Experience from a large-scale railway project - handling multiple environmental noise sources in populated areas

Adam Suleiman
Norconsult AS, Kjørboveien 22, NO-1337, Norway, adam.suleiman@norconsult.com

Nelly-Ann Molland
Norconsult AS, Stensarmen 4, NO-3112, Norway, nelly-ann.molland@norconsult.com

In Norway there is a great amount of major railway projects planned, called The InterCity initiative. This development has its focus in the south eastern part of Norway, and includes 25 stations and 270 km of new double track, which will give 1.5 million residents and commuters faster journeys and an increased amount of departures. The Intercity-project Drammen – Kobbervikdalen has a starting location in a densely populated city-area and will have noise impact on approximately 700 residential buildings. These residents will be exposed to permanent noise from trains, in addition to noise from a temporary rail yard. Besides, noise from the associated construction work which will last for 5-years, needs to be considered. With several different noise sources in the same residential areas, complex noise evaluations need to be carried out to ensure that the current domestic requirements will be satisfied with a minimal annoyance and via ensuring good communication with the residents. The question is, are the noise requirements suited for this complexity? With respect to the different sources, how should the outdoor noise calculations be performed to assess whether the current noise limits are satisfied at nearby housings? With so many different sound sources, how do we design acoustic measures that consider the complexity of the low frequencies from one source and the high frequencies from the other? Regarding the construction work it is often challenging to predict the noise levels at given periods, because off the deviations and uncertainties in the planning and timetables. To illustrate this approach in practice, we will present a specific example of the ongoing project and look at consequences for both residents as well as for the contractors and Bane NOR.

1 Introduction

The Norwegian railway infrastructure manager, Bane NOR, is a state-owned company that has the responsibilities to plan and build new railway infrastructure in Norway. Bane NOR is responsible for a number of the country's biggest public transport projects, such as the development of The InterCity Initiative and the Follo Line [1].

The development of The Intercity Initiative has its focus in the southeastern part of Norway and includes 25 new stations and 270 km of new double track, which will give 1.5 million residents and commuters faster journeys and an increased amount of departures. For Oslo and the central part of eastern Norway the expectation is a strong population growth over the next few decades. Significant improvement of rail services on the InterCity network will play an important part in relieving the pressure om the capital city and in the development of the areas where people live and work along the InterCity sections.

The ongoing project Drammen – Kobbervikdalen is a part of the Intercity initiative, and an important part of the modernization of the Vestfold line. The Vestfold line is being modernized in order to reduce travel times and increase capacity. To attract travellers, the railway needs to shorten travel times, increase train frequency, improve punctuality, and needs to have centrally located stations.

Drammen, the starting location is, as Norways 6th largest city, a densely populated city-area located 45 km south-west of Oslo.

The InterCity project consists of a new station and a 10 km doubletrack railway including a 7 km long railway tunnel between Drammen and Kobbervikdalen. The extent of this InterCity project is shown in Figure 1.

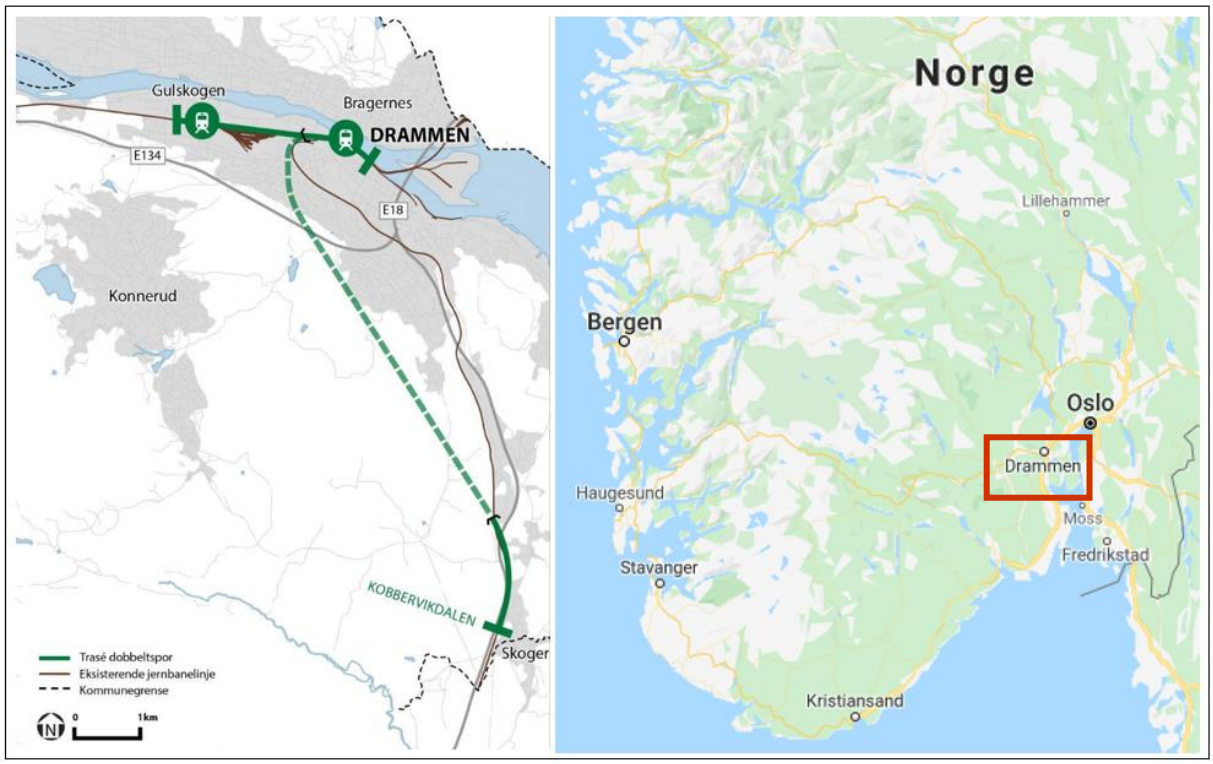


Figure 1: Overview of the IC-project Drammen – Kobbervikdalen [1].

There is a great amount of development due to the railway system as well as the stations, and it is very exciting but also challenging to work with engineering and planning to ensure good projects and good community development. The IC-project Drammen - Kobbervikdalen will have noise impact on approximately 700 residential buildings. These residents will be exposed to permanent noise from trains, temporary rail yard noise, as well as noise from the associated construction work which will last for 5 years. As acoustic consultants we contribute to ensure an optimised project and make sure that noise annoyance in the exposed neighbourhoods will be as low as possible.

2 Framework

The question is how to appraise the occurring noise levels in relation to the desired use in an area nearby noise sensitive buildings. For that we can make use of the legal framework, but in complex projects with different noise sources, also more qualitative factors are important.

Since 2005 a guideline for handling noise in relation to land use planning (Retningslinje for behandling av støy i arealplanlegging), T-1442, is implemented in Norway [2]. In this guideline different situations regarding noise are described, mostly related to development of new sources or new receiver areas. What levels are perceived as annoying depends on the type of area you are in, and the use of the area that is desirable.

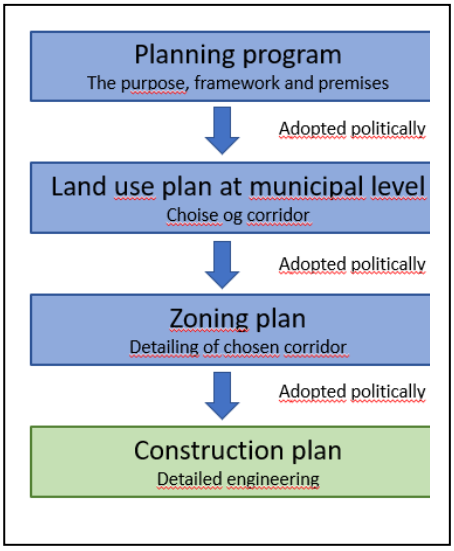
In T-1442 you will find a list with recommended noise levels at residential buildings for different types of sound sources (see Table 1). Due to the different spectrum and characteristics, each source type has a different noise limit. When there is a plan for establishment of a new project, T-1442 provides a guideline for the use of these noise limits. However, this guideline has no legal status until it is part of a zoning plan, and it can sometimes be challenging setting strict limits within a project, especially when there are several different sound sources in the exposed area.

Table 1: Recommended noise level limits for different sources at residential buildings and outside windows to room with noise-sensitive purpose of use.

Noise source	Recommended noise limits (day, evening, night)	Outside bedroom, at night 23–- 07
Railway	Lden 58 dB	L5AF 75 dB
Road	Lden 55 dB	L5AF 70 dB
Construction noise	Leq_d 60 dB, Leq_e 55 dB,	Leq_n 45 dB
Rail yard	Lden 55 dB	Leq 45 dB / L_{AFMAX} 60 dB

3. The planning process

When it comes to the planning and engineering part of a new railway project, there are several stages of development and different levels of detailing to relate to. All new railway infrastructure projects in Norway must be planned according to an official planning process. This planning process is divided into different steps, and the main steps are as described below. The figure illustrates this planning process.



The final step of the planning process is the construction plan. Once the zoning plan is approved by politicians, with established legal status noise limits, the work to detail all technical matters according to the project starts. This includes all engineering work that is necessarily to be completed before the entrepreneurs starts up with the construction work on site.

For the acoustic consultants the work in the construction plan involves performing detailed outdoor noise calculations and optimization of noise screens along the line. Levels outside building facades are calculated with respect to the different sound sources. All residents, schools and nursing homes with noise levels outside the facade that exceed the set noise limit, are identified. All these buildings are further on considered for local noise reduction measures in the facade and in the local outdoor living area.

The evaluation of the need of noise reduction measures on the facade, is based on calculations of the indoor noise level and the facade constructions of the building. An essential part of these evaluations is inspecting the entire building to detect the floor plan and evaluate the construction of facades and windows. If the calculated indoor noise level exceeds the set noise limit, noise reduction measures must be described for facade elements. In addition to satisfying the indoor levels, all homes should also have a quiet outdoor area. For noise exposed outdoor areas a noise screen is being described or a glazed balcony is designed if necessary. To ensure good solutions and good adaption to existing buildings, acousticians cooperate with architects when designing these outdoor noise reduction measures.

4 IC Drammen – Kobbervikdalen - noise evaluations

With several different noise sources in the same residential areas, extended noise evaluations have been carried out to ensure that the legal noise limits will be satisfied with a minimal annoyance. Important in this process is ensuring good communication with the affected residents.

The noise mapping of the railway showed that the project would have noise impact on approximately 700 residential buildings. Many of these residents are in addition to railway noise also exposed to noise from one or more different noise sources, such as road traffic, temporary rail yard noise, as well as noise from the associated construction work which will last for 5 years. The aim of the noise mapping in the project is to determine the need of noise reduction measures for these residents which will have satisfying effects on all relevant noise sources. The complexity of this work leads us to a multiple step calculation-procedure.

4.1 Calculation method

All noise zone maps, with the respective sources, have been calculated using Nordic prediction methods. Furthermore, the calculations of indoor noise have been performed using the method according to "Byggforsk HB47" [3] and "Prosjektrapport 102" [4]. In the following, the calculation and evaluation procedure will be presented.

4.1.1 Step 1 – Evaluating noise from railways

First, future permanent railway noise is calculated to determine which residents have noise levels above the given limits on the facade and should be further inspected and evaluated for acoustic measures. As part of these evaluations the entire building must be inspected to detect the floor plan and evaluate the construction of facades and windows. Thereafter, the indoor noise level is calculated according to the above mentioned Sintef – method. If the indoor noise level exceeds the set noise limit, noise reduction measures must be described for the given facade elements. Furthermore, the main outdoor area should be considered for local noise reduction measures.

4.1.2 Step 2 – Designing local noise measures with respect to transportation noise

As this is a railway project, the local measures initially need to be designed with respect to railway noise only. However, in this project, since many of the exposed residents are located in an area with significant road traffic noise, it is decided that the local noise measures triggered from modernizing the railway should also take into account noise generated from road-traffic. This will ensure that the landlord / owners will experience a greater overall effect of the implemented noise reduction measures, on the facade and outdoor area, and the respective residents will be more satisfied with Bane NORs compensation for the inconvenience caused by the modernization of the railway. This is also considered to give an increase in the overall social benefit.

4.1.3 Step 3 – Noise from the construction plants

Based on the upcoming 5-year construction period, involving heavy construction work in a densely populated area, it is decided that the residents exposed to construction noise should be evaluated for noise measures as a compensation for this inconvenience. In practice, these compensating measures are evaluated to the same extent as the measures with respect to permanent railway noise. This means that the need for measures must be described for the exposed facade elements such that the construction noise is reduced to a sufficiently low indoor noise level, similar to the previous steps. Outdoors area should be considered as well.

Due to the fact that construction noise has a different frequency-character, as well as a more variable behaviour compared to noise from road-traffic and railway, it is necessary to perform a separate evaluation used for designing noise measures with respect to this sound source. The workload and noise levels associated with the construction work will off course vary within this 5-year period. It is however, decided to design the measures with respect to a worst case scenario / period within the construction phase.

4.1.4 Step 4 – Residents exposed to noise from transportation and construction work

The residents have different noise exposure, some residents are exposed to all four sources, others only to one or two sound sources. We focus here on those exposed to both future railway-noise, current road-traffic noise and construction noise. Having started designing the measures needed to reduce the transportation (railway and road) noise sufficiently, the next step is to test whether these measures have sufficient effect with respect to construction noise as well. If not, additional measures are implemented to ensure that the noise measures have sufficiently effect on all relevant sound sources. These evaluations are based on complex calculations as the three sound sources generate different levels on a certain facade / outdoor area, as well as a different frequency-character. In addition different noise limits apply. An example of such a case is shown in Figure 2 and Figure 3 below.

Figure 2 shows the calculated equivalent outdoor noise levels on a residential building exposed to noise from future railways, road traffic and construction work. The picture to the left shows noise levels with respect to future railways only, while the picture in the middle shows the summed levels from railway and road traffic noise which has increased by 1 dB for some facade points compared to the railway noise alone. The picture to the right shows noise levels with respect to construction noise only.

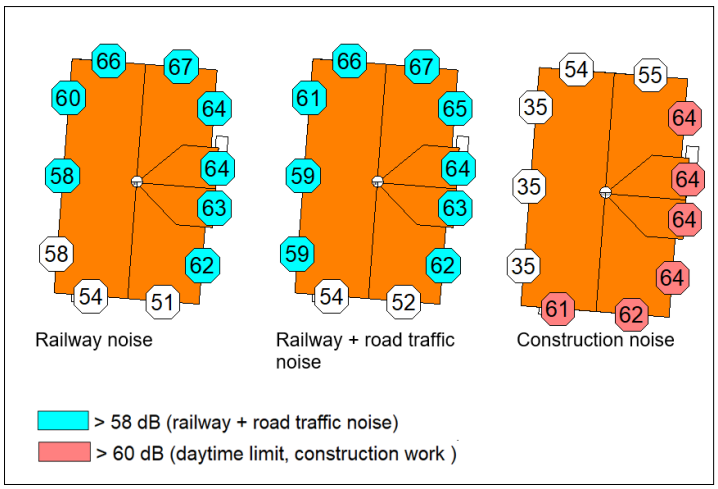


Figure 2: Facade noise levels with respect to various noise sources. Noise limits are also shown.

Figure 3 shows the floor plan of a dwelling unit in the north end of the building shown in Figure 2, where the recommended facade measures are sketched. The measures in the living room and in bedroom 2 are calculated with respect to both railway and road traffic noise, while in bedroom 3 only noise from the railway had a decisive impact designing the measures. Bedroom 1 is quite equally exposed to all three sources. In this case, the measures are first calculated with respect to construction noise which corresponded to the highest noise level on the facade outside the room. Then, after calculating the measures needed (one window and one fresh air valve) the calculations are adjusted to make sure these measures are also sufficient with respect to railway noise and road traffic noise. If they are not, the measures are adjusted.

In this particular case only windows and fresh air valves are needed, but for other residents noise measures on walls, roof and ceilings are also necessary in order to fulfil the indoor noise limits.

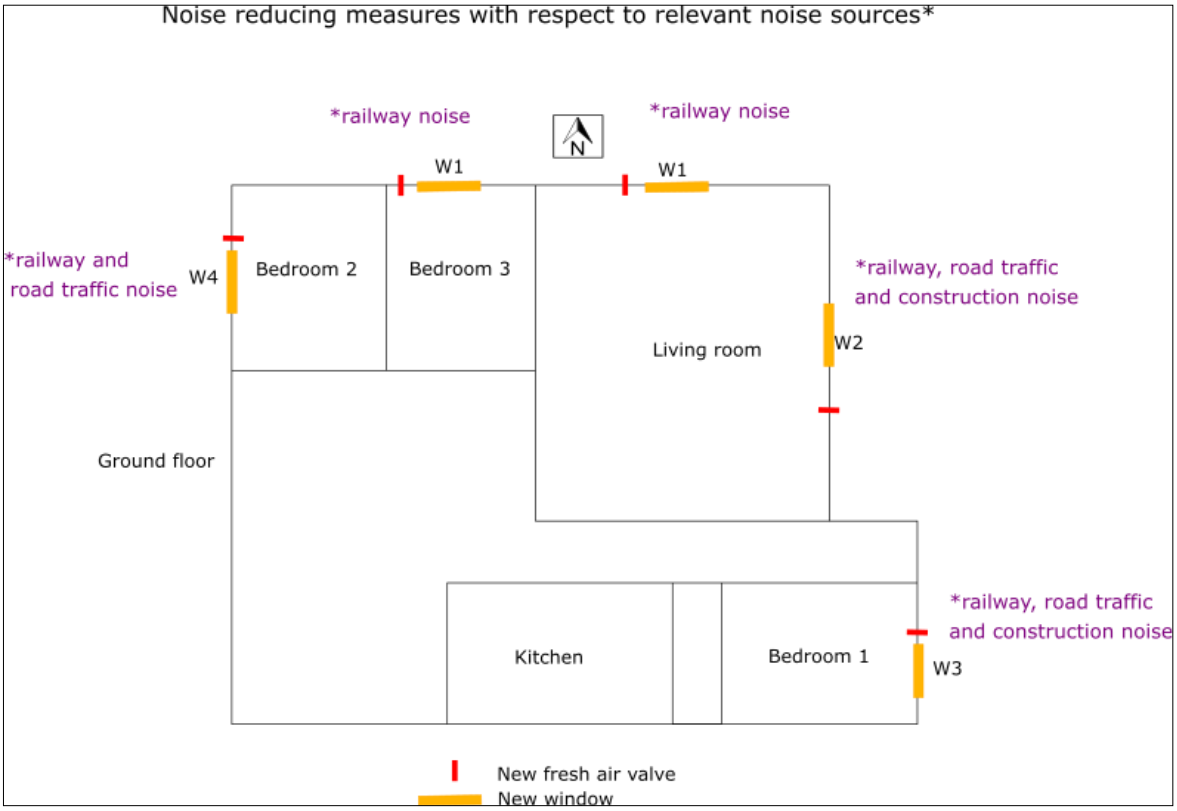


Figure 3: Example of acoustic measures with respect to various noise sources.

Evaluating the local acoustic measures with respect to all the various noise sources at the same time, as shown in Figure 3, can have several advantages:

- There will be less disruptions for the landlords / residents as they will only have their house rebuilt once instead of first receiving measures with respect to railway / road traffic noise, and then later receiving additional measures with respect to construction work / rail yard – noise.
- The method gives a better foundation for designing the measures in a more overall and integral matter, considering the whole building as one instead of considering each room as independent from each other with respect to aesthetics and choice of materials.
- The method leads to a more cost efficient and timesaving process for both the contractor and the construction client.

5 Consequences for residents

In the most exposed areas, one of the key objectives was to finish the local noise measures before the construction period started. In addition, prior to specific heavy construction work within a certain area, all affected housings have been notified with information on the expected progress before start-up. When, in some cases, heavy construction works are necessary during night-time for a short period, the affected housings are offered alternative stay if needed.

Generally, good communications between the construction client and the public is crucial in these types of large-scale project to minimize scepticism and worries. Initially, public meetings were held before the project started to inform the people in Drammen about the general progress. The aim was also to reassure that noise measures will be evaluated for all residents which are considered exposed to future railway- and/or construction noise. Then later, based on the initial noise mappings, the residents who were likely to be further evaluated with respect to local noise measures, were contacted by the construction client for further information about the noise evaluation process.

The number of residents to be evaluated for need of noise reduction measures are given as to Table 2.

Table 2: Residents evaluated for measures.

Number of residents evaluated for measures (approximately), due to				
Permanent railway noise	Construction noise	Temporary rail yard noise	Both permanent railway noise and construction noise	Both rail yard noise and construction noise
~ 700	~ 220	~ 15	~ 30	~ 10

Noise calculations are often considered quite theoretical by the general public, and the results are not always received as reasonable from the resident's perspective. For example, small differences in calculated noise levels within residents in the same neighbourhood, can theoretically result in quite different conclusions for each house. As the objective is to protect the exposed residents, the construction client will consider equal treatment for such cases for a more fair and reasonable approach within a cost benefit evaluation.

This, combined with the fact that all significant sound sources were included in the noise evaluations, can be considered as a suitable action to obtain a good relationship between the construction client and the neighbours exposed to noise.

6 Conclusion

The IC-project Drammen - Kobbervikdalen will have noise impact on approximately 700 residential buildings. With several different noise sources in the same residential areas, noise evaluations have been carried out to ensure that the legal noise limits will be satisfied with a minimal annoyance and via ensuring good communication with the affected residents.

The aim of the noise mapping in the project is to determine the need of noise reduction measures for these residents which will have satisfying effects on all relevant noise sources. The complexity of this work leads us to a multiple step calculation-procedure.

Noise calculations are often considered quite theoretical by the general public, and the results are not always received as reasonable from the resident's perspective. Therefore, in most cases the construction client involves the landlord for discussing a reasonable approach.

By including all the various noise sources at the same time when evaluating the local acoustic measures, there will be less disruptions for the landlords / residents. All the measures are then installed in one session such that the houses only needs to be rebuilt once. Also, the method gives a better foundation for designing the measures in a more overall and integral matter. This way, the building can be considered as a whole instead of evaluating each room as independent from each other with respect to aesthetics and choice of materials.

The method also leads to a more cost efficient and timesaving process for both the contractor and the construction client.

References

[1] http://www.banenor.no/Prosjekter/prosjekter/ , 2021

[2] Klima- og Miljødepartementet: *T-1442 Retningslinje for behandling av støy i arealplanlegging*, 2016.

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