INSTYTUT KOLEJNICTWA

Noise in Railways

Piotr Tokaj, Witold Groll

Warszawa, June 6, 2017

Content

The regulations concerning noise in rail transport

COMMISSION REGULATION (EU) No 1304/2014 of 26 November 2014 on the technical specification for interoperability relating to the subsystem 'rolling stock - noise'

Defined limits for:

- **stationary noise,**
- **starting noise,**
- **pass-by noise,**
- **driver's cab interior noise.**

ISO 3095 - Acoustics - Railway applications - Measurement of noise emitted by railbound vehicles

EN ISO 3381- Railway applications - Acoustics - Measurement of noise inside railbound vehicles

PN-EN 16452:2015- Railway applications - Braking - Brake blocks

Stationary noise

It applies to:

Lokomotives, multiple-unit sets (EMU, DMU), coaches, track-laying machine (OTM), wagons (with generators, refrigerators)

Noise sources:

- **additional components (cooling systems, air conditioning systems, compressors, refrigerators)**

The limit values for stationary noise :

Category of the rolling stock subsystem	$L_{pAeq,T\,[unit]}$ [dB]
Electric locomotives and OTMs with electric traction	70
Diesel locomotives and OTMs with diesel traction	71
Electric Motor Units (EMU)	65
Diesel Motor Units (DMU)	72
Coaches	64
Wagons	65

Starting noise

It applies to:

Lokomotives, multiple-unit sets, coaches, track-laying machine

Noise sources:

- **traction components (engines, friction gears, ventilators, generators,**
- **additional components (cooling sysyems, air conditioning systems, compressors)**

The limit values for starting noise($L_{pAF,max}$) :

Category of the rolling stock subsystem	$L_{pAF,max}$ [dB]
Electric locomotives with total tractive power P < 4 500 kW	81
Electric locomotives with total tractive power P ≥ 4 500 kW	84
Diesel locomotives P < 2 000 kW at the engine output shaft	85
Diesel locomotives P ≥ 2 000 kW at the engine output shaft	87
EMUs with a maximum speed v_{max} < 250 km/h	80
EMUs with a maximum speed v_{max} ≥ 250 km/h	83

Pass-by noise

It applies to:

Lokomotives, multiple-unit sets, coaches, track-laying machine, couches, wagons.

Noise sources:

rolling noise, linked to the interaction of wheel/rail, which is a function of speed caused by the combined wheel and rail roughness and by the dynamic behavior of the track and wheelset

The limit values for pass-by noise ($L_{pAeq, Tp,(80\,km/h)}$) :

Category of the rolling stock subsystem	$L_{pAeq, Tp,(80\,km/h)}$ [dB]
Electric locomotives and OTMs with electric traction	84
Diesel locomotives and OTMs with diesel traction	85
Electric Motor Units (EMU)	80
Diesel Motor Units (DMU)	81
Coaches	79
Wagons	83

Driver's cab interior noise

It applies to:

Lokomotives, multiple-unit sets, coaches, track-laying machine, couches, wagons.

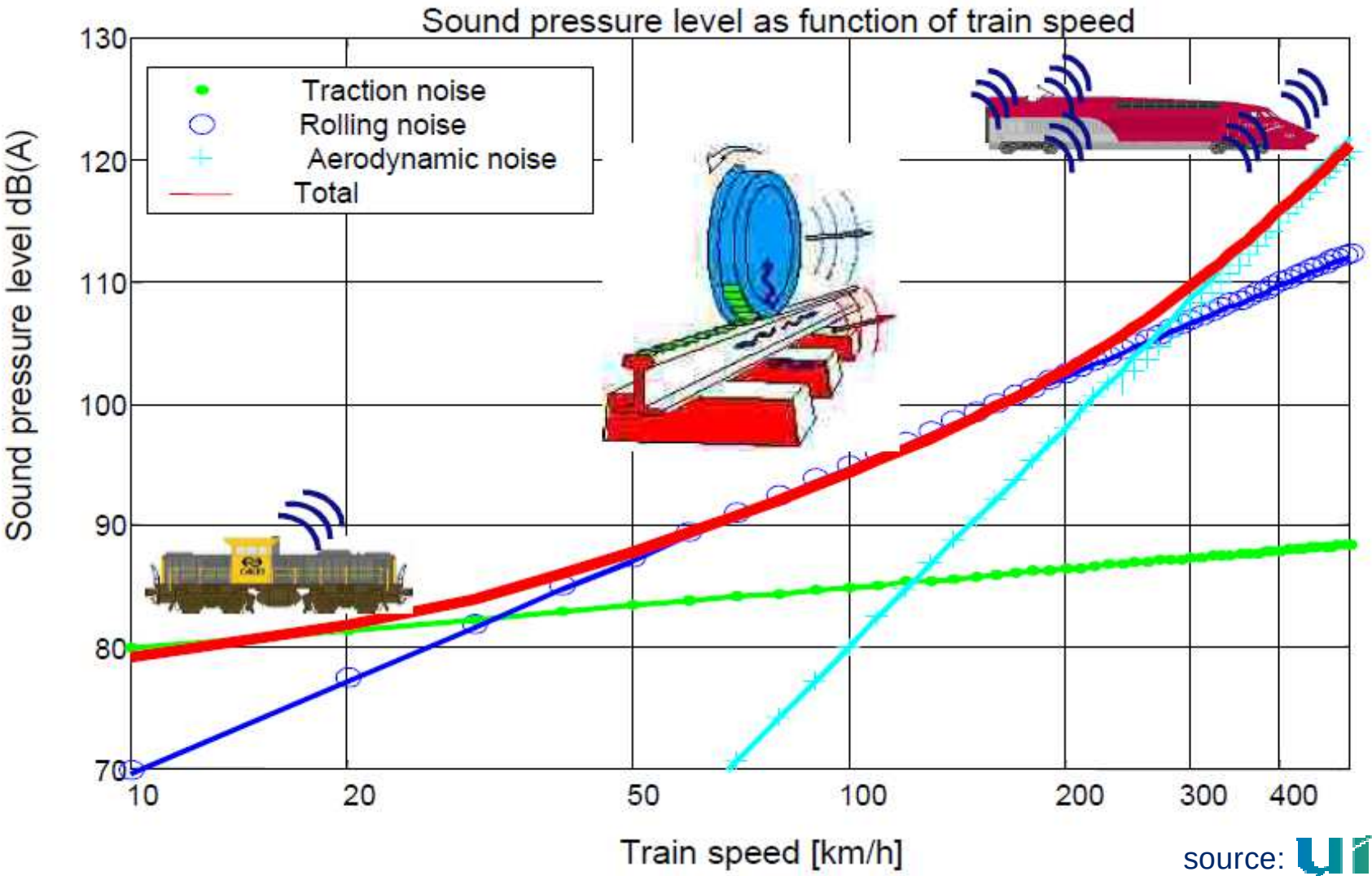
Noise sources:

the noise within the driver's cab of electric and diesel locomotives, OTMs, EMUs, DMUs and coaches fitted with a cab

The limit values for driver's cab interior noise ($L_{pAeq,T}$) :

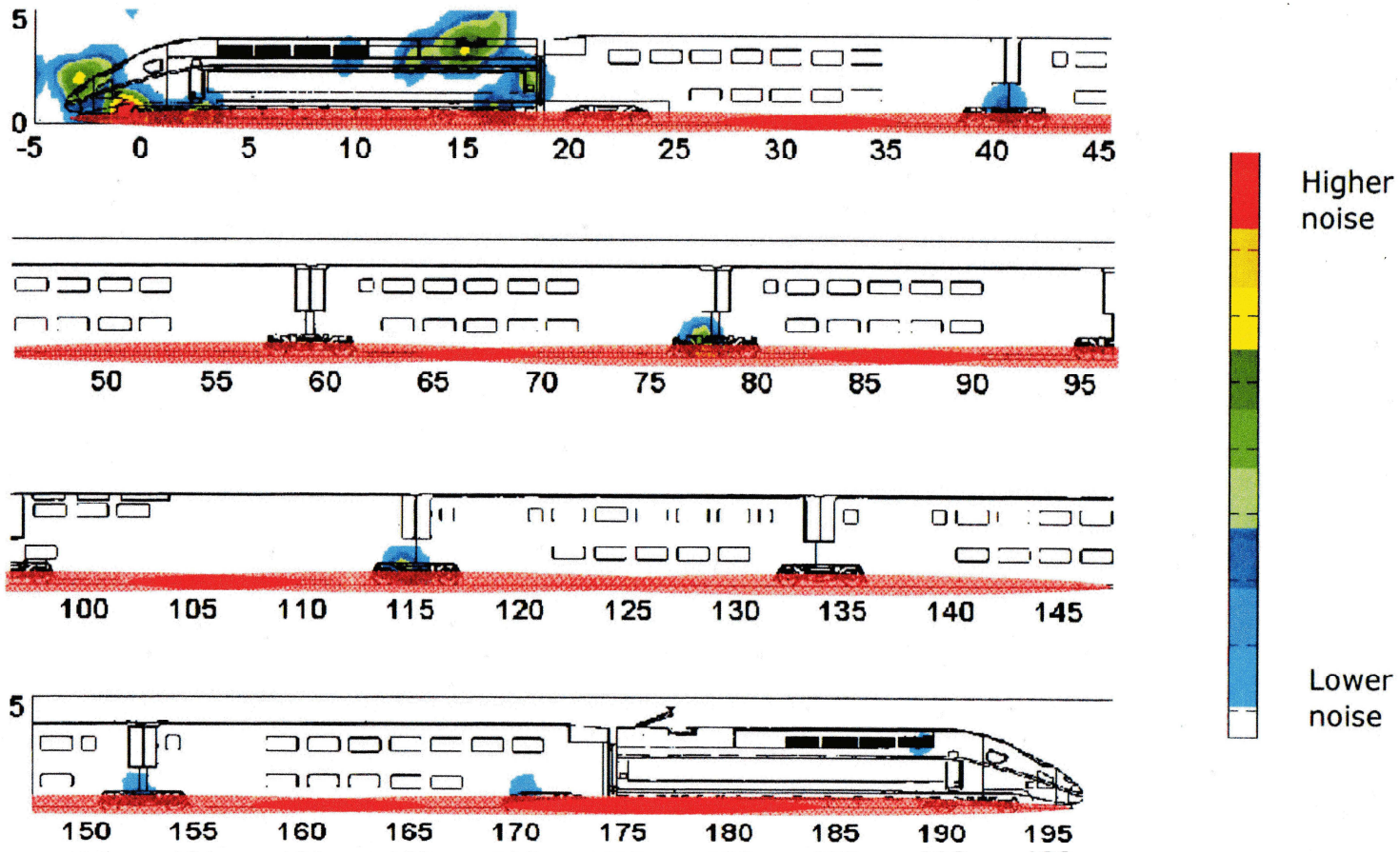
Category of the rolling stock subsystem	$L_{pAeq,T}$ [dB]
At standstill with horns sounding	95
At maximum speed v_{max} if $v_{max} < 250$ km/h	78
At maximum speed v_{max} if 250 km/h $\leq v_{max} < 350$ km/h	80

Pass-by noise



source: uic

HSR noise sources & barriers



source: UIC

HSR noise sources & barriers

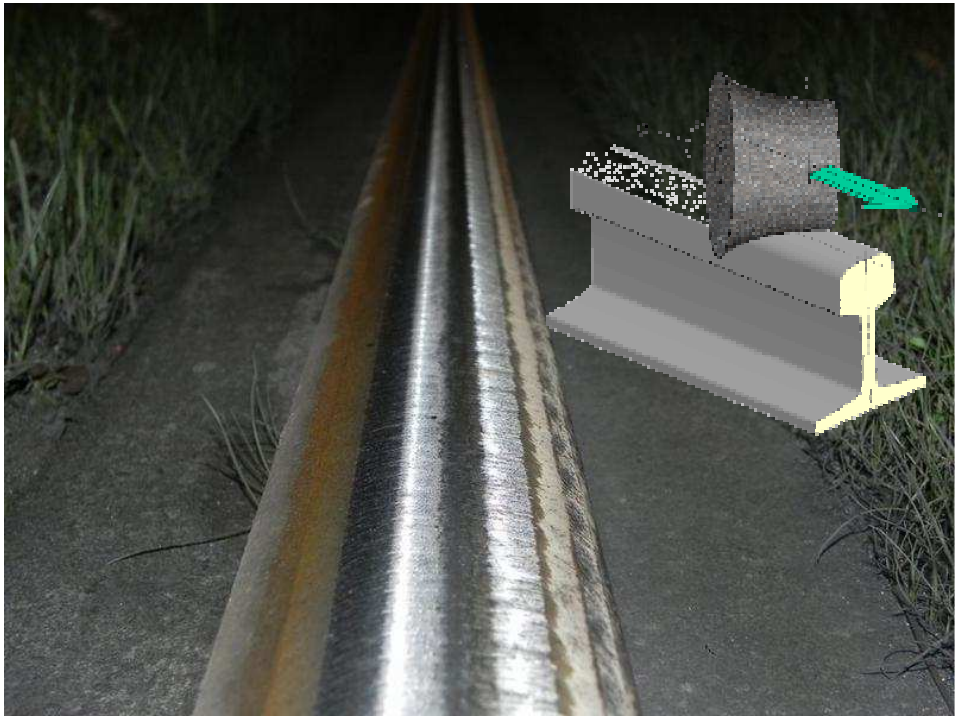
HSR noise sources & barriers

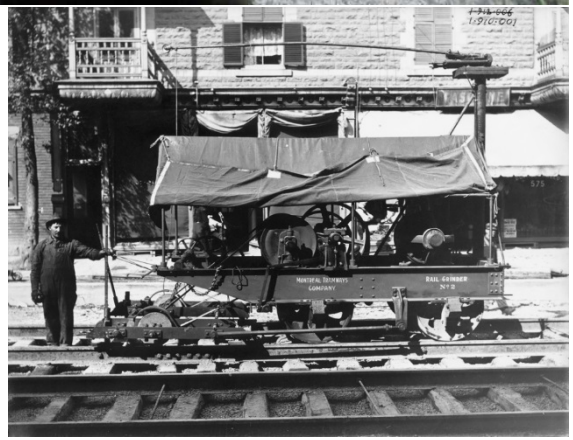
source: UIC

HSR noise sources & barriers

source: UIC

HSR noise sources & barriers – rail grinding





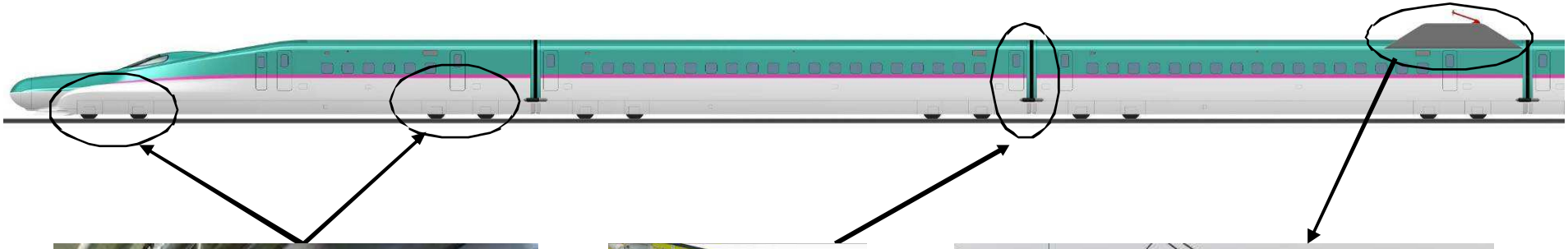
source:
ASMO Sp. z o.o.

HSR noise sources & barriers ? ? ?





For instance: Technology, Shinkansen



Bogie Cover and
Sound-absorbing Panels

Smooth Covers
between Cars

Pantograph Noise
Insulation Panels

Noise of Series E5 at 320km/h is same as Series E2 at 275km/h.

source: UIC

For instance: Technology, Shinkansen

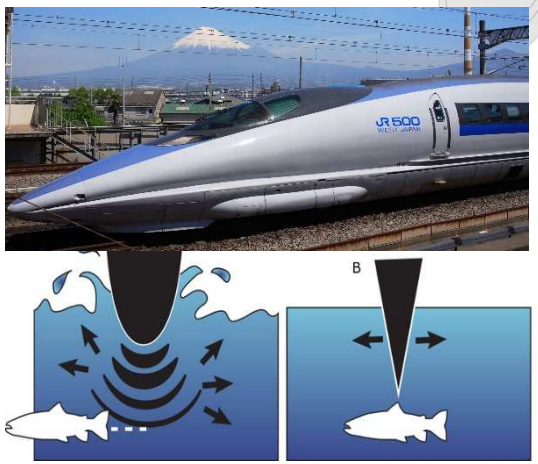
Problem	Animal	Characteristic	Application
The pantograph, a piece that connects the train to its power source, vibrated and made loud noise.		The owl has a concave face capable of absorbing sound. Its body has ample down to absorb fluttering sounds. Tiny serrations on its primary feathers minimize the vortex generated by movement.	The pantograph was reshaped like an owl's wing, including small serrations, that resulted in no vibrations and a quieter impact for residents near the tracks.
The supporting frame for the pantograph had a high degree of wind resistance resulting in aerodynamic noise.		The body of the Adelie Penguin is shaped like a spindle which allows it to move effortlessly through water to catch fish.	The pantograph's supporting shaft was reshaped like a penguin's body to lower its wind resistance.
When the train would enter a tunnel. a loud bang would occur due to the fixed air volume of the tunnel and the sudden increase in pressure from the entering train.		The shape of the Kingfisher's head and beak allow it to glide through the air and precisely dive into water to snag fish. It is the most efficient animal on earth to transition from low pressure (air) to high pressure (water).	The nose of the Shinkansen train was reshaped in the form of the Kingfisher to eliminate the sudden pressure increase. No more bang.

For instance: Pantograph, Noise reduction

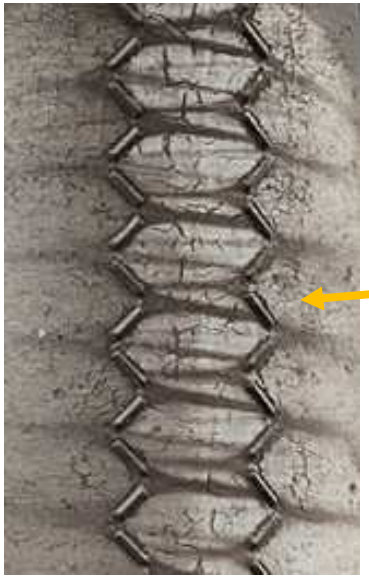
Thinking and Idea from natural

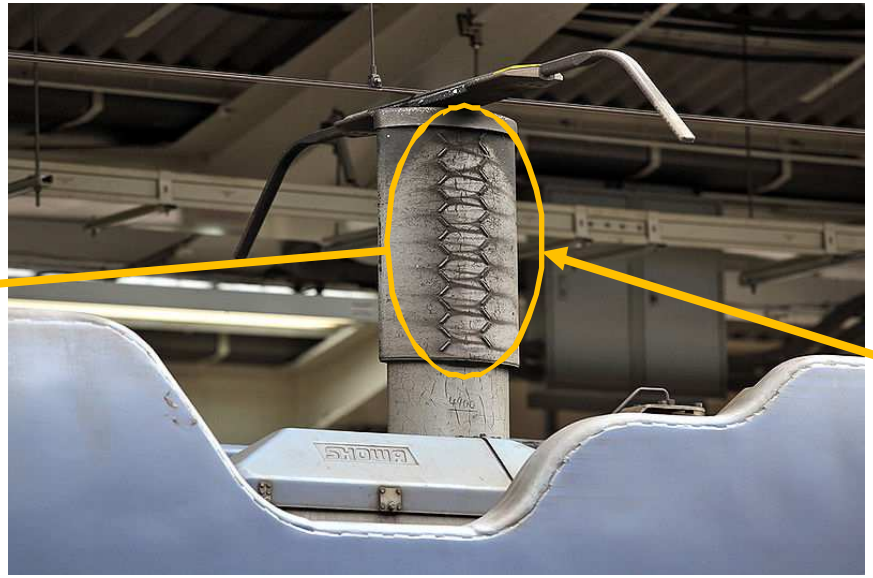
Series 500 Shinkansen (JR West)

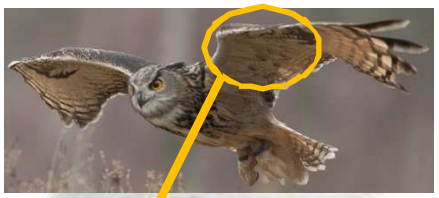
Indian kingfisher



source: Shinkansen



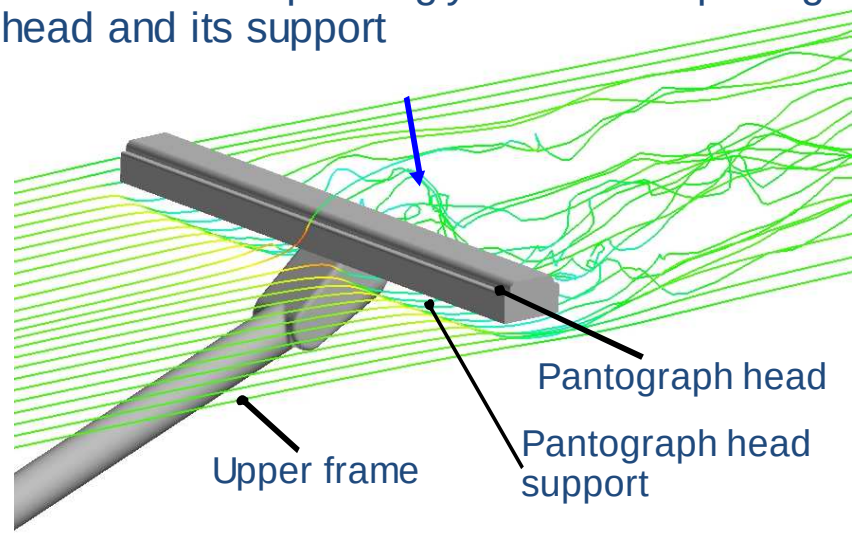




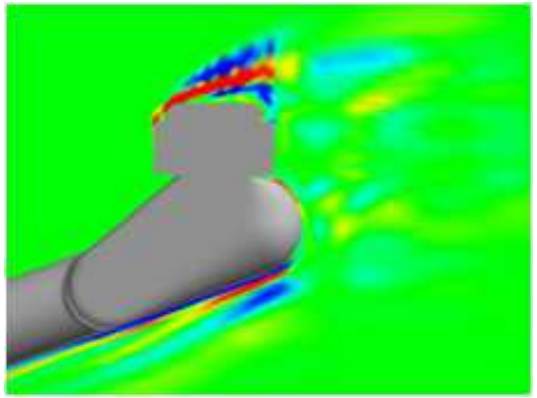
Owl

For instance: Pantograph, Noise reduction

The flow rolls up strongly behind the pantograph head and its support



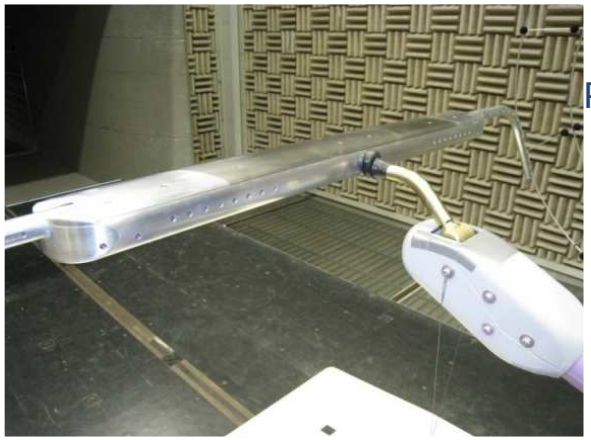
Simulation of air flow



Sound source identification

Computational simulation is helpful in developing new noise reduction technologies.

Improvement of panthograph shape

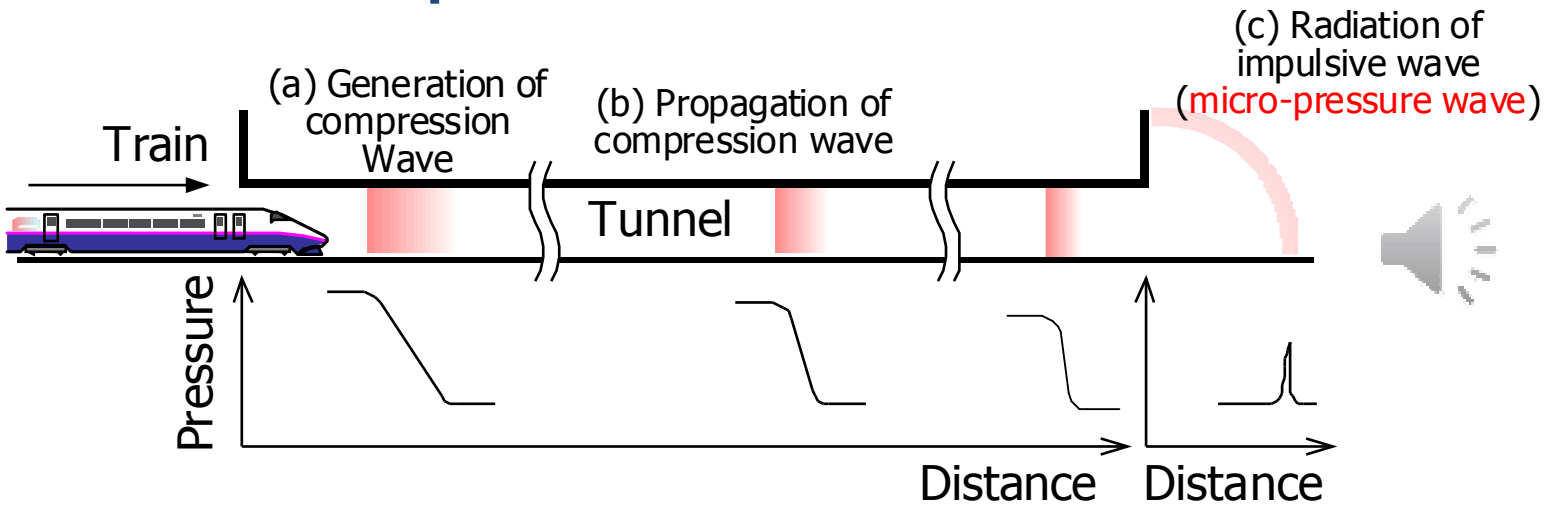


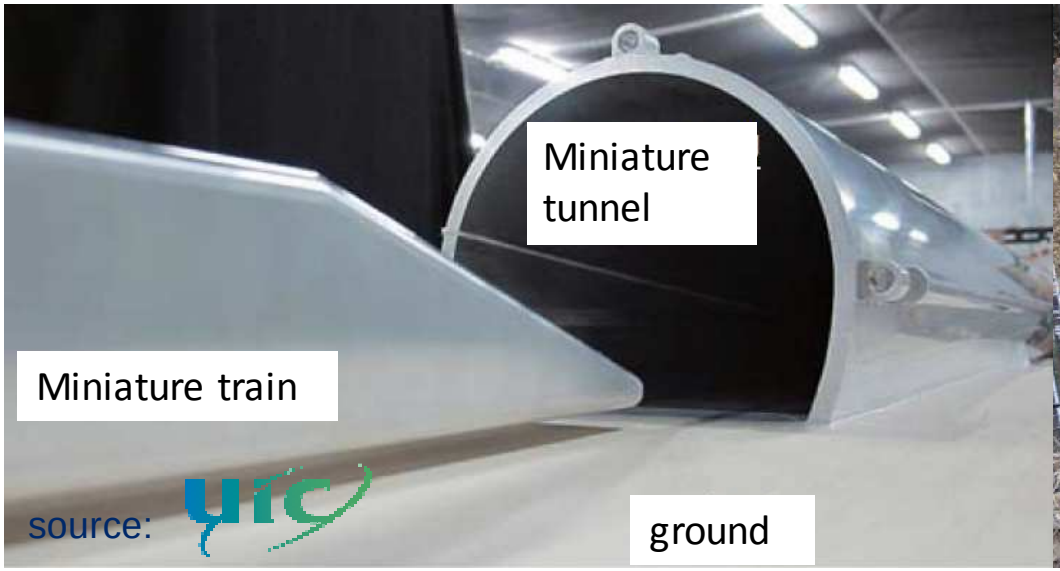
Application of new materials

Porous material

source: UIC

Reduction of micro pressure wave



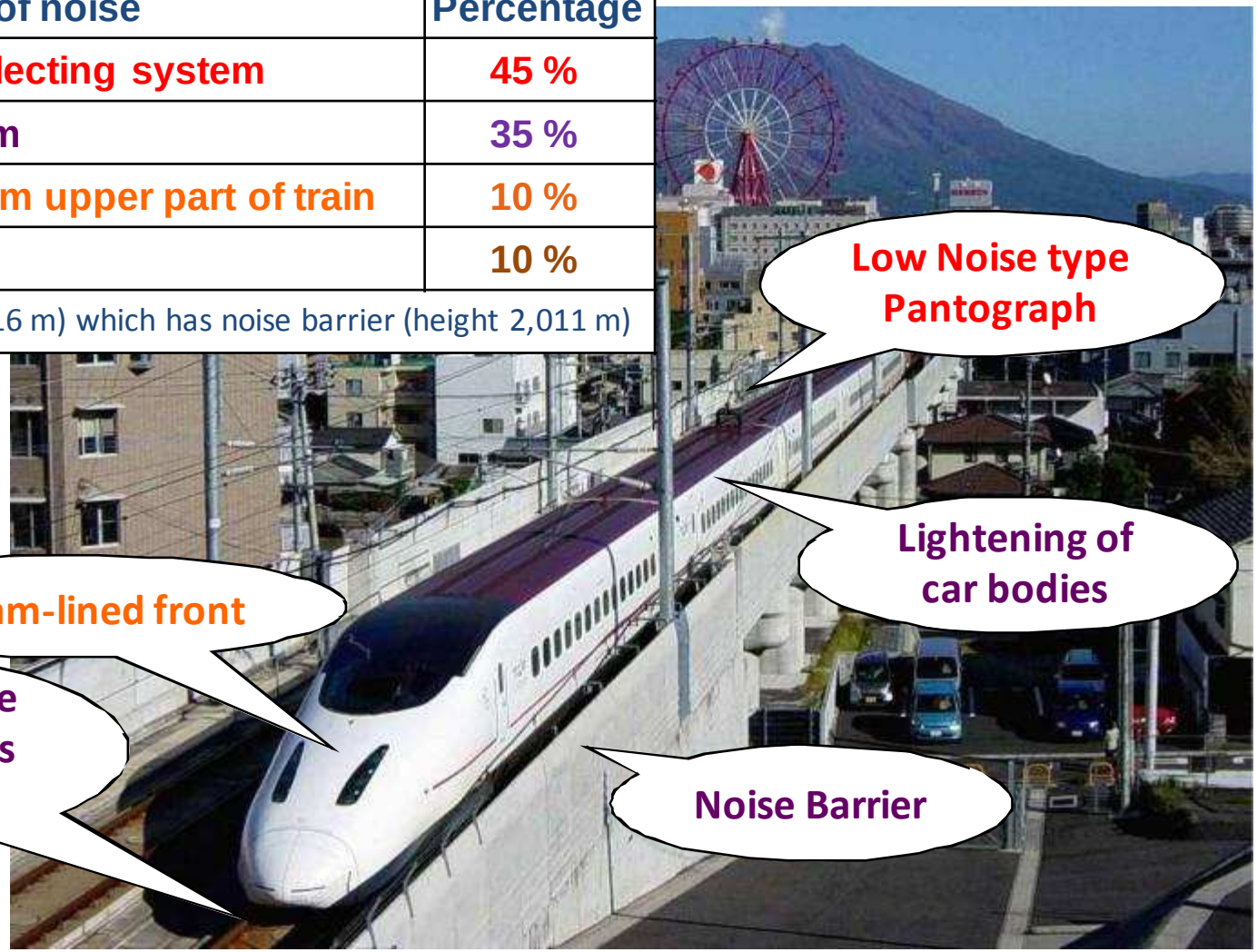


Model experiment of micro pressure wave

Tunnel entrance hood

Countermeasures Against Noise

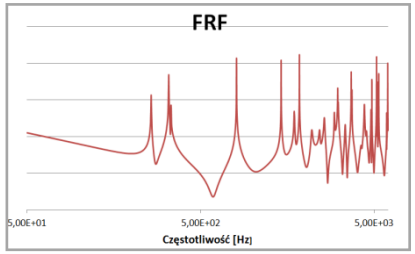
Source of noise	Percentage
Noise from current collecting system	45 %
Noise from train bottom	35 %
Aerodynamic noise from upper part of train	10 %
Noise from structures	10 %
in case of viaduct (height 8,016 m) which has noise barrier (height 2,011 m)	



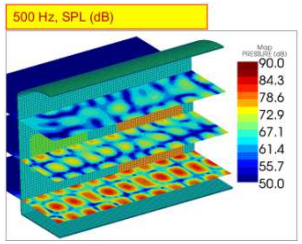
Source: Japan Ministry of Land, Infrastructure and Transport

Noise reduction in passenger trains- Poland

Acoustics – FEM
(finite element method)



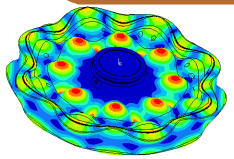
NASTRAN



ACTRAN

Modal analysis → Extraction of own frequencies → Frequency response → Interaction liquid - structure → Acoustic power radiation

Model 3D



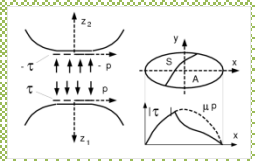
Contact force: N(f), T(f)

Results: $L_{pAeq,T}$ [dB(A)]
L_{pAFmax} [dB(A)]

SIMPACK

Multibody → Contact force: N(t), T(t) → FFT

Timing analysis of wheel-rail contact



Calculation according to the standards:

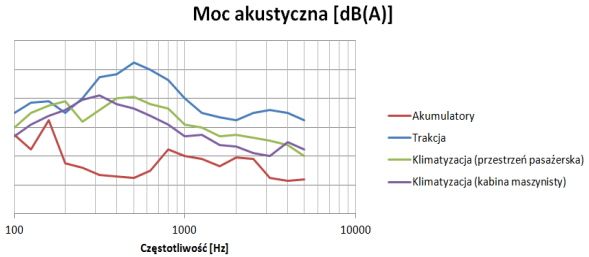
- **ISO 3095**
  - o stationary noise
  - o pass-by noise
  - o starting noise
- **EN 15892:2011**
  - o driver's cab interior noise
- **PN-EN ISO 3381**
  - o noise inside railbound vehicles

source:

EC ENGINEERING

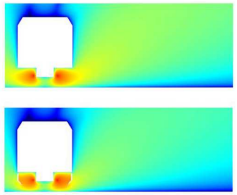
Noise reduction in passenger trains- Poland

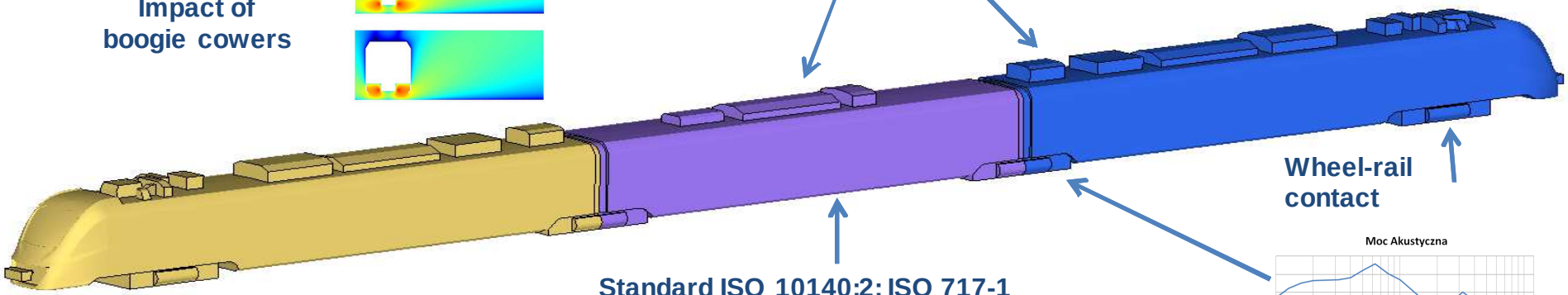
- Identification of noise sources
- Effectiveness of measures to reduce noise emission



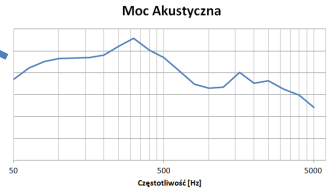
Air conditioning and traction units

Impact of boogie cowers

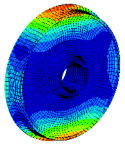


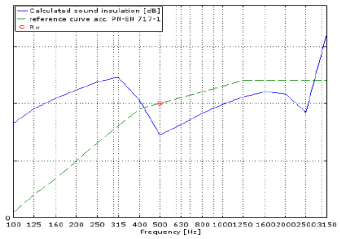


Wheel-rail contact

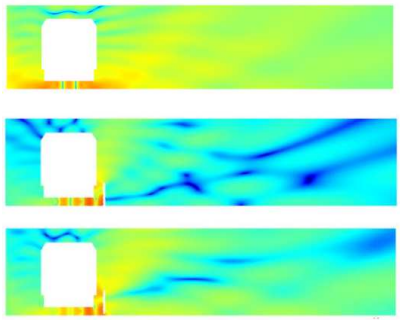


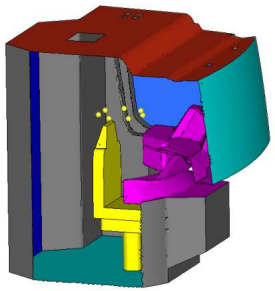
Standard ISO 10140:2; ISO 717-1
Sound insulation of partitions





Standard PN ISO 10847:
Efficiency of the acoustic barrier





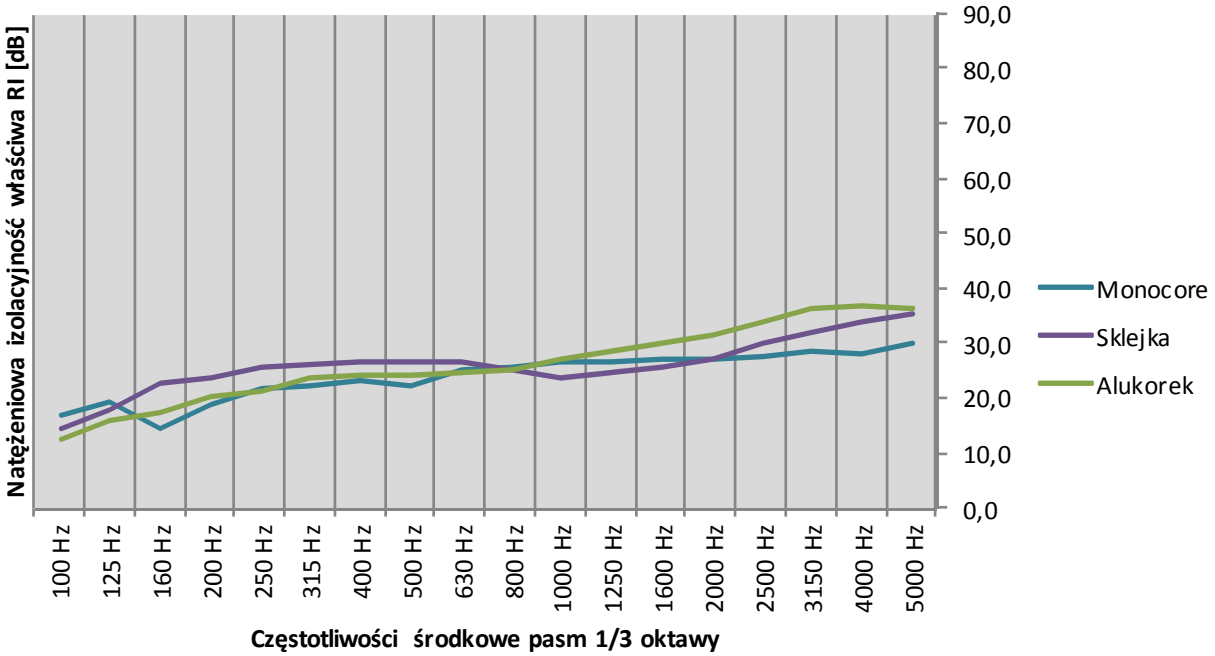
source :

EC ENGINEERING

Noise reduction in passenger trains- Poland

Ways of reducing vehicle weight while maintaining acoustic parameters

At present, a great deal of emphasis is placed on reducing vehicle weight. In the interior of the vehicle, a large part of the mass is the floor. So far used mainly plywood, however, it has a high density of 1620 kg / m^3. Less dense materials such as monocore 390 kg / m^3 or alucork appear on the market, providing similar sound insulation properties. Below is a comparison of the deafening properties of these materials.



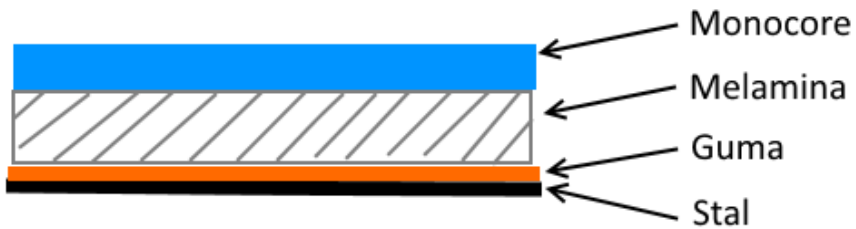
source :

Pojazdy Szynowe PESA Bydgoszcz SA

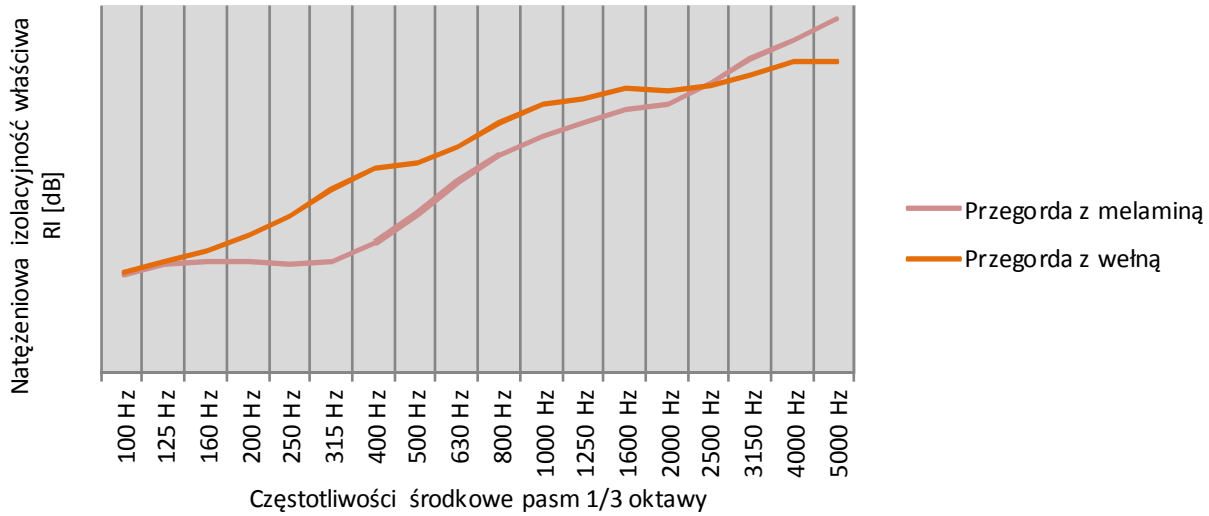
Noise reduction in passenger trains- Poland

Optimization of damping materials

Thanks to the measurement of dulling baffles, we can optimize them. For example, we face the problem of drowning passenger space from the impact of the truck. The bulkhead consists of four materials as below



By measuring the partitions we can verify how the acoustic properties change after changing the melamine to mineral wool.



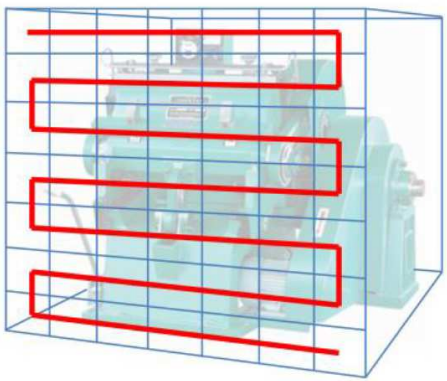
source :

pesa
Pojazdy Szynowe
PESA Bydgoszcz SA

Noise reduction in passenger trains- Poland

Introduction of modern methods of detecting noise sources.

In the finished vehicle, the origin of the noise must be determined. Measurement of noise inside the vehicle gives us only information on the sound level but does not tell us anything about the source of its origin. In this case, it is a very useful solution to use the judgment court. It allows you to precisely determine the intensity of the sound and the direction from which it comes. Below the left is a GRAS 50GI intensity probe and the surface scanning method on the right hand side of the example of an industrial machine.



source:

Pojazdy Szynowe
PESA Bydgoszcz SA

Noise reduction in passenger trains- Poland

Noise Reduction in Rail Freight

Composite Brake Shoes

LL material *
friction material with a mean coefficient of friction of **0,10 to 0,15**

L material *
friction material with a mean coefficient of friction of **0,15 to 0,25**

K material *
friction material with a mean coefficient of friction of **0,25 to 0,30**

Cast Iron Brake Shoe

* Definitions from PN-EN 16452:2015

Noise Reduction in Rail Freight

Composite Brake Shoes

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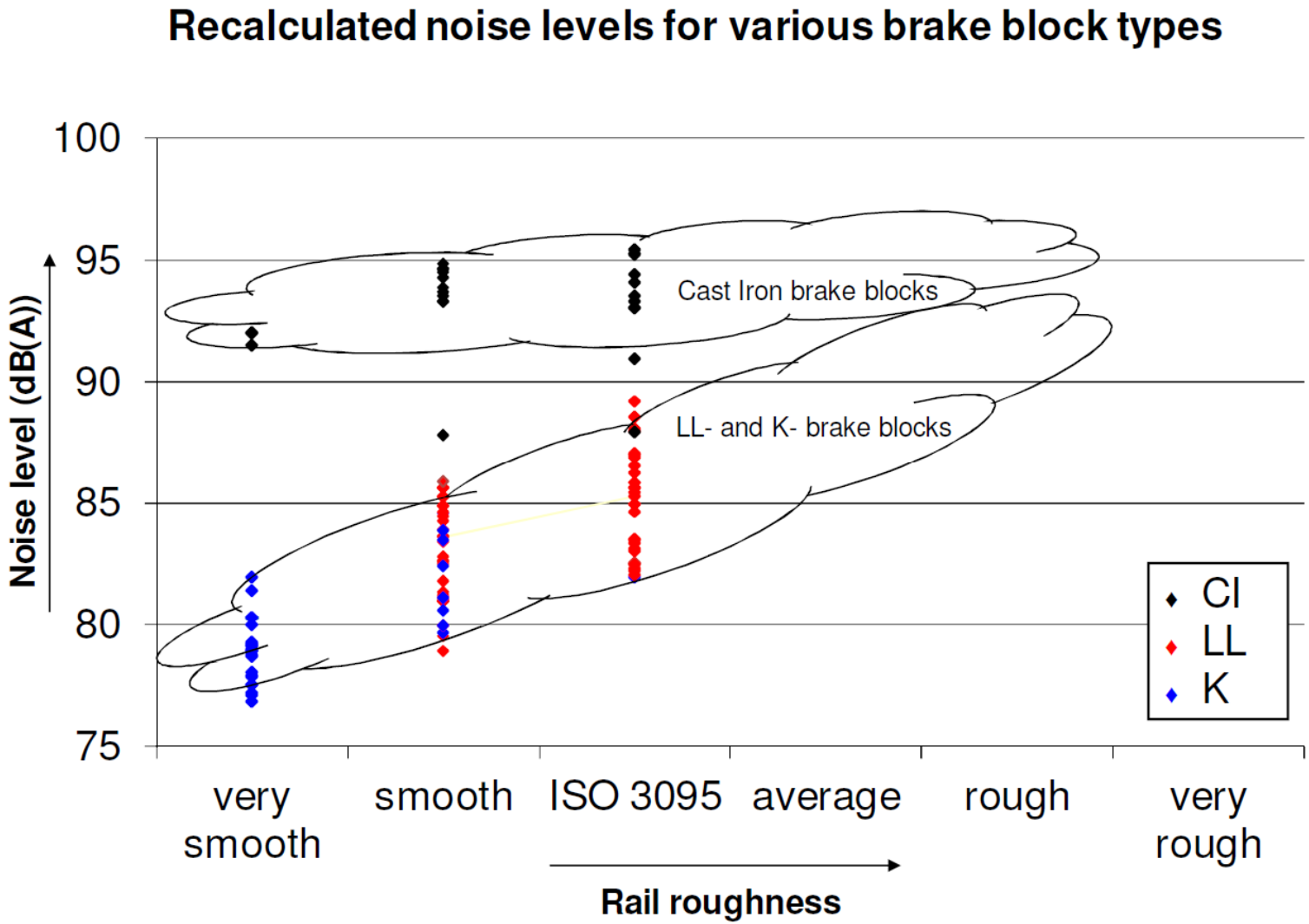
Cast Iron Brake Shoe

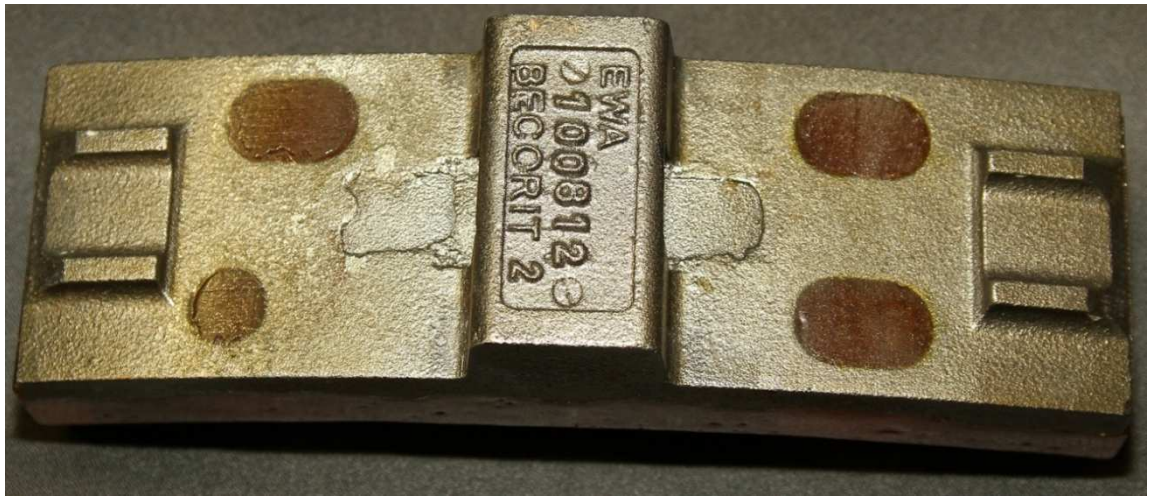
* Definitions from PN-EN 16452:2015

Noise Reduction in Rail Freight



Cast Iron & Composite LL Brake Shoes ($\mu = 0{,}10 \div 0{,}15$)*

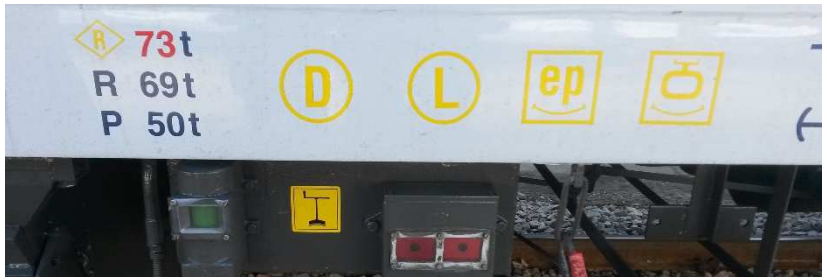
Cast Iron Brake Shoes



LL Brake Shoes

* Definitions from PN-EN 16452:2015

Composite L Brake Shoes ($\mu = 0{,}15 \div 0{,}25$)*

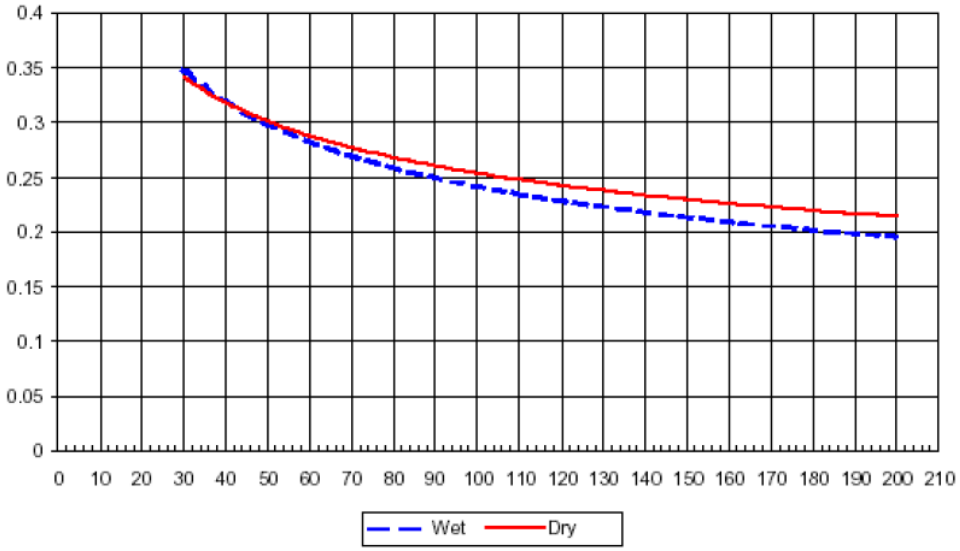


* Definitions from PN-EN 16452:2015

Organic K Brake Shoes ($\mu = 0{,}25 \div 0{,}3$)*

* Definitions from PN-EN 16452:2015

Sintered K Brake Shoes ($\mu = 0{,}25 \div 0{,}3$)* ???



* Definitions from PN-EN 16452:2015

Cast iron vs. composite brake shoes

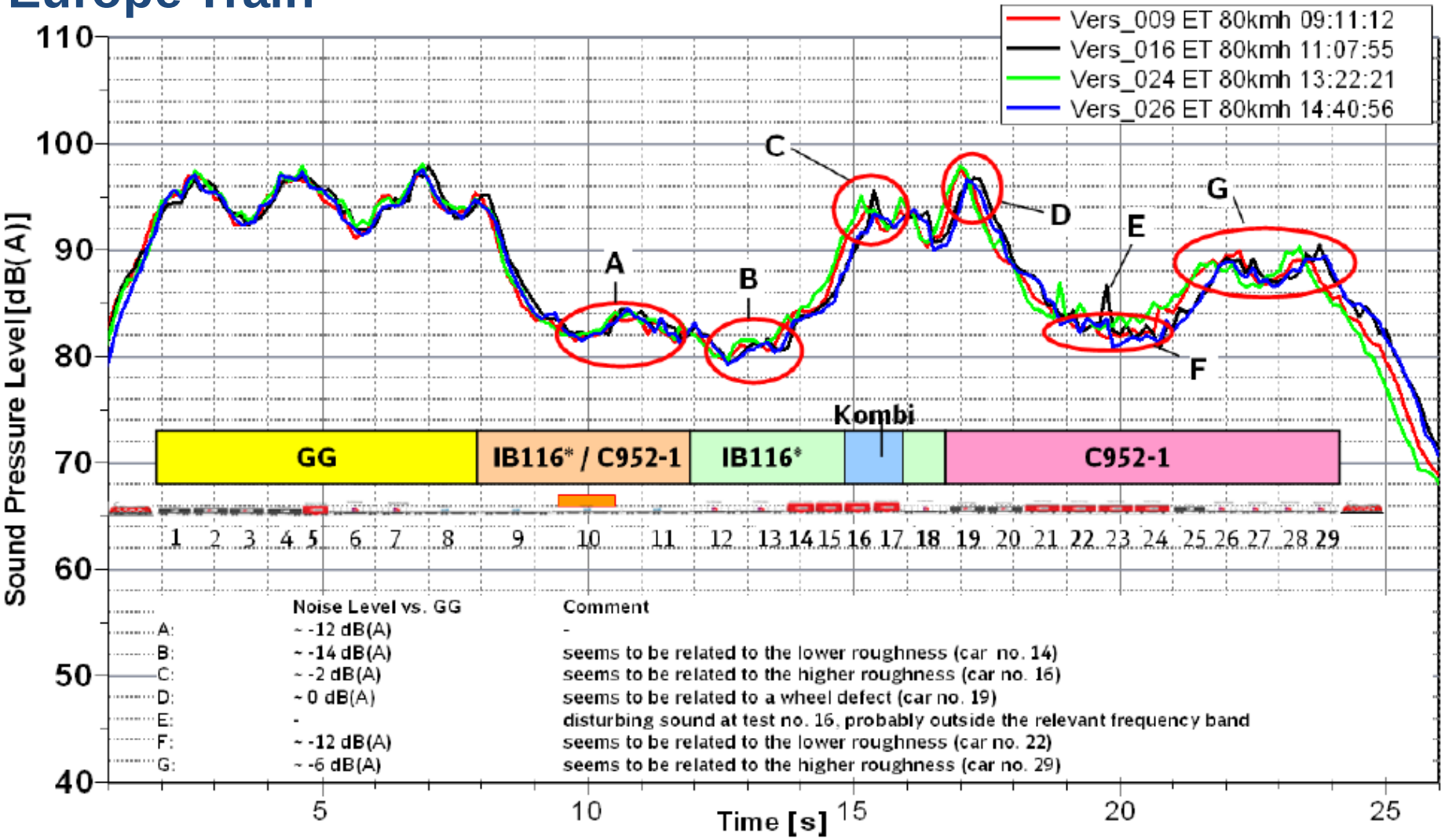
Rough wheel (braked with cast iron brake shoes)

Smooth wheel (braked with composite brake shoes)

Cast iron vs. composite brake shoes

Cast iron vs. composite brake shoes

Europe Train

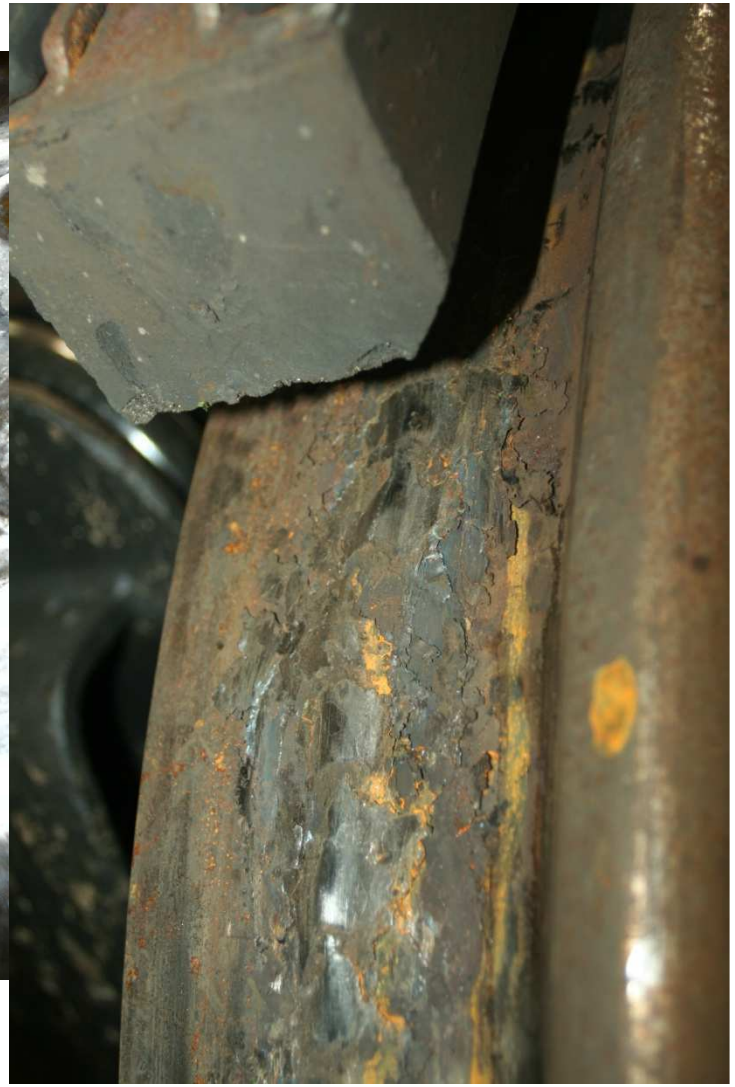


Preliminary Results Acoustic Test Pass-by (80 km/h)

source: DB Mobility Networks Logistics

Wagons noise sources

Wagons noise sources



Wagons noise sources

Diagnostic systems

Rolling stock emergency detection system - ASDEK

- detection the overheated bearings vehicle axle,
- detection the overheated, blocked brakes of rail vehicle,
- detection flat places on the wheals,
- axis pressure measurement rail vehicles on the track.

source: TENS

Wagons noise sources

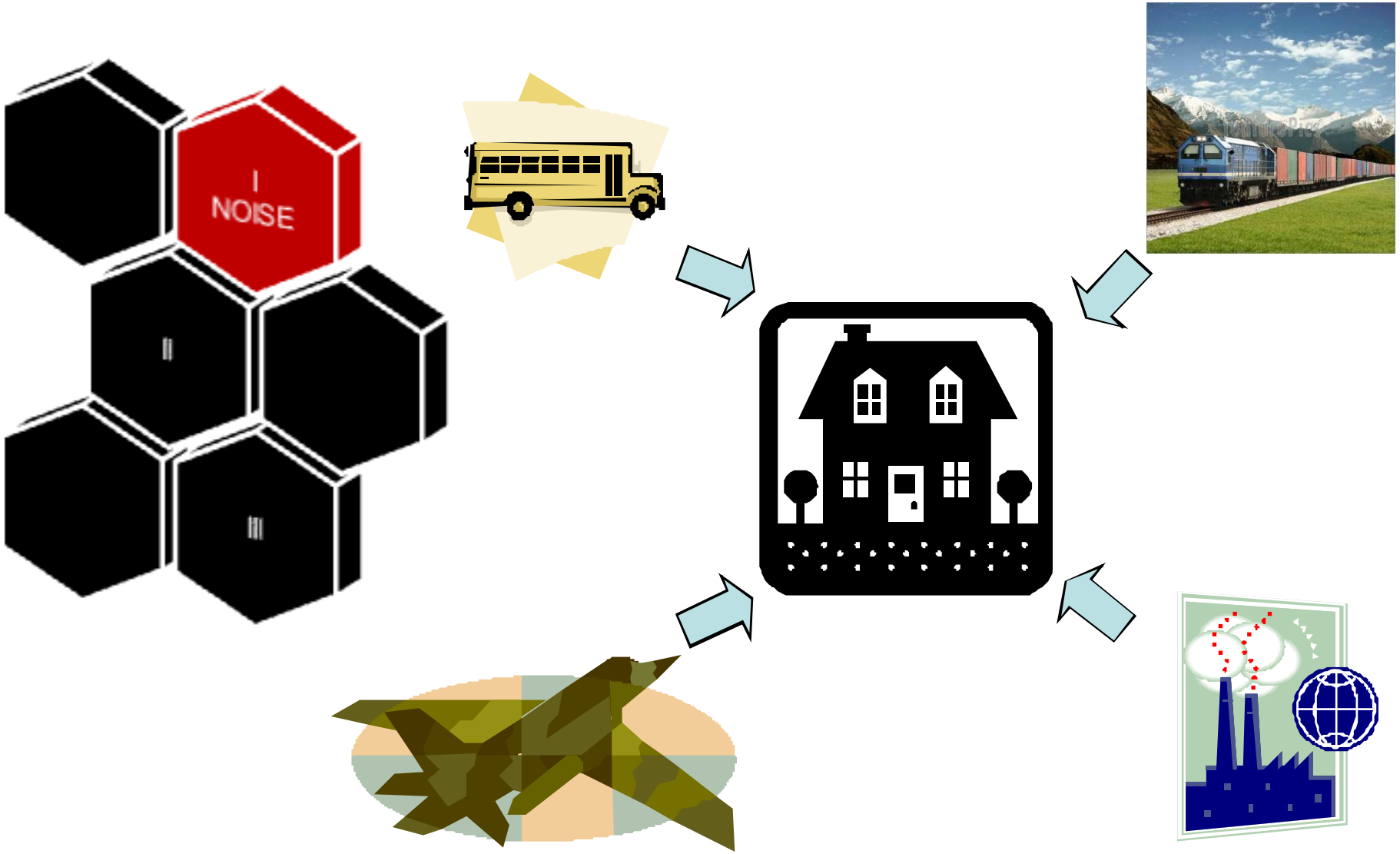
Ring dampers reduce noise by 6 dB

Wheel web shields reduce noise by up to 9 dB

Wheel-tuned absorbers reduce noise by up to 7 dB

WG3

NOISE



WG3

Hałas jest zjawiskiem złożonym.
Przeciętny Kowalski chciałby aby ograniczyć oddziaływanie hałasu od wszystkich źródeł.
Wyeliminowanie/ograniczenie jednego źródła hałasu nie wystarczy jeżeli nie jest to dominujące źródło hałasu.
W różnych krajach/obszarach/regionach ze względu na ich specyfikę podstawowe źródła hałasu mogą się różnić

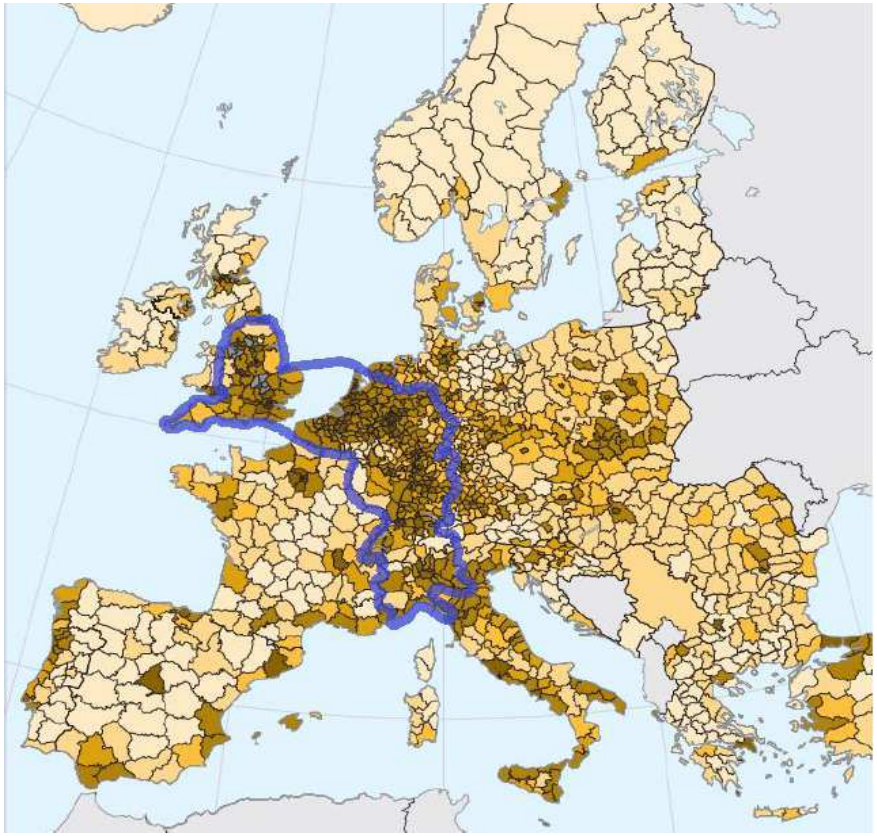
Groll; 2016-10-04

NOISE

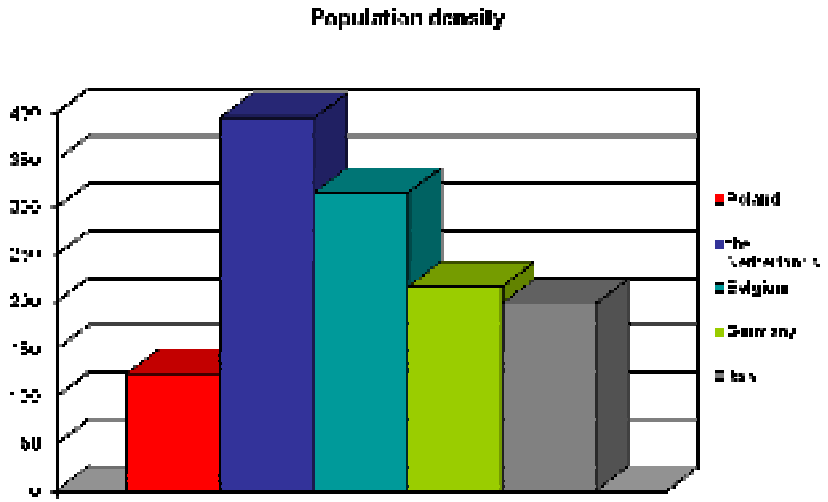
Exposure to noise caused by different means of transport varies depending on the place where it is generated (e.g. village, town, local settlement, nature area etc) and it is determined by numerous factors like:

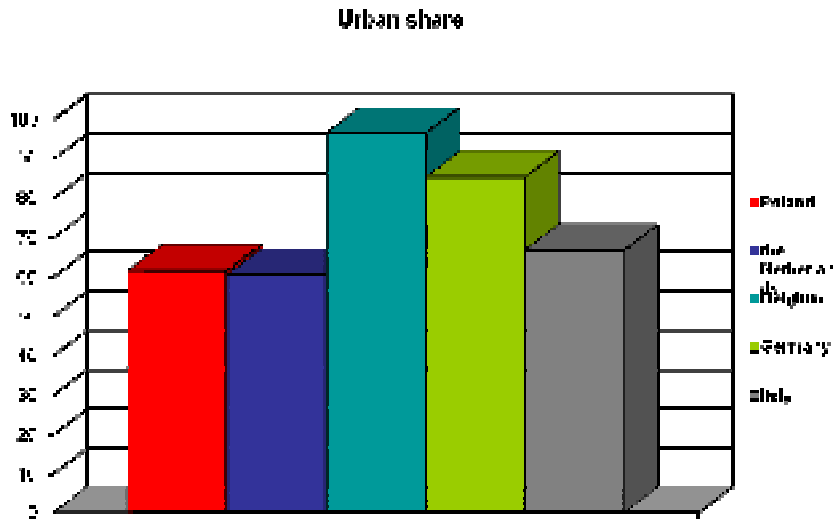
- *density of population,*
- *density of road infrastructure or railway infrastructure,*
- *intensity of road traffic or railway traffic,*
- *type of vehicles passing nearby: trucks or cars, passenger trains ` or freight trains,*
- *speed of running vehicles ,*
- *permissible axle load of running vehicles,*
- *quality of infrastructure,*

NOISE



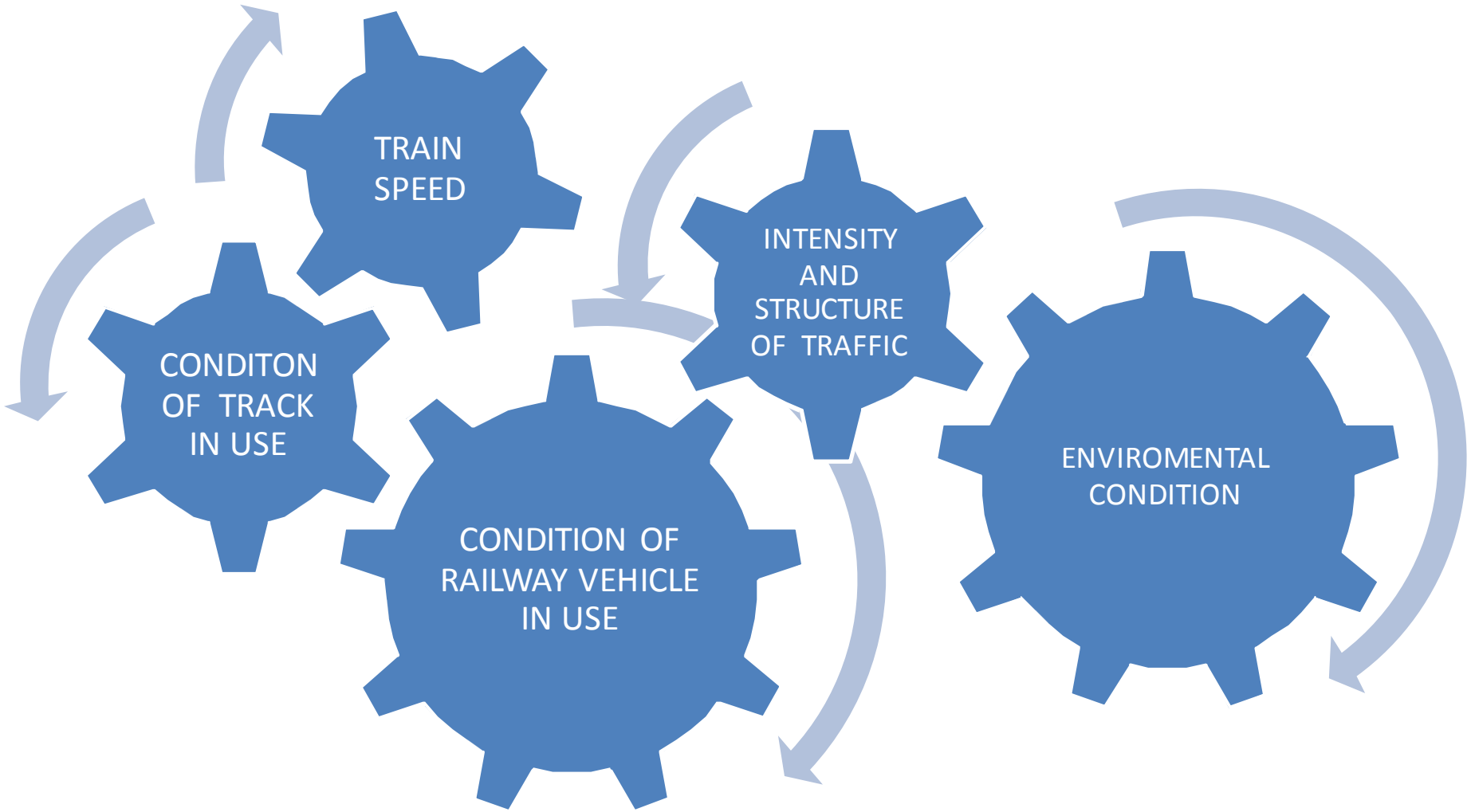
Population densitiy





Source: „Working Paper Series in Economics No. 61, September 2014"

EXSPOSURE TO RAILWAY NOISE



EXPOSURE TO RAILWAY NOISE

Source: „Acoustic map of PKP PLK ”

Analyzed area - 996.7 km2

22% - towns

78% - villages

20% - residential areas
24,4% - transport areas
11% - industrial areas
21.6% - agricultural areas
22,9% - green belts

Distance covered - 1215 km out of total 20 000 km railway network (6% of its overall length)

Urban agglomerations with population > 250 000

approx. 230 000 persons L_{DWN} > 55 dB

approx. 168 000 persons L_N > 50

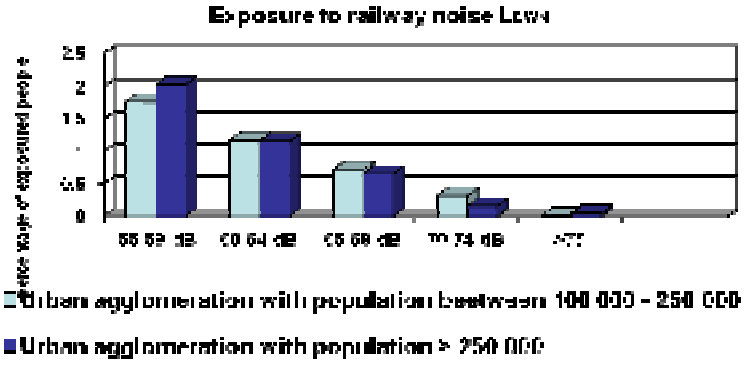
Total population 5 855 410

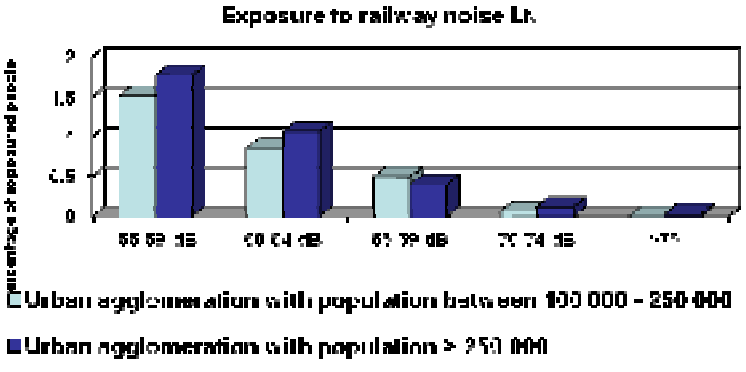
Urban agglomerations with population 100 000 - 250 000

approx. 170 000 persons L_{DWN} > 55 dB

approx. 140 000 persons L_N > 50

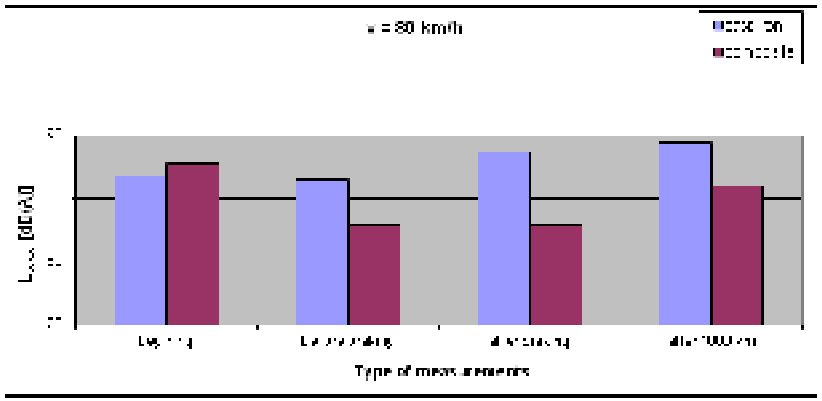
Total population 4 148 629

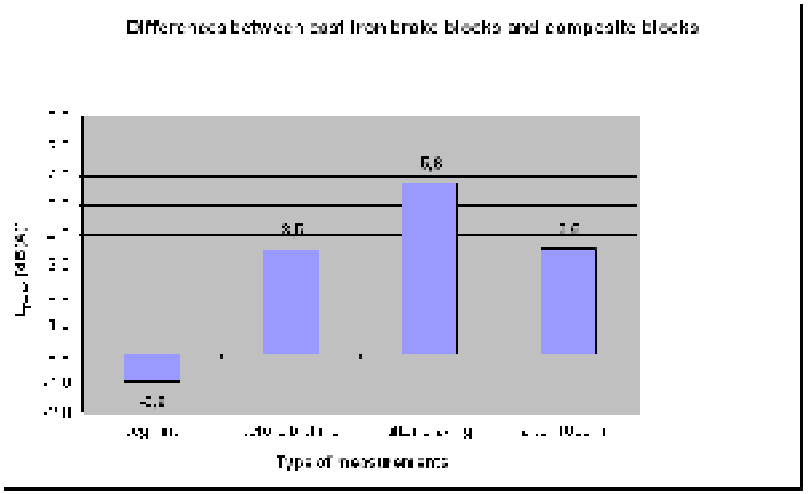




Source: „Report about state of environment ” –National Inspectorate for Environment Protection

EXPOSURE TO RAILWAY NOISE – mitigation methods





Comparative test with wagons fitted with cast iron brake blocks and composite brake blocks. Differences could be higher up to 7 - 10 dB (A).

Tread wheel defects increase noise up to 8 dB(A)

Source: Railway Institute research

Does the railway noise poses the risk of health hazard in Poland ?

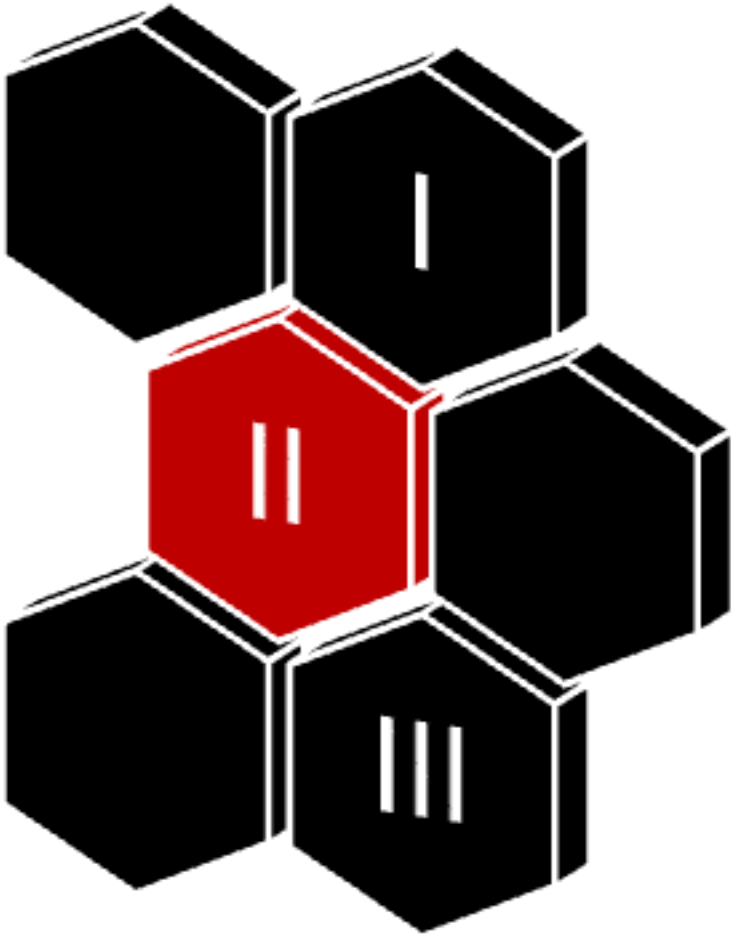
The nature of transport noise and its impact on the population in Poland has its own specificity – different from many other Member States:

- ***density of population*** *(in Poland: 124 person/km^2 vs Netherlands: 395 person/km2),*
- ***lower speed and lower permissible axle load of railway transport*** *caused by technical characteristics of rolling stock and technical condition of infrastructure*
- ***well-developed railway network including dedicated freight routes bypassing*** *large cities (eg. Line No. 131 from Silesia to the sea ports of Gdansk and line No.273 from Wroclaw to sea port Szczecin)*
- ***poorly developed motorways and express road network*** *(in Poland 3 000 vs in Germany 12 500 km)*
- ***poorly developed road network*** *which runs mainly through the city centers (due to lack of bypass roads)*

The railway noise is neither a predominant problem …
…nor defined as the social problem

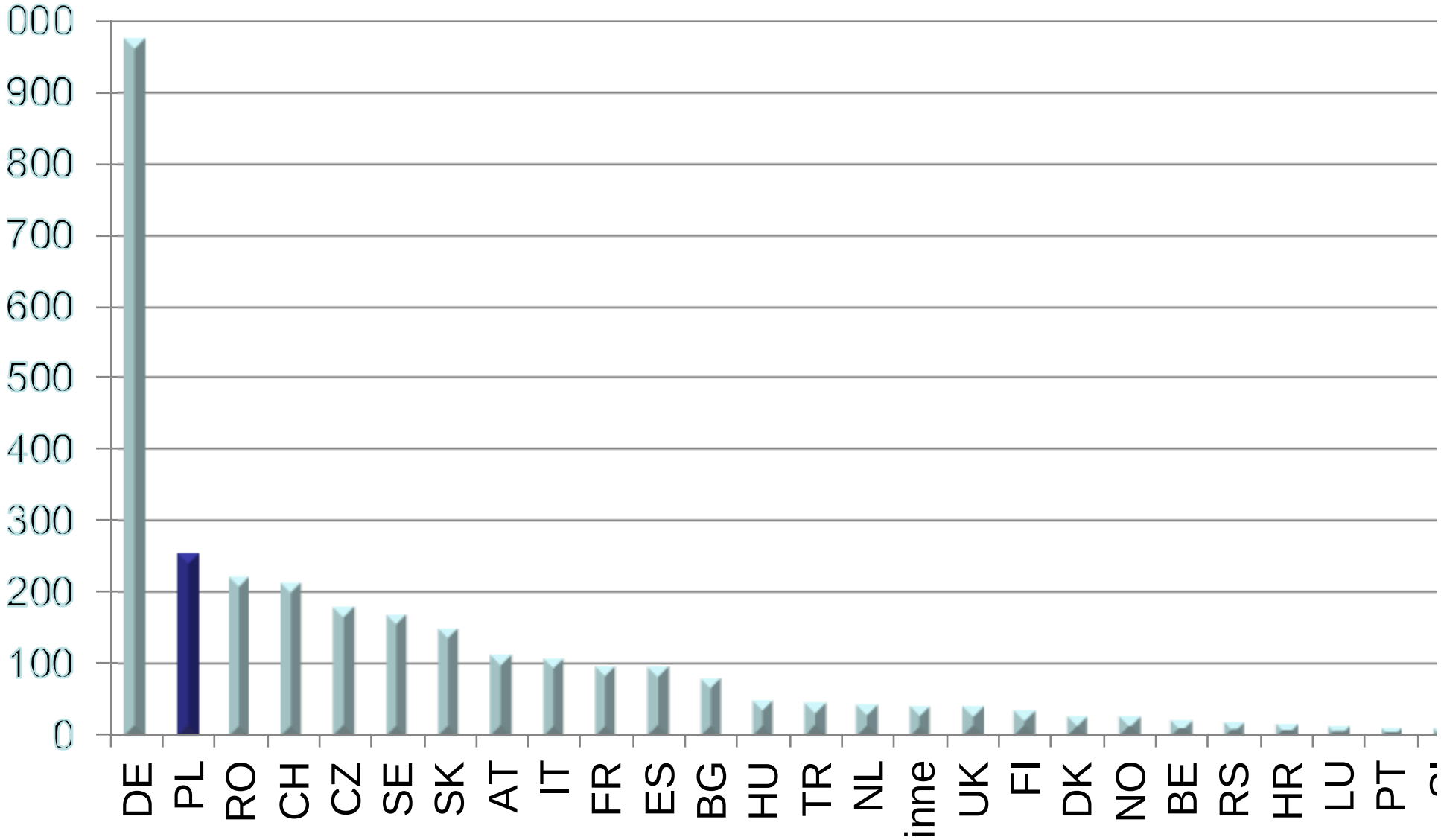
Conclusions from „Report on acoustic climate in environment" made by National Inspectorate for Environment Protection:

„..In this view, on the basis of analyzed acoustic map, ***the main problem is the road noise*** *outside the towns, coming from the main roads. Exposure on this type of noise is generally higher than average exposure in other EU Member States …."*



MARKET

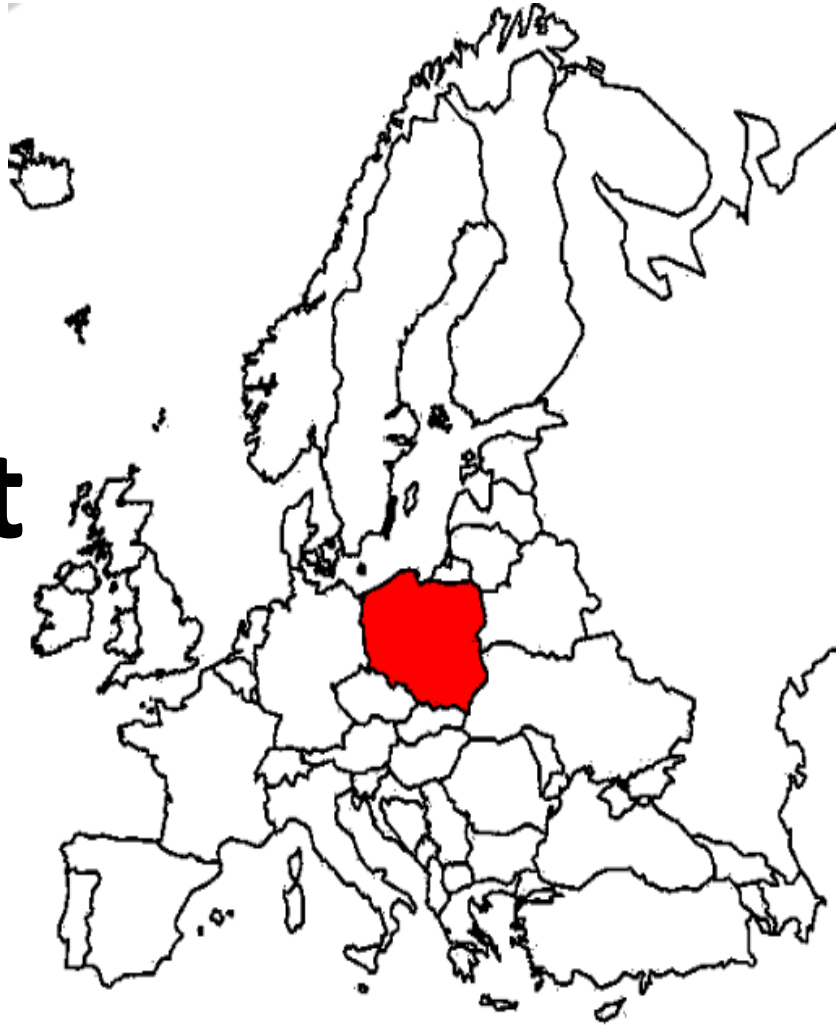
OPERATORS OF RAILWAY VEHICLES (VKM)



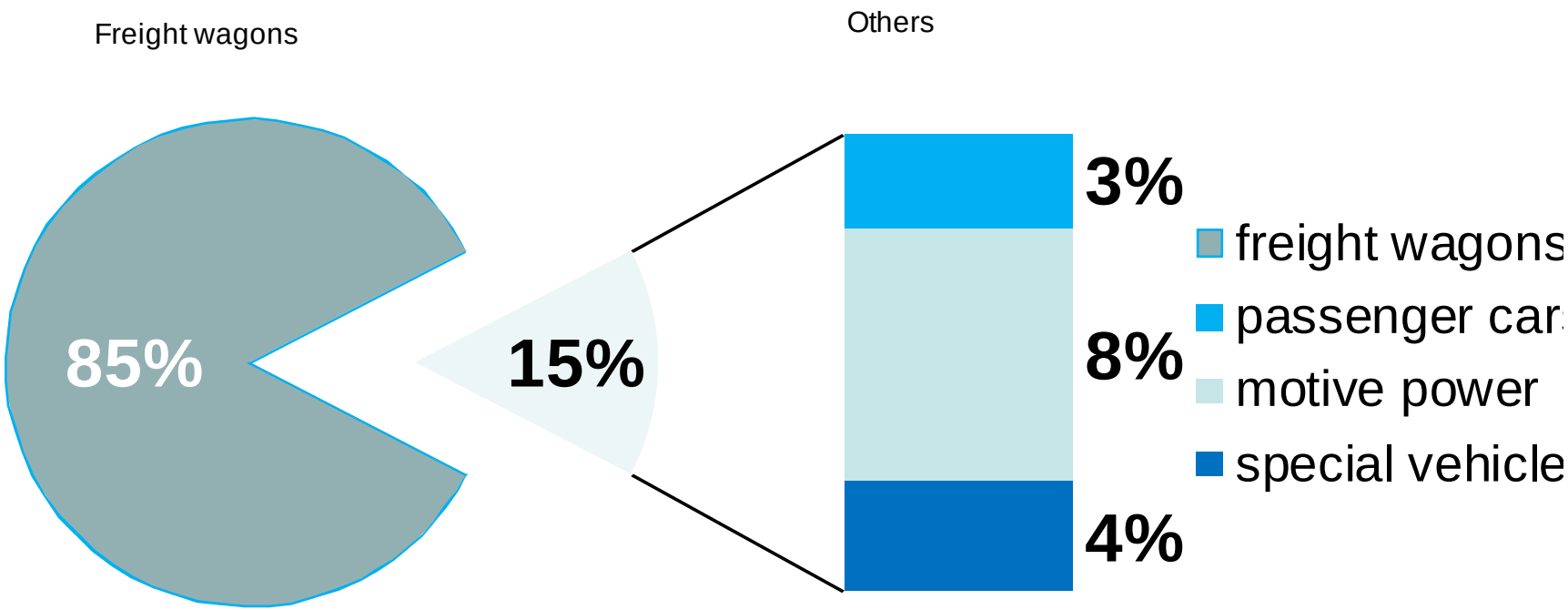
NATIONAL REGISTER OF RAILWAY VEHICLES (NVR)

108,5 K vehicles

13 % of UE market

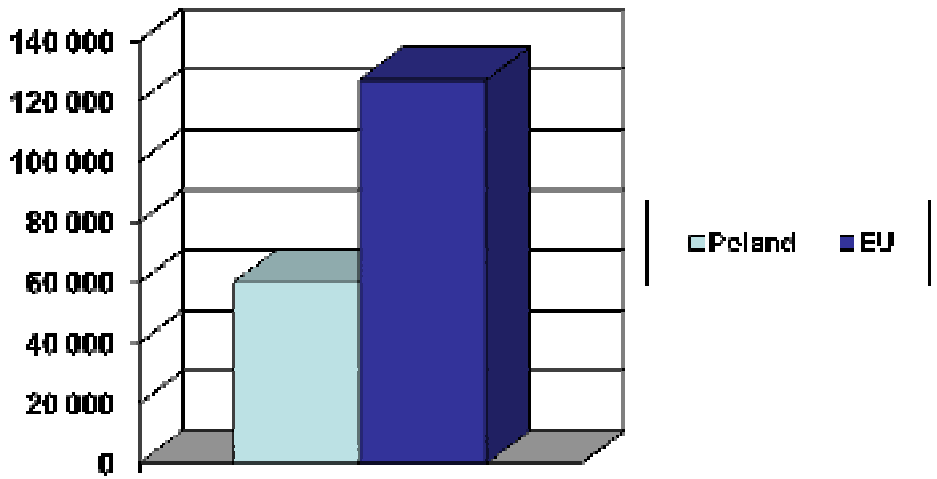


NATIONAL REGISTER OF RAILWAY VEHICLES (NVR)



NATIONAL REGISTER OF RAILWAY VEHICLES (NVR)

- Fleet of freight wagons – 98 643
- Number of wagons foreseen for adjustment to TSI Noise requirements – 78 914
- Number of wagons complying with TSI Noise requirements – 2367
- Number of wagons with monoblock wheels without composite blocks - 16571
- Number of wagons with tyred wheels – 59 976



47% of freight wagons with tyred wheels are registered in Poland !!!!!!

Concept of compliance with NOI TSI

TSI NOISE 2006/66/WE

…The Commission will take initiatives to discuss option for retrofitting of freight wagons with the relevant stake-holders to achieve a general agreement with the industy.

IMPLEMENTATION STRATEGY

- based on wagons authorisation background or on its actual use (international/national wagons)
- NOI TSI compliant wagons on quieter routes

FIRST INTERNATIONAL THEN NATIONAL WAGON STRATEGY

- This implementation strategy requires to define ‘international wagon’ .
  - *Definition based on authorisation*
  - *Definition based on actual use of the wagon*

QUIET ROUTE STRATEGY – FIRST STEP

- The first step starts with a one-off calculation. It is assumed that all freight trains are equal to a conventional train, in which all the wagons are fitted with cast-iron blocks. This conventional train is defined by fixed levels of pass-by noise, speed and length. It is also assumed that the impacted population lives at a conventional (fixed) distance from the railway lines.
- The result of this one-off calculation is the number of passages of conventional freight trains per night exceeding the immission noise limit value. This number of passages will be incorporated as reference value in NOI TSI
- The freight traffic of each route is then compared to the reference value above
- If the freight traffic on a route is higher, the route should be quieter. Otherwise, the route should not be made quieter

QUIET ROUTE STRATEGY – SECOND STEP

- In the second step, possible exemptions are defined for the routes that should be quieter in accordance with the calculation and comparison in the first step
- A quieter route can be declassified if all the sections of the route fulfil at least one of the following conditions:
  - The population density in the section is below x people/km (on average, at a distance of 25 m from the line)
  - The section is equipped with additional sufficient noise reduction devices (walls, rail damping, tunnels etc.)

DEADLINES

First international wagons, then national

- The European Commission proposes to set out different deadlines for the mandatory NOI TSI compliance of existing international wagons (first phase - 1st January 2022) and all existing wagons (second phase - 1st January 2026), with a possible extension of the first phase in case of wagons subject to bilateral agreements between neighbouring Member States.

NOI TSI compliant wagons on quieter routes

- No general deadline would be applied to the retrofitting of the wagons. All Member States should notify to the European Commission the quieter routes of their networks 6 months after the entry into force of the revised NOI TSI. NOI TSI will be applicable to the existing wagons circulating on these routes 2 years after the entry into force of the revised TSI.

POSSIBLE SCENARIO

POSSIBLE SCENARIO

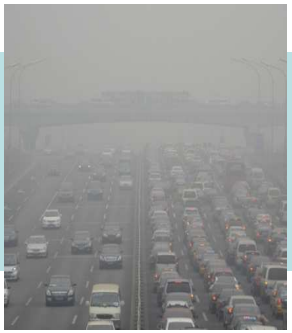
IDIOSYNCRASY OF POLISH FREIGHT WAGONS:

- Very high percentage of freight wagons with tyred wheels
- Installation of composite brake blocks entails use of monoblock wheels
- Necessity of purchasing monoblock wheels increases wagon adjustment costs to TSI Noise requirements significantly
- High average lifetime of wagons – sense of investment in old wagons

Substantial increase of costs for railway sector

Shifting transport of goods to roads

Increase of road noise level and decline of safety



Polution increase

COST OF ADJUSTMENT

No	Wagon type	Number of wagons	Brake block purchase cost	Wheels purchase cost	Replace - ment cost	Overall cost
1	TSI Noise compliant wagons	2 367				
2	Wagon with monoblock wheels, without composite brake blocks	16 571	4 000 PLN 958 Euro		320 PLN 76,6 Euro	71,5 mln PLN 17,1 mln Euro
3	Wagons with tyred wheels, without composite brake blocks	59 976	4 000 PLN 958 Euro	29 500 PLN 7 066 Euro	2 680 PLN 642 Euro	2170 mln PLN 520 mln Euro
4	**TOTAL**	**78 914**				**2241,5 mln PLN** **537 mln Euro**

Application of TSI Noise 2022 – 89.5 mln Euro/year

Application of TSI Noise 2026 – 59,88 mln Euro/year

Profit in 2015
7,5 mln Euro

537 mln Euro = 9 100 new silent wagons

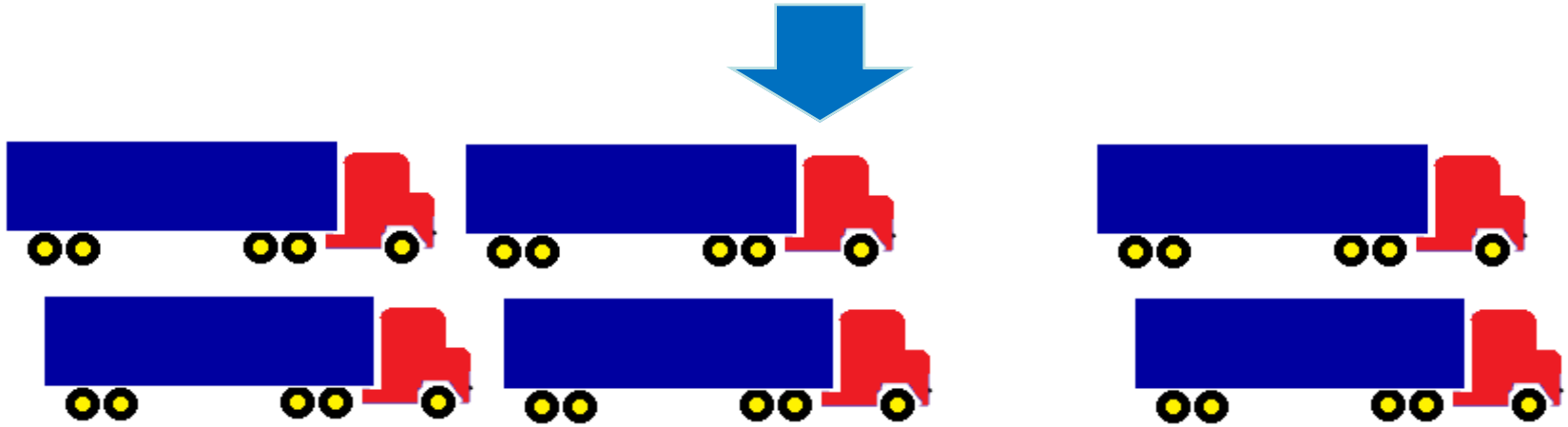
FIGHTING RAILWAY NOISE = INCREASE OF ROAD NOISE

- Currently road transport dominates freight transport in Poland with over 65.7 % share in modal split, while railway accounts for just 23.8 (Eurostat 2014)
- Fighting railway noise generates **huge costs for the railway sector** which will need to be recovered from its clients – significant increase of transport rates (up to 400 euro more for an average freight train over average travel distance)
- Result: **increase of road transport share** and more road-related noise
- Road noise is considered much worse than the rail noise:
  - due to density of road network, road noise is generated closer to people
  - road noise is constant over time due to high traffic volumes, while rail noise appears only for a short moment where the train passes

COST OF ADJUSTMENT

Assumption*):

- 1 train set = 40 wagons
- (60 t of load on each) x 40 = 2 400 t of load.

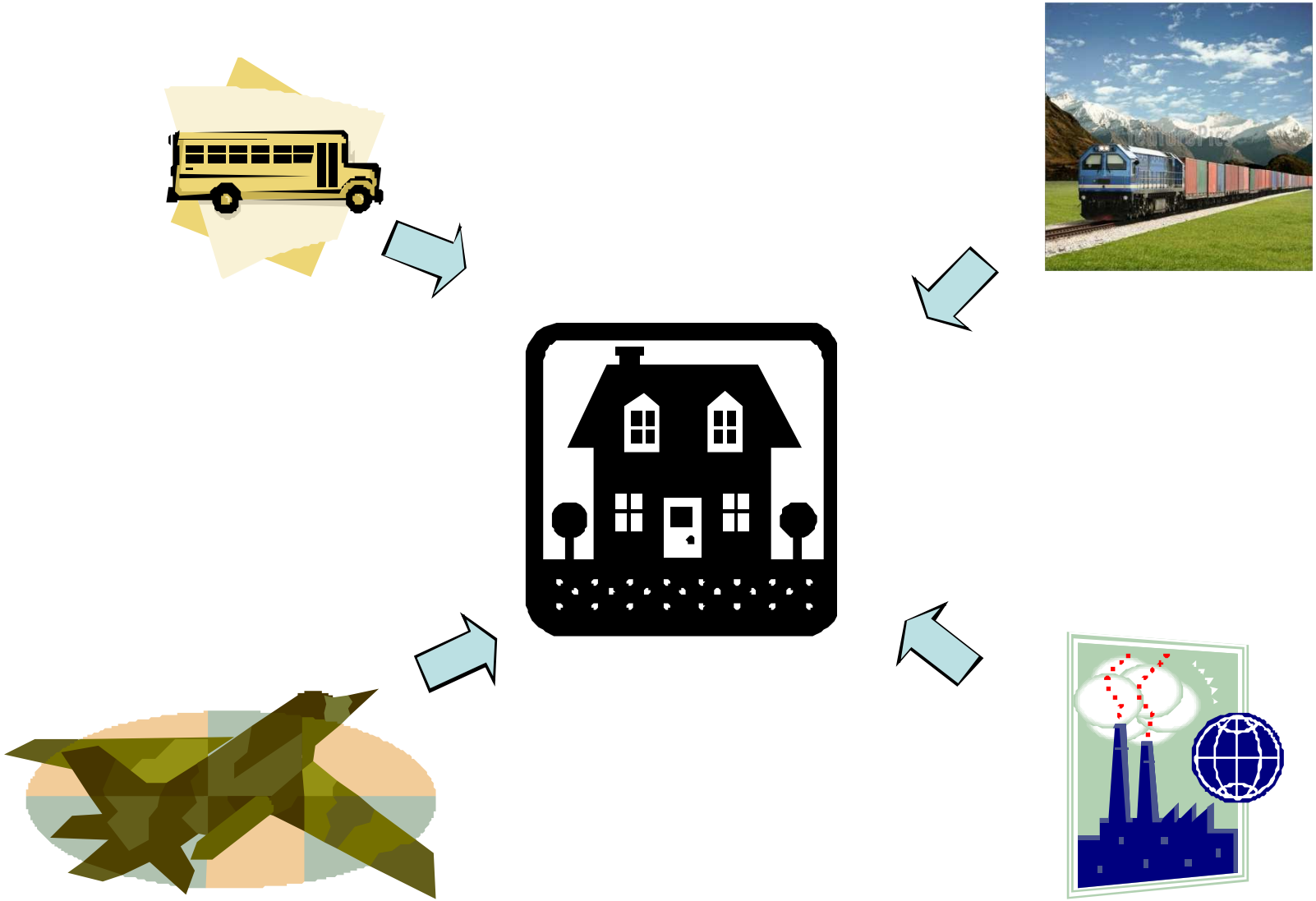


= 60 vehicles

*) Requirements of UIC Leaflet IC 421 and 544-1 and Instruction Ir-1 oraz Cw-1.
For the assesment of total load of road vehicle taking into account Act of Minister of Infrastructure from 31 December 2002r. (Journal of Law from 2003 No. 32, pos.. 262 with later changes)

wg2

SUSTAINABILITY



wg2 Tak jak w obliczeniach komputerowych dla znalezienia optymalnego rozwiązania określamy funkcję celu, którą jest np. ograniczenie liczby ludności narażonej na negatywne oddziaływanie hałasu, stosuje się kolejne iteracje mające doprowadzić do jak najszybszego w czasie rozwiązania problemu. Niestety nieumiejętne dobranie kroku iteracji bądź jego kierunku sprawia, że metoda jest rozbieżna, a proces obliczeń trzeba zaczynać od początku wyznaczając nową funkcję celu co w naszym przypadku oznacza, że zamiast ograniczyć liczbę ludności poddaną oddziaływaniu hałasu komunikacyjnego możemy ją zwiększyć i na nowo podejmować działania zapobiegawcze.

wgroll; 2016-10-05

QUESTIONS FOR DISCUSSION

1) The European Commissions White Paper on Transport from 2011 among 10 goals for the creation a competitive and resource efficient transport system identifies, that 30% of road freight over 300 km should be shifted to other modes such as rail or waterborne transport by 2030, and more than 50% by 2050. How the costs of revision of the TSI Noise will impact the realization of this goal?

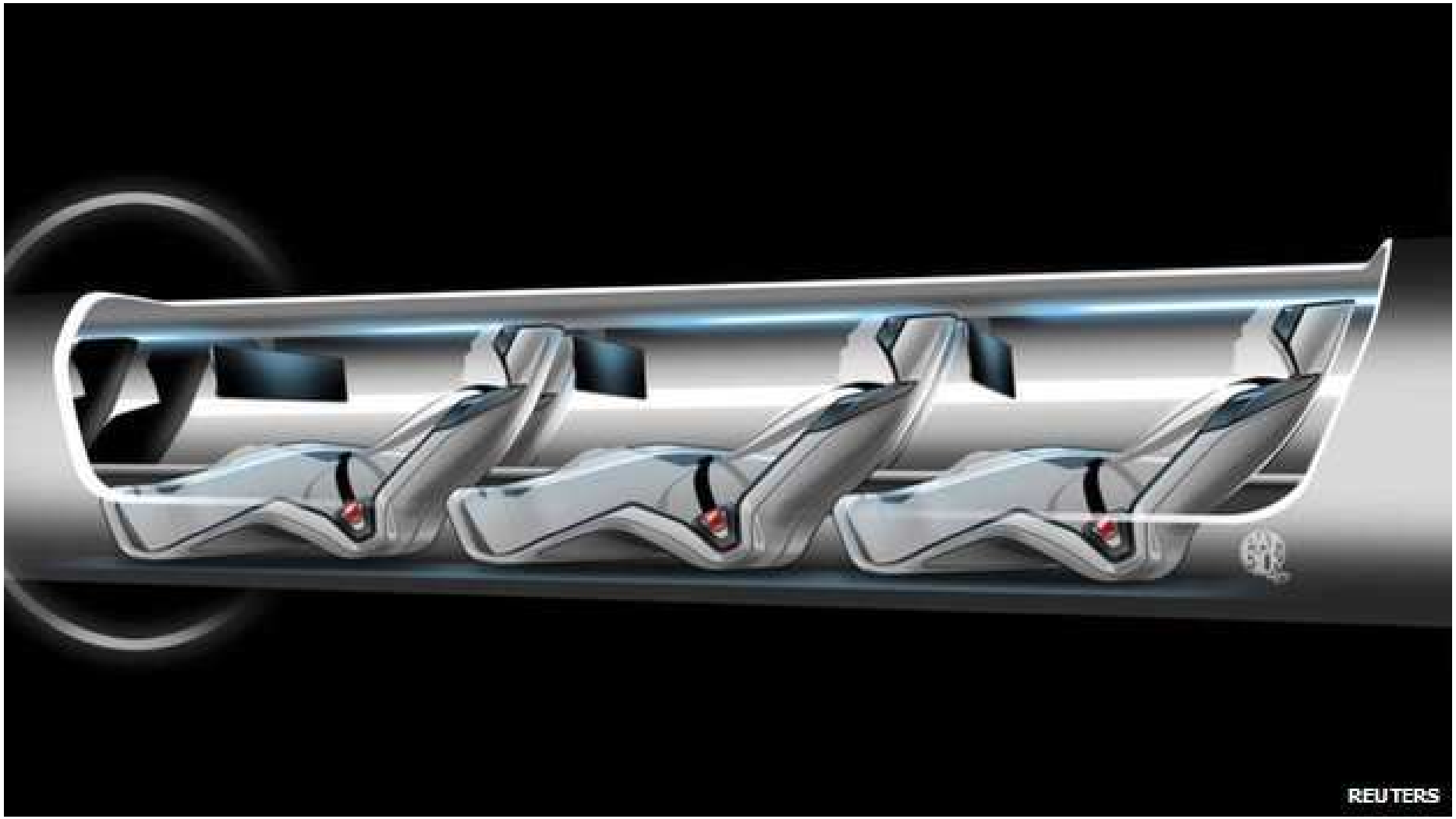
2) The European Court of Auditors recently indicated that despite European actions for promoting rail transport, its market share is declining. Are we really sure that imposing costly obligations for railway transport, will help it regain its market share?

3) How implementation of the TSI Noise will impact ther competitive condition of the railway transport?

4) As the rail noise problem is restricted to specific areas in some Member States, shouldn't adequate measures be deployed only where they are needed?

5) Do we really need a „one-size-fits-all" approach?

Hyperloop



Thank you for your attention

wgroll@ikolej.pl

ptokaj@ikolej.pl