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ACOUTRAIN: simplifying and improving the acoustic certification process of new rolling stock

Railway noise is an environmental issue that significantly affects the population living along railway lines. It not only causes annoyance but may also have a negative effect on the health of citizens. Thus for some time politicians and policy-makers in Europe have recognised that environmental noise has to be reduced. At the same time, a strong growth in traffic volume is foreseen for the rail sector in Europe in the coming years. The highly sensitive noise situation along many strategic railway lines could impede this important development. One solution to compensate for the noise increase due to traffic growth is to limit the noise emission of each train.

In 2006, the TSI Noise (Technical Specifications for Interoperability) came into force, introducing limiting values in noise emission for the certification of new or upgraded rolling stock. By gradually lowering the limiting values in the TSI Noise, the supply industry is put under pressure to develop quieter products. Today, vehicles are assessed according to established standards for field measurements. This can be a very costly and time consuming process which includes measurements of stationary noise, starting noise, pass-by noise as well as interior noise in the driver's cab. The pass-by noise measurement, as it is specified in the TSI Noise, can be particularly expensive due to the fact that a specific low-noise reference track is required. The relatively high demands on track quality and maintenance mean such reference tracks are hard to access.

The excessive time and cost of the TSI Noise certification process may lead to a reduced and delayed effectiveness of the legislation which could even hamper the introduction of innovative solutions.

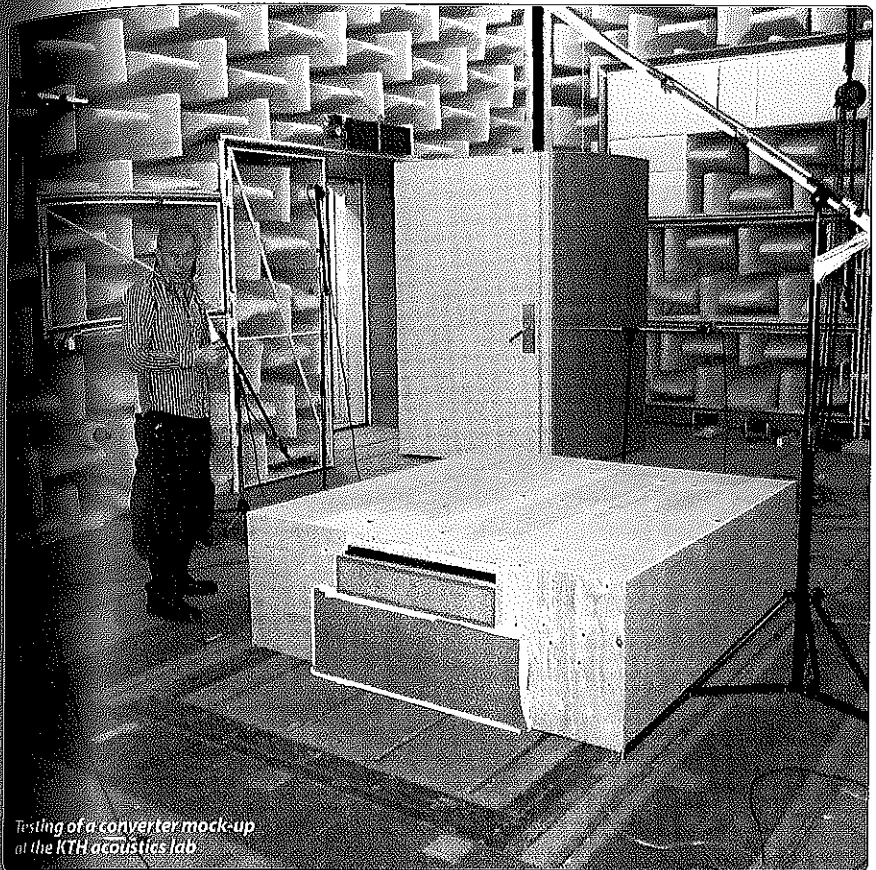
ACOUTRAIN[1] is a research project co-funded by the European Commission with the goal of simplifying and improving the acoustic certification process of new rolling stock. It began in October 2011 and is already starting to deliver results.

Virtual testing in TSI NOI

The concept of virtual testing, replacing all or part of the tests by computations, has gained acceptance in other fields, such as crash testing or fatigue. Certification based on virtual testing is used in areas where full scale tests are highly impractical or even impossible, for example when assessing an aircraft fuselage for its capability to withstand aerodynamic loads. The main goal of ACOUTRAIN is to develop a quicker and simpler acoustic certification process by introducing some elements of virtual testing, while ensuring a sufficient degree of reliability and accuracy.

By introducing the possibility to replace part of the noise testing with certain elements of simulation, the updated certification process to be developed within ACOUTRAIN will support the railway industry to comply with the noise limits in a timely manner. Such updated procedures are expected to reduce costs and speed-up time-to-market for new, quieter vehicles, resulting in a strengthening of the competitiveness of the European railway sector.

In a virtual test in the TSI Noise, as proposed by ACOUTRAIN, the limiting values and indicators are retained as they are currently defined but some aspects of testing will be replaced by simulations. For instance, this means that a pass-by noise measurement is simulated considering parameters such as operating conditions, speed, and receiver positions as found in the TSI Noise today. To perform a pass-by noise simulation the vehicle under assessment is defined in a specific software tool. This vehicle definition basically consists in the vehicle geometry and the sound power spectra of individual sound sources that contribute to the acoustic emission of the vehicle. The characteristics of the single sources can be assessed with laboratory measurements,



Testing of a converter mock-up at the KTH acoustics lab

numerical models or a combination. The tool takes physical effects like wave propagation, ground reflection and the Doppler Effect into account. Many manufacturers already have their own tools for this type of computation but a common tool is also being developed within ACOUTRAIN.

A key foundation for acoustical simulation models of vehicle noise is accurate source descriptors. For this reason a substantial effort within the project is devoted to developing and enhancing existing procedures to

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characterise noise sources relevant for rail vehicles. For certain sources, mathematical models can be applied to characterise the source – like the well-established TWINS code for rolling noise[2]. For other sources enhanced test procedures are needed, focusing on increasing the accuracy of the source power estimation. One complicating factor is that source characterisation is typically carried out in a lab environment neglecting the integration effect present when the source is assembled in the vehicle. In addition, industrial testing facilities do not always comply with the conditions stipulated in the applicable ISO standards.

The simplified evaluation method within TSI NOI

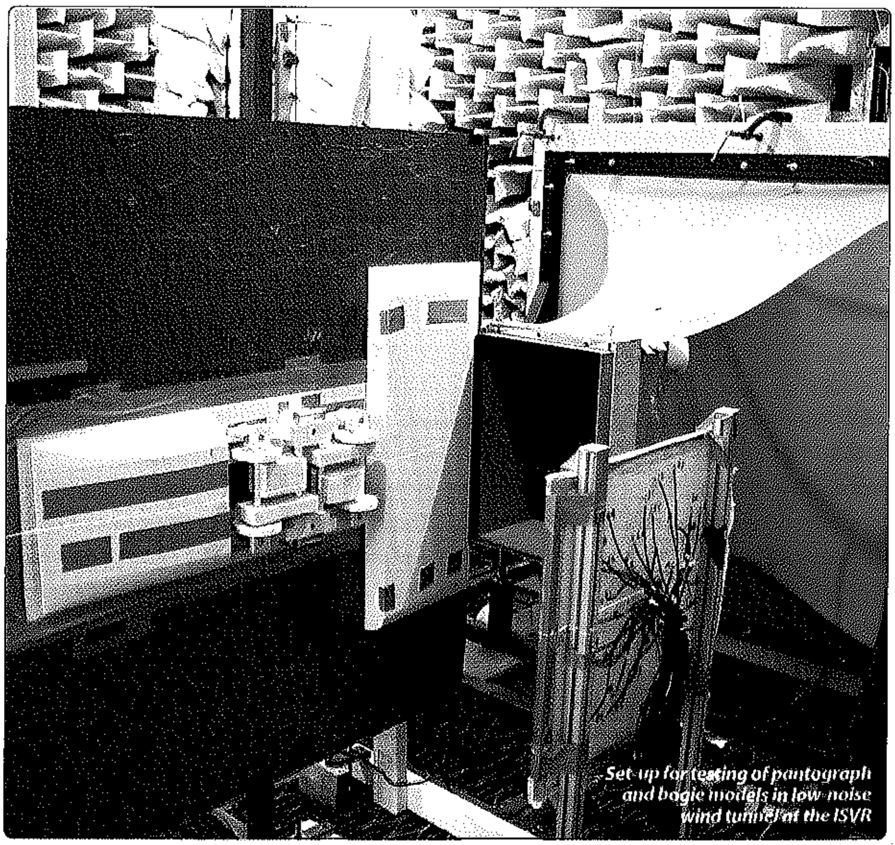
The last TSI Noise revision (2011/229/EU) already introduced some flexibility in the certification process in specific cases:

- Vehicle families: variants of a vehicle type are very often produced to satisfy different requirements of end-users; this results in several similar vehicle types belonging to the same vehicle family
- Different formation of multiple units: multiple units are often produced with different combinations of powered and unpowered vehicles
- Retrofitted vehicles: it should be demonstrated that noise levels are not increased if a component is replaced on a vehicle (for instance an HVAC unit).

A so-called 'simplified evaluation method' is allowed for these cases, but further clarifications on the process to be applied were needed: ACOUTRAIN has proposed some procedures to be applied in this framework.

A number of different application cases have been selected, corresponding to the most common cases where a simplified method will be useful:

- Modification of number of axles
- Modification of the maximum speed



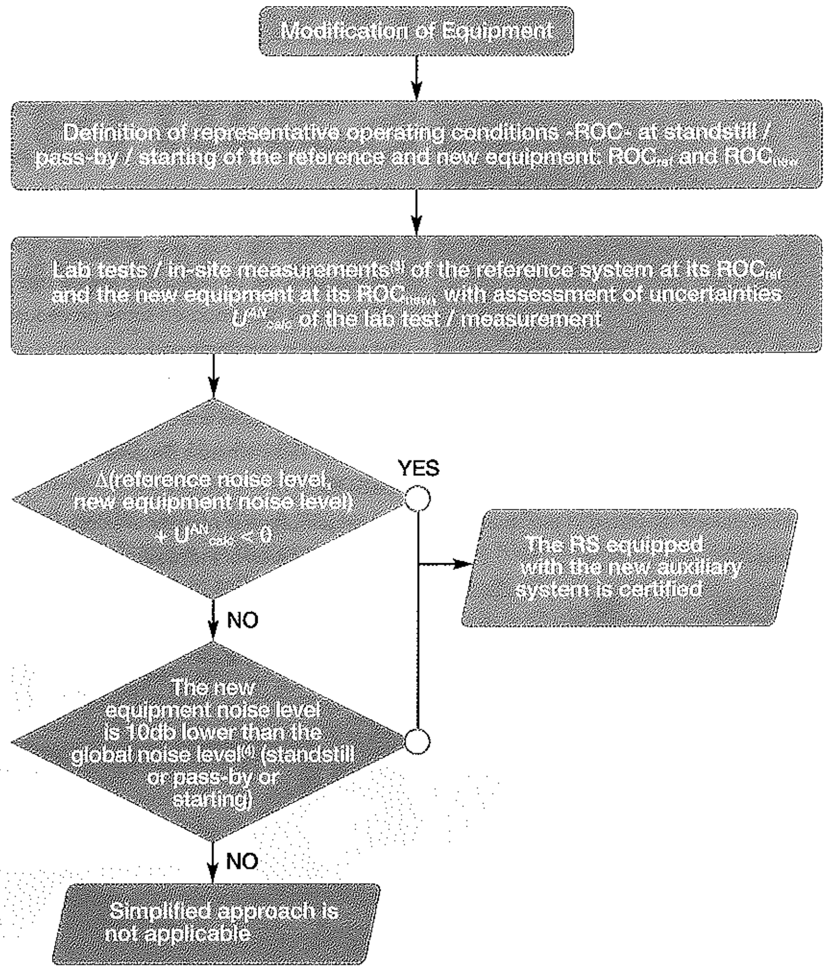
Set-up for testing of pantograph and bogie models in low-noise wind tunnel at the ISVR

- Modification of the wheels
- Modification of the brake system
- Different formations of multiple single cars (add or remove a single car)
- Selection of the worst case within a family of vehicles
- Modification of equipment (traction equipment or auxiliary system) or its installation.

These cases do not represent an exhaustive selection of what could be encountered when applying the TSI Noise; the type of rolling stock to which the method is applicable has to be specified case by case.

The procedures that could be used as a simplified method have been described with dedicated flowcharts by ACOUTRAIN in a document that is foreseen to be included in the TSI Noise application guide. The flowcharts define the limits of application of a simplified approach in each of the cases aforementioned and give a procedure to check if noise levels (for stationary and/or pass-by running condition) are lower or equivalent to the noise levels of a reference vehicle (already certified as TSI Noise compliant). For example, for the case of a modification of an equipment or its installation, **Flowchart 1** proposes a simplified approach to check that there would be no effect (no change in the noise level) or a positive effect (decrease of the noise level) on the stationary, pass-by or starting noise so that the train equipped with the new equipment is automatically certified. The reference equipment corresponds to the equipment on a reference vehicle, i.e. a vehicle already certified.

For all the flowcharts, it is considered that the proposed methodologies can only manage one modification at a time. Of course, positive effects (reduction of noise level) can be considered as cumulative and in this case several modifications can be handled. In addition, indications are given to justify their reliability, considering either previous experience or analytical justifications.



Flowchart 1: Modification of equipment for installation

Towards virtual certification

A long-term goal of ACOUTRAIN is to provide the foundation for the introduction of increased virtual testing in the TSI NOI. Virtual testing in the acoustic field is less common than other fields, but models for calculating the pass-by sound levels based on sound power inputs of the relevant sources are already available and extensively used as a decision support tool during the design phase of new rail vehicles.

However, for such models to complement real testing within a certification process, the tools themselves, as well as the methods to assign acoustic source strengths, must be thoroughly scrutinised and a rigorous tool validation and verification procedure must be in place. Such procedures are being addressed within the ACOUTRAIN project, including a procedure to deal with uncertainties. Uncertainties in the input data must be controlled and monitored, and limits for the variability in the sound levels calculated should be determined by the tool based on the input uncertainties.

It will take time to introduce virtual testing into the TSI NOI procedure and for it to gain wide acceptance but it has great potential to achieve significant cost and time savings in the certification of new, quieter railway vehicles.

References

1. www.acoutrain.eu
2. D.J. Thompson, B. Hemsworth and N. Vincent. Experimental validation of the TWINS prediction program, Part 1: Method. Journal of Sound and Vibration 191, 123-135, 1996

BIOGRAPHY

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