INTEGRATED INTELLIGENT PLATFORM FOR MONITORING THE CROSS-BORDER NATURAL-TECHNOLOGICAL SYSTEMS

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ABSTRACT

The paper presents the ongoing INFROM project 'Integrated Intelligent Platform for Monitoring the Cross-Border Natural-Technological Systems', ELRI-184 within the Estonia-Latvia-Russia cross border cooperation Programme within ENPI (European Neighbourhood and Partnership Instrument) 2007-2013. The project aims to improve integrated monitoring and control of cross-border complex systems which contain natural, technological and social elements, in normal and emergency situations based on heterogeneous data received from space and ground-based information sources.

Keywords: integrated monitoring and control, cross-border complex systems, natural, technological and social components.

1. A SHORT SUMMARY OF THE PROJECT

Nowadays, monitoring and control methods are applicable only for specific Natural Technological Systems (NTS). As a result, statistical information about existing systems is not well coordinated. This drawback becomes more evident in emergency situations, when effective decisions must be taken within a short time period while different information flows have to be analysed.

Monitoring information regarding incidents and disasters is received typically from different facilities (e.g. biometric systems, aerospace systems, etc.), and, therefore, it is heterogeneous in nature (e.g. electrical signals, audio and video information, text, etc.). Thus, since modern NTS are very complex and multi-functional objects, their monitoring and control should be performed in conditions of large-scale heterogeneous data sets. Nowadays, the monitoring and control processes of NTS are still not completely automated.

The INFROM project addresses the problem of integrated monitoring and control of cross-border natural-technological systems in normal and emergency situations, based on analysis of heterogeneous data received from both space and ground-based facilities.

The project results will provide a unified approach for integrated monitoring and control of complex systems based 1) on analysis of heterogeneous data received from space and ground-based facilities; and 2) on different types of systems models (i.e., analytical, algorithmic, mixed) used to model behaviour of these systems. In order to select and develop an appropriate model, techniques for estimation of the model quality and its adjustment to a real application, are enrolled.

The INFROM project is an integrated one in which each partner carries out a part of activities of a joint project on its respective side of the border. And, the project priority and measure are defined as common challenges and joint actions aimed at protection of environment and natural resources.

The project is being implemented in close partnership of Riga Technical University (RTU, Latvia) and St. Petersburg Institute for Informatics and Automation of the Russian Academy of Sciences (SPIIRAS, Russia), and with the participation of associate partners, i.e. Committee on IT and Communication government of City of St. Petersburg (Russia), Latvian Transport Development and Education Association, and Diplomatic Economic Club (Latvia). Each project partner has accumulated unique experience and competence to fulfil its specific role in the project.

Key research activities of RTU include modelling and optimization of complex systems using artificial intelligence techniques, simulation in engineering, logistics and industrial management, as well as visualization in simulation. SPIIRAS has reach experiences of developing software and hardware for information real-time processing, developing information technologies for intelligent automation systems of control, developing fundamentals, models and methods aimed at investigating information processes in various complex systems. Besides, the lead partner, Riga Technical University, holds responsibility for the overall project management and administration; implementation of project activities and communication with all project participants, which is going to be established during implementation of the project.

The target groups which are the final beneficiaries of the project are ministries and agencies of regional development; environment, geology and meteorology

centres, departments of civil defence and emergency, local authorities, and academic and research staff of universities and research institutions. These institutions will benefit from possibilities to use the innovative intelligent information technology for monitoring and control of NTS structural dynamics (Okhtilev et al. 2006) in both normal and emergency situations. Integration of numerous heterogeneous data sources will unify and simplify the monitoring and control processes. Moreover, the proposed information technology will allow non-professional users to design and develop integrated real-time monitoring and control systems of natural-technological facilities.

2. OBJECTIVES

The overall objective of the project is to develop a universal common intelligent platform for unifying efforts of specialists from Russia and Latvia to protect the environment and natural resources, based on the integrated space-ground monitoring.

Specific objectives of the project include:

- Description of the state-of-the-art in automation and intellectualisation of complex systems monitoring and control in normal and emergency situations considering data from both space and ground-based sources;
- Development of a conceptual framework for intelligent monitoring and control of NTS based on mixed-type data processing;
- Development of IT tools for synthesis of an integrated intelligent platform for the cross-border NTS monitoring and control;
- Development of a software prototype to demonstrate possibilities and advantages of suggested tools for analysis and synthesis of an integrated system for the cross-border NTS monitoring and control;
- Creating a distributed network of workstations to support commercialisation of the project results during and after the project lifecycle.

3. PROJECT SCOPE

The project scope is specified by five Activity Packages (APs): AP1 – Management and Coordination; AP2 – Information and Visibility; AP3 – Information Technology Design and Development; AP4 – Implementation of Integrated Support Tools; and AP5 – Capacity Building.

The first activity package is aimed to ensure an efficient project management and information flows between partners and activity leaders. Traditional project activities such as organising technical meetings, steering committee and advisory board meeting are also in the AP1 scope.

The second activity package provides the project publicity measures and target audience with information about the project opportunities and results. Kick-off, progress and closing conferences are the main activities in the scope of the second activity package.

The third activity package focuses on development of methods for NTS's information representation under conditions of system structure dynamics and data uncertainty (Kokorin et al. 2012) and for NTS integrated modelling and simulation including dynamic reconfiguration of these systems under degradation process of their structures, as well as on development of innovative information technology for analysis and synthesis of an integrated intelligent platform for cross-border NTS monitoring and control. The monitoring and control of NTS will be based on integration of heterogeneous information received from space and ground-based facilities. The above-mentioned tasks will be solved by means of accumulating results of classical control theory, operations research, artificial intelligence, systems theory and systems analysis.

The forth activity package focuses on design of techniques for accumulating and usage of knowledge about NTS states; techniques for analysis and synthesis of NTS monitoring, and control systems considering heterogeneous space and ground-based data, as well as on design of a software prototype for synthesis and intellectualization of NTS monitoring and control technology that is oriented on concurrent on-line user software assurance for different types of space and ground-based monitoring data. This technology is based on flow computing models executed in real-time and in territorially distributed computing networks (Okhtilev and Vasiliev 2004).

The last activity package is centred on approbation of the developed technology platform within existing application domains and capacity building involving external experts and representatives of target groups for analysis and discussion of the project results. Attention will be paid to the growing potential of cooperation between Russia and Latvia and EU at all levels by creation of an international network, including scientific and educational institutions, local government agencies.

Implementation of all activity packages is organised within International Working Groups consisting of researchers and specialists from project partner organisations and external experts.

4. INNOVATIVE APPROACH

The innovative approach to integrated monitoring and control of complex systems including natural, technological, economic and social elements is introduced in the project. This approach supposes (see Fig. 1):

1) Integrated real-time monitoring and control based on analysis of heterogeneous information from space and ground-based facilities;
2) Unified processing environment for processing heterogeneous data from different sources and their integration;
3) Distributed, real-time database embedded into the monitoring and control system for creating a common information space;

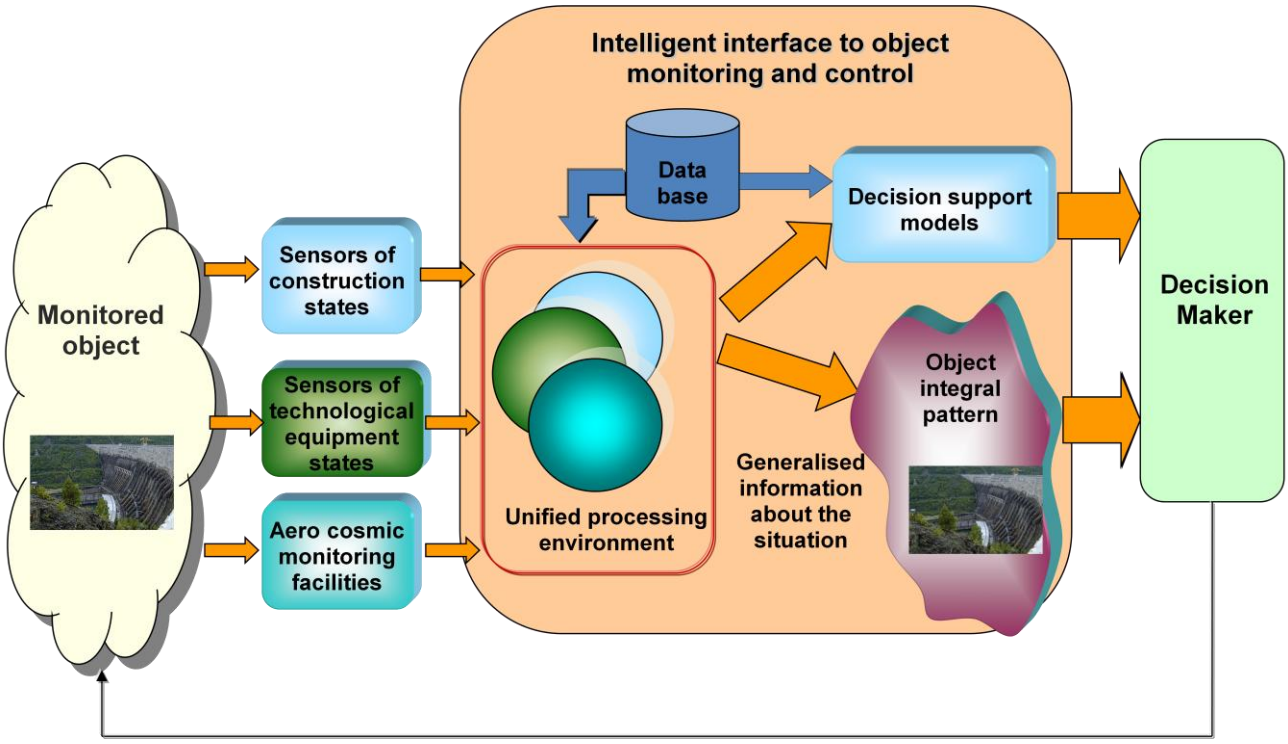

Figure 1: Integrated Monitoring and Control System

4) Multi-models for behaviour analysis of complex objects in normal and emergency situations and decision support.
5) Intelligent interface to object monitoring and control;
6) Data-flow computing models for large-scale datasets executed in real-time and in territorially distributed computer networks.

5. EXPECTED RESULTS

The following results from project implementation are expected:

- Improved monitoring of cross-border natural-technological systems by implementation of an integrated intelligent monitoring and control platform in Latvia and Russia;
- An increased precision of event forecasting for the situation course by using simulation techniques;
- Increased capabilities of specialists by organisation of their training in both Latvia and Russia;
- Intelligent IT tools for NTS monitoring and control considering integrated data from both space and ground-based sources;
- Models of NTS as well as monitoring and control systems in normal and emergency situations;
- Methods of dynamic reconfiguration of NTS monitoring and control systems;
- Techniques for synthesis of intelligent NTS monitoring and control systems considering heterogeneous space and ground-based data;
- A software prototype for NTS monitoring and control based on heterogeneous space and ground-based data;
- An integrated distributed network of workstations to provide a remote access to data archives and their integrated processing in Latvia and Russia.

6. SUSTAINABILITY OF PROJECT RESULTS AFTER THE PROJECT LIFE CYCLE

Sustainability of project results after the project life cycle is defined by a high level of their topicality for various natural and technological systems in different problem areas, as well as by an innovative nature of project developments.

The project will contribute to sustainable development of the cross-border region environment. Environmental sustainability will be ensured by providing an integrated intelligent platform and related intelligent information technology for efficient monitoring and control of NTS in normal and emergency situations providing a higher level of the ecological safety. Also, the elaborated GIS (geographical information system) prototype is aimed to support an Internet-based customer service system by receiving and processing heterogeneous space and ground-based data within the cross-border regions for control of monitoring objects. The developed customer

service system will provide integrated monitoring and control facilities and an intelligent interface with them suitable for non-professional users. The sustainability of project results after its completion will be also secured by scalability and flexibility of the developed intelligent platform providing possibilities to replicate and extend the implemented functionalities. Moreover, the implemented information network of workstations will provide a unified information and intellectual space for cross-border communication at different levels. Additionally, planned within the project training activities will allow capacity building for providing the sustainability of project results after the project life cycle.

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