

DEVELOPMENT OF OPERATIONS RESEARCH IN YUGOSLAVIA — A COMPREHENSIVE SURVEY

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Abstract. On occasion of the promotion of first several issues of the Yugoslav Journal of Operations Research, which took place on the plenary session of the nineteenth Yugoslav Symposium on Operations Research (YU-SYM-OP-IS'92) in Belgrade, in October 1992. J. Petrić, Editor-in-Chief of YUJOR prepared a review of the development of Operations Research in Yugoslavia. The way it passed was necessary in order to put together the conditions for such a journal to appear. This text is dedicated to the promotion of the journal, aiming the in-depth consideration of its origins and everything that should be done before its first issue appeared.

Key words and phrases: development, OR, Yugoslavia, promotion, YUJOR.

1. INTRODUCTION

A long and strenuous way was needed to make the conditions for the publishing of the international scientific Yugoslav Journal of Operations Research. It lasted more than 25 years of organized and well coordinated work in the field of OR, which has been performed through various activities of scientific research, educating and journalistic character, and which, bit by bit, step by step, was completing the set of necessary conditions that brought to the promotion of the first numbers of YUJOR. This crowns and synthesizes a broad spectrum of activities of operations researchers in Yugoslavia, their persistent and continuous work permeated with enthusiasm and good mutual collaboration on several joint papers and projects. All Yugoslav operations researchers in the process of work on the development and application of OR have become intellectually richer, scientifically and professionally maturer and more secure that work has a public justification and scientific value with which one can enter into the worldwide OR scene and improve the conditions for the international transfer of knowledge, achievements and experiences.

Because of that it is understandable to point out and to remind the readers of YUJOR about the important events that preceded the foundation and publishing of the international journal YUJOR, some of which refer to isolated examples of work in the field of OR, but the major part refer to continuous and organized activities that have lasted over 25 years. Here we emphasize the seven-year work of

the Permanent Conference for Management of Business Systems (known under abbreviation SKUPS = Stalna konferencija za upravljanje poslovnim sistemima) and its natural continuation — the nineteen-year activity of the Yugoslav Symposium on Operations Research (YU-SYM-OP-IS). An adequate attention will also be paid to the development of scientific research and realization of common several years lasting OR projects, education and publishing activities, as well as to international activities in OR with us and in the world, in which our operations researchers gave significant contributions and built the necessary conditions for publishing the international journal YUJOR, respecting the high criteria and standards customary with international journals.

2. SOME ISOLATED WORKS IN THE FIELD OF OR

Before the organized and continuous work on development of OR with us, several isolated, individual or collective, results had been known. The first of them was associated with the name of colonel Vlastimir Ivanović [40], which has a special historical importance for our operations researchers, since it dates back to 1940. That paper gives an analysis of computation of the minimal number of vehicles needed for the transport of a certain quantity of material under two assumptions: (i) when a regular supply is necessary in the case the daily consumption of material is constant, and, (ii) when for a certain period of time a given amount of material is to be transported. Historically looking, we can't avoid stating that the mentioned paper appeared just between two eminent and known names in the world science — Kantorovich [39] and Hitchcock [41], where the first was solving the transporting problem, and the latter accomplished to give its strict mathematical formulation. The challenging of the results of Kantorovich hadn't by that time be finished, when, less than a year after his paper, appeared the paper of the Yugoslav colonel Vlastimir Ivanović, which was for the first time noticed a few years ago (see Vukadinović [88] and Zlobec [88]).

The second particular result in OR in Yugoslavia appeared 13 years later, that is in 1953. It was the publishing of the first book on operations research in Yugoslavia written by general Božidar Kraut [53]. The communications of that book are yet actual. The first review of it gives Rajko Tomović [54] in the journal *The New Thought (Nova misao)* entitled — *An Indispensable Initiative*. Thanks to that book and later publications and activities of operation researchers in Yugoslavia, especially in the middle of the 60's and the beginning of the 70's, we hardly escaped the ideological condemnation of this discipline, which did not bypass the countries of Eastern Europe.

The following events in the development and applications of OR in Yugoslavia, which appear individually and with certain pauses, have to some extent a character of organized teamwork. First of such events was in the year 1960 when the Yugoslav Bureau for the Productivity of Work, upon initiative of Prof. Stjepan Han, made the entirety of preparations for the organization of first postgraduate studies for 30 students with lecturers from abroad.

But because of some legal barriers that such studies could be organized by the Yugoslav Bureau for the Productivity of Work, Professor Branislav Ivanović took the whole prepared material for the beginning of the postgraduate studies and those studies were organized in the same year on the Faculty of Economy within University of Belgrade. Almost all participants graduated in time the studies and achieve the M.A. degree in the field of Operations Research. Upon an initiative of Branislav Ivanović in 1963. the Yugoslav Bureau of Statistics in Belgrade organized the first two-day Conference on Operations Research.

In the middle of the year 1967 Professor Alojzij Vadnal from the Faculty of Economy in Ljubljana and Professor Ljubomir Martić from the Faculty of Economy in Zagreb organized, together with the Society of Economists of Slovenia, a Yugoslav Conference on Operations Research in Bled in attendance of about 100 participants. On this conference were exposed 33 papers by operations researchers from Slovenia, Serbia and Croatia (see: Proceedings [67]).

In the same 1967 year in Belgrade, as an edition of *Export-Press*, there were published 6 volumes comprising altogether 1390 pages entitled *Technology of Management* [67]. The publication was financially supported by the Business Association *Progres-invest* from Belgrade, and the preparation and authors' engagement and coordination were done by Milosav Drulović and Aleksandar Pavićević, leading people from the industrial firms "14. oktobar", Kruševac, and MAG, Belgrade.

In parallel with the preparations of the edition *Technology of Management* began the preparations for the first Permanent Conference for Management of Business Systems (SKUPS). So in the mid of 1967 there was formed the Administrative Committee of SKUPS made up of prominent directors of economic and scientific research organizations (President — Milosav Drulović, Vice-President — Joviša Prokopijević) and the Organization Committee of SKUPS made up of 25–30 researchers and experts from the faculties, institutes and the industry (President — Jovan Petrić, Vice-President — Aleksandar Pavićević). The beginning of the activity of the Organization and Administrative Committees of SKUPS was a real beginning of an organized and continuous work on professional activities in the field of Operations Research, information systems, reliability theory, management and system sciences in Yugoslavia.

3. THE CONTINUOUS AND ORGANIZED WORK IN THE FIELD OF OPERATIONS RESEARCH

In this section we give a review of the organized and continuous work on development and application of Operations Research in Yugoslavia. We shall discuss the continuous organizing and preparation of scientific meetings (conferences and symposia) connected with Operations Research, the scientific research and education, publishing activities, as well as international and other activities of operations researchers. The aim of pointing out these activities is, also to give a real overview of all basic facts preceding the foundation and publication of the international journal *Yugoslav Journal of Operations Research*. Looking back on everything that was

Table 1

SKUPS (1968-1973)

Year	Published materials of SKUPS					Number of papers
	Proceedings		Bibliographies			
	Book	No. of pages	Part	No. of pages	No. of bibl. units	
1968	I	688	I	312	4450	60
	II	563				
1969	I	607				82
	II	784				
1970	I	501	II	181	1670	89
	II	625				
1971	I	463	III	143	1250	105
	II	458				
	III	447				
1972	I	709				116
	II	588				
1973	I	812				59
Total:	12	7245	3	636	7370	511

done, we can see that the way passed was a way of confirmation and maturing of operations researchers in Yugoslavia to begin doing this responsible and complex job required for publishing such journals as YUJOR. We shall mention only the main activities of operations researchers in Yugoslavia that were a natural prerequisite that the whole work be crowned by the appearance of the journal YUJOR.

3.1. SKUPS (1968-1974)

In the development and application of OR and system theory in Yugoslavia there was a constant growth, except in the period 1972-1974, when we heard the brunt of Yugoslav "cultural revolution", which influenced the break of the activities of SKUPS in 1974. Anyway, seven conferences of SKUPS which took place in the period 1967-1973 had been very successful.

SKUPS was characterized by the following important features:

(i) Besides its Yugoslav character SKUPS had also an international reputation, since each year in its activity were taking part 5-20 authors and participants from abroad (Romania, Czechoslovakia, Bulgaria, Hungary, Great Britain, USA and USSR).

(ii) Proceedings of refereed contributions were published and they were classified into several sections, among which has always been the permanent section of SKUPS entitled as follows:

Section I — System and environment / Design of the business systems

Section II — Marketing and the development of new products and processes

Section III — Planning and optimization of business systems

Section IV — Information systems

Section V — Reliability and quality, and

Section VI — Human Resources.

(iii) The published contributions, their presentation and discussions during the conference played a significant role in the development of education and scientific research in Operations Research, Information Systems, Management and System Theory. The Faculty of Organizational Sciences (FON) in Belgrade was founded and began its activity in 1971. Its foundation and financial support was in those times direct from the industrial firms, through the Special Education Community, and the first curricula of the FON were mostly based upon the ideas and programs of SKUPS that had been put into effect.

After 1974 SKUPS was held a few times more, but not with the contents and in the way as it had been with the first seven conferences. According to the records of the *Business Policy*, year X, December 1981, pp. 27, 28, these conferences were held in Vrnjačka Banja in 1976, when the complete Administrative and Organization Committee of SKUPS were changed, then in Belgrade in 1977 and 1978, in Split in 1980 and again in Vrnjačka Banja in 1981. All those conferences, according to the journal *Business Policy*, were thematic and after 1974 they did not comprise the Sections III, IV and V, which became the framework for YU-SYM-OP-IS (Yugoslav Symposium on Operations Research) that began its regular and continuous work from 1974 till present days.

For the first six conferences of SKUPS there were published the Proceedings, which can be found, among other libraries, in the Special library at the Laboratory for Operations Research on the Faculty of Organizational Sciences in Belgrade, where all the documentation about organized work of operations researchers from Yugoslavia has been repositied. Some relevant facts concerning the published Proceedings of SKUPS and corresponding Bibliographies are given in Table 1 (see Proceedings of SKUPS [68]–[73]).

It should be emphasized that SKUPS founded the journal *Business Policy* in 1971, and it is published also at present in 4000 copies. Except for this journal, later, SKUPS transformed into Community for planning and business cooperation for the technology of management, following journals within the *Business Policy* were launched out: *Production*, *Sale*, *Court Practice*, the periodical *Public Self-Protection*, as well as an edition of tens of books about the technology of management. In this publishing activity, within the *Business Policy*, large numbers of collaborators were engaged. So we may say that, besides of the Proceedings, as a result of SKUPS remained several books and periodicals, as well as a number of full-time collaborators in the publishing activities. In contrast to the activities of SKUPS developed after 1974, the Yugoslav Symposium on Operations Research, on an international scheme, cares for and develops both the theoretical and the application aspects in the field of Operations Research in its widest meaning.

3.2. YU-SYM-OP-IS (1974–1992)

The first organized and continuous activity on the development and application of Operations Research in Yugoslavia goes back to 1974, when the first Yugoslav Symposium on Operations Research (YU-SYM-OP-IS) was held. The Chairman of the Organizing Committee was Radivoj Petrović. Since then it has been regularly held each year at the beginning of October. In the past 19 years, the greatest number of YU-SYM-OP-IS' was held in Herceg-Novi (14 times), in Belgrade and Kupari (2 times each) and once on the island of Brioni. The initiators and permanent organizers of this symposia are Mihajlo Pupin Institute, Institute of Economy, Faculty of Organizational Sciences and Faculty of Traffic and Transportation, all from Belgrade. Operations researchers from these organizations took upon themselves the major part of duties of organizing and care of the symposia. The program orientation of the YU-SYM-OP-IS is conducted by the Program Committee which put together the most distinguished operations researchers from the whole Yugoslavia, whereas the organizational and economic aspects of the symposia were being commissioned to the Organizing Board composed of young operations researchers.

The topics of the first YU-SYM-OP-IS were Information Systems, Optimization Methods in Planning and Management and to Reliability. Later on, the topics were considerably enlarged by introducing new sections. To illustrate this we give the section titles and the number of papers presented in each one during the fifteenth YU-SYM-OP-IS'88 on island of Brioni, October 11–14, 1988: 1. Management of production and stocks (17); 2. Mathematical programming (19); 3. Transportation and traffic (20); 4. Simulation (15); 5. Economic models and econometrics (18); 6. Expert systems — a support to decision-making (14); 7. Reliability and maintenance (14); 8. Information systems and OR software (9); 9. Multicriteria decision-making (10); 10. Water resources management and environment (9); 11. Energy (11); 12. Statistics and forecasting (8); 13. Graphs, networks and their applications (7) and 14. OR software demonstration (7). The structure of sections and the number of papers in each of them that were presented on the fifteenth YU-SYM-OP-IS'88 faithfully represents the state and research directions of Yugoslav operations researchers. That may be completed by the data on the number of papers contributed and presented on particular symposia, as showed in Table 2, which gives an overview for all 19 meetings held up to now. These data are arranged according to the YU-SYM-OP-IS Proceedings issued so far, in which, during the past 19 years, 1574 papers and 242 communications were published (see YU-SYM-OP-IS Proceedings [74]–[92]). The latest five YU-SYM-OP-IS Proceedings were published according to the international standards applied on similar scientific conferences all over the world. The published Proceedings are available in all libraries of the institutions that are permanent organizers of the symposia.

A special feature of each YU-SYM-OP-IS is the participation of 3–7 invited speakers, mostly from abroad, who appear on the plenary sessions with topics and problems of Operations Research. This orientation towards the meetings with distinguished operations researchers from the whole world, as well as publication in the YU-SYM-OP-IS Proceedings of an ever growing number of papers in English,

Table 2

SYM-OP-IS (1974–1992)

Year	Place	Published proceedings of papers and communications				Format of SYM-OP-IS proceedings
		Book	No. of pages	No. of papers	No. of commun.	
1974	Herceg-Novi	I	144	10		B-5
	— " —	II	368	29		— " —
1975	— " —	I	224	12		— " —
	— " —	II	587	37		— " —
1976	— " —	I	473	34		— " —
1977	— " —	I	613	46		— " —
1978	— " —	I	497	30		— " —
1979	— " —	I	563	37		— " —
1980	— " —	I	761	74		— " —
1981	— " —	I	440	28		— " —
	— " —	II	185		41	— " —
1982	— " —	I	667	66	26	— " —
1983	— " —	I	369	12	4	— " —
	— " —	II	650	68	18	— " —
1984	— " —	I	987	89	33	— " —
1985	— " —	I	733	84	14	— " —
1986	— " —	I	1047	118	24	— " —
1987	— " —	I	1050	135	19	— " —
1988	Brioni	I	571	138	22	A-4
1989	Kupari	I	639	147	12	— " —
1990	— " —	I	735	167	21	— " —
1991	Beograd	I	490	117	8	— " —
1992	— " —	I	385	96		— " —
Total:		23	13178	1574	242	

has an outstanding importance for a faster development of operations research in Yugoslavia and that is why an adequate attention will be paid to it also in future.

3.3. SCIENTIFIC RESEARCH IN OR

In the last 20 years the scientific research in OR has been performed in several institutes and faculties as: Mihajlo Pupin Institute, Institute in Vinča, Institute of Economy, Mathematical Institute, Military Institute (all from Belgrade), Faculties of Organizational Sciences in Belgrade, Maribor and Varaždin, Faculty of Traffic and Transportation in Belgrade, Faculties of Mechanical Engineering in Belgrade, Sarajevo and Podgorica, Faculty of Electrical Engineering in Belgrade, Faculty of

Mathematics in Belgrade, Faculty of Mining and Geology in Belgrade, Faculties of Civil Engineering in Belgrade and Split, Faculty of Technology and Metallurgy in Belgrade, Faculties of Economy in Belgrade, Zagreb, Ljubljana, Subotica and Split, Faculties of Agriculture in Belgrade and Novi Sad, Faculty of Technical Sciences in Novi Sad etc. Operations researchers from the research institutes and faculties listed were the authors of more than 90% of papers presented in the last 19 years on YU-SYM-OP-IS. Their participation in the realization of scientific research projects in OR was even greater in percentages. The financial support of the scientific research in OR has been given by the Science Funds of particular republics. Other financial support have been supplied by the economy on the basis of direct contracts between research institutes and faculties with particular companies. According to data that had been collected up to two years ago, our operations researchers had participated during the period 1986–1990 on about 20 larger research projects, which had unfortunately been located only in more developed university centres and republics. In Serbia, for example, during the latest medium-term period (1986–1990) Science Community of Serbia financially supported the macro project *Operations Research in the Management of Complex Systems*. In its realization participated the Faculty of Organizational Sciences, Mihajlo Pupin Institute, Institute of Economy, Institute in Vinča, Faculty of Traffic and Transportation and Faculty of Technology and Metallurgy (all from Belgrade). The Federal Committee for Science and Technology from the Fund for encouragement of the technological development of Yugoslavia gave the financial support to the project *Development and Practical Application of new Computer-Oriented Methods of Operations Research*, in realization of which 14 faculties and research institutes from Beograd, Ljubljana, Novi Sad and Sarajevo took part. It has come to a tight collaboration of operations researchers from various research institutes and faculties, which had a great impact on faster exchange of knowledge and experience, on rising the new generation of researchers, as well as affirmation of the profession and trade. After 1990 the Science Fund of Serbia gives again the financial support for projects directly involved in particular activities, which has brought to a fragmentation of projects and which has led to smaller teams of operations researchers. Nevertheless, development and application of Operations Research is constantly growing, which can be seen from the number of published papers and communications in the YU-SYM-OP-IS Proceedings and international scientific conferences, as well as in national and international journals. An exception are certainly 1991 and 1992, when due to the splitting of Yugoslavia, two OR symposia began to take place. One is within Serbia and Montenegro and the other within Croatia and Slovenia. We note that the entries into Table 2 for 1991 and 1992 count only for Federal Republic of Yugoslavia.

3.4. EDUCATION IN OPERATIONS RESEARCH

The first remarkable step in the education of operations researchers in Yugoslavia was connected with the organization of the first postgraduate studies in Belgrade in 1960, what we have already discussed. Considerable progress in this

direction was made in 1970. The first two-semester material in OR with a fund of 3 + 3 lessons a week was introduced of the undergraduate studies on the Faculty of Organizational Sciences in Belgrade in 1971, followed by similar actions of some faculties of technology, mathematics and economy in the country. Starting from 1980, some elements of OR have been introduced also in a number of secondary schools. On the majority of faculties of technology, mathematics and economy, postgraduate studies in OR have been introduced. On these faculties and within the Center for Multidisciplinary Studies in Belgrade several dozens of Ph.D. degrees, more than a hundred of MA degrees and several hundreds of BA degree dissertations were defended. All that has considerably influenced the development of the young researchers in OR, as well as the foundation of the profession and trade with which the operations researchers in education and scientific research are concerned.

3.5. OPERATIONS RESEARCH AND THE PUBLISHING ACTIVITIES

Within publishing activities concerning OR, in 1984 an extensive drive was launched in order to compile and publish a glossary of OR words in English, Russian, French, German, Serbo-croatian, Slovene, Macedonian, Hungarian and Albanian languages. A group of 68 operations researchers from the whole Yugoslavia worked on this project. Immediately after publishing of the first version of the Terminological Dictionary of OR it was spread among the participants of the YU-SYM-OP-IS under their obligation to give comments and suggestions within a fixed period. After this stage finished, the work on the publishing of a definitive version of the Terminological Dictionary of OR began. This dictionary influenced not only the better understanding in the education, but also in research and applications of OR with us. The publication of this dictionary gave rise to the publishing house "Naučna knjiga" to start a series entitled OPERATIONS RESEARCH AND INFORMATION SYSTEMS, in whose Editorial Committee from its foundation up to present are Jovan Petrić, Radivoj Petrović, Slobodan Krčevinac and Branko Lazarević. Twenty-three books and monographs has been published in this series so far (see the references about the series OPERATIONS RESEARCH AND INFORMATION SYSTEMS — OPERACIONA ISTRAŽIVANJA I INFORMACIONI SISTEMI). In 1991, besides the YU-SYM-OP-IS Proceedings and the series *Operations Research and Information Systems*, for the first time appeared the international journal entitled YUGOSLAV JOURNAL OF OPERATIONS RESEARCH published in English.

3.6. INTERNATIONAL ACTIVITIES OF OUR OPERATIONS RESEARCHERS

Since 1982 Yugoslavia is a full member of I.F.O.R.S. and EURO with representative Radivoj Petrović.

Belonging to I.F.O.R.S. family operations researchers in Yugoslavia have developed a considerable activity concerning, first of all, the organizing of international scientific conferences in Yugoslavia. So, they organized in 1986 in Herceg-Novi

the meeting EURO WORKING GROUP "LOCATION THEORY" in the presence of 28 scientific researchers from all parts of Europe. In 1987, also in Herceg-Novi, took place the THIRD MINI EURO CONFERENCE "OPERATIONS RESEARCH METHODS IN TRANSPORT PLANNING AND TRAFFIC CONTROL" now in the presence of nearly one hundred operations researchers from Yugoslavia and from abroad.

The greatest appreciation of Yugoslav operations researchers was the entrusting them with the organization of the TENTH EUROPEAN CONFERENCE ON OPERATIONAL RESEARCH (EURO X), which was successfully organized in Sava Center in Belgrade at the middle of 1989 in the presence of several hundreds participants from all over the world. The Chairman of the international Organizing Committee was Vladan Batanović. For 1991 an international scientific conference on combinatorial optimization was prepared and it should have been held in Dubrovnik under auspices of the Serbian Academy of Sciences and Arts. But, due to the war in Yugoslavia, this conference was cancelled only a few days before its opening, in spite of all preparations that were completed by that time.

What concerns the presence of Yugoslav operations researchers in the world, we should say that they actively participate on all international conferences on Operations Research organized by I.F.O.R.S., on European conferences on Operations Research (EURO). The active participation of our operations researchers on the First Balkan Conference for Operations Research in Thessaloniki, October 17-20, 1988, was very noticeable.

On all above-mentioned and other international conferences and symposia our operations researchers regularly present their achievements. Besides of that, they take an active part and publish their papers in most distinguished OR international journals as *EJOR*, *Operations Research*, *Mathematical Programming*, *JOTA*, *NL-RQ*, etc. Special acknowledgement to our operations researchers is given by their election into the Editorial Board of renowned journals in OR. One of the latest acknowledgements was the election of Radivoj Petrović for the President of the jury for awarding the EURO Gold Medal in 1992.

4. YUJOR

The top of the desires and ambitions of Yugoslav operations researchers is mostly expressed in the publishing of the international journal YUGOSLAV JOURNAL OF OPERATIONS RESEARCH. On the very start, organizations-publishers of YUJOR established very strict criteria in order the journal preserve an international reputation. This implies a selection of high-quality papers that should be published in English, the fact that more than a half of the Editorial Board should be well-known OR experts from abroad, providing an international exchange of YUJOR with other journals from OR published all over the world and reviewing the papers published in YUJOR in known reviews and abstracts bulletins in the world. We hope that all these requirements have been entirely met so far in the first two years of publication of YUJOR.

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