System Research of Space System of Remote Sensing of the Earth

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Abstract – The space systems (SS) of remote sensing of the Earth (RSE) consist of different on a principle of operation and physico-technical nature subsystems, which, interacting among themselves, will derivate multilevel (hierarchical) frame. In this connection SS RSE it is possible to relate to composite systems, for which research the methods of the systems analysis will be utilized. In the given report the methodical fundamentals of SS RSE system researches are considered which allow evenly to analyze relationships of cause and effect in a system and to receive numerical evaluations of efficiency of operation as separate subsystems, and SS as a whole. Thus as an effectiveness criterion the estimations of probability of the solution of RSE theme problems will be utilized.

Keywords: Remote Sensing Space System, System Analysis, System Dynamics, ABC-method.

1. INTRODUCTION

The obtaining of the space information ensuring the solution of a broad circle of scientific and applied problems, is composite technical-organizational process requiring of serious preparation, bound with considerable temporary, labor and material costs. SS RSE consist of different on a principle of operation and phisico-technical nature of subsystems (observing of an earth surface, registration of the remote sensing information, control, transmitting and receiving of the information, processing and distribution of the information), which, interacting among themselves, will derivate multilevel, outline. In this connection SS RSE it is possible to relate to composite systems, for which research the methods of the systems analysis will be utilized. Last, depending on solved problems, provides the multifold analysis of a composite system at different levels of the abstract description: linguistic, logic-mathematical, information, heuristic etc. With the count of correlations between subsystems, external actions and limitations on the basis of selected criterion of an estimation of the received solutions. The implementation of these methods in each concrete case demands formation of the criteria, simulations of process of operation of a system and creation of the conforming procedure of decision making. The development of computer technology has allowed to attract in a base arsenal of the systems analysis modern mathematical methods from the theory of operational research and common theory of control, that has allowed widely to utilize the mathematical description (simulation) researched systems, phenomena and processes. The common rules of construction of mathematical models of composite systems practically do not exist. The basis are steep comprehension of specificity of operation of a researched system, capability to utilize the mathematical vehicle, which is disposed by explorer, and also his experience and intuition.

Thus, the systems analysis represents set of methods based on the multifold analysis and simulation of composite systems, and its successful development in many respects is determined by modern capabilities and perspectives of development of computer technology.

2. MAIN BODY

The purpose of the given activity - substantiation of a technique, on the basis of which the program permitting to estimate informational - technical efficiency of SS RSE can be designed to simulate process of its operation, to forecast by experts the unpredictable scripts of development and to receive the solutions with the count economic and social factors. As an effectiveness criterion the estimations of probability of the solution of RSE theme problems will be utilized, which are perceived as obtaining the RSE information, used, alongside with other data, for the solution of scientific and applied problems in different branches of economic activity.

Existing software products based on a method of system dynamics [1], decide given problems partly. However they have essential limitations stipulated by methodical lacks of a method of system dynamics. The known program complex STK allows to conduct simulation of SS RSE operation process. It contains series of models, which allow to imitate orbital motion and orientation of space vehicle, to calculate the temporary and qualitative characteristics of coverage of sites of an earth surface, to determine reliability of radio communication between space vehicle and ground stations. To lacks of the STK it is possible to relate: absence of a method and conforming program for an estimation of SS RSE efficiency and its subsystems (calculation of the ballistic characteristics and control space vehicle, onboard recording systems, communication channels, ground receiving systems etc.), on a degree of conformity of SS RSE parameters to the characteristics ensuring fulfillment of a RSE scientific-applied program in a full volume. A corollary it is the absence of a capability of obtaining of a numerical evaluation of influence of each SS subsystem on efficiency of SS RSE operation as a whole and on final RSE outcome - quality, efficiency and quantity of the obtained information. The STK does not allow to simulate the different scripts of SS RSE development, to forecast consequences of contingencies, and also to determine the requirements to parameters again developed SS RSE on an effectiveness criterion of problem solving of a scientific - applied RSE program.

The creation of mathematical model, flexible and adapting for a varying situation, and computer programs of the SS RSE systems analysis will allow to optimize structure and parameters of SS RSE, sequentially to receive the rational solutions concerning maintenance and development of SS RSE, estimating its efficiency taking into account: conformity of parameters of instrumentation to information tags of theme problems, coverage of sensing regions, bandwidth of radio communications channels, optimization of operation of the ground-based information complex and complex of flight control of space vehicle (SV), arrangement of ground-based regions of the information

transmitting, rational resource allocation of systems of maintenance etc.

For construction of SS RSE dynamic models we shall take advantage of ABC method, which essence consists of the supposition, that the modules, components a controlled composite system, are in a condition of dynamic equilibrium bolstered by influence functions connecting modules among themselves. Therefore inside a system the mode of dynamic balance of influences is saved, and the external action at a system operates this mode. Usage of a ABC-method for an estimation of SS RSE efficiency is stipulated by that at the solution of this problem there is a necessity to balance operation of two inverse tendencies. On the one hand, tendency to increase probability of the solution of RS theme problems demands constant improvement of the quality of the obtained RS information, and with another - the technical feasibilities and financing superimpose limitations on improvement of SS RSE parameters. The concept of dynamic balance postulates additive character of influences on each of modules of a composite system on the part of other modules and on the part of external forces. In this connection the set of equations can be obtained which describes correlations of SS RSE units and dynamic balance of a system as a whole.
The process of creation of model contains some phases: at first, development of conceptual model of a system, secondly, wiring design of the main relationships of cause and effect between components of a system; in third, construction on the basis of last system diagram of model and in fourth, formalizing of model, i.e. obtaining of mathematical equations in an explicit form.

The conceptual model of SS RSE represents connection of purposes with the main structural members (subsystems), which operation provides achievement of an object in view. On the basis of conceptual model the main relationships of cause and effect between levels of model are shaped which mirror character of operation of SS RSE subsystems.

Taking into account, that the problem of an estimation of efficiency as SS and separate subsystems is put, in the scheme of relationships of cause and effect as levels the estimations of efficiency of operation of SS RSE subsystems will be utilized: Y_1 - efficiency of a sighting of an earth surface, Y_2 - efficiency of registration of the information, Y_3 - management efficiency, Y_4 - efficiency of transmitting and receiving of the information.

The efficiency of RSE problem solving (X_5) is influenced with following parameters: X_1 - quality of the RSE information, X_2 - efficiency of obtaining of the information, X_3 - SS RSE productivity, X_4 - probability of a decoding of space images. The listed parameters are simple enough and obvious, have clear physical sense and can be considered as individual criteria of an estimation of efficiency of fulfillment of the RSE program - the probabilities of the solution of RS theme problems.

External units of effect in model are: meteorological conditions - Z_1 , methods of a decoding - Z_2 , error of orbit and orientation of a space vehicle - Z_3 , space vehicle energy supply resource - Z_4 , hardware faults - Z_5 .

For the subsequent formalizing of model the time interval τ is entered, during which value of influential functions it is possible approximately to consider as stationary values. The formalizing of a ABC-module of SS RSE model is made as a set of equations (1):

$$X_{1k} = X_{1j} + \tau \cdot X_{1j}\left[\alpha_{X_1}(\Delta Y_1) + \alpha_{X_1}(\Delta Y_2) + \alpha_{X_1}(\Delta Z_1) + \alpha_{X_1}(\Delta Z_3)\right],$$

$$X_{2k} = X_{2j} + \tau \cdot X_{2j}\left[\alpha_{X_2}(\Delta Y_1) + \alpha_{X_2}(\Delta Y_4) + \alpha_{X_2}(\Delta Z_5)\right],$$

$$X_{3k} = X_{3j} + \tau \cdot X_{3j}\left[\alpha_{X_3}(\Delta Y_3) + \alpha_{X_3}(\Delta Y_4) + \alpha_{X_3}(\Delta Z_3) + \alpha_{X_3}(\Delta Z_4) + \alpha_{X_3}(\Delta Z_5)\right],$$

$$X_{4k} = X_{4j} + \tau \cdot X_{4j}\left[\alpha_{X_4}(\Delta X_1) + \alpha_{X_4}(\Delta Z_2)\right], \qquad (1)$$

$$X_{5k} = X_{5j} + \tau \cdot X_{5j}\left[\alpha_{X_5}(\Delta X_2) + \alpha_{X_5}(\Delta X_3) + \alpha_{X_5}(\Delta X_4)\right],$$

$$X_{6k} = X_{6j} + \tau \cdot X_{6j}\left[\alpha_{X_6}(\Delta Y_1) + \alpha_{X_6}(\Delta Y_2) + \alpha_{X_6}(\Delta Y_3) + \alpha_{X_6}(\Delta Y_4) + \beta_{X_6}(\Delta X_6)\right],$$

$$X_{7k} = X_{7j} + \tau \cdot X_{7j}\left[\alpha_{X_7}(\Delta Y_1) + \alpha_{X_7}(\Delta Y_2) + \alpha_{X_7}(\Delta Y_3) + \alpha_{X_7}(\Delta Y_4) + \beta_{X_7}(\Delta X_7)\right],$$

Where k and j - number of temporary countings of simulation of RSE process.

The operation algorithm of model consists in series simulation of subsystems: sightings, registration of the information, control, transmitting and receiving of the information by the ground-based complex, processing and distribution of the information. For an estimation of efficiency of operation and conformity of parameters of each SS RSE subsystem to the characteristics ensuring the solution of theme problems and the RSE program in as a whole, the procedure of the systems analysis based on function evaluation of conformity and a fitting of parameters of subsystems to the characteristics of problems will be utilized. As a result of such analysis of the characteristics of RSE problems X_6 and SS parameters X_7 are determined of efficiency Y_1 - Y_4 .

3. CONCLUSIONS

In summary it is necessary to underline, that the systems analysis is not equivalent to the computer program, that there are necessary analysis methods operating experience, intuition, ability of the man. In a series of cases the analysis techniques on the basis of common sense, experience, subjective judgment of the explorer play a main role. It, first of all, falls into to formation of mathematical model of a composite system, which creation a procedure informal, in a large degree dependent from abilities of the explorer. Therefore, the systems analysis necessarily includes the informal and heuristic procedures inscribed in formalized techniques of system researches. The conclusive advantage of system researches is represented in three aspects: a capability to expand views about "mechanism" of SS RSE operation; to increase a degree of justification of the received solution and to find ways of efficiency increasing of SS RSE operation. Thus it is necessary to have in view

of, that the guidelines obtained on the basis of the systems analysis, not always will be completely authentic, i.e. there is a risk element. But it is risk, when the scientific methods of an estimation of possible consequences are utilized, as against version, when risk without attempt to avoid acceptance of the negative solutions.

4. REFERENCES

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