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# DECISION SUPPORT SYSTEM IN THE FIELD OF URBAN TRANSPORT ECOLOGY

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The ecological monitoring system examined in this article is a complicated system with a number of specific features exercising an essential influence upon the efficiency of its operation. The investigations conducted in the field of applying modern database technologies allow one to improve the existing analytical information systems and accelerate the development of the new generation of these systems for EDSS (ecological decision support system). Such systems should be developed through using Data Warehouse Technologies, On-Line (interactive) Analytical Processing (OLAP), Data Mining, and Temporal Database. The obtained results are of universal character and can be used in EDSS of various applications.

***Keywords:*** *urban transport, ecology, monitoring, decision support system, data warehouse*

## 1. Introduction

The current environmental degradation in major cities is connected with the permanent increase of urban traffic and production volumes, etc. All this poses new requirements both to management of municipal economy and urban infrastructure development as such [1]. Searching optimal solutions on environmental situation management implies using up-to-date mathematical methods and computer technologies. An important role in this issue is imparted to the establishment of an information system supporting the decision-making process [2]. The system should provide for the collection and accumulation of various statistical data received across different channels of information, including various kinds of ecological monitoring stations, automatic meteorological stations, manual input of data obtained as a result of various measurements, etc.

Integration of all constituent parts of monitoring in a single analysis and information system developed through using the cutting-edge computer technologies minimizes their integration costs, reduces the data exchange and conversion time, and excludes any losses of information – therefore, increasing reliability and efficiency of the systems created.

The approach described in the work is oriented towards of such data bases in the up-to-date technologies of decision support systems (DSS) that allow the use of existent systems and speed up development of information and analytical system applied to fulfil the tasks of transport ecology. Such systems should be developed through using Data Warehouse Technologies, On-Line (interactive) Analytical Processing (OLAP), Data Mining, and Temporal Database [3–5].

## 2. Organization of Ecological Monitoring in the Urban Environment

Ecological monitoring – this is an information system for monitoring, assessment and prognosis of changes in the surrounding environment that has been developed with a view to establish an anthropogenic constituent part of the changes in the frameworks of natural processes [1]. Two main reasons determine the aim of executing monitoring: to evaluate whether the requirements are meat and to introduce ecologic data reporting. It should be noted that data of monitoring carried out with one particular aim can be efficiently used for other purposes, too. Efficiency of public ecological monitoring depends on correct organization thereof. Several approaches to monitoring of different indices are possible; however, not all of these approaches can be used for a particular parameter:

- direct (immediate) changes;
- implicit (or substituted) parameters;
- material balances;

- computational methods;
- emission coefficients (emission factors).

Selection of the approach is determined by several factors, including the likelihood of excess of maximum concentration and the consequences of such excess, required precision, costs, simplicity, efficiency, reliability, etc. Moreover, the selected approach should conform to the form of emission or discharge of a particular component.

When elaborating requirements for monitoring, it is necessary to pay attention to temporary parameters, the most important of them being as follows:

- the time of probe sampling and/or introduction of changes;
- the time of averaging;
- periodicity of changes.

The conception that lies on the basis of determination of temporary monitoring traffic can be illustrated by parameters A, B, C and D as it is showed on Figure.1. They demonstrate the character of emission changes (vertical axis, i.e. *Y*) in the course of time (horizontal axis, i.e. *X*).

**Process A** is a very stable process. The time of probe sampling does not play a major role, which means that frequency of monitoring can change, which is driven by consistency of results irrespective of the time interval between the measurements.

**Process B** is a typical example of cyclic or periodical technological process. The probe sampling time and the averaging time can be restricted by the periods of executing the periodic process.

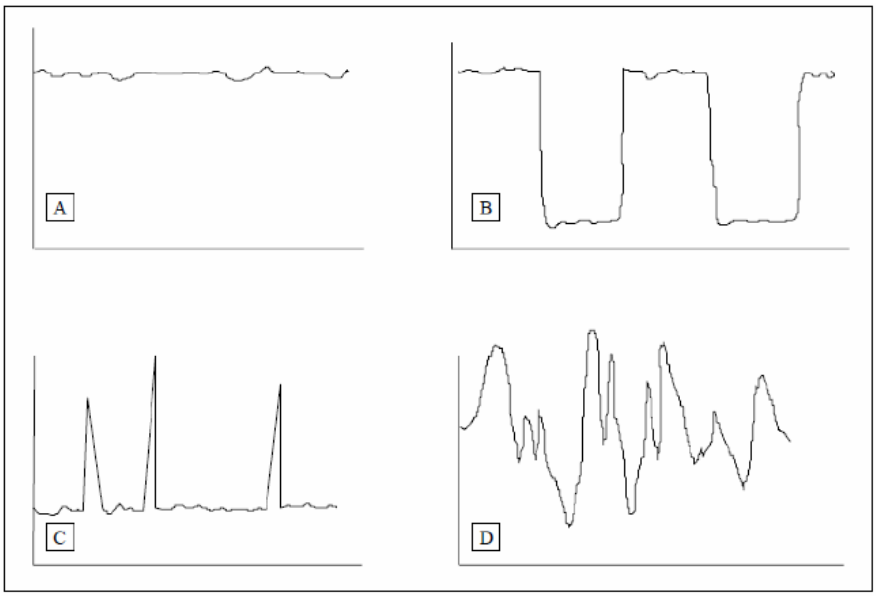


*Figure 1.* Examples of changes of emission though time and influence of these characteristic features on the selection of schedule of monitoring

**Process C** is a relatively stable process with periodical short-tem peaks, though being substantial as to their readings that have almost no impact on the aggregate indices of emissions.

**Process D** is a very unstable process. In the particular case, the probe sampling time is very relevant because different results that can be obtained due to irregularity of parameters of technical process for probe sampling on different stages [6].

Tasks of city environment ecological monitoring are rather difficult due to large quantities of mutually interacting and dynamically changing factors. They ensure constant accumulation of statistical data that are retrieved in the result of numerous observations of different objects, like data on concentration of polluting substances in different environments measured in different places of a city within certain time intervals. On the other hand, such systems should contain data on all measures regarding environment protection or improvement of ecology, effectiveness indices of such measures, etc. Consequently, ecological monitoring serves as a base for the system for maintaining ecologic situation in a city environment. Such a system includes the following tasks [7]:

- observation of impacting factors and state of the environment;
- evaluation of actual condition of the environment;

- prognosis of the environment and assessment of prognosticated state of the environment;
- regulation of quality of the environment.

The scheme of interrelation of the above mentioned tasks is illustrated on Figure 2. A separate box of the scheme contains tasks of mathematic modelling that ensure fulfilling of the tasks of assessment and forecasting of the ecologic situation. Moreover, as systems of ecological monitoring and management of ecology of cities develop, the importance of mathematical models constantly increases.

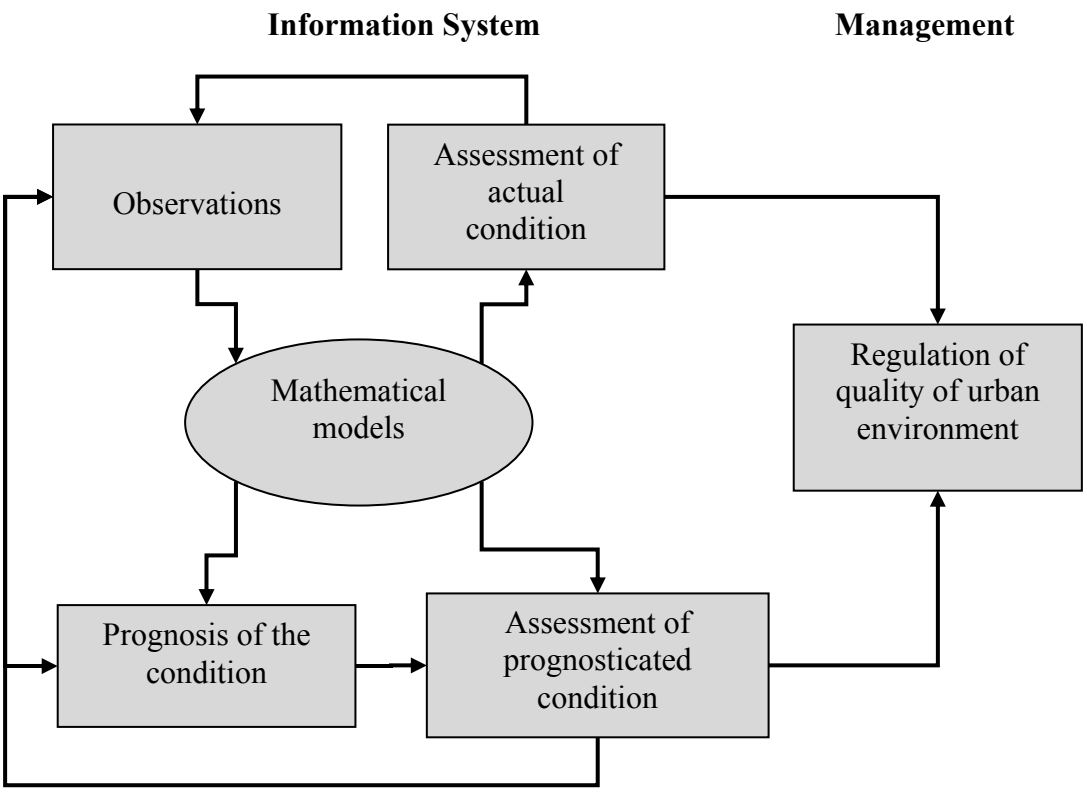


*Figure 2.* Scheme of mutual interaction of the tasks of ecological monitoring and management of urban environment

The ecological monitoring system examined in this article is a complicated system with a number of specific features exercising an essential influence upon the efficiency of its operation. Among them, the following should be mentioned first:

- intensive dynamics and impermanence of all the processes;
- the dependence of functioning processes upon a variety of random factors such as modes and velocity of transport, the height of adjacent buildings, weather conditions, and some others;
- stringent requirements to accuracy and regularity of data-generating process;
- considerable demands for financial, labour, and material resources;
- the complicated network of ecological monitoring stations for which management and planning processes are organized.

The features enumerated above pose special requirements to ecological of decision support system (EDSS) with respect to transport since even some minor errors in the data used can result in making wrong decisions on the improvement of urban ecological situation.

## 3. Formation of Decision Support System in the System of Ecological Monitoring of Urban Environment

Generally the process of decision-making for a subsequent period of system functioning lies in the analysis of generated data that characterize objects of management and a set of management activities developed on the basis of them, these activities ensuring fulfilment of the aims set.

To analyse the dynamics of changes in the ecology and to determine regularities of development thereof, it is necessary to store all generated date for a long time by ensuring a convenient access to them. To ensure an efficient management of a company, it is necessary to have the EDSS that uses all data generated by all IS of a company. Moreover, the use of the data stored in the EDSS is hampered by the following problems:

- heterogeneity of information systems used;
- large quantities of data;
- the difficulty of simultaneous use of one and the same IS data to fulfil the tasks of decision-making by a group of analysts;
- loss of information credibility.

These problems can be successfully solved by applying new concepts of storage and analysis of corporate data in systems of distribution architecture when developing the EDSS [3], [4], including the following:

- creation of data warehouse, the main task of which is accumulation of large quantities of data from different sources [5];
- on-line analytical data processing (OLAP) [5].

The ideology of creation of data warehouse lies in the following. In the process of decision-making, an analyst must interact with a range of information systems that are called operative data bases (DB) that undergo constant updating and generation of data (in real time). To make a decision at a particular time, a user needs constant integrated data. These data from operative DB should be transferred to an integrated DB where information is not updated in real time but according to a certain regime and within a certain time frame. Into this integrated system, data from external operative sources can also be uploaded, these sources being Internet, hard copies of documents and other sources that are necessary for modelling of a system under observation (see Figure 3). This problem-oriented integrated DB is, in fact, a data warehouse. This data warehouse is provided with the model of "mass upload" of data that is executed within certain time frames by generating the data from information sources, namely, operative DB. If compared to operative data bases (On-Line Transaction Processing, OLTP), data warehouse provides a more complete image of system functioning in general, because it contains historical related data related with functioning of certain OLTP systems for the entire period of their existence, as well as data from external sources.

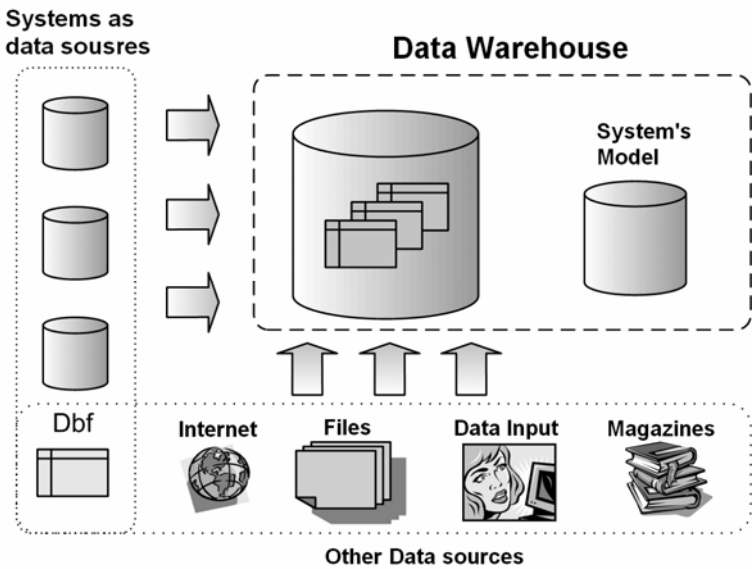


*Figure 3.* Conceptual schema of architecture of an analytical system

One of the measures to delimitate access to data (see Figure 4) that is broadly used when working with data warehouses, are Data Marts [5]. Data marts mean a segment of data warehouse that ensure decision-making support for a certain group of users. Data marts may have a physical and a virtual form. Physical data marts store data in certain structures of an external data carrier. Virtual data marts do not perform direct storage of data, whilst they request the date from the respective systems when addressed.

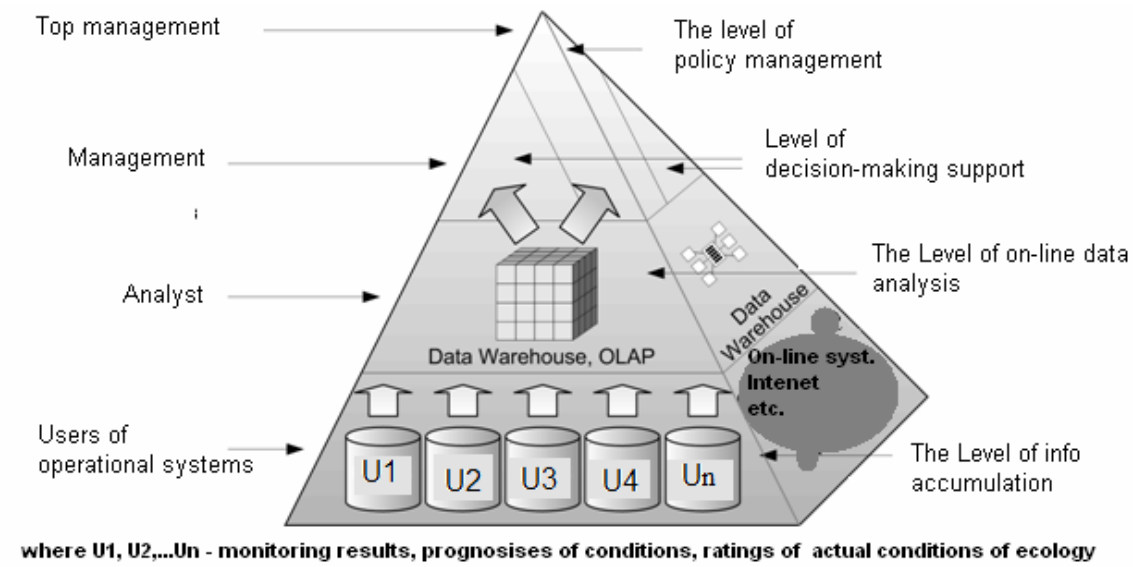


*Figure 4.* Pyramid model of the EDSS

The use of data marts offers a range of advantages. Generally, the process of functioning of the information-analytical system under review includes five main stages: decoding and cleaning of data, uploading of data into a warehouse, creation and stocking up of data marts, operative analysis of data and generation of reports.

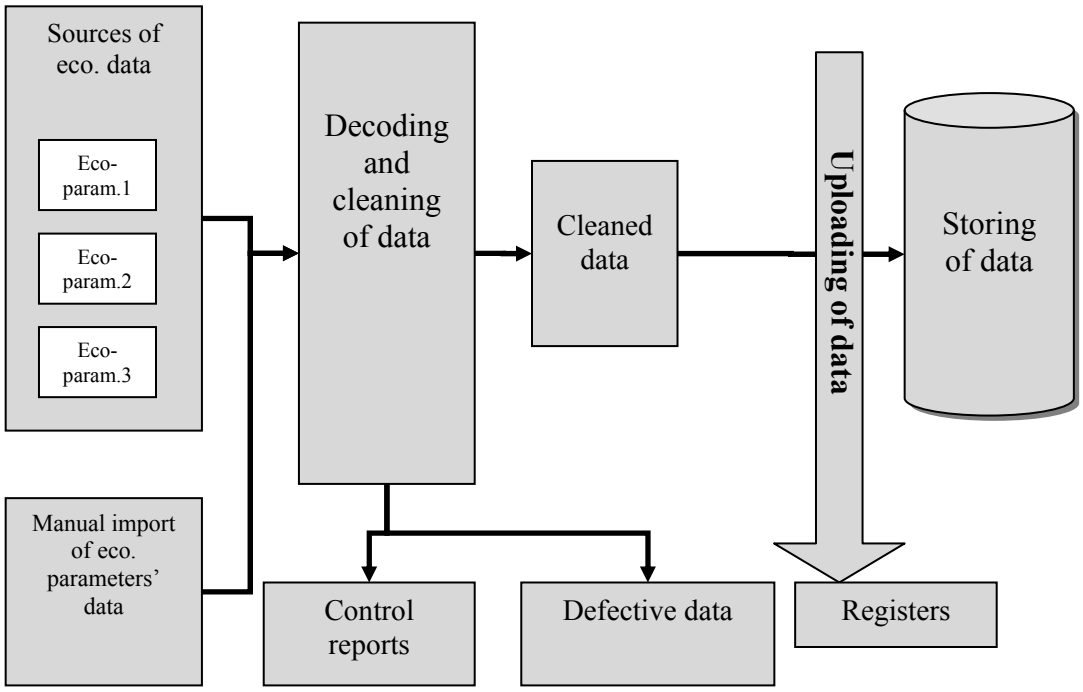


*Figure 5.* Organization of processes of decoding, cleaning and uploading of data into the warehouse

Now let us examine the content of the above stages on the example of a system of analysis and statistical reporting on ecological monitoring, this system fulfilling the following functions [3]:

- collection, decoding, cleaning, consolidation, accumulation and storage of data of different levels of aggregation from various information sources (Figure 5);

- transformation of data and formation of data marts to enable operative analysis in any dimension, for any period of time and at any degree of detailed elaboration;
- formation of the entire reporting system on ecological monitoring and operative forming of now forms of reports for any time frame, staring with the creation of the system;
- singling out of errors in the data of ecological stations and errors of functioning of equipment software;
- explanation of data anomalies.

***Operative analysis of data and reporting*** *(*see Figure 6*).* Data marts are used as data sources for OLAP. The mathematical model, after having obtained data, should generate special reports for further data processing by analysts. To simplify data perception, it is necessary to present them in the form that is convenient for carrying out analysis.

This reduces efficiency of the system of ecological monitoring at a considerable rate and might lead to great financial losses.

The main advantages of the EDSS described herein are as follows:

- effective processing of large quantities of data that are transferred from various information sources;
- ensuring of data credibility when transforming them into EDSS;
- formation and simultaneous use of a range of alternative mathematical models that serve as basis for different scenarios of behaviour of the ecological monitoring system avoiding material increase of the amounts of data to be stored;
- fast analysis of large amount of different scenarios with different combinations of management and external impacts and elaboration of suggestions for management of ecological monitoring system in different situations;
- historical data support with an access to all versions of objects available.

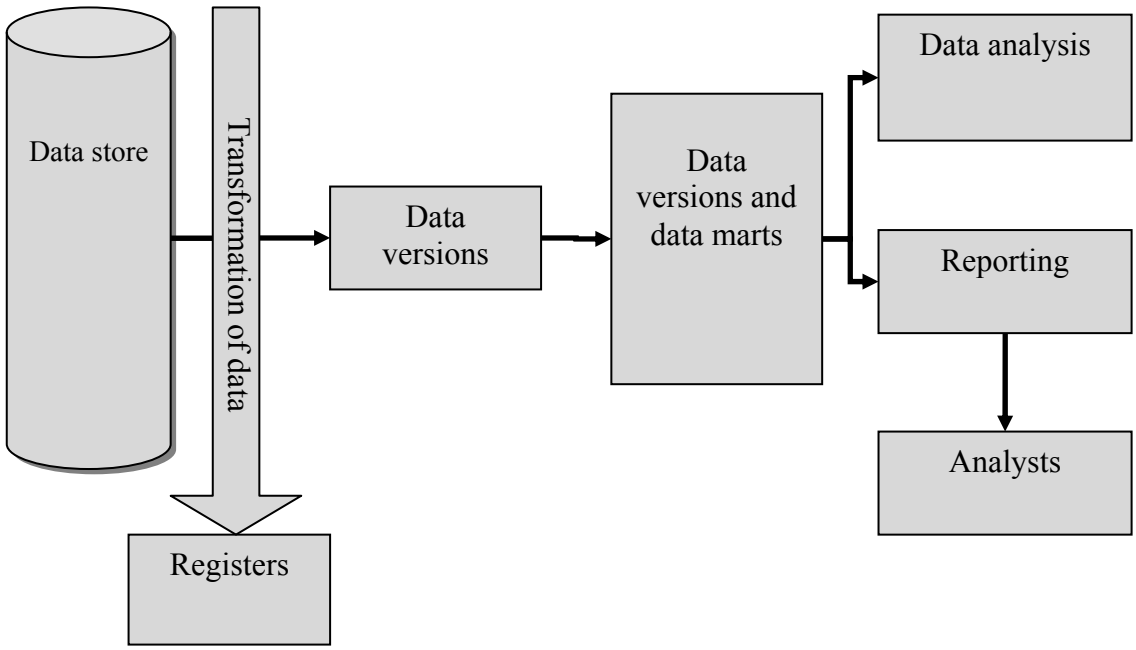


*Figure 6.* Organization of processes of data transformation, formation of data marts, executing of operative analysis and reporting

It is preferable to apply, to the system, a tool of flexible accounting. Each enterprise use standard forms of reporting that are characterized by strict requirements regarding their timeliness and credibility. Along with this, the system should allow generating of reports of a random structure by using a special report constructor.

## 4. Conclusions

Fulfilling of the tasks of ecological monitoring cannot be achieved without up-to-date measurement and communications means and new information technologies. The practice of the use of monitoring systems shows efficiency and viability of the general concept of it, as well as certain technical solutions in real conditions. Integration of all constituent parts of monitoring into one single technology reduces costs for joining of it, reduces data exchange and transformation time, excludes loss of information by thus increasing credibility and effectiveness of systems to be formed.

The open architecture of equipment and software allows developing the structure of equipment changed and introduces new algorithms of environment control, developing and modernization of existent systems.

Researches performed in the field of application of up-to-date technologies of data bases allowed suggesting principles for elaborating new information-analytical systems for the ecological system of decision-making support (EDSS). The main advantages of the EDSS are as follows:

- effective processing of large quantities of data that are transferred from various information sources;
- ensuring of data credibility when transforming them into EDSS;
- formation and simultaneous use of a range of alternative mathematical models that serve as basis for different scenarios of behaviour of the ecological monitoring system avoiding material increase of the amounts of data to be stored;
- fast analysis of large amount of different scenarios with different combinations of management and external impacts and elaboration of suggestions for management of ecological monitoring system in different situations;
- historical data support with an access to all versions of objects available.

The results obtained have a universal character and they can be used in the EDSS of different types.

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