
TSI NOISE

Rolling Stock – Conventional Rail

OTIF Workshop, Skopje, 26-27 may 2010

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European Noise policy - Green paper 96

- One objective
 - Nobody should be exposed to noise levels which endanger its health and quality of life
- Two complementary strategies
 - Reducing the noise exposure (END directive)
 - Strategic noise mapping
 - Noise action plans
 - Reducing noise at source by setting noise emission limit values (Directives for interoperability)
 - Technical specifications for Interoperability
- Common measures
 - Harmonized methods
 - Public information



Interoperability directives – noise aspects

- Applicable to the Trans European rail system for the conformity assessment of RS (EC verification)
- Concerning the noise aspect :
 - Applicable only to the Rolling Stock
 - To limit the noise at source through :
 - The setting of noise emission limit values
 - The harmonization of measurement procedures & Test conditions
- Implementation of Technical Specifications for Interoperability (TSIs)
 - High Speed
 - Conventional Rail



Key dates

- 2002 HS RS TSI
 - 2005 TSI NOI
 - 2008 Revised HS RS TSI
- AEIF
- Ongoing limited TSI NOI revision → ERA

AEIF : European Association for Railway Interoperability
ERA : European Railway Agency

Characterization of the Subsystem (§4)

- Type of Rolling Stock concerned :
 - Locos
 - Multiple Units (Electric & Diesel)
 - Freight Wagons
 - Coaches
 - Infra maintenance machines during transfer travel but not while working
- Applicable to :
 - new vehicles
 - renewed or upgraded vehicles
- Infrastructure not concerned



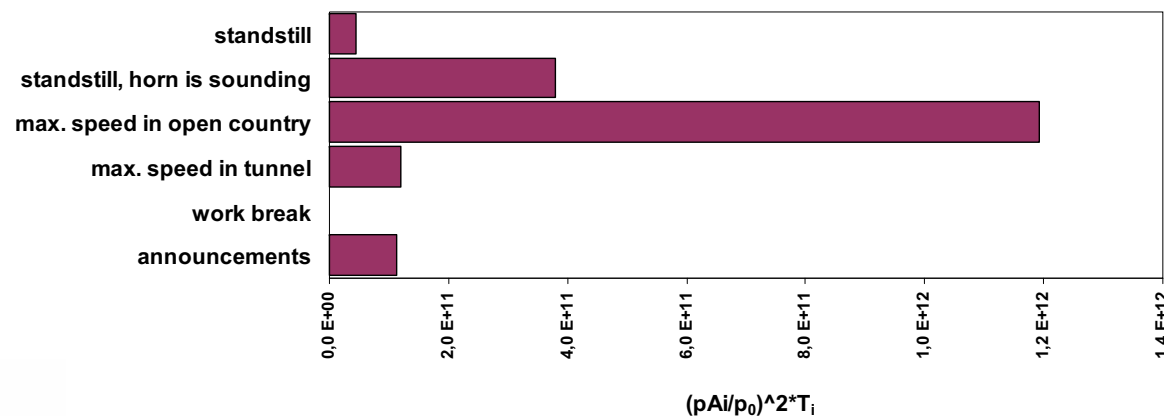
Functional & Technical specifications

- Stationary noise → *all vehicles*
 - Case of wagons : relevant only if equipped with auxiliary devices (engines, cooling systems...)
- Starting noise → *for powered vehicles only*
- Pass-by noise → *all vehicles*
- Noise within driver's cab → *locos, E/DMUs & driving trailers*
 - Not an interoperability parameter
 - Related to safety and health of drivers
- ~~Braking noise~~ → *NOT CONSIDERED*
 - Large spread of values (mainly due to brake squeal occurrences)
 - Lack of repeatable data available



Cabnoise / General

- Objective :
 - limit the noise exposure of driver's when working (occupational noise)
- Identification of 2 main running conditions in a typical driver's working shift (simulations)
 - Sounding of the horn (external warning device)
 - Noise produced at maximum speed in open country



Cabnoise / noise during horn sounding

- Measurement at standstill when the horn is sounding
 - no standard available
- Control of the horn emission level (external micro in the near field of the horn)
- Characterization of the noise level in the cab
 - average over 8 micro positions around the driver's head position
→ to prevent large spatial variations due to standing waves

	LpAeq,T	Measurement time interval T
Standstill meas. during external acoustic warning of the horn SPL <125dB(A)	95 dB(A)	3s



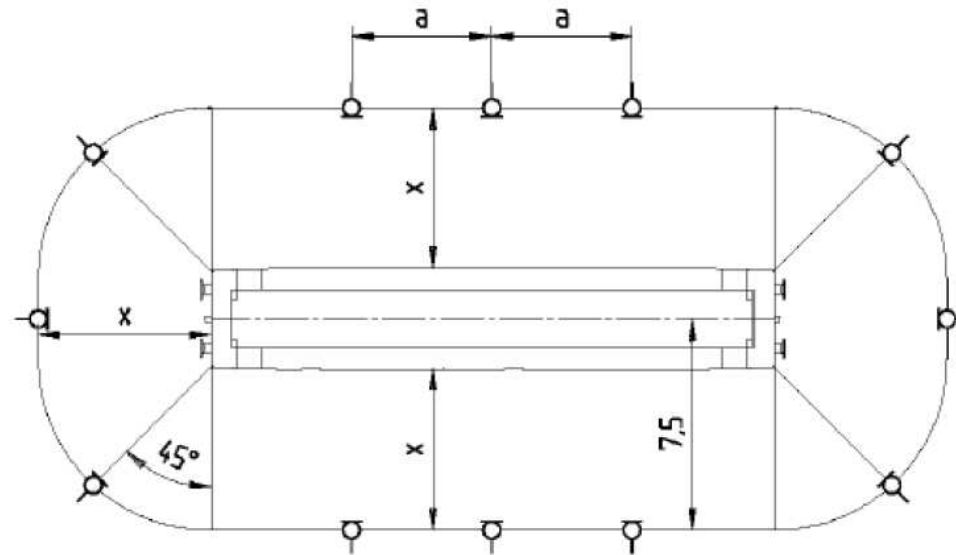
Cabnoise / measurement at maximum speed

- No reference to any standard
- Environmental conditions : open country
- Hauled load $> 1/3$ max permissible load
- Micro position :
 - one micro at the centre of the cab / height of the driver's ears

	LpAeq,T	Measurement time interval T
Max speed $< 190\text{km/h}$ open country without int & ext warnings	78 dB(A)	60s

Stationary noise / measurement procedure

- Based on prEN ISO 3095 : 2001 + deviations
 - Mesh of measurement points all around the vehicle (7.5m dist / 1.2m high)
 - The result is the energy average of all measured values
- Normal mode defined for an external temperature of 20°C
 - Normal mode preferred to Max mode to better characterize noise in stations
 - Design parameters for forcing operation are to be provided by the manufacturer



Stationary noise / limit values

Vehicles	$L_{Aeq,T=60s}$ dB(A)
Electric Locomotives	75
Diesel Locomotives	75
Electric Multiple Units	68
Diesel Multiple Units	73 (77 UK)
Passenger Coaches	65
Freight wagons	65

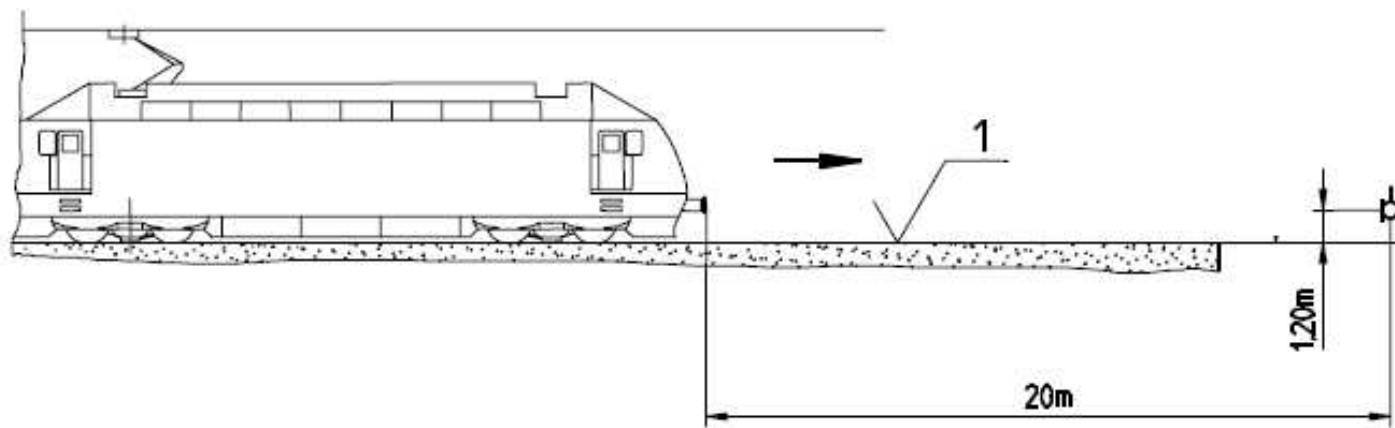
Specific cases :

- Cat T: 65+7 dBA in FINLAND for wagons with a Diesel aggregate >100KW
- Cat P : in UK for DMUs due to the gauge (less room for mitigation measures)



Starting noise / Measurement procedure

- Based on prEN ISO 3095 : 2001 + deviations
 - Indicator L_{pAFmax} to characterize the non stationarity of the noise
 - vehicle conditions
 - The load shall be typical of the normal service conditions
 - Test shall be carried out with maximum tractive effort without wheel slip
 - Measurement positions :
 - Locos : one micro 20m ahead of the front of the train (7.5m dist / 1.2m high)
 - Trains with distributed power : 2 micros (front of the train/ and $\frac{1}{2}$ bogie dist)



Starting noise / Limit values

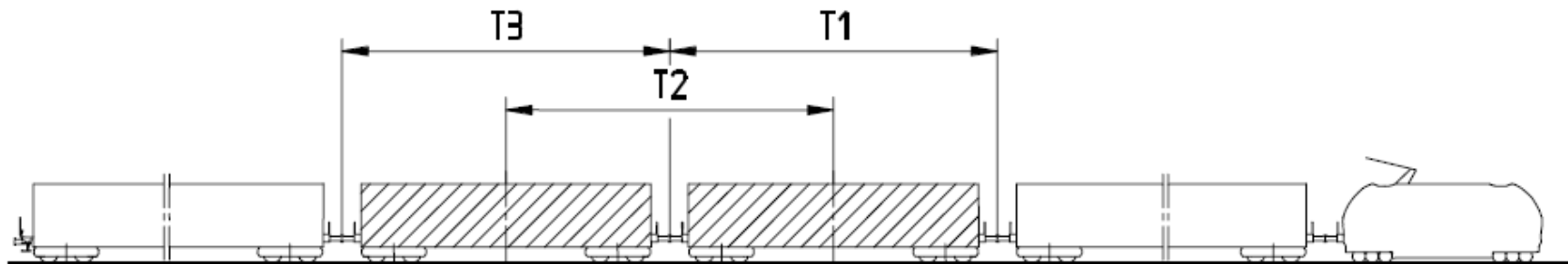
Vehicles	L_{pAFmax} dB(A)
Electric Locomotives $P < 45000$ kW at the rim	82 <i>(84 UK, IRE)</i>
Electric Locomotives $P \geq 45000$ kW at the rim	85
Diesel Locomotives $P < 2000$ kW at the shaft	86 <i>(89 UK, IRE)</i>
Diesel Locomotives $P \geq 2000$ kW at the shaft	89
Electric Multiple Units	82
Diesel Multiple Units $P < 500$ kW/engine	83 <i>(85 UK, IRE)</i>
Diesel Multiple Units $P \geq 500$ kW/engine	85

Specific case : Cat P for UK, IRE due to the gauge



Pass-by noise / measurement procedure #1

- Based on prEN ISO 3095 : 2001 + deviations
 - One microphone @7.5m from track centreline & 1.2m above the railhead
- case of trailed vehicles
 - 2 vehicles under test are required
 - At least one acoustically similar vehicle before and after the vehicles under test



Pass-by noise / measurement procedure #2

- Two different train speeds
 - 80 km/h
 - $V_{\max} < 190 \text{ km/h}$
- Results are compared to limit values at 80km/h
 - $\Rightarrow L_{Aeq,Tp}(V_{\max})$ shall be normalized to 80km/h according to

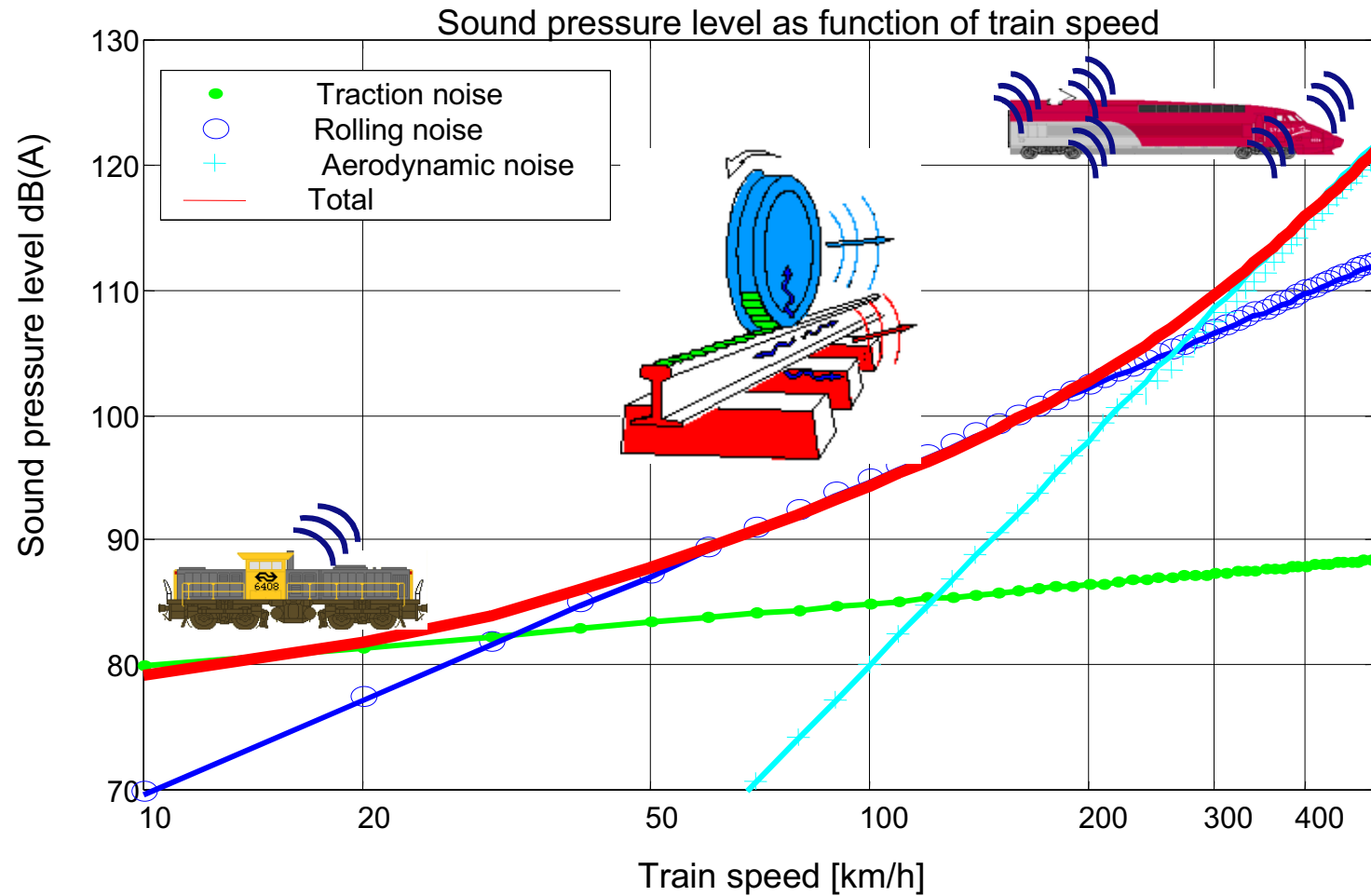
$$L_{Aeq,Tp}(80 \text{ km/h}) = L_{Aeq,Tp}(V) - 30 \cdot \log\left(\frac{V}{80}\right) \quad V \text{ is the train speed in km/h}$$

This equation reflects the rolling noise dependency on train speed

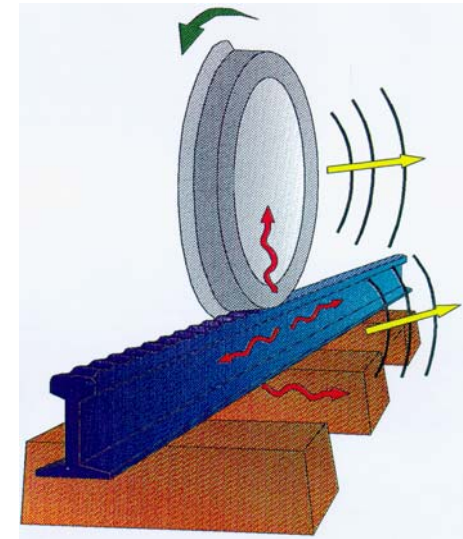
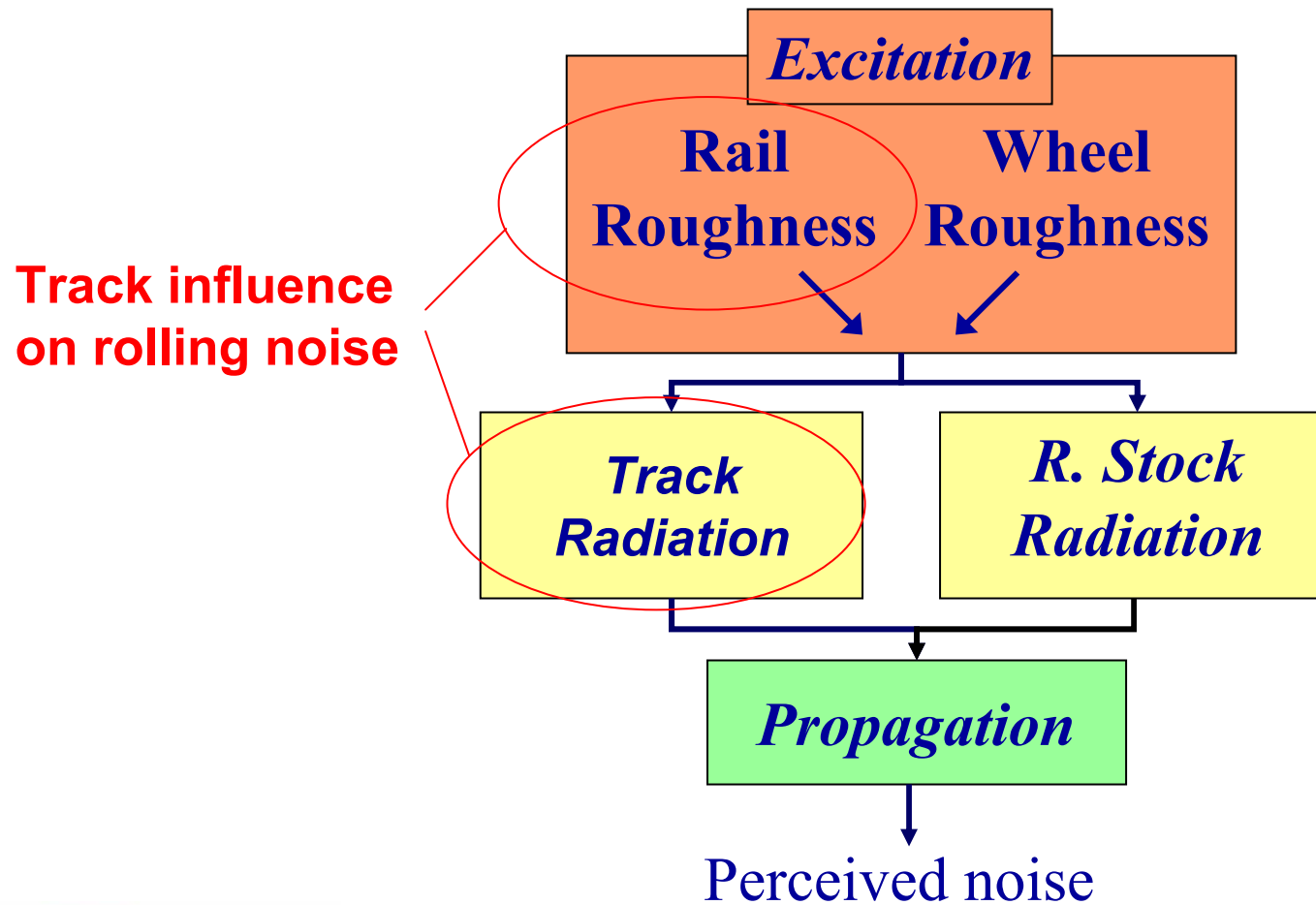
- **Measurements shall be carried out on a Ref Track**
 - See TSI NOI annex A.1.4

Reference Track / Components of pass-by noise

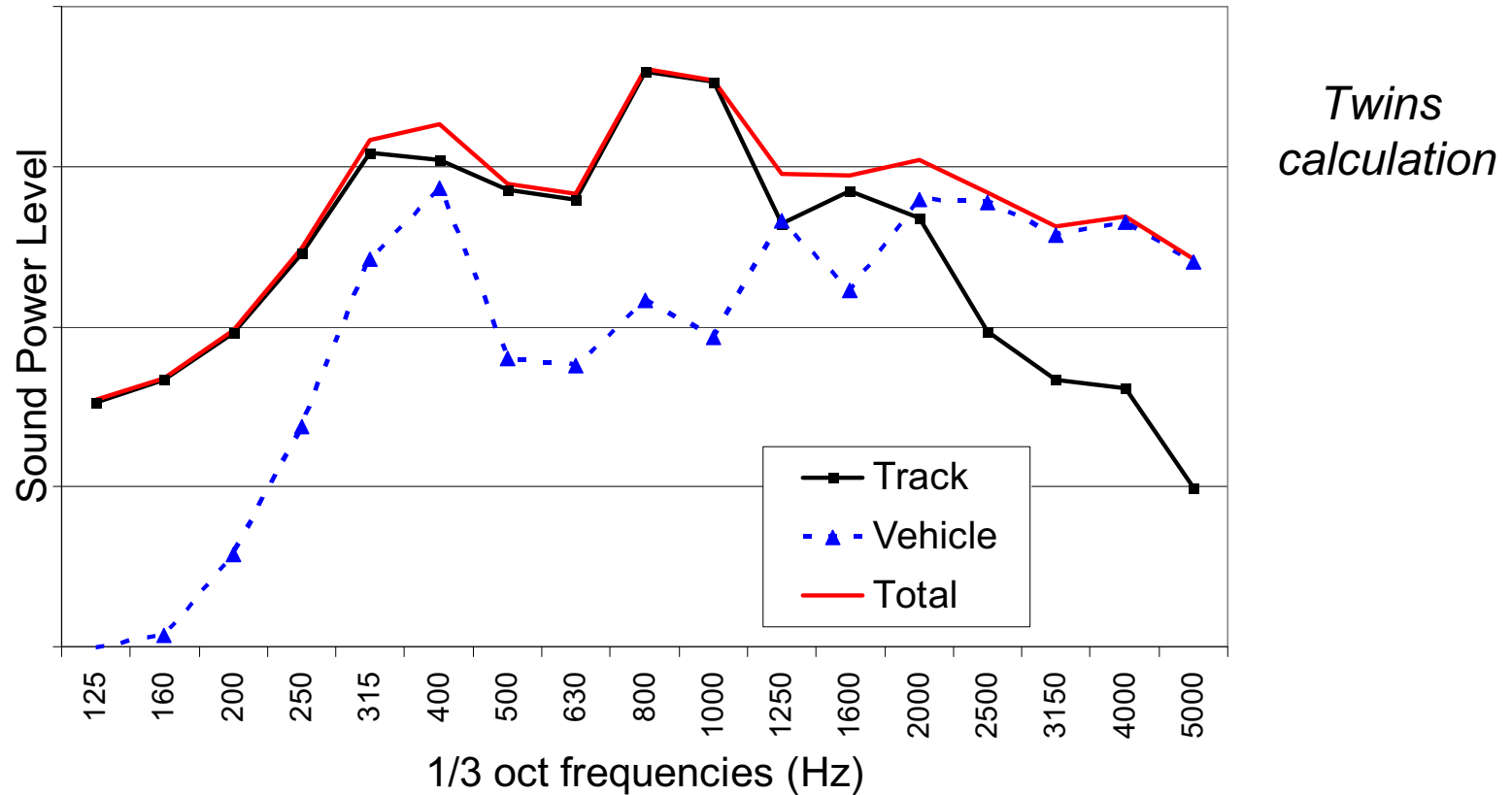
Weight of the main sources vs train speed



Reference Track / rolling noise mechanism



Reference Track / Track noise contribution



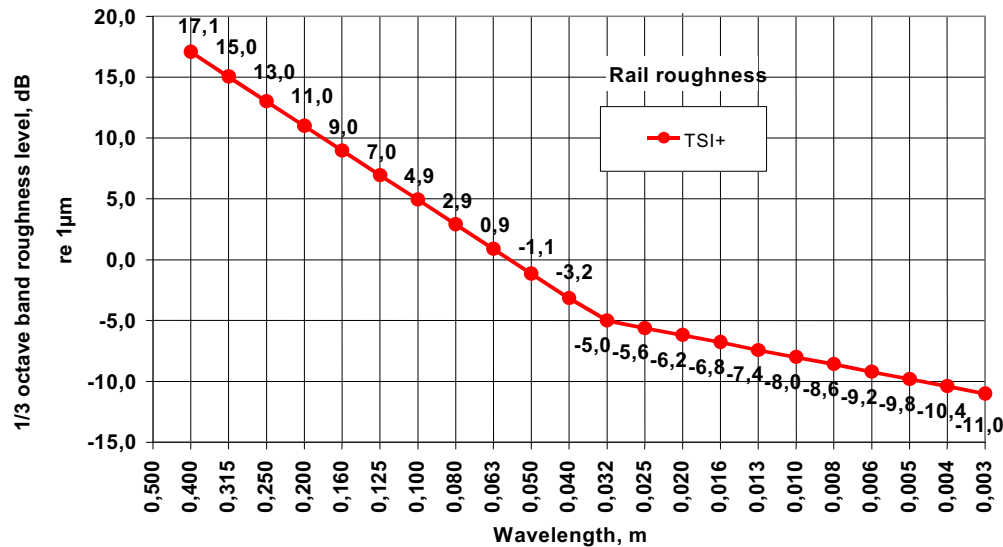
Noise contribution of the track may be an important part of the total noise emitted by a train during a pass-by

Reference Track / Requirements

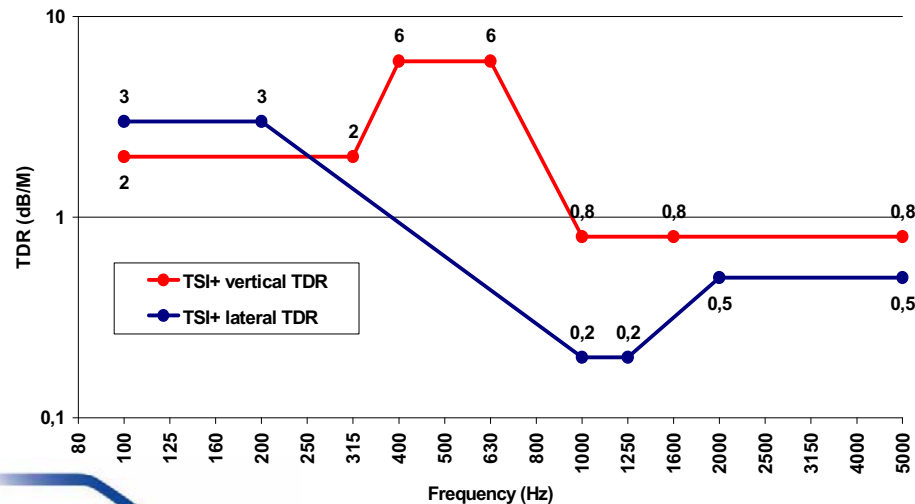
- Rolling stock pass-by type testing require :
 - To assess the acoustic performance of the R.Stock
 - independently of the track conditions
 - with a controlled precision level
 - To allow comparison and reproducibility of the measurements
 - of different RS on the same test site
 - of a given RS on different test sites
- Principles for the definition of the reference track
 - Specifications of acoustic performances (no imposed track design)
 - Specifications close to performances of existing operated track



Reference Track / Detailed Specifications



**Limit the excitation due to the rail irregularities :
Upper limit of the acoustic rail roughness**



**Limit the acoustic radiation of the track :
Lower limit of Track Decay Rates (in vertical and lateral directions)**

Reference Track \ measuring rail roughness

- Direct acquisition method only :
 - Measure the rail roughness independently from the wheel roughness
 - Transducer directly addressed to the rail surface
- 2 types of existing devices
 - Straight edges devices
 - Trolleys
- Sampling of the rail surface of the test section
 - ⇒ actual running surface



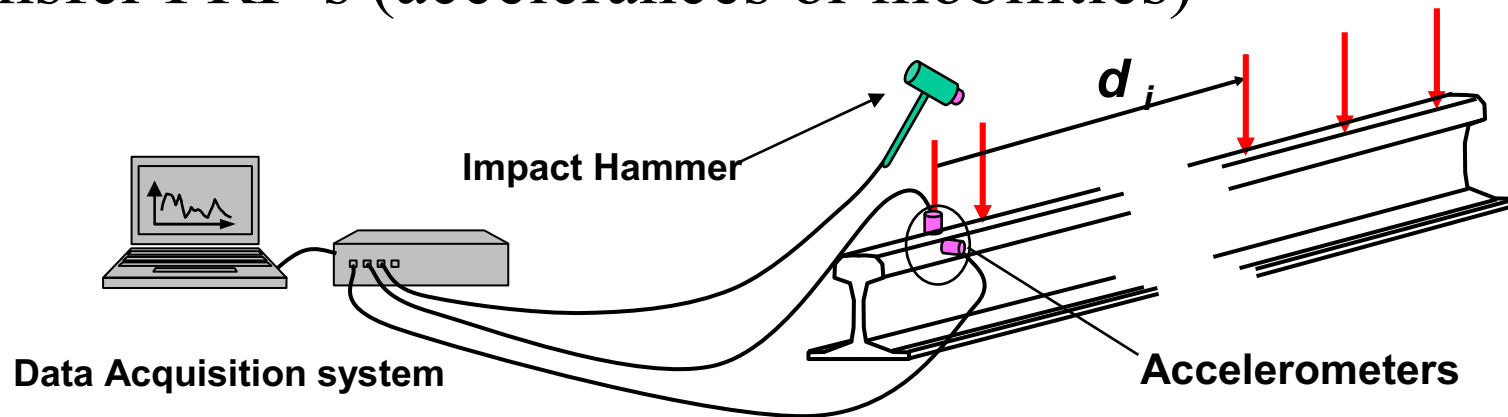
***Straight edge device
(LVDT transducer)***



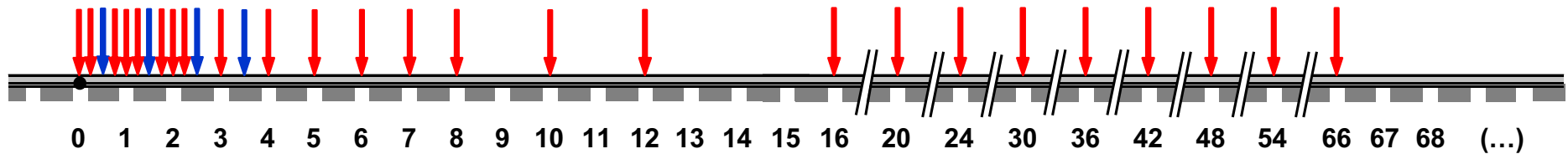
Trolley (accelerometer)

Reference Track \ measuring Track Decay Rates

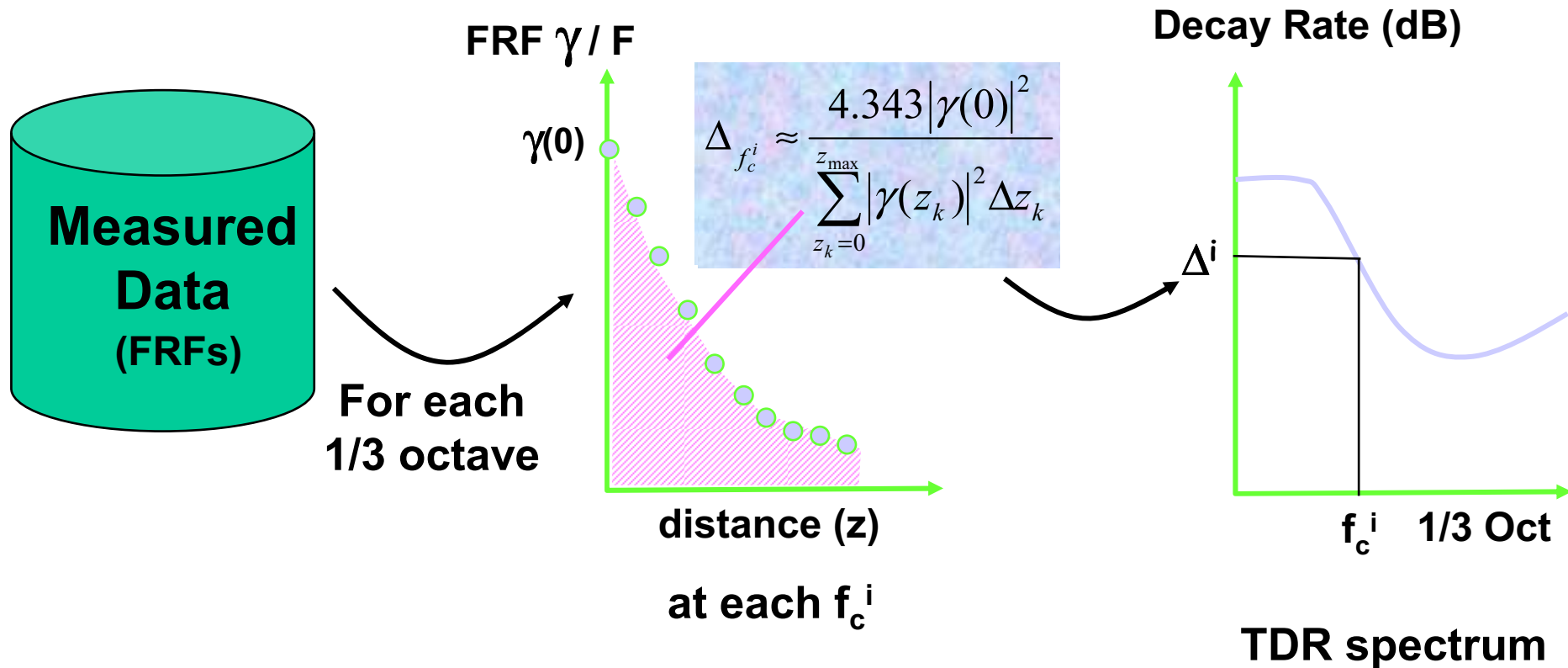
- Transfer FRF's (accelerances or mobilities)



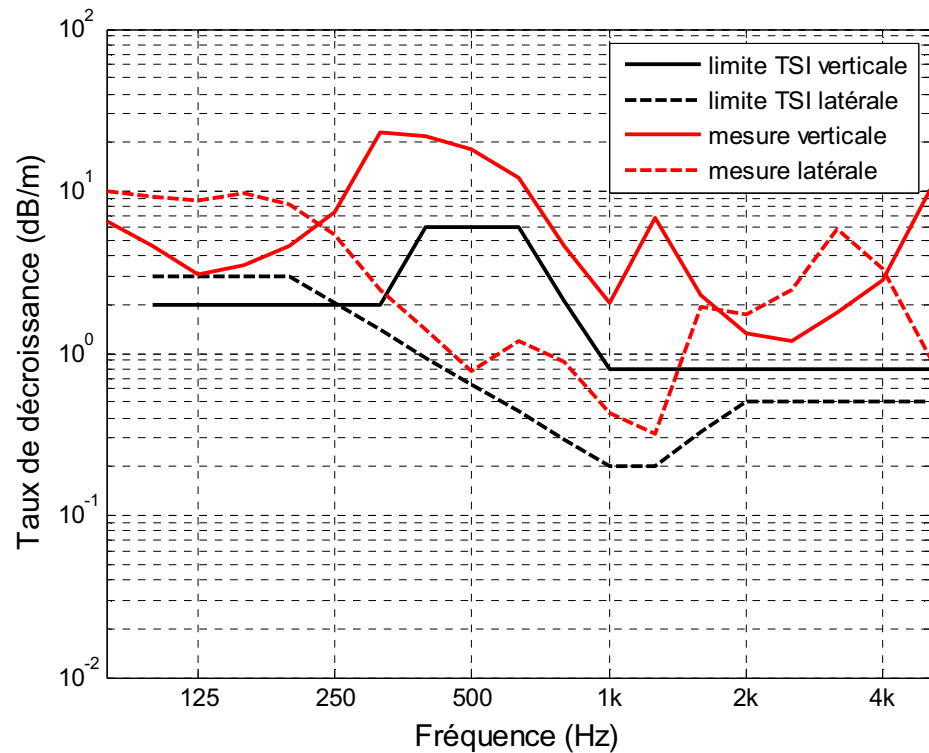
- Mesh of measurement positions



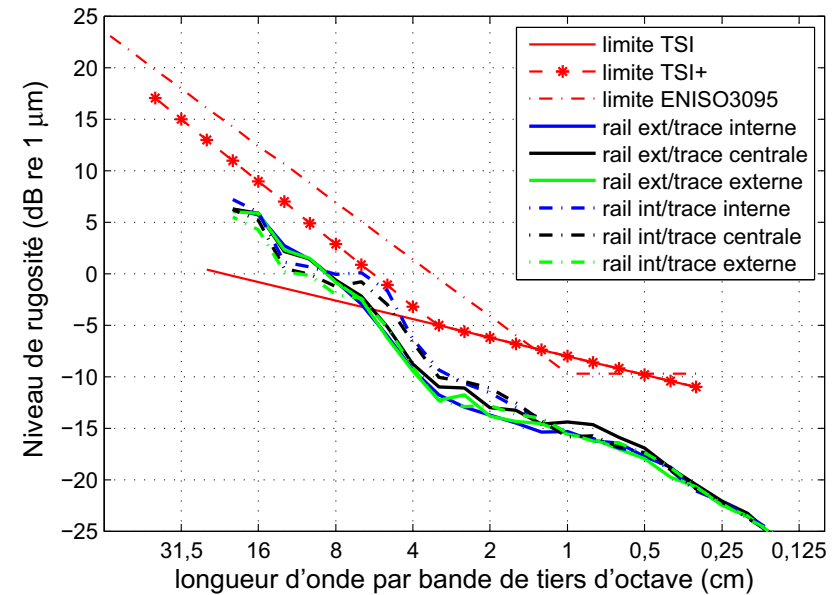
Reference Track \ Processing Track Decay Rates



Reference Track / example of compliant operated track



Track decay rates



Rail roughness

Pass-by noise / limit values @ 80km/h

Vehicle	L _{Aeq,Tp} dB(A)	
	New	Renewed or upgraded
Electric Locomotives	85	X
Diesel Locomotives	85	
Electric Multiple Units	81	
Diesel Multiple Units	82	
Passenger Coaches	80	
Wagons with $APL \leq 0,15 \text{ m}^{-1}$	82	84
Wagons with $0,15\text{m}^{-1} < APL \leq 0,275 \text{ m}^{-1}$	83	85
Wagons with $APL > 0,275 \text{ m}^{-1}$	85	87

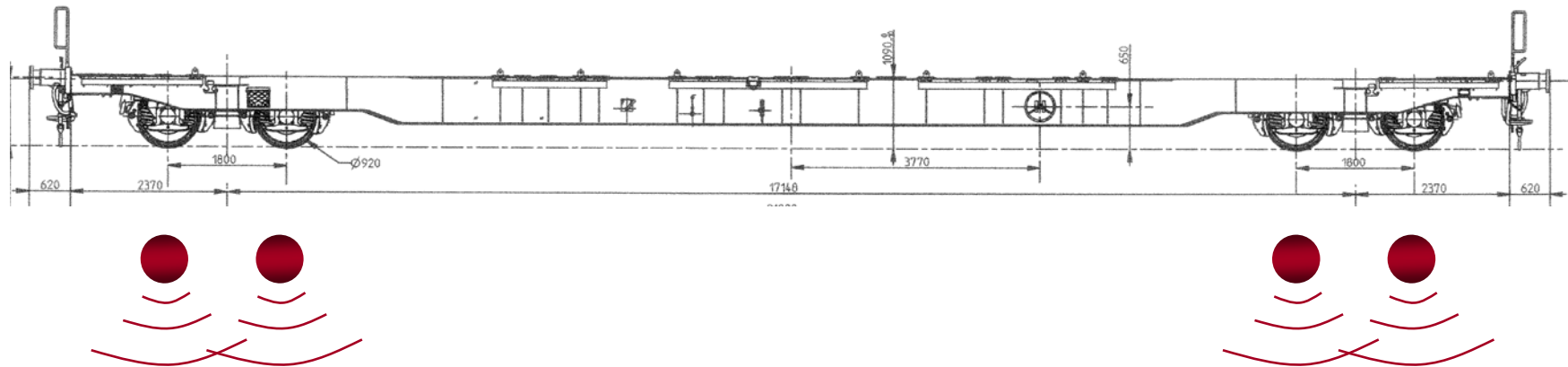
Specific cases for Freight wagons (§ 7.7):

- LIT, LET, EST, FIN, NOR not concerned (safety aspects in winter cond. for composite blocks)
- GRE (track gauge $\leq 1\text{m}$)



Pass-by noise / APL Parameter

- APL means Axle Per Length and is equal to the number of wheelsets divided by the length over buffers of the vehicle
- APL characterize the density of rolling noise sources



Implementation /Transitional period for new RS

- **All external noise limits** are increased by 2 dB(A) during 2 years starting from the date of entry into force of the TSI for all vehicles except freight wagons if :
 - Contracts already signed or at a final stage of tendering procedure at the date of entry into force (options also concerned)
 - Contracts for purchasing new RS of an existing design during the transitional period
- **Starting noise limits** are increased by 2 dB(A) for all DMUs with $P > 500 \text{KW}$ /engine if put into service during a period of 5 years from the date of entry into force of the TSI (not cumulative with previous one)
- **Cabnoise limits** for new & existing designs are increased by 2 dB(A) for 3 years :
 - Contracts already signed or at a final stage of tendering procedure at the date of entry into force (options also concerned)
 - Contracts for purchasing new RS of an existing design during the transitional period

Implementation / Renewed or upgraded vehicles

- E/DMUs, E/D locos, Passenger coaches :
 - Demonstrate that there is no increase of noise
- Freight wagons :

Pass-by Noise	Modif of the brake	Composite blocks & no added noise sources	TSI NOI Compliance assumed
		Other cases	TSI Pass-by tests limit values for retrofit veh
	Other cases		Demonstrate that there is no increase of noise
Stationary noise	All cases		Demonstrate that there is no increase of noise

Implementation / Second step approach

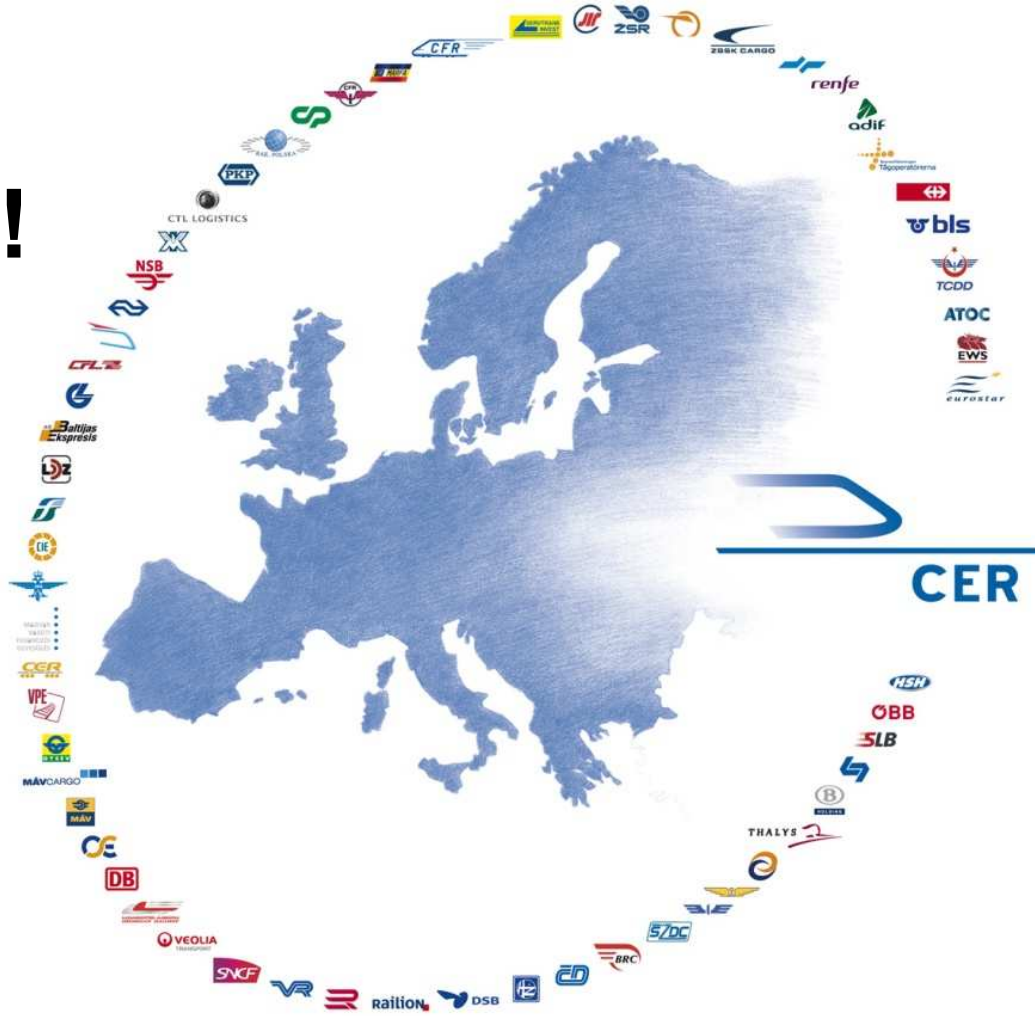
- Recommendation for a further reduction of noise passby noise limits :
 - RS ordered 10 years after TSI NOI application
 - RS put into service 12 years after TSI NOI application
- Proposed reduction of passby levels:
 - 2dB(A) for EMUs and DMUs
 - 5dB(A) for Freight wagons, locos and Pass coaches



Implementation / TSI revision

- The TSI NOI revision should address :
 - An assessment of the implementation of this TSI (cost & benefit analysis)
 - Use of a continuous APL curve for the pass-by noise of freight wagons
 - A second step pass-by noise limits of all vehicles
 - A possible second step starting noise limit values for DMUs and Diesel locos
 - The introduction of the infrastructure into the scope of this TSI
 - The inclusion of a monitoring scheme for wheel defects

**Thank you for
your attention!**



The Voice of European Railways