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QUIESST: toward a better knowledge and understanding of how efficient noise barriers could actually be

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Abstract

Since the early 80's, one models noise propagation, in the early 90's one started to standardize how to measure the intrinsic characteristics of manufactured noise barriers: in 1997, the EU funded ADRIENNE research ([1] and [2]) was a first step, but many problems still remained. Since years, all the noise propagation software are still modeling noise barriers while characterizing those rather roughly, if not basically, whatever it is for sound absorption, airborne sound insulation or sound diffraction. The EU funded QUIESST research aims to drastically improve the knowledge and understanding of how noise barriers actually works, in function of all their intrinsic characteristics and the environment within which they are installed. This paper introduces QUIESST's objectives / work schedule for the next 3 years.

1 Introduction

1.1 What is QUIESST?

QUIESST: QUIetening the Environment for a Sustainable Surface Transport is a research launched within the European Commission 7th Framework Programme on the 1st of October 2010 for 36 months duration. It targets to improve the knowledge of the actual acoustic performances of Noise Reducing Devices (NRDs) placed along surface transport infrastructures as highways or railways.
Following the EN14388 [3], NRDs are: noise barriers, claddings, covers and added devices.

1.2 Background

The European Commission, through its 2002/49/EC Directive [4] supports a global environmental noise reduction within which surface transport is one of the main targets. However, with EC expected noise reduction impacts of about 10 to 20 dB, it is evident that no action limited to a single step of the whole noise problem could obtain such reduction in noise values: one should act (and optimize the means of action) at all the consecutive steps of the whole process (sound emission, sound propagation, and sound reception). Acting on sound propagation, ground transport NRDs do play an important role in the reduction of noise: depending on numerous different factors, their global effectiveness could be as low as a few decibels (if used inadequately), or reaching up to 20 dB (while using appropriate design).
Today, many efforts have been done on both sides of the characteristics leading NRDs to be effective: the product side (intrinsic characteristics, mainly: absorption, airborne sound insulation), and the in-situ side (extrinsic characteristics: final effectiveness). However, too few and limited research has been done yet in order to integrate both sides, while the true final noise reduction clearly depends on both (in a true holistic approach).
The best example is the way the noise propagation software are modeling NRDs: almost all the software either consider generic sound absorption properties while they very often totally neglect airborne sound insulation, or do consider (test report) product characteristics, but tested following the existing standard methods [5] and [6] still corresponding to (inside) building products, what is definitely not the intended use of NRDs.
Furthermore, no global noise propagation software considers yet shaped NRDs or NRDs with heterogeneous acoustic properties...
Finally, the sustainability of the acoustic and non acoustic characteristic of NRDs is of major importance if we want to get sustainable noise reductions with those devices.

1.3 Concept and objectives

In facts, the "true final" NRDs performance depends on:

- the initial intrinsic acoustic characteristics of the industrial products used, and the long-term durability of those characteristics;
- their relevant global design (intrinsic acoustic performances, flat / non flat / shaped - homogeneous / heterogeneous devices, dimensions and location) in function of the types and shapes of the vehicles, the infrastructure and the global concerned environment;
- the whole sound propagation process: the intrinsic performances, which directly affect the near field propagation, could affect the far field performances in a complete different way.

(one has to remember that the END Directive [4] can lead to more stringent noise criteria and thus to more important noise reductions, affecting more and more distant areas…)
QUIESST aims to control all those important factors through a true holistic approach.
The main deliverable of QUIESST will be a comprehensive reference guidebook about NRD holistic optimization (referring to associated databases, simulation methods, measurement methods and recommendations: all these being also QUIESST deliverables).

1.4 Main topics

The research is subdivided into 7 work packages: the first one concerns the research management and the seventh one concerns the dissemination of the research results. The other work packages address: the near field / far field relationship, the in-situ measurement of "true" sound absorption and airborne sound insulation, the comparison of the existing laboratory tests results of European NRDs with the corresponding in-situ measurement test results, the holistic approach of NRDs optimization, and the sustainability.
The interdependencies between activities are schematically represented in Figure 1.

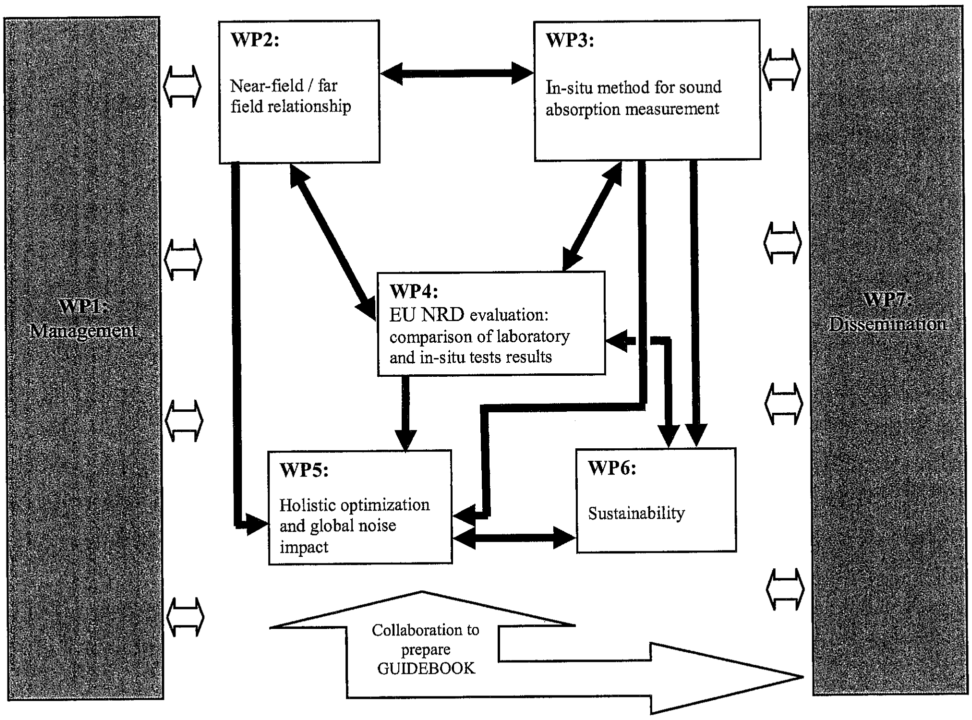

Figure 1 – Existing interdependencies between QUIESST activities.

2 The near field / far field relationship (WP2)

After more than 30 years using NRDs alongside roads and railways, the debate about the real significance / need to use sound absorptive and / or specifically shaped devices for getting a better noise reduction in the far field still stays almost the same: one says it is really effective, one says it is useless, but no definitive survey has been done yet in order to clearly demonstrate the true global effect of specifically designed NRDs.
In short, shape and sound absorptive materials are tools for achieving better noise reductions but, at present, it is impossible to properly simulate non flat and / or sound absorptive NRDs effect in the far field.
Mastering the NRD performance, whatever their sound absorptive characteristics and / or shape in the near field and in the far field is the first objective of QUIESST.
The main steps to achieve this objective are:

- to develop a numerical simulation method for the conversion of near-field sound reflection patterns to far field effects of sound reflections with NRD of different sound absorption and / or shape;

- to validate the numerical simulation method against measured data acquired in near and far field;
- to develop an (analytical) engineering computation method for the translation of near field measurement data into far field reflection effects to validate the engineering method against the results of the numerical simulation method and the available measurement data;
- to define an appropriate indicator for the rating of the NRD sound reflecting characteristics based on the far field effect.

The verifiable result will be a validated engineering computation method, drafted with user friendly instructions for data processing and the corresponding far field indicator derivation.

3 In-situ measurement method of NRD intrinsic "true" sound absorption and airborne sound insulation (WP3)

Since the early beginning of the NRDs use, one characterizes their intrinsic acoustic performances in closed and / or reverberant field (reverberant rooms in relevant laboratories) as if they were products to be used inside buildings (the latest applicable standards being EN 1793-1 [5] and EN 1793-2 [6]). This is totally inadequate relatively to their intended use, i.e. in open spaces. Moreover, this way does not allow an easy control of the NRDs long term acoustic performances years after years, what is in facts a real need in order to assess NRDs (acoustic) sustainability.

For in-situ measurements, the tentative CEN/TS 1793-5 [7] , based on the results of the ADRIENNE research ([1] and [2]) is currently used by several European Member States but has serious problems while characterizing / comparing flat and non flat products: as it stands, CEN/TS 1793-5 has been rejected as an harmonized EN standard.

Today, the need to characterize NRDs in-situ is more than ever a priority if one wish to master the NRDs "true" intrinsic characteristics: addressing that priority is the second objective of QUIESST.

The main steps to achieve this objective are:

- to develop the new measurement method for sound absorption/reflection and airborne sound insulation of NRDs with regard to: choice of sound sources and signals, use of multiple sensors, signal analysis and the essential physical representativity (near field/far field, whatever the shape of the NRDs);
- to assess the uncertainty of this new method.

The verifiable result will be the new measurement method and its uncertainty (assessment of accuracy).

4 Comparison between the laboratory and the corresponding in-situ tests results of existing NRDs (WP4)

The European NRDs market offers many already approved products (often tested under different methods), while many new ones are appearing. However, even if the European product standard EN 14388 [1] is published since 2005, no comprehensive database of the NRDs acoustic performances does exist yet. Such a database would allow a fair comparison between products referring to common standards, and provide the stakeholders with relevant data in order to better use the existing NRDs.

On the other hand, facing the expected coexistence of laboratory and in-situ tests results, the stakeholders strongly need a working method in order to relate, if possible and relevant, the new in-situ test results to the existing laboratory results which have been used for years.
Addressing both needs, the third objective of QUIESST is to build a relevant database comparing the European NRD intrinsic performances according to the different test methods, and to establish the relationships between the different results.
The main steps to achieve this objective are:

- to collect and analyze laboratory and in-situ tests results concerning sound absorption and airborne sound insulation (according to EN 1793-1 [5] and 1793-2 [6], CEN/TS 1793-5 [7], and to the new method to be developed within this QUIESST research);
- to build a comprehensive database of test results, taking into account different European NRDs types;
- to establish the relationship between laboratory and in-situ measurements and to supply data for an easy comparison of the two methods in terms of applicability;
- to provide a guideline helping manufacturers and road administrations to assess NRDs performances and, thanks to the in-situ methods, to also fairly assess the lifetime acoustic behavior of products.

The verifiable results will be the European database of the NRDs acoustic performances, the effective relationship between laboratory and in-situ test results, and a guideline helping the stakeholders in their use and interpretation of the NRDs acoustic performance data.

5 The holistic approach of how to optimize the use of NRDs (WP5)

Whatever the numerous existing "comprehensive" guides about NRDs of these last 30 years, no one has yet included the holistic approach, i.e.: starting from the "true" intrinsic performances, considering the optimized combination of their acoustic characteristics and design shapes, considering the best situation in order not only to reduce noise, but also the amount of people exposed to noise, without forgetting the cost / benefit ratio and the sustainability...
QUIESST's fourth objective is to develop a comprehensive strategy on how to optimize NRDs within a true holistic approach: in order to do so, this part of the project will merge the results of the other parts (near / far field, "true" intrinsic performances, sustainability) together with all the other acoustic and non acoustic considerations at the widest possible scale (road / rail, close / far field, urban / rural configurations).
The main steps to achieve this objective are:

- to develop an optimization strategy adapted to typical road and railway traffic noise configurations where both urban and rural areas are addressed;
- to apply this methodology to intrinsic performances, considering NRDs shapes and surface impedances;
- to apply this methodology to extrinsic and holistic NRDs optimization, considering acoustic, non acoustic and environmental (site) parameters, building a database of results from these optimizations;
- to provide the expected global impact of optimized noise abatement solutions in terms of reduced number of exposed people in typical urban and rural situations;
- to draft a report merging all the results issued in the project and giving recommendations and guidelines through good practices.

The verifiable result will be a comprehensive reference guidebook about NRDs holistic optimization (referring to associated databases, simulation methods, and measurement and assessment methods).

6 Sustainability (WP6)

Sustainability is a brand new, but very important topic, it is also a too often neglected characteristic of NRDs.
Sustainability of surface transport is a key objective of the White Paper on European Transport Policy [8]: it includes not only the vehicles and their infrastructure but also the numerous adverse effects they can have on the environment, noise being a major one. One then clearly understands the high interest to master all the systems which are able to reduce the number of affected people.
Optimized and sustainable NRDs can play a very important part in this achievement towards a more sustainable ground transport. Furthermore, one also has to consider NRDs as an integral part of the whole transport system, and their sustainability is equally important.
At present, there is no method allowing the assessment of NRDs sustainability: QUIESST's fifth objective is to provide a relevant method for assessing the overall sustainability of ground transport noise reducing devices.
The main steps to achieve this objective are:

- to define the relevant generic sustainability criteria for NRDs:
  - sustainable design criteria, sustainable materials and their carbon footprint;
  - sustainable construction technology and practice and their carbon footprint;
  - sustainable maintenance; sustainable decommissioning;
  - future sustainable solutions...
- to research relevant methods for assessing the overall sustainability of NRD;
- to build a database of those generic relevant criteria and indicators for existing European NRD;
- to apply the method/s on existing NRD in order to compare and rank them from the point of view of their overall sustainability.

The verifiable result will be a report about NRDs sustainability (referring to relevant parameters and generic sustainability criteria and associated assessment method) which will be included in the QUIESST final report.

7 Dissemination (WP7)

All the research results will be delivered in the most efficient and effective way: dissemination is a major part of QUIESST project, as it ensures that the objectives and results of the projects are brought to the attention of targeted groups through appropriate dissemination channels. Without it, QUIESST results would remain unknown or reserved to a limited number of scholars whilst the objective is the QUIESST recommendations to be known (and adopted) by all stakeholders involved in Sustainable Surface Transport Systems.
The main steps to achieve this objective are:

- to exploit as much as possible the project's potential through a comprehensive review of previous and existing initiatives and potential target groups, as well as a continuous clustering effort with all interested parties;

- to ensure that the objectives and results of the project are brought to the attention of these groups through appropriate dissemination channels (web site, articles and trainings);
- to confront the QUIESST expectations and conclusions with the needs expressed by the end users through dedicated workshops and by participating in major European and international events dealing with noise issue.

8 Final remarks and perspectives

The objective of this paper is to inform the corresponding international experts about the QUIESST effective work programme. The research has started in October 2010 and its results are scheduled for September 2013.

The 6 important QUIESST deliverables will be:

- a validated engineering computation method for assessing the near field / far field relationship of NRDs effectiveness;
- a new measurement method for measuring the intrinsic "true" sound absorption and airborne sound insulation properties of NRDs: this method should be as close as possible ready for being translated into a (harmonized) EN standard;
- the first European database of the intrinsic acoustic properties of European manufactured NRDs, together with the established relationship between laboratory and in-situ test results;
- a comprehensive strategy on how to optimize NRDs within a true holistic approach that no other guideline has done up to now;
- the first study done yet about NRDs sustainability, referring to relevant parameters and generic sustainability criteria and an associated assessment method;
- all of those deliverables being combined in a comprehensive "Guidebook to NRDs optimization in a sustainable way", aiming to be the future reference tool for noise mitigation.

External international experts willing to exchange with the QUIESST team partners are strongly advised to visit the research website: www.quiesst.eu and to attend the corresponding workshops and dissemination congress: any support is of course welcome.

Acknowledgments

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