On track for reduced noise pollution and railway safety amplifiers

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As sustainable rail transport becomes a policy priority, promising significant environmental benefits, EU researchers are addressing some of the side-effects of increasing rail traffic. Credit: Thomas via Pixabay

With more people getting on track for sustainable high-speed rail,

reducing noise pollution and sophisticated traffic management will boost adoption.

The whistle coming down the tracks is the sound of Europe's rail renaissance. Coming round the bend is increased adoption of high-speed rail transportation which promises to reduce road traffic and to curb harmful emissions. Cars are major culprits in air pollution, accounting for 14.5% of Europe's total carbon emissions. Around half the flights in Europe are short haul journeys of less than 1,500km which generates many more emissions than the equivalent journey by rail.

The European Green Deal policy features plans to double high-speed rail by 2030 and triple it by 2050. At the moment, 75% of freight is moved by road, so movement of goods by rail is set to double by 2050.

Making trains more competitive with road and air travel means market reform and improvements to the passenger experience as well as infrastructural upgrades. Prioritizing sustainable rail transport promises significant benefits but unfortunately, it comes with unseen dangers of its own and not just for passengers.

Low frequency

One of the lesser-known hazards of rail transport is the kind of noise pollution nobody can hear. Inaudible, low frequency ground vibrations emanate from the rolling stock on the railway as it passes. As well as affecting the structural integrity of nearby infrastructure, these vibrations can have a detrimental effect on people's health, causing headaches, fatigue and even irritability in people experiencing them.

"Right now, it is possible to reduce vibrations by putting rubber pads under the tracks," said Giovanni Capellari, co-founder of Phononic Vibes. "That system is okay for new railways because you can put them

in during construction." His company specializes in noise and vibration technology. For an existing railway line, rubber pads are very expensive because you have to remove the tracks to install them, according to Capellari.

The BioMetaRail project is researching and developing special submerged barriers that can be deployed alongside the track to absorb the vibrations. The barrier walls rely on their shape for their noise reduction performance, rather than the properties of the material.

Known as metamaterials, these synthetic composite materials have designer properties not found in nature. Their internal structures are engineered to interact with the low frequency sound waves of a passing train to trap and insulate against them.

"Basically, the idea is that we use shapes that have some resonant effects at frequencies that are typical for vibrations in the railway sector," Capellari said. In this context, the frequency of vibrations is typically between 30 and 60 Hertz. The result is a design for a two-by-three meter concrete structure that resembles a large window.

This works for very low frequencies, which is very good for railway trains. Additionally, the "window panes" could be divided into even smaller sizes to trap a wider range of frequencies.

Distinctive design

If the panels did not have their distinctive shape and design and were simply slabs of concrete, they would not be able to halt the train's ground-borne vibrations as effectively as BioMetaRail's barriers. For ease of installation, there is no need to lift the railway line as these panels can be inserted into the ground alongside the track like a sunken fence, to protect clusters of homes or buildings.

The research team is also investigating the ideal material, thickness and sizes of the barriers for their vibration damping effects.

The SAFETRACK project's sensors can pick up vibrations on the railway track and identify where on the track the sound originates and what could have caused it. Credit: © NGRT SL

Capellari's BioMetaRail project is an offshoot of the BOHEME project, which stands for Bio-Inspired Hierarchical MetaMaterials. BOHEME investigates and develops different types of mechanical metamaterials inspired by principles found in nature.

From spider webs to shell whorls, BOHEME characterizes natural systems and studies their possible applications. "The goal is to take the results from BOHEME and try to understand the best geometry (for the rail barriers) considering the market, the cost, production and installation," said Capellari.

"The next step is to go to market," he said, as well as obtain certification for the vibration-blocking intervention. "There's no such kind of system in the market right now."

Ultimately, these panels will be lining the ground alongside the track in residential areas, allowing rail networks to significantly boost their train traffic without adversely affecting the people and buildings nearby.

In 2021, it was proposed to increase speed limits on Trans-European Transport Network trains to 160km/h or more by 2040. Increasing rail traffic also makes it vital that network operators are able to monitor the entire length of their railroads in real time. Acoustic monitoring can help achieve both these goals.

Richard Aaroe's Next Generation Rail Technologies has developed a passive listening device that can provide railroad operators with an early warning about obstructions on the track. It can even predict what the obstruction most likely is, and where it might be found. The SAFETRACK project is working on a standalone system to 'give accurate real-time warning of anything that happens on the infrastructure," Aaroe said.

The system comprises sensors, which pick up vibrations on the track, and software that identifies where on the track the sound originates and what could have caused it.

Sophisticated microphone

"In a way, it is a very, very sophisticated microphone," Aaroe explained. The acoustic vibrations on the track that are picked up by the sensors have a "unique fingerprint." The sound of a tree branch falling on the track is distinct from a mudslide, for example. Aaroe's company has built up a "library" of these railway acoustic fingerprints.

He compares the technology to when submarines use sonar to detect surface ships by picking up its acoustic signature. "Today, that technology has evolved so that you can not only pick up that there is a vessel passing, but you can pick up the type of engine, the class of the vessel itself, the speed, direction, and so on," Aaroe said.

The same principles apply with rail acoustics. "Every incident has a uniqueness and we have identified that and then we can report this to either the train controller, operator or even the driver themselves."

The sensors are relatively small, about the size of a smartphone. An installation includes four sensors, one on each rail of the track and then another two 10 meters further along the track. Because sound travels through solid rails much better than through air, one sensor package can detect acoustic vibrations five kilometers in each direction.

The technology is currently being trialed by national rail networks in the U.K., Germany and Spain, and it will soon be deployed in another three countries, according to Aaroe.

The European Union is committed to growing its rail transportation as part of the European Green Deal which aims to make Europe the first carbon-neutral continent by 2050. As more people opt for rail over cars, technology that makes trains safer and quieter will increasingly be important.

More information:

- BioMetaRail
- SAFETRACK
- BOHEME project
- European Green Deal

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