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CONSTRUCTION OF INFRASTRUCTURE AND MODELS OF SCIENTIFIC RESEARCH WORK IN THE CASE OF THE PROJECT "SLAVONIAN NETWORK"

IZGRADNJA INFRASTRUKTURE I MODELI ZNANSTVENO-ISTRAŽIVAČKOG RADA NA PRIMJERU PROJEKTA „SLAVONSKA MREŽA“

ABSTRACT

State of technical infrastructure systems in the Republic of Croatia is below EU average, i.e. in many areas regarding current level of development, equipment, business operation and use of infrastructure systems, Croatia lags behind most of the EU countries. This is reflected on inefficient business operations, high unemployment rate, lower standard of living of the inhabitants and high debt of Croatia. The paper points to: (a) the need to examine the issues in a longer time horizon and (b) the importance of five essential elements in respect to infrastructure development; These are: (1) the exponential growth of scientific knowledge in the world, (2) narrower specific areas of scientific disciplines and narrow specialization of experts, (3) processes of increasing community dependence on technical systems, (4) the increasing investments in infrastructure systems in EU and (5) the growing importance of electronic communication and supranational connectivity of network infrastructures. The analysis of practices shows that Croatia does not have a sufficient number of experts for development and management of infrastructure nor will it have them in the future – unless the process of education begins. The structure of the problems within infrastructure – planning, design, construction and maintenance of infrastructure and business management of infrastructure organizations requires amendments to the curriculum in the graduate program of technical and social sciences, with update of the existing courses and implementation of new ones. Also – in the time frame from 2020 to 2030 – there is a need to initiate a multidisciplinary post-graduate studies programme in the field of infrastructure, and a model of organization of this studies programme in J.J. Strossmayer University of Osijek is proposed, the intention being for this studies programme to be a gravitation point for students from twenty countries.

***Key words**: Broadband, infrastructure, networking, scientific research*

SAŽETAK

Stanje tehničkih infrastrukturnih sustava u RH nije ni u prosjeku EU, tj. u mnogim područjima izgrađenosti, opremljenosti, poslovanju i korištenju infrastrukturnih sustava RH zaostaje za

*većinom zemalja EU članica. To stanje se u praksi manifestira neučinkovitim privrednim poslovanjem, velikom nezaposlenosti, nižem životnom standardu stanovnika i velikoj zaduženosti naše zemlje. U radu se ukazuje na potrebu sagledavanja problematike u dužem vremenskom horizontu i na važnost pet bitnih elemenata razvoja infrastrukture, a to su: (1) eksponencijalni rast znanstvenih spoznaja u svijetu, (2) sve uža područja znanstvenih disciplina i specijaliziranost stručnjaka, (3) sve veća ovisnost društvenih zajednica o tehničkim sustavima, (4) sve veća ulaganja u infrastrukturne sustave unutar EU te (5) sve veći značaj elektroničkih komunikacija i nadnacionalnog povezivanja mrežnih infrastruktura. Analiza pokazuje da u RH ne postoji dovoljan broj stručnjaka za razvoj i upravljanje infrastrukturom niti će ih biti u bliskoj budućnosti ukoliko se već danas ne počne s procesom edukacije. Planiranje, projektiranje, izgradnja i održavanje objekata te poslovanje infrastrukturnih organizacija zahtijeva dopune nastavnih planova i programa u d*odiplomskom i diplom-skom *studiju tehničkih i društvenih znanosti dopunama sadržaja postojećih kolegija i uvođenjem novih kolegija . Isto tako – promatrajući u vremenskom horizontu do 2030. godine – ukazuje se potreba i za po-kretanjem multidisciplinarnog doktorskog studija iz područja infrastrukture. Predlaže se model organizacije ovakvoga studija u Osijeku koji bi mogao biti centar kojem gravitiraju regije iz dvadesetak zemalja.*

Ključne riječi: *infrastruktura, širokopojasni pristup, umrežavanje, znanstveno-istraživački rad*

1. Introduction

Providing community services (water distribution, wastewater removal, public lighting), transportation of energy (electricity, gas, heat, oil), transportation of people and goods (roads, railroads) and electronic co-mmunication services are all in the function of individuals or conducting economic activities. All these activities have a share in the corresponding infrastructure that was created and was adapted to needs of life. The exponential growth of scientific understanding and the change in technology are reflected on the need for an adequate infrastructure. The experience concerning specific characte-ristics of infrastructure was acquired in specialized enterprises. A characteristic of construction of every type of infrastructure is its position in space. Limited space resources have resulted in a need for space arrangement. A choice for market economy resulted in a significant change of established practice. The relationship between owners of infrastructure have been broadened to include the ow-ners of land on which this infrastructure was built, all for the purpose of regulating property relations. Also, a switch of construction and maintenance activity to commercial outsourcing out-side of original companies resulted in a break in systematic experience gathering. Another consequence of market criteria are new relations between owners and users of infrastructure and immediate surroundings.
Since Croatia is a member state of the EU since 2013, greatest efforts have been dedicated towards acheiving EU standard, especially considering that Croatia is below EU average in some infra-structure sectors. This also led to a break in continuity of investment in infrastructure as well as to a degrading in work experience on all levels, from planing, project making and construction to infra-structure maintenance. It has been observed that multidisciplinary knowledge is required as an ade-quate response to new challenges. A major purpose of this paper is to initiate a discussion on the need of creation of a specialist, multidisciplinary, post-graduate studies programme in the field of infrastructure and to initiate the deepening of existing programmes and introduction of new ones, whose content and acquired knowledge would significantly contribute to the development of eco-nomy.

2. Starting points for proposal consideration

At this point, it is necessary to consider the problematic on a longer time period and to realize the importance of five essential elements for infrastructure development:
1) Exponential growth of scientific understanding in the world,

2) Narrowing fields of specialization and focusing of experts on ever narrower research topics
3) Processes of ever increasing dependance of social communities on technical systems
4) Ever increasing investment in infrastructure systems in the EU
5) Ever increasing importance of electronic communication and supranational connection of network infrastructure

2.1 Exponential growth of scientific understanding

New cultural knowledge and understanding grow exponentially in time. The time necessary for doubling knowledge is ever shorter. According to published scientific papers, scientific knowledge (measured by the number of patents and the number of original articles published in world magazines) is being doubled the fastest in the field of nanotechnology – in less than two years. In the field of global warming, prions, computer programming, cell research and epidemiology the time period is five years. In other areas, the time necessary for the doubling of knowledge is between 10 and 15 years. Raymond Kurzweil (a noted theoretician of artificial intelligence) points to the possibility of double exponential growth of human knowledge with the help of intelligent machines and points to the possibility that after 2020, scientific knowledge will double every couple of months.

2.2. Ever narrower field of scientific disciplines and increasing specialization of experts

The development of science gives simultaneous birth to two separate processes: a) differentiation and b) integration of knowledge; the research results in the process of specialization and differentiation of fields of knowledge, or, the development of new scientific disciplines which cover ever narrower fields of reality; humans adopt more "shattered" knowledge of the world, this being the outcome of ever greater specialization. Different opinions exist concerning this process:
a) *Science today is a partial practice of research;* (M. Životić)
b) *The destiny of scholars of every scientific discipline is to focus on ever narrower field of research in his area of specialization and to consume ever increasing amount of knowledge;* (J. Gribbin)
c) *One of the traits of today's science (and scientists) is a limitedness in their own, very narrow field of research. Apart from few undoubtedly useful aspects of specialization in science, the problem of communication barrier arises, not only between scientists and non-scientists but also among scientists of different branches themselves. Even scientists from the same branche oftentimes have a hard time communicating amongst themselves due to the accentuated focus on only one kind of issues*. (S. Kutleša)
According to estimates of a number of authors, at the end of the 20th century, the number of scientific disciplines passed the 2000 mark, with some estimates even talking of tens of thousands of disciplines. At the same time, the process of differentiation is coupled by a dialectical process of integration of knowledge and science which leads to connections between scientific disciplines and interdisciplinary and transdisciplinary research. In theory and practice, the border between scientific disciplines such as physics – chemistry, chemistry – biology, economics – political science often disappears. Contemporary research requires an integration of science, but – it needs to be said – this does not mean abolishing individual scientific disciplines. [1]

2.3. Dependance of man on nature, society and infrastructure technical systems

Through the progress of civilization (culture, technology and economy) humans become less nad less dependent on conditions of nature in their surroundings and more and more dependent on social relations and technical systems, Therefore peace, democracy and tolerance (within civil society) are basic elements for the development of economy and technology in the world up to the end of the 20th century, whereas at the beginning of the 21st century human societies are becoming more and

more dependent on infrastructure technical systems in transport, energetics, water supply, waste management and electronic communications. [1]

2.4. Investments in infrastructure systems are ever increasing worldwide

European Union, by way of European structural and investment funds (ESIF), secured investments until 2020 for all the regions in the amount of 453 billion euros. The access to information and communication technologies (including investment in broadband network) as well as its quality and use are for the first time ranked as top priority. A significant amount of investment (up to 80%) are planned to be non-refundable. The potential investment market wil additionally include the funds of national economies and private investors.

2.5. Electronic communications and network infrastructure

Economy, public administration, education and scientific and research work today depend on the establishment of developed communications network for a fast and efficient transfer of information. The development of fast access networks today has the same revolutionary effect that construction of roads had in the Roman Empire or the development of eleectro-energetic network and railways had one hundred years ago. Modern electronic communications, especially Internet, significantly changed people's lifestyle in the last twenty years. The transfer of data and information has been sped up, coupled with increased quality and reliability, the cost of doing business has been decreased, business transactions have also been sped up and fast access to information on the global market has been enabled. New investment funds, goods and services have been developed, the amount of accessible information in the public and private sector has been increased. The new IT is a foundation for the development of economy and society of knowledge. The information and knowledge took the place of capital by becoming the foundation of individual and social growth and development; information and knowledge = capital. Estimates indicate that digital content and applications will almost entirely be delivered through Internet by 2020. The development of better quality, faster, mor reliable and cheaper public services in economy, public sector (healthcare, education, culture...) and public and regional administration and encouragement of growth of rural areas depend on the broadband access coverage level, enabling high speed Internet, of a given territory. In Digital Agenda 2020, Europe recognized electronic communication infrastructure as important for the development of society.

3. State of infrastructure systems in the Republic of Croatia

- The amount of infrastructure in Croatia is visible from table 1. Each from the listed infrastructure systems is important for the proper functioning of the state, be it through providing services to citizens or as economic activity.
- The total value of infrastructure in Croatia is estimated at one third of the value of all the living quarters in Croatia.
- Economic indicators show that it is reasonable to assume that individual infrastructure system can have an important effect on the life of citizens, economy and it can also increase the efficacity of existing infrastructure.
- Regulatory agencies in Croatia are tasked with assuring that infrastructure-related business is conducted in a transparent manner according to clearly defined market principles.
- Legal regulation of infrastructure systems is different. The infrastructure system in its completeness (apart from public lighting) is of special interest for the state, so that owners of the real estate must accept expropriation. In case of roads and railroads, complete (total) expropriation is usually the norm, whereas limited (partial) expropriation is conducted for other infrastructure, with relevant obligations being marked in the land registry.
- In case of complete and limited expropriation, the owner receives a compensation. In the case of

electronic communications infrastructure, it is paid out on a yearly basis, whereas in the case of private ownership the compensation can be paid out at once for up to 20 years in advance.
- It has been observed that development and exploatation of infrastructure mimics the origins of rent economy. This is especially true for electronic communications infrastructure, in case of which a payment of rent was proscribed in 2008 for all the real estate on which electronic communications infrastructure was based. Croatian regulatory agency for the field of electronic communications (HAKOM) proscribed a set of prices for the usage of extra capacity in order to prevent a monopoly on developed electronic communication infrastructure.

Table 1 *Lenght of infrastruture in the Croatia*

Infrastructure	Length /km/	Reference source	Commentary
Water distribution	44367	DSZ/2012	
Wastewater removal	10539	DZS/2012	
Public lighting	2158		estimate
Electric energy	147365	HERA/2013	
Gas	21239	HERA/2013	
Heat	428	HERA/2013	
Oil	622	HERA/2013	
Electronic communications infrastructure	81300	HAKOM/2013	
Roads	26960	MPPI/2013	Not including minor roads
Railroads	2722	MPPI/2013	From 2014, railroad was in HAKOM's jurisdiction
Total	337700		

Source: DSZ/2012; HERA/2013; HAKOM/2013; MPPI/2013

- The capacity of rent economy (not including roads and railroads) is estimated at 0,5 – 2 billion kunas per year.
- Damaging of infrastructure is a criminal offence, sanctioned by article 216 of the Penal code of the Republic of Croatia.

4. Future development of infrastructure systems in the Republic of Croatia

According to plans of development of the Republic of Croatia for the next ten years, up to 10 billion Euros from various sources will be invested in water distribution, wastewater removal, energy, transportation and electronic communication infrastructure. These developments include planing, project-making, construction and maintenance of infrastructure objects. All of this as well as usage of these services and management of infrastructure organizations will require highly educated experts for the solution of business and development problems. Furthermore, significant inter-disciplinary scientific research will also be necessary.
A sufficient number of such experts does not exist in Croatia, nor will they be available in the future, unless a process of education does not begin today. The structure of today's infrastructure problems requires an update of existing plans and programs in graduate studies of technical and social sciences, both in existing courses and through introduction of new ones. Also, in the time frame from 2020 to 2030, a need for the initiation of multidisciplinary PhD studies programme in the field of infrastructure is also suggested.
An evidence in favor of the above explained consideration can be found in the practice of ten of the world's leading universities which initiated such studies programmes in the last couple of years:
- EPSRC Centre for Doctoral Training in Future Infrastructure and Built Environment
  (The University of Cambridge, UK); [5]

- Urban Planning and Design; Transportation and Infrastructure
  (Harvard University, Cambridge, MA) [6]
- Centre for Doctoral Training in Sustainable Infrastructure Systems
  (University of Southampton, Southampton, UK) [7]
- Ph.D. Program in Infrastructure and Environmental Systems (INES)
  (The University of North Carolina at Charlotte, USA) [8]
- International Graduate Program in the Field of Civil Engineering and Infrastructure Studies
  (The University of Tokyo) [9]

Below are the theses for discussion that the authors wish to initiate, expecting a response from the state, scientific community as well as other participants whose business focus is connected to infrastructure. Our wish is to initiate a thourough education of experts for infrastructure management.

5. Study levels

Keeping in mind the strong growth of requirements coupled with constant technological innovations in the field of infrastructure, the transfer of new knowledge in this area – in organizational sense- needs to be organized on three levels of university studies: doctoral, specialist and graduate. In addition to these levels, life-long learning programme also needs to be instituted.
In the construction of such a concept, knowledge in the field of technical and social sciences is necessary in order to enable both the providers and the users of services to develop simultaneously – because only in this way can optimal economic effects for the community be achieved.

5.1. Doctoral studies

The complete scientific level would be undertaken in the form of a doctoral studies program. This program is based on a scientific synthesis of existing knowledge and skills and on a model of infrastructure development according to the triple helix matrix (scientific community – system architects – state). [10] [11] [12] A constant verification of competences is expected from the candidates after the end of their doctoral studies program by giving scientific review to their research works. A broad base of candidates of various profiles for this study ensures a base that can be capable of connecting scientific realizations, the needs of the state and that can be capable of educating necessary experts for planning, construction and managing systems.

5.1.1. Prospective candidates of the doctoral programme

Doctoral interdisciplinary studies in the field of infrastructure is accesible to engineers or students with graduate education from technical universities in the field of electrotechnics, software engineering, machinery, construction, architecture, land measurement, traffic, information science as well as to graduate students in the field of economics, law and sociology.
The studies programme should have a regional character and it is therefore proposed that the program be realized in the english language. Apart from students from Croatia, and keeping in mind future needs, interest from students from Austria, Bulgaria, Bosnia-Herzegovina, Montenegro, Greece, Kosovo, Hungary, Macedonia, Moldavia, Romania, Slovakia, Slovenia, Serbia and the Ukraine can be expected.[1]

5.1.2. Professors of the doctorate studies programme

Professors on this doctoral studies programme can be only individuals with a doctorate in science with following conditions being fulfilled:

- having a minimal level of associate professor,
- at least three published scientific papers in the last three years in the field connected to the contentc of the course they are to teach,
- having a certificate of fluency in the english language

1 These markets need to be researched and an appropriate marketing campaign needs to be undertaken.

The formation of the studies programme requires experts in the field of: electrotechnics, machinery, land measurement, architecture, traffic, information science and software engineering, economics, law and sociology. The selection of candidates would be public and would be points based.

5.1.3. Institution organizing the doctoral programme

This doctoral studies programme would be organized and lead by Josip Juraj Strossmayer University in Osijek.

5.2. Specialist studies programme

The specialist studies programme would include students who are currently working with infrastructure systems, with the programme being focused on skills and knowledge which are required in the individual systems. This type of studies programme would serve as a verification for knowledge in the field of infrastructure and would help the students in their life-long learning. With the end of the specialist studies programme the knowledge acquired by the student (ECTS points) would be recognized in entering the doctoral studies programme. The candidates of existing specialist studies of faculties at J.J. Strossmayer University would be motivated to write their seminar papers on the topic of infrastructure.

Selected experts, students of the doctoral studies programme would lead exercises with the students of the specialist studies programme and would pass their specialist experience on to them. In this context, it is important to mention that a specialist interdisciplinary studies programme in regulation of electronic communications market has been recently organized at the Faculty of Electrotechnics and Computer Science in Zagreb (candidates: engineers of electrotechnics, economists and jurists).

5.3. Undergraduate studies programme

Undergraduate studies programme in the field of infrastructure would be undertaken in different courses on the faculties from which potential candidates for the doctoral programme would be recruited. The lecturers on these courses would be select experts with practical experience.

5.4. Lifelong learning

Lifelong learning would be undertaken under the auspices of Ministry of sea, transportation, traffic and infrastructure with cooperation of the academic community, expert chambers, institutes and expert associations.

6. Scholarship

Scholarship fees for the specialist and doctoral studies would be paid by the students (or their employers) and public funds. Students of the doctoral studies programme working on an infrastructure project can repay their scholarship costs by working on the said project, or as lecturers in the postgraduate studies programme.

7. The concept of the doctoral studies programme

7.1. Competences to be achieved

Excellent knowledge of the types and purposes as well as the principles of energy, telecommunication, gas, oil, water supply, sewage, heat and transport infrastructure (roads, railways, waterways, airports) in stages:

- Planning
- Design
- Construction

• Maintenance

7.2. The fundamental areas of the doctoral studies programme

The content of each course is a topic of discussion. The following are the working titles of courses of doctoral studies:

- Economic importance of infrastructure
- Legal regimes on real estate and infrastructure
- Spatial planning infrastructure
- Designing infrastructure
- Building Infrastructure
- Maintenance of infrastructure
- IT systems and infrastructure
- The sociological significance of infrastructure
- Infrastructure, environment and cultural heritage

8. Conclusion

J.J. Strossmayer University in Osijek could be the organizer of a multidisciplinary studies programme on all levels with the purpose of educating experts in infrastructure management. In East Slavonia, revolutionary first considerations of a multidisciplinary approach to planning and development of significant infrastructure capacities are to be observed. The description of the organizational forms which resulted in the above mentioned considerations are beyond the immediate topic of this paper. It is from this very knowledge however that we gather strength to try a new expert and organizational advance in this area, by promoting systematic education for infrastructure management.

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