



---

## **NOISE PROTECTION IN URBAN ENVIRONMENT- DESCRIPTION OF A PROJECT**

**M. Kolarević, Z. Šoškić, Z. Petrović, B. Radičević**

[kolarevic.m@mfkv.rs](mailto:kolarevic.m@mfkv.rs)

*Faculty of Mechanical Engineering Kraljevo, University of Kragujevac, Dositejeva 19, Kraljevo  
SERBIA*

**Abstract:** *The paper presents a project of Ministry of Science of Republic of Serbia, which has the goal to establish technical platform for implementation of governmental policies in area of noise protection of urban environment. The project is realized by universities from Kragujevac, Niš and Belgrade, and it has three groups of goals: development of methodologies for estimation of noise impact, design of modular means for noise protection and establishment of software support for application of the methodologies and means developed in project. In order to achieve the goals a consistent and coherent set of activities was devised, and the appropriate resources are engaged. On the basis of the requests derived from the activities and restrictions imposed by resource limitations was designed project plan which facilitates realization of the project goals. Along with presentation of the team organization and project plan, the paper also presents a brief techno-economic analysis of the project.*

**Key words:** *noise, noise protection, urban environment, project management*

### **INTRODUCTION**

According to the researches performed in EU countries, which considered only areas with high exposition to noise, 18% of population is exposed to noise level higher than 65 dB. Part of population which is endangered by railway noise of the same level is 11%. Addressing these problems, EU financed international research projects that should contribute to understanding and solution of the problem, like FP7 projects "Imagine" and "Silence". [1, 2]

According to research made by authors in Municipality of Kraljevo, measured noise level was higher than permitted by national norms [3] at more than 90% of measurement points. The same research established also that noise level is higher than permitted in 75% of schools. Considered the facts that Serbia has only low-speed railway lines, that highways do not pass thorough Kraljevo, that industry in the municipality works with reduced capacities, it is reasonable to assume that the noise level will substantially rise in near future with development of modern traffic infrastructure and revitalization of the industry.

The fact that similar researches are for decades performed in developed countries testifies on their importance. For example, law of noise reduction, considering construction of high-speed-railway system, is in Germany passed in 1974. The program, called "noise prevention program" provided 50 million of EUR for noise protection. By the end of 2006, German government increased the budget of the program to 60 million EUR. In period 1999-2005, the program included construction of 110 kilometers of sound barriers, mounting of 24000 of sound-resistant windows and 17000 windows designed to enable air circulation without opening of the windows. [3]

Government of Republic of Serbia passed in 2009 Law on environment noise protection [4] that addresses:

- subjects in charge for environment noise protection
- means and conditions for environment noise protection
- measurement of environmental noise
- access to information about noise
- surveillance and other topics of relevance for environment and health protection

Further directions are defined by respective regulations [3], guidelines [6-10] and standard [11] that are relevant to environment noise protection and are in line with the Directive 2002/49/EC [13] of European Parliament and The Council of The European Union. Overview of the valid regulations and standards relevant for environment noise protection is shown in Table 1.

**Table 1: Serbian regulations considering environment noise protection**

Category	Regulation	Explanation
Laws	Law on environmental noise protection of Republic of Serbia (Official Gazette of Republic of Serbia, No. 36/2009 and 88/2010)	Relevant for topics of subjects in charge for environment noise protection, means and conditions for environment noise protection, measurement of environmental noise, access to information about noise, surveillance and other topics of relevance for environment and health protection
Regulation	Regulation on noise indicators, limiting values and methods for estimation of noise indicators, annoyance and detrimental effects of noise (Official Gazette of Republic of Serbia, No. 75/2010)	Determines environment noise indicators, limiting values, methods for estimation of noise indicators, annoyance and detrimental effects of noise to human health
Guidelines	Guidelines on methodology for determination of acoustical zones (Official Gazette of Republic of Serbia, No. 72/2010)	Determines in details methodologies for determination of acoustical zones.
	Guidelines on methods for noise measurements, contents and scope of noise measurement report (Official Gazette of Republic of Serbia, No. 72/2010)	Determines in details methods for noise measurements, contents and scope of noise measurement report
	Guidelines on methodology for design of action plans (Official Gazette of Republic of Serbia, No. 72/2010)	Determines in details methodology for design of action plans for environment noise protection.
	Guidelines on contents and methods of strategic noise mapping and their public presentation (Official Gazette of Republic of Serbia, No. 80/2010)	Determines in details contents and methods of strategic noise mapping as well as public presentation of the maps.
	Guidelines on conditions and documentation for expert organization for noise measurements (Official Gazette of Republic of Serbia, No. 72/2010)	Determines conditions that an expert organization for noise measurements has to fulfil, but also documentation that has to be submitted with application for authorization.
Standards	Serbian standard ISO 1996-1 (Official Gazette of Republic of Serbia, No. 72/2010)	Acoustics–Description, measurement and estimation of environment noise-Part 1: Basic quantities and procedures of estimation
	Serbian standard ISO 1996-2 (Official Gazette of Republic of Serbia, No. 72/2010)	Acoustics- Description, measurement and estimation of environment noise-Part 2: Estimation of environmental noise level
Other	Manual for environment noise measurements ( <a href="http://www.ekoplan.gov.rs/srl/upload-centar/dokumenti/razno/uputstvo_za_merenje_buke.pdf">http://www.ekoplan.gov.rs/srl/upload-centar/dokumenti/razno/uputstvo_za_merenje_buke.pdf</a> , 2011)	The manual describes procedures for environmental noise measurements for noise monitoring and individual noise measurements in noise measurements area.

Majority of the measures prescribed by the regulations is still not supported by existence of the relevant accredited institutions and research groups, noise protection means available at market and adequate software support. Project "Development of methodologies and means for noise protection of urban environment" (acronym "urbaNoise") is aimed to facilitate solution of the present problems and deficiencies.

## GOAL AND EXPECTED RESULTS

In order to realize the project in the most efficient possible way, it is necessary to rationally arrange needed resources and activities by methods of project organization, planning and control.

Project management is divided in four phases:

- Definition of the project and setting the project goals
- Project planning
- Organization of the project
- Control of execution of the project

Definition of the project resulted in project chart that shows basic project data, shown in Table 2:

- Project title
- Dates of start and end of the project
- Main project goals
- Project phases and milestones
- Project manager and project team members

**Table 2: Project chart**

<b>Project chart</b>		
<b>Project title:</b> urbaNoise		
<b>Project manager:</b> Dr Zlatan Šoškić		
<b>Start date:</b> 1.1.2011		<b>End date:</b> 31.12.2014
<b>Subject:</b>	Development of methodologies and means for noise protection of urban environment	
<b>Main goals:</b>	<ul style="list-style-type: none"> <li>• Development of methodologies for estimation of degree of exposition to noise</li> <li>• Development of methods and materials for noise protection</li> <li>• Design of means for active and passive noise protection</li> <li>• Dissemination of the results</li> </ul>	
<b>Project phases/milestones</b>	<ol style="list-style-type: none"> <li>1. Theoretical and methodological preparation of the project/ 21.4.2011</li> <li>2. Development of methods for estimation of exposition to noise/ 6.8.2014</li> <li>3. Development of methods and materials for noise protection/ 2.9.2014</li> <li>4. Design of means for active and passive noise protection/ 2.9.2014</li> <li>5. Dissemination of the results/ 31.12.2014</li> <li>6. Project closure/ 31.12.2014</li> </ol>	
<b>Project team</b>		
<b>Name</b>	<b>Role</b>	<b>Institution</b>
Zlatan Šoškić	Project manager	Faculty of Mechanical Engineering Kraljevo
Zoran Petrović	Team leader	Faculty of Mechanical Engineering Kraljevo
Miomir Vukićević	Team leader	Faculty of Mechanical Engineering Kraljevo
Milan Kolarević	Member	Faculty of Mechanical Engineering Kraljevo
Ljubormir Lukić	Member	Faculty of Mechanical Engineering Kraljevo
Dragan Cvetković	Member	Faculty of Occupational Safety Niš
Momir Prašević	Member	Faculty of Occupational Safety Niš
Srdan Rusov	Member	Faculty of Traffic Engineering Belgrade
Nebojša Bogojević	Member	Faculty of Mechanical Engineering Kraljevo
Mišo Bjelić	Member	Faculty of Mechanical Engineering Kraljevo
Aleksandar Zlatković	Member	Faculty of Traffic Engineering Belgrade
Aleksandra Petrović	Member	Faculty of Mechanical Engineering Kraljevo
Branko Radičević	Member	Faculty of Mechanical Engineering Kraljevo

Social meaning of the project is establishment of technical basis for implementation of policies prescribed by laws. The main goals of the project are development of methodologies for estimation of hazards caused by exposition to noise and means for noise protection of urban environments.

The basic project goals which determine research directions and activities are:

- Development of methodologies for estimation of degree of exposition to noise
- Development of methods and materials for noise protection
- Design of means for active and passive noise protection
- Dissemination of the results

The structure of the goals and the expected results are presented in the Table 3. In accordance with the proposed goals are defined project phases and workpackages of the project.

**Table 3: Structure of goals and results**

Aim	Development of methodologies and means for noise protection of urban areas			
Goals	Development of methodologies for estimation of degree of exposition to noise	Development of methods and materials for noise protection	Design of means for active and passive noise protection	Dissemination of the results
Intended results	Study on dominant noise sources in urban environment	Design and testing of reverberation chamber	Methodologies for application of active noise protection	Web site of the project
	Database on urban noise sources	Accreditation of laboratory for urban noise measurements	Design of modular noise barriers	Launching of regional journal on noise protection
	Software support to strategic noise mapping	Investigation of acoustic properties of materials	Design of modular cabins for noise protection	Seminars on noise protection
	Methodology for drawing of action plans for noise protection of urban environment	Database on acoustic properties of materials	Implementation of the designed solutions	Monograph on noise protection of urban areas

Workpackage 1, *Development of methodologies for estimation of degree of exposition to noise* comprises collection of data describing noise sources in urban environment, development and accomplishment of relevant classification and design of software platform suitable for drawing of strategic noise maps. The activities establish conditions for characterization and monitoring of exposition of urban areas to noise and understanding of future directions of development of noise protection systems.

Workpackage 2, *Development of methods and means for noise protection* comprises as initial step construction of reverberation chamber that should enable research in area of acoustic characteristics of materials and structures. It creates basis for systematic research of methods and materials for noise protection. Particular attention will be dedicated to acoustic characteristic of waste materials (PET containers, plastic bags, worn car tyres) and plants (*Viburnum rhytiphyllum*, *Ilex aquifolium*, *Arpinus belutus*) and their potentials for applications for noise protection.

Workpackage 3, *Design of means for active and passive noise protection* has goals to improve understanding and methodologies for active noise protection, as well as to design, manufacture and test modular means for passive noise protection (barriers and absorbers for various exploitation conditions and applications). This workpackage has special importance for Serbian industry because specialized manufacturers of noise protection equipment do not exist in Serbia, and the designed products may become the basis for development of new production programs or even establishment of new companies.

Workpackage 4, *Dissemination of the results* has two goals: the first, spreading of knowledge about influence of noise as well as about methods and means for noise protection in general public, and the second, presentation of the project results to experts in area by articles in scientific journals and conferences.

## PROJECT PLAN

Development of project plan comprised:

- Project planning (Identification of project phases and activities, estimation of duration and dependencies between activities)
- Project scheduling (Estimation of resources for activities, allocation of personnel to activities and creation of project chart)
- Cost planning
- Arrangement of project goals and constraints
- Cross-checking of the project plan

The result of project planning is work breakdown structure (WBS) that presents the project decomposed to its constituents in multiple levels (workpackages, activities and tasks). The structure provides possibility to manage each of the constituent parts at all management levels, facilitating management of the project as a whole.

The developed WBS structure of the project is as follows:

1. Theoretical and methodological project preparation
  - 1.1. Analysis of the present state
  - 1.2. Definition of project aim and structure of goals
  - 1.3. Establishment of team and organizational structure of the project
  - 1.4. Determining of WBS
  - 1.5. Resource requests analysis
  - 1.6. Cost-Benefit analysis
  - 1.7. Determining expected results
  - 1.8. Risk analysis
  - 1.9. Project plan control

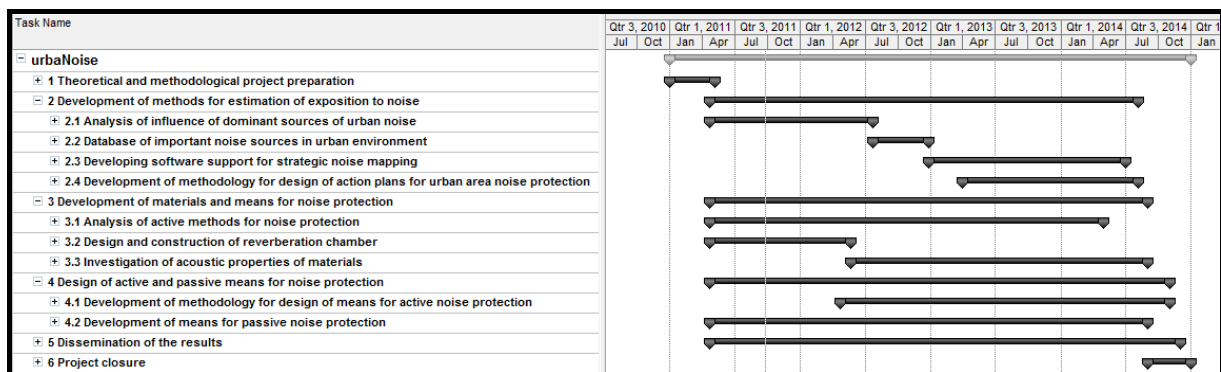


Figure 1: Gantt chart of the project "urbaNoise"

2. Development of methods for estimation of exposition to noise
  - 2.1. Analysis of influence of dominant sources of urban noise
    - 2.1.1 Analysis of standards and regulations relevant for noise protection
    - 2.1.2 Defining dominant sources of urban noise
    - 2.1.3 Study of influence of dominant sources of urban noise in pilot settlements
  - 2.2. Database of important noise sources in urban environment
    - 2.2.1 Development of methodology for acquisition and processing of data describing traffic, industrial, environmental and communal noise
    - 2.2.2 Building database for pilot settlements
  - 2.3. Developing software support for strategic noise mapping
    - 2.3.1 Analysis of GIS representation of noise sources
    - 2.3.2 Developing software modules for noise mapping
    - 2.3.3 Drawing strategic noise maps for pilot settlements
  - 2.4. Development of methodology for design of action plans for urban area noise protection
    - 2.4.1 Development of methodologies for estimation of the influence of urban noise
    - 2.4.2 Design of methodology for drawing of action plans for noise protection
3. Development of materials and means for noise protection
  - 3.1. Analysis of active methods for noise protection
    - 3.1.1. Analysis of active methods for noise protection in traffic

- 3.1.2. Analysis of active methods for noise protection in industrial plants
- 3.1.3. Analysis of active methods for noise protection in public services
- 3.2. Design and construction of reverberation chamber
  - 3.2.1. Designing reverberation chamber
  - 3.2.2. Adaptation of the present room
  - 3.2.3. Equipment installation and testing
- 3.3. Investigation of acoustic properties of materials
  - 3.3.1. Investigation of acoustic properties of construction materials
  - 3.3.2. Investigation of acoustic properties of waste materials
  - 3.3.3. Investigation of acoustic properties of plants
  - 3.3.4. Report on acoustic properties of investigated materials
- 4. Design of active and passive means for noise protection
  - 4.1. Development of methodology for design of means for active noise protection
    - 4.1.1. Active means for noise protection from traffic
    - 4.1.2. Active means for noise protection from industry
    - 4.1.3. Active means for noise protection from public services
  - 4.2. Development of means for passive noise protection
    - 4.2.1. Analysis of solutions present at the market
    - 4.2.2. Design of modular barriers for protection from traffic noise
    - 4.2.3. Design of protective equipment (acoustic screens, panels, curtains, cabins etc)
    - 4.2.4. Manufacturing and testing of prototypes
    - 4.2.5. Analysis of technologies for the proposed solutions
- 5. Dissemination of the results
  - 5.1. Running website of the project
  - 5.2. Initialization of regional journal for noise protection
  - 5.3. Publishing international monograph on noise protection in urban areas
  - 5.4. Organization of seminar on the project's results
- 6. Project closure
  - 6.1. Analysis of the results
  - 6.2. Delivery of the blueprints to beneficiaries
  - 6.3. Final project report

		Required knowledge and skills					
		Noise and vibration	Software development	Engineering	Measurement techniques	Project management	Legal matter on noise protection
Researchers	Z. Šoškić						
	Z. Petrović						
	M. Vukićević						
	M. Kolarević						
	L. Lukić						
	D. Cvetković						
	M. Praščević						
	B. Radičević						
	M. Bjelić						
	A. Petrović						
	N. Bogojević						

**Table 4. Matrix of knowledge and skills**

The presented breakdown of the project by WBS technique enables design of proper project realization plans by application of Gantt charts or network charts, and to manage appropriate resource allocation and assignment of tasks. The obtained network plan was then optimized with respect to the limitations of timelines, human and material resources. The Gantt chart of the project plan is shown in the Figure 1.

# PROJECT ORGANIZATION

Project team consists of set of experts, specialists in research fields of relevance for the project, as well as specialists for project management and informatics. Besides, majority of participants have experience in research and development projects as well as knowledge of project management concepts and procedures. Participation of all team members from the phase of project planning was aimed to better understanding of project plan in order to provide coordinated and aim-oriented action needed for successful and efficient project realization.

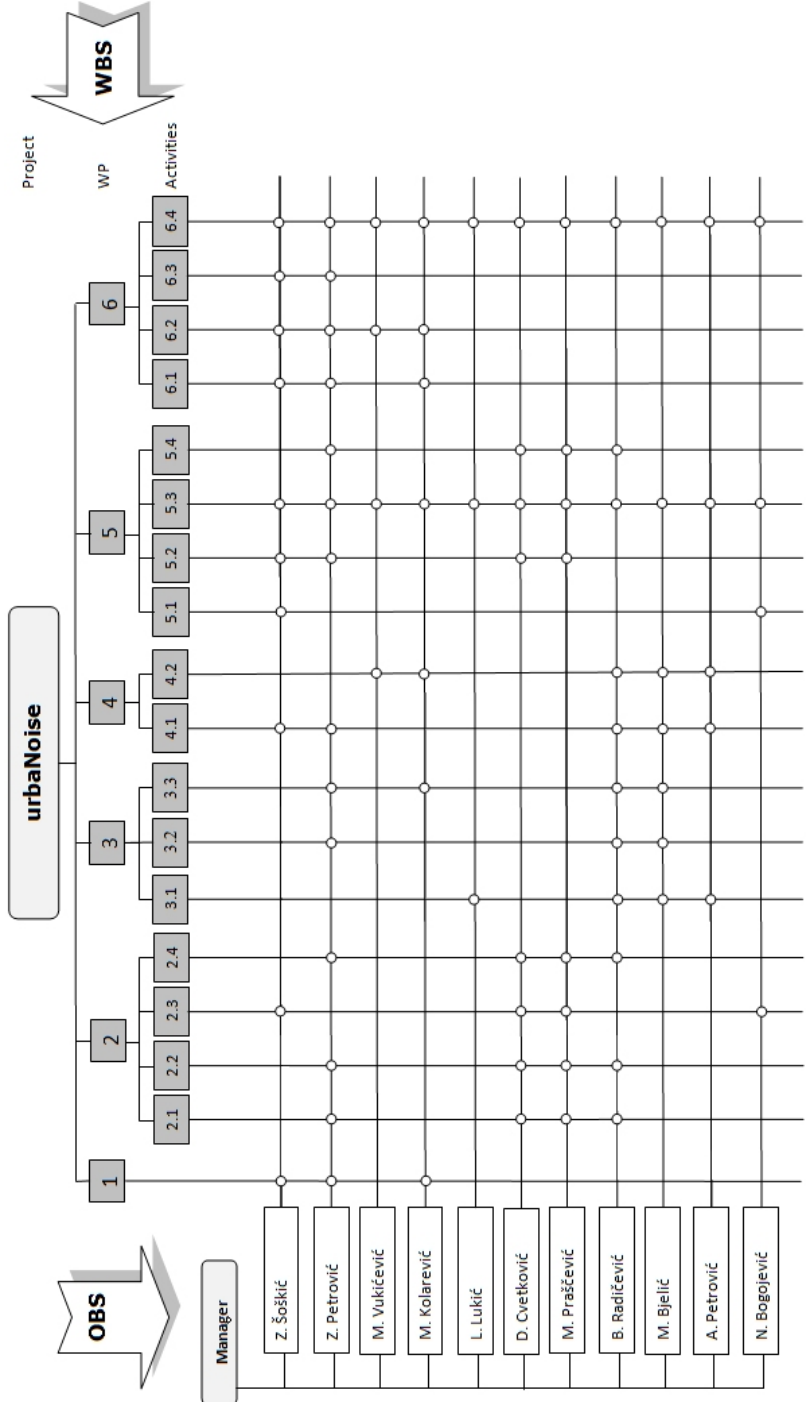


Figure 2: Relationship between OBS and WBS elements of project structure

Matrix of required knowledge and skills is shown in the Table 4, and it enables creation of organizational breakdown structure (OBS), leading to optimal selection of teams for realization of project activities. The relation between OBS and WBS is shown in Figure 2.

Considering high level of expertise of individual members, a *self-defining* type of team was selected, because it enables fast communication between team members and efficient work. Due to the fact that team members work in three companies in three cities, *virtual team* organization is adopted, with extensive use of internet communication, which enables reduced costs of room, travel and accommodation.

From the point of view of the character of scientific research in the proposed project, there exist to fundamental, applied and development research activities.

The research activities of fundamental nature, which, on the basis of relatively small-scale empirical research, lead to the results of a general nature, which can be applied to a large number of practical cases include:

- Analysis of sources of urban noise, which generalize experimental results to determine the priorities in the fight against noise in the future;
- Development of methodology for the preparation of action plans to prevent and protect from noise in urban areas, based on which will be able to prepare an action plans of noise protection in many cities;
- Development of reverberation chamber, which create the conditions for research of noise absorption in the broadest scope
- Research of the noise absorption properties of waste and other materials, thus creating the basis for the application of these materials in a number of concrete products for protection against noise.

The researches of applied nature include researches that bring an immediate solution of existing problems, and these are the following activities:

- Development, analysis and selection of most appropriate solutions against noise in the selected pilot cities
- Development, analysis and selection of most appropriate solutions protect against noise in the selected pilot facilities.

The research activities of developmental characters, which represent designing of new products and technologies include:

- Development of means for the prevention of noise
- Development of the means of protection against noise.

Some of the basic researches provide the basis for applied research: without the proposed construction of reverberation chamber and measurements of absorption properties of different materials is not possible to design optimal and efficient means for protection against noise. On the other hand, some of the basic researches are not directly necessary for the applied and developmental research activities. This is the case with the analysis of urban noise and the development of a methodology of design of action plans to prevent noise in urban areas. However, absence of such researches reduces the remaining actions to non-creative use of solutions developed abroad, which seriously compromises the effectiveness and quality of the results.

## CONCLUSION

That urban noise is a health risk in Serbian settlements is already established in National strategy of sustainable development [14], proclaimed in 2008. The document points out all means of transportation and industrial plants as the main sources of noise pollution. The basic problems that the National strategy are:

- lack of harmonization with EU standards,
- lack of modern regulations of noise measurements, lack of permanent noise monitoring, expect in the largest cities,
- lack of central plans for combating noise problem,
- non-conforming to legal norms in civil building.



In accordance with the conclusions of the National strategy, and with goal to achieve harmonization with EU legislature, a new Law on noise protection, Regulation on noise indicators and set of rule books were proclaimed, thus solving the initial two problems from the list above.

Further, in order to achieve remaining sector goals, it is needed to [14]:

- establish standards about monitoring of noise in settlements along main roads,
- find out endangered zones and determine actions for reduction of noise level within them, as well as to find out quiet zones and determine actions for their preservation,
- draw up strategic noise maps for designing action plans,
- establish efficient public information system,
- establish sufficient number of accredited institutions for noise measurements,
- establish referent laboratory.

The project "Development of methodologies and means for noise protection of urban areas" establishes the technical basis for achievement of some of the measures. Development of software tools for noise mapping will support zoning activities and drawing up of strategic noise maps. Design and construction of reverberation chamber represents important part of development of accredited laboratory for noise measurements, and potential referent laboratory. After the achievement of initial project goals, the action moves towards exploitation of the established technical basis through scientific research, which should investigate acoustic properties of materials, and technological research, which should lead to noise protection means that should contribute to decrease of noise pollution by traffic, industrial and communal noise.

The successful achievement of project goals should also bring substantial economic benefits to Serbia, as it will be explained in the following techno-economic analysis.

The development of systematic procedures for noise data acquisition and processing should simplify drawing up of noise maps, which would enable appointment of municipal servants for the task of noise mapping instead of specialized companies. It means reduction of costs of legally obligatory noise mapping of the order of 10,000 EUR per city, and Serbia has more than twenty cities with more than 100,000 inhabitants, which are obliged to conform to the obligation. Besides, the development of software tools for support to noise mapping which is capable of partial or complete replacement of commercially available tools should further reduce costs of noise protection. Considering both aspects, the results of the project should reduce costs of noise mapping in Serbia for the estimated amount of 500,000 EUR.

Investigation of acoustic properties of materials and successive design of means for noise protection offers also possibilities for substantial savings through replacement of imported products. The cost of noise protection barrier nowadays is as high as 1,000,000 EUR per kilometre. If only 10 km of barriers were to be built per year, replacement of import noise protection products by domestic ones would mean multi-million EUR savings for Republic of Serbia and its economy.

## ACKNOWLEDGEMENT

Authors wish to express their gratitude to Ministry of Education and Science of Republic of Serbia for the support through the project grant TR37020.

## REFERENCES

- [1] <http://www.silence-ip.org>
- [2] <http://www.imagine-project.org>
- [3] *Regulation on noise indicators, limiting values and methods for estimation of noise indicators, annoyance and detrimental effects of noise*, Official Gazette of Republic of Serbia, No. 75/2010
- [4] A. Zlatković, *Analysis of railway vehicles noise management*, Master thesis, Faculty of Traffic Engineering, Belgrade, 2010.
- [5] *Law on environmental noise protection of Republic of Serbia*, Official Gazette of Republic of Serbia, No. 36/2009

- [6] *Guidelines on methodology for determination of acoustical zones*, Official Gazette of Republic of Serbia, No. 72/2010
- [7] *Guidelines on methods for noise measurements, contents and scope of noise measurement report*, Official Gazette of Republic of Serbia, No. 72/2010
- [8] *Guidelines on methodology for design of action plans*, Official Gazette of Republic of Serbia, No. 72/2010
- [9] *Guidelines on contents and methods of strategic noise mapping and their public presentation*, Official Gazette of Republic of Serbia, No. 80/2010
- [10] *Guidelines on conditions and documentation for expert organization for noise measurements*, Official Gazette of Republic of Serbia, No. 72/2010
- [11] *Serbian standard ISO 1996-1,2*, Official Gazette of Republic of Serbia, No. 72/2010
- [12] *Manual for environment noise measurements*, Ministry for environment, mining and spatial planning of Republic of Serbia, [http://www.ekoplan.gov.rs/srl/upload-centar/dokumenti/razno/uputstvo\\_za\\_merenje\\_buke.pdf](http://www.ekoplan.gov.rs/srl/upload-centar/dokumenti/razno/uputstvo_za_merenje_buke.pdf), 2011
- [13] *Directive 2002/49/EC of The European Parliament and The Council of The European Union*
- [14] *National strategy of sustainable development*, Government of Republic of Serbia, Belgrade 2008
- [15] A. Lester, *Project Planning and Control*, 4<sup>th</sup> edition, Elsevier Ltd, Oxford, 2003.
- [16] P. Jovanović, D. Petrović, V. Obradović, M. Mihić, *Methods and techniques of project management*, Faculty of Organizational Sciences, Belgrade, 2007.
- [17] A.H. Levine, *Practical Project management, Tips, Tactics and Tools*, John Wiley & Sons Inc, New York, 2002.
- [18] E. Frigenti, D. Comnios, *The Practice of Project Management – a Guide to the Business-focused Approach*, The Association of MBAS, 2002.
- [19] J. Westland, *The Project Management Life Cycle*, Kogan Page, London, 2006.
- [20] <http://www.mfkv.rs/urbaNoise>

## ЗАЩИТА ОТ ШУМ В ГРАДСКА СРЕДА - ОПИСАНИЕ НА ПРОЕКТ

**M. Kolarević, Z. Šoškić, Z. Petrović and B. Radičević**

*Faculty of Mechanical Engineering Kraljevo, University of Kragujevac, Dositejeva 19, Kraljevo  
SERBIA*

**Ключови думи:** шум, заштита от шум, градска среда, управление на проекти.

**Резюме:** Статията представя проект на Министерството на науката в Република Сърбия, който има за цел да създаде техническа платформа за изпълнението на правителствената политика в областта на защитата от шум на градската среда. Проектът се реализира от университетите в Крагуевац, Ниш и Белград и има три групи цели: разработване на методологии за оценка на въздействието на шума, проектиране на модулни средства за защита от шум и създаването на софтуер за прилагане на методологиите и средствата, разработени в проекта. За постигане на целите е създаден последователен и съгласуван комплекс от дейности и са осигурени подходящи средства. Въз основа на потребностите във връзка с осъществяването на дейностите и ограниченията, наложени от недостатъчните ресурси, е разработен план, който улеснява реализацията на целите на проекта. Наред с организацията на екипа и плана докладът представя и кратък технико-икономически анализ на проекта.