

## THE NEW DEVELOPMENT TREND OF OPERATIONAL RESEARCH IN CIVIL ENGINEERING AND SUSTAINABLE DEVELOPMENT AS A RESULT OF COLLABORATION BETWEEN GERMAN–LITHUANIAN–POLISH SCIENTIFIC TRIANGLE

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**Abstract.** In this article the scientific cooperation between the three academic centres from Germany, Lithuania and Poland, represented by Prof. F. Peldschus (Leipzig University of Applied Sciences), Prof. E. K. Zavadskas (Vilnius Gediminas Technical University), and Prof. O. Kapliński (Poznan University of Technology), is presented. Formal meetings have been called Colloquia, and were organized every two years in different academic centres.

The research achievements and activities during the period of 2007–2009 are presented. The main research fields of OR in Civil Engineering and Sustainable Development of three academic centres are surveyed. As a result of productive collaboration in the period between the 11th and 12th Colloquiums, several postdoctoral theses and doctoral dissertations were defended, research papers and books were published and conferences were organized with published proceedings, etc. On the basis of these achievements EURO Working Group OR in Sustainable Development and Civil Engineering (EWG-ORS DCE) was established.

**Keywords:** collaboration, sustainability, operational research, civil engineering, development.

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### 1. Introduction

Active collaboration between German - Lithuanian - Polish scientific triangle caused the new development trend of research. The research areas till 2009 were limited to Operational Research (OR) and Civil Engineering. Prof. E. K. Zavadskas raised the idea to analyse Operational Research and Civil Engineering in the context of sustainability. These issues were analysed at the 12<sup>th</sup> colloquium. As the consequence of new trend of research development the EURO Working Group OR in Sustainable Development and Civil Engineering (EWG-ORS DCE) was established.

## **2. The idea and development of German–Lithuanian–Polish scientific triangle**

During thirty years of scientific cooperation of three academic centers, i.e. Leipzig University of Applied Sciences, Vilnius Gediminas Technical University and Poznan University of Technology, due to the main initiators Prof. E. K. Zavadskas, Prof. F. Peldschus and Prof. O. Kapliński the active collaboration has started. Collaboration in exchanging of research achievements, consulting on publications, cooperating in joint papers, supporting the future research was realized through organization of colloquiums, which were held every two years in different academic centres (Kaplinski 2009a).

Five of mentioned colloquiums were organized in Germany, four held in Lithuania and three in Poland. Every colloquium from the first one held in 1986 and to the last had given the considerable contribution to the publication of research papers and books, development of further academic research, preparing doctoral dissertations and for international recognition (Fig. 1).

The initiating members of the first colloquium held in 1986 were Prof. K. Fiedler (Leipzig Higher Technical School), Dr F. Peldschus (Leipzig Higher Technical School) and Dr E. K. Zavadskas (Vilnius Civil Engineering Institute). The second colloquium was held in 1989 and representative from Poland Prof. O. Kaplinski was invited (Zavadskas 2008b).

The 11<sup>th</sup> German–Lithuanian–Polish Colloquium “Planning Instruments in Construction Management”, which took place in Kołobrzeg, Poland in 2007, was organized by Poznan University of Technology. The major theme of this colloquium was planning instruments in construction management (Zavadskas 2008e).

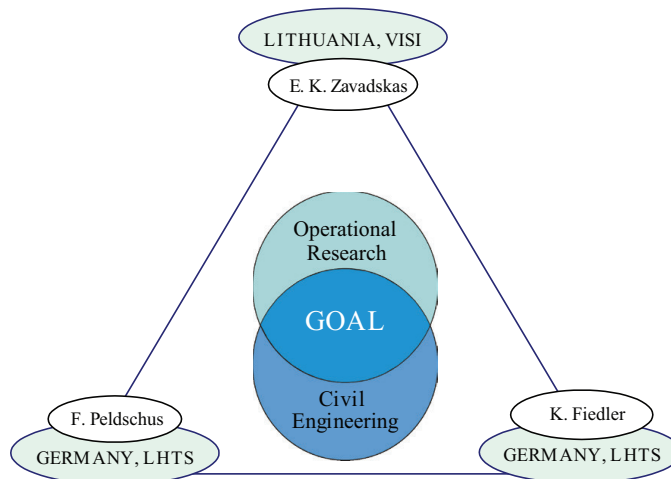
There were also other subjects analysed such as development and usefulness of planning techniques, intelligent green construction, investment problems in cooperating countries, artificial intelligence, facility management, life cycle of objects, achievements and application of Multi-Criteria Decision Analysis (MCDA) and Multi-Criteria Decision Making (MCDM) methods (Kapliński 2010).

In the colloquium further research on the aspects of operational research methods, sustainable development and its application for problem solution in civil engineering was initiated. The 11<sup>th</sup> colloquium was exceptional due to aspiration to make the achievements of colloquiums known to the scientists of other European Union countries, and the idea to create the working group of “Operation Research in Sustainable Development and Civil Engineering” has originated. Prof. E. K. Zavadskas on the basis of his long-term scientific research, with his former PhD students, now colleagues, initiated the implementation of the mentioned idea.

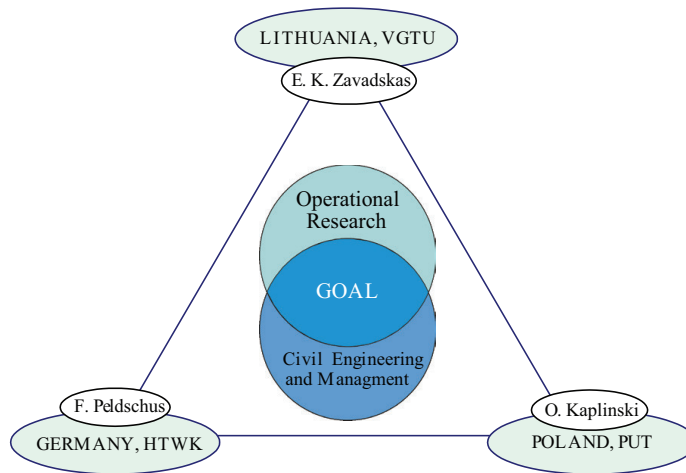
This purpose required further cooperation in the area of Sustainable Development and Construction problems (Zavadskas 2008b). The mentioned area was the core topic of the 12<sup>th</sup> colloquium, which was organized by Vilnius Gediminas Technical University.

The 12<sup>th</sup> German–Lithuanian–Polish Colloquium was held in Vilnius, Lithuania, on 20–24 May 2009. It was entitled “Sustainable Development in Civil Engineering and

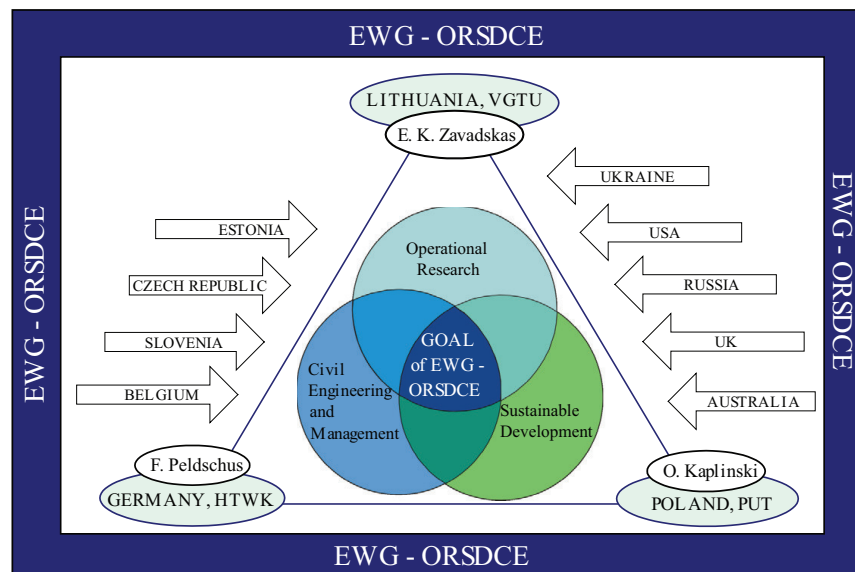
1986  
The 1<sup>st</sup> Colloquium



2007  
The 11<sup>th</sup> Colloquium



2009  
The 12<sup>th</sup> Colloquium  
and establishment  
of EWG-ORSDCE



**Fig. 1.** Development of collaboration between three German–Lithuanian–Polish academic centres during 1986–2009

Multi-Attribute Decision Making”. The chairman of International Programme Committee was Prof. Habil. Dr E. K. Zavadskas and responsibility to be the chairman of organizing committee was assumed by one of the first Prof. E. K. Zavadskas’ PhD students, now Prof. L. Ustinovičius. The theme of colloquium covered two broadly defined areas: the first one is the development of operational research (OR) methodology and the second - Sustainable Development in Civil Engineering and Management. 56 scientists from 7 European and other countries took part in the 12th German–Lithuanian–Polish colloquium and new participants from Czech Republic, Slovenia, UK, US have joined the scientific collaboration. 43 papers were presented during the meeting and abstracts had been published (Vilutiene 2009).

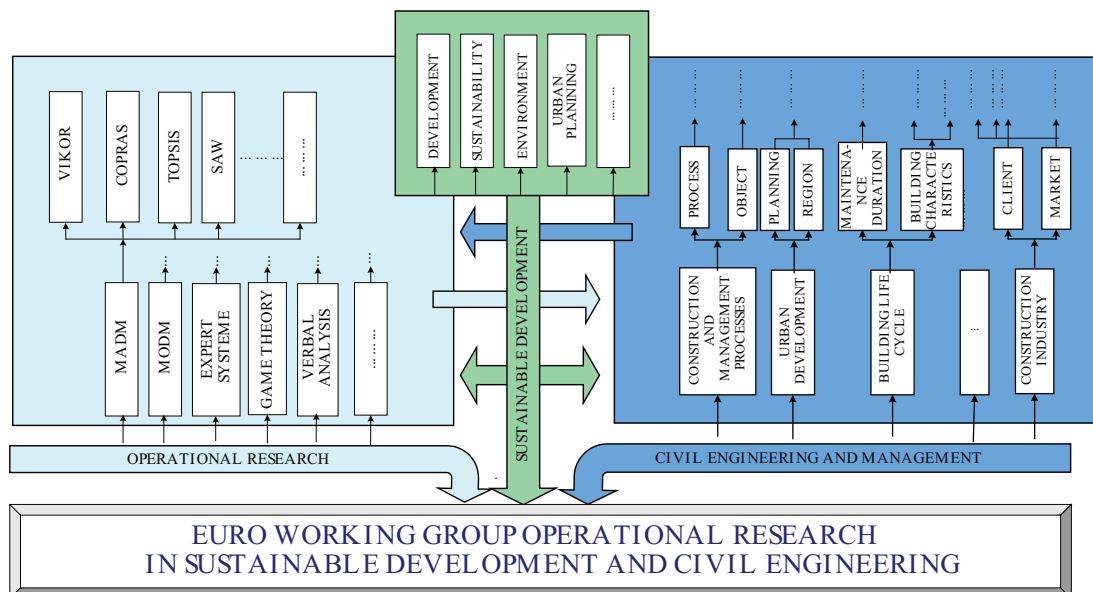
As a result of unique collaboration between three academic centres during the period of 2007–2009 on the basis of aforementioned themes, the high research achievements were obtained and EWG-ORSDC was established. The achievements during the period from the 11<sup>th</sup> to 12<sup>th</sup> colloquia are further analysed in the next section.

### 3. The achievements and activities in scientific research during 2007–2009

The achievements gained from 1986 until 2007 were surveyed by (Kapliński 2009a, c; Zavadskas 2008b). The productive collaboration during the period of 2007–2009 resulted in the following achievements divided into these groups: defended postdoctoral and PhD theses; published books, conference proceedings; organized conferences, published research papers in the journals and conference proceedings. The mentioned achievements are further analysed.

#### 3.1. Main aspects of research development

The fields of the research concentrate in three broad fields (Fig. 2).



**Fig. 2.** The general topics of the new working group OR in Sustainable Development and Civil Engineering activities

The fields of the research are:

- 1) Operational Research: operations research theory, MCDM, MADM methods, statistics, optimization, strategies, game theory, intelligent support system, etc.;
- 2) Civil Engineering: building life-cycle, urban development, construction and management, maintenance, approaches for construction problems', effectiveness' assessment, automation in construction;
- 3) Sustainable Development: developing of alternative construction processes, economic and other aspects, sustainable development challenges for business and management in construction enterprises, political influence dimensions of sustainability, technological change, innovation and sustainability, sustainable building design, environmental impact processes.

Broad fields as well as narrow groups compose the goal of EWG-ORS DCE.

### **3.2. Achievements in books, postdoctoral and PhD theses publication**

The scientific achievements during the period from the 11th German–Lithuanian–Polish Colloquium until 12th German-Lithuanian-Polish Colloquium are presented in Table 1.

**Table 1.** Number of books, defended postdoctoral theses (Dr Sc) and Doctoral theses(PhD)

Scientific results	Year			Total
	2007	2008	2009	
Number of books	4	4	5	13
Number of Conferences Proceeding books	3	2	3	8
Postdoctoral theses (Dr Sc) defended	0	0	3	3
Doctoral theses defended (PhD)	0	6	5	11

As a result of these activities the monographs, manuals, etc. were published covering the following topics: the methods and models in engineering (Kaplinski 2007); new construction, urban planning and utilities problems (Lias 2007a); multicriteria solution problem in construction (Zavadskas and Kaklauskas 2007); construction technology (Zavadskas *et al.* 2007e); fundamentals of enterprises management (Ginevičius and Silickas 2008); theory of organisation (Ginevičius and Sūdžius 2008); theory and practice of facilities management (Lepkova and Vilutienė 2008); technology of construction processes (Zavadskas *et al.* 2008i); information and intelligent technologies (Kaklauskas 2009); urban sustainability and governance (Kaklauskas 2009; Kaklauskas and Holt-Jensen 2009; Lepkova *et al.* 2009); construction organization (Zavadskas *et al.* 2009d); economics for the modern built environment (Ruddock 2009).

During 2007–2009 3 postdoctoral theses were defended. Postdoctoral thesis title of S. Mitkus (2009) (Lithuania) was “Modeling of Preparation of Construction Management Decisions Evaluating Law Environment of Construction” and thesis title of Z. Turskis (2009) (Lithuania) was “Multi-attribute assessment modeling of buildings’ life cycle”. M. Nowak (2008) (Poland) defended his postdoctoral thesis „Interactive multi-criteria decision aiding under risk: methods and applications”.

During this period PhD theses were defended: 10 from Lithuania (Jakimavičius 2008;

Keršulienė 2008; Mickaityte 2008; Naimavičienė 2008; Viteikienė 2008; Anikenienė 2009; Kalibatas 2009; Šliogerienė 2009; Tamošaitienė 2009; Urbanavičienė 2009) and 1 from Poland (Gajzler 2008b).

### **3.3. Publication in journals and proceedings**

The research papers during 2007–2009 were published in 29 scientific journals in different research fields. The contribution of each country considering fields of research is presented in Fig. 3.

The published articles and proceedings during 2007–2009 are approximately 196 papers. Three papers in 2009–2010 were nominated by ScienceWatch.com. It has tracked the following papers which had the highest percentage increase in citations in Essential Science Indicators<sup>SM</sup> of Thomson Reuters (<http://sciencewatch.com>):

- In June 2009 as Fast Breaking Paper in the field of Economics & Business the paper prepared by Turskis (2008) was selected;
- In January 2010 as New Hot Papers in the field of Economics & Business the paper prepared by Ginevičius *et al.* (2008b) was selected and in the field of Engineering the paper prepared by Zavadskas *et al.* (2008f) was selected.

The authors of surveyed scientific publications are not necessarily the participants of these aforementioned colloquia but they actively work in achieving the goals of EWG-ORSDCE. These high achievements in publishing articles became the basis for the establishment of EWG-ORSDCE.

### **3.4. Organization of International Conferences**

For the scientific activity during 2007–2009 7 international conferences were organized. The 5 of them were organized by Vilnius Gediminas Technical University (Zavadskas 2008f):

- the 9th International Conference „Modern building materials, structures and techniques” (May 16–18, 2007, Vilnius, Lithuania) (Skibniewski *et al.* 2007). On the basis of this conference special Issue of The Baltic Journal of Road and Bridge Engineering was published.
- the 11th Lithuanian–German–Polish Colloquium “Planning instruments in construction management” (October 23–25, 2007, Kolobrzeg, Poland) (Kapliński 2007, 2008d).
- the 20th International Conference, EURO Mini Conference “Continuous Optimization and Knowledge-Based Technologies” (EurOPT-2008) (May 20–23, 2008, Neringa, Lithuania). The Proceedings book (Sakalauskas *et al.* 2008) of selected papers as well as special issues in the journals *Informatika* (Dzemyda and Sakalauskas 2009) and *Technological and Economic Development of Economy* (Sakalauskas and Zavadskas 2009) have been published.
- the 25th International Symposium on Automation and Robotics in Construction ISARC-2008 (June 26–29, 2008, Vilnius, Lithuania). The Proceedings book of

Publications in journals		Publications in proceedings	
2009	2008	2007	2008
Research fields		Research fields	
Peldschus 2009	Brauers et al. 2008a Peldschus 2008a, b, c Reichelt et al. 2008		Brauers et al. 2008b Kaklauskas et al. 2008a Mikus and Trinkumiene 2008 Saparauskas 2008 Sivilevičius et al. 2008a Tamosaitis 2008b Ustinovichius et al. 2008a Ustinovichius et al. 2008c Zavadskas et al. 2008o
Kaklauskas et al. 2009b Liudanskienė et al. 2009 Maskeliūnaitė et al. 2009 Podovazko 2009 Podovazko and Podoviazko 2009 Sivilavičius and Sukavičius 2009 Urbanavičienė et al. 2009a Urbanavičienė et al. 2009b Ustinovicius et al. 2009 Zavadskas et al. 2009b Sakalauskas and Zavadskas 2009 Zavadskas and Vaidogas 2009	Banaitiene et al. 2008 Brauers and Zavadskas 2008 Brauers et al. 2008a Brauers et al. 2008b Ginevičius 2008 Ginevičius and Podvezko 2008e Ginevičius et al. 2008c Mickaitytė et al. 2008 Podvezko 2008a Sivilevičius et al. 2008b Ustinovichius and Kochin 2008 Zavadskas 2008a Zavadskas 2008c Zavadskas et al. 2008f Zavadskas et al. 2008k	Peldschus 2007 Ginevičius and Podvezko 2007b Ignatavičius et al. 2007 Kaklauskas et al. 2007a Turskis et al. 2007 Ustinovichius et al. 2007a Ustinovichius et al. 2007c Vilutiene and Turskis 2007 Zavadskas et al. 2007g Nowak 2007a Sobotka and Czarnigowska 2007 Kutui et al. 2007 Ustinovichius et al. 2007a Ustinovichius et al. 2007b	Blaszyk and Nowak 2008 Kapłinski 2008a Kapłinski 2008b Paślawski 2008d Wiecekowi and Skibniewski 2008 Brauers et al. 2008b Skibniewski 2008 Skibniewski and Ghosh 2008 Ustinovichius et al. 2008a Ustinovichius et al. 2008c Wiecekowi and Skibniewski 2008 Vaimiūnas et al. 2009 Kapłinski 2009b
Kapłinski 2009a Kapłinski 2009c Kapłinski 2009e Ustinovichius et al. 2009 Zavrli et al. 2009	Hajdasz 2008a Kapłinski 2008c Brauers et al. 2008a Mallene et al. 2008b	Brauers and Zavadskas 2007 Kaklauskas et al. 2007b Migliniskas and Ustinovichius 2007 Ustinovichius 2007 Vaidogas and Zavadskas 2007 Zavadskas et al. 2007b Nowak 2007b Lias 2007b Yeigin and Lepkova 2007	
	Brauers et al. 2008c Ginevičius and Podvezko 2008c Ginevičius and Podvezko 2008d Kaklauskas et al. 2008b Morkvenas et al. 2008 Lepkova et al. 2008 Podvezko 2008b Reichelt et al. 2008 Shevchenko et al. 2008 Zavadskas 2008d Zavadskas et al. 2008a Zavadskas et al. 2008k Zavadskas et al. 2008p Zavadskas et al. 2008q Zavadskas et al. 2008r Zavadskas et al. 2008s		Ginevičius et al. 2008a Kaklauskas et al. 2008c Kaklauskas et al. 2008d Migliniskas and Ustinovichius 2008 Tamosaitiene et al. 2008 Tamosaitis 2008a Ustinovichius 2008b Vilutiene 2008 Zavadskas and Kaklauskas 2008b Zavadskas and Vaidogas 2008 Zavadskas et al. 2008b Zavadskas et al. 2008g Zavadskas et al. 2008m Gajzler 2008a Karłowski 2008
Turskis et al. 2009 Ginevičius 2009 Ginevičius and Zubrecovas 2009 Kaklauskas et al. 2009a Turskis et al. 2009 Zavadskas et al. 2009c Kapłinski 2009d.	Hajdasz 2008b Kapłinski 2008d Kapłinski 2008e Meszek 2008 Paślawski 2008a Paślawski 2008b Bejler et al. 2008 Brauers et al. 2008c Mallene et al. 2008b Paadam and Lias 2008	Ginevičius 2007 Ginevičius and Podvezko 2007b Ginevičius et al. 2007 Kaklauskas et al. 2007c Ustinovichius et al. 2007d Vaidogas et al. 2007	
Germany	Lithuania	Poland	Other countries

Publications in journals			Publications in proceedings		
2009	2008	2007	2007	2008	2009
<p>Brauers and Ginevičius 2009 Brauers and Zavadskas 2009 Burninskienė 2009 Burninskienė and Rudzkiene 2009 Ginevičius and Ginevičienė 2009 Ginevičius and Podvezko 2009 Jakimavičius and Burninskienė 2009a Jakimavičius and Burninskienė 2009b Jonaskauskienė and Demčiuk 2009 Kaklauskas <i>et al.</i> 2009c Sliogerienė <i>et al.</i> 2009 Zavadskas <i>et al.</i> 2009a</p> <p>Paslawski 2009 Brauers and Ginevičius 2009 Brauers and Zavadskas 2009 Malienė and Malys 2009 McDonald <i>et al.</i> 2009</p>	<p>Antuchevičienė and Zavadskas 2008 Ginevičius and Krivka 2008 Ginevičius and Podvezko 2008a Ginevičius and Podvezko 2008b Tvaronavičienė <i>et al.</i> 2008 Zavadskas and Kaklauskas 2008a Zavadskas and Kaklauskas 2008c Zavadskas and Turskis 2008 Zavadskas <i>et al.</i> 2008n Zavadskas <i>et al.</i> 2008p</p> <p>Kapiriski 2008c Karłowski and Paslawski 2008 Paslawski 2008c Thiel 2008a Thiel 2008b Maliene <i>et al.</i> 2008a Maliene <i>et al.</i> 2008b</p>	<p>Banaitis and Banaitiene 2007 Burninskienė and Rudzkiene -2007a Burninskienė and Rudzkiene 2007b Ginevičius and Podvezko 2007a Jakimavičius and Burninskienė 2007a Juškevičius and Burninskienė 2007b Viteikienė and Zavadskas 2007 Zavadskas and Antuchevičienė 2007 Zavadskas and Burninskienė 2007 Zavadskas <i>et al.</i> 2007a Zavadskas <i>et al.</i> 2007c Zavadskas <i>et al.</i> 2007h Yeigin and Lepkova 2007</p>	<p>Sustainable Development and Urban Planning</p>	<p>Matuliauskaitė <i>et al.</i> 2008 Zavadskas <i>et al.</i> 2008c Zavadskas <i>et al.</i> 2008d Zavadskas <i>et al.</i> 2008h Zavadskas <i>et al.</i> 2008j Zavadskas <i>et al.</i> 2008i</p>	<p>Zavadskas <i>et al.</i> 2009c</p>
Germany	Lithuania	Poland	Other countries		
<p>Control and Cybernetics European Journal of Operational Research Informatica</p>			<p>Archives of Civil Engineering Automation in Construction Business: Theory and Practice Computer-Aided Civil and Infrastructure Engineering Computer Modeling and New Technologies Engineering Applications of Artificial Intelligence Evolution of Science and Technology International Journal of Management and Decision Making International Journal of Strategic Property Management International Journal of Technology Management Inzinerine Ekonomika-Engineering Economics Journal of Business Economics and Management Journal of Civil Engineering and Management Local Economy Omega – International Journal of Management Sciences Technological and Economic Development of Economy The Baltic Journal of Road and Bridge Engineering Transformations in Business &amp; Economics Transport</p>		
OR			CIVIL ENGINEERING AND MANAGEMENT		
Journal included in Web of Science database			Journal included in other database		
Title of the journal			Title of the journal		
Building and Environment Ekologija Energy and Buildings Geodesy and Cartography International Journal of Environment and Pollution Journal of Environmental Engineering and Landscape Management			SUSTAINABLE DEVELOPMENT		

Fig. 3. Scientific publications in journals and proceedings of each country and journals title during 2007–2009



selected papers was published (Zavadskas *et al.* 2008c). The Special Issue of expanded papers on the basis of this Symposium has been published in scientific journal *Automation in Construction* (Kaklauskas *et al.* 2010; Popov *et al.* 2010; Ustinovichius *et al.* 2010; Zavadskas 2010a, b).

- International Conference “Reliability and Statistics in Transportation and Communication” (RelStat’08) (October 15–18, 2008, Riga, Latvia) (Kabashkin and Yatskiv 2008).
- the 13<sup>th</sup> International Conference “Applied Stochastic Models and Data Analysis” *ASMDA-2009* (June 30 – July 3, 2009, Vilnius, Lithuania). The Proceedings book has been published (Sakalauskas *et al.* 2009).
- the 5th International Conference EURO Mini Conference “Knowledge-Based Technologies and OR Methodologies for Strategic Decisions of Sustainable Development” *KORS-2009* (September 30 – October 3, 2009, Vilnius, Lithuania). Proceedings of selected papers have been published (Grasserbauer *et al.* 2009). In addition Special Issue of the *Technological and Economic Development of Economy* containing expanded versions of the selected papers will be published.

#### **4. Establishment of new EURO Working Group EWG-ORS DCE**

On the basis of the analysed wide range of topics during the 12th and the previous colloquiums and under the initiative of Prof. Edmundas Kazimieras Zavadskas the proposal to create EURO working group “OR in Sustainable Development and Civil Engineering (EWG-ORS DCE)” was prepared and presented to the participants of the 12<sup>th</sup> German–Lithuanian–Polish colloquium. The scientists approved the proposal by their signatures and decided to submit this proposal to EURO (Association of European Operational Research Societies) Executive Committee during the annual 23rd European Conference on Operational Research „OR creating competitive advantage”, which took place in Bonn, Germany, 5–8 July 2009.

To the Board of EURO working group Prof. Edmundas Kazimieras Zavadskas, Prof. Leonidas Sakalauskas, Prof. Marija Burinskiene, Assoc. Prof. Tatjana Vilutiene (Vilnius Gediminas Technical University), Prof. Oleg Kaplinski (Poznan University of Technology), Prof. Friedel Peldschus (Leipzig University of Applied Sciences), Assoc. Prof. Jana Selih (University of Liubliana) and Dr Vida Maliene (Liverpool John Moores University) have been elected.

EURO committee during the EURO 23rd Conference in Bonn has discussed the proposal and approved the establishment of new working group under the sign of EURO. Currently the group joins 80 members from 19 countries (Lithuania, Germany, Poland, United Kingdom, Belgium, Denmark, Netherlands, Portugal, Latvia, Estonia, Czech Republic, Slovenia and Romania, Peru, Mexico, Russia, Ukraine, Australia and USA).

The scope of problems in research activities of the Working Group OR in Sustainable Development and Civil Engineering covers a wide range of rational decision-making problems within the field of sustainable development and civil engineering.

For more information regarding EWG-ORS DCE, its objectives, members, publications

written in the field of Operational Research and activities of EURO Working Group OR in Sustainable Development and Civil Engineering (EWG-ORSDC) visit the official website <http://www.orsdce.vgtu.lt>.

## 5. Conclusions

The achievements and scientific results of collaboration between German–Lithuanian–Polish scientific triangles give the next trend of OR and Civil Engineering science development including sustainability.

The collaboration which took almost 30 years resulted in significant achievements, which were accomplished by approximately 100 participants of this activity.

The main result of this activity was establishment of new EURO Working Group OR in Sustainable Development and Civil Engineering (EWG-ORSDC).

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## **VOKIETIJOS – LIETUVOS – LENKIJOS MOKSLINIO TRIKAMPIO BENDRADARBIAVIMO REZULTATAS – NAUJAS ETAPAS OPERACINIŲ TYRIMŲ STATYBOS INŽINERIOJE IR DARNIOS PLĖTROS SRITYSE**

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Santrauka

Straipsnyje apžvelgiami mokslinio bendradarbiavimo rezultatai tarp Vokietijos, Lietuvos ir Lenkijos akademių centrų. Šių centrų susitikimai buvo vadinami kolokviumais, kurie buvo organizuojami kas antrus metus skirtingame akademiniam centre. Šiame straipsnyje apžvelgiami moksliniai pasiekimai ir nuveikti darbai 2007–2009 m., pateikiami Vokietijos, Lietuvos ir Lenkijos akademių centrų atlikti darbai operacinių tyrimų, statybos inžinerijos ir subalansuotos plėtros temomis. Produktyvaus bendradarbiavimo rezultatai nuo 11-ojo iki 12-ojo kolokviumo yra: apgintos habilitacinių darbų tezės bei daktaro disertacijos, paskelbti moksliniai straipsniai ir išleistos knygos, suorganizuotos mokslinės kon-



ferencijos ir išspausdinti konferencijų straipsnių rinkiniai. Remiantis šiais pasiekimais buvo įsteigta darbo grupė „OR in Sustainable Development and Civil Engineering“ (EWG-ORSDC).

**Reikšminiai žodžiai:** bendradarbiavimas, darba, operacijų tyrimai, statybos inžinerija, plėtra.

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