MATEC Web of Conferences **102**, 01030 (2017) DOI: 10.1051/matecconf/201710201030
V International Forum for Young Scientists "Space Engineering"

The prerequisites of forming a risk management system in the design of facilities space application

Sergey Panychev[1,*], *Vyacheslav* Guzik[1], *Anatoly* Samoylenko[2], and *Andrey* Panychev[3]

[1]Southern Federal University, Department of computing, 347928 Taganrog, Russia
[2]Southern Federal University, Department of radio engineering and telecommunication systems, 347928 Taganrog, Russia
[3]Southern Federal University, Department of antennas and radio transmitters, 347928 Taganrog, Russia

Abstract. The problem of increasing the term of active existence of space-use equipment is relevant. Application of risk management system in the design and manufacture of space-use equipment is a promising approach to increase resiliency and reliability of spacecraft. This paper discusses the preconditions of the risk management system, which is based on the use of critical small amounts of the state of control objects. The technique of statistical processing of the data of the risks based of the additive approximation of the standard statistical distributions is presented. The generalized structure of the adaptive system of statistical diagnostics risk of abnormal conditions in the space application equipment is offered.

1 Introduction

In any project to develop space application objects (SAO) there are many uncertainties. Whenever the process of creating the new system has a significant departure from the usual practice, the result of the development becomes unpredictable. An important task of system engineering is to develop the management system so that the uncertainty was eliminated as early as possible [1]. Any suddenness in the later stages of the development system can cost significantly more than her detection in the early stages.

Problem of assessment and risk mitigation at its core is the task of identifying and eliminating uncertainties at all stages of the SAO lifecycle. Such problems can be solved by analysis, simulation, full-scale tests, which allow to diagnose and quantify the critical important characteristics of the system.

A promising direction for providing an increase fault-tolerance and reliability of SAO is the creation and implementation of an adaptive risk management system for the design and manufacture of SAO. This system will enable detect, locate and remove the causes of defects at all stages of the SAO lifecycle. The testing of system fragments is the means for collecting of important data on the behavior of the entire system and components under controlled conditions.

* Corresponding author: ruu2011@mail.ru

2 Materials and methods

A detailed description of the risk management is given in [2]. The main disadvantage of used risk management today is to use only quality scale of probability of potential importance of different sources of risk.

The proposed risk management system for the design SAO allows to quantify the significance of risks. It is based on a statistical diagnosis, adaptive to the actual condition of the equipment. To this end, the SAO is introduced into a non-standard mode, which causes random output of basic and additional parameters of the permissible area. Assessment of SAO levels is based on the analysis of level and duration of emissions of monitored parameters.

The risk management system is implemented at three levels. The first level provides a qualitative (rough) assessment. On the second level is produced the approximate continuous quantitative assessment of the actual state. On the third level is made accurate calculation of quantitative characteristics of reliability and adopting risk management solutions.

At the first level of SAO diagnostics is solved the problem of admission control. At this level is given a preliminary assessment of the actual condition of the equipment in the form of "fit – not fit." If any of the monitored parameters has gone beyond the limits of tolerance limits, the risk level is classified as high.

The second level of the SAO diagnostics is implemented, if the result of admission control was the "fit". At this level is produced an approximate quantitative estimate of the risk based on a continuous model of monitored parameters.

At the third level of risk control is made accurate calculation of quantitative characteristics of reliability for inhomogeneous Markov model. It is believed that diagnostic system has properties of adaptability to the structure and the number of available statistics through the use of special algorithms for processing of critical small volume of samples. Deciding on the potentially defective SAO fragments and generation of issue control actions is based on the application of the principles of fuzzy logic and is carried out on all the steps of SAO lifecycle.

3 Results

Figure 1 shows a generalized structure of the adaptive system of statistical diagnostics of risk for abnormal mode of SAO operation with regard to actual state of the equipment [3]. The principle of operation of this system is as follows.

The signals of controlled parameters of SAO (unit 1) $x_i(t)$, $i=\overline{1,N}$ are input to the threshold elements (TE) $2_1 - 2_N$. Here emissions of controlled parameters from tolerance zone are recorded. In unit 3 the parameters with emissions from tolerance zone are detected with an identification of address of the respective channels. In unit 4 the magnitudes of emissions A_{ij}, $i=\overline{1,k}$, $j=\overline{1,N}$ are measured by means of quantization of tolerance ranges to q levels, where k – is a number of parameters, which have emission from tolerance zone, N – is a number of emissions. The value q is determined depending on the specified value of reliability of identification random process $x_i(t)$. Similarly, in unit 5 emission duration τ_{ij} on k parameters through quantization in time of a random process $x_i(t)$ is measured. Accumulated during the process of diagnosing the amplitudes and durations are fixed in the form of emission samples formed respectively in units 6 and 7.

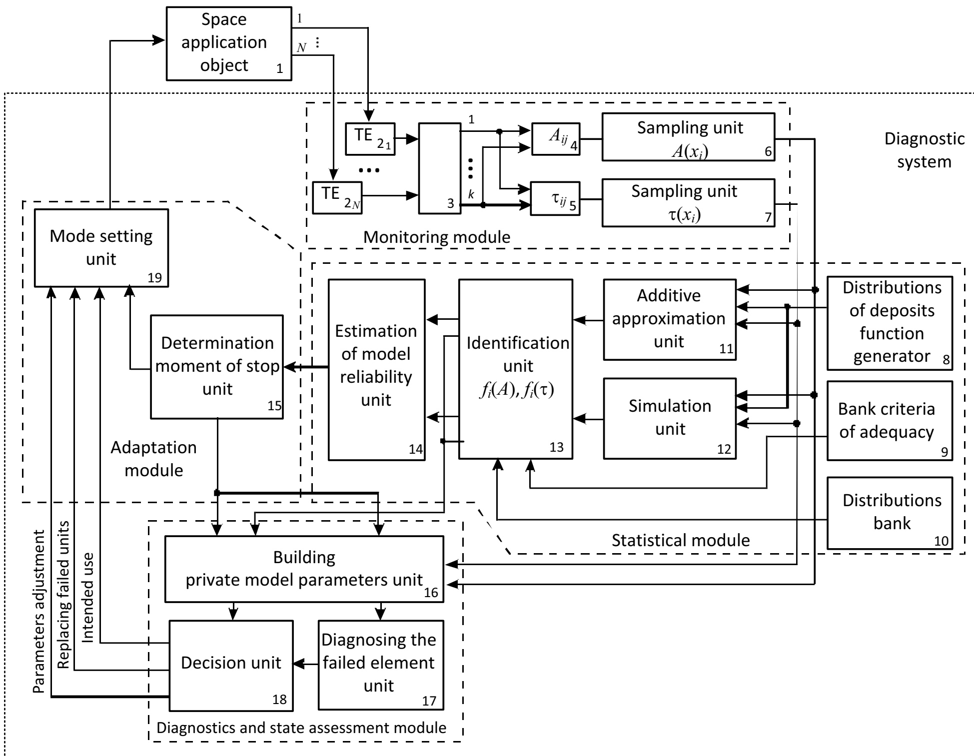

Fig. 1. Generalized structure of the adaptive system of statistical diagnostics of risk for abnormal mode of object operation with regard to the actual state of the equipment.

The sampling of amplitudes and durations parallel is given to the units 11 and 12. Unit 11 implements a method of additives for constructing the empirical density function of the distribution. Unit 12 implements the algorithm of kernel estimation of empirical data. Inputs units 11 and 12 are also connected to the generator output distributions of the function of deposits necessary for the implementation of method of processing of arrays of small samples. In unit 13 an identification of functions of amplitude distributions and emission durations of SAO diagnostic parameters $f_i(A)$, $f_i(\tau)$, which have been received in units 11 and 12, are performed. This procedure is made by sequential revision a plurality of the most common laws of probable distributions (equiprobable, exponential, normal, Rayleigh, Weibull et al.) from the bank of distributions 10. Calculations of corresponding values the criterion of consent are performed using the bank of criteria for adequacy 9. The designing of ranked series, based on which a decision on the conformity of empirical data to one of the theoretical distributions, is performed in unit 13.

The validity of the estimated statistical models of the individual parameters is assessed in unit 14, according to results of unit 13. Doing it, we calculate the conditional density distribution emissions of each controlled parameter $f_i(E) = f_i(A) f_i(\tau / A) = f_i(\tau) f_i(A/\tau)$.

In accordance with the theory of reliability the emission distribution density is equal to the frequency of failures i-th parameter. Then, the reliability (probability of failure-free operation) of the test piece for the i-th parameter is estimated by the formula

$$P_i(t) = 1 - \int_0^t f_i(E) dx . \quad (1)$$

Equation (1) gives a quantitative description of the significance of different sources of risk.

In unit 15 the proposition about stopping control process or its continuation, based on the calculation and analysis of the trajectory of the functional loss and the terminal benefit, is decided [4]. If unit 15 detects the inadequate reliability of the statistical models of the some parameters, then the unit of mode setting 19 generates a signal to continue the monitoring process. If unit 15 decides to move to the statistical diagnostic mode, then the unit of diagnostics and assessment of the SAO state will be initiated.

In unit of the construction of private models of parameters 16 is carried out formation of continuous models of efficiency for individual SAO parameters on the basis of sampling small size and probability models in form of two-dimensional functions of the density distribution for emission characteristics . Thereafter the intensities of gradual failures are calculated and an inhomogeneous Markov models for the three statuses are constructed. Based on result of operation of unit 16 the diagnosing of the failed element of SAO is performed in unit 17 that implements a technique localizing faults in the face of uncertainty.

Unit 18 uses the results of units 16 and 17 for producing three types of the control action to unit 19:

- the use of the SAO for its intended purpose in normal operation;
- regulation of unstable parameters and the SAO output to a normal operating mode;
- replacement of the failed unit (or fragments) of the SAO.

4 Discussion

The full-scale simulation and test of object fragments (and subsequently the facility as a whole) is applied based on the threshold principle of formation of the parameters emissions from the acceptable zone. As a result, monitoring values are presented as a series of random of levels of emissions object parameters [3].

Statistical processing of emissions critically small volumes is based on the additive principle. The emissions are presented as a set of standard symmetric distributions (deposits), or as a set of arrays of random values generated approximately the point of emission parameter.

Each mode of full-scale simulation is displayed as the numerical statistical characteristics of the corresponding random processes.

5 Conclusions

Thus, the proposed statistical diagnostics risk system can be put in the basis of full-scale tests and simulation of SAO fragments. This will mitigate the risks associated with the design and reduce the cost of resources in the production of facility.

References

1. A. Kossiakoff, W.N. Sweet, S. Seymour, S.M. Biemer, *Systems Engineering Principles and Practice* (A John Wiley & Sons, INC. Publication, 2011)
2. L. Wilson, D. McCutcheon, *Industrial Safety and Risk Management* (Edmonton, University of Alberta Press, 2003)
3. V.F. Guzik, V.I. Kidalov, A.P. Samoylenko, *Statistical diagnostics of non-equilibrium objects* (SPb, Sudostroenie, 2009)
4. A.P. Samoilenko, A.I. Panychev, S.A. Panychev, *SIBCON*, 7491722 (2016)