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Review of recent EU funded research projects from the perspective of urban sound planning: do the results cope with the needs of Europe's noise policy?

DOI 10.1515/noise-2016-0007
Received Oct 31, 2015; accepted Apr 12, 2016

Abstract: Noise pollution is one of the major environmental problems affecting European citizens in urban areas. Although the Environmental Noise Directive is in force since 2002, there is still a gap between defined objectives and outcomes. The EU Seventh Environment Action Programme attempts to achieve the reduction of noise pollution by means of more effective European noise policies. This must be coupled with providing assistance to local administrations on dealing with existing noise problems, for example through Urban Sound Planners.
The aim of this paper is to present the results of a systematic review of European projects addressing urban sound planning topics and furthermore an overview of the most relevant research results that can be applied by practitioners. In order to understand the European funding strategy, the most valued research topics (number of projects and funding support) are assessed. A key finding of this review is the disagreement between air traffic noise research funding and its importance on overall noise exposure. Another finding is that the scientific knowledge for urban sound planning exists but it requires adequately dissemination of results, among the policy makers and local authorities, who are usually responsible for policy implementation.

Keywords: Review EU projects; Urban sound planning; Environmental noise

1 Introduction

Environmental noise pollution is a major problem affecting European citizens, in particular those living in urban areas [1]. Due to the expected urbanisation growth this problem tends to aggravate. The European Union is well aware of it and in its Seventh Environment Action Programme (7^{th} EAP) [2] has set the objective to decrease noise pollution to levels close to the limits established in WHO guidelines [3, 4] ($L_{Aeq,\,16h} \leq 50$ dB and $L_{night,outside} \leq 40$ dB), by 2020. Above these limits adverse health effects can be observed. Achieving such a demanding target will require much more effective European noise policies. In force since 2002, the Environmental Noise Directive (END) [5] is still the main legislative tool. Despite a few achievements, there is still a long way to go in order to have a significant impact on environmental noise pollution [6]. The 7^{th} EAP requires an updated noise policy in order to achieve the noise reduction objectives by 2020. This should be aligned with actual urban planning and include the latest scientific knowledge to reduce noise at source. The inclusion of urban sound planning as part of the urban planning is therefore necessary.

The development of environmental policies is a complex problem as it demands the inclusion of different views: updated scientific knowledge, technical feasibility and attention to national/regional policies and socio-economic context. Effective communication at all levels is necessary and very often poor communication represents a major obstruction to the implementation of policies: on one hand, research results are often not successfully communicated, failing to reach policy makers and other stakeholders [7]; on the other hand, consultation of stakeholders is sometimes neglected by policy makers, resulting in inadequate legislation. Currently there is a big effort to design better EU environmental policies, in particular the END revision includes: an evaluation within the scope of the REFIT programme, the European Commission's Regu-

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latory Fitness and performance programme [8] and a revision of the END annexes (I, II and III), so that the latest scientific knowledge and research results are reflected by future guidelines [9].

Following the guidelines expressed in the 7th EAP on the inclusion of urban sound planning in the cities' planning processes and the evaluation and changing episode that the END is going through, it seems appropriate to conduct a review on the latest results for this topic.

EU funded research projects can have a significant contribution in the improvement of environmental noise policies, but can also help local administrations on dealing with existing noise problems, by supporting the implementation of urban sound plans. In some cases, research projects' outcomes might be considered cutting edge knowledge and, in this sense, support a new approach to urban sound planning and even provide data that contributes to revise environmental acoustic policies. Thus, this paper presents the results of a systematic review of EU funded research addressing urban sound planning topics. It includes an assessment of the major EU research funding programmes, an evaluation of the most funded topics within the scope of urban sound planning and also an evaluation of the project's results availability. Additionally, a toolbox with the most relevant results for urban sound planning is described and might support practitioners, public officers and policy makers on the process of including urban sound planning in the overall city plan processes.

2 Methods

2.1 Search strategy

A review of EU-funded research projects was conducted and is reported according to the flow diagram proposed by PRISMA [10] and the MOOSE guidelines [11].

The main EU research and technology funding programme was the "Framework Programme for Research and Technological Development" (FP) which was used to support and promote research and technological development according to the several FP themes and following different technical calls. The most recent version of the FP programme is "Horizon 2020" which aims in particular to foster innovation, sustainable and inclusive growth, focused on providing solutions for end users [12]. The other relevant funding programme, LIFE, is more focused on the improvement and implementation of environmental policies and legislation that are not included in other EU funding schemes. Both the FP and LIFE programmes provided financial support for all the projects mentioned in this review.

The CORDIS database (cordis.europa.eu) (Community Research and Development Information Service) is the primary public repository to disseminate information on EU-funded research projects, including information about framework programmes (FP5, FP6 and FP7), Horizon2020 and other previous or specific programmes since 1990. Although this database includes projects since 1990 it was decided to consider only the most recent (since 2000) as the purpose of this research was to obtain results on the latest scientific knowledge. Also, it is expected that research results from previous projects were already included in more recent projects.

The LIFE database (http://ec.europa.eu/environment/life/project/Projects/index.cfm) is part of the programme's website (http://ec.europa.eu/environment/life/funding/lifeplus.htm) and can be found under sections "LIFE search" and "Project database".

This review reflects the search conducted until the 14th of September of 2015. More recent projects or results published later than that were not included.

2.1.1 Search in the CORDIS database

The CORDIS database search tool requires that the user predefines a keyword strategy. Thus, for the purpose of this research and as the scope of urban sound planning is very wide, a multiple level structure was followed as identified in Table 1. Each keyword was used with the "Free-text" tool under "Projects and Results" section.

The authors discussed if more general topics like for example "urban planning", should also be considered, however it was decided that this would widen the scope of this review in such a way that it would be difficult to retrieve the most relevant outcomes to urban sound planning. Moreover, using the selected keywords, all the projects related with urban sound planning would be retrieved.

2.1.2 Search in the LIFE database

The LIFE database has its own search tool that is based on the application of pre-defined filters. It allows choosing a strand of filters, including: "Year range", "Country", "Themes", "Keywords" (among pre-defined keywords), "Beneficiary" and "Free text". It was decided to use the filter "Themes", by selecting theme "Air and Noise" and sub-

Table 1: Multilevel search structure.

1st level: General topic	2nd level: Noise sources	3rd level: Tools
Acoustic*	Aeroacoustic*	Acoustic Auralisation
Environmental Acoustic	Aircraft noise	Noise Map
Environmental Noise	Air traffic noise	Soundscape
Noise	Aviation noise	
	Railway traffic noise	
	Road traffic noise	
	Tyre noise	

Note: * indicates truncation

theme "Noise Pollution" as it was the most straightforward filter to the aim of this review.

2.1.3 Exclusion and eligibility criteria

Within the CORDIS database, each keyword was considered individually and the results were listed in an Excel sheet. In the LIFE database all the retrieved results were assessed for eligibility as it was considered that the application of pre-defined filters would correspond to the first screening phase.

The screening was conducted by two authors independently, based on the pre-defined criteria.

At the first screening stage (title and project summary screening), two criteria were applied:

(i) Admission if the project's title and summary were within the scope of urban sound planning;
(ii) Admission if the project's start date was after 01-01-2000;

In order to obtain an agreement on the meaning of the first criterion, 30 results were assessed by the two reviewers simultaneously. After the first selection stage, eventual disagreements were solved by the inclusion of the project for the next screening phase.

Duplicate results retrieved by keywords search within the CORDIS database were excluded. There were no duplicate results from the LIFE database search or between the funding programmes.

After the first screening stage, the projects selected for eligibility were listed, together with the following information: acronym of the project, start and end date, complete name of the project, programme and call, research topic, website link (when available), "Included" (check-box) or "Excluded" (check-box) and when applicable, motive of exclusion and other observations.

The projects selected from the first stage were then screened for eligibility, according to the following criteria:

(a) Admission if results are published and available, either in the form of a website, project´s deliverables or as a comprehensive final report. If research results were not available on the project´s website, other sources were consulted:
    - X3-Noise network (http://www.xnoise.eu/home) – this network coordinates research activities and seeks to disseminate research results in the area of aeroacoustics;
    - Transport research & innovation portal (http://www.transport-research.info/web/index.cfm) – this portal gives an overview of research results on transport related projects;
    - OpenAIRE portal (https://www.openaire.eu) – it is a portal where European funded research outputs can be shared. Research results from FP7 and Horizon2020 projects are largely publish here;
    - Zenodo database (https://zenodo.org) – it is a database where European funded research outputs can be shared;
(b) Exclusion if relevant outcomes are not published in English;
(c) Exclusion if the project's topic was too specific and would not have a direct application for this review or sound was used as a tool only;

In order to clarify criterion c., two projects can be used as an example: the SAFTINSPECT project (Ultrasonic synthetic aperture focusing technique for inspection of railway crossings (FROGS)), would be excluded because the project's topic was too specific and would not have an application for this review; and the SAFE-AIRPORT (Development of an innovative acoustic system for the improvement of co-operative air traffic management), would also be excluded because from the project's result's it is con-

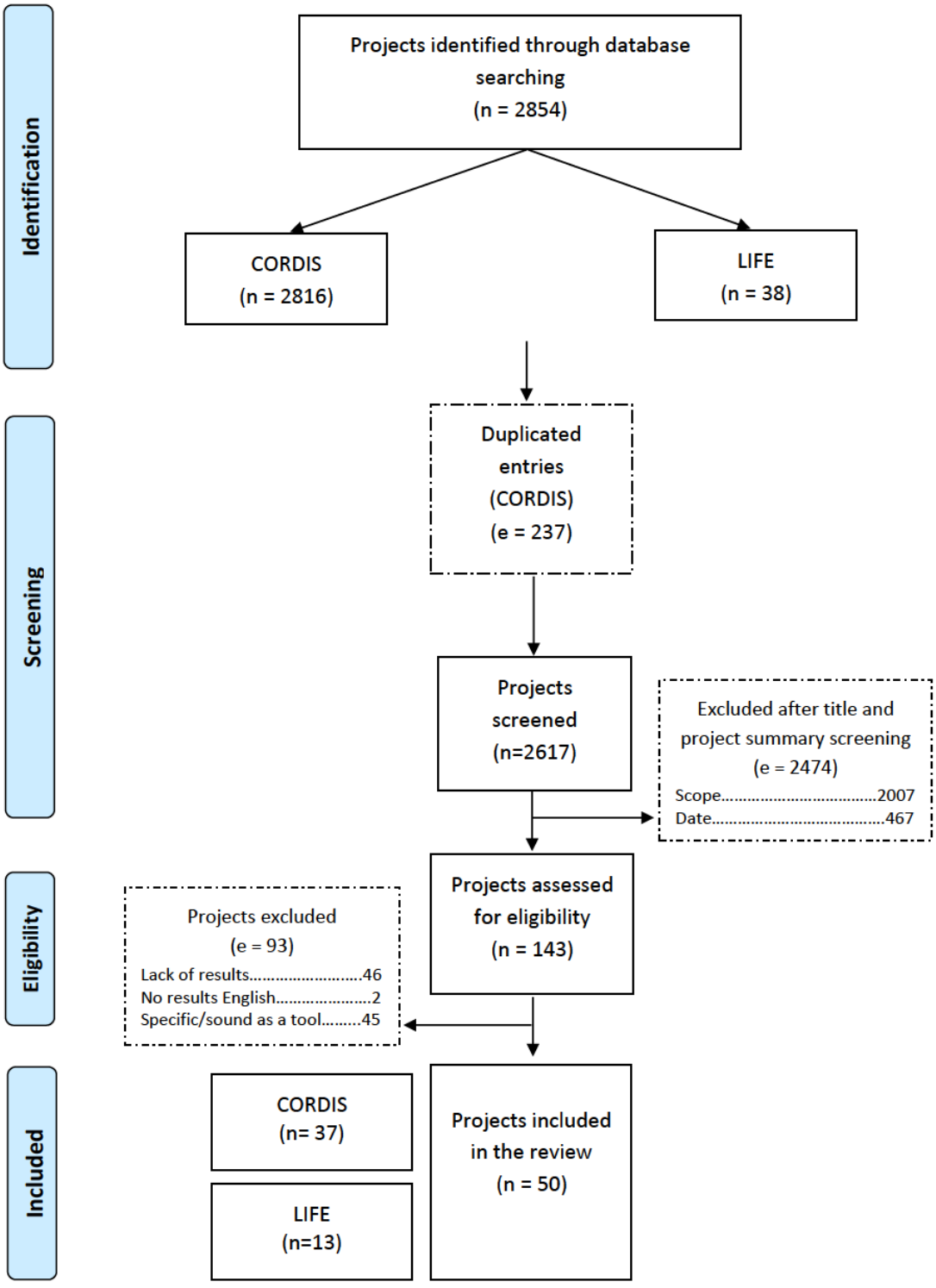

Figure 1: Flow diagram of EU projects' screening.

cluded that sound was used only as a tool to find and track aircrafts. This system could later be integrated with an airport's traffic management procedure.

The flow diagram of the projects' screening is presented in Figure 1.

2.2 Results analysis

In order to have an overview on EU funded research within the urban sound planning topics, we conducted an analysis of the projects that were assessed for eligibility: a frequency distribution and an economic distribution.

The review process identified that most projects focused on only one urban noise source, in particular, or on environmental noise as a whole. Thus, from the perspective of urban sound planning four main research categories were considered: road traffic noise, railway traffic noise and air traffic noise, and a fourth category, environmental acoustics. The last category included the projects researching simultaneously the different urban noise sources, as well as the ones that: investigated sound propagation methods in urban environment, created acoustic auralisation tools, developed new approaches to noise maps and action plans, investigated urban soundscape and its impact to improve the urban sound environment, studied the environmental noise impacts on health and also those that developed new urban planning policies. Although there might be a tendency to locate airports away from urban environments, air traffic noise still affects many cities and its impact must be considered in the general urban sound planning.

The frequency distribution was analysed, both in terms of number of projects funded and economic support from the EU. The most frequent reasons for exclusion after second screening stage were also analysed. An overview of the selected projects for each of the funding programmes concludes this analysis.

3 Results

The results of this review are presented in two sections: the first presents an overview of the main research funding programmes within the EU: the FP and the LIFE programme; the second presents an overview of relevant results for urban sound planning.

3.1 Overview of research funding programmes within the EU

3.1.1 Frequency distribution analysis

The analysis of the projects assessed for eligibility (n = 143), reveals that 85% of the projects were supported by the FP and 15% were supported by the LIFE programme.

	FP		LIFE	
Environmental acoustics	33	27%	18	86%
Road traffic noise	20	16%	2	10%
Railway traffic noise	10	8%	1	5%
Air traffic noise	59	48%	0	0%
Total	122		21	
	85%		15%	

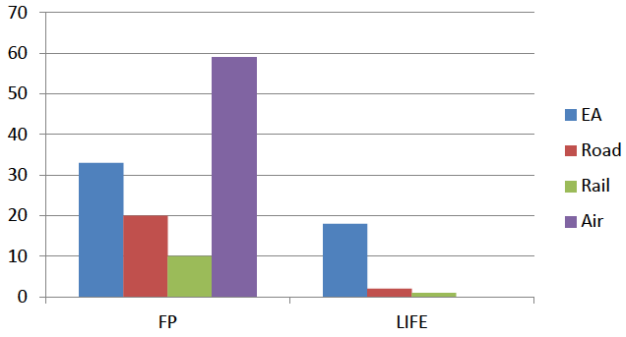

Figure 2: Distribution of research topic within financing programmes (number of projects).

Figure 2 shows that within the FP, air traffic noise was the most funded topic, representing 48% of the selected projects with 59 supported projects. Research in railway traffic noise was the least supported topic, with 10 projects, representing only 8% of the selected projects. Within the LIFE programme, 18 projects, representing 86% were under the general topic "Environmental Acoustics", while no specific project on air traffic noise research was supported.

3.1.2 Financial distribution analysis

As previously stated, an analysis of the EU funding according to research topic was also performed; Table 2 reinforces the fact that, within FP, the air noise topic was the most funded topic, with 67% of the funding, while railway was the least funded topic with 8%. While within the LIFE programme the most funded topic remains the environmental acoustics and no funding was assigned to air traffic noise.

3.1.3 Exclusion process analysis

Following the application of the second stage selection process, 93 projects were excluded. The reason for the projects' exclusion was then investigated and the results are presented in Table 3.

Table 2: EU funding distribution and average of funding per project, according to research topics and programmes (in millions €).

	FP		Avg. of funding/ project	LIFE		Avg. of funding/ project
Environmental acoustics	73.5	15%	2.2	15.2	87%	0.8
Road traffic noise	51.0	10%	2.6	1.6	10%	0.8
Railway traffic noise	37.9	8%	3.8	0.6	4%	0.6
Air traffic noise	326.9	67%	5.5	0.0	0%	0,0
Total (millions €)	489.5			17.6		

Table 3: Criterion for project exclusion (at second stage).

	FP	LIFE	Total
Results not available	41	5	46
Research results too specific	44	1	45
Results not published in English	0	2	2
Total	85	8	93

From Table 3 it is observable that the non-availability of results is one of the main reasons for not selecting a project. It is also clear that most projects published the results in English.

3.1.4 Overview of selected projects

After the application of the eligibility criteria, 50 projects were selected to undergo an outcome's assessment: 37 projects from FP and 13 projects from LIFE.

In order to check if the category distribution was maintained after the selection process, we analysed the projects included in the review. The results can be seen in Table 4. From Figure 3, it is clear that, after the selection, within the FP the distribution is very different, while for the LIFE programme there is not such a relevant change.

For the FP the major difference is on the eligibility of air traffic noise projects (as only 5 projects met the criteria) and of road traffic noise projects (as less than half met the criteria).

The list of selected projects, as well as some information about projects and the financing programmes is presented in Table 5. This list is complemented with a summary of each of the selected projects in Appendix 1.

It was intention of this review to provide the most up to date overview on European research projects, therefore even the most recent projects were considered. Nevertheless, at the second selection stage, projects' starting after January 2015, were excluded due to the lack of published results. For future reference, as the outcomes of such projects might be relevant for the topic, the authors decided to mention the projects excluded under such circumstances: MUSAL (Multi-scale modelling of waves of porous media with applications to acoustic control and biomechanics) one of the objectives of this project is to improve methods for better noise control; EVERYSOUND (Computational analysis of everyday soundscapes) which is developing computational models that will recognize automatically sound sources in realistic soundscapes; Rool2Rail (New dependable rolling stock for a more sustainable, intelligent and comfortable rail transport in Europe) they expect among others to have an impact on reducing noise emission from rolling stocks and more efficient power electronics that will reduce fan noise.

Table 4: Distribution of projects included in the review.

	FP		LIFE	
Environmental acoustics	17	46%	11	85%
Road traffic noise	9	24%	2	15%
Railway traffic noise	6	16%	0	0%
Air traffic noise	5	14%	0	0%
Total	37		13	

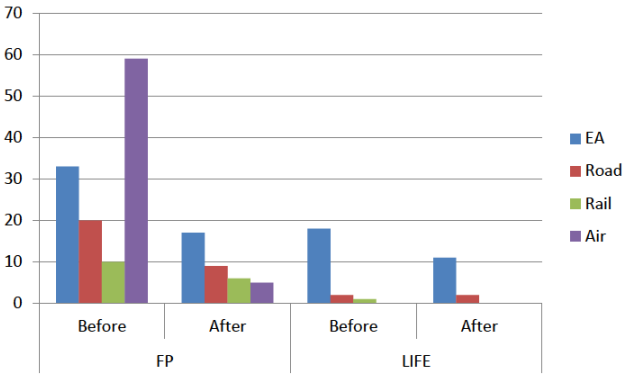

Figure 3: Comparison of projects, according to research topic, before and after the selection process.

Table 5: List of the projects selected for a results' screening.

	Project Acronym	Start Date	End Date	Financing Programme and call	Project Website
FP	ACOUTRAIN	01.10.2011	31.12.2014	FP7-TRANSPORT	www.acoutrain.eu/
	CALM II	01.11.2004	31.10.2007	FP6-SUSTDEV	No website available*
	CARGOVIBES[1]	01.04.2011	31.03.2014	FP7-TRANSPORT	www.cargovibes.eu/Home
	CITYHUSH	01.01.2010	31.12.2012	FP7-TRANSPORT	www.cityhush.eu/
	CO2NTROL	01.09.2009	31.12.2012	FP7-TRANSPORT	www.fp7-co2ntrol.eu
	CORRUGATION	01.06.2002	30.09.2006	FP5-GROWTH	www.corrugation.eu/
	COSMA	01.06.2009	31.03.2016	FP7-TRANSPORT	fp7-cosma.eu/
	EAR-IT	01.10.2012	30.09.2014	FP7-ICT	www.ear-it.eu/
	ECOQUEST	01.12.2009	31.05.2013	FP7-TRANSPORT	No website available*
	ENNAH	01.09.2009	31.01.2012	FP7-ENVIRONMENT	www.ennah.eu/
	EVADER	01.10.2011	31.12.2014	FP7-TRANSPORT	No website available*
	GREENSCOM	01.04.2000	31.12.2003	FP5-EESD	www.mrfood2012.com
	HARMONOISE	01.08.2001	31.07.2004	FP5-IST	No website available*
	HEARTS	01.09.2002	31.08.2005	FP5-LIFE QUALITY	No website available*
	HOSANNA	01.11.2009	30.04.2013	FP7-TRANSPORT	www.greener-cities.eu/
	IMAGINE	01.12.2003	30.11.2006	FP6-POLICIES	No website available*
	INMAR	05.01.2004	14.01.2008	FP6-NMP	www.inmar.info/
	INQUEST	01.06.2006	31.05.2008	FP6-SUSTDEV	www.fehrl.org/?m=89
	ITARI	01.02.2004	31.05.2007	FP6-SUSTDEV	No website available*
	MyWay	01.09.2013	29.02.2016	FP7-ICT	myway-project.eu/
	OPENPSTD	01.09.2012	31.08.2016	FP7-PEOPLE	www.openpstd.org/
	PERSUADE	01.09.2009	31.08.2015	FP7-TRANSPORT	persuade.fehrl.org/
	PROMPT	01.03.2000	31.12.2003	FP5-EESD	prompt.vtt.fi/
	Qcity	01.02.2005	31.01.2009	FP6-SUSTDEV	www.qcity.org/
	QUIESST	01.11.2009	31.12.2012	FP7-TRANSPORT	www.quiesst.eu/
	QUIET-TRACK	01.06.2013	31.05.2016	FP7-TRANSPORT	www.quiet-track.eu/
	RUROS	01.01.2011	31.01.2004	FP5-IST	alpha.cres.gr/ruros/
	SILENCE	01.02.2005	31.05.2008	FP6-SUSTDEV	www.silence-ip.org/
	SILVIA	01.09.2002	31.08.2005	FP5-GROWTH	No website available*
	SONORUS	01.10.2012	30.10.2016	FP7-PEOPLE	www.fp7sonorus.eu/
	SOUNDTRACK	05.03.2013	04.03.2015	FP7-PEOPLE	folk.ntnu.no/meritxef/Objectives_ST.html
	SPURT	01.12.2003	31.05.2007	FP6-SUSTDEV	No website available*
	STAIRRS	01.01.2000	31.12.2002	FP5-GROWTH	www.stairrs.org

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Table 5: ... continued

	Project Acronym	Start Date	End Date	Financing Programme and call	Project Website
	SUPERPANELS	01.08.2010	31.07.2013	FP7-PEOPLE	www.superpanels.unina.it/
	TEAM_PLAY	01.12.2010	31.03.2013	FP7-TRANSPORT	www.teamplay-project.eu/
	TWO!EARS	01.12.2013	30.11.2016	FP7-ICT	twoears.aipa.tu-berlin.de/
	VALIANT	01.09.2009	31.05.2013	FP7-TRANSPORT	No website available*
LIFE	CEDM	01.11.2005	30.04.2008	LIFE05 ENV	www.life-cedm.info
	DECIBELL	05.01.2009	14.12.2012	LIFE07 ENV	www.decibell-faiveley.eu/en/Project
	DYNAMAP	01.07.2014	30.06.2019	LIFE13 ENV	www.life-dynamap.eu/
	HARMONICA	01.10.2011	31.12.2014	LIFE10 ENV	www.noiseineu.eu/
	HUSH	01.01.2010	30.06.2013	LIFE08 ENV	www.hush-project.eu/
	NADIA	01.10.2010	01.10.2014	LIFE09 ENV	www.nadia-noise.eu/
	NoMePorts	01.03.2005	31.08.2008	LIFE05 ENV	No website available*
	P.A.A.S.A	01.01.2010	30.08.2012	LIFE08 ENV	medioambiente.cuenca.es/portal/lang__es-ES/tabid__10554/defa%20ult.aspx
	QSIDE	01.09.2010	31.08.2013	LIFE09 ENV	www.qside.eu/
	QUADMAP	01.09.2011	31.03.2015	LIFE10 ENV	www.quadmap.eu/
	Solar Highways	01.06.2014	30.06.2020	LIFE13 ENV	solarhighways.eu/
	SPAS	01.10.2006	31.12.2009	LIFE06 ENV	www.life-spas.at/
	UNISASH	01.04.2009	30.06.2011	LIFE07 ENV	unisash.eu/en/

[1]This project deals with vibration induced noise and the outcomes include mitigation measures to reduce it.

*When results were not available on the project's webpage, they were retrieved through the sources mentioned in Methods section.

Concluded

3.2 Overview of relevant outcomes for urban planning

This review also aimed to present the most relevant research outcomes in particular the sound planning tools that can be applied by urban sound planners. The need for the inclusion of urban sound planning within the cities' planning processes was previously demonstrated as well as the need for new tools. The outcomes review was not a systematic process, and it was assessed from the perspective of a future practical implementation to improve urban sound planning processes, nevertheless the projects outcomes are obviously more extensive.

To facilitate the process of reporting, the outcomes were classified according to their general application such as: noise prediction tools, design of noise control solutions and planning solutions.

3.2.1 Noise prediction tools

This category includes a variety of solutions that can be used to predict noise such as: auralisation software, propagation methods or noise perception tools.

– **Auralisation /prediction tools:**

Developing an auralisation tool was one of the tasks in the **HOSANNA** project. This tool was mainly used to assess the efficiency of noise abatement measures. The report [13] presents a detailed description of the auralisation process, from the algorithm architecture to the application in selected test cases. Also, the **ACOUTRAIN** project developed an auralisation tool to test and demonstrate the virtual certification procedure of TSI (Technical Specification for Interoperability) implemented for rolling noise. The benefit of using this virtual technique was also tested to work with the **CNOSSOS** (Common Noise Assessment methods in Europe) propagation model [14], obtaining good results [15]. Although this tool is currently not available to the public, it is expected that it will be in the future. The methodology developed for virtual certification corresponding to TSI Noise, is well documented on the deliverables of the project and can be consulted for the time being [16–18].

Another prediction tool is being developed within the **Open-PSTD** project. A 2D-version of Open-PSTD software is already available for download from the website (www.openpstd.org). This software enables to compute sound propagation in the urban environment, for research purposes. It is expected that future versions of the software will include a 3D implementation.

The predict effect of greenery solutions and recycled materials as noise abatement measures was investigated in **HOSANNA**. Some examples include: simulation tools to test the noise reduction effect of applying vegetated façades, green low barriers and green roofs [19]; new propagation models to assess the effects of vegetation, crops and shrubs [20] or the influence of meteorological conditions on the performance of noise abatement actions [21].

In the **CityHush** project, a refined method for predicting annoyance from traffic noise in residents is described in the report [22]. An application of this tool to real test cases can be found in [23] along with its integration in a noise mapping software.

– **Propagation models:**

Both the **HARMONOISE** and **IMAGINE** projects developed extensive propagation methods and mapping methods that include road, railway, aircraft and industrial sources as well as other database sound sources that can be used with other model. The tools and models developed within these projects gave very important contributions to more advanced propagation models, as the recently adopted **CNOSSOS** models [14].

– **Noise perception tools:**

A computational framework for modelling active exploratory listening that assigns meaning to auditory scenes was developed in the **Two!Ears** project. In [24] the main components of the project are described. In particular for urban sound planning applications, a database of binaural recordings of acoustic environmental scenes will be available. The main software, models and a database from psychoacoustic experiments and acoustic measurements can be downloaded from the project's website (twoears.aipa.tu-berlin.de).

The **EVADER** project intended to provide innovative methods to improve the acoustic detectability of electric vehicles, especially in urban environments. In urban environments, where the speed limit is set between 30 km/h and 50 km/h, engine noise is frequently the dominant noise source. However in electrical (and hybrid) vehicles, there is no engine noise (in electrical mode), which might be a hazard for pedestrian's safety. This project studied the soundscape of this category of vehicles and proposed models to improve the detectability of such vehicles [25].

3.2.2 Design of noise control solutions

The results and tools described in this section will be grouped according to the addressed noise source: road

traffic noise, railway traffic noise, air traffic noise and general tools that can be applied independently of the noise source or to different noise sources.

– **Road traffic noise:**

Reducing the annoyance and pollution caused by freight distribution within the urban environments was the aim of the **CEDM** project. The consortium included municipalities, logistic companies and governmental institutions. On their website (www.life-cedm.info), several strategies are described which can help municipalities to optimize their logistics' solutions.

An effective noise reduction can be achieved in urban environments, by replacing normal road surfaces with low noise road surfaces. Although this action is often mentioned as a noise abatement measure, some of the EU projects are dedicated exclusively to this topic. The **PERSUADE** is one of the most recent projects on research related to low noise road asphalt, in particular the poroelastic road surfacing (PERS). They developed and tested both in laboratory and in situ different combinations of PERS. Results are presented on their website (persuade.fehrl.org).

A guidance manual for the implementation of low noise road surface [29] is one of the main outcomes of the **SILVIA** project. Here, advices on low-noise surfaces, integration with other noise abatement measures and cost-benefit analysis are described. This manual was widely disseminated by **INQUEST** project (www.fehrl.org/?m=89), which was responsible for organizing several workshops in different European cities.

One of the most recent projects, **Solar Highways** is investigating an innovative and sustainable noise barrier that will also generate energy (www.solarhighways.eu).

– **Railway noise:**

Within the **CALM II** project, the II Strategic Paper [26] identified key-research topics that could contribute to a potential reduction of the railway noise: rolling noise (retrofitting of cast iron block brakes, implementation of K blocks), special rail grinding technologies, maintenance technologies, quieter wheels and tracks, modelling and validation of curve squeal); brake noise (control of brake screech); traction equipment noise (quieter diesel engines and cooling fans); and aerodynamic noise.

The **CargoVibes** project main research topic was the assessment of acceptable vibration levels for people living in the vicinity of railway lines and their attenuation. The main deliverables of the project include: a guide for the evaluation of vibrations in humans; a protocol for the assessment of mitigation measures; new mitigation measures for rolling stock maintenance, for the track infrastructure and for the propagation path (concerning vibrations); and mitigation performance data sheets for vibrations from freight trains. Innovative solutions to mitigate vibrations, especially from freight trains, are examples of the tools provided by this project [27].

Quiet-track is an on-going project that is investigating noise mitigation solutions that can be applied in urban environments. It is expected that innovative and effective solutions will be delivered concerning noise mitigation: development of new track solutions by reducing the rail roughness and also a combination of noise and vibration mitigation or the development and implementation of track maintenance programmes. In the meantime, a comprehensive report describing a procedure to select the combination of solutions for optimal noise performance [28] is already available to be used by possible stakeholders, including urban planners.

– **Air traffic noise:**

Within the **COSMA** project the aim was to develop new criteria for aircraft design and operations in order to reduce the annoyance within airport communities. Various tools were developed: perception and annoyance models, a "virtual resident" tool, to simulate the human subjective perception of aircraft noise. Findings suggest that in terms of annoyance around airports the current exposure-response curve can be replaced [30].

– **General design tools:**

A collection of noise abatement solutions can be very helpful when designing the best approach for an existing or potential acoustic problem. Several projects present such tools: either as a starting point to support research carried out within the project (usually a state-of-the art review) or as a research outcome. In the following paragraphs a few examples are summarised. A guidebook to noise reducing devices [31] was published by the **QUIESST** project, where several examples of noise reduction devices (NRD) are presented. In particular these are noise barriers, sound absorptive claddings, covers and "added advices". One of the **HUSH** project's outcomes is a collection of cases for reducing noise in urban environments [32]. This collection includes the description of a test case, the advantages and disadvantages of its implementation and cost of each of the identified actions. In the **HOSANNA** project a database of green noise mitigation measures with implemented solutions and results of on-site measurements is presented in [33]. This database can be used together with other green solutions as for example: vegetation in low profile barriers (to be used mainly in urban environments), or as

a layer applied on roofs or façades [20], ground treatments including adding artificial roughness elements [21, 34], or the application of Helmholtz resonators as road surface resonators [35]. Also the **HARMONICA** project presents a list of initiatives to prevent or reduce noise, including the following categories: "road traffic noise", "rail traffic noise", "aircraft noise", "noise from activities", "recreational noise", "quiet areas", "town planning and development" and "prevention" [36].

A design of noise abatement tools can be found in the **Qcity** project as the work-package 2.3 was dedicated to the evaluation of noise mitigation measures [37–45]. Besides providing examples of possible noise mitigation tools it also informs about potential impacts of each solution implementation.

3.2.3 Planning solutions

The planning solutions described in this section will be grouped according to the following categories: prioritisation indices, innovative noise maps, creation and protection of quiet areas, cost-benefit assessment and manuals or guidance documents.

– **Prioritisation indices:**

Action plans, as referred in the END [5] are part of member states obligations; however, the END does not establish strict guidelines regarding the identification of critical areas. Generally, these areas are affected by noise from road, railway, air and/or industry. The noise impact varies due to different factors and therefore it is necessary to identify those factors, evaluate the impact and prioritise the most affected areas, integrating the solutions in a more general urban planning project. Several projects investigated and presented different solutions: a priority index, an algorithm, a score or a prioritization matrix. Some of these solutions will be described in the following paragraphs, but a more extensive approach of this topic can be found in [46]. The **Qcity** project proposes a noise scoring tool based on noise levels at the most exposed façade and number of residents in each dwelling. An exponential relation between these two parameters will result in a Noise Score for each building [47]. Another rating system suggested in [48] evaluates annoyance due to different noise sources, sleep disturbance, the number of individuals with unacceptable noise exposure (hot-spots) and also the percentage of non-quiet areas and it prioritises actions according to the results of the assessment. Ranking of noise annoyance based on perception was also applied in the **Qcity** project and the results are described in deliverable [49]. Also the **HARMONICA** project developed a new index to facilitate the understanding by non-experts that includes an "energy-based" and an "event-based" component, and also integrates the background noise component. Altogether they form a new indicator to describe the characteristics of sound over a period of time. To support the dissemination of this index, a software tool was developed – Toots – which automatically calculates the index and is freely available for download from the **HARMONICA** website (www.noiseineu.eu). The use of this tool in combination with the initiatives shared by other stakeholders can support the planning process, by providing examples of actions and results.

Evaluation and ranking of noise abatement solutions can also be a helpful planning tool. Several projects approached this topic and some helpful outcomes can be found in: the **Qcity** project [50] which presents and compares several scenarios, considers an evaluation methodology in terms of noise reduction, cost, level of acceptance, and site limitations. This tool can be applied to planning activities.

– **Innovative noise maps:**

If the expectations of the recent project **Dynamap** are fulfilled at the end of the project a new planning tool will be available: real time updated noise maps that can be integrated with other intelligent transport systems (ITS). This will allow the implementation of immediate noise abatement actions by acting on the traffic (*e.g.* such as speed limit reduction) but also to have a reliable estimate of the traffic and its environmental impact [58].

Another noise mapping approach was followed within the **SONORUS** project with the development of a dynamic noise mapping tool. A real test case was presented in [59] and demonstrates how this tool can support the improvement of acoustic quality. Within this project a new technique is also being assessed, integrating soundscape features into the traditional noise mapping, resulting in a sound map [60].

– **Creation and protection of quiet areas:**

In 2002, the **END** [5] introduced the concept to protect "quiet areas in agglomerations" (article 8b) however the END does not present a strict definition for it. Since then, this topic has been investigated by different projects and a few planning tools are now available to identify and protect such areas. One example is the **CityHush** project where Q-zone was defined as being "an area where low level traffic noise is maintained by allowing only low noise vehicles to enter" [61]. The impact of implementation of Q-zones was simulated for five cities (Bratislava, Bristol, Es-

sen, Gothenburg and Stockholm). With these simulations it was sought to identify the characteristics that such areas should have in terms of dimension, expected noise levels, network road/rail impact. The **QSIDE** project developed an engineering noise calculation method for courtyards. It also established a definition for quiet areas, based on the experience of several European cities, as an area where the sound pressure level is not higher than the surrounding areas; the L_{day} value preferably does not exceed 45 dB (central part) and certainly does not exceed 55 dB. According to the purpose of the area, other limits can be considered [62].

– **Cost-Benefit Assessment (CBA):**

The cost-benefit assessment can facilitate the planning process as it evaluates the potential benefits versus costs of noise mitigation tools. This topic was part of the workpackages of several research projects, thus a few tools are available. An example is the **HOSANNA** project OPENCBA tool. The methodology is described in [63]. A few applications of this tool to evaluate green noise abatement measures are reported in [64]. Within the **City Hush** project, a CBA was also performed to evaluate the creation of Q-zones, in some test-sites. Another methodology is described and explained in the **SILVIA** manual [29]. The CBA tool is provided as a spreadsheet where the costs and benefits of low noise road surfaces are assessed. This spreadsheet is provided in a CD together with the manual. All these tools are specific for the environmental noise topic and based on the HEATCO methodology, considered to be the reference methodology for CBA, developed within the **HEATCO** project (Developing Harmonised European Approaches for Transport Costing and Project Assessment) [65].

– **Manuals or guidance documents:**

Manuals or guide books are excellent tools that can assist public officers, urban planners or others involved with implementing noise action plans. Often they include strategies, templates, case studies, which can be great tools and facilitate the planning process. A few examples of manuals covering topics as broad as noise reduction actions, acoustic planning policies or means to promote pedestrian traffic, are: **SILENCE** practitioners handbook [51]; **RUROS** designing of urban spaces manual [52]; **SILVIA** guidance manual on low noise road surfaces [29]; **NoMePorts** manual that includes urban sound planning suggestions which can be applied to road and rail traffic outside ports [53]; **PROMPT** manual on optimising pedestrian traffic [54]; **HEARTS** manual where an integrated methodology to assess health risks and effects of road traffic is demonstrated [55] and **HOSANNA** brochure that present novel solutions for quieter and greener cities [56].

The **NADIA** project outcomes are a good practical example of how to implement noise maps and noise action plans [57]. Finally, in this category, not only manuals but also interactive tools are good examples of urban planning tools: the tool-kit produced by the **GREENSCOM** project (www.mrfood2012.com), includes fourteen cases on how to balance the use of green areas in urban environments.

4 Discussion and conclusions

4.1 European research funding strategy

This review aims at understanding the European research funding strategy and to assess it with respect to its results and their implication. It is clear that the FP is a bigger financial instrument than the LIFE programme. Our review has concluded that among the projects assessed for eligibility, 85% were funded by FP and 15% by LIFE. A closer look reveals that LIFE supported more environmental acoustics projects, which is aligned with the programme's aim; whilst the FP supported more projects on the air traffic noise topic, followed by the more general environmental acoustics topic. It can also be noted that within FP, the distribution of number of projects according to noise source shows that 48% projects dealt with air noise research related, 16% with road traffic noise and 8% with railway noise; whilst the funding resulted in a different distribution with 67% for the air noise research, 10% for road traffic noise and 8% for the railway research projects. It is evident that the air traffic noise research besides having a greater number of projects also received more funding. This fact cannot be justified from the perspective of noise source relevance, as the most recently published statistics [6] identifies road traffic noise as the environmental noise source that affects more people in urban areas. It estimates that more than 125 million people are exposed to road traffic noise levels above 55 dB L_{den}. According to the same document, 8 million people are estimated to be exposed to railway noise affects and less than 3 million people are estimated to be exposed to air traffic noise. Nevertheless, the successful strategy of aeronautic industry could be explained by:

- **Better coordination of efforts:** research advisory councils were created for Road (European Road Transport Research Advisory Council- ERTRAC-www.ertrac.org), Rail (European Rail Research Advisory Council – ERRAC – www.errac.org/) and

Aeronautic industry (Advisory Council for Aeronautics Research in Europe – ACARE – www.acare4europe.com), with the intention to support the European research and innovation of transportation industries in general. Aeronautical industry, besides playing an important role within the European industry it also puts a lot of effort on noise reduction research with the ACARE coordination. The two ACARE Strategic Research Agendas (SRA1 and SRA2) [66, 67] include the goal to research aviation environmental issues, including noise reduction. To strengthen this goal, the ACARE vision for 2020 also included as targets the reduction of aircraft noise by 10 dB and reduction of airport noise issues. Additionally, the X-Noise collaborative network had a fundamental role to lead research strategies in the noise topic (http://www.xnoise.eu/home) and coordinated a technical strategy that resulted in the approval of several projects for different calls. Comparable efforts for noise reduction of the Road and Rail advisory councils could not be identified. Last but not least, in order to reduce e.g. road traffic noise, different industries must be involved (car industry, tyre industry and road construction "industry") whilst the reduction of air traffic noise is mostly dependent on the reduction of aircraft noise.

- **Public support to reduce noise from aircrafts:** recent studies show that air traffic noise exposure might almost double the number of related hypertension cases at the same noise exposure from road traffic noise [68]. Nevertheless other health effects are also associated with the exposure to air traffic noise, such as annoyance, mental health, sleep disturbance and cognitive development particularly in children, making the reduction of air traffic noise, in situations of higher exposure, a higher priority.

It is clear from Table 4 that most of the air traffic noise related projects were largely excluded, after the second selection stage, because of the lack of published results but also because these projects focused on a very specific and complex problem. While the reduction of airplane engine noise or turbo fans noise might have a future impact on air traffic noise reduction, it would not have any immediate application for urban sound planning.

Finally, the time distribution of the projects shows that the vast majority ran between periods of 2003-2006 and 2010-2014 [Appendix 2], which shows agreement with the running periods of FP6 and FP7. Eight of the selected project will continue in the year 2016: six projects within the FP programme and two within the LIFE programme. The most recent project considered in the review started in second semester of 2014 (LIFE project: SolarHighways).

4.2 Relevant outcomes for urban sound planning

It was found that the outcomes for urban sound planning from EU- funded projects are extensive and many tools and other relevant information is available and can be used by local planners to improve their approach to urban sound planning. Nevertheless this does not seem to be happening. As reported in the EAA report [6], the second round of noise mapping, due on December 2012 had a lower completeness level than the first round, only 63% (at country level) against 90% on the first round. (A complete overview on the EU noise mapping process can be found in [69]). Although some reasons can be identified to explain this situation (financial crises in EU, lack of harmonisation on noise mapping and action planning within the European noise policies, among others) it might be questioned whether the outcomes and tools of research projects are being properly disseminated and consequently facilitating the inclusion of urban sound planning as part of the urban planning process as required by the 7th EAP. Within this review it was found that 46 projects were excluded because they did not publically share any reports or research results. In order to cope with this lack of dissemination, the most recent programme, Horizon2020, established new rules for dissemination. Project owners are now encouraged to disseminate their results [70]. Within Horizon2020 there are two levels of dissemination: by granting access to publications or by depositing research data. OpenAIRE (https://www.openaire.eu) is a publications deposit that H2020, FP7 or other EU funding projects can use to disseminate their publications and research results. Also ZENODO (https://zenodo.org) is a database linked to the dissemination of research results. It is clear that EU is making an effort to improve the access to research results, but in order to influence or improve decisions and policies a new communication framework might be necessary [7]. A direct contact between researchers and the stakeholders of the urban sound planning process (*e.g.* local decision makers, national environmental agencies, economic agents, etc.) is necessary to create this communication platform. In [71] it is argued that different levels of communication are necessary in order to develop a science-policy integration framework: a first level, explaining the environmental policies implications in an accessible way (directed towards the general public); a second level, which means making the research outcomes accessible to the op-

erational officers, responsible for the implementation of the policies requirements (*e.g.* as informal technical guidance, or best practice examples, test cases, etc.); a third level, meaning the flow of information that is necessary amongst the scientific community.

As a conclusion, we would like to add that the END is going through a re-design process, making this, the ideal moment to incorporate the latest research results. It is clear that the scientific knowledge is available. The lack of communication between researchers, deciders, planners and citizens might be one of the reasons explaining why the results do not agree with the expectations. It is necessary to increase the awareness on the impacts of noise exposure and the sense of urgency in policy makers. The recommended limits for environmental noise exposure are far from being achieved. As stated in the 7th EAP, the integration of updated noise policy, aligned with cities planning will be essential to reduce noise pollution in Europe.

Acknowledgement: This research received funding through the People Programme (Marie Curie Actions) of the European Union's 7th Framework Programme FP7/2007-2013 under REA grant agreement n°290110, SONORUS "Urban Sound Planner".

The authors would like to thank Francesco Aletta and Laura Estévez Mauriz, SONORUS project colleagues, for the comments that contributed to the improvement of this paper.

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Appendix 1

Overview of EU funded research on environmental acoustics

In this section a short summary of each of the selected project will provide the reader with an insight perspective of the diversity of research topics and different approaches followed by each project.

- **Framework Programmes for Research and Technological Development (FP)**

Acoutrain (Virtual certification of acoustic performance for freight and passengers trains): this project developed tools, namely a software and a new methodology for acoustic certification of train vehicles. It had as main objectives to promote the interoperability of rail traffic in Europe by introducing a virtual certification with simulation approach, establish a method for separation of infrastructure and rolling stock noise, establish a measurement procedure for new running conditions (braking and curving) and obtain input data for the END, in particular for CNOSSOS.

CALMII (Advanced noise reduction systems): this project consisted of a working network that gathered different partners (public authorities, universities and privately held companies). This project consisted on different network activities with the objective to gather a comprehensive knowledge of the main noise problems related with the transportation industry, by promoting the discussion with the main stakeholders, and later support the development of a new European environmental noise policy.

CargoVibes: it is the intention of European rail operators to increase the transportation of goods in railways, which will inevitably add a pressure in terms of noise and vibration for residents living close to railways. There was a gap in legislation and guidance as no criteria to evaluate the adverse effects of railway vibration existed, but also no mitigation measures were defined.

CITYHUSH (Acoustically Green Road Vehicles and City Areas): the main objective of this project was to provide tools that could be used by local authorities in the implementation of noise action plans according to the END, including the concept of Quiet Zone (Q-Zones) and the development of a methodology to identify these areas, noise scoring models and methodologies and other tools were developed within this project.

CO2NTROL (Green City Car): the aim of this project was to developed integrated solutions to deal with noise and vibration issues by combining the latest technologies and conventional solutions to the future generation of city-cars.

Corrugation (Wheel rail corrugation in urban transport): the main objective of this project was to develop more efficient (in terms of noise and safety) and cost effective solutions for the corrugation problem in trams.

COSMA (Community oriented Solutions to Minimise Aircraft Noise Annoyance): this project continued the work developed in previous projects on the development of design criteria for aircrafts in order to reduce emission noise.

EAR-IT (Experimenting Acoustics in Real environments using Innovative Test-beds:) making use of new technologies, namely acoustic sensors, this project intended to demonstrate the potential of applying acoustic data to other improve people's daily life. Event detection, traffic and pollution monitoring, energy efficiency are just a few examples.

ECOQUEST (Efficient Cooling Systems for QUieter Surface Transport): the driving force of this project was the forethought on the aggravation of EU policies concerning the emission limits for surface vehicles, which would put an extra pressure from cooling units to reduce CO2 emissions and at the same time maintain or reduce the noise levels.

ENNAH (European Network on Noise and Health): this was a working network that reviewed the available research on noise and health effects to support the development of environmental noise policies for Europe. Dissemination was a relevant part of this network.

EVADER (Electric Vehicle Alert for Detection and Emergency Response): the topic of noise reduction with the adoption of electric cars has been considered a safety hazard for pedestrians and bicyclists. Normal combustion vehicles noise emission is caused by two main sources: the power unit and tyre/road interaction. An electrical vehicle will only have one source from the tyre/road noise interaction, which can be a safety hazard for pedestrians, especially at low speeds. This project researched for an optimal soundscape of e-vehicles that at the same time improved other users of the road safety.

GRENSCOM (Communicating urban growth and green: assessment of planning concepts and policy instruments for sustainable development of the urban landscape): this project outcome consists of a tool-kit which provides different strategies that focus on the balance between urban growth and "urban green".

HARMONOISE (Harmonised, accurate and reliable prediction methods for the EU directive on the assessment and management of environmental noise): within this project, prediction methods for environmental

noise from road, rail and industrial sources were developed. It also included a database for source related data and a model for meteorological conditions.

HEARTS (Health effects and risks of transport systems): this project had the objective of developing an integrated approach for estimating the health effects of air pollution, noise and road accidents. It also developed several software tools and models to simulate the emission and propagation of air pollutants, noise and time-activity patterns.

HOSANNA (HOlistic and Sustainable Abatement of Noise by optimized combination of Natural and Artificial means): using vegetation at the propagation path, as noise barriers, or as buildings facades treatments to reduce noise was the main objective of this project. The outcome of this project is a tool-box for the reduction of road and rail traffic noise.

IMAGINE (Improved Methods for the Assessment of the Generic Impact of Noise in the Environment): this project supported the production of strategic noise maps as required by the END. Computational methods and measurement methods were suggested to calculate or measure for different noise sources: roads, railways, airports and industry. The project also expanded databases for the different sources.

INMAR (Intelligent Materials for Active Noise Reduction): the objective of this project was to reduce noise at the source (roads and railways) using smart materials. The application of active solutions for the reduction of noise at bridges and tunnels was also investigated.

INQUEST (Information Network on Quiet European road Surface Technology): communication and dissemination were the main tasks of this project. Promotion of research results of another EU-funded project SILVIA, like road surface measurements, methodologies, equipment and the use of low-noise road surfaces on European roads.

ITARI (Integrated Tyre and Road interaction): this project main objective was to develop, design and test new low-noise road surfaces meeting, at the same time, the road safety requirements. A few designs were tested and the final report includes the results of a few tested surfaces.

MyWay (European Smart Mobility resource Manager): is a project focused on the creation of an integrated platform to improve the mobility through enabling a balance between public and private transportation. The developed tools are being tested at the "living labs".

OpenPSTD (Open-source software tool for the detailed reproduction of the urban sound environment): the major outcome of this project is a software tool that can be used to compute sound propagation.

Persuade (PoroElastic road surface: an innovation to avoid damages to the environment): within this project a PoroElastic road surface mixes were developed and tested during this project. Good noise reductions were obtained. Nevertheless further tests are still needed to achieve a solution that can be applied at large scale.

PROMPT (New means to Promote Pedestrian Traffic in Cities): methodologies for the assessment of pedestrians' mobility. This project created a tool-box of solutions for pedestrians' mobility problems in urban environments.

QCITY (Quiet City Transport): the main objective of this project was to provide tools for the several stages of noise planning: noise maps and action plans. The tools include action plans templates, decision support tools to evaluate/prioritise noise measures.

QUIESST (Quietening the Environment for a Sustainable Surface Transport): as it is indicated by the project's name, it addressed the topic of noise abatement, in particular roads and railways noise, to support the implementation of the END. Several tools were developed, inclusive a "Guidebook to Noise Reducing Devices optimisation" to be used by the stakeholders of the noise planning process.

QUIET-TRACK (Quiet tracks for sustainable railway infrastructures): this is an ongoing project that is addressing different research topics on rail tracks. The outcomes of this project will consist on a measurement system to be applied to the monitoring of physical aspects that affect noise emission from tracks; enhancements on existing models to describe rolling noise; developments of concepts and tools to be applied at the maintenance of tracks; and also tools for noise management.

RUROS (Rediscovering the Urban Realm and Open Spaces): the improvement of urban open spaces, by holistically integrating the different aspects affecting the liveability of an open space, was the main topic of the project. A design manual was published in the end of the project and the sound environment and acoustic comfort in urban spaces are part of the recommendations.

SILENCE (Quieter Surface Transport in Urban Areas): this project provided strategies and tools to support the development of noise action plans on urban transport noise abatement. The widely disseminated "Practitioner Handbook for Local Noise Action Plans" and specific websites with advices and training for different stakeholders (local decision makers, transport planner, transport engineers) are two examples of outcomes from this project.

SILVIA (Sustainable road surfaces for traffic noise control): this project's intention was to assess the impact that the implementation of low-noise road surfaces might have as a noise abatement measure. Topics such as the

different road surfaces design, construction and maintenance techniques, innovations of the design technique, quantification of low-noise surfaces benefits, cost benefit analysis are some of the topics that were explored within this project.

SONORUS (The urban sound planner): is an initial training network (ITN) project which has a research and training component. This project is focused on improving urban acoustics with better and earlier planning and state of the art design tools, following a holistic approach.

SOUNDTRACK (The autonomous assessment of aircraft sound power and position): this project purpose was to develop an improved aircraft noise monitoring system that could be capable of 1) identifying and locate aircraft noise events, 2) reducing the influence of the background noise of the measurement site and 3) providing an estimate of the aircraft sound power.

SPURT (Seamless Public Urban Rail Transport): this project focused on the development of solutions for the urban rail transport industry: collected data in order to support the development of an optimised solution for the wheel/rail interaction; defined guidelines to improve infrastructure requirements and maintenance; all these in order to try to harmonise vehicles specifications.

STAIRRS (Strategies and tools to assess and implement noise reducing measures for railway systems): supporting railway operators and infrastructure owners on the choice of noise reduction measures by providing a cost-benefit tool, assessment of the efficiency of combining different measures (e.g. track and rolling stock), and assessment of the efficiency of traditional railway noise abatement measures.

SUPERPANELS (Strengthening and Upholding the Performances of the new Engineered Research PANELS): panels are important components of vehicles such as cars and aircrafts that can be in the origin of noise problems. This project looked in detail to the origin of such problems and suggested a few solutions to cope with these problems.

TEAMPLAY (Strengthening and Upholding the Performances of the new Engineered Research PANELS): the main objective of this project was to create an efficient model to forecast aircraft noise and that could be a tool to policy makers.

TWO!EARS (Strengthening and Upholding the Performances of the new Engineered Research PANELS): the objective of this project was to develop a computational model of auditory perception and experience in a multi-modal context. This tool can be useful to test different urban scenarios.

VALIANT (VALidation and Improvement of Airframe Noise prediction Tools): this project focused on validating and improving the prediction tools behind noise sources in aircrafts.

- **LIFE programme**

CEDM (Centre for Eco-friendly city freight distribution): the goal of this project was to implement and test an innovative approach to urban logistics and contribute to reduce the negative effects of the current logistics process, including environmental noise.

Decibel (Disseminate in Europe Cast iron Brake shoe Ersatz, LL): this project aim was to develop a new type of brake shoe, that would reduce noise by 10 dB and to disseminate its use.

DYNAMAP (Dynamic Acoustic Mapping): this is an on-going project that is focused on obtaining an automatic update of noise maps using integrated systems for data acquisition. For municipalities this would facilitate the process of updating noise maps according to the END.

HARMONICA (Harmonised noise information for citizens and authorities): the objective of this project was to create a noise indicator that could be easily understood by the general public and the public authorities. In this way, the dissemination of noise related topics would be facilitated and would reach more citizens.

HUSH (Harmonisation of urban noise reduction strategies for homogeneous action plans): the rehabilitation and improvement of the acoustic environment in the city of Florence was the main objective. The development of the project included a comprehensive analysis of the Italian environmental noise legislation in order to harmonise the legislative framework.

NADIA (Noise abatement demonstrative and Innovative actions and information to the public): this project developed several tools (noise mapping techniques, definition of critical areas, noise action plans template and structure of dissemination activities) that supported municipalities to comply with their obligations under the END.

NoMePorts (Noise Management in European Ports: the main objective of this project was to develop a good practice guide for ports and local authorities on how to manage noise sources and decrease annoyance due to noise related issued of people living near ports. This guide is not exclusively for ports, as road and railway noise are some of the topics being approach by this guide.

PAASA (Cuenca Municipal Action Plan for sustainable environmental acoustics): this project was exclusive of the municipality of Cuenca and reports the approach followed to comply with the END requirements.

QSIDE (The positive effects of quiet facades and quiet urban areas on traffic noise annoyance and sleep disturbance): the benefits of a quiet side and quiet areas in urban noisy environments were investigated.

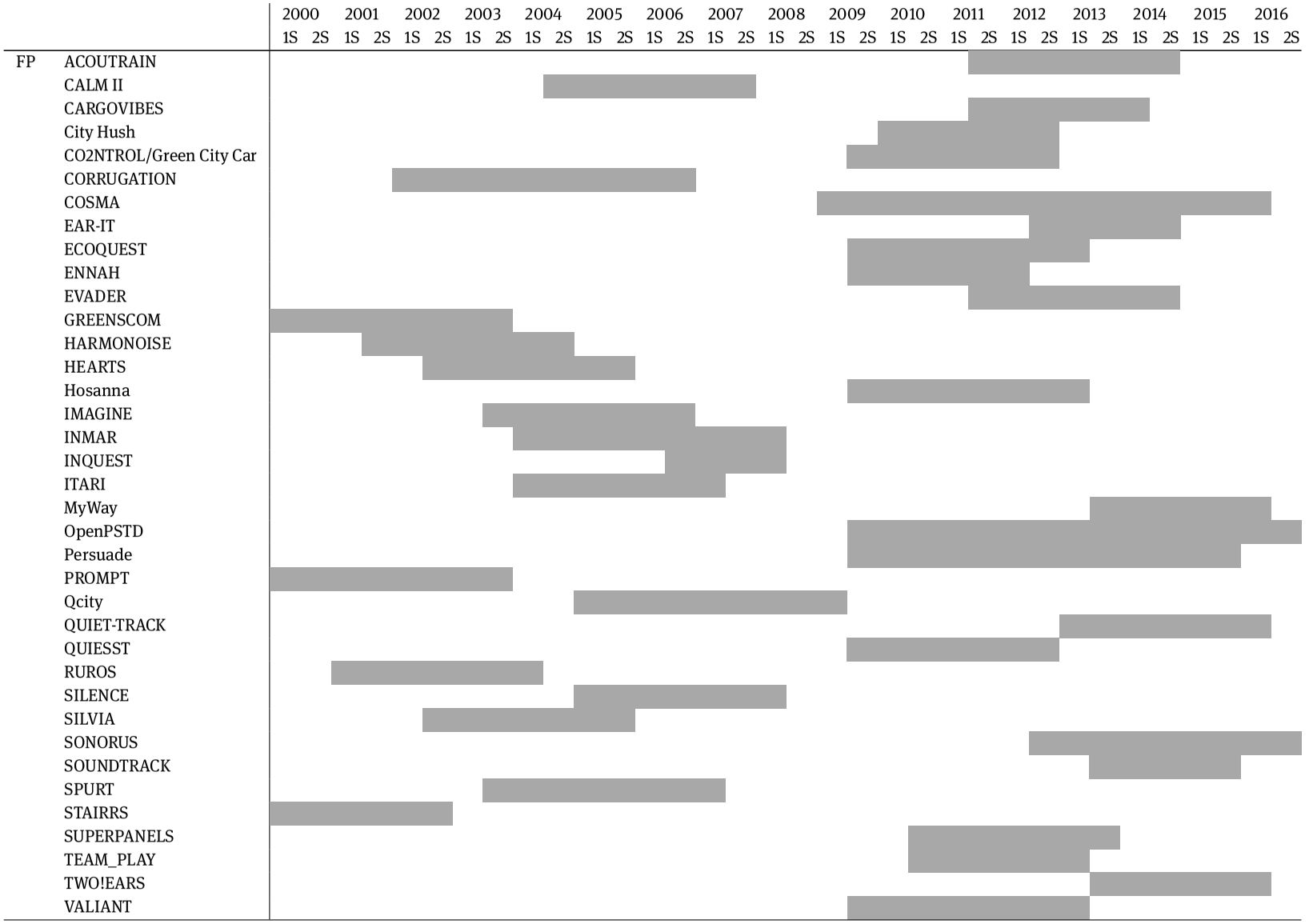
QUADMAP (Quiet areas definition and management in action plans): the main objective of this project was to develop a harmonized methodology for the selection and management of quiet areas, aiming at support the implementation of the END.

Solar Highways (Solar panels as integrated constructive elements in highway noise barriers): this ongoing project intent to demonstrate the efficiency of an integrated noise abatement solution: noise barrier that can also generated energy.

SPAS (Sound and particle absorbing system): the main research topic of this project was to test an optimized noise wall that could be integrated with a fine dust filter.

UNISASH (Resource efficient, universal window Sash): this project focused on the development of a noise protection measure to be applied at the receiver.

Appendix 2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CO2NTROL/Green City Car
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COSMA
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ECOQUEST
ENNAH
EVADER
GREENSCOM
HARMONOISE
HEARTS
Hosanna
IMAGINE
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INQUEST
ITARI
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