



Vehicle selective monitoring of noise and vibration generation from rolling stock



The *acramos* measurement system

further information:

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Objective

As an infrastructure manager you would like

- to know, how noisy trains are that run on your network
- to know, what trains are extremely noisy and which are the quiet ones?

As a consulting Engineer you have to

- assess the effect of infrastructure related noise control (e.g. rail dampers)
- document changes in noise generation and noise reception from rail transport?



We have the solution!



***acramos: acoustic railway
monitoring system***

- Automatic noise monitoring including autonomous train categorisation
- Automatic data processing according to your individual requirements
- Reconstruction of unaffected pass-by level of single axles & vehicles

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acramos - Sensors

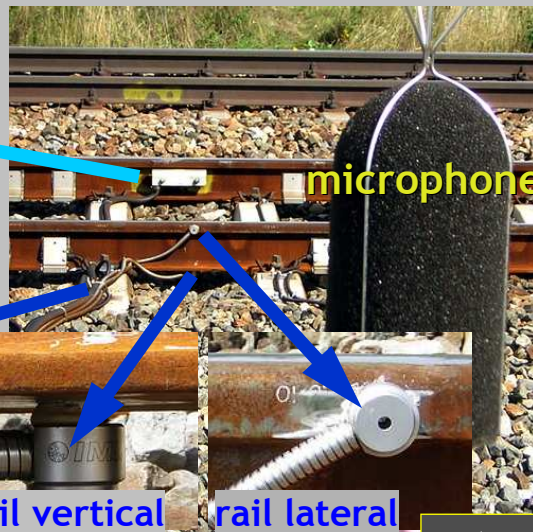


wheel sensor

accelerometers



sleeper



microphone

rail vertical

rail lateral

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acramos - Analyser

stationary *acramos* system
is mounted in a 19" rack
and requires 60x60x45cm



mobile *acramos* system is
placed in a weatherproof
box and can be controlled
by mobile Internet



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acramos - user window

zur Messung

Allgemein Kanäle/Messen Kanäle/Rechnen Datenablage

K.-Nr.	Aktiv	Sensorposition:	Sensor:	ICP an:	ohne DC:
1	<input checked="" type="checkbox"/>	Mikrofon M2-1 (Gleis2, Qu1)	Mikro LD2541 weiss	<input type="checkbox"/>	<input checked="" type="checkbox"/>
2	<input checked="" type="checkbox"/>	vert. Schienenbeschl. V1	V3	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
3	<input checked="" type="checkbox"/>	hor. Schienenbeschl. H1	V5	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
4	<input checked="" type="checkbox"/>	vert. Schwellenbeschl. S1	V6	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
5	<input checked="" type="checkbox"/>	Mikrofon M2-2 (Gleis2, Qu2)	Mikro LD2541 gelb	<input type="checkbox"/>	<input checked="" type="checkbox"/>
6	<input checked="" type="checkbox"/>	vert. Schienenbeschl. V2	V8	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
7	<input checked="" type="checkbox"/>	hor. Schienenbeschl. H2	V9	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
8	<input checked="" type="checkbox"/>	vert. Schwellenbeschl. S2	V10	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
9	<input checked="" type="checkbox"/>	Geophon X-Richtung	Sensor 30	<input type="checkbox"/>	<input checked="" type="checkbox"/>
10	<input checked="" type="checkbox"/>	Geophon Y-Richtung	Sensor 31	<input type="checkbox"/>	<input checked="" type="checkbox"/>
11	<input checked="" type="checkbox"/>	Geophon Z-Richtung	Sensor 32	<input type="checkbox"/>	<input checked="" type="checkbox"/>
12	<input checked="" type="checkbox"/>	Mikrofon M2-1 (Gleis1, Qu1)	Mikro ICP rot	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
13	<input checked="" type="checkbox"/>	Radsensor R2-1	FRAUSCHER Radsensor	<input type="checkbox"/>	<input type="checkbox"/>
14	<input checked="" type="checkbox"/>	Radsensor R2-2	FRAUSCHER Radsensor	<input type="checkbox"/>	<input type="checkbox"/>
15	<input checked="" type="checkbox"/>	Radsensor R1-1	FRAUSCHER Radsensor	<input type="checkbox"/>	<input type="checkbox"/>
16	<input checked="" type="checkbox"/>	Radsensor R1-2	FRAUSCHER Radsensor	<input type="checkbox"/>	<input type="checkbox"/>

configura-
ting
acramos:

sensors can
freely be
assigned to
the system
channels

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acramos - Die Menüführung

zur Messung

Allgemein Kanäle/Messen Kanäle/Rechnen Datenablage

K.-Nr.	Sensorposition:	Zeitsignale speichern	FFT speichern	Zeit-Bewertung	Frequenz-Bewertung	L(t) speichern	L(Terz,t) speichern
1	Mikrofon M2-1 (Gleis2, Q)	<input checked="" type="checkbox"/>	<input type="checkbox"/>	Fast	A	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
2	vert. Schienenbeschl. V1	<input checked="" type="checkbox"/>	<input type="checkbox"/>	Fast	LIN	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
3	hor. Schienenbeschl. H1	<input checked="" type="checkbox"/>	<input type="checkbox"/>	Fast	LIN	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
4	vert. Schwellenbeschl. S	<input checked="" type="checkbox"/>	<input type="checkbox"/>	Fast	LIN	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
5	Mikrofon M2-2 (Gleis2, G)	<input checked="" type="checkbox"/>	<input type="checkbox"/>	Fast	LIN	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
6	vert. Schienenbeschl. V2	<input checked="" type="checkbox"/>	<input type="checkbox"/>	Fast	A	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
7	hor. Schienenbeschl. H2	<input checked="" type="checkbox"/>	<input type="checkbox"/>	Fast	LIN	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
8	vert. Schwellenbeschl. S	<input checked="" type="checkbox"/>	<input type="checkbox"/>	Fast	LIN	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
9	Geophon X-Richtung	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	Fast	LIN	<input type="checkbox"/>	<input type="checkbox"/>
10	Geophon Y-Richtung	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	Fast	LIN	<input type="checkbox"/>	<input type="checkbox"/>
11	Geophon Z-Richtung	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	Fast	LIN	<input type="checkbox"/>	<input type="checkbox"/>
12	Mikrofon M2-1 (Gleis1, G)	<input checked="" type="checkbox"/>	<input type="checkbox"/>	Fast	A	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
13	Radsensor R2-1	<input checked="" type="checkbox"/>	<input type="checkbox"/>	Fast	LIN	<input type="checkbox"/>	<input type="checkbox"/>
14	Radsensor R2-2	<input checked="" type="checkbox"/>	<input type="checkbox"/>	Fast	LIN	<input type="checkbox"/>	<input type="checkbox"/>
15	Radsensor R1-1	<input checked="" type="checkbox"/>	<input type="checkbox"/>	Fast	LIN	<input type="checkbox"/>	<input type="checkbox"/>
16	Radsensor R1-2	<input checked="" type="checkbox"/>	<input type="checkbox"/>	Fast	C	<input type="checkbox"/>	<input type="checkbox"/>

For each channel different parameters can be selected, analysed & stored

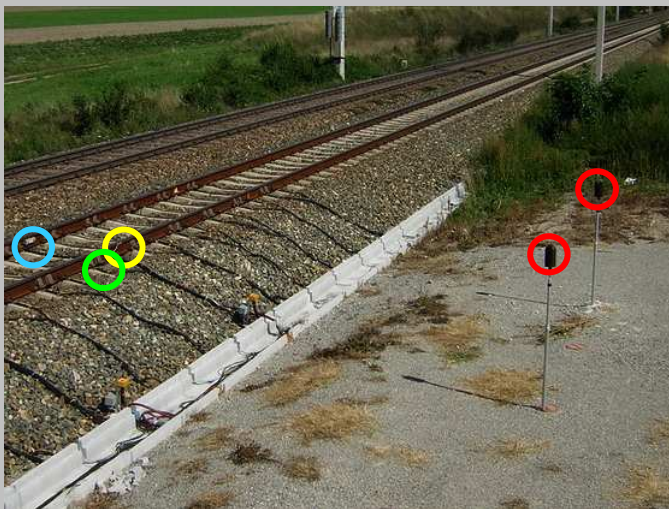
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acramos site of Austrian Fed. Rlys



Data acquisition during pass-by of a train

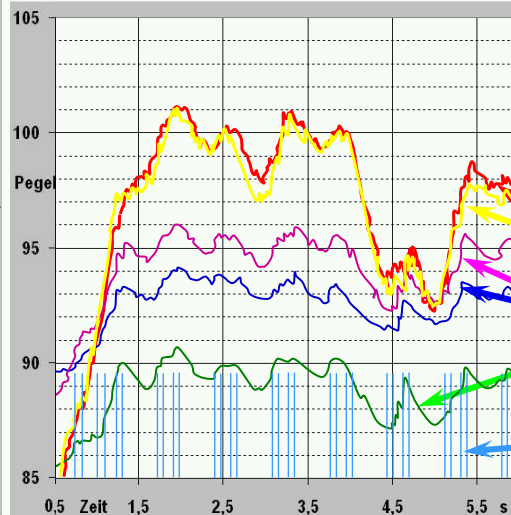
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acramos - data acquisition



During train pass-by a number of different signals is recorded:

Noise level

Rail & sleeper acceleration

Signal from the axles

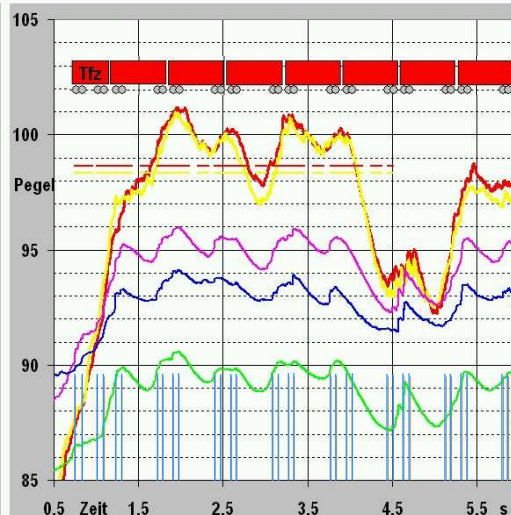
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acramos - data merging



Axle signals are merged with noise and vibration levels.

This exercise allows to correlate emission data and train/wheel positions

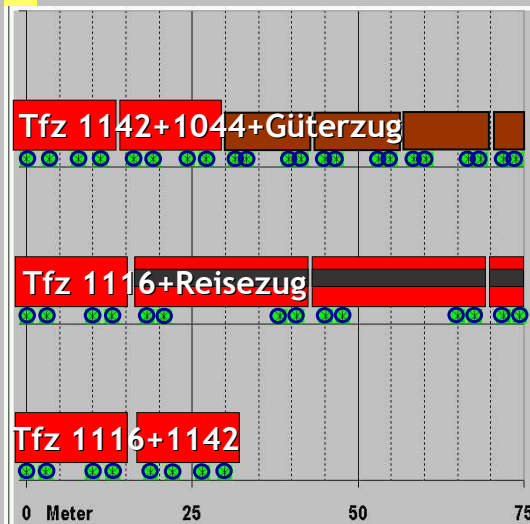
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acramos - train categorisation



axle patterns are compared with an internal database and the train category is assigned.



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acramos - sample data set

Date:	11.09.06
Time:	17:36:20
LogDelay:	0,00000251
Regelrichtung:	1
Regen:	0
RegenH:	0
RegenTot:	56,4
WindRi:	247,5
WindVm:	3,7
TempLuft:	23,8
TempRail:	23,8
Feuchte:	46
Luftdruck:	1020,2
Validation:	OK
Vmin:	119,5
Vmax:	121,75
ZugTyp:	80-33

data of a
train pass-by

Ax	CH01.M1	CH02.V1	CH03.H1	CH04.S1	CH05.M2	CH08.S2	Q1	m	valid	Q2	m	valid	m/s	km/h	dL	L
1	82,5	-4,1	22,63	-22,47	83	-17,97	0,198	0	OK	0,304	0	OK	33,82	121,75	0	0
2	83,57	0,25	23,27	-23,7	83,3	-18,54	0,286	2,921	OK	0,394	2,988	OK	33,19	119,5	2,954	2,954
3	84,17	0,05	22,93	-22,67	84,22	-17,63	0,494	7,035	OK	0,6	6,967	OK	33,82	121,75	7,001	9,955
4	84,68	0,88	23,94	-23,62	84,46	-17,9	0,584	3,044	OK	0,69	3,044	OK	33,82	121,75	3,044	12,989
5	85	0,37	27,52	-23,22	85,38	-17,58	0,742	5,245	OK	0,95	5,311	OK	33,19	119,5	5,278	18,277
6	85,42	0,78	30,12	-24	85,85	-18,26	0,818	2,57	OK	0,924	2,503	OK	33,82	121,75	2,537	20,814
7	85,35	-2,57	26,93	-23,11	85,54	-18,65	1,342	17,722	OK	1,448	17,722	OK	33,82	121,75	17,722	38,536
8	86,38	-1,54	28,16	-23,19	86,77	-17,77	1,416	2,503	OK	1,522	2,503	OK	33,82	121,75	2,503	41,038
9	86,5	-0,55	28,5	-24,36	87,05	-18,73	1,544	4,249	OK	1,662	4,315	OK	33,19	119,5	4,282	45,32
10	86,23	-0,17	28,71	-24,67	86,81	-18,03	1,62	2,57	OK	1,726	2,503	OK	33,82	121,75		
11	85,29	-2,8	27,09	-23,92	85,69	-18,26	2,144	17,722	OK	2,25	17,722	OK	33,82	121,75		
12	86,62	-0,39	28,46	-21,99	86,64	-17,99	2,218	2,456	OK	2,326	2,523	OK	33,19	119,5		

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acramos - System features

- Direction of the train and speed per axle
- Axle pattern of the train (=distance between the single axles)
- Automatic categorisation of trains based on the axle pattern
- A-weigh. pass-by level $L_{p,A,pb,T}$ of a train
- A-weighted level statistic $L_{p,A,01}$, $L_{p,A,10}$, $L_{p,A,90}$, $L_{p,A,95}$ of a train
- A-weighted pass-by level $L_{p,A,pb,AX}$ of each single axle in a train
- 3rd octave spectra of a train or vehicle
- Results are stored in a MS-Access Database: statistic analysis of speed dep. A-weighted pass-by level $L_{p,A,pb}(V)$ per train category
- Recording of time signals during train pass-by (optionally)

Results of 4 month of monitoring

Cat	Train description	Trains	Axles
1	Güterzug, allgemein	3.241	292.104
9	Güterzug, Kfz-Transport	243	15.504
12	Reisezug (EC/IC)	667	19.487
13	Regionalzug, BR 29-35	13	452
21	Regionalzug, BR 80-33	1.629	38.522
22	Regionalzug, BR 80-73	22	496
31	S-Bahn, BR 4020	4.651	101.564
33	S-Bahn, BR 4024 (Talent)	185	3.331
51	D-Triebwagen, BR 5047	196	784
30	E-Triebwagen, BR 4011 (ICE-T)	1	56
41	E-Tfz, BR 1014	2	12
42	E-Tfz, BR 1016/1116 (Taurus)	284	1.136
43	E-Tfz, BR 1042/1142	107	428
44	E-Tfz, BR 1044/1144	85	340
45	D-Tfz, BR 2016 (Herkules)	352	1.408
47	D-Tfz, BR 2143	85	340
0	unbekannt	121	2.274
gesamt		11.884	478.238

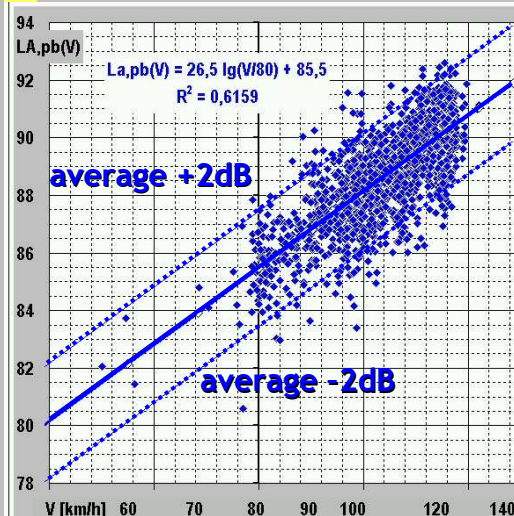
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acramos - Databank



Every measurement of each single train is stored in a databank

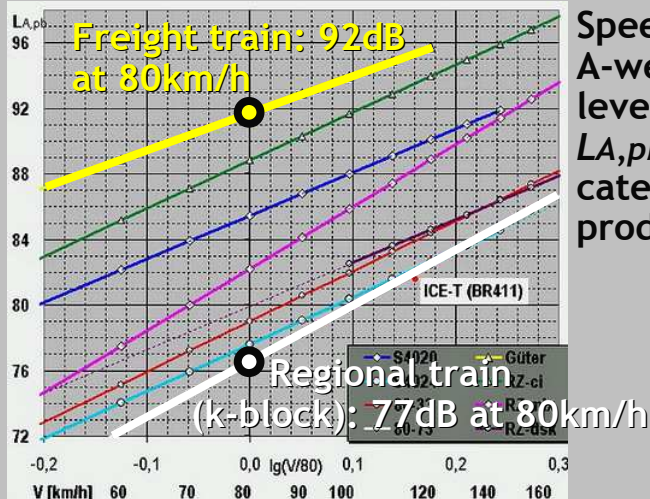
Hence average and statistical spread of A-weighted pass-by level in 7,5m are determined per train category

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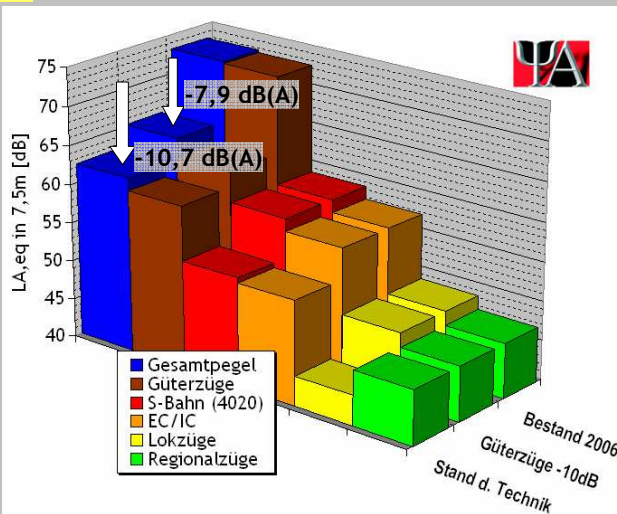
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acramos - Databank



Speed dependent A-weighted pass-by levels in 7,5m $LA_{pb}(V)$ per train category are produced

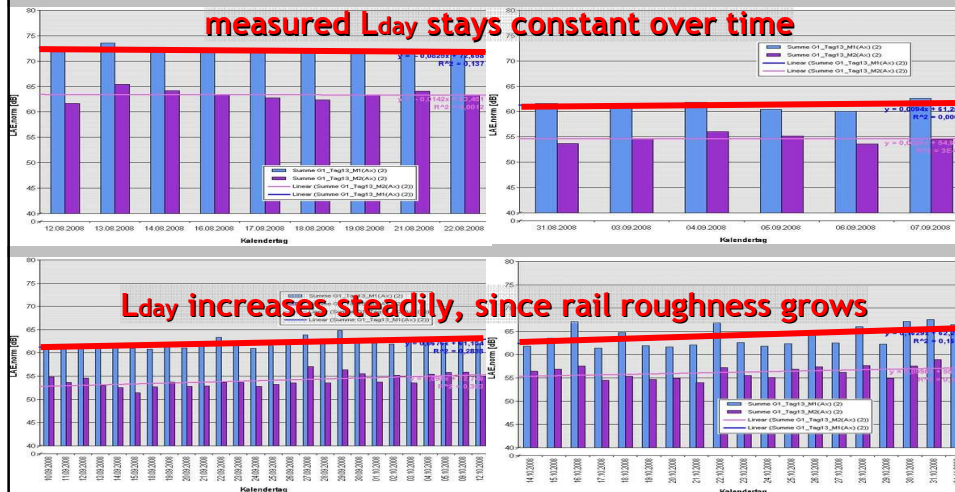
acramos - Data analysis



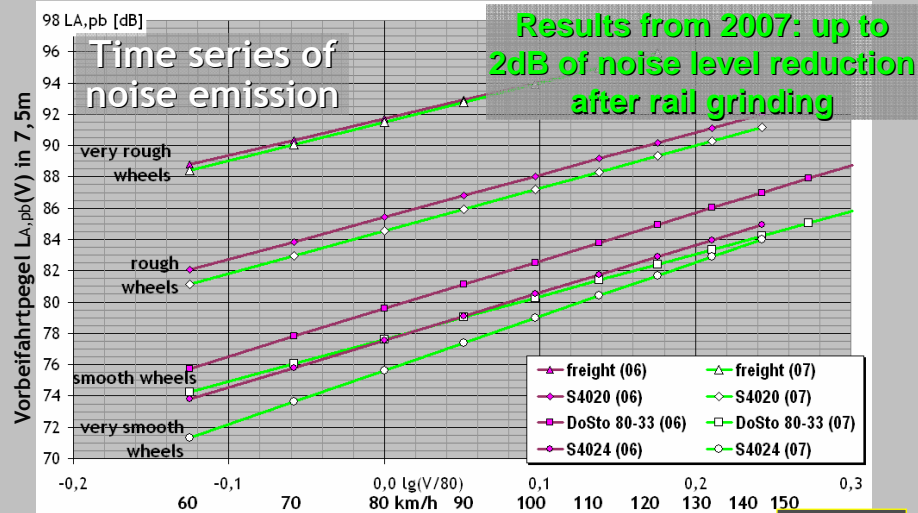
Equivalent levels per train category show for which trains noise reduction measures are most effective



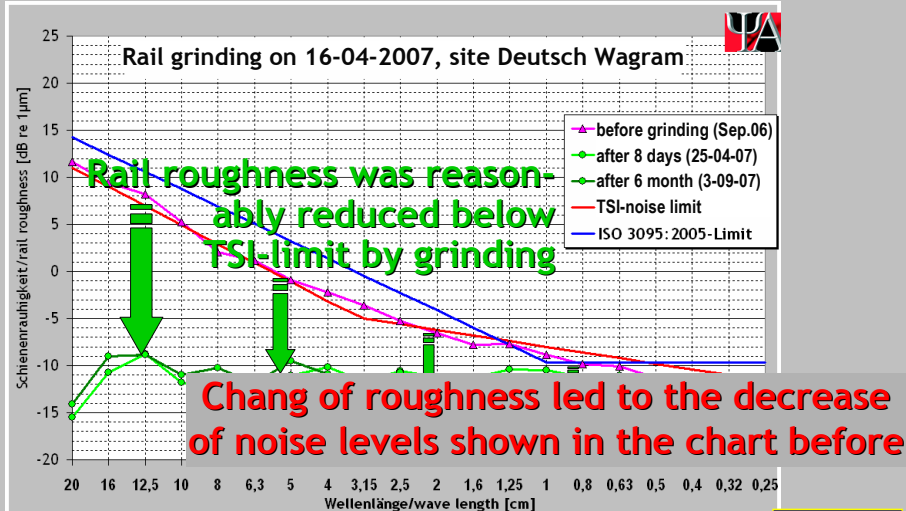
acramos - identifying trends



acramos - Data analysis



acramos - Data analysis

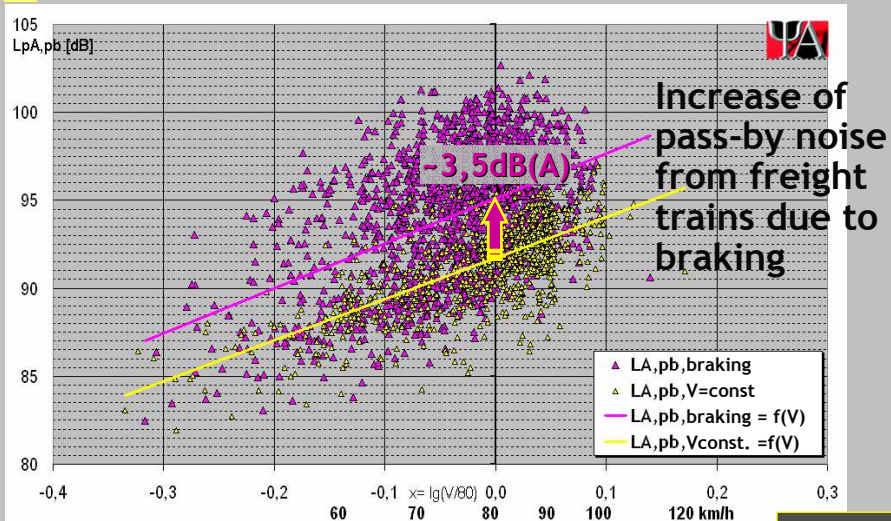


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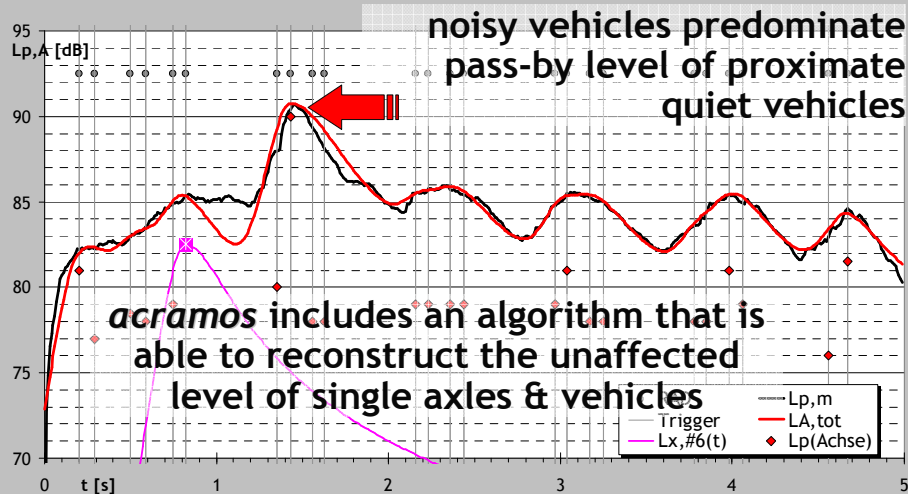
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acramos - true level of an axle



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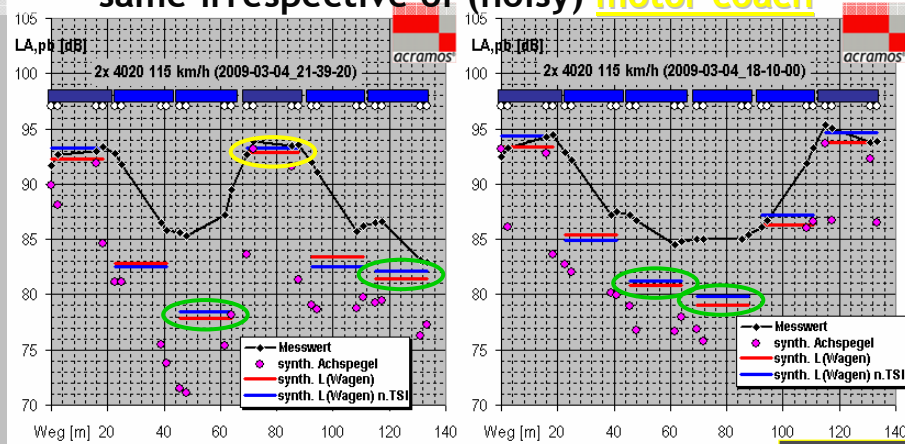
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acramos - true level of an axle

reconstructed levels of **driving trailers** stay the
same irrespective of (noisy) **motor coach**

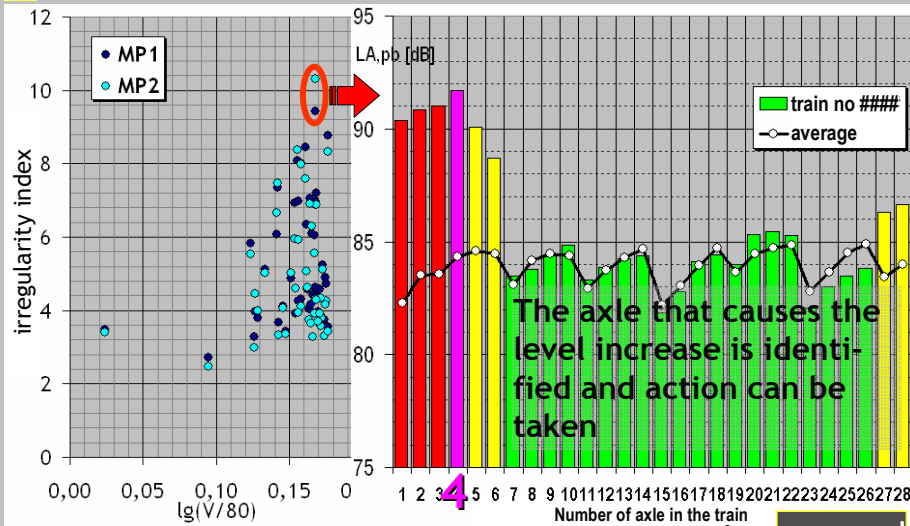


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acramos - Data analysis



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Vehicle selective monitoring of noise and vibration generation from rolling stock



The *acramos* measurement system

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