DOI: 10.61782/fa.2023.0726

forum acusticum 2023

RAILWAY NOISE MONITORING – A TOOL TO ANALYSE IN DETAIL THE EVOLUTION OF NOISE OVER TIME.

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ABSTRACT

As part of the commissioning of a rail freight project, a noise monitoring system was set up to track the increase in rail freight traffic and to monitor noise over time.
Noise monitoring is done by two continuous measurement stations, an analysis of the classic noise exposure indexes LAeq,6-22h and LAeq,22-6h is realized, completed by an analysis of several event acoustic indexes, with a distinction between the different traffic types (Freight, regional trains).
In addition, the European Regulation EU 2019/774 on the application of the technical specification for interoperability relating to the subsystem 'rolling stock — noise' to the existing freight wagons, obliges the circulation of less noisy freight trains on certain itineraries called "Quieter routes" from 8/12/2024. The projected benefit will not be limited to the nearby residents of these routes but will, by indirect consequence, enable a gradual acoustic gain on all the French rail freight routes, due to the retrofit or renewal of the existing rolling stock. The goal of the noise monitoring system is also to quantify the acoustic gains from the indirect effects of this new regulation.

Keywords: n*oise monitoring - - quieter routes - rail freight - renewal rolling stock.*

1. INTRODUCTION

In order to meet the environmental challenges of tomorrow, France has set itself ambitious objectives in the field of rail freight:

- doubling of freight traffic by 2030;
- improved competitiveness of rail compared to road (20,000 fewer trucks on the road each year, i.e. 425,000 fewer tonnes of CO2 emissions).

A Freight Recovery Plan has been put in place, which aims to support rail operators (by taking 70% of the tolls from the French state), to support isolated wagon and combined transport, and to create rail freight highways. The modernisation of infrastructure is an essential element in meeting the objectives and includes the improvement of the rail network and marshalling, the improvement of port areas, the digitalisation of freight, and automatic coupling.
The major Seine Normandy rail project, which came into service on 12 March 2021, consisted mainly of modernising the railway line between the two towns Serqueux and Gisors. The objectives of this project were twofold:

- to create a new freight route to strengthen the rail service to the port of Le Havre: in order to support the growth of its activities and to face up to competition from the ports of northern Europe, the major seaport of Le Havre is equipping itself with the means to better irrigate its hinterland. This involves the development of mass transport modes, the most important of which is rail transport;
- to offer additional capacity for goods trains between the ports of Normandy and the Paris region: due to the growth in passenger transport and the renovation of the network, it was essential to have an alternative route to continue to rely on a

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quality rail service, with sufficient capacity to handle the traffic between Rouen and Paris, without penalising the major seaports of Rouen and Le Havre.

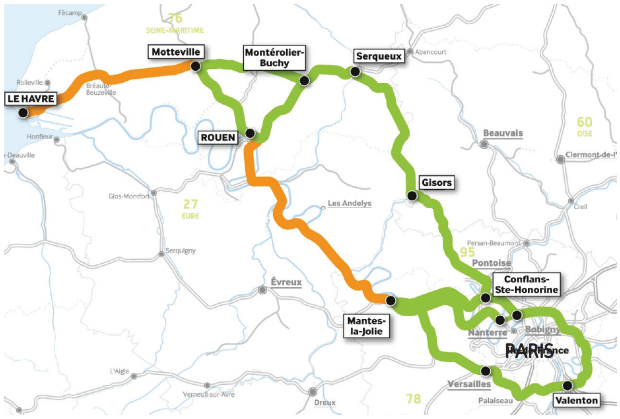

Figure 1. Railway freight routes between Le Havre and Paris.

For this project, the modernisation was of very different kinds: electrification, modification of engineering structures, signalling, etc. Acoustic protections were also carried out within the perimeter of the project in order to reduce the impact of the traffic on neighbourhood near the railway line. In the most urbanised sectors, noise barriers have been chosen, and in sectors where the houses are alone, exterior insulation has been proposed to the local residents.
This project was the subject of a public enquiry which took place in spring 2016, followed by a specific consultation phase in the main municipalities concerned by the noise barriers until early 2017. These stages highlighted the strong concerns of local residents and their elected representatives about the noise pollution caused by rail traffic. The construction of acoustic protections was carried out between 2018 and 2021.

1.1 French noise regulations and SNCF Réseau doctrine

French regulations require compliance with noise thresholds that vary according to the sectors concerned (construction zone/outside the construction zone), and only if the project generates a significant increase in noise (decree n°95-22 of 09/01/1995 relating to the limitation of noise from land transport facilities and infrastructures / decree of 08/11/1999 relating to railway infrastructure noise). In addition, SNCF Réseau ensures that the railway project does not exceed the limit values including on the surrounding sections
In response to the noise impacts generated by the project, both direct and indirect, noise reduction measures have been carried out in the sectors concerned, which also allowed the treatment of housing exceeding the limit values, already existing before the project.

1.2 Strong demands from local residents

The modernisation railway line project between Le Havre and Paris aims to create an alternative freight route to the original ones. No new passenger stations and no increase in the number of passenger trains stopping at stations are planned. As a result, the project does not provide any additional rail services for local residents.
In addition, the route of this railway project is sometimes located in sectors where there was initially little traffic and where the noise environment was relatively calm (so-called moderate). Residents of these areas have focused on the fear that they will be confronted with higher levels of railway noise in a few years' time.

1.3 Commitment of SNCF Réseau

In order to improve communication and consultation with local residents, and to work towards reducing rail noise pollution within the project perimeter, SNCF Réseau proposed in its assessment of the consultation process (with comments and letters taken into account) to set up a noise observatory.

2. IMPROVEMENTS EXPECTED IN FREIGHT TRAIN NOISE

EU Regulation 2019/774 on the application of the Technical Specification for Interoperability (TSI) Noise - existing freight wagons requires from 08/12/2024:

- the introduction of quieter routes: track segments longer than 20 km with more than 12 night-time freight trains based on the average annual night-time traffic from 2015 to 2017;
- only trains equipped with more acoustically efficient brake blocks (10dB gain, i.e. half the perceived noise) are allowed to run on these routes.

The major Seine Normandy railway project has not yet been identified as a low noise route. However, it is expected to benefit from the indirect effect of the application of this European regulation.
In order to be ready at the end of 12/2024, the railway undertakings have established a programme to retrofit their

rolling stock and/or renew their wagons so that they can run on the less noisy routes - even if these represent only part of their routes.
The following map illustrates the quieter routes identified in the Paris region and the different rail freight routes that should progressively benefit from noise improvement as an indirect effect of the implementation of the European regulation.

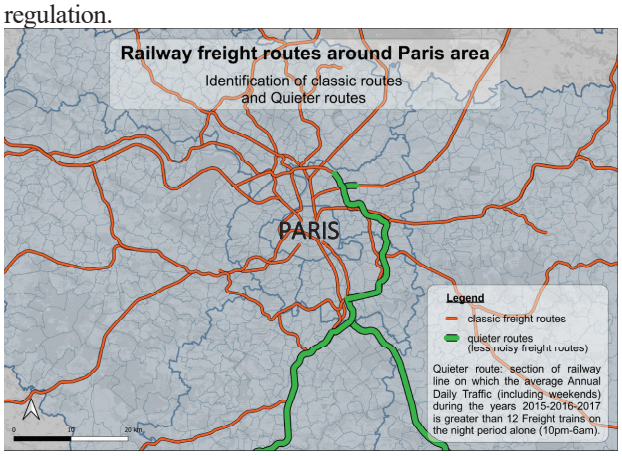

Figure 2. Railway freight routes, and quieter routes.

3. DESCRIPTION OF THE NOISE OBSERVATORY

The main objective of the Noise Observatory is to work towards informing local residents and ensuring that the measures taken to reduce railway noise are properly applied. Another aim of this observatory is to measure the rate of noise improvements made to rolling stock.

3.1 Continuous monitoring of railway noise through acoustic measurements

Two noise monitoring stations are installed around Paris aera in the municipalities of Chars and Herblay sur Seine. The two measurement sites allow the monitoring of noise evolutions in two different areas.
The results are transferable to areas with similar rail traffic, where the measurements would have shown identical results regarding noise evolution (similar variations). However, it is planned to do some temporary measurements at the request of some local authorities to document other sites.
The official in-service date of the railway project was 12/03/2021. Noise measuring stations were installed on 01/2021.

Figure 3. Photo of the noise monitoring station installed at Herblay sur Seine, along the railway line.

3.2 Detection of sound events crossed with rail traffic

The detection of railway noise events is based on the relative noise threshold being exceeded in the signal. The occurrence of an acoustic event corresponds to an exceedance of the background noise by at least 5 dB(A).
This background noise is calculated with a statistical index, the LA90, which corresponds to the sound level reached or exceeded 90% of the time during the 10 minutes before the noise event. To exclude unwanted noise peaks, filtering of the detected events can be applied on duration and sound level. An additional step is also applied to the noise event, the noise level during the event must have exceeded a given threshold for a given duration, e.g. the noise event must have exceeded 60 dB(A) for 5 successive seconds. All parameters (exceedance threshold, duration, LAmax) are adjusted to the specific characteristics of each measurement site.

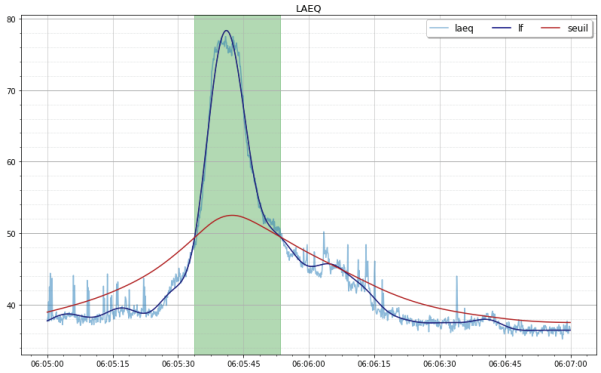

Figure 4. Example of a sound event detection.

The detailed rail traffic data are provided by SNCF Réseau (regularity observatory, ORE tool) which gives information on train movements at specific points on the rail network such as railway stations. The data available includes the arrival and departure time at the railway station for trains that make a stop, and the passing time for trains that do not make a stop. The time code is given to the round minute (e.g. 10:23). The data also contain the train direction, the train family (Freight, Regional, Local, Intercity...) and the train type. Only train movements with a time separation of more than two minutes can be associated with the sound events detected by the measurement. The combination is made as close as possible in time.

The method applied enables the maximum number of cross-train sound events to be detected. For Herblay noise monitoring station, the difference between the number of train movements and the number of noise events varies each month and is less than 6%, depending on periods when there are no measurements or when the data is invalidated. The aim of this article is not to present more details on the detection rate.

3.3 Online access to noise measurements and noise indexes

All data are available on a public website (https://grand-projet-ferroviaire-seine-normandie.bruitparif.fr) to follow the noise evolution (ambient noise and railway noise) in real time at the two measuring stations:

- raw data to visualise the noise levels every second;
- ambient noise exposure indices per period (24 hours, day, night), per day of the week, per month and per year;
- the railway acoustic events detected

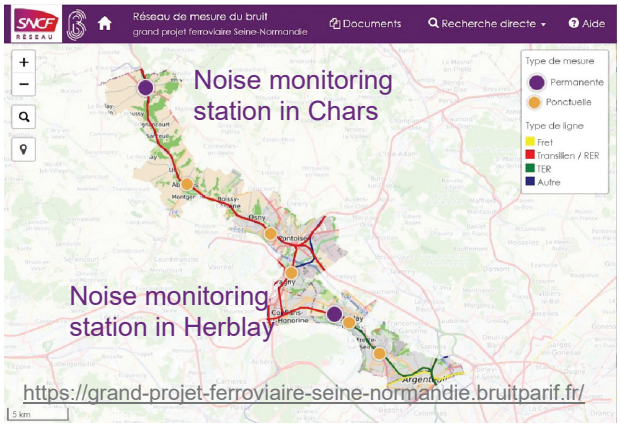

Figure 5. Website platform to access data.

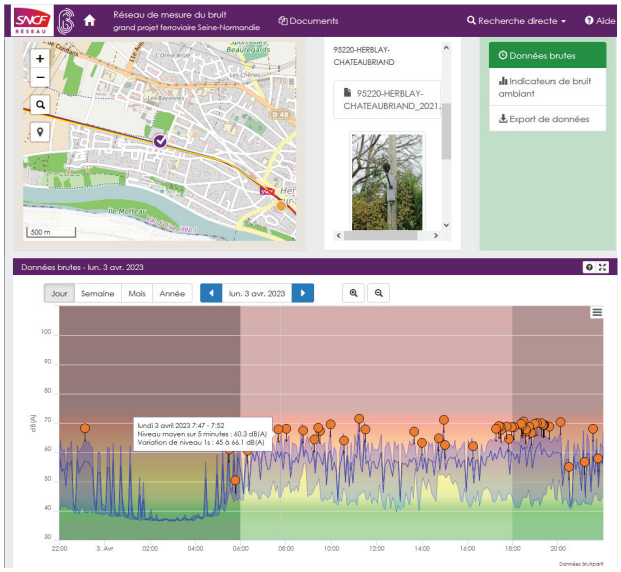

Figure 6. Website page with access to raw data and sound detection.

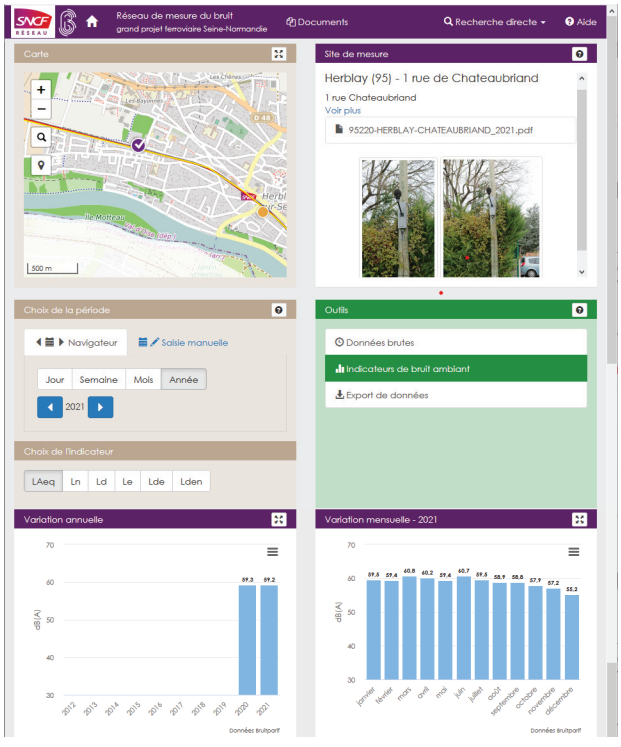

Figure 7. Website page to the evolution of the noise exposure indexes.

4. DESCRIPTION OF THE NOISE OBSERVATORY

An analysis of the results is made every three months for each of the two permanent noise monitoring stations. Lots of informations are presented to complete the strict analysis of the regulatory noise indexes.
Thus, information on rail traffic is published for the various types of use (regional TER, local Transilien, Freight, etc.). The data processing, which is done with finesse, also allows the presentation of results on the noise of railway crossings.
In the rest of the document, examples of results presentation are given based on data from the Herblay sur Seine measurement site only. Similar analyses are conducted at the second site located in Chars, but are not presented in this document.

4.1 Monitoring of railway traffic

Information on actual rail traffic is presented for daytime, night-time and 24-hour periods, by traffic family (regional TER, local Transilien, Freight and maintenance or works trains).

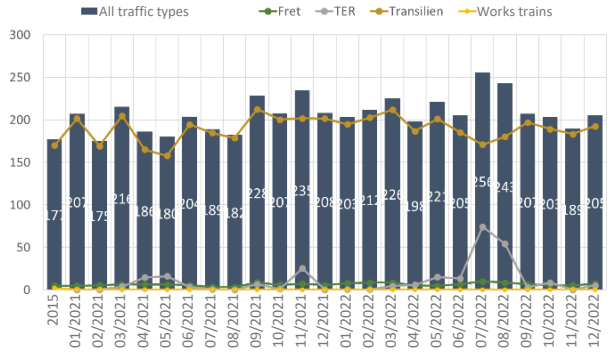

Figure 8. Monitoring of monthly railway traffic by type of circulation (monthly averages, 24h period, all trains).

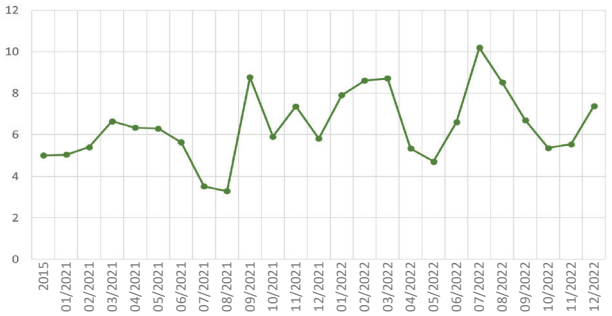

Figure 9. Monitoring of monthly railway freight traffic (monthly averages, 24-hour period, Freight)

A specific graph on the monitoring of Freight traffic is presented (daytime, night-time and 24-hour periods) to follow the growth of the Freight railway corridor.

4.2 Noise exposure indexes

The noise exposure indexes represent the noise levels established in the applicable French regulations for both day and night periods, taking into account the noise generated by all observed railway traffic. These indexes are presented with limit values in the areas affected.

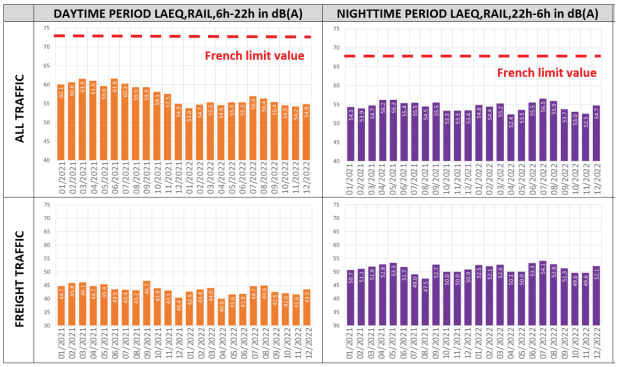

Figure 10. Monthly evolution of the railway noise exposure indexes LAeq,6-22h and LAeq,22-6h (regulatory indexes).

Noise exposure indexes for rail freight traffic are calculated and also presented.

4.3 Passage noise indexes

4.3.1 Indexes selected: LAmax / LAeq,evt

The passage noises (also called noise "peaks") can be characterised in different ways, so there are different indexes to analyse them (LAeq,event, LAmax, SEL, Number Above...). In the context of railway noise, two indexes are usually considered to characterise passage noise. These two indexes are LAeq,event, LAmax. The Noise Observatory presents the results for these two indexes. In the following, various graphs are presented with only the LAeq,event index, plus a short analysis of the results.

4.3.2 Example of results analysed

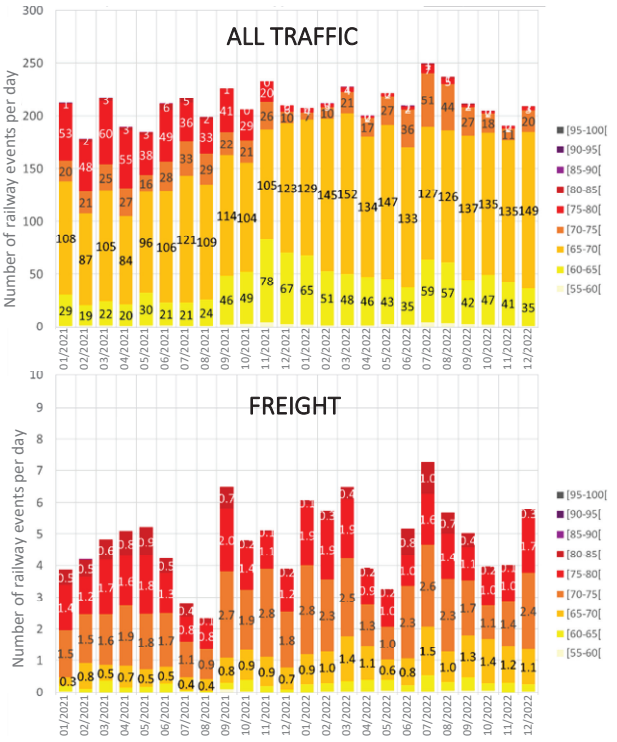

Figure 11. Monthly overview of railway noise levels at the LAeq,event passage by range of levels.

The graphs above show the evolution of noise by sound level range. In addition to the fact that the number of noise events measured varies from month to month, there is also a trend of decreasing noise levels in the last quarter of 2021, for all rail traffic and for freight trains.

Another representation is the Box plot, which allows the spread of noise levels of passing trains to be observed. The dispersions appear to be relatively stable over time for freight traffic; they are stable from July 2021 for all movements combined. Differences between the minimum and maximum levels of about 25 dB are observed for freight trains, and up to 40 dB for all movements combined.

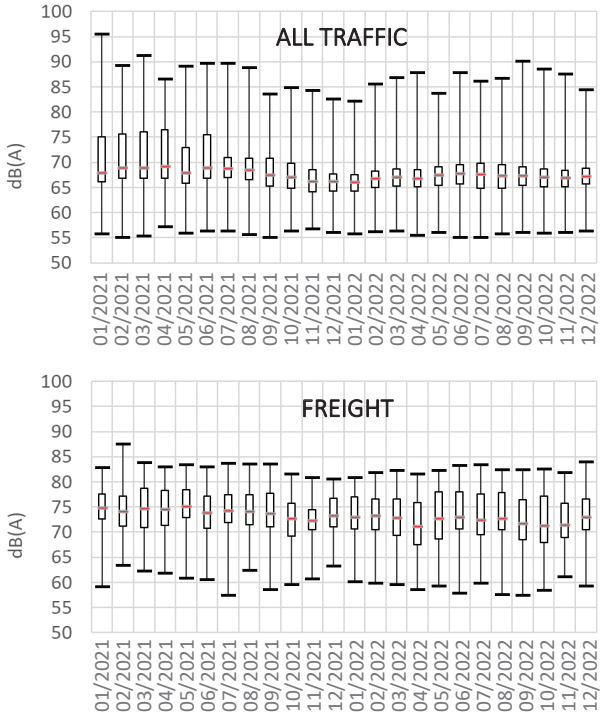

Figure 12. Presentation of railway noise levels at the LAeq,event passage in box plot, 24h period, by monthly period.

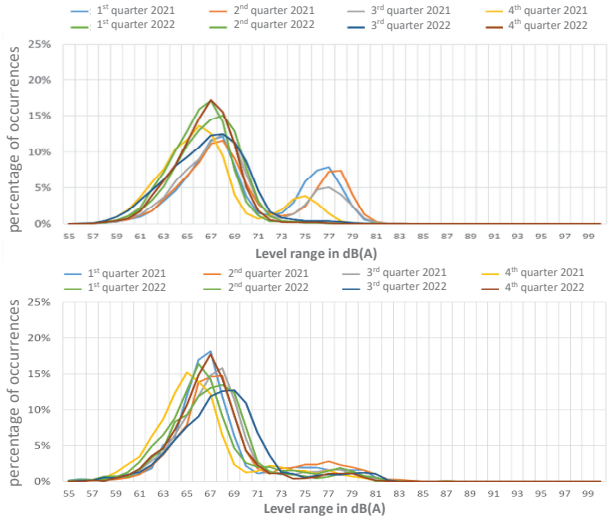

Figure 13. Railway noise level distribution at the LAeq,event passage, by quarter period (daytime upper graph, nighttime bottom graph).

A third type of graph is presented to show the distribution of railway noise levels at the LAeq,event. For all traffic, there are two bumps (bi-modal distribution) in the daytime period, which represent two major noise classes. At night, only the left-hand mode is observed, which means that the most important noise levels during the day are not present at night.

The last graph presented is the most complete because it shows the noise levels measured for each train passage. The graph allows the distinction of train types, with the monitoring of the temporal evolution.

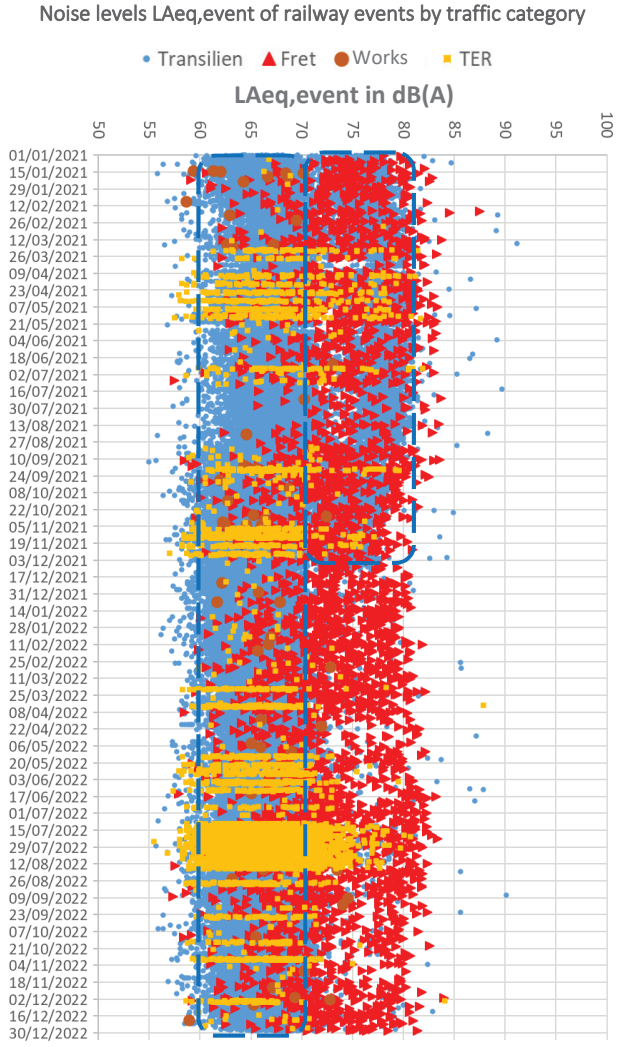

Figure 14. Illustration of all rail noise levels at the LAeq,event passage, by traffic type, with temporal evolution.

In this presentation, two classes of noise generated by local Transilien trains can be observed, indicating different speeds, different directions of travel or different rolling stock. Figure 14 shows an average difference of around 10dB, which corresponds to the total renewal of Transilien rolling stock (VB2N trains replaced entirely in October 2021 by quieter Z50000 trains). This result can already be seen in figure 13 (the noisiest mode disappears completely from the 1st quarter of 2022).

Freight trains show a great variability of noise levels, with most of them having a noise level equivalent to that of the noisiest local Transilien trains.

5. CONCLUSION

A Noise Observatory has been set up for the Seine Normandy Railway Project. This observatory provides detailed information on the noise levels of railway traffic.

It consists of two permanent noise monitoring stations. The raw data produced by these noise stations are available in real time on a public website. Many noise exposure or railway passage noise indexes are calculated and presented with various graphs. An analysis is done on the first few years of observation, in particular for Freight train traffic and on the renewal of Transilien trains.

The analyses of the long-term averages of the LAeq and event indices are complementary but difficult to compare. The analysis of noise peaks provides more detail in the analysis.

The goal of monitoring the results of this Observatory over time is, on the one hand, to examine and present in a transparent way the evolution of noise during the growth of railway freight traffic on the route in consideration and, on the other hand, to monitor the noise reduction linked to the European Quieter Routes Regulation.

The next step of the study will be to continue at the two noise monitoring stations the analysis of the evolution of railway noise linked to the progressive renewal of Freight rolling stock.

6. REFERENCES

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