Reducing Noise & Vibration for High Speed Rail

Fixed Track Forms for
High Speed Lines Conference
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Julie Dakin & Brian Stewart
With silence favour me
Horace

... increases in noise are frequently among the potential impacts of most concern to residents in the vicinity of the proposed project.

California High Speed Rail Project
Noise from transportation

An Old Problem

Detrimental

Wide-Ranging

Increased Say

65%
Growth

The global population is rising and urbanising.

Demand for efficient transport is increasing.
Urbanisation

... the higher population density of urban environments favours public transport, particularly rail.

The lure of the city

Urbanisation rate, %

Economies: developed developing

Source: UN
... the development of new lines to provide high-speed rail services appears to be highly desirable in reducing GHG emissions in the long-term.

Network Rail

Transport Emissions (Source: European Commission)
The passage of time is likely to make high-speed rail more and more desirable, making it critical that politicians of today think ahead to tomorrow.

Anthony Albanese

A developed country is not a place where the poor have cars, it's where the rich ride public transportation.

Enrique Penalosa
High Speed Lines in Operation and Forecast (thousand km)

Elaboration by Susdef and IEA based on UIC (2014a) and UIC (2015)
Transmission of air-borne noise
Sound Levels

Units of decibels (dB)
Not a linear scale
Doubling is +3dB
Medium speed

Rolling noise
Equipment
High speed

- Aerodynamic
- Pantograph
- Between coaches
- Bogies
Total noise at high speed
Air-borne noise sources – at 386km/h

Source: Investigation into external noise of a high-speed train at different speeds. Bin He, Xin-biao Xiao, Qiang Zhou, Zhi-hui Li, Xue-song Jin
Noise barriers
Rail dampers
Transmission of ground-borne noise
Frequency

Units of Hertz (Hz)
Feelable <80Hz
Audible 20-20kHz
Attenuation with frequency

Constant proportion of signal lost in each cycle
Lower frequency (50Hz)
- Longer wavelength
- Fewer cycles/m
- Less damping/m
- Greater distance

Higher frequency (500Hz)
- Shorter wavelength
- More cycles/m
- More damping/m
- Smaller distance
Amplification / attenuation with frequency

For single degree-of-freedom model
Resilient rail seat

Delkor Alt 1

$F_0 = 90\text{Hz}$
Booted sleeper

Sonneville

$F_0 = 70\text{Hz}$
High resilience

Vanguard

$F_0 = 40$Hz
Floating slab track

\[ F_0 = 10-20\text{Hz} \]
Insertion gain

![Graph showing insertion gain over frequency](image)
Relative performance

Including wheel rail interaction
Relative to stiff track

Performance relative to stiff track (dB)

Frequency (Hz)
Challenges of HSR!

Noise & Vibration
Ground-borne noise v speed

![Graph showing the relationship between train speed (km/h) and sound level. The graph illustrates an upward trend, indicating an increase in sound level with increasing train speed.](image-url)
Excitation

Frequencies increase

=> may coincide with resonant peak (or offset from peak)
Critical speed

Softer rail support and greater mass lowers the critical speed towards operating speeds.
Deflections

Limits for ride comfort and safety

Increased speed reduces allowable deflections

Constraint on design

=> Stiffer rail support may be required
Impact on mitigation

With higher speeds:
- Sound level increases
- Excitation frequencies change
- (Critical speed may become significant)
- Rail deflections need to be reduced

Same forms of mitigation possible, with:
- More attenuation
- Increased stiffness
- More mass
- Narrower range of mitigation
Looking ahead

Traditional approaches divide source, path and receiver

Tighter limits and more interaction require refinement

Holistic approach to the problem and earlier involvement in design
Continuing to meet the challenges
Thank you