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International Science and Technical Cooperation of the Faculty of Mechanical Engineering in Kraljevo

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The Faculty of Mechanical Engineering of Kraljevo is the bearer of regional, commercial and technological development and is also a significant bearer of an international science and technical collaboration of the Republic of Serbia. By participating in the realization of science and research projects was achieved collaboration with the recognized universities and science institutions in the world, which brought an international affirmation of the science and research programs of the Faculty of Mechanical Engineering in Kraljevo. With the realization of two projects from the FP 7 program and two from the regional programs over the past three years were achieved vital results in terms of integration of research activities of the Faculty of Mechanical Engineering in Kraljevo into European flows, the burst of science and research staff and laboratory furnishing.

The paper shows the realized goals and results from the four current projects realized by and in which participates the Faculty of Machine Engineering in Kraljevo: SeRViCe - Center for Strengthening Railway Vehicles of the Faculty of Mechanical Engineering Kraljevo, TransBonus - Western Balkan Network for Training, Support and Promotion of Cooperation in FP7 research activities, ATC Serbia – Automotive Training Centre for Central Serbia and IMPuls - Innovation Management for new Products.
Keywords: International projects, research, development, education

0 INTRODUCTION

The Faculty of Mechanical Engineering in Kraljevo first began its international science and technical cooperation in the field of railway mechanical engineering, through the development of its own research center, only to later broaden this collaboration by building one of the most modern experimental facilities in Europe for testing railway vehicles. After this project, the collaboration extended to the TransBonus project through which activities took place in several countries in the Balkans.

The competence of the Faculty of Mechanical Engineering in Kraljevo in the education of engineers was confirmed by its participation in the project – ATC Serbia. Furthermore, through the IMPuls project, valued at around EUR 1mn, realized over the following two years, the Faculty of Mechanical Engineering became one of the most significant bearers of science and technical cooperation from the University in Kragujevac. With the realization of a couple of project from the FP 7 program over the past three years were achieved vital results in terms of integration of research activities of the Faculty of Mechanical Engineering in Kraljevo into European flows, the burst of science and research staff and laboratory furnishing.

1 SeRViCe PROJECT

The project Center for Strengthening Railway Vehicles of the Faculty of Mechanical Engineering Kraljevo (SeRViCe) is the first big international project coordinated and realized by the Faculty of Mechanical Engineering of Kraljevo. Dragan Petrovic took over the duty of project manager after Ranko Rakanovic.

The basic goal of the project is the development of the Center for Railway Vehicles of the Faculty of Machine Engineering in Kraljevo, and is focused on:

- Higher quality and more efficient teaching process and education of students of all study levels from the field of railway mechanical engineering and testing of machine constructions,
- The growth of staff in line with leading global trends from the field of railway mechanical engineering and procurement of lab equipment and
- Participation in science and research and development projects with commerce,

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participation in science conferences, publishing the achieved results.

Project SeRViCe for the Faculty of Mechanical Engineering in Kraljevo has great significance because the faculty, as an institution-coordinator, is thus included in the FP program of projects, thereby making it a relevant partner for European research projects. The significance of the project is reflected in the improvement of collaboration between MFK and renowned global and domestic institutions and scientists from this field. Particular importance within a European framework plays the development of the railway as a mass transport system, safe, economical and with the least harmful effects on the environment.

The content of the project is the improvement of collaboration with domestic and foreign commerce, science and research centers, local government and Republic institutions, particularly the Ministries of Education, Science and Technological Progress. A qualitative improvement of collaboration, teaching and science and research work leads to raising the reputation of the Center for Railway Vehicles and the Faculty of Mechanical Engineering, and was attained through seven work packages, including:
WP-1 Knowledge – exchange of employees and study visits,
WP-2 Newly employed and researchers,
WP-3 Workshop,
WP-4 Measuring equipment and S-shape tracks,
WP-5 Partnerships,
WP-6 Advertising and promotion,
WP-7 Management.

A significant result of the project is an overall increase in the level of knowledge of researchers of the Center for Railway Vehicles that was realized through an exchange of employees and expert training at renowned research institutions like KTH Royal Institute of Technology from Stockholm and the DIEM Department of the University in Bologna. Also, several study visits took place at leading European institutes and companies from railway mechanical engineering of which the most important are ALSTOM – France (figure 1), VUKV – the Czech Republic and IMA – Austria. These activities resulted in signing an agreement on strategic collaboration with KTH, the Royal Institute of Technology from Stockholm and the DIEM Department of the University in Bologna.

Fig. 1. *Study visit to company Alstom – France*

This was realized primarily through the direct organization of several workshops under the auspices of the Faculty of Mechanical Engineering of Kraljevo (figure 2) at which had participated, apart from domestic, the leading worldwide experts from the field of railway vehicle dynamics, mechanical construction fatigue, sensory analysis and other areas. Through these activities was realized the connecting and transfer of knowledge between domestic and foreign researchers and introduction to leading global trends from the field of railway mechanical engineering.

Fig. 2. *Work group "Workshop on Railway Vehicle Dynamics" – Kraljevo*

Among the more important realized results of the project is the employment of several younger researchers – students of postgraduate, PhD programs, that through the realization of the project had gained significant experience in research and know-how that will be of use to them in their further work and for the writing of their Doctor's Dissertation. Also, it should be

highlighted that through the realization of the project was achieved a significant affirmation of the Faculty of Mechanical Engineering in Kraljevo, both in domestic and international frameworks.

The most significant output of the project is reflected in the development and procurement of modern measuring equipment for dynamic and quasistatic testing of railway vehicles according to the international UIC standards in force. This is a measuring equipment that is one of the most contemporary achievements from this area. The following measuring systems were developed and procured:

- Measuring system for measuring the lateral (Y) and vertical (Q) components of the force that occurs in the contact between the wheel and rail,
- Measuring system for measuring the lateral force (H) and lateral acceleration of the axial structure, as well as the height of raising the wheels,
- A measuring system for measuring the pressure force on an automatic clutch,
- A measuring system for measuring the acceleration of the railway car,
- Test stand for calibration and testing of measuring axial structures (figure 3).

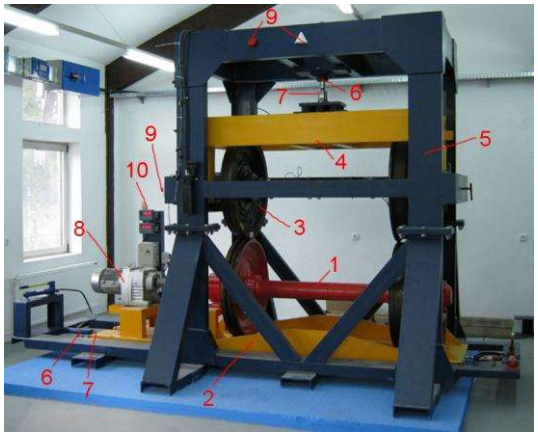

Fig. 3. *Device for calibrating and testing measuring axial structures of the cars*

This measuring equipment enables a further planning and participation in very current research in the field of security and safety of axial structures of railway vehicles, optimization shapes and dimensions.

The project should result in the building of a test polygon with an S-shaped track for testing railway vehicles in line with international standard UIC 530-2. It should be mentioned that no such polygon existed in Serbia or the neighboring countries, up till now, and that the domestic railway car factories were forced to perform such research in countries of Western Europe, at very high prices. The project results directly cause a growth in competitiveness of domestic railway car factories on foreign markets. Also, conditions are created for increasing export through the possibility of car factories from neighboring states testing their cars on the polygon in Kraljevo.

2 TransBonus PROJECT

The TransBonus project (Transport EU-Western Balkan Network for Training, Support and Promotion of Cooperation in FP7 research activities) is co-managed by Novak Nedic, Mirko Djapic and Dragan Petrovic, while the project coordinator is the institution Applied Research and Communications (ARC) Fund – Sofia from Bulgaria. The project participants/institutions are:

- SenterNovem, Den Hague, Nederland,
- Foundation for Research and Technology Hellas (HELP-FORWARD), Thessaloniki, Greece,
- Integrated Resources Management (IRM) Company, Valeta, Malta,
- Higher school of Transport "Todor Kableshkov", Bulgaria,
- University of Kragujevac, Faculty of Mechanical Engineering Kraljevo, Serbia,
- Automotive center - Centar for Vehicles, Sarajevo, Sarajevo, Bosnia and Herzegovina,
- University of Skopje, Faculties of Mechanical Engineering Skopje, Macedonia and
- Polytechnic University of Tirana, Mechanical Engineering Faculty, Albania

The overall objective of TransBonus is to improve and promote closer scientific and technological (S&T) cooperation opportunities between European Member States (Greece, the Netherlands, Malta and Bulgaria) and the Western Balkan Countries (WBCs: Albania, Bosnia and Herzegovina, Former Yugoslav Republic of Macedonia and Serbia). It further

seeks to establish a *Balkan Transport Network of Researchers, Universities and Experts* among these countries in order to improve and enlarge the research capacity of Western Balkan centers, competence in terms of research programs and human resources through trans-national placements of research staff and knowledge.

During the life span of the project, the partners carried out the following activities and contributions:

- Creation of a freely accessible database providing Collaboration and technology profiles for WBCs and Bulgarian transport research.
- Promotion of Research and Technological Development funding opportunities available at European level that can support international cooperation with WBCs transport researchers.
- Training and support in FP7 knowledge and best practices for academic personnel. Enhance the readiness of the Balkan transport research community to prepare cooperative activities and joint RTD proposals in European RTD programs.
- Setting up a matching tool – "Project Lab", supporting the creation and preparation of efficient and innovative project proposals. Stimulate partnering schemes and facilitated knowledge transfer at National and European level.
- Implementing expert study visits between WBC partners and EU partners in order to expand the specific relationships and networking between the two regions.
- Stimulate partnering schemes and national collaboration between researchers and the industry in the surface transport sector in the Balkan region.

The project was realized through six subprojects:

WP1 Identifying the existing capacities and specific researcher needs in the Western Balkan countries in terms of FP7 funding opportunities,

WP2 Partner training and support to WBC transport researchers of FP7 knowledge and practices for dissemination and effective support,

WP3 Setting up of a partnering tool – "Project Lab",

WP4 "Research Bonus" services,

WP5 Dissemination and awareness-raising,

WP6 Project Management.

In regard to the targets of the TransBonus project the Serbian partner collected 42 collaboration organization profiles which are a part of some research in the field of surface transport.

The structure of the Serbian research systems in surface transport consist of:

- Knowledge suppliers,
- Knowledge users,
- Research infrastructure and intermediaries and
- Organizations engaged on the national level.

Main results are: Training in 'Six hat' methodologies for new idea generation (figure 4) and translation of Manuals for researchers in the field of transport – 50 pages (figure 5).

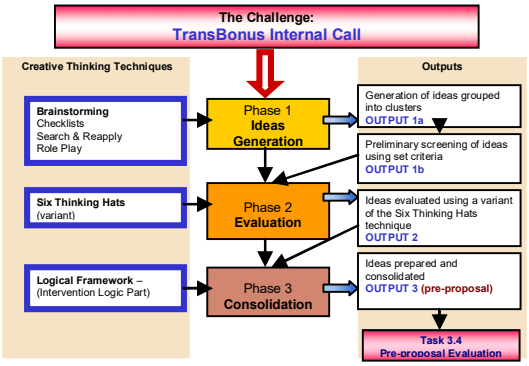

Fig.4. *Training in the 'Six hat' methodology*

Fig.5. *Manual for transport researchers*

The Faculty of Mechanical Engineering Kraljevo, organized in Serbia two "Idea Generation Events" (IGE) on September 10th

2009 and April 15th 2010. More than 40 new ideas were generated for the FP7 project. The direct results from this meeting are two new project proposals for the FP7 call from June 2010. On figures 6 and 7 are presented some of the parts of the SmartAxles project proposal.

List of participants:

Participant no. *	Participant organisation name	Country
1 (Coordinator)	University of Kragujevac, Faculty of Mechanical Engineering Kraljevo, (**FME**)	Serbia
2	University of Bologna, Department of Mechanical Engineering, (**DIEM**)	Italy
3	Higher School of Transport – Todor Kableshkov, (**FMCTT**)	Bulgaria
4	University of Belgrade, Faculty of Electrical Engineering, (**FEEB**)	Serbia
5	Integrated Microsystems Austria GmbH, (**IMA**)	Austria
6	The Laboratory for ICT Technologic Transfer, (**T3LAB**)	Italy
7	Optical Sensor Systems d.o.o., (**OSS**)	Serbia
8	Thermal Power Plants "Nikola Tesla" Ltd, (**TENT**)	Serbia
9	Rail Authority, (**RA**)	Czech Republic

Fig.6. *Part of the SmartAxles project proposal*

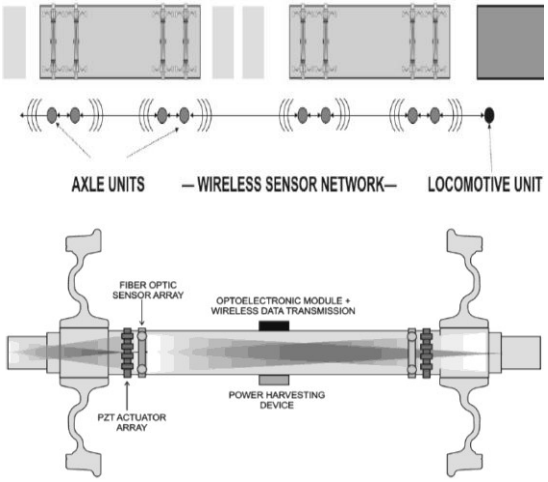

Fig.7. *Technical part of the SmartAxles project proposal*

Main results of WP4 are study visits (figure 8):

- Thessaloniki, October 1-2 2009,
- Sofia , November 5-8 2009,
- Sofia, January 27-29, 2010,
- Sarajevo, July 7-9, 2010,
- Netherlands (Den Hague, TU Delft and TU Eindhoven) September 15-18, 2010,
- Sofia, December 06-08, 2010.

Fig.8. *TransBonus study visits*

The TranBonus project was completed on December 31st, 2010. The researchers who were involved in its realization have a duty to

disseminate the knowledge and experience they gained by working on this project.

Regarding this, the researchers from the Faculty of Mechanical Engineering in Kraljevo had actively participated at the conference SEETRANS 2011 (Transport Research Opportunities for South East Europe In the EU) held in Ljubljana, Slovenia from April 12-13th, 2011. At this conference a possibility was given to researchers from Eastern Europe to present their ideas for new research projects and to attempt to find partners that would participate in this research. All this is linked to the upcoming publishing of the competition of the European Commission for projects that will be financed starting from 2012 by the framework programs of the FP7 program.

3 ATC SERBIA PROJECT

The project ATC - Automotive Training Centre for Central Serbia coordinated by the Polytechnic School in Kragujevac refers to enabling the technical staff in working in Fiat's factories that will be working with the new car industry technology in Serbia. The project managers on this project are Novak Nedic and Dragan Prsic. The project will last for two years and the following will participate:

- UNIBO – University in Bologna, Italy
- MFKG – Faculty of Mechanical Engineering in Kragujevac, Serbia
- MFKV – Faculty of Mechanical Engineering in Kraljevo, Serbia
- TFCK – Faculty of Technics, Chachak, Serbia
- IAL – Friuli – Venezia Giulia region, Italy
- RCCK– Regional Chamber of Commerce of Kragujevac, Serbia.

For the past two decades, the Serbian automotive industry, mainly located in the Central Serbian region, has gone through a very difficult period in its development. There was a drastic reduction of the market, reduction of production capacities, worker layoffs, losing step with technological development. At Kragujevac-based Zastava in 1989 worked 35,000 mainly involved in car production. This number had by 2000 gone down to 13,000 with only 3,500 workers working in Zastava in 2010. The negative trends in Zastava reflected on the supplier network that accompanied their production. Based on official reports of the Agency for Business Registers in Serbia around 160 companies from the field of the automotive industry are registered with a total of 25,000 employees. However, according to SIEPA standards, for the realization of current products and services demand in the field of the automobile industry, some 70 companies are sufficient.

This situation is a serious economic problem, with unwanted effects in other areas of the social life, especially in Central Serbia. The Serbian tradition in technics and knowledge, for years among the strongest in Europe, has faced the risk of a complete and speedy disappearance.
On the other hand, one of the leading global car manufacturers, Italian FIAT had officially expressed its intention in broadening its investments in Serbia, raising the level from the current 20,000 to 200,000 vehicles per annum since 2011. Accordingly, a significant demand for workers, technicians and engineers is to be expected, with somewhere around 3,000 employed in 2012. Furthermore, an increase in the number of employees in the ancillary industry is expected (Magneti Marelli has already signed a contract for significant investments in Sumadija region).
There are several problems that make the integration of FIAT into our environment harder and in general don't facilitate the development of the car industry:

- Outdated technology and production equipment;
- Poor connection between education institutions (high schools and faculties) and companies;
- The lack of specialized educational programs;
- The lack of courses for retraining and additional training of workers.
- Lack of experts for project management;
- Lack of entrepreneurial initiative;

This project has as a goal to advance the level of training in faculties and technical schools in Central Serbia so as to prepare the people in line with the needs of the labor market. The project aims to reduce the existing gap between industrial requirements, and the offer of the educational system by bringing the syllabus and

labs up to date. The automobile sector is exposed to intensive technological innovation, and the high schools and faculties can't keep up with this. Therefore this proposal is aimed at testing a new training model for high school students and workers that would use new teaching resources (labs, education at work).

The Faculty of Mechanical Engineering of Kraljevo is one of the partners on the realization of development projects of the automobile training center of Central Serbia. The goal is to promote the skills and knowledge from the field of hydraulics and pneumatics, as parts of a broader specter of knowledge that characterize the modern car industry. Activities unfold in two directions:

- The modernization of syllabuses and their adapting to the needs of the car industry. Training for different levels is envisaged (figure 9).
- Equipping the didactical lab for hydraulics and pneumatics as support to practical teaching.

Fig.9. *The experimental device for training of specialists for work in the automotive industry*

It is planned that training in the training center for hydraulics and pneumatics is realized through five thematic wholes (figure 10):

- Hydraulics and pneumatics.
- Measuring and acquisition of data in fluid techniques.
- Management systems in fluid techniques.
- Software tools in fluid techniques.
- Use of hydro-pneumatic systems in the car industry.

Fig.10. *Laboratory equipment for the project ATC Serbia*

The classes will go through 15 themed courses of modular type, suited to different levels of enrollee knowledge (figure 11).

1. Basic principles in hydraulics and pneumatics
2. Hydraulic and electro-hydraulic components
3. Hydraulic and electro-hydraulic systems
4. Pneumatic and electro- pneumatic components
5. Pneumatic and electro-pneumatic systems
6. Measure transducer and data acquisitions in hydraulic and pneumatic systems
7. Control of hydraulic and pneumatic systems
8. Hydraulic brake systems - basic course
9. Hydraulic brake systems - advanced course
10. Pneumatic brake systems - basic course
11. Pneumatic brake systems - advanced course
12. Hydraulic suspension systems
13. Pneumatic suspension systems
14. Software tools for engineering calculations in hydraulic and pneumatic systems
15. Software tools for modeling and simulation hydraulic and pneumatic systems

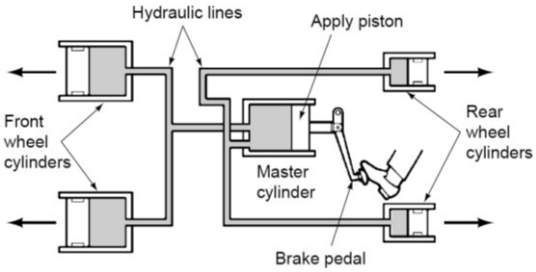

Fig.11. *Scheme of the hydraulic brake system for cars*

For practical teaching are planned 4 training desks: for hydraulics, pneumatics, braking and leaning.

4 IMPuls PROJECT

IMPuls - Innovation Management for new Products is a project backed by IPA funds, and was gotten by the invitation of the Regional Socio-Economic Development Program II (RSEDP2). The project manager is Snezhana Chirich Kostich, PhD and is realized by the Faculty for Mechanical Engineering of Kraljevo, while the participants are:

- Regional Chamber of Commerce of Kraljevo,
- City of Kraljevo,
- DIEM Department of the University in Bologna and
- Regional Center for the Development of Small and Medium-sized companies – Kruševac.

The basic goal of the project is to raise the competitiveness of small and medium-sized companies in the Morava, Rasina and Raska districts. The expected project results are:

- Regular on-line informing about new technologies for a faster development of products for 500 companies,
- Monitoring and continued systematic valuating of competitiveness of 200 companies,
- Increasing capacities for innovations in 100 companies,
- The development of the 300 CAD model of products and the appropriate technical documents for the needs of 100 companies
- The development of 100 prototypes of new products for the requirements of 50 companies.

The project idea is governed by results and experiences of previous projects performed by partners in the past. The recent projects "Strategy for Competitive and Innovative Small and Medium-sized Enterprises 2008 - 2012" and "Assessment of the Level of Innovativeness and Competitiveness in the SME Sector in the Raska and Morava Districts" showed that the key for improvement of competitiveness of companies from the Morava, Raska and Rasina Districts is the development of new and improved products which would be more attractive to customers.

The conclusion leads to an idea to achieve the overall objective of the campaign, improvement of competitiveness of the manufacturing industry of companies in the Morava, Raska and Rasina Districts, through enhancing innovation activities in the companies by modern design technologies, as a specific objective. The project addresses not only the technical aspect of innovation, but also considers support to product implementation and marketing, considering the product from the marketing aspect, tending to measure competitiveness through the capacity to generate revenue.

The expected result is support to the development of 300 models of new and improved products in 100 companies and 100 prototypes of new and improved products in 50 companies from all three considered districts over a period of 24 months. A fast development of such a large number of products will be facilitated by application of modern fast design methods, reverse engineering and rapid prototyping. Therefore, the first activity of the project activities will be the establishment of a technological basis for rapid product development.

The technology basis for the project will be established at the Faculty of Mechanical Engineering Kraljevo, located in the geographical centre of the considered region. The present knowledge, equipment and software will be complemented by a 3D scanner and a 3D printer which will be provided for the purposes of the project and training of personnel for application of the new equipment. The faculty will be in this activity supported by the DIEM department of University of Bologna that already has experience in rapid development technologies.

The second project scope of activities comprises the development of models for new and improved products. The faculty of Mechanical Engineering in Kraljevo will provide initial information on rapid development technologies on the project website and organize on-line support to at least 500 companies from the considered region. The faculty will also organize suitable quick courses for 100 targeted companies in order to facilitate efficient communication between the Faculty of Mechanical Engineering

Kraljevo and the companies during the process of rapid product development.

The companies that will be supported will be selected by the Regional Center for SME Development Kruševac, center for the Rasina District and Regional Chamber of Commerce Kraljevo, which is gathering companies from the territory of the Morava and Rashka district. The criteria for selection will be results obtained in the project "Assessment of the level of Innovativeness and Competitiveness in the SME Sector in the Raska and Morava District", while also taking into consideration the regional distribution and issues of gender equality and vulnerable groups (figure 12). In this process, the companies will provide the technical documentation for the proposed new products, and in cases where such documentation does not exist, the Faculty of Mechanical Engineering Kraljevo will apply a reverse engineering methodology for a fast development of models of present products which are going to be the basis for development of new and improved products, and more competitive compared to existing ones.

In the third project activity, the development of prototypes of new products, the Faculty of Mechanical Engineering Kraljevo will apply rapid prototyping techniques to produce a very large number of prototypes in a short period of time. Prototypes will be examined by the relevant criteria, and companies will afterwards submit documentation for the revised prototypes, which will also be made in a short period of time. In cases where it is needed, the Faculty of Mechanical Engineering Kraljevo will also support the production of tools and moulds by rapid prototype technologies.

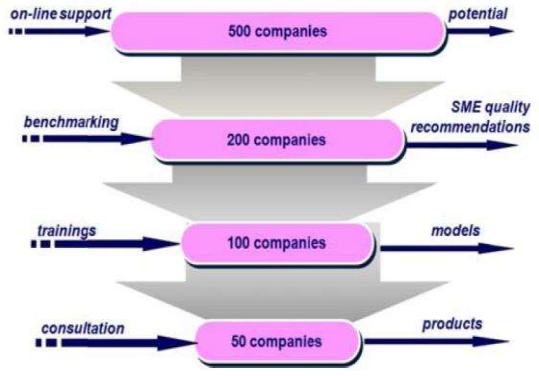

Fig. 12. *Structure of core goals of the IMPuls project*

After the technical phase of development of new products, targeted companies will receive consulting services regarding the implementation and marketing of each individual product as the fourth project activity, in order to provide for maximal market effect of new products. Consulting will be provided by the Regional Center for SME Development in Krushevac, the Center of the Rasina District, which will engage consultants to develop plans on how to make improvements or adapt specific best practices with the aim of increasing business performance and market positions of companies who will utilize new products created in this project.

The Regional Center for SME Development Kruševac will also provide analysis of project results as the fifth project activity, by benchmarking a change of competitiveness and innovation capacity of supported companies against companies that have not received the support during the project. Competitiveness benchmarking will enable comparison of business processes and performance metrics and also enable further improvements from learning – which means doing things better, faster, and cheaper. Benchmarking in enterprises will include measuring and benchmarking of 5 dimensions of competitiveness (speed, dependability, flexibility, quality, price) and 11 dimensions (innovative activities, innovative politics, innovative goals, innovation sources, innovation expenses, innovation strategy, innovative practice, obstacles or innovation, market orientation, factors of innovation, innovation motivation) of innovation capacity for each of the 200 enterprises included in the project. The goal of the benchmarking would be measuring the relation between competitiveness of the companies before and after the implementation of new product development and their market utilization.

5 CONCLUSION

Project SeRViCe is a foundation for the further development of science and research potential of the Faculty of Mechanical Engineering in Kraljevo in the area of promoting security, safety and comfort of riding railway vehicles. In that regard, great importance will have diversified measuring equipment and realized contacts with institutions in member countries of the EU, Russia and Turkey.

The TransBonus project has fullfilled its basic goals in relation to requests and expectations of the Faculty of Mechanical Engineering in Kraljevo and the broader regional community in the field of surface transport. Over 40 ideas have been generated for new projects in the field of surface transport, two of which were entered at the invitation of the European Commission from June 2010. Researchers from Serbia had a chance to visit the leading universities in the Netherlands (Delft and Eindenhoven) and to become familiar with the latest research there and which are related to the field of surface transport.

Project ATC Serbia will enable for our engineers, technicians and highly qualified workers to overcome new technologies that are today applied in the automobile industry and to provide employment in the Fiat factories in Kragujeac, which will further affirm the Faculty of Mechanical Engineering in Kraljevo as a scientific institution that develops its own program for domestic industry needs.

Project IMPuls will provide for the development of small and medium-sized companies in the Republic of Serbia on the basis of introducing modern technologies of product design and technologies and the transfer of knowledge and experiences from the Universities of developed European countries.

Through the realization of international research projects will be conducted the education of a large number of researchers according to the methodology of the Universities of countries of the EU, which will contribute to the integration of the Faculty of Mechanical Engineering in Kraljevo into European flows and the raising of the overall scientific and technical-technological level of our country as a whole.

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