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-ORSDCE) 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 12th colloquium. As the consequence of new trend of research development the EURO Working Group OR in Sustainable Development and Civil Engineering (EWG-ORSDCE) 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 11th 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 (Kaplinski 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 11th 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 12th colloquium, which was organized by Vilnius Gediminas Technical University.

The 12th 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 1st Colloquium

2007
The 11th Colloquium

2009
The 12th 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-ORSDE was established. The achievements during the period from the 11th to 12th 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).
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-ORSDCE.

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.

| 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 (Kapliński 2007); new construction, urban planning and utilities problems (Liias 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 multicriteria 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 IndicatorsSM 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-ORS.DCE. These high achievements in publishing articles became the basis for the establishment of EWG-ORS.DCE.

### 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 Informatica (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
| 2009                  | 2008                   | 2007                   | 2009                  | 2008                   |
|-----------------------|------------------------|------------------------|-----------------------|------------------------|
| "Peldschus 2009"      | "Brauers et al. 2008a"| "Ginevicius and Podvezko 2006a" | "Brauers et al. 2008b"| "Kaklauskas et al. 2008a" |
| "Kaklauskas et al. 2009b" | "Ginevicius and Podvezko 2008a" | "Brauers 2008c" | "Gaklauskas et al. 2008b" | "Migilinskas and Ustinovicus 2008a" |
| "Liadamuziene et al. 2009" | "Ginevicius 2008c" | "Ustinovicius and Kedrinskis 2008" | "Brauers and Zavadskas 2007b" | "Ustinovicius et al. 2008a" |
| "Maskeviciute et al. 2009" | "Ginevicius 2008c" | "Vainiunas" | "Gaklauskas et al. 2008c" | "Ustinovicius et al. 2008b" |
| "Podorabka 2009"      | "Ginevicius 2008c" | "Zavadskas 2008a" | "Gaklauskas et al. 2008c" | "Ustinovicius et al. 2008c" |
| "Podorabka and Podorabka 2009" | "Ginevicius 2008c" | "Zavadskas 2008a" | "Gaklauskas et al. 2008c" | "Ustinovicius et al. 2008c" |
| "Sivilavičius and Sivilavičius 2009" | "Ginevicius 2008c" | "Zavadskas 2008a" | "Gaklauskas et al. 2008c" | "Ustinovicius et al. 2008c" |
| "Urbanavičiūnė et al. 2009a" | "Ginevicius 2008c" | "Zavadskas 2008a" | "Gaklauskas et al. 2008c" | "Ustinovicius et al. 2008c" |
| "Urbanavičiūnė et al. 2009b" | "Ginevicius 2008c" | "Zavadskas 2008a" | "Gaklauskas et al. 2008c" | "Ustinovicius et al. 2008c" |
| "Ustinovicius et al. 2009" | "Ginevicius 2008c" | "Zavadskas 2008a" | "Gaklauskas et al. 2008c" | "Ustinovicius et al. 2008c" |
| "Zavadskas et al. 2009b" | "Ginevicius 2008c" | "Zavadskas 2008a" | "Gaklauskas et al. 2008c" | "Ustinovicius et al. 2008c" |
| "Zavadskas et al. 2009" | "Ginevicius 2008c" | "Zavadskas 2008a" | "Gaklauskas et al. 2008c" | "Ustinovicius et al. 2008c" |
| "Kapliński et al. 2009a" | "Ginevicius 2008c" | "Zavadskas 2008a" | "Gaklauskas et al. 2008c" | "Ustinovicius et al. 2008c" |
| "Kapliński et al. 2009b" | "Ginevicius 2008c" | "Zavadskas 2008a" | "Gaklauskas et al. 2008c" | "Ustinovicius et al. 2008c" |
| "Kapliński et al. 2009c" | "Ginevicius 2008c" | "Zavadskas 2008a" | "Gaklauskas et al. 2008c" | "Ustinovicius et al. 2008c" |
| "Ustinovicius et al. 2009" | "Ginevicius 2008c" | "Zavadskas 2008a" | "Gaklauskas et al. 2008c" | "Ustinovicius et al. 2008c" |
| "Zavadskas et al. 2009" | "Ginevicius 2008c" | "Zavadskas 2008a" | "Gaklauskas et al. 2008c" | "Ustinovicius et al. 2008c" |
| "Kapliński et al. 2009d" | "Ginevicius 2008c" | "Zavadskas 2008a" | "Gaklauskas et al. 2008c" | "Ustinovicius et al. 2008c" |

**research fields**

- OR and Civil Engineering
- OR and Management in Civil Engineering
- Germany
- Lithuania
- Poland
- Other countries
**Research fields**

| Publications in journals | Publications in proceedings |
|--------------------------|-----------------------------|
| **2009** | **2008** | **2007** | **2008** | **2009** |
| Brauers and Ginevičius 2009 | Ginevičius and Podvezko 2008a | Antuchevičienė and Zavadskas 2008 | Sustainable Development and Urban Planning | Zavadskas et al. 2009 |
| Brauers and Zavadskas 2009 | Ginevičius and Podvezko 2008a | Buminis and Banarinienė 2007 | Matuliais et al. 2008 | Zavadskas et al. 2009 |
| Burinskienė 2009 | Ginevičius and Podvezko 2008b | Burinskienė and Rudzkienė 2007 |
| Burinskienė and Rudzkienė 2009 | Tveramavičius et al. 2008b | Zavadskas and Durys 2008 |
| Ginevičius and Ginevičienė 2009 | Zavadskas and Tomas 2007 | Zubavichūnas and Zavadskas 2007 |
| Ginevičius and Podvezko 2009 | Zavadskas et al. 2007a |
| Jakimavičius and Burinskienė 2009 | Zavadskas et al. 2007c |
| Jakimavičius and Burinskienė 2009b | Zavadskas et al. 2007b |
| Jovanaskienė and Demečius 2009 | Yetgin and Lepkova 2007 |
| Kaklauskas et al. 2009c | Zavadskas et al. 2009e |
| Sliogerienė et al. 2009 | Zavadskas et al. 2009f |
| Zavadskas et al. 2009a | Zavadskas et al. 2009h |
| Patulewski 2009 | Zavadskas et al. 2009i |
| Brauers and Ginevičius 2009 | Zavadskas et al. 2009j |
| Brauers and Zavadskas 2009 | Zavadskas et al. 2009l |
| Malienė and Malyš 2009 | Zavadskas et al. 2009m |
| McDonald et al. 2009 | Zavadskas et al. 2009o |

**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 13th 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” KORSID-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-ORSDCE

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-ORSDCE)” was prepared and presented to the participants of the 12th 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 Vilutieni (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-ORSDCE, 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-ORSDCE) 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-ORSDCE).

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**VOKIETIJOS – LIETUVOS – LENKILOS MOKSLINIO TRIKAMPIO BENDRADARBIAVIMO REZULTATAS – NAUJAS ETAPAS OPERACINIŲ TYRIMŲ STATYBOS INŽinerijoJE IR DARNIOS PLĖTROS SRITYSE**

**J. Tamošaitienė, L. Bartkienė, T. Vilutienė**

**Santrauka**

Straipsnyje apžvelgiami mokslinio bendradarbiavimo rezultatai tarp Vokietijos, Lietuvos ir Lenkijos akademinių centrų. Šių centrų susitikimai buvo vadinami kolokviumais, kurie buvo organizuojami kas antrus metus skirtingame akademiniame centre. Šiame straipsnyje apžvelgiami moksliniai pasiekimai ir nuveikti darbai 2007–2009 m., pateikiami Vokietijos, Lietuvos ir Lenkijos akademinių centrų atlikti darbai operacinių tyrimų, statybos inžinerijoje ir subalansuotos plėtros temomis. Produktiavus 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 išspausti konferencijų straipsnių rinkiniai. Remiantis šiais pasiektais buvo įsteigta darbo grupė „OR in Sustainable Development and Civil Engineering“ (EWG-ORSDCE).

Reikšminiai žodžiai: bendradarbiavimas, darna, operacijų tyrimai, statybos inžinerija, plėtra.

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