TEXTE
115/2021

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Abstract

Für Mensch & Umwelt

Umwelt Bundesamt

TEXTE 115/2021

Ressortforschungsplan des Bundesministeriums für
Umwelt, Naturschutz, Bau und Reaktorsicherheit

Research code number 3717 54 102 0

FB000543/KURZ,ENG

Reduction of noise from trams in urban areas

Abstract

by

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On behalf of *Umweltbundesamt* (UBA, German Environment Agency)

Imprint

Publisher
Umweltbundesamt
Wörlitzer Platz 1
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Execution of the study:
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50827 Köln

Finalisation:
Dezember 2020

Professional support:
Fachgebiet I 2.3 Lärmminderung im Verkehr
Percy Appel

Publications as pdf:
http://www.umweltbundesamt.de/publikationen

ISSN 1862-4804

Dessau-Roßlau, July 2021

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Introduction

The expansion of local public transport (ÖPNV) is a socio-economic and ecological necessity. Not only according to the *Umweltbundesamt* (UBA / Federal Environment Agency), together with bicycle and pedestrian traffic it should be the backbone of sustainable mobility in cities (*Umweltbundesamt* 2017a). Tram systems already play an important role in the public transport system today, not only because of their reliability, performance and favorable CO2 balance. The federal government also focuses on maintaining and expanding rail-bound public transport systems. Thus, an amendment to the *Gemeindeverkehrsfinanzierungsgesetz* (GVFG / Municipal Transport Financing Act) will come into force on January 1st, 2020, with the explicit aim of promoting rail-bound transport systems.

In order to achieve a high level of user acceptance of trams, it is necessary to bring the stops as close as possible to potential passengers and thus keep barriers to access the public transport system low. Driving in densely populated urban areas where road space is thus often narrow and to be used in competition with other modes of transport is therefore essential. This causes noise emissions which can also result in noise pollution. Particularly in the inner city, track layouts are subject to narrow radii in order to follow the course of the road, and track crossings cannot be avoided. Due to space restrictions tracks are often laid in the driving lane area of streets where the surfaces are sound-reflecting (asphalt or paving). Contamination such as dust and grit lead to a roughening of the rail running surfaces. All of this leads to high noise emissions, which are recognized as squeaking in curves, rumbling or whoosh-like noises and which are perceived as annoying by residents, especially when buildings are standing in narrow vicinity and close to the track.

The environmental noise mapping in metropolitan areas shows local noise conflicts. The UBA commissioned an investigation of the possibilities for reducing noise from trams in urban areas so that the authorities responsible for noise action planning, among other things, receive technical suggestions for developing suitable measures and tools. The aim of the study is to promote the expansion of rail-bound public transport systems, especially in metropolitan areas, and to accelerate the construction of new routes through their increased public acceptance.

This short report serves primarily as a first orientation. For a detailed discussion of this complex topic, we recommend reading the long version of the report. This can be viewed and downloaded from the website of the *Umweltbundesamt* (Federal Environment Agency).

Methodological framework

The report considers acoustic noise emissions from tram traffic in accordance with the *Verordnung über den Bau und Betrieb von Straßenbahnen* (BOStrab / Regulation on the Construction and Operation of Trams). The focus of the investigation is on tracks in the traffic area of public roads, the so-called embedded track, and on segregated track. Completely independent tracks in elevated or tunnel situation are not the subject of this investigation.

Focus of the work is on the emitted airborne noise, its possible effects on those affected and suitable measures for reduction. Foremost, noise emissions at their source (technical measures on the vehicles and the route) shall be reduced. Furthermore, the possibilities of structural noise protection as well as operational measures are taken into account during the investigation.

In addition to measures on the existing infrastructure and the vehicles, the construction of new routes and the commissioning of new innovative vehicles are also important for discussion. This report examines to what extent the current legal, approval, operational and economic framework conditions promote or hinder the noise reduction (see *Umweltbundesamt* 2017b, p. 1).

The following questions are addressed in this report:

- Who are the relevant stakeholders to implement noise-reducing measures in the operation of trams?
- Which legal or organisational tools are available to the relevant stakeholders?
- Which noise-reducing measures are available when operating trams?
- Which noise-reducing measures in the operation of trams make economic sense and how could incentives for their implementation be created?
- How could a monitoring system be designed serving to inform citizens and to monitor the effects of noise-reducing measures in the operation of trams?

Competitive framework

The Public Transport authorities have the greatest scope of action towards a reduction of noise from trams. In public transport, these are the independent cities, districts, special purpose municipal associations, transport associations or the states. The responsible authorities can define noise-relevant criteria in different contracts and plans. These criteria can be set out in the local transport plan (NVP), in the tender documents or in the final public service contract.

The other stakeholders - the municipal transportation companies and the approving authorities - each have only limited scope of action. The transportation companies have to implement the requirements of the transport authorities, which limits their scope of action to the selection of specific vehicles, measures to be taken where the infrastructure is concerned or operational measures. Since noise-reducing measures are usually associated with additional cost, there is no sufficient incentive system for transportation companies to invest in this area. Only the factors “image gain” and “technical pioneer” could be incentives.

The approving authority, like the transportation companies, cannot set reference values or limit values for noise emissions. It is responsible for the technical approval of new track/routes or new vehicles. The approving authority could only refuse or restrict the operating permit in the event of non-compliance with previously defined limit values.

In the field of public transport with light rail and trams in Germany, there is basically no competition on the operator side. Normally the municipal or communal transportation companies are entrusted directly with the provision of the transport service by the respective transport authority. Thus, it is a (natural) monopoly. It turned out that the public transport authorities do not always use the available scope of action for noise reduction in the award procedure for public service contracts to define (noise-specific) award criteria. One reason for this may be that noise reduction measures incur additional costs and are usually borne directly or indirectly by the responsible body.

On the other hand, in particular the cities compete with one another for attractiveness. Livability is a locational advantage that also includes minimizing noise emissions and thus immissions. Consequently, the public transport authorities in the tram sector should have a vested interest in implementing noise-reducing measures without putting trams at a disadvantage in the competition between the transport systems.

To counteract this situation, it makes sense to support the transport authorities in this regard. Regulatory and economic incentives for noise reducing measures can, for example, include defining suitable measures and allowing the municipal transportation companies to implement them as cost-effectively as possible. It should be noted, however, that noise reduction requirements must be designed in a “fair” overall concept, taking into account all modes of transport, so that there are no distortions of competition to the disadvantage of trams and that the aim of promoting the environmental alliance is not endangered.

You can read more about this topic in the long version of the report in chapter 3.

Legal framework

There are several potential regulatory instruments available to reduce noise emissions from vehicles and tracks in tram traffic:

- The establishment of limit values for the **noise emissions** of tram traffic according to the state of the technology sets the priority of measures at the noise's source. At the European and national level there are currently no emission limit values. It is recommended that they be based on the existing specifications for interoperable rail vehicles (TSI rolling stock noise). In addition to a regulation for the vehicles, it is recommended to develop specifications for permanent compliance with the limit values as also for lanes. Basically, the EU is responsible, but it seems more expedient to introduce national rules on the basis of § 38 BImSchG, since the EU Commission currently prefers to limit itself to standardisation specifications.

- Requirements for **noise emissions** of tram traffic in Germany exist for the construction of new as well as major changes to existing transport routes. Trams in urban areas require the use of quiet vehicles and the use of emission-reducing components for the track. It is recommended to supplement these specifications with immission limit values also for the existing routes, preferably as part of the noise action planning. Noise immission limit values should correspond to the state of knowledge of noise impact research. An overall noise assessment must be introduced for the interaction between the acoustic noise emissions caused by trams and road vehicles.

- The hitherto existing calculation rules for immissions (**Annex 2 (to Section 4) 16. BImSchV** or **CNOSSOS-DE**) do not adequately reflect the reduction measures presented in this project. They should therefore be further developed with the aim of introducing a toolbox of components - also for retrofitting vehicles and tracks - to which a certain emission reduction can be assigned (application of Chapter 9 of Appendix 2 (to Section 4) of the 16th BImSchV for illustration of acoustic innovations). Furthermore, regulations must be integrated that ensure compliance with the emission assumptions according to Annex 2 (to Section 4) BImSchV in the long term. It is recommended to set up a federal research and development program with the participation of the federal states, with which the approval of noise-reducing components and measures can be achieved.

- The noise reduction on existing routes (noise remediation) in the form of **noise action planning** for the European metropolitan areas and the tram networks therein is, a systematic, binding and continuous approach to reduce the noise emissions from vehicles and tracks. The binding character of the noise action planning in Germany should be strengthened by the definition of immission limit values so far missing (e.g. according to §47f BImSchG). The explicitly specified public participation can also develop a high level of pressure for authorities to justify themselves.

- **Local Public Transport master plans (NVP / *Nahverkehrspläne*)** can set binding specifications for the noise emissions of new vehicles to be purchased as well as for maintenance and monitoring regulations and allow the state of the art to be promoted

through bonus systems for particularly quiet vehicles. It is therefore recommended to strengthen the position of the NVP by giving it a more binding character and to support it by improving the financial support for effective measures. A nationwide harmonization of the noise specifications at a high level overcomes the restriction of small local markets and is therefore ideally supported by a sample NVP - Noise (e.g. by the *Bund/Länder-Arbeitsgemeinschaft Immissionsschutz* (LAI / Federal/National Working Group on Immission Control), in which the Sound recommendations of VDV should be followed (VDV 2011b).

- **Operating restrictions** play a subordinate role with the exception of speed restrictions (especially in curves). It is accordingly difficult to design models that create an incentive for the use of quieter vehicles through user advantages.

You can read more about this topic in the long version of the report in chapter 4.

Measures to reduce emissions

When operating trams, acoustic noise is emitted from various sources (see Section 5.2 Annex 2 (to Section 4) of the 16th BImSchV):

- Driving noise caused by
  - Rolling noise due to roughness on wheel and rail surfaces and
  - Drive noise (motors, gears) and
- Unit noise (power converter, compressor, air conditioning or ventilation units).

In order to sustainably reduce the acoustic noise emissions resulting from the operation of trams, the overall vehicle/wheel-rail system must be considered. Acoustic noise reduction measures come into question in the following areas:

- Measures at the source (vehicle and track),
- Measures on the propagation path (acoustic noise barriers) and
- Operational measures (e.g. speed restrictions).

The reduction in acoustic noise emissions directly at the source offers the highest level of effectiveness, appropriate measures must therefore be applied with priority. A wide range of measures with different effects is available to achieve this goal. Measures to reduce noise emissions must be implemented both when ordering the vehicles and when creating the track, as retrofitting is not always possible or involves great effort.

In addition to the measures taken at the source, acoustic noise barriers are a way of reducing immissions from tram operation on the propagation path. However, they are limited in terms of their use (space, urban design) and are generally not available, for example, in the case of embedded track in densely developed areas.

Operational measures such as the strategic vehicle roster planning of quiet vehicles or speed restrictions can require greater organisational effort or sometimes have undesirable effects. For example, by reducing the speed of the route - also only for specific sections - public transport can become less attractive, especially in direct competition with motorized individual transport. In addition, the potentially longer loop times might result in higher vehicle and driver demands, which would lead to higher operating costs.

You can read more about this topic in the long version of the report in chapter 5.

Monitoring

In Appendix 2 (to Section 4) 16. BImSchV a wheel-rail system subject to average maintenance is assumed. In order to maintain this condition, the following steps are essential:

- Description of a "wheel-rail system subject to average maintenance "
- Inventory of the current condition
- Regular inspection of the status quo in relation to the reference condition
- Initiate the necessary measures to restore the initial state.

The implementation of monitoring procedures at the transportation companies has so far been limited to a few individual cases in which generally the out-of-roundness of the wheels (flat spots, polygons) is checked. The monitoring takes place stationary on both rails of a track. Acoustic monitoring of the track and the vehicles has not yet taken place for trams. There are basically two options for this:

- Stationary acoustic monitoring on a measuring cross section:
  In EN DIN 38452-1, acoustic monitoring of noise emissions from rail vehicles is described. Both the wheel conditions and the other acoustic sound-emitting sources can be recorded. The following measurements are possible:
  - Long-term acoustic monitoring of vehicles on a straight stretch of track and comparison of the measured values with fixed reference values,
  - Determination of the effectiveness of noise-reducing measures on vehicles or on the track in the area of the measuring section over a long period of time. Sound measurements of this kind can be carried out on straight track sections as well as in track curves, switches and crossings.
- Acoustic track monitoring from the vehicle:
  A simplified procedure inspired by the noise monitoring car of DB AG can be used in the rail network of trams. The following measurements are possible:
  - On appropriately equipped vehicles
    - Acceleration measurements on the wheelset bearings,
    - Airborne acoustic noise measurements on the area of the bogies or in front of individual wheels.
  - Use of a special car (trailer) similar to the DB AG noise monitoring car, with which the entire track network of a transportation company can be used at regular intervals and the (acoustic) condition can be determined.

These approaches offer considerable advantages for the municipal transportation company and residents. On the one hand, it guarantees residents that the calculated average immission values will not be exceeded on a permanent basis and provides transportation companies with strong

arguments for the operation and further expansion of the route network. The transportation company guarantees that certain acoustic noise levels will not be exceeded.

You can read more about this topic in the long version of the report in chapter 7.

Socio-economic evaluation

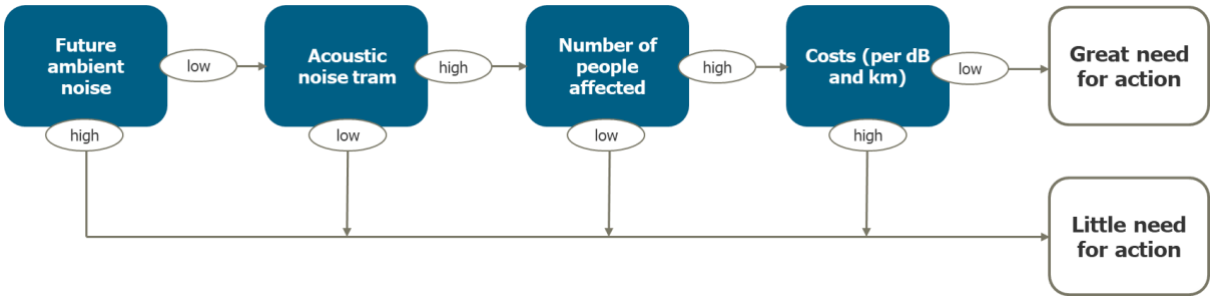
Noise causes costs that are borne by society as a whole. For this reason, the report examined the extent to which noise reduction measures can be socio-economically reasonable. For this purpose, different impact scenarios and framework conditions were defined in order to be able to plausibly cover the various areas of application.

The results show that, despite different scenarios and impact categories, generally always the same measures can be quantified with a positive cost-benefit factor. On closer examination of all the results, sorted according to their effect, it is also obvious that the order of the measures hardly changes, even with the results of the costs per decibel.

The most socio-economically profitable measures as well as the most unprofitable measures remain the same despite different scenarios. The question which of the measures is most profitable is therefore largely independent of the number of those affected. A simple comparison of the costs per decibel is sufficient. For the question of whether a measure is worthwhile at all, the number of those affected must be included in any case.

In summary, there are a total of four key factors in order to be able to compare noise-reducing measures: costs per decibel and kilometer, number of people affected, acoustic noise emissions from the tram system and the ambient noise. A measure is most likely to pay off socio-economically, the lower its costs, the higher the level of impact, the more noise-intensive the previous tram system and the lower the ambient noise (Figure 1).

Figure 1: Key factors for comparing noise reducing measures



Source: own illustration (Ramboll Deutschland GmbH)

If the ambient acoustic noise is high and there are no plans to significantly reduce it in the future, there is little need for action in the area of trams. However, if the ambient noise is low and the noise emission of the tram is comparatively high, action should be taken. If the number of those affected is also high and the costs of the measure are low, the need for action is very great. In addition, it can be said that the low-cost measures are recommendable already with a few people affected

You can read more about this topic in the long version of the report in chapter 6.

Conclusion

The independent cities, districts, special purpose municipal associations, transport associations or the states as responsible authorities can define criteria for the provision of services and therefore have the greatest scope of action. It is possible to set out these criteria in the local transport plan, in the tender documents or in the final public service contract.

From the point of view of immission control, it is recommended to eliminate the loopholes in regulatory law. In the short term, noise emission specifications in local transport plans are also an effective instrument. In the medium term, these can also serve as the basis for the public service contract.

The catalogue of noise-reducing measures is extensive overall and offers different effects at a wide range of costs. Acoustic vehicle and route monitoring offers considerable advantages for the transportation company and for the residents affected. Above all, regular track monitoring and track maintenance based on this guarantee permanently low acoustic noise emissions. This increases the acceptance of local residents for tram operation.

There are a total of four key factors in order to be able to compare acoustic noise-reducing measures: Costs per decibel and kilometer, number of people affected, noise emissions from the tram system and ambient acoustic noise. A measure is most likely to pay off socio-economically, the lower its costs, the higher the impact, the more acoustic noise-intensive the previous tram system and the lower the ambient acoustic noise.

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