BASIC SECONDARY ASPECTS OF THE LIFE DYNAMAP PROJECT

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In this work some basic secondary aspects of the DYNAMAP project, a LIFE+ project on dynamic noise mapping co-financed in the framework of the LIFE 2013 program, will be described and discussed. Such basic secondary aspects include relevant issues that could strongly influence the success of the project, namely benefits and costs of the proposed solution, public response and user ability in consulting and managing the system (in compliance with the Environmental Noise Directive 2002/49/EC), future development of the system applications. As for the first aspect, an in depth cost-benefit analysis is foreseen in the project in order to demonstrate the possibility of reducing the resources needed to update noise maps (time, costs and dedicated personnel) through the noise mapping process automation. With regard to information and communication to the public, the DYNAMAP system will deliver a tool where simplified and easy-to-read noise maps will be made available to inform the public about noise levels and actions to be undertaken by local and central authorities to reduce the noise impact on the environment. The tool will be structured with different access levels to the system data base and tested to check public response and user ability in consulting and managing the system. Finally, the DYNAMAP project will investigate the possibility of strengthening the system with applications for dynamic reporting of integrated environmental impacts (noise, air quality, meteorological conditions, etc.), so as to provide a more comprehensive and complete overview of the environmental impact of road infrastructures present in the monitored areas.

1. Introduction

The main aim and outcome of the Dynamap project is the provision of dynamic noise maps able to detect and represent in real time the acoustic climate of road infrastructures. The success of the project, could be, however, strongly influenced by the fulfilment of some secondary objectives, such as the reduction of costs, the public response and user ability in consulting and managing the system, as well as the future development of the system applications.

Indeed dynamic noise maps, although very appealing, could be inapplicable if their cost were judged unsustainable. Likewise, their added value would be negligible if the possibility of collating many data in real time couldn't be exploited to provide useful applications, such as the control and management of traffic to reduce noise emissions, the upgrade of the system towards smart integrated environmental maps (including air pollutions indicators, traffic flow information and meteorological conditions), user-friendly tools to inform and communicate to the public.

In the following paragraphs the issues of costs and benefits, public information and communications and the future upgrade of the Dynamap system will be discussed in details so as to provide a comprehensive overview of its wider benefits and potential exploitation.

2. Expected cost and benefits of the Dynamap System

The project includes a comprehensive costs and benefits analysis in order to assess the feasibility and economic sustainability of the Dynamap system on a large scale. Aim of this study is to demonstrate that noise mapping costs can be reduced and that benefits can be improved by providing updated real time information on the acoustic climate of road infrastructures at any place and time. As a matter of fact, the success of the project mostly depends on the economic burden required to local and central authorities for implementing the system compared to costs and benefits associated to traditional noise mapping procedures. Therefore, costs and benefits can't be considered secondary aspects for the success of the project, but basic specifications to be fulfilled to reach the final goal.

The cost-benefits analysis will be at first carried out locally in the two pilot areas foreseen in the project (i.e. the A90 motorway surrounding the city of Rome and Milan district n° 9), and then extended to the whole ANAS network and the agglomeration of Milan, to demonstrate the feasibility and economic sustainability of the system. The study includes the development of a standardized method for assessing costs and benefits based on the most recent results available in literature. The analysis will be referred to a static scenario prepared following the traditional noise mapping procedures and will be accomplished in three steps.

In the first step costs related to the implementation of traditional and dynamic noise maps will be collated and costs estimates on a large scale will be accomplished. Costs will be extended and updated taking into account a time horizon of 20 years (4 END cycles). A standard method for costs evaluation will be provided and a simple tool running on a general purpose platform (i.e. Excel) will be developed to help local authorities and transport administrations proceeding with a detailed costs analysis.

In the second step, benefits will be identified and quantified taking into account the effects associated to the efficiency of the two options in terms of rapidity of response, evaluation accuracy and impact on the population. Further aspects linked to socio-economic effects will be also included to determine the benefits resulting from changes on social costs due to the implementation of the system. To monetize those costs coefficients available in literature, opportunely adapted, will be used.

In the third step, a cost-benefit analysis of the Dynamap system will be accomplished to assess the feasibility and economic sustainability of the Dynamap system on a large scale. Costs and benefits resulting from previous steps will be used to determine the economic impact of the Dynamap system. Next, the Net Present Value (NPV) will be calculated to assess the feasibility of the Dynamap system on a large scale and the Benefits/Costs Ratio (BCR) will be determined to evaluate its efficiency.

Finally, the system recovery time and non-monetized components (risks and political consequences) will be assessed to complete the impact analysis of the proposed solution.

As a starting point, a first rough estimate of the expected costs of the system will be given and compared to costs related to traditional noise mapping methods. Then, during the life of the project, costs will be constantly monitored and updated in order to provide a final reliable assessment of the Dynamap System economic impact as a whole.

2.1 The Costs of traditional noise mapping activities

The cost of noise mapping activities has been investigated and reported by the CEDR (the Conference of European Directors of Roads) Working Group Road Noise in 2013. Costs were collected through a questionnaire referred to the first cycle of strategic noise mapping (END) sent to all CEDR Member States. Results from the questionnaire show that costs depend substantially on the possibility of outsourcing or arranging in house activities. In particular, six out of seventeen respondents reported in house noise mapping activities with an average cost of €160. Outsourced costs, instead, ranged from € 6.500 for mapping 11 km to € 8.000.000 for mapping 17.000 km with an average value of 604 € per kilometer with peaks higher than 1.500 €. In Fig. 1 the results of the survey are shown 1.

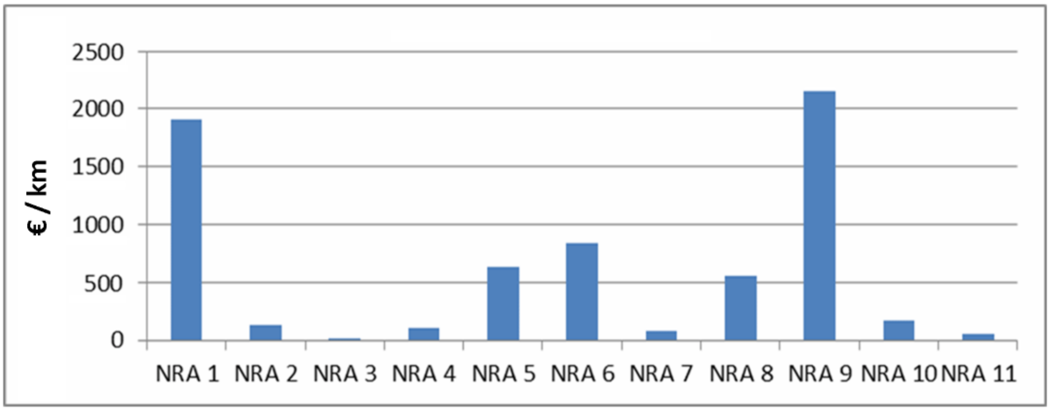

Figure 1. Noise mapping costs provided by eleven National Roads Administrations (NRA) for the first cycle of strategic noise mapping (END)[1].

Costs differences can be attributed to many factors, such as the availability of basic information to noise map the road network (traffic flow, cartography, meteorological data, number of inhabitants, etc.). Therefore, when basic information was not available, expensive measurement campaigns were necessary to collect data and estimate noise levels.

2.2 Expected costs of the Dynamap system

A first rough estimate of dynamic noise mapping costs has been accomplished with a simple calculation referred to the expense that should be paid in the Dynamap project to prepare the pilot area located along the A90 motorway that surrounds the city of Rome, where a minimum number of 25 monitoring stations will be installed (1 device every 2 km). The calculation includes the cost of the monitoring stations, their installation and maintenance for twenty years, the cost related to the preparation of the basic noise maps. A cost of 545 €/km has been estimated using customized low-cost devices. However, it should be noted that the latter refers to prototype and that a cost reduction of 70% is expected when the devices will be fully developed and made available as standard items. Likewise, costs for installation and maintenance can also be decreased to 20% if planned together with other ordinary maintenance activities (i.e. road lighting maintenance, road panels maintenance, etc.). In the end, a value of 125 €/km can be achieved for hardware and software provision, installation and maintenance. This cost doesn't include the preparation of the first set of basic noise maps (150 €/km), that should be added to the latter figure to obtain the final cost of 275 €/km, whose value is less than a half of the average cost reported by CEDR2.

3. Public response and users ability in consulting and managing the system

Another aspect that could influence the success of the project relies on public response and users ability in consulting and managing the system. The project will have a greater chance of attracting the public interest if user friendly interfaces and tools will be developed, so as to make the information gathered by the system usable on a large scale through easy to access applications, in accordance to European directives communication rules. In the following paragraphs, a detailed description of the project's contribution to meet such requirements is reported.

3.1 Public information and communication requirements from END

Public information and communication rules and obligations are based on the Directive 90/313/EEC3, that enforces public authorities to give free access to environmental information, setting out the basic terms and conditions on which such information should be made available. According to this directive, Member States shall ensure that public authorities make environmental information available to any natural or legal person at his request and without his having to prove an interest. They shall also define the practical arrangements under which such information is effectively made available and shall take the necessary steps to provide general information to the public on the state of environment by such means as the periodic publication of descriptive reports.

In 2002 the obligation of providing environmental information and communication to the public was introduced in the Directive 2002/49/EC on environmental noise (END). According to ENDMember States shall ensure that strategic noise maps and action plans are made available and disseminated to the public in compliance with National and European standards. This information shall be clear, comprehensible and accessible. Furthermore, Member States shall ensure also that the public is consulted about proposals for action plans, given early and effective opportunities to participate in the preparation and review of the action plans, that the results of that participation are taken into account and that the public is informed on the decisions taken. As a matter of fact, involving the public in the preparation of noise action plans is one of the fundamental requirements of the END. According to the END, the most appropriate information channels should be properly selected in order to have a wide spread of information to the public 4.

3.2 State of the art on public information and communication

In 2013 the CEDR Project Group Road Noise published a report on action plans, where the issue of informing and communicating to the public was analysed to evaluate the effectiveness of the strategies used to boost the participation of the public in preparing and selecting the most appropriate mitigation measures. The survey involved seventeen National Roads Administrations (NRA) of many Member States.

In all Member States, public consultations were conducted after the release of the draft action plan. Information and consultations were solicited through advertisements in newspapers (80%), NRAs websites (100%) and public hearing meetings (30%). A consultation period of at least 8 weeks was provided to ensure a reasonable time-frame to prepare appropriate proposals. Public participation in consultation activities ranged from 0 to 154 and varied from Member State to Member State.

Despite the common agreement on the importance of consulting the public about Noise Action Plans, the survey also highlighted that get the public involved in the hearing process is not an easy task and that consultation activities gave no useful feedback 5.

Another interesting experience on public information was carried out within the Life project Harmonica, where innovative tools were developed to better inform the public about environmental noise and to help local authorities in the decision making process. To improve public comprehension on noise issues and impacts, the Harmonica project suggested the creation of a simple, dimensionless noise index, closer to the feelings of the populations than the usual averaged indicators, in a similar way to the ones used for air quality. Besides, a database on noise abatement actions was created and published on an interactive platform to share useful information and experiences. Thanks to this innovative tool, all relevant information was made available in an easy-to-understand way, facilitating the assessment of the impact of noise abatement actions. This collaborative platform 6, open to all stakeholders involved in fighting noise nuisances, was intended to ease the work of decision-makers by bringing together experiences, innovations, and action plans.

3.3 The communication approach foreseen in the DYNAMAP project

The core idea of the Dynamap project is based on the possibility of implementing a software able to dynamically update noise maps in real time. The software output, as a GIS file, will feed another software application for real-time web presentation of the results to the public.

The latter will be able to read data coming from the system, and depict noise values as colored geo-referred noise maps to be published on the system's web site in a user-friendly format.

Access to data will be granted according to the privilege assigned to different users categories. Two main types of privilege will be defined: low and high. The first category includes the general public, while the second one comprises authorized stakeholders. Users with low privilege will be able to plot only noise maps, while users with high privilege will be able to see the time history of noise levels, some statistics and additional parameters linked to the sensors installed in each monitoring station. This software application will be also designed to plot other environmental data, in addition to noise maps, such as air quality, weather and traffic conditions, when available.

To optimize the software application communication skills, the project foresees an iterative process where users ability in accessing information and managing the system will be checked through a series of tests.

Two test steps are foreseen. The first step includes two sessions, with a time gap of one month, to check users ability in learning and managing the Dynamap tools. If necessary, some corrective actions will be undertaken to meet users requirements and a last test will be accomplished to provide a final assessment of the Dynamap system interface.

For each session, two kind of tests will be prepared. The first test type will be addressed to system's operators and aims at assessing users ability in managing the system. The test will include direct observation of system managing skills and the compilation of a technical evaluation form.

The second test type will be addressed to stakeholders and the general public. In this case, the test will require a remote access to the system through the project website and the compilation of a short questionnaire to collate information about users reactions. The questionnaire will include questions on project tools capability of raising people awareness on noise through freely accessible information and communication from the website, such as educational applications to explain citizens roles as subjects exposed to noise, but also as generators of noise, information on noise effects on health, environmental laws, the influence of driving habits on noise levels, the exposure to noise and the solutions that could be applied to abate noise (comparison between different scenarios).

Finally, the project includes the monitoring of action plans preparation for the agglomerations of Milan and Rome, to check the effectiveness of the information delivered to the public and verify their actual participation in selecting and adopting proper noise mitigation measures. As consequence of the results achieved, corrective actions will be taken to meet users requirements and improve the accessibility of the software interface.

4. Future vision on system applications

A very relevant aspect as regards the deployment of the DYNAMAP system on a large scale is related to its evolution from its original conception towards a more complete, multimodal and informative tool. Indeed, endowing the DYNAMAP system with capabilities beyond the real time mapping of road noise traffic can be a distinctive factor that increases its acceptance and attractiveness.

For this reason, the development of the DYNAMAP project foresees two actions addressing how to upgrade the system by adding environmental sensors to the DYNAMAP monitoring stations and how to obtain information for traffic management and control from the sensors.

The following sections describe the rationale, main goals and activities undertaken in those two actions of the project.

4.1 System upgrade with added environmental sensors

One of the main features of the DYNAMAP system resides in its capacity of implementing a dynamic graphical representation of road traffic noise. Despite the importance of such maps as a tool for updating noise maps as required by the European Directive 2002/49/EC relating to the assessment and management of environmental noise (END), the interest of authorities and the general public in the DYNAMAP system could be limited due to the restricted scope of the mapped data. However, it is not difficult to conceive that such real time maps could be extended and adapted to display dynamic information about other environmental parameters. This extension of the DYNAMAP system is envisaged as a means for increasing its attractiveness and interest.

For instance, DYNAMAP maps could be extended to inform about the volumetric concentration of pollutant agents in the atmosphere, thus providing a visual and constantly updated map of air quality. Another example could be the creation of maps displaying the value and evolution of meteorological parameters, such as air humidity or wind speed. This same idea could be expanded to create dynamic maps of human-caused environmental parameters, such as traffic density.

To that end, the DYNAMAP monitoring stations should be equipped with additional environmental sensors capable of measuring the environmental parameters of interest. On the other hand, the open architecture of the DYNAMAP system will allow the easy integration of the new sensors (and of any data processing algorithms involved).

Investigation about possible future upgrades of the DYNAMAP system is undertaken in three tasks. The first of these tasks is devoted to hardware aspects, i.e. those related to how the DYNAMAP system should physically communicate with external devices (such as cameras, Bluetooth signal detectors or other types of sensors), including the study of standard communication protocols that would allow extending the hardware capabilities of the system.

The second task is focused on the upgrade of the anomalous noise event detection (ANED) algorithm that is in charge of filtering out those acoustic events not caused by road traffic that could alter the noise levels displayed in the real time maps. Thanks to the inclusion of additional sensors, it could be possible to correlate noise measures and other sensed parameters (e.g. Bluetooth signals). By doing so, the system would have more information to determine whether a set of high noise values are due to actual anomalous events rather than to higher traffic density.

And the third task is devoted to the study of the upgrade of the DYNAMAP system software as regards the creation and publication of dynamic maps referred to additional environmental parameters, including the management of the access to the new environmental data sets.

The main difficulties associated to the upgrade of the DYNAMAP system with additional environmental sensors are related with sensors technology. Due to the fast evolution of hardware, it may be difficult to foresee which should be the way to interface the DYNAMAP system with hypothetical added sensors. For this reason, in order to avoid future restrictions and reduce the probability of incompatibility between the DYNAMAP system and sensors that could be added to the monitoring stations in the future, sensors front-end will be considered as part of the sensors themselves. In this way, the system will operate as an open structure where sensors output will be treated just as simple electrical signals, making the system easily adaptable to a wide range of devices. As for the software side, future compatibility is foreseen to be much easier because name, range and calibration of sensors are just customized fields of the sensors database, so that data management is not envisaged to be a real problem.

As a result of this study, the potential of future upgrade of the DYNAMAP system will be clear.

4.2 Traffic management and control based on information retrieved from sensors

Road traffic noise is highly correlated with traffic density and activity. For this reason, it is sensible to envision the DYNAMAP system in the future as a source of valuable information about the status of traffic in the monitored areas. Definitely, this feature could boost the interest of authorities and general public in the DYNAMAP system, as traffic is one of the most complex factors that authorities must manage in urban and suburban environments, besides affecting citizens' quality of life to a large extent.

Clearly, having a real time map of traffic noise allows the development of multiple mitigating, short-term corrective and informative applications. The mitigating applications of the system are related to long term measures, and are of main interest to authorities. Based on the data acquired by the DYNAMAP system, the most critical areas in terms of noise and atmospheric pollution can be identified. Thus, action plans to mitigate the noise impact on people who live and work in those areas can be effectively addressed, such as the construction of acoustic barriers and low-noise pavements, the planting of trees to compensate for air pollutants, traffic calming policies and ITS systems for controlling and managing vehicles speed and traffic flow in real time could be efficiently designed thanks to the data provided by the DYNAMAP system.

The detection of high traffic noise levels in certain areas at a specific moment can be used with short term corrective and informative purposes, which can be of interest to both authorities and to general public. An example of this includes the development of an early warning system based on the interconnection between the DYNAMAP system and electronic roadside informative boards, which can be used to inform drivers of alternative routes, or to display traffic related messages.

The investigations in these directions will be undertaken in four tasks. The first of these tasks deals with the identification of possible future applications of the DYNAMAP system. To that end, the structure, periodicity and reliability of the data gathered by the system will be firstly analyzed to put forward realistic applications that are compatible with the hardware and software features of the system.

The second and third tasks are focused on evaluating the feasibility of the previously proposed application in terms of the hardware and software capabilities of the DYNAMAP system.

And the fourth and final task will compile the outcomes of the previous tasks to describe a series of feasible future applications of the DYNAMAP system related to traffic information and management.

5. Conclusions

The main aim and outcome of the Dynamap project is the provision of dynamic noise maps able to detect and represent in real time the acoustic climate of road infrastructures. Although such an appealing objective, the success of the DYNAMAP project is tied up to a series of basic secondary aspects that could boost or alienate its implementation on a large scale, such as costs and benefits, public response and user ability in consulting and managing the system, future development and exploitation of the system applications.

To prove and test the Dynamap system real implementation potential and economic sustainability, the project foresees a dedicated action where costs and benefits will be accurately analyzed and compared to those associated to traditional noise mapping activities. It is expected that providing updated information on the acoustic climate of road infrastructures (at any place and time) could lead to a significant reduction in noise mapping costs and offers perceptible benefits.

Another aspect that could drive the success of the project is linked to the ability of providing effective tools to manage the system and inform the public about noise issues. The tools should be able to read data coming from the system and depict noise values as colored geo-referred noise maps to be published on the system's web site in a user-friendly format. To improve the software application communication features, the project foresees an iterative process where users' ability in accessing information and managing the system will be checked through a series of tests.

This application will be also prepared to plot other environmental information in addition to noise maps, so as to yeld an integrated and comprehensive overview of road infrastructure impact, such as the volumetric concentration of pollutant agents in the atmosphere and weather indicators, thus providing a visual and constantly updated map of air quality and meteorological conditions. Based on the data acquired by the system, the most critical areas in terms of noise and atmospheric pollution can be identified, so that appropriate action plans to mitigate the noise impact on people who live and work in those areas can be effectively addressed.

Finally, the interest towards the project and its exploitation on a large scale could also be determined by the possibility in the future of linking the Dynamap system to intelligent transportation systems (ITS), thus contributing to reduce vehicles noise emissions through the control and management of the traffic flow. Also this issue, like the other above mentioned aspects, will be accurately analyzed in a dedicated action on future development applications.

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