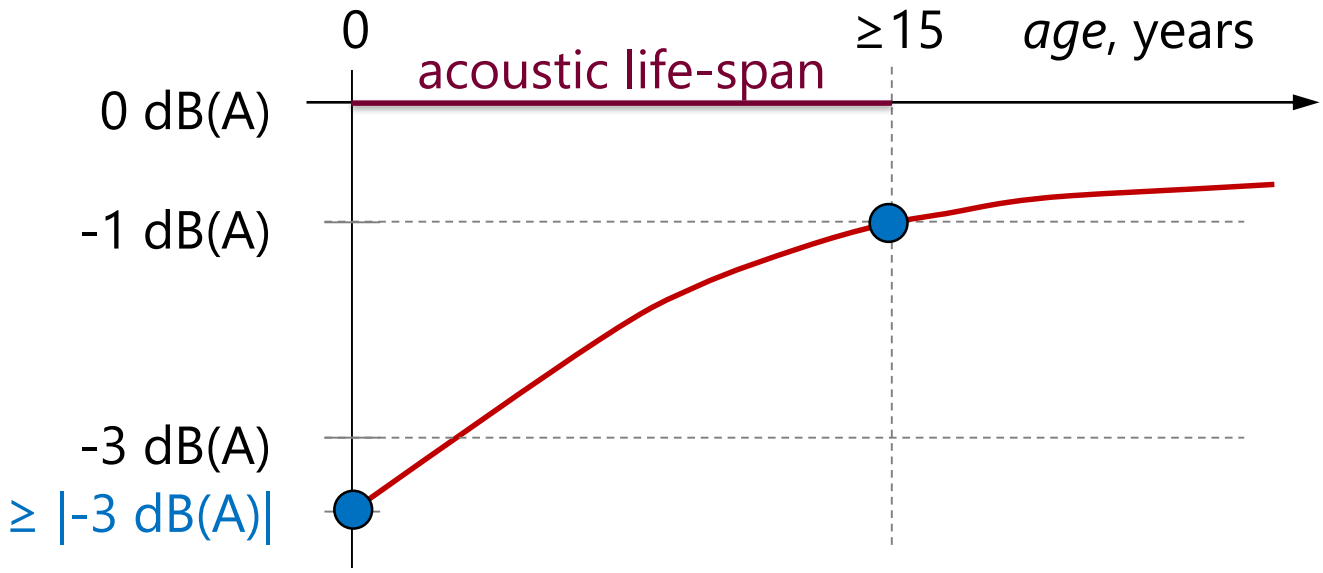


Current situation

- Switzerland
  terms and definitions
  - tyre/road noise reference values, passenger cars

	50 km/h	80 km/h	120 km/h
SPB, dB(A)	70.5	77.6	83.7
CPX, dB(A)	90.1	97.1	-

  - low noise road surface



Current situation

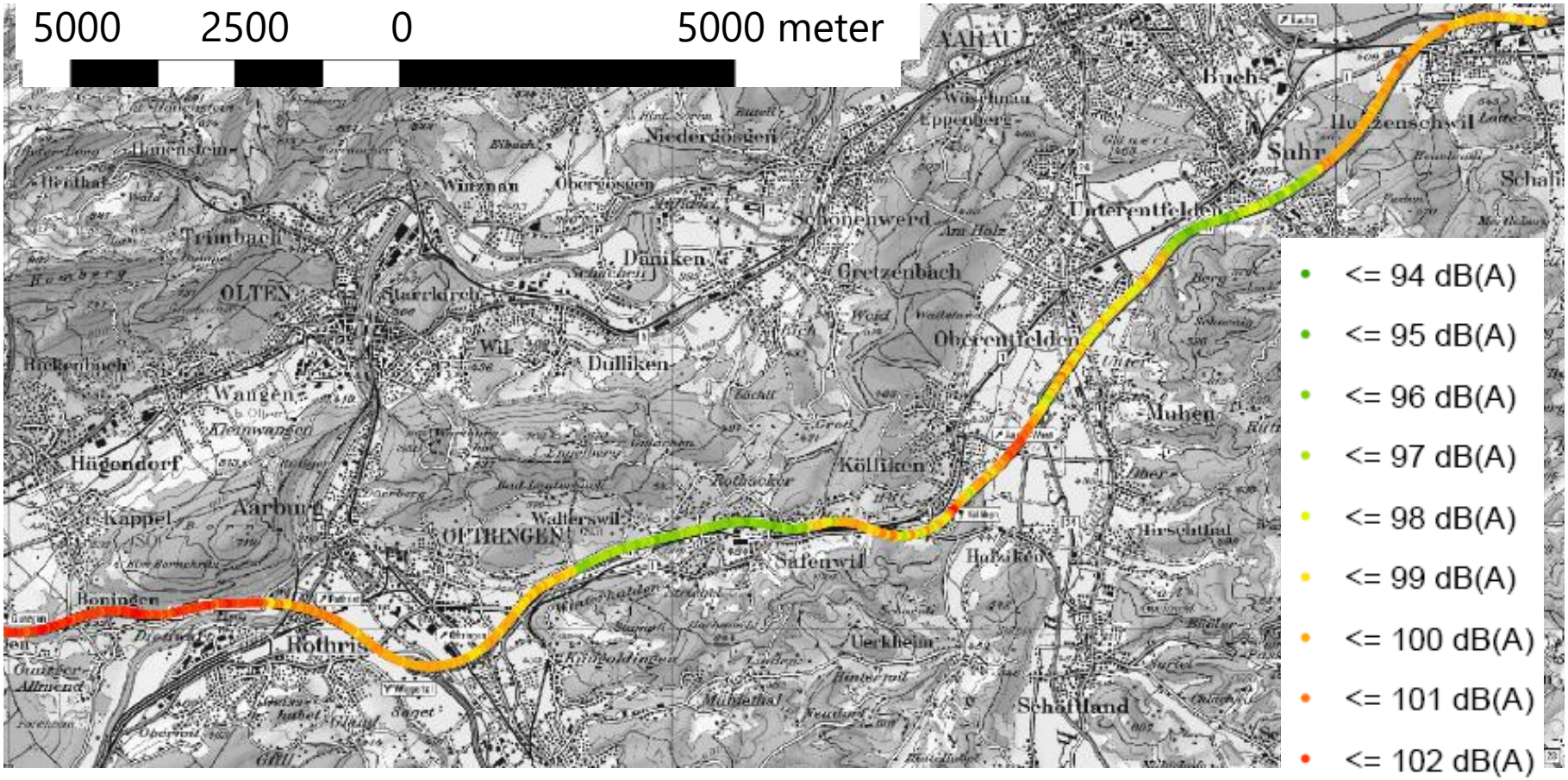
- Switzerland
  facts and figures

  - 8.5 Mio. people
  - 41,000 km²
  - 72,000 road km
    - motorways 1,500 km speed limit 120 km/h
    - federal roads 400 km speed limit 80 km/h
    - state roads 17,800 km speed limit 80 km/h
    - rest (estim.) 52,300 km speed limit 50/80 km/h

Switzerland – large scale road network monitoring in 2009

- measurement method of choice: CPX
- all motorways
- all traffic lanes on each motorway
- tyre P1 on the right, tyre H1 on the left
- one reference speed 80 km/h
- 6,400 measurement kilometers
- measurements took 3 months

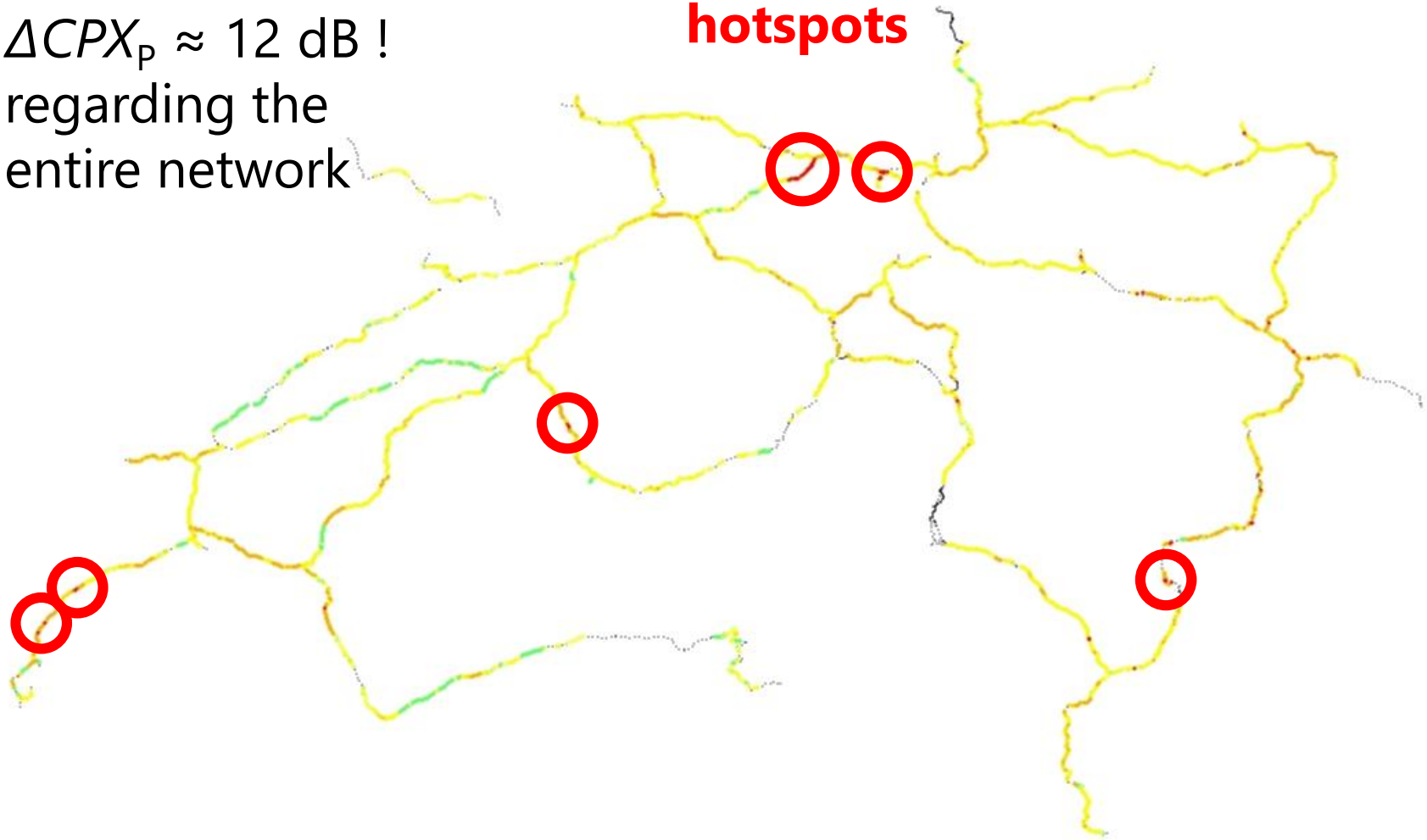
Switzerland – large scale road network monitoring



CPX_P , @80 km/h

Switzerland – large scale road network monitoring

$\Delta CPX_P \approx 12$ dB !
regarding the
entire network



Switzerland – low noise road surfaces, best practice

- Two tables: pavements with 4 to 6 mm max. grain size
  pavements with 8 to 11 m max. grain size

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Département fédéral de l'environnement, des transports, de l'énergie et de la communication DETEC
Office fédéral de l'environnement OFEV
Division Bruit et RNI

Liste des meilleurs revêtements silencieux posés en agglomération en Suisse
Liste der besten leisen Beläge innerorts in der Schweiz
Etat / Stand 17.08.2017

www.bafu.admin.ch/routes-silencieuses
www.bafu.admin.ch/leise-strassen

Konstanten für Berechnung
A 43.0
V0 50.0 Referenzgeschwindigkeit
B 20.0

surface type	date of constr.	municipality		contact person	year 0 méthode Methode	year 0 N1	year 0 N2	year 0 Mixte Misch (8% N2)	year 1 méthode Methode	year 1 N1	year 1 N2	year 1 Mixte Misch (8% N2)	ye méthode	ye N1	Mixte Misch (8% N2)
4mm - 6mm															
Nanosoft 4	2008	Plan-les-Ouates	GE	DT, Canton de Genève, Christian Gorce, christian.gorce@etat.ge.ch	CPX	-8.8	-6.7	-7.5	CPX	-8.2	-6.1	-6.9	CPX	-7.4	-7.2
PA4	2011	Hölstein	BL	TBA, Kanton Basel-Landschaft, André Schenker, andre.schenker@bl.ch											-5.7
Nanosoft 4	2012	Münchenstein	BL	TBA, Kanton Basel-Landschaft, André Schenker, andre.schenker@bl.ch	SPB	-7.7	-6.0	-6.7	SPB	-7.1	-5.8	-6.3			
Nanosoft 4	2009	Aire-la-Ville	GE	DT, Canton de Genève, Christian Gorce, christian.gorce@etat.ge.ch									CPX	-8.6	
Sapaphone 4	2009	Anières	GE	DT, Canton de Genève, Christian Gorce, christian.gorce@etat.ge.ch									CPX	-6.7	
Nanosoft 4	2009	L'Avenir	GE	DT, Canton de Genève, Christian Gorce, christian.gorce@etat.ge.ch									CPX	-7.9	
Nanosoft 4	2010	Meyrin	GE	DT, Canton de Genève, Christian Gorce, christian.gorce@etat.ge.ch					CPX	-8.5	-7.9	-8.2	CPX	-8.6	
Nanosoft 4	2010	Versoix	GE	DT, Canton de Genève, Christian Gorce, christian.gorce@etat.ge.ch					CPX	-8.8	-7.4	-8.0	CPX	-8.4	
Nanosoft 4	2010	Collex-Bossy	GE	DT, Canton de Genève, Christian Gorce, christian.gorce@etat.ge.ch					CPX	-8.4	-7.2	-7.7	CPX	-8.3	
Nanosoft 4	2010	Meyrin	GE	DT, Canton de Genève, Christian Gorce, christian.gorce@etat.ge.ch					CPX	-8.8	-7.7	-8.2	CPX	-8.3	
Nanosoft 4	2010	Bellevue	GE	DT, Canton de Genève, Christian Gorce, christian.gorce@etat.ge.ch					CPX	-8.5	-7.2	-7.7	CPX	-7.7	
Nanosoft 4	2010	Collex-Bossy	GE	DT, Canton de Genève, Christian Gorce, christian.gorce@etat.ge.ch					CPX	-8.2	-7.1	-7.6	CPX	-7.9	
Nanosoft 4	2010	Presinge	GE	DT, Canton de Genève, Christian Gorce, christian.gorce@etat.ge.ch					CPX	-9.1	-8.3	-8.6	CPX	-8.4	
Sapaphone 4	2010	Sauverny	GE	DT, Canton de Genève, Christian Gorce, christian.gorce@etat.ge.ch					CPX	-7.2	-7.1	-7.1	CPX	-6.7	
Nanosoft 4	2010	Presinge	GE	DT, Canton de Genève, Christian Gorce, christian.gorce@etat.ge.ch					CPX	-8.6	-8.0	-8.3	CPX	-7.2	
Nanosoft 4	2010	Avully	GE	DT, Canton de Genève, Christian Gorce, christian.gorce@etat.ge.ch					CPX	-7.8	-7.6	-7.7	CPX	-6.9	
SDA 4C	2013	Safenwil	AG	ATB, Kanton Aargau, Hanspeter Gloor, hanspeter.gloor@ag.ch	CPX	-6.9	-7.2	-7.1	CPX	-8.0	-7.4	-7.7	CPX	-6.0	
Nanosoft 4	2010	Presinge	GE	DT, Canton de Genève, Christian Gorce, christian.gorce@etat.ge.ch					CPX	-8.0	-7.3	-7.6	CPX	-7.3	-8.1	-7.7	CPX	-5.1	-5.8	-5.5
Nanosoft 4	2010	Onex	GE	DT, Canton de Genève, Christian Gorce, christian.gorce@etat.ge.ch					CPX	-7.7	-7.2	-7.4	CPX	-7.0	-8.0	-7.5	CPX	-5.0	-5.8	-5.4
LNA 6 C	2013	Basel	BS	OFROU / ASTRA (TP2)	CPX	-6.0	-3.9	-4.7	CPX	-7.3	-8.1	-7.7	CPX	-6.1	-7.2	-6.7	CPX	-4.6	-6.0	-5.3
Sapaphone 4	2010	Bardonex	GE	DT, Canton de Genève, Christian Gorce, christian.gorce@etat.ge.ch					CPX	-6.8	-6.6	-6.7	CPX	-6.2	-8.2	-7.2	CPX	-4.5	-5.6	-5.1

measurement 1 year after construction

noise level reduction

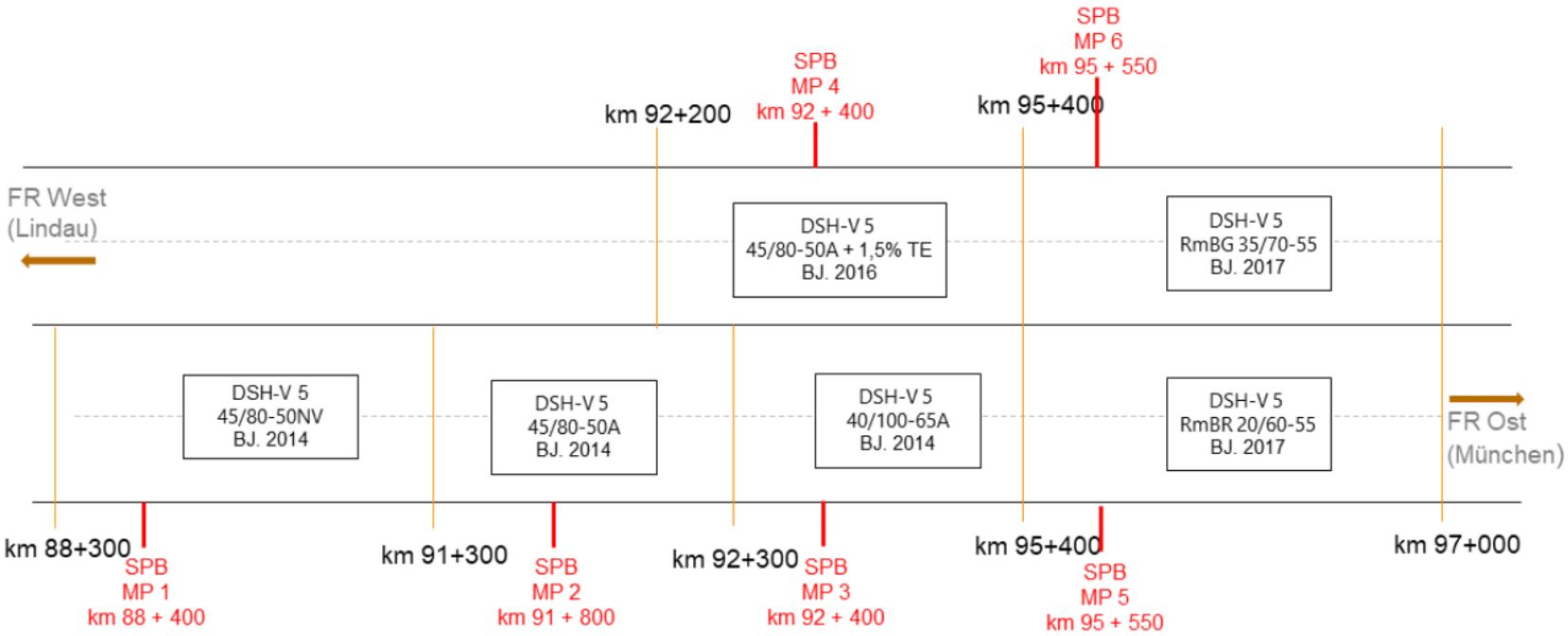
meas. method	light veh.	heavy veh.	mix with 8% heavy
CPX	-8.8	-6.7	-7.5

Germany – learning from the roads

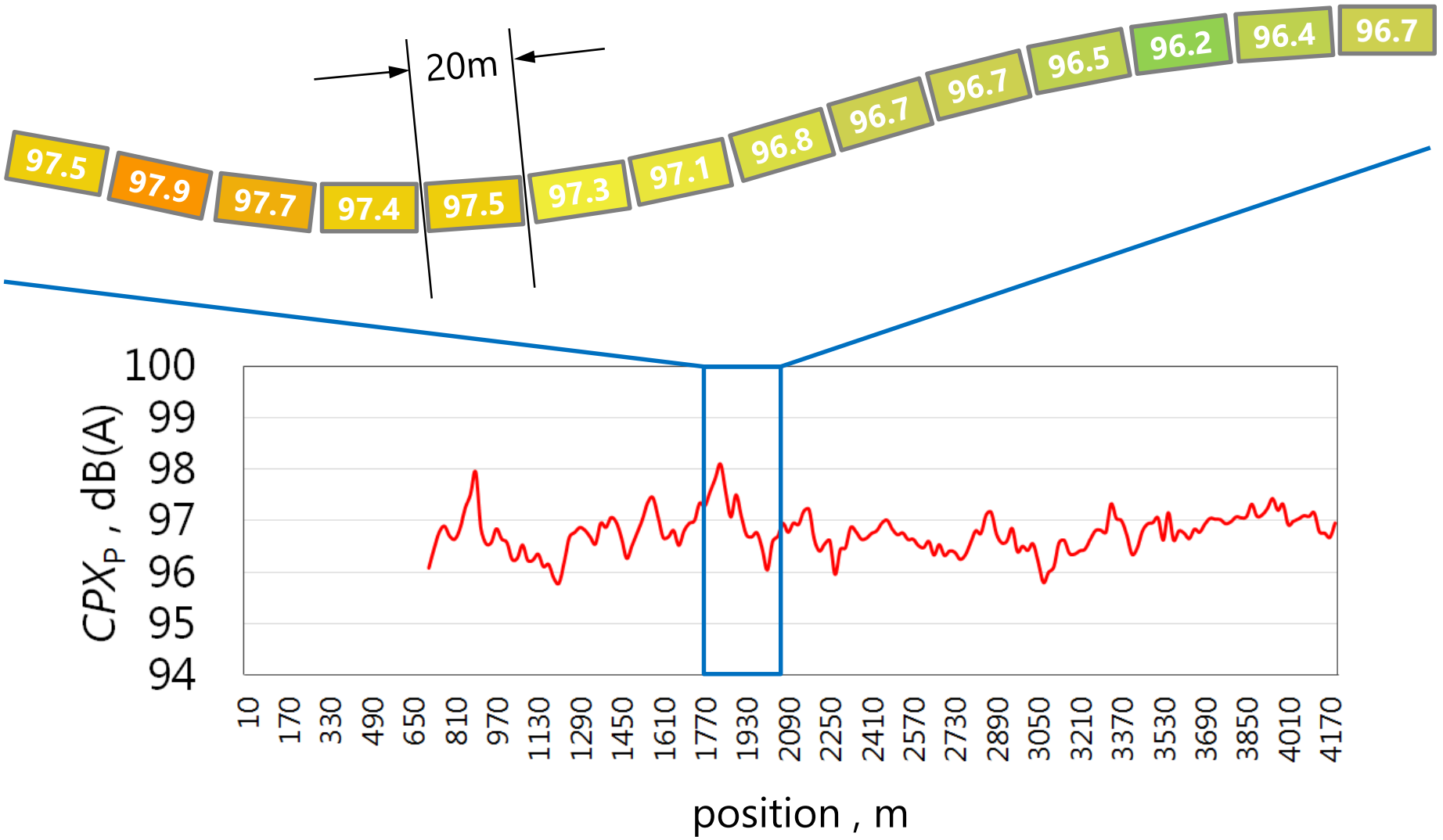
- transition from regulation based to performance based road construction contracts
- acoustic performance
  - **magnitude** of the tyre/road noise level
  - **homogeneity** of the tyre/road noise along the road
  - **durability** of the noise level reduction
- tyre/road noise monitoring
  - big data collection
  - easy determination of performance parameters
  - assuming that road adminsitration is willing to test materials, machinery, production technology within the boundaries of the building regulations

Germany – learning from the roads

- a good practice example: a road administration's playground



Germany – road surface monitoring

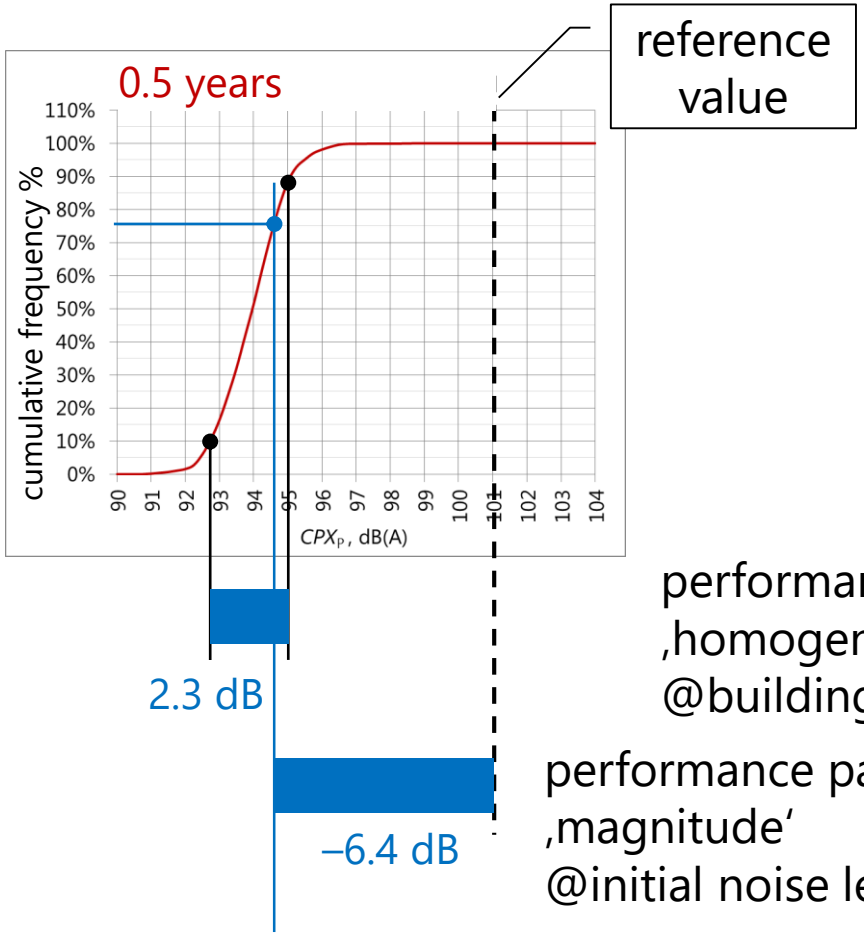


Germany – road surface monitoring

- an example

  thin layer asphalt 0/5 (low noise asphalt)
  11 road sections
  48 km
  2,400 CPX segments at 20m each
  age 0.5 … 8 years after construction
  construction between 2005 und 2010
  CPX_P , 80km/h

Germany – road surface monitoring



acoustic performance	
magnitude	–6.4 dB
homogeneity	2.3 dB
durability	?

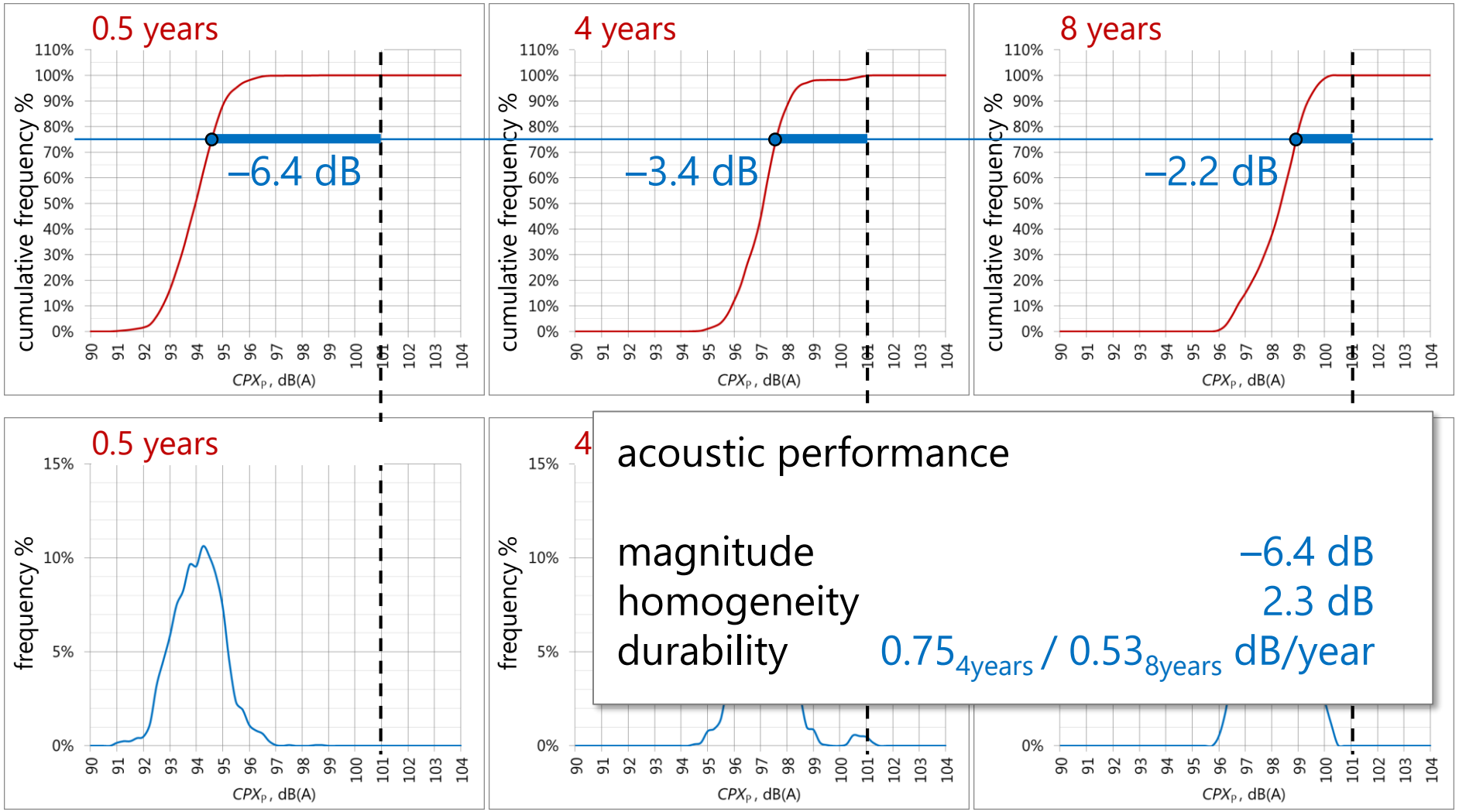
performance parameter
‚homogeneity' (overall = inter and intra road)
@building process reliability

performance parameter
‚magnitude'
@initial noise level reduction

performance parameter
‚magnitude'
@initial noise level

Germany – road surface monitoring

thin layer low noise asphalt 0/5

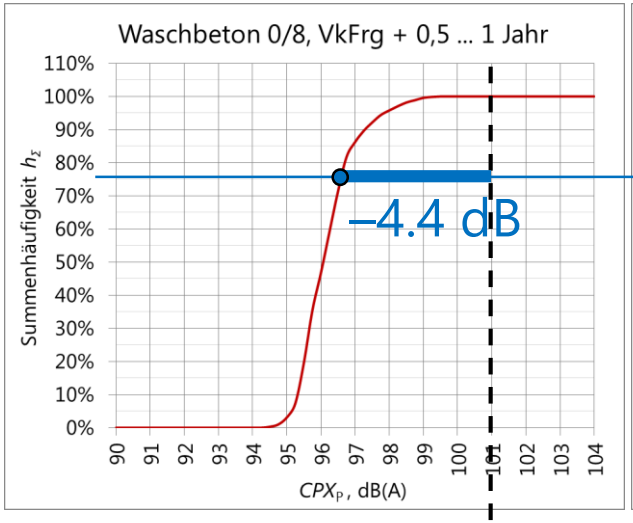


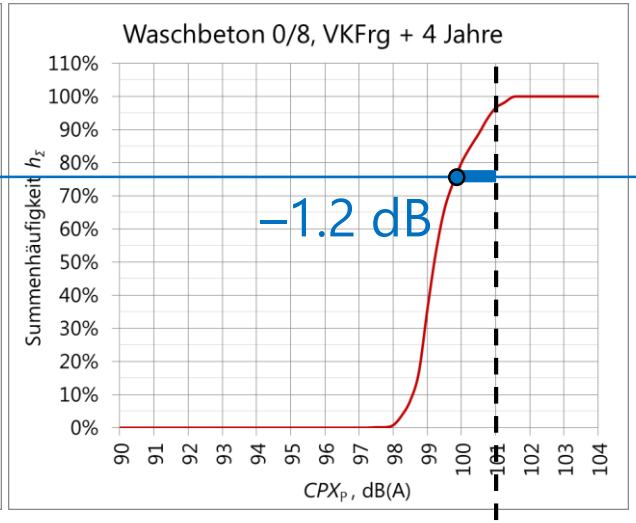
acoustic performance

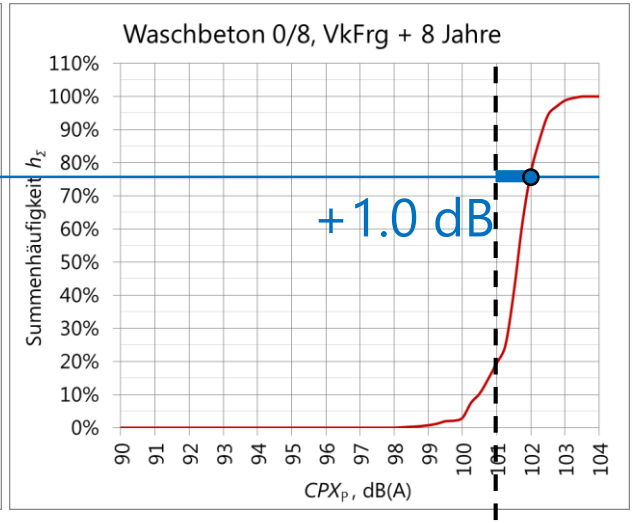
magnitude	–6.4 dB
homogeneity	2.3 dB
durability	$0.75_{4\text{years}}$ / $0.53_{8\text{years}}$ dB/year

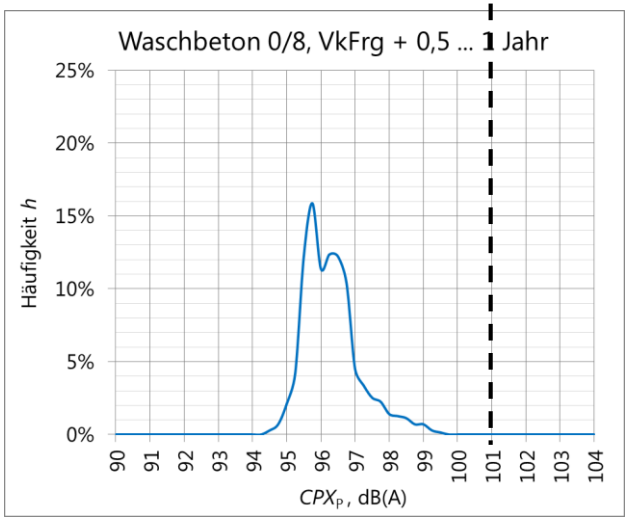
Germany – road surface monitoring

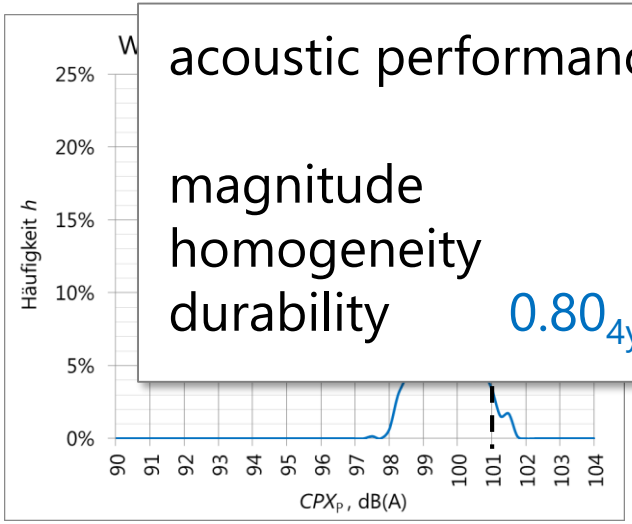
exposed aggregate cement concrete 0/8

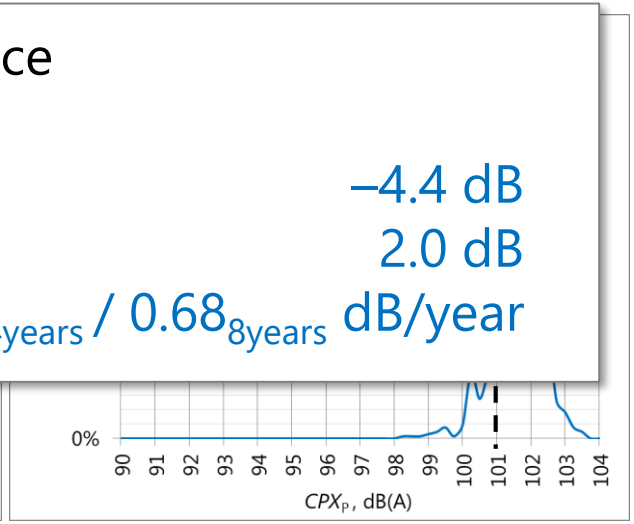










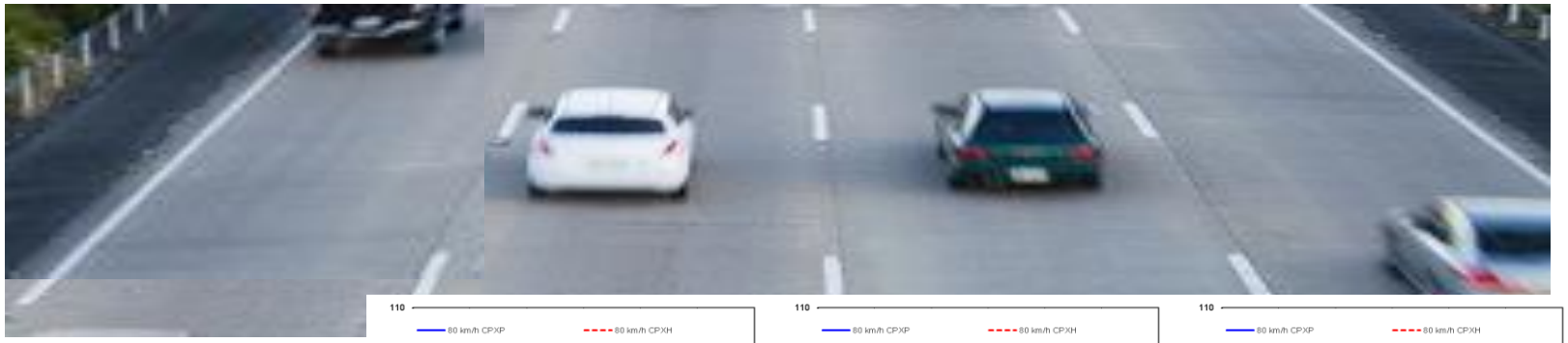


acoustic performance

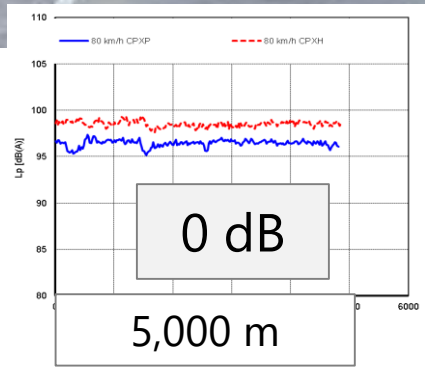
magnitude	–4.4 dB
homogeneity	2.0 dB
durability	$0.80_{4\text{years}}$ / $0.68_{8\text{years}}$ dB/year

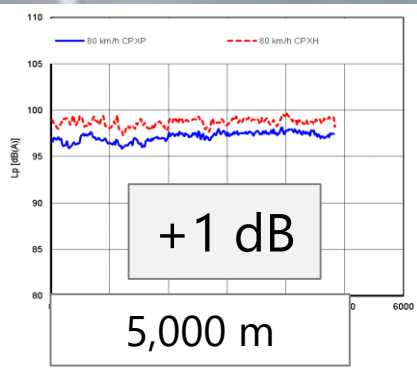
Germany – road surface monitoring

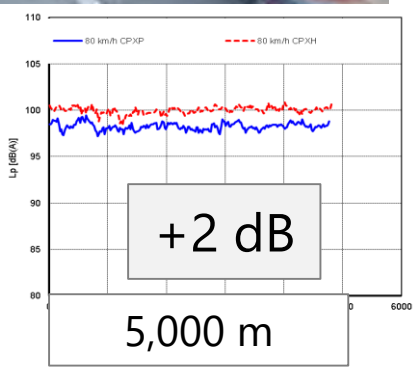
Germany – road surface monitoring



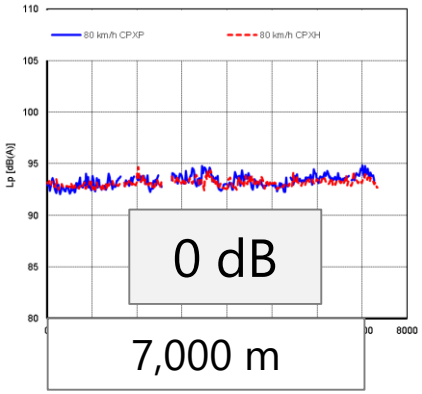
tyre P1
tyre H1
80 km/h

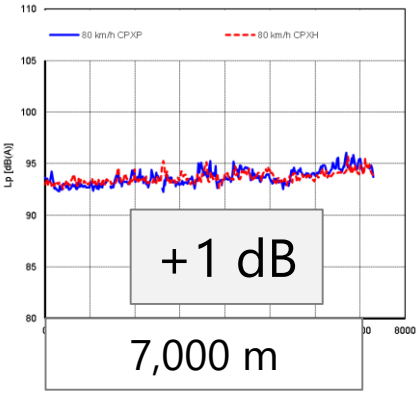


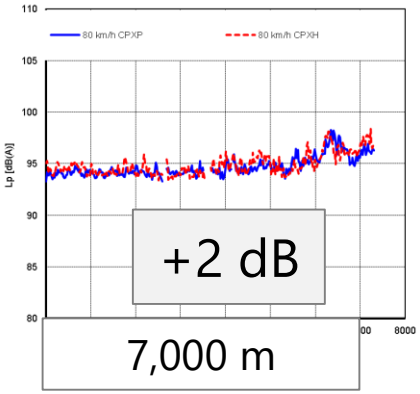


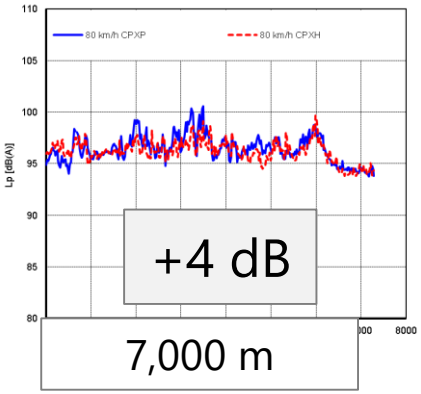


thin layer 0/5









porous asphalt 0/8

Making the CPX method applicable

Minimization of uncertainties – DE's and CH's approach

- Choice of the test vehicle

self powered standard vehicle

self powered special purpose vehicle

open trailer

trailer with auxiliary wheels

uniwheel trailer

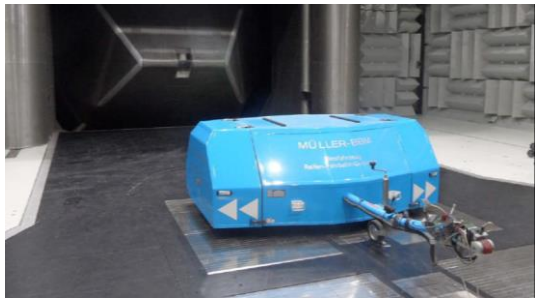
closed trailer with towing van

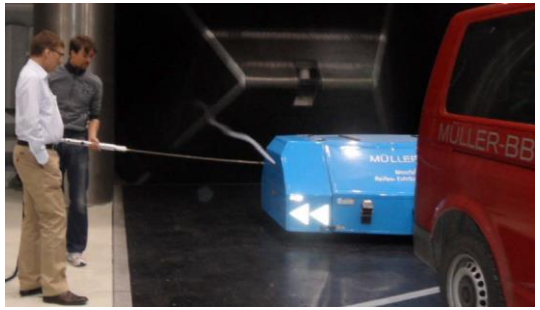
Minimization of uncertainties

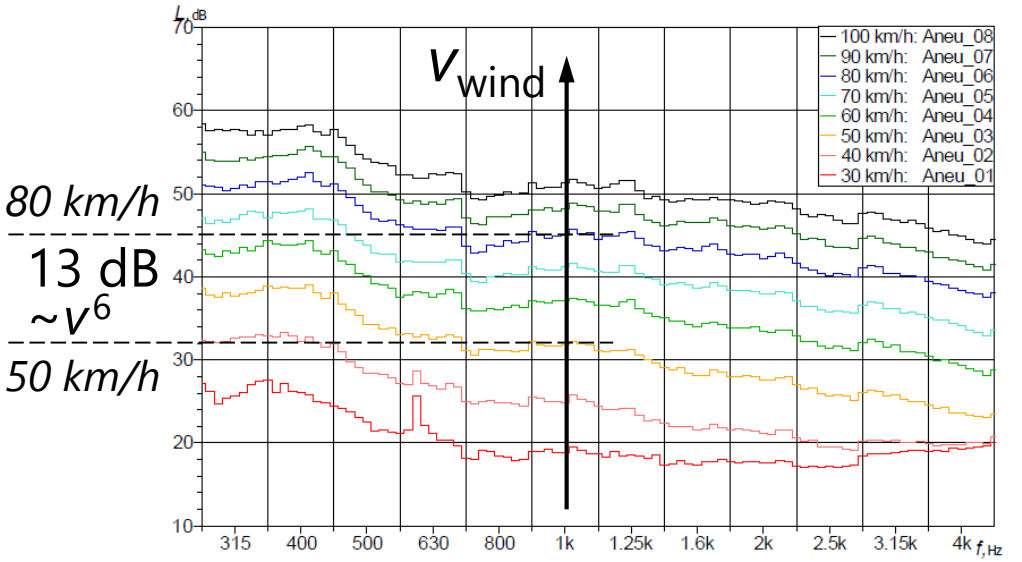
- Choice of the test vehicle in Germany and Switzerland
  - prevention of interfering noise ▶ closed version
  - avoidance of interfering sound sources ▶ no auxiliary wheels
  - unbiased tyre/road noise ▶ two wheels rolling in the wheel tracks
  - well defined sound field ▶ absorbing hatches

Minimization of uncertainties

- towing vehicle



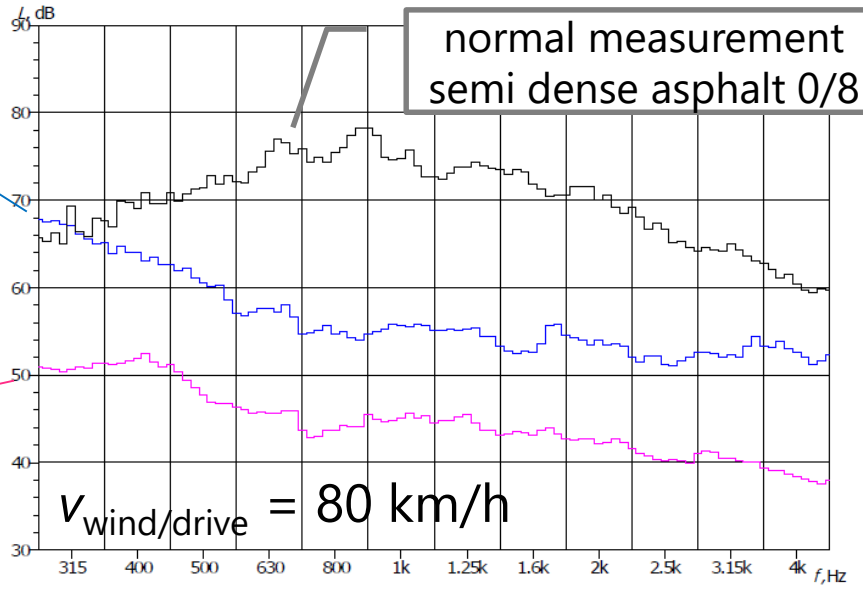




without

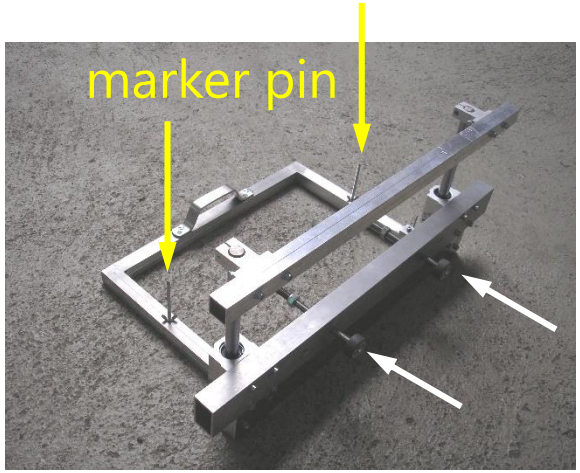
towing vehicle

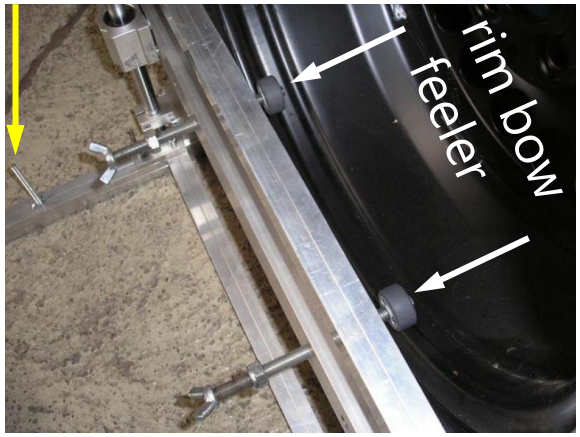
with

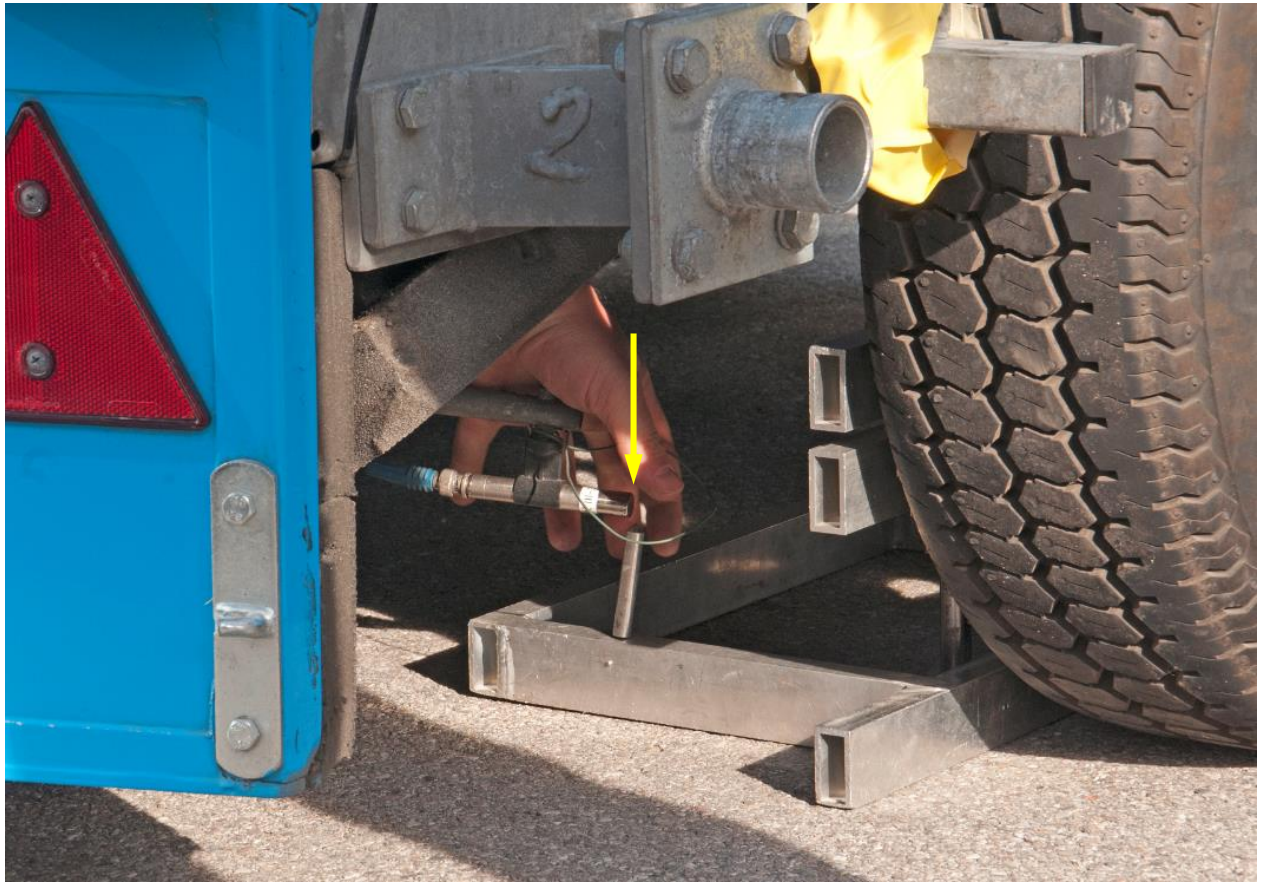


Minimization of uncertainties

- defined positioning of the microphones
  - use of a setting gauge

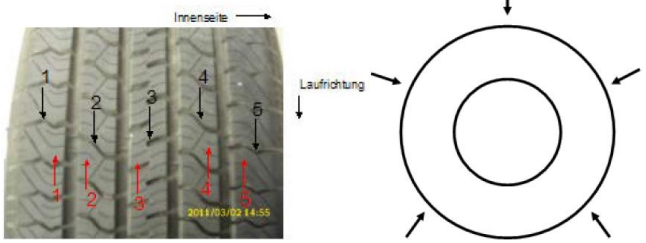


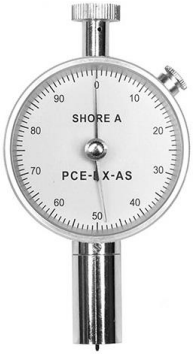


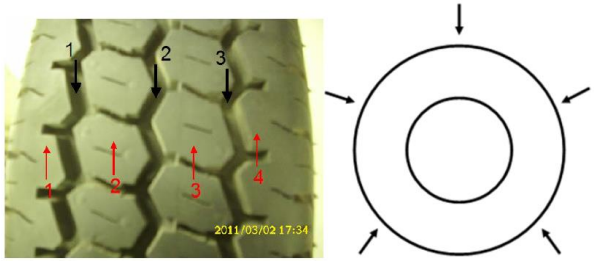


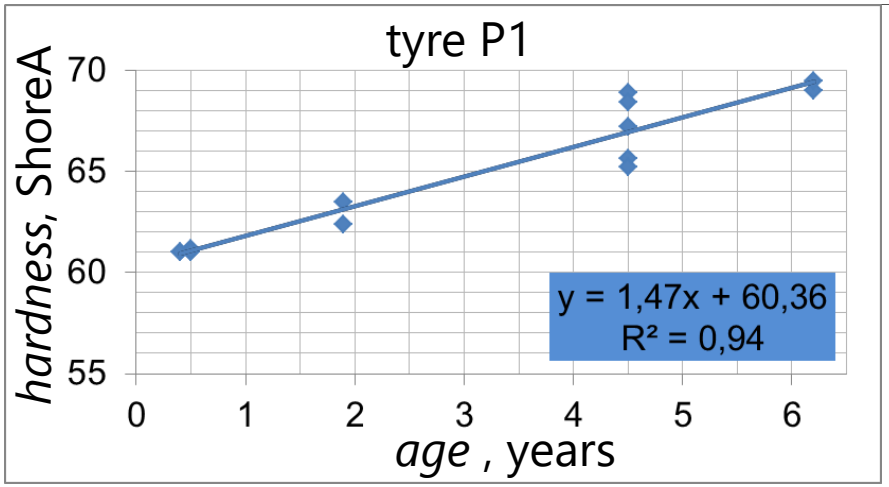
Minimization of uncertainties

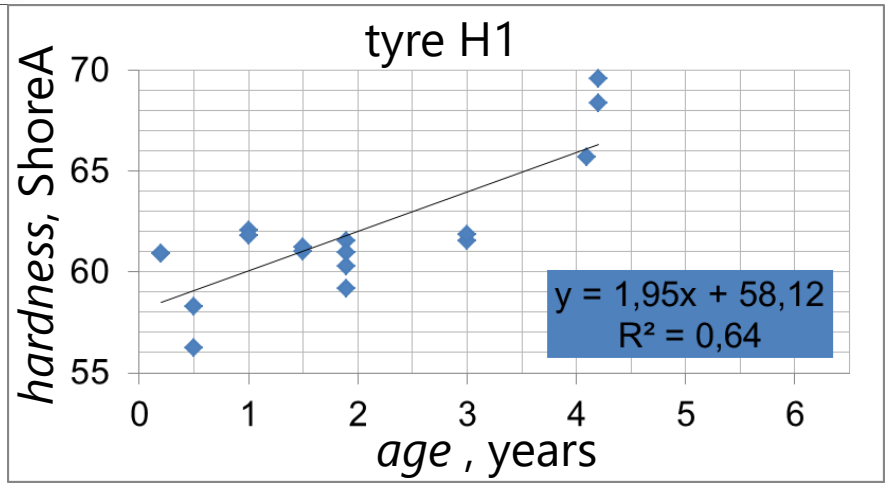
- Tyre management
  - check tread profile depth
  - check hardness







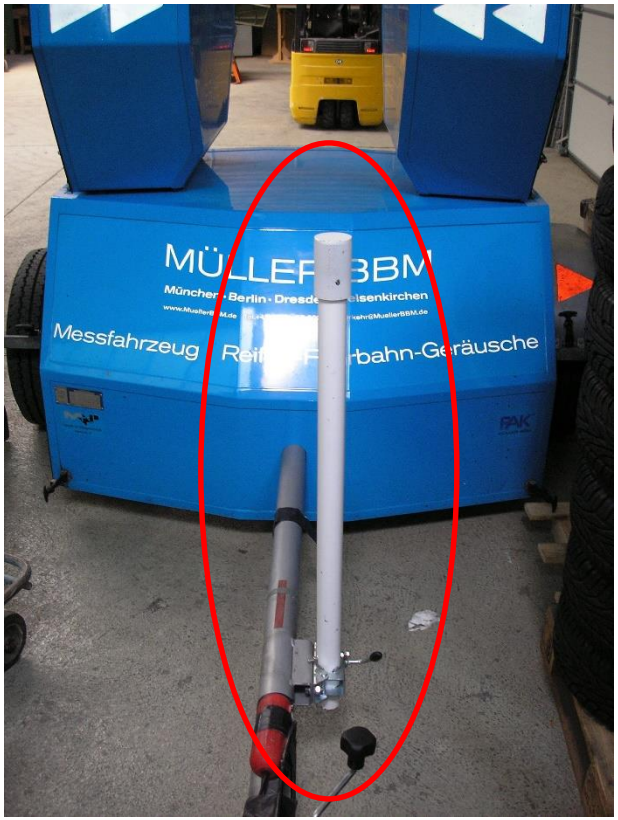


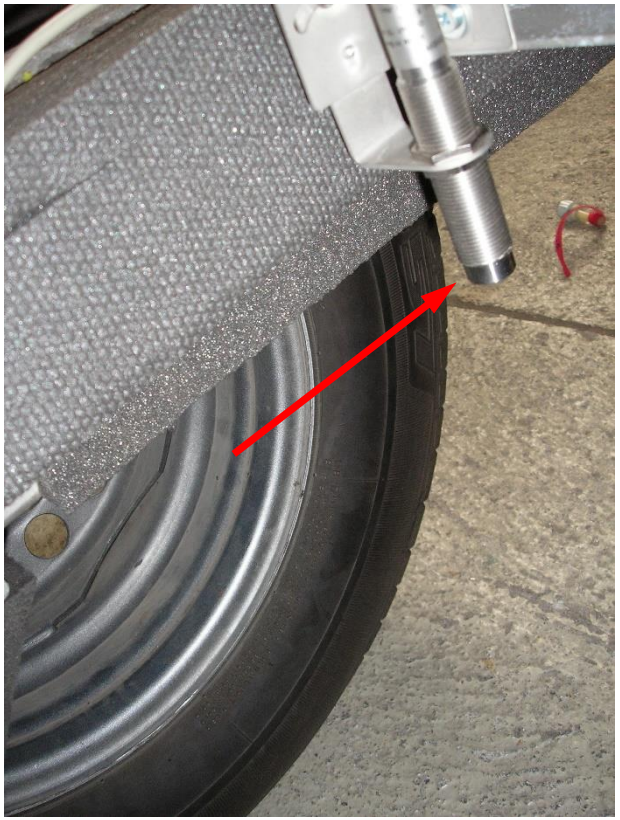


  - store suitably

Minimization of uncertainties

- temperature measurement
  continuous and well shielded measurement of ...
  ... air temperature ... road surface temperature





Minimization of uncertainties

- temperature measurement

air temperature measurement under the lee of the towing vehicle

road surface temperature measurement facilitating the identification of surface transitions

Minimization of uncertainties

- dry road surface condition

  waiting period after precipitation events
  (Central Europe)

type of road surface	average air temperature			
	5°C	10°C	15°C	20°C
porous asphalt	72 h	48 h	36 h	24 h
double-layer porous asphalt	72 h	60 h	48 h	36 h
semi porous asphalt	48 h	36 h	24 h	12 h
impervious pavement	24 h	18 h	12 h	6 h

Thank you very much for listening!

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