



INTERNATIONAL UNION  
OF RAILWAYS

*11th Noise and Vibration Workshop*

# Vibration State of the Art Report

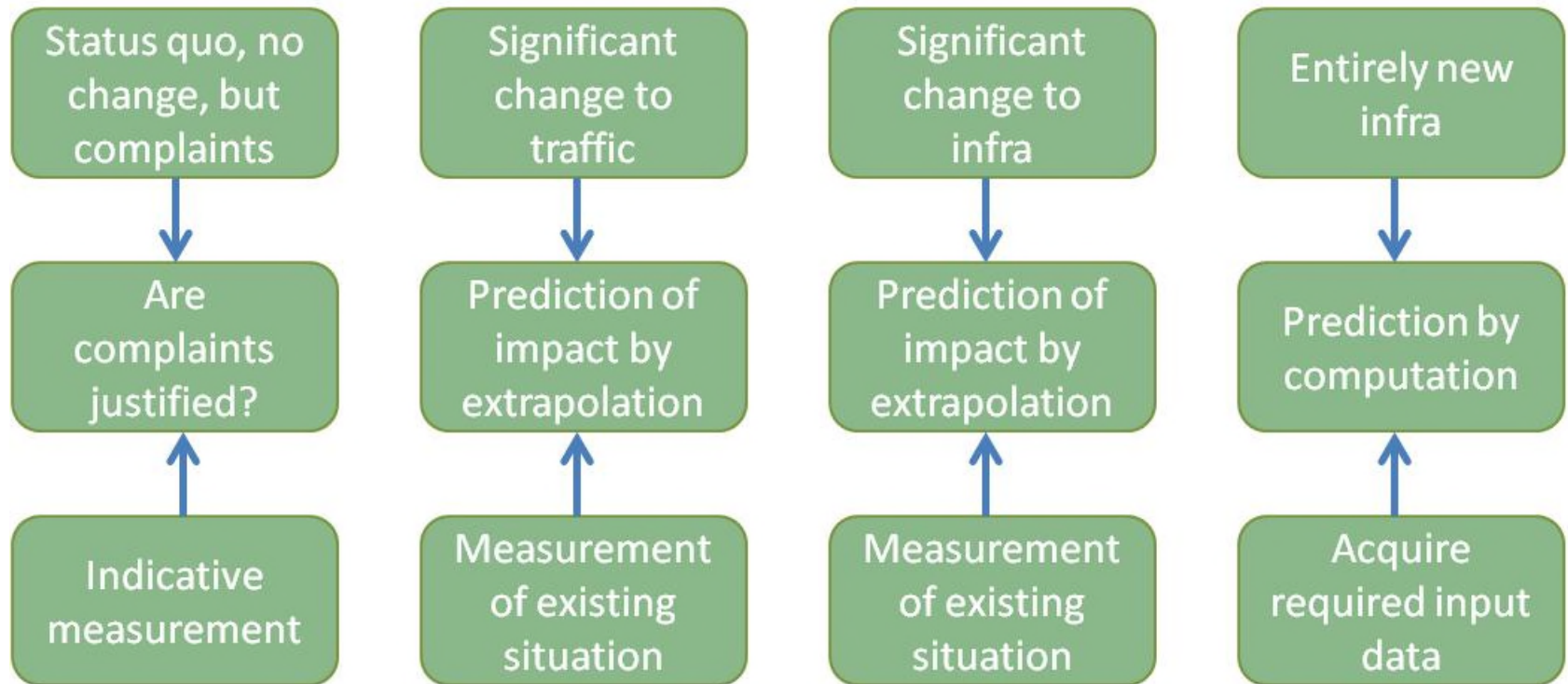
## 3

Practice of vibration control

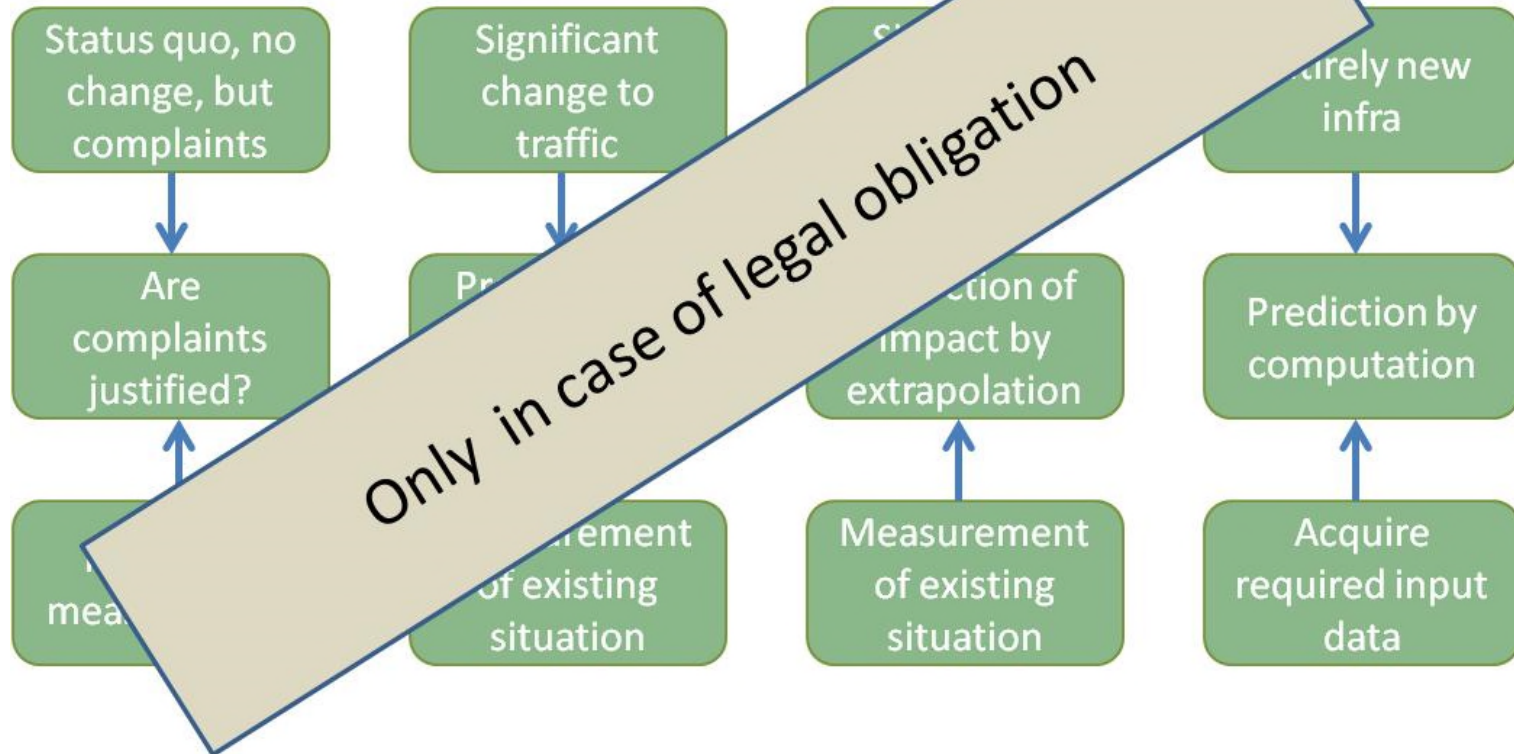
Measurement, prediction, mitigation

*Paul de Vos, SATIS*

# Action required?



# Action required?



# Vibration measurement

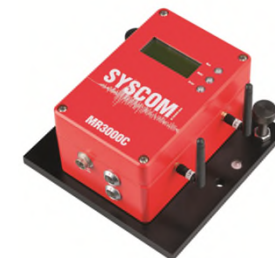
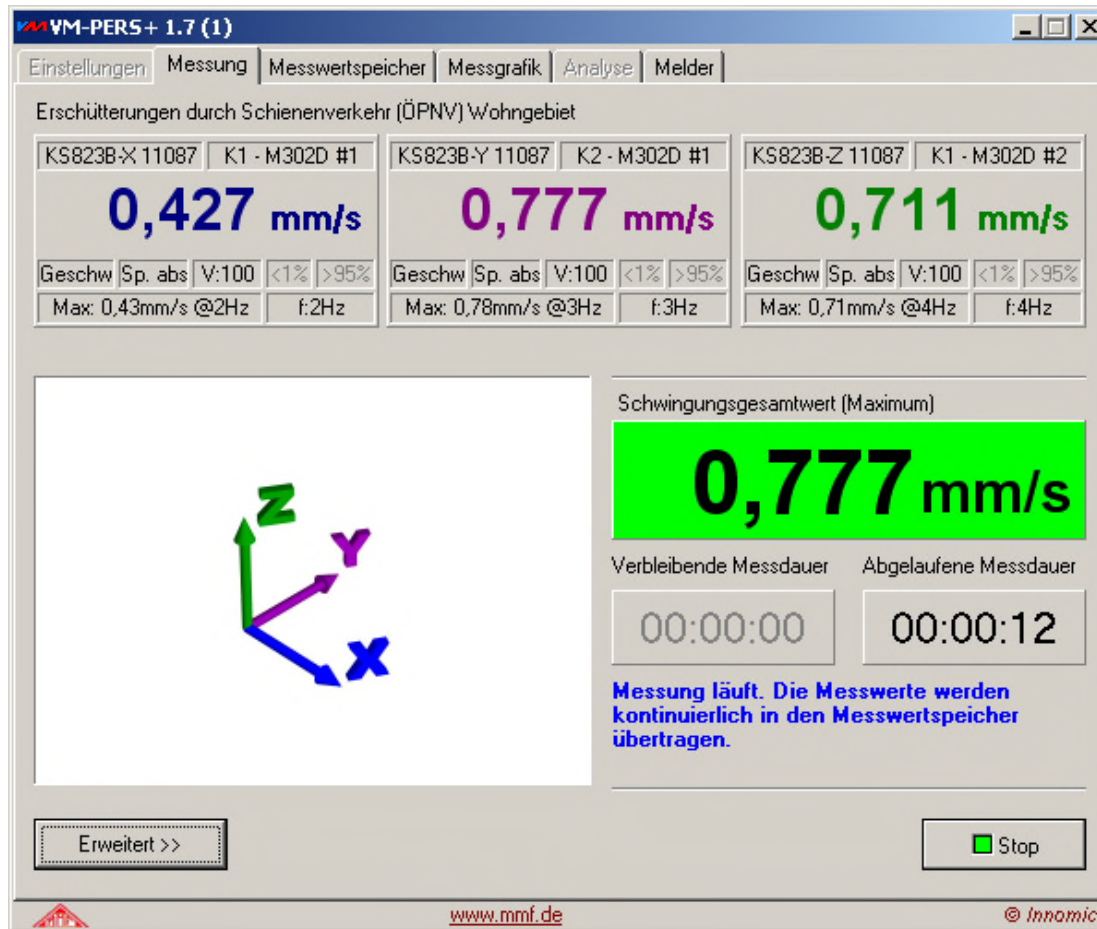
- > **Vibration amplitude has to be assessed for 3 directions**
- > **Usually indoors (and long duration)**
- > **Transmission through ground varies from site to site**
- > **Amplification in buildings varies from building to building (1x to 10x)**
- > **Vibration amplitude depends on train speed and train type**
- > **Vibration amplitude varies for individual trains**

**Therefore: Statistics!**

- > **Measurements at many locations and long duration**
- > **Therefore expensive**



# Measurement equipment





# Different results at different positions

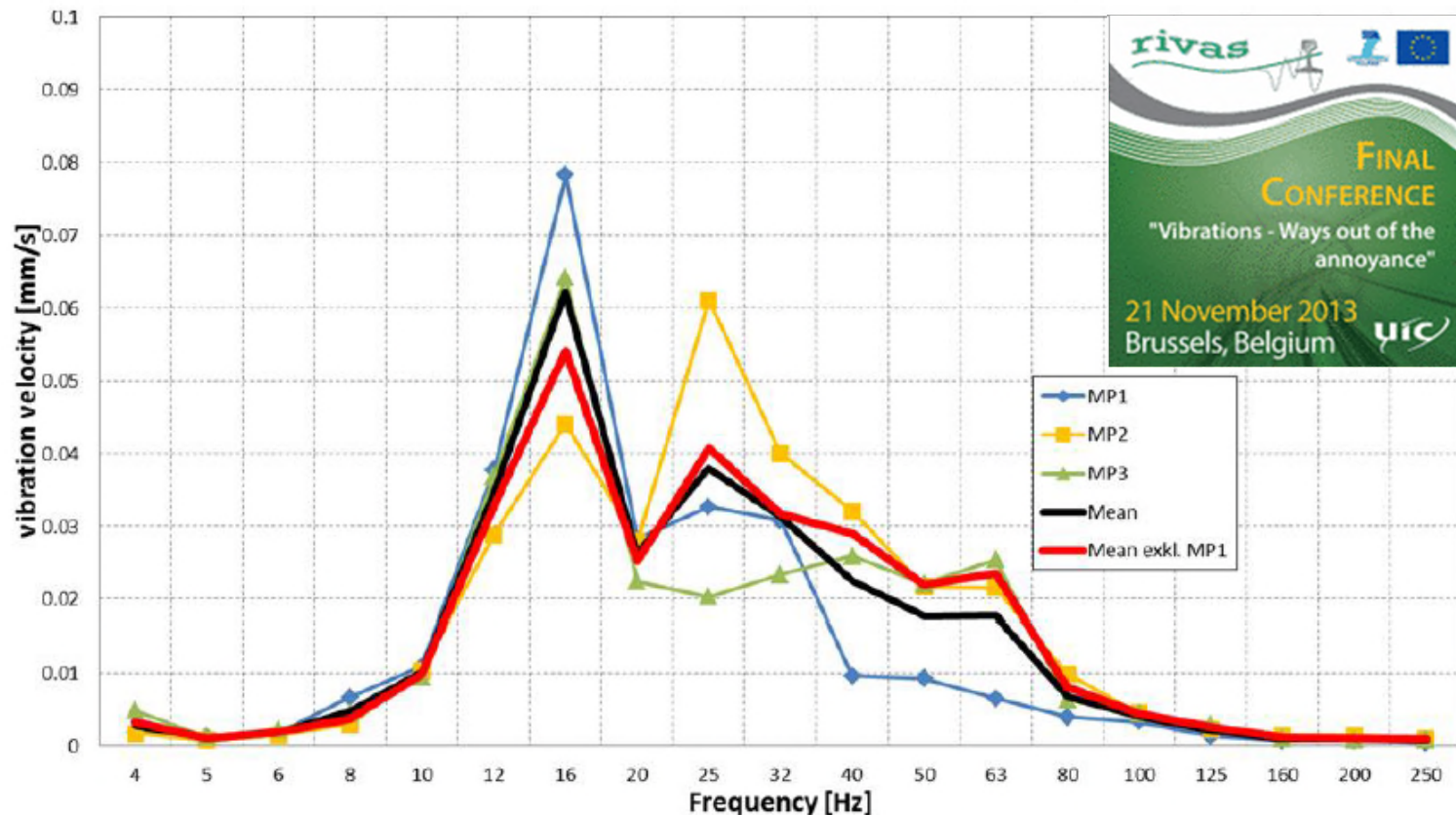
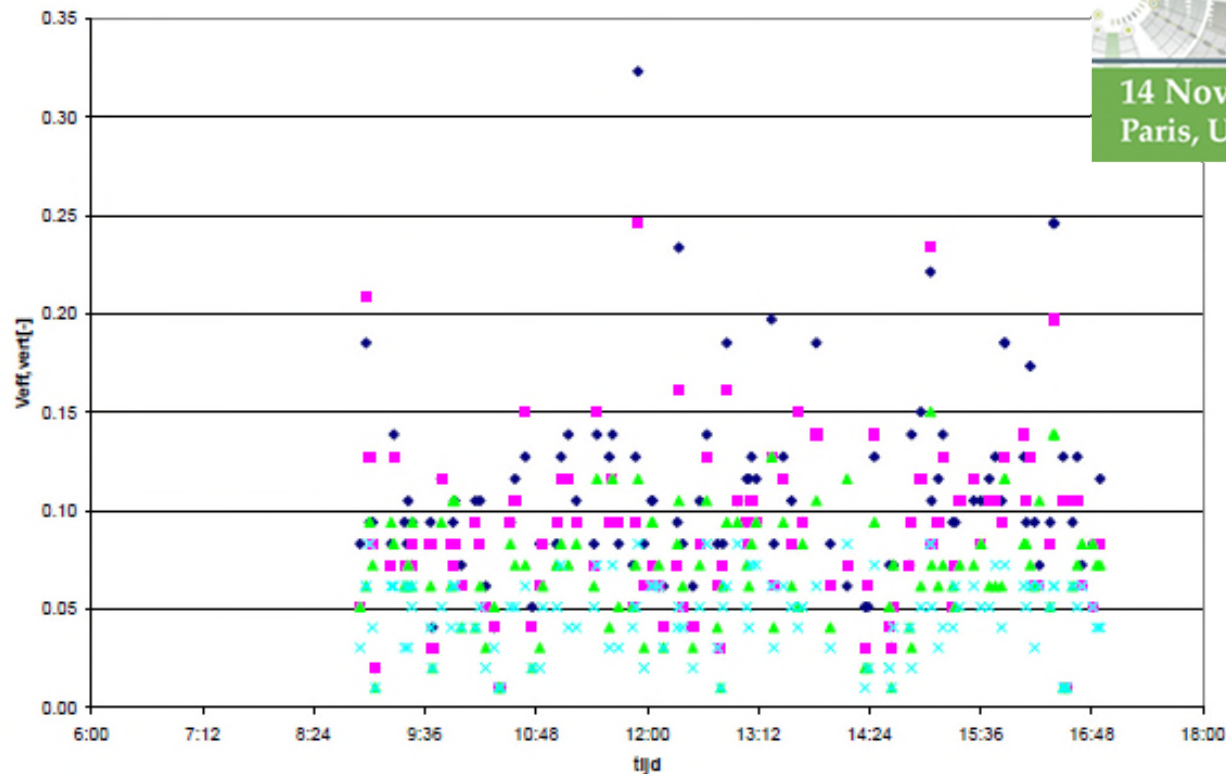


Figure 4.3: Vibration measurements of Intercity trains in 8 m distance for reference track, southern track 2.

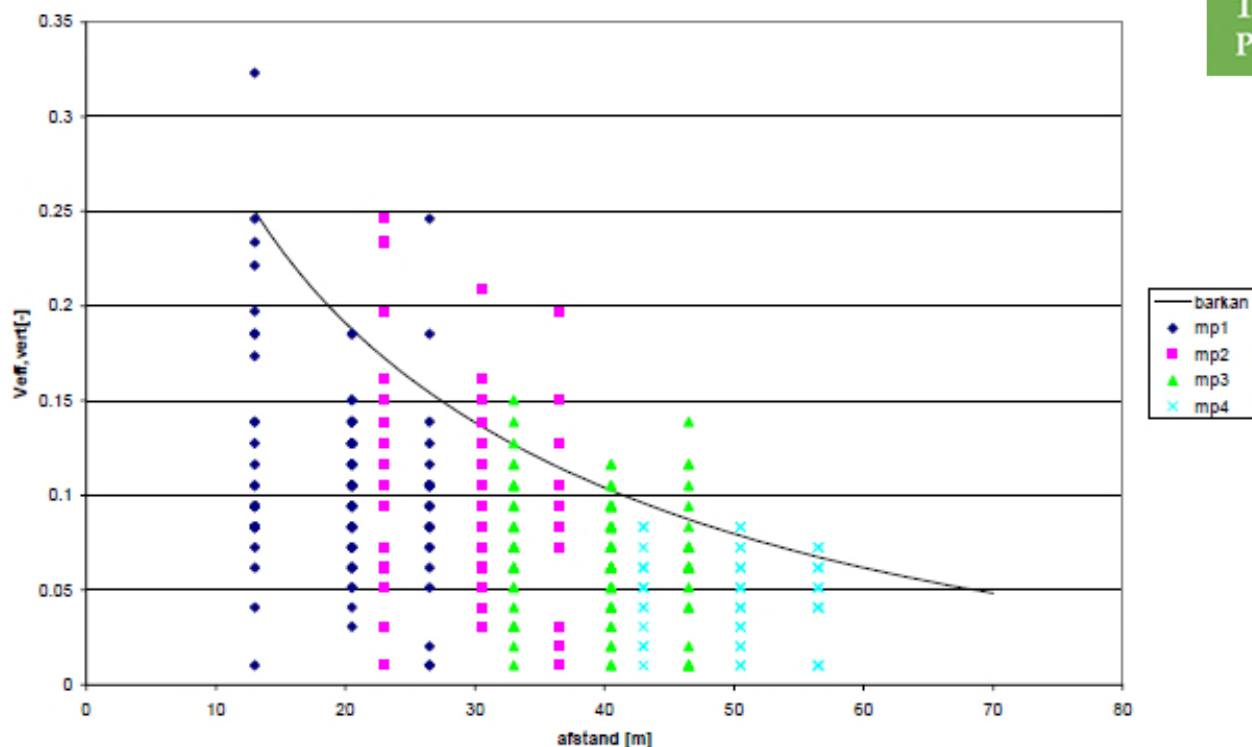
# Large variation between spots and trains



**Figuur 2-1** gemeten maximale trillingssnelheid per trein gedurende de meetperiode van de 4 opnemers

Courtesy Movares, H.Stuit

# Distance dependence (Barkan Curve)

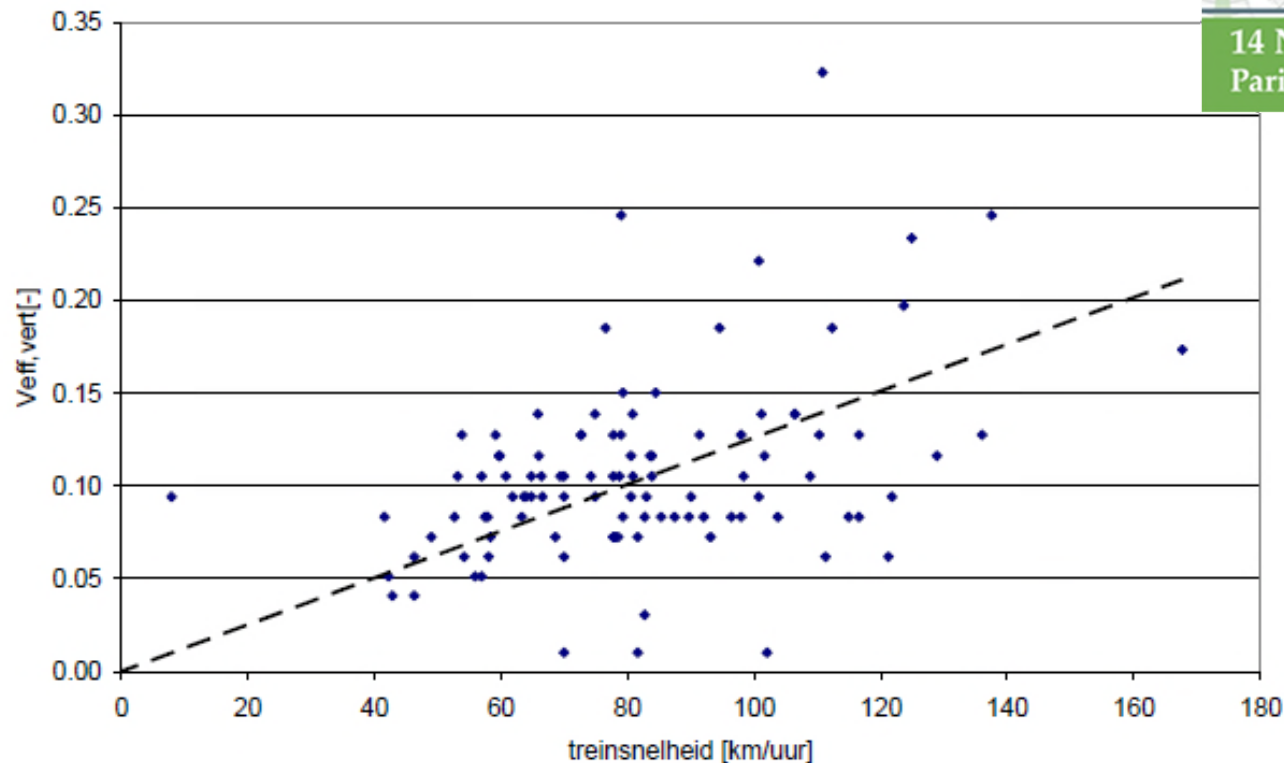


**Figuur 2-2** gemeten maximale trillingssnelheid per trein als functie van de afstand

Courtesy Movares, H.Stuit



# Train speed dependency (large spread)



**Figuur 2-4 de trillingssnelheid is uitgezet tegen de treinsnelheid**

Courtesy Movares, H.Stuit

# Change of traffic



- > Speed increase or freight trains where they weren't before probably causes increase in vibration amplitude**
- > Prediction of effect difficult, therefore only indicative results**
- > Traffic growth may or may not cause amplitude increase (depends on the indicator)**
- > Assessment before and after the change in a selection of characteristic locations**
- > In some countries action required if the increase exceeds certain limit (e.g. 25%)**
- > Action may consist of removing the increase or reaching a target value**

# Change of infrastructure



- If (additional or existing) track comes closer to residential area, there may be an increase in vibration amplitude
- Measurement at different distances on a line perpendicular to the (existing) track gives indication of transmission
- Indicative prediction of impact possible at limited number of sites
- Extrapolation to (all) other sites
- In some countries action required if the increase exceeds certain limit (e.g. 25% or 40%, as increment threshold)
- Action may consist of removing the increase or reaching a target value

# Entirely new situation



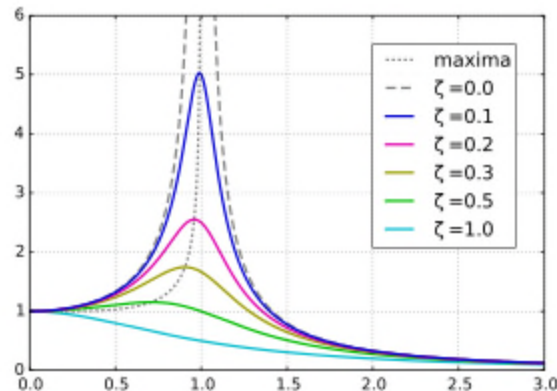
- > **Avoid being too close to existing residential areas (preferably stay away 100 m or more in soft ground)**
- > **Prediction is only possible after acquiring input data on:**
  - Soil characteristics (with sufficient detail), this may require mass drop tests, boring holes, etc
  - Building amplification for all typical building types
  - Track and subsoil information
  - Traffic data (number and type of trains, operation period, speed)
- > **Even with this input data the predicted amplitude has substantial uncertainty**
- > **Financial risk of over- or underestimation of measures**

# Mitigation measures

- At the source, in the propagation path or at the receiver
- Where is the problem: vibration or ground borne noise?

The answer will decide the frequency range for the measures to be effective

Mass spring system is only effective above resonance frequency





# Measures at the source

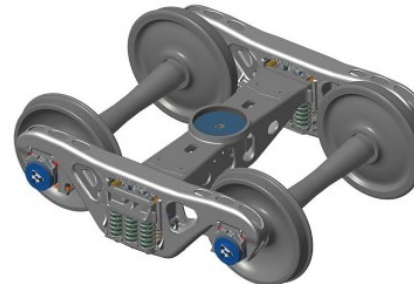
- Track alignment



- Wheel out of roundness



- Dual suspension



# Measures for surface tracks

- Resilient fasteners



Pandrol

- Under sleeper pads



Getzner

- Under ballast mats



Calenberg

- Track stabilisation



Hayward Baker



# Measures for tunnels

- **Floating slab track**

Not for retrofitting!

- **Under sleeper pads**

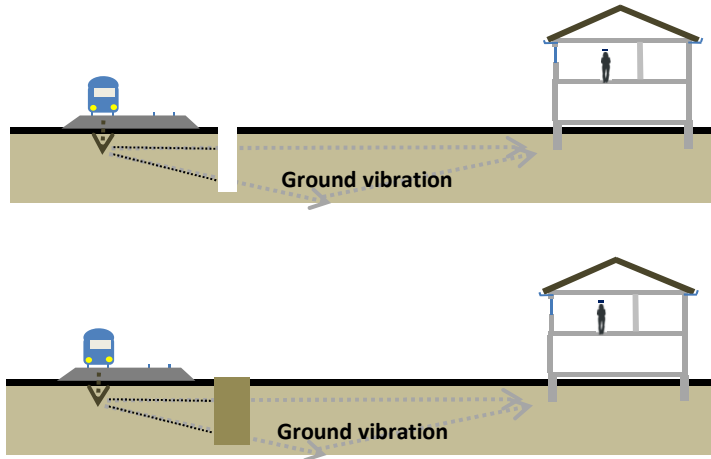
- **Ballast mats**



Gerb

# Measures in transmission

## > Trench

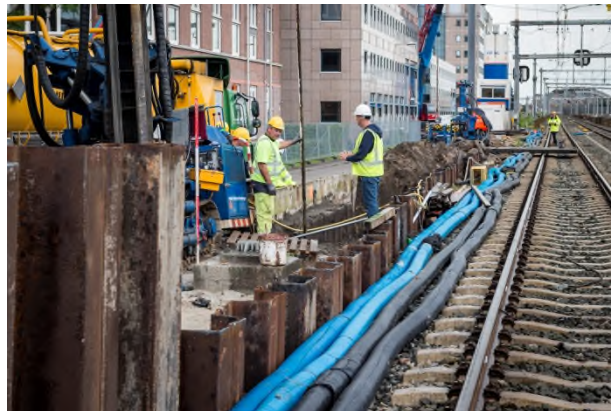


## > Sheet piling wall



## > Jet grouting wall

Fotografie Gerrit Serné





# Measures at the receiver



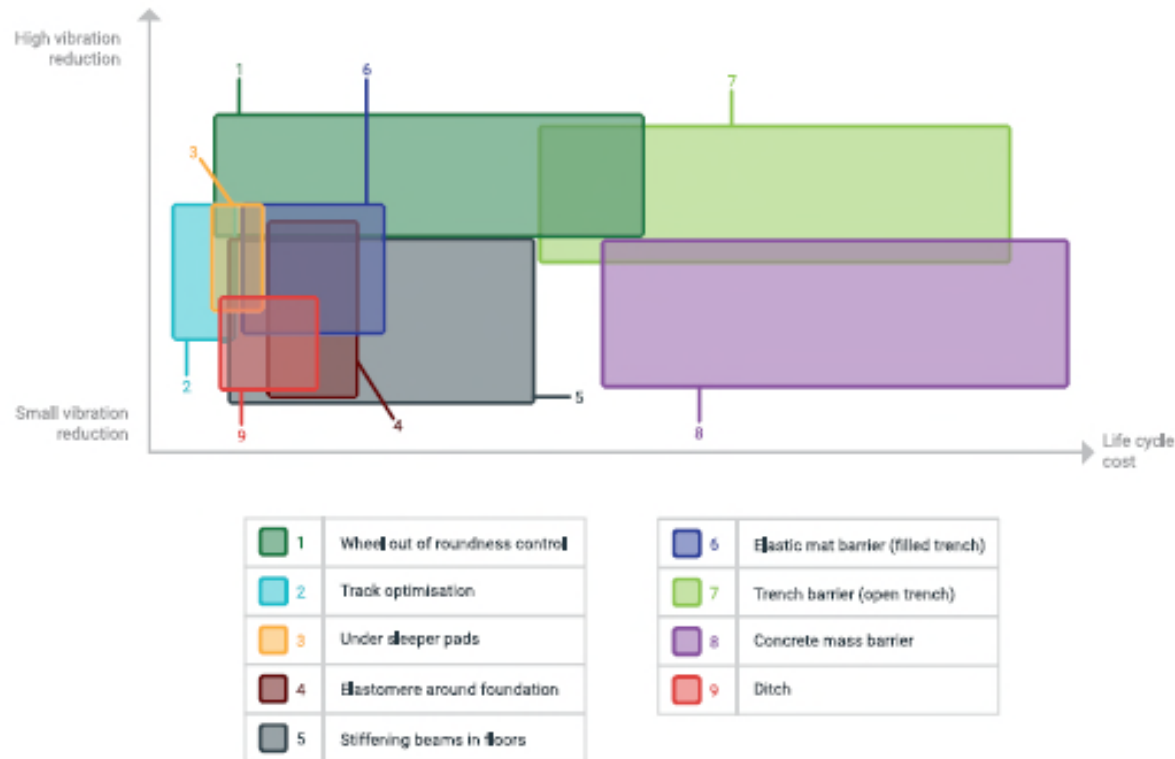
Resilient bearing



Reinforcement of wooden floors



# Cost benefit (life cycle)



Graph 39. Comparison of mitigation measures suitable for application in existing surface line situations. Annual simplified life-cycle cost for mitigation at a hot spot of 500 m length with 40 premises, and their effectiveness in terms of percentage reduced of the rms vibration velocity.

# Measures at the receiver





Please don't forget to pick up the “State of the Art of rail vibration” report before you leave

