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METHODICAL PRINCIPLES OF INTEGRATED SPACE MONITORING OF COMPLEX ENVIRONMENTAL SYSTEMS

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To address the large-scale environmental problems it is important to have control of a current situation as well as estimate and the forecast of arising changes. Thus tracing relationship between activity of a society and change in a quality of environment will be absolutely impossible without carrying out of large scale monitoring. The need in such monitoring from both supervising and the operating organizations of any State is huge and doubtless.

The ideal solution of such problem would be creation of a complex monitoring system capable of simultaneous tracing of a wide spectrum of changes occurring in all components of the environment-territorial complexes such as the national parks, administrative area, a battlefield or even a State.

Complex monitoring consist of specific monitoring operation, periodically carried out as a unified program for the purpose of a timely exposure of arising changes as well as a control of the processes, taking place in a monitored territory.

Complex monitoring allows addressing of the following sets of problems:

- monitoring of a structural integrity of region, including changes in a configuration of borders, disappearance and occurrence of new objects;
- monitoring of activities of enterprises and organizations maintaining natural resources of region;
- near real-time monitoring of regular or emergency transformation of any of the objects in on a region territory;
- address of the scale and major parameters of the catastrophic phenomena or acts of nature;
- prevention or minimization of an environmental damage;
- inventory of natural resources;
- evaluation of the general conditions and the tendencies in the environment change;
- estimate of effectiveness of nature-conservative measures.

The classic monitoring consists of consecutive data collection and analysis, evaluation of tendencies in the conditions propagation, identifying of critical points and outlining the forecast. It is done by cyclic repetition of five standardized operations:

- carrying out of a series of the unified measurements;
- formation of a full picture of actual conditions of an object;
- analysis of speed and an direction of the revealed changes;
- forecast of a developing situation;
- presentation of the obtained results.

Theoretically complex monitoring could be carried out by means of a classical monitoring. However within the limits of existing systems of monitoring it will require collection and processing of large amount of information, so that the cyclic approach to the monitoring becomes technically impracticable.

The alternative approach to the situation became possible with the advent of digital space pictures and a wide circulation of powerful hardware-software tools of their processing. It opened the possibility of near real time transformation of a digital image in a multidimensional matrix containing thousand and even millions of statistically authentic definitions [1, 2, 3, 4]. It allowed not only simplifying the main task of monitoring – a timely data collection of large amounts of information, but also opened way to automation of the whole monitoring process [5, 6, 7]. This approach allows for creation of qualitatively new monitoring service, based on a

significant amount of specialized tracking systems with repeatedly improved characteristics and increased number of monitored functions.

Use of images taken from space increased almost 10 times the reliability and accuracy of the meteorological forecasts, solved the problems of monitoring of the farmlands, forest fires, floods and high waters tracing etc. However the problem of complex monitoring of an environment has not been solved. In this case the problem is attributed not to technical but methodological issues. There is a clear absence of specialized methodical procedure which could describe functional principles of the complex specialized hardware-software system. Ideally this system would be receiving images, taken from the space as an input an and giving out on as a result guaranteed decision of same 3 base problems of classical monitoring - gathering and the analysis of the information on a present condition of object, the analysis of tendencies of development of conditions, and outline of critical situations and forecast.

Procedure of complex space monitoring assumes the solution of a standard problem of classical monitoring with the new methods and at the new technological level. Such system should cyclically carry out the same operations on gathering and processing of the information, but work in an automatic mode and on the basis of the newest methods of space imaging and computer facilities.

In a general view the system of complex space monitoring consists of three functionally isolated components [8, 9]:

- a space based imaging complex (a space segment);
- an antenna-reception complex of data collection and preliminary imaging processing;
- a hardware-software complex of the final image processing and results representation.

Distinguishing feature of such system is that the only the block of final image is a specialized component of structure. The space segment and an antenna-reception complex can exist as isolated components, structurally focused on the working with the wider class spectrum of tasks. The implementation of specialized systems of monitoring are not necessarily require deployment of the specialized space vehicles and land structures. The task of uninterrupted data delivery can be solved and by the implementation of a reliable communication channel from already existing space information reception stations, or from constantly updated databases with the access via. Internet.

The main problem of the complex space monitoring is that the task cannot be solved without automation of the entire procedure, from the data collection procedures to the final processing of the huge digital files with the information of various quality.

The overall complex space monitoring can be described in general as following sequence of the operations, carried out in an automatic mode with a set of objects unusual for classical monitoring:

- reception and preliminary preparation of the current image of region.
- comparative comparison to the reference image.
- analysis of the revealed changes and an estimation of their importance.
- identification and parameterization of the processes which have caused occurrence of significant changes.
- revealing of the dangerous processes and the general estimate of an actual condition of an environment in the region.
- retrospective comparison of the changes fixed for a consecutive number of previous pictures, estimate of the basic tendencies in the objects transformation in the region and construction of short-term and long-term forecasts of situation development.

The overall structure of complex space monitoring is not only has no theoretical contra-indications to realization, but also can form a basis for creation of efficient technology of space monitoring

With reference to large and non-uniform structured regions it is impossible to execute these operations without digital space images and powerful enough hardware-software means of their processing. Possibility of almost real-time transformation of a raster image in to the

multidimensional matrix containing thousand and even millions of statistically authentic definitions allows for simplifying the solution for the main problem of monitoring – timely reception of large amounts of the measured information. It is also opens door for automation of the entire cycle of monitoring operations.

The very important specific feature of complex space monitoring is that the main interest is in the changes which have occurred with each or in each object of monitoring rather than in the object itself. Thus the core of the proposed technique is not in the difficult and labor-intensive repetitive recognition and tracing of the objects, but in much more simple operation in identification of differences and changes between the current image and the etalon. The revealed distinctions can be interpreted as quantitative characteristics of the normal (evolutionary) or abnormal processes occurring within controllable region.

In order to system to function the certain requirements are imposed on the system components. For example, the specific requirements for the images taken from space and suitable for the complex space monitoring are:

– the multi-aspect interpretations of the data which allows to execute multilateral and purposeful mapping;
– the uniform basis used for thematic decoding which facilitates the coordination of characteristics and their uniform localization in the cartographic image;
– simultaneous and timely transfer of information, received on several spectral channels;
– high repeatability and efficiency;
– possibility of continuous registration of a condition of traced territory to reveal the basic tendencies of transformation and create a basis for forecasting.

In addition, it is required to find optimum balance between imaging parameters and data processing to create simple and reproducible procedure. The procedure will be using standard hardware-software means, proceeding from scale of controllable objects, parameters of existing image-making techniques (the permission, visibility of pictures), and hardware/software limitations. In the basis of a selection technique for balanced shooting and data processing parameters there shall be a correct and methodically verified sequence of the operations representing ordered procedure.

It is possible to represent algorithm of work of complex space monitoring in the form of consistently carried out stages (steps).

As a result of the first step in complex space monitoring the initial sketch of a matrix of the revealed changes and an explication of an actual condition of controllable territory will be produces. For this purpose all significant changes of the environment revealed during the given cycle of measurements are put on a topographic map or a hybrid vector-raster picture (the complete set of pictures) using a special color scale and in an interactive mode. Their characteristics and genesis are market and in an interactive mode the description of an actual situation is created. This description outlines:

– specificity of time transformation of the basic objects of land tenure of controllable territory.
– the list of objects undergone changes in a course of the given cycle.
– the list of the dangerous and catastrophic phenomena with instructions of co-ordinates or zones of their distribution in region territory.
– the general changes of the area of the basic grounds on areas or economy.

Further, in the second step the analysis of an orientation and character of the revealed transformations is done. It results in set of short-term or long-term forecasts of development of a situation. Since during monitoring certain strict quantity of the processes with different both often fixed speed and an orientation, the analysis procedure in most cases can be minimized to monitoring of the speed of processes of transformation occurring with reference to each of fixed objects. Examples of such processes could be expansion of woods into meadows and pastures, effects of drainage and bogging, transformation of river deltas and riverbeds. There is also a possibility of dynamic visualization of results of action of the given processes.

Last step is modernization of the reference (etalon) image for the region and representation of results of monitoring. The modernized standard, filled up with images of newfound and irreversible transformed objects is put in a database

Creation of a technological chain on the basis of the developed and tested methodical procedure assumes the preliminary solution of some problem questions. First, it is a question of creation of the reference image capable of complex characterization of structure of the basic components of an environment of given region. Second it is a question of an establishment of unequivocal communication between changes fixed in a picture and real processes of transformation of an environment. The answer to these points in question has key value in creation of projected system because it can affect cardinally not only the list of the requirements shown to quality of all its other knots, but even its structure.

It is possible to conclude that for creation of technology of complex monitoring of the environment, capable to work in automatic mode, the program-technical complex (PTK) systems of complex space monitoring should consist of following structural blocks:

- the block of reception and preliminary processing of digital space images (DSI);
- the block of target processing DSI;
- a database of standards and DSI;
- the block of the analysis of results;
- the decision-making block;
- the block of representation of results.

It is obvious that the created system should represent the uniform, constantly operating PTK regularly accepting space images on "input" and giving out information on character and parameters of changes of landscape structure of large region «on an exit». Thus bearing structure of this complex, one should make or a little enough powerful connected computers, bearing or one large, or some specialized packages of the software.

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