Use of Hydroinformatics technology in Central and Eastern Europe during last decade

L'utilisation de la technologie hydro-informatique en Europe centrale et orientale au cours de la dernière décennie

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RÉSUMÉ

Au cours de la dernière décennie, l'hydro-informatique s'est progressivement développée dans le secteur de l'ingénierie de l'eau, complétée par des méthodes adéquates et des approches qui diffèrent souvent beaucoup des normes largement acceptées. L'expérience acquise par son application en Europe centrale et Europe de l'Est au cours de la dernière décennie montre que l'hydro-informatique est en ce moment largement acceptée et appliquée dans de nombreux projets d'ingénierie civile et d'études, apportant une meilleure compréhension du milieu aquatique et de ses processus. L'expérience acquise à partir d'un certain nombre de projets menés en République Tchèque, en Pologne, en Bulgarie, en Slovaquie et en Roumanie est traitée dans le document qui suit, pour expliquer l'état actuel de l'hydro-informatique dans cette région.

ABSTRACT

During the last decade the hydroinformatics have been gradually developing their position in the water engineering sector, being complemented with adequate methodology and approaches which often differ much from widely accepted standards. The experience gained from the application of Hydroinformatics in Central and Eastern Europe during the last decade shows up that at present the Hydroinformatics are widely accepted and applied in numerous civil engineering projects and studies bringing better insight into aquatic environment and its processes. The experience gained from a certain number of projects executed in the Czech Republic, Poland, Bulgaria, Slovakia and Romania is discussed in this paper to explain the present status of hydroinformatics on this territory.

KEYWORDS

Hydroinformatics, master plan, software, innovation technologies

1   INTRODUCTION

By following Wikipedia - the Hydroinformatics is a branch of informatics which concentrates on the application of information and communications technologies (ICTs) in addressing the increasingly serious problems of the equitable and efficient use of water for many different purposes. Growing out of the earlier discipline of computational hydraulics, the numerical simulation of water flows and related processes remains a main stay of Hydroinformatics, which encourages a focus not only on the technology but on its application in a social context.

The idea of Hydroinformatics was at first invented by M.B.Abbott around 1991 as a successor of former "computational fluid dynamics" trained in a frame of postgraduate courses at IHE, Delft. Later in 1991 this term was fundamentally described in Abbot's famous book "Hydroinformatics – information technology and the aquatic environment" where he argues that Hydroinformatics is to be understood rather as technology then a science. This in fact opened for civil engineering new era of understanding and coping with phenomenon of water.

2   URBAN DRAINAGE MASTER PLANNING

Urban Drainage Master Plans are essential tools for assessment, maintenance, designs or further development of whole systems. Former Master Plans of sewerage and watercourses are now substituted by Master Plans of urban drainage, which are complex projects based on an integrated approach to drainage of urbanized areas as a whole. The main principle of the contemporary methodology is the complexity, the effort to see each problem as a piece of a more complex puzzle in relation to the other problems, not to see the particular problem as a separate one, which was many times done in the past.

It is possible to spot the main cause for the change in the conception, in the change of the approach to the protection of the environment. An optimal solution is obtained only when the complex system of urban drainage, including all the elements that belong to the process of urban drainage, is evaluated. Integral approach to wastewater drainage and disposal represents the main shift in the conception and evaluation of urban drainage systems.

The impact of Hydroinformatics is therefore clearly recognized in the domain of urban drainage. Standard sewerage master planning has been gradually changed with a new approach of integrated urban drainage modeling which affects the overall view of the drainage system in the city, its objectives, goals bottlenecks and challenges [1]. Next examples intend to give the insight in the Hydroinformatics impact in respect to urban drainage.

Generally, these are main outputs processed in frame of the UDMP project:
- Evaluation of present stage of urban drainage
- Sewerage overloading plan
- Proposal for a technical solution of urban drainage
- Economical analyses of proposed constructions
- Sewerage layout plans (overall, construction, hydrotechnics)
- Water quality profiles of the rivers and creeks
- CSO`s evaluation
- Hydraulic overloading of water courses due to CSO`s volumes
- Overall balance of waste water and pollution production and inflow to WWTP
- Evaluation of WWTP efficiency

2.1 Prague UDMP

The project Urban Drainage Master Plan for the capital city of Czech Republic - Prague was executed

between 1998 and 2001 in the Czech Republic. The computational schemes originated from integrated approach of rainfall-runoff processes, hydraulics and water quality in sewer pipelines, treatment plants and receiving waters using especially the DHI technology. Large application of Hydroinformatics tools, GIS and special design programs supported the project execution. In a scope of the project a comprehensive monitoring campaign had been carried out. There were completed "situation reports" in the area of the capital city of Prague providing the basic assessment of the most important elements and factors of the drainage system. Using relevant inputs, sophisticated modelling approach was used to evaluate the whole urban drainage system and to prove new designs [2].
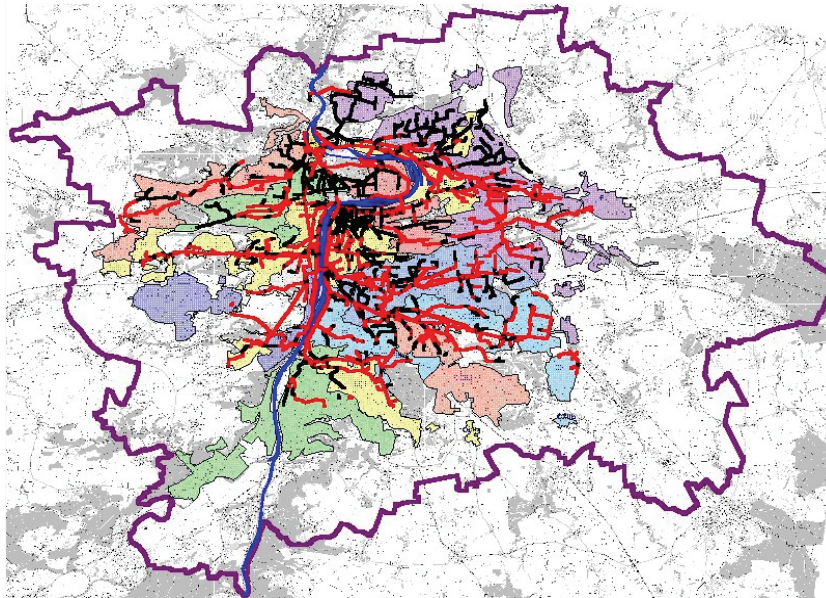
Prague combined sewer network – main collectors and their tributary areas.

2.2 Brno UDMP

In 2007, an elaboration of the Urban Drainage Master Plan of the second biggest city in Czech Republic – Brno was started. The project covers all main fields of urban water infrastructure, such as combined storm and separated sewer systems, river network and drinking water distribution system. This project represents a unique combination of one - and two-dimensional quantitative and qualitative mathematical models. Final results of the project will be delivered in 2010

2.3 Sofia DAP

By the end of March 2003 the first simulation model for the sewer system was developed in Bulgaria. The skeletal, planning model was built in a scope of Drainage Area Plan (DAP) project for the capital city of Sofia. Project execution was supported by use of Hydroinformatics tools for data pre and post processing (e.g. databases, GIS, special tools).

The main DAP goal was focusing the development of a sewerage simulation tool serving as a decision support for strategic investment program. A number of important topics was then identified as a particular project targets including the improvement of sewer network knowledge, the development of the digital tool representing behavior of the urban drainage system, technology transfer and knowledge to local staff, the application of European legislation and standards in Bulgaria and support for further detail modeling activities [3].
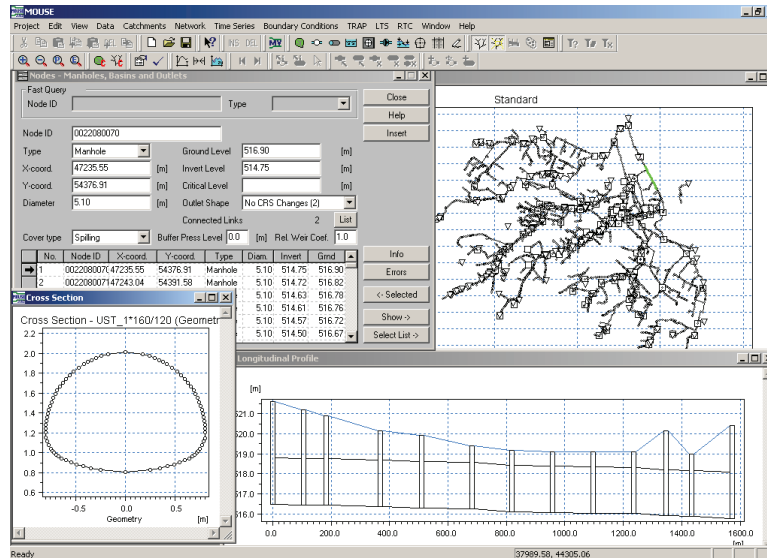
Sofia Catchment and Sewerage System

3 WATER SUPPLY MASTER PLANNING

Numerical modelling of water supply and water distribution systems has become a standard and an inevitable practice in any serious attempt of evaluating hydraulic, water quality, and economic aspects of these complex systems. Modelling capacity of well-suited models, featuring advanced technologies including links to models, GIS systems, telemetry systems, accurate fire flow calculations, water quality analysis, and leakage reduction which is incomparable with any alternative approach for these purposes.

There was a number of large scale water supply master plans executed in the region of CEE. Methodology and results of such integrated conceptual projects comprise several interconnected parts as follows [4]:

•	Building and calibration of the hydraulic model of water supply system.

•	Providing measurement campaigns

•	Provision of detailed leakage distribution survey.

•	Verification of the existing capacity of the water supply system;

•	Evaluation of future requirements,

•	Evaluation of existing pressure conditions

•	Evaluation of existing system of measurement.

•	Evaluation of hydraulic and water quality parameters in hydraulic model

•	The inclusion of the technical conditions evaluation of the water supply network and plan of its rehabilitation.

3.1 Usti nad Labem water supply study

To document results of projects mentioned above, it is possible to introduce a local water supply study in the city Usti nad Labem located in the north part of Czech Republic. The study was based on application of hydroinformatic tools, water supply system hydrodynamic models as well as field flow and pressure measurements. The project covered 2 of total 12 pressure zones in Usti nad Labem. The result of the study showed that 90% of the total leakage was identified in 36% of the length of the network. After finding and repairing hidden breakdowns by operation in these areas a reduction leakage of 16.8 l/s was verified in the identified area. If this status was permanently sustainable, this result represents an operational saving of approx. 860 000 EUR/year.
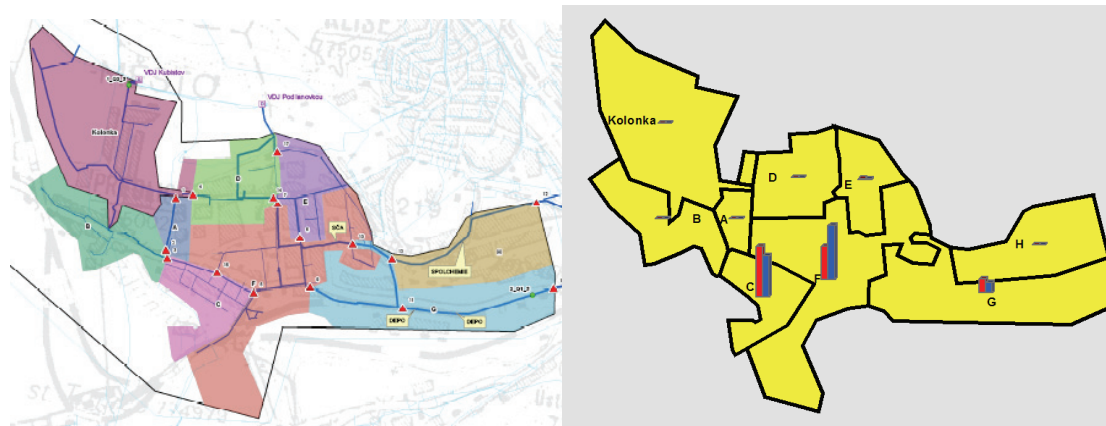
Plan of measurement campaign for leakages evaluation for water mains and illustration of determined leakages in network

3.2 Daruvar – leakage modelling and control

The water supply system in Daruvar – Croatia was mostly built in 1971, and it supplies ca. 20,000 inhabitants and industry. By the end of the 1970s it was observed that there was a shortage of water during the summer months. The problem was partially solved in 1982 when pump installations were built which increased the capacity of the pipeline. In 1996 the device for measuring the quantity of produced water was installed on the water-conditioning unit. By comparing the produced quantity of water with the conveyed (invoiced) quantity of water it was found out that the losses in 1999 were 46.50% on average. The project was focused on assessing and improving the water supply system as well as recovery of water loses. The model of the water supply system was developed as a base for detecting leakage areas. Significant leakage sources have been found on both modelling and measurements of water distribution system of Daruvar. It was proposed that the systematic inspection of the system using the instruments for crack detection on pipes will be focused on the zone No. 4 to detect other leakage sources. Zone No. 4 includes 6.58 km of pipes (21%) and 482,500 m3/year of leakage (80%).

4 OTHER APPLICATIONS OF HYDROINFORMATICS TOOLS

4.1 Parallel planning

The parallel planning can be presented on a case of town Unicov located in Czech Republic. The project was focused on a design and optimal of a function of a storm water retention system (retention tank and in line storage) at sewer network. The system design based on MOUSE mathematical model in 2001. The structures were constructed based on this design during the period of 2002 – 2003. It was possible to make first evaluations of the system performance in 2004, having one year of the operation experience. The new concept reduced the volume of the storm water tank to 1/10 of the original volume to 1000 m3 and it is using in-line storage volume in existing pipes of 2300 m3. A prediction of the system behavior was made based on the model. The number of spills was predicted to decrease from 50 to 7 events per year and spill volume from 150 000 m3 to 20 000 m3. The reduction of sedimentation in sewers was expected [5].

4.2 Sewer system flooding

Collection systems operation during serious floods represents another possible field for mathematical modeling. In August 2002 the Czech Republic was hit by devastating floods, the biggest natural disaster in modern Czech history. In some areas the floods - which affected over one third of the country - were the worst in the last 500 years. The Prague sewerage network, as well as the central waste water treatment plant (CWWTP), was also hit by the floods. Rising water in the Vltava River flooded the CWWTP and prevented the outflow of wastewater. Together with direct runoff caused by a local storm, the system was highly overloaded due to the high water level in the river, closing flood defense caps and overflowing of outlets from the main sewers beneath the city. Measures to remedy

this disaster began immediately in autumn 2002. A great deal of attention was also focused on measures to prevent a "self-flooding" of the city, caused by a combination of floods and urban waters transported through the Prague sewer system. The project, using both, mathematical model of the sewer network as well as 2D model of Vltava river consisted of the following phases - evaluation of the sewer system operation during the August 2002 floods in Prague, design of new flood protective structures, proposal for an operation scheme for different flood scenarios, evaluation of designed structures and various scenarios using mathematical models [6].

Type of flood protection closure in the sewer network in the City of Prague.

5   TECHNOLOGICAL TRANSFERS AND SUPPLY

The spread of use of Hydroinformatics technology is accelerated by transfers of know-how and technology to Central and Eastern European countries under the framework of European pre-accession or cohesion plans (e.g. ISPA, EUROPEAID).

As example, the project called "Supply of diagnostic and modelling tools, training and services for 13 regional water companies in Bulgaria" (ref. No. EUROPEAID/121561/D/S/BG) is mentioned. The project is financed from the EC general budget for Environment and the client is Bulgarian Ministry of Environment and Water. The scope of the project was to provide the delivery of hardware (plotters, PCs, laptops, printers) sewer and water supply diagnostic tools (flowmeters, pressure meters, samplers, pipe locators etc., software (Mike Urban CS - collection systém and Mike Urban WD - distribution system) as well as substantial training on modelling with Mike Urban and use of diagnostic equipment. The target beneficiaries are selected 13 large Bulgarian Water Utility companies from Plovdiv, Vidin, Vratza, Veliko Tarnovo, Burgas, Sliven, Kardzhali, Kyustendil, Dobric, Rouse, Yambol, Gabrovo and Perník.
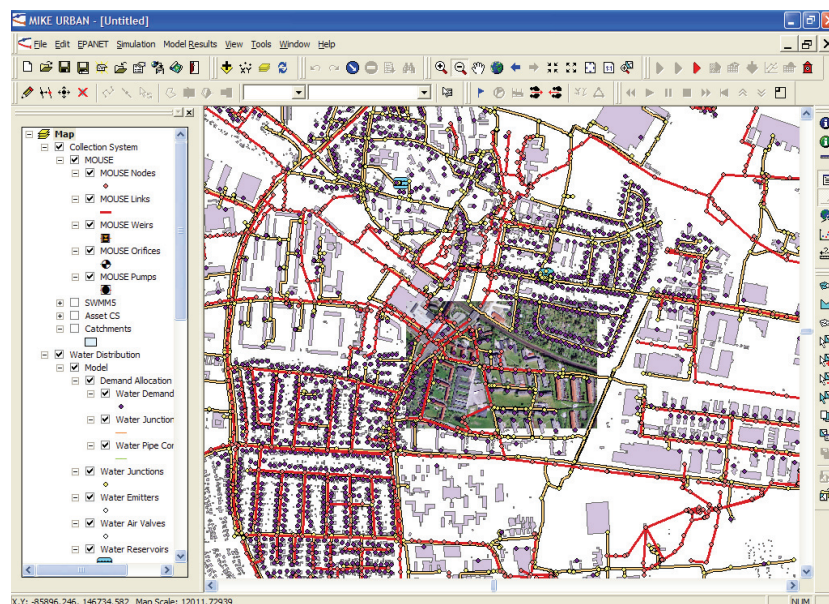
6   INNOVATIVE AND EMERGING TECHNOLOGIES

The technology of Hydroinformatics obviously calls for innovations in relation to the innovations on the level of information technology. In addition, the growing competition among distinct providers of Hydroinformatics technology develops stimulating environment for new emerging technologies, approaches, methods and tools which water engineering industry can profit from.

There are new trends recognised in the development of information technology and particularly in software development. These trends are focussing on technology integration, increasing openness in interfacing, flexible human interface configuration and intuitive working environment. The main purpose of this approach is seen in the integration of distinct functionalities and consequently in increase of comfort and flexibility of use.

The user demands requires from producers of simulation models search for new approaches and standards to be used in software development. The "openness" and "integration" features are then key elements of new system design and they are getting applied at distinct levels of system architecture including:.

•	Coupling with GIS system represents a common strategic feature for most of present simulation models.

•	To be open and easily integrated the software has to be component based. Present software development is successfully using concept of COM (Component Object Model) and its alternatives to share distinct pieces of code in a form of components with specific interfaces.

•	Open database access belongs to key features representing system openness. Current RDBM (relational Database Management) databases are in principle accessible via ODBC (Open Data Base Connectivity) or OLEDB (Object Linking and Embedding Data Base) connections.

•	The concept of "geo-database" is applied in modern simulation tools.

•	Model coupling by new concept invented and gradually getting used called Open Modelling Interface (OMI).

•	Configured GUI (Graphical User Interface) is being implemented in many present software packages, example in the possibility of programming on top of simulation model with help of Visual Basic, C++ or other development environments.

MIKE URBAN mathematical model environment.

## 6.1	Daywater - Storm water control project

The Framework Programs for Science, Research and Technological Development of EC constitute good platform for innovation and emerging technology. For instance, the Daywater project of 5th Framework Program for Science, Research and Technological Development of EC focused on the optimal storm water management in urbanized areas. The Adaptive Decision Support System (ADSS) has been developed in a scope of the project aiming to serve as an information portal for consensual decision making support in complex environments (e.g. multiple actors, multiple interests, multiple alternatives acting in complex physical domains). The ADSS prototype was composed from a set of specialized components (databases, models, learning tools, negotiation tools, multi-criteria analysis tools), serving with basic analytical, management, library and communication functions and providing the multiple usage modes, views and scenarios as well as self moderation functionalities.

## 6.2	Raindrop - Storm water management project

The RAINDROP-Project funded within the EU-Interreg IIIB-Programme CADSES. Its partners include the cities of Karviná (CZ), Kupferzell (G), Vsetin (CZ), Trencin (SK) and Aharnai (GR). The project started in 2005 and finished in 2007. The main goal of RAINDROP is to create guidelines and

knowledge for stormwater management (SWM) in the Central Adriatic Danubian South East States (CADSES region) [7].

Storm Water Master Plans (SWMP) were developed. Beside of the classical elements of a master plan like hydrodynamic modeling of the sewer system and pollution load modeling for the CSOs the SWMP had strong focus on storm water Best management practices (BMP) - source control measures. In the first part SWMP were developed and the second part dealt with the realization of demonstration projects for BMP. Each project partner developed the project, which respects local specifics. Based on the experience gained in frame of projects execution the guidelines were developed. The guideline provides a methodology for storm water management in two levels - small-scale – as BMP and large scale - as planning process in level of SWMP.

7   CONCLUSIONS

The Central and Eastern Europe passed a hectic decade in many aspects including those of Hydroinformatics. The introduction of this technology was not easy at the beginning however, it can be argued that the present technology of Hydroinformatics belongs to the standards in the water engineering sector and is becoming more and more practical for project cases. This brings better understanding of the aquatic environment and its processes, allows for optimization of complex system performance and highlights the ecological and societal aspects of the aquatic environment.

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