STRUCTURE OF ONBOARD INFORMATION COLLECTING, PROCESSING AND REGISTRATION SYSTEM OF FLIGHTING UNIT

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ABSTRACT

Modern onboard information processing system, depending on the tasks assigned, has a complex architecture aimed at parallel measuring processes and increasing tolerance to hardware failures of onboard equipment during its entire service life.

On the basis of a systematic approach to the analysis of a technical object from the standpoint of the problems being solved, systemic models and design object, which are the basis for creating a methodology for data extracting, synthesis and modeling of a technical object, are invariant with respect to the introduced levels of division. A lot of basic and auxiliary functions of the technical object were formed; the need for functional analysis for the evolution of a technical object was noted.

The interrelation of the function and structure of the technical object is considered, and a number of technical object structures are identified that are necessary and sufficient for mapping the process of the functional state.

The connection with the generation of auxiliary functions and the structure of a technical object is shown, the structure of the object's objectives research tree is determined.

Analysis of prospective systems for processing measurement information clearly shows the trend of using artificial intelligence in such systems and measuring hardware structures depending on the environment and the problem being solved.

Key words: space vehicles, information collection and processing system, abnormal situation, diagnostics, forecasting, digital system, automatic control, intellectual system, artificial intelligence.

INTRODUCTION

The establishment of the real causes of accidents and the preconditions for them is possible only if there is reliable information available. This task is solved by using a system of automatic registration of traffic parameters, crew members' conversations and air traffic service, as well as the use of ground-based technical means for recording and processing flight data. Recorded in flight and on the ground - the information allows more objective determination of the causes of abnormal situations and the preconditions for them, and systematic processing and analysis of flight data after each flight warns for abnormal situations and allows for objective monitoring of the performance of functional computer systems (CS) and the actions of the crew in flight, as well as assess their reliability and predict failures. For this, the information collection system (ICS) is used [1].

ICS is intended for the accumulation and preservation of information about flight conditions, the technical condition and quality of operation in flight of aircraft systems and devices, for assessing the crew's actions on aircraft control and determining other flight parameters. There are onboard and ground ICS.

The information from the onboard ICS is usually processed on the ground and is used to solve the following tasks: establishing the causes of accidents and the prerequisites for them; analysis of the actions of the aircraft and assessment of efficiency, technical diagnostics and forecasting of aviation equipment. The use of onboard ICS provides a significant reduction in the number of abnormal situations with unknown causes, which makes it possible to prevent analogous abnormal situations.

MATERIALS AND METHODS

The recording of the flight parameters from the onboard ICS allows you to reproduce the flight trajectory of the spacecraft and its position in space, determine the beginning of the development of a special situation and its nature, evaluate the actions of crew members, and the performance of certain functional spacecraft systems. Recording of conversations between the crew members among themselves and with the controlling services makes it possible to determine the correctness of their interaction, the accuracy of the commander's instructions and their execution by the crew members of the aircraft. A joint examination of the synchronized flight and conversations parameters during the time makes it possible to understand the causes that led to the change in the flight parameters, the operating mode of the engines, and so on.

Onboard ICS can be classified according to purpose, principle and form of recording. According to purpose, the onboard ICSs are subdivided into emergency, operational, combined and test. Emergency systems are designed to accumulate and store information used in the investigation of abnormal situations. They are equipped with special devices to protect the information carrier from impacts, fire, water and aggressive fluids, rescue and detection assets.

Operational systems serve for the accumulation of information, designed to assess the operability, the state of aircraft, the quality of piloting, as well as diagnostics and prognosticating. In these systems, there is no emergency protection of the information carrier, the number of recorded parameters reaches several hundred, and the record is made during the entire flight. Combined systems combine the functions of emergency and operational systems. They are performed in two versions; with one storage device, protected from destructive influences, and with two accumulators of information: one of which is emergency, and the other is operational. Test systems are used in the testing of new aircraft models. These are mostly non-standard ICS, used to record a large number of various flight parameters and the operation of onboard equipment. They include various recorders, oscilloscopes and other devices [2].

By the principle of recording information, onboard ICS are divided into systems with mechanical, magnetic, optical recording and combined. According to the recording form, the onboard ICS are divided into systems with analog, discrete and analog-discrete forms of information recording. Systems with an analog recording form include almost all systems with mechanical and optical recording principles, as well as dictaphones and magnetones, in which direct recording of negotiations on a magnetic medium is applied.

The general drawback of such ICSs is the low density and accuracy of the registration of parameters and the large laboriousness of automation of the processing process recorded by information to systems with a discrete recording form refer primarily to systems with a magnetic recording principle. The advantages of systems with a discrete form of recording - high accuracy of recording parameters and recording density, as well as the possibility of automation of the processing process, recorded information using a computer.

The main technical data of the onboard magnetic ICS. The proposed system for managing, collecting and processing data from the onboard recording equipment (ORE) of a space vehicle (SV) includes at least one ORE unit associated with at least two communication channels with a control and data processing unit (CDPU) that is connected with onboard equipment of the spacecraft at least one communication channel for the subsequent transmission of information to the Earth. The CDPU includes: an interface device, an autonomous timer device, a single-board computer, a forced cooling system, a thermal sensor system, a memory unit, a synchronous data transfer unit, a secondary power supply unit, and a command and power distribution system.

A system for controlling, collecting and processing data from an ORE of a SV, including one or more ORE connected units, with two communication channels with a control and data processing unit, for subsequent transmission of information to the Earth, also CDPU:

- interface device (ID), which is connected by two channels with the ORE;
- an autonomous timer device (ATD) connected by a local bus to the ID;
- a single-board computer (SBC), connected by a local bus to the ID;
- SBC associated forced cooling system (FCS), a system of temperature sensors (STS), a storage unit (SU) and a synchronous data transfer unit (SDTU);
- Secondary power supply unit (PSU), which carries out constant power supply of SBC, FCS, STS, SU and SDTU;
- command and power distribution system (CPDS) that feeds the PSU with primary (onboard) voltage and controls the PSU with the help of commands, in addition, the CPDS receives telemetric information from each ORE and transmits it to the onboard measurement system (OMS) of SV, and also translates them into the onboard measurement system for subsequent transmission to the ORE via communication channels [3].

The SDTU receives information from the SBC, buffers it in its own memory for subsequent synchronous transfer of digital arrays (DAs) to the OMS of the SV in the regime of an operational transmission of the DA to the Earth.

The system for controlling, collecting and processing data from the ORE of the SV is characterized by the fact that the command and power distribution system includes telemetric sensors: a relay contact, a temperature sensor, an electronic key, analog sensor (AS) and docking control (DC) information from which the OMS issues to the onboard space vehicle measurement system.

The system for controlling, collecting and processing data from the ORE of the SV includes a support control channel and an information transfer channel.

The disadvantage of this option is the impossibility of simultaneous control of various onboard equipment [4].

RESULTS AND DISCUSSION

Tasks solved with the proposed system:

- cheaper construction of scientific equipment due to cheaper element base (corresponding to less critical operating conditions under conditions of hermetic volume) used in CDPU;
- standardization and unification of the CDPU element base;

- reduction of the heat release of the ORE due to the distribution of the control system, data collection and processing;
- creation of a flexible system of operational control, collection and processing of information due to the simultaneous combination of management functions, organization of reception, accumulation and preliminary processing of information from various unrelated OREs;
- saving financial resources and increasing the reliability of the system due to the maintainability of the CDPU in the regular operation (the possibility of maintenance of the CDPU by the cosmonaut crew);
- technical result - the possibility of an easy, convenient, reliable simultaneous connection to the device of various onboard recording equipment installed outside the spacecraft space and control of it in future.

The technical result is achieved by the fact that the data acquisition and processing system from the ORE of the SV includes at least one ORE unit connected by at least two communication channels with a CDPU, which is associated with the OMS of the SV on at least one communication channel for subsequent transmission of information to the Earth.

The communication channels associated with the ID with the - information management system are SpaceWire and/or MIL1553 and/or LVDS and/or CAN.

The high-speed data transmission interfaces of the SBC for communication with the IMS are RS422/485 and/ or USB and/or Ethernet.

The communication channels connecting the ORE to the CDPU include a support control channel and an information transfer channel.

In the system for managing, collecting and processing data from the ORE of the SV removable information carriers are used as a storage unit, and the ID has its own memory to conduct the buffering of the data entering the DC from the ORE.

Onboard equipment of SV (for the space station there is an additional opportunity to use, if necessary - in the case when the inboard equipment is unreasonable and cannot receive data and apply control actions to the CDPU, to control the operation of the CDPU and receive the data from the CDPU - onboard laptop);

- CSOE - control system for onboard equipment, from which the CDPU receives power and receives relay control commands (RCC);
- IMS - information management system;
- ORE 1 ... ORE N - onboard recording equipment, in the number of N-pieces (N-whole), mounted on the outer side of a space station or spacecraft and each having at least two communication channels: the service control channel of the DCS and the information transfer channel (depending on the experimental conditions and the amount of the transmitted data flow, it is possible to use one bidirectional interface such as RS422 with a transmission rate of up to 1 Mbit/s for simultaneous implementation of the above channels communications - SCC and CIT);
- SCC - service control channel;
- ITC - information transfer channel;
- CDPU - control and data processing unit, this unit is installed inside the space station or spacecraft, i.e. in a hermovolume of station or spacecraft.

The CDPU contains the following systems:

- ATD - autonomous timer device;
- LB - local bus, which is connected with ATD and ID, ID and SBC;
- ID - interface device that connects ORE 1 ... ORE N with SBC and has communication channels: Space Wire, MIL1553, LVDS, CAN;

- DA - digital arrays;
- SBC - single-board computer with high-speed data transmission interfaces (RS422 / 485, USB and Ethernet) intended for communication with IMS of onboard equipment of SV;
- FCS - forced cooling system associated with the defense industry;
- STD - a system of thermal sensors associated with the SBC;
- SU - a storage unit associated with the SBC;
- SDTU - the synchronous data transfer unit in the OMS, also associated with the SBC;
- Secondary power supply unit (PSU), which carries out constant power supply of SBC, FCS, STS, SU and SDTU; - CPDS - command and power distribution system, controlling the power supply unit, as well as broadcasting of service telemetry information from the ORE to the OMS. The composition of the CDPS includes telemetric sensors, RC - relay contact, TS - temperature sensor, EK - electronic key, AS - analog sensor, CD - control of docking;
- DC, ATU and PSU are connected to the internal SBC bus (local buses (LBs) such as PCI, ISA, etc.) through standard mezzanine connectors.

In the claimed system, CDPU is intended for:

- organization of management of various OREs via service control channels (SCC) via interfaces MIL1553, SpaceWire, USB, RS422 / 485 or CAN or other necessary interfaces;
- receiving digital information from different OREs via information transfer channels (ITCs), through the high-speed interfaces MIL1553, RS422 / 485 or CAN (with speeds of about 1 Mbit/s) or high-speed (more than 10 Mbps) - LVDS, LAN, SpaceWire (for one ORE there can be several ITCs working on different high-speed interfaces);
- receiving digital information arrays from various OREs on high-speed SpaceWire interfaces (with speeds from 2 to 400 Mbit/s), LVDS, Ethernet;
- collection of auxiliary service information (interrogation of additional thermal sensors installed in the heat-emitting elements of the CDPU in the thermal sensor system (TSS) for subsequent inclusion in the scientific information format;
- collection of auxiliary service information received from telemetric sensors installed in the ORE for its subsequent transmission to the OMS;
- accumulation, temporary storage, received from various ATD information arrays and transferring them to the IMS of the SC on the LAN (Ethernet) channel for subsequent transmission to Earth;
- reception of the onboard time code (OTC) (at least once a day) and four-byte command words from the IMS of the SV on the control channels RS422 or CAN;
- obtaining ballistic-navigational data via control channels RS422 / 485, Ethernet or CAN for their subsequent inclusion in the data format for the subsequent binding of the position in the ORE space at any time during the registration of the data;
- development of an independent time stamp (with the help of ATD) with a view to its further binding to the mark of the OTC; - processing and compressing the received information sets from various OREs and transferring them through the SDTU to the OMS for an operational transmission to Earth and analysis.

The SBC is the central element of the CDPU and represents a commercially available powerful industrial-standard processor module (it is possible to use a specialized SBC created separately for a specific CDPU development and having all the necessary interfaces for interface with onboard equipment of SV and ORE, but the creation of such a SBC is an extremely costly task, it must additionally undergo certification to determine whether it can be used in space technology) that has an internal bus (a local bus such as PCI, ISA or others).

The SBC manages the ORE, the program collection of the service and scientific information from the ORE according to the measurement program encoded in the programmable read-only memory (PROM) of the SBC, writes the data to the RAM of the SBC, and preprocesses information and outputs it to the memory via Serial ATA, or in the onboard equipment of SV through its own high-speed interfaces (Ethernet, USB, etc.), or by first transmitting the above information via LM to the CS (if the SBC does not have the necessary high-speed interfaces for transmitting information in the onboard equipment of SV), and then in the onboard equipment of SV through high-speed interfaces (LVDS, Space Wire, etc.).

The SBC typically includes the following main elements: processor, RAM, Ethernet network controllers, video controller, serial RS422 / 485/232 ports, USB ports, soldered flash drive, standard parallel port (SPP), Serial ATA interface, watchdog timers, etc.

To fulfill the assignment requirements, the CDPU uses the QNX-type real-time operating system (RTOS) installed in the SBC, which has high reliability when working in network applications and allows to achieve full compatibility with, for example, the RTOS of the Russian Segment (RS) of the International Space Station (ISS), which allows you to effectively interact (to exchange data on requests) at the CDPU level of the ISS RCs (for example, according to the known system "server" - "client").

The ID enhances the capabilities of the CDPU, providing interfaces for exchange with OREs that are not in the SBC.

The ID receives scientific information from the ORE in the form of digital arrays through the KPI channels and transmits it to the SBC on the LM. The UE has its own memory to conduct, if necessary, the buffering of the NI entering the DC from the ORE (buffering occurs when the ARU operates in the high load mode and the LM cannot handle the large data stream).

The ID carries out the exchange of data between the ORE and the CDPU via SCU channels: CU and IPM arrive in the BRA, and responses (receipts) from the BRA to the BRA KU arrived.

The need for an independent (from the SBC processor) autonomous timer device (ATD), which controls the periodic procedures of software devices, is dictated by the possibility of the emergence of the facts of "hangup" (looping) of microprocessors due to single failures that have a nonzero probability. Simultaneously, ATD can supply the system of information collection with a code of relative system time with an accuracy of 0.1 microseconds. Thus, in the second place, ATD is designed to associate the event registration time with the time stamp issued by the information control system (ICS) of the space vehicle.

The CPDS receives onboard power supply voltage of 28V from the OMS via a separate feeder, CPDS has inside it a protection against improper connection of the power poles and from a short-time impulse starting current of 10A, and also filters (blocks) the input power from electrical interference as from the load side connected to feeder, and vice versa, on the part of CDPU.

CPDS accepts discrete (relay) control commands (DCS) from the CSOE and translates them into the ID and the ORE. In the command circuit, a ± 28.5V supply is applied to the CDPU and, respectively, to the ORE via independent power lines. The commands are sent to the CDPU / ORE to the control windings of the relay, duplicated by the "dry" relay contacts. In parallel to the commands, the onboard relay contacts are supplied with a 28.5 V onboard power supply, which, when the relay is activated, is applied to the load and creates a constant load current (electronic CDPU / ORE nodes). The passage of all DCS is confirmed by receipts (CDPU / ORE response to DCS passage), issued by CDPU / ORE via discrete channels of SBM telemetry through relay contacts (RR) of "dry contact" type. In this case, the load current to the external circuit is limited to a value of 10 mA (when the normally open contacts are closed). In addition, receipts are duplicated and sent to the CDPU as a format for the register status of the commands. The structure of CDPS for monitoring the supply voltage of 5V includes one sensor type EK (electronic key). In addition, CDPS issues information from the telemetry sensors (TM sensors) to the ICS of the satellite system.

The main function of the SDTU is to receive data in the form of digital arrays (DA) of information from the SBC via the synchronous data transmission channel (after their preliminary processing of the SBC and compression), buffering them in their own memory for subsequent transmission to the OMS of the SV for an operational transmission to the Earth and analysis.

Formal description of the onboard decision-making system

Recently, in the onboard information processing systems, elements of artificial intelligence have become widely used, such as the decision-making procedure. One of the main tasks to be solved by such a procedure is the selection, processing and transfer of "relevant" current streams of measurement information received on board, as well as the optimal distribution of computing and hardware resources for solving the tasks posed: (Fig. 1).

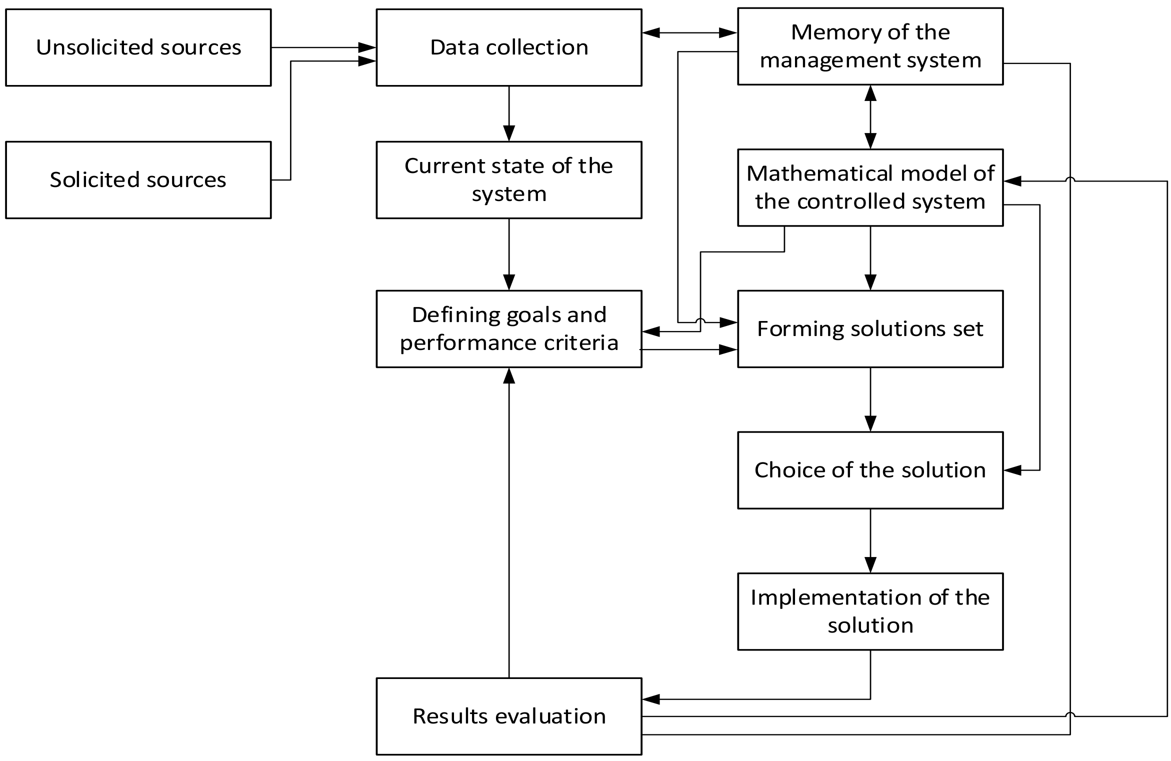

Fig. 1. Decision Making Procedure

To organize information exchange between different classes of a complex technical system, it is necessary to consider the development of an information model of a technical system. [4] Let's imagine a technical object in the form of a two-level system including description, analysis and synthesis and consisting of:

• a system model describing a technical object;

• a system model consisting of the necessary information for a technical object.

The system model of the description as an object includes the structural-parametric and functional descriptions [5]. The relationship of these descriptions is a one-to-one correspondence of f: $\sum \to \Phi$.

A two-level system model for describing a technical object can be represented in the form of the following relationships:

$$TO_P \begin{cases} \left\{ {}^kL^i, k=0,1; i=1,n_k \right\}; \\ \left\{ {}^k\sum{}^i = < {}^kI, {}^kF, {}^kTO, {}^kA, {}^kG, {}^kZ, {}^kC, {}^kW, {}^kQ >^i, k=0,1; i=1,n_k \right\}; \\ \left\{ {}^k\Phi^i = < {}^kW_{in}, {}^kW_{out}, \left\{ {}^{k+1}\Phi^i \right\}, {}^kS_\phi, {}^kZ_\phi, \left\{ {}^{k+1}Z^\phi{}_i \right\} {}^kZ^\phi, {}^kZ_0, {}^kR, T >^i, k=0,1; i=1,n_k \right\}; \end{cases} \quad (1)$$

where L is the set of design goals at the k-th hierarchical level;

k = 0, 1 - respectively, the zero or first levels of the partition representing the technical object, as a whole or at the level of its functional modules;

i - the 1st functional module, which is part of the first level of the division;

n_k - number of modules at a given level of division (for k = 0 - n_k = 1);

I - a set of names of functional modules; F is the set of functions of the functional module;

A - the set of abstract functional elements;

G is the set of geometric elements uniquely corresponding to the abstract;

U - set of relations between elements (succession, compatibility, inclusion, etc.);

O_P - set of features that describe the components of the system model at a qualitative level;

Z - set of properties; C is the set of relations between the module and the environment;

W - set of correspondences defining the equations of design, construction and functioning;

Q - set of correspondences that evaluate the effectiveness of the projected object;

W_{in} - input actions of the environment on the functional module;

W_{out} - the system's output actions on the environment;

G - the output operator;

S_ϕ - the structure of the process of functioning of the object;

Z^ϕ - set of properties that are characteristic for the functioning processes;

$\left\{ {}^{k+1}Z_i^\phi \right\}$ - set of states of technical subsystems;

Z_0 - variety of environmental properties of operation;

R - set of conditions for the existence and termination of the process;

T - time.

The concept of the function F of the object is defined as the consumer F_n and technical functions F_τ of the technical object. A consumer function F_n is an action produced by a technical object, leading to the realization of a person's interest, designation of a technical object. Technical function F_τ describes the intra-system actions between the elements of a technical object, leading to the realization of its consumer function by transforming some input effect, i.e. is uniquely described as an output statement [6]:

$$F_T : T \times Z^{\phi} \times W_{in} \rightarrow W_{out} \tag{2}$$

The description of the consumer function of any technical object can be represented in the form of four sets of the following form:

$$F_n = \langle D, X, H, {}_f P \rangle \tag{3}$$

where D is the set of actions produced and leading to the desired result;

X - the set of objects (operands) to which these actions are directed;

H - set of special conditions and constraints of the performed actions;

${}_f P$ - a set of functional characteristics, allowing to specify and hierarchically structure the function description. [7]

Practically at all levels of functional specification of a technical object the following sets of invariant attributes P_d, P_x, P_k are used:

P_d = {mode of action, place of action, degree of action, nature of action, mode of action};

P_x = {type of operand, type of operand, state of operand};

P_k = {type of medium, medium temperature, medium characteristic}.

By entering other characteristic values from the characteristic space $P_d \times P_x \times P_k$, the whole set of specific descriptions of the abstract function is received, as well as the set of corresponding technical objects. Thus, it is possible to generate a space of possible functional descriptions of a technical object and analyze the correspondence of qualitative descriptions of the existing technical object to their form [8].

In general, the structure of a technical object on the upper levels of hierarchical division can be described by the following many types of structures:

$$S \langle S^*, U_s \rangle$$

where is S^* the set of technical object module structures;

U_s - a set of relations of communication. [9]

There are seven aspects of the S^* description:

$$S^* = \langle S_d, S_{\phi}, S_a, S_M, S_v, S_s, S_g \rangle, \tag{4}$$

where S_d is the structure of actions;

S_{ϕ} - structure of functions;

S_a - abstract structure;

S_M - morphological structure;

S_v - variant structure;

S_s - spatial structure;

S_g - geometric structure.

An indicative description of the structural elements of a technical object, as well as the set of relations between these elements, determine the specific type of structure of a technical object, each of which can be represented by the following generalized expression:

$$\forall \times x \times \underset{i=1}{\overset{n}{e}}(\underset{i=1}{\overset{n}{\wedge}} PQ(x,y) \underset{\substack{i=1 \\ j-i+1}}{\overset{n}{\wedge}} PR(y_i, y_j)) \rightarrow e \times \mu(PS(x,\mu)), \quad (5)$$

where PQ is a predicate, meaning that the object consists of a set of elements $\{y_i, i=1,n\}$;

PR - predicate, meaning that between the elements y_i and y_j there is a relation that has a different essence in different types of structures;

PS - predicate, meaning that the object "has a structure S, described by an adjacency matrix " μ ".

The structure of the action consists of a set of actions and follow-up actions performed by the technical object or the pumping module U_d , indicating the order of actions [10].

The structure S_d is constructed when the designer is not satisfied with known functional structures and he is looking for new ones S_ϕ.

The functional structure S_ϕ can be represented in the form

$$S_\phi = \langle F, U_\phi \rangle, \quad (6)$$

where F is the set of operational functions of the technical object;

U_ϕ - set of relations of following S_ϕ.

An abstract structure $S_a = \langle A, U_a \rangle$ has many interrelated generic elements that perform functions $\{F_i\}$, as well as a variety of relationship relations U_a.

The structure S_a is the basis for constructing the morphological structure S_M of a technical object, which, as noted above, at the initial stages of design is necessary and sufficient to represent a two-level tree. The morphological structure $S_M = \langle A \cup B, U_1 \cup U_2 \rangle$ has two subsets of vertices: $A = \{A_i\}$ - the types of the functional module (vertices "AND") and $B = \{B_i\}$ - the set of variants of technical execution of types A_i (the "OR" vertex), as well as two subsets of the relations: U_1 - inclusion relations between the elements A_i; U_2 - the generic relations between the elements of the sets A and B [11].

The replacement in the structure S_a based on the generated S_M abstract elements A_i by concrete variants of their execution B_j forms a variant structure $S_v = (B, U_B)$, where $U_в$ - the concrete relationship of the connection between the execution variants B_j (in contrast to the abstract communication relations U_d, U_ϕ, U_a, U_M.

The difference between the structures S_v and S_a is that the S_v elements have specific names instead of abstract S_a ones, the abstract relationship of communication is replaced by a specific connection relationship [12].

The spatial structure S_n is the development of a variant structure $S_в$ that reflects the layout of a technical object in space:

$S_n =< B, U^n >$, where $U^n = {}_1U^n \cup {}_2U^n \cup {}_3U^n$ - a set of spatial relationships, which is a combination of three types of relationships: mutual location ${}_1U^n$, affiliation ${}_2U^n$ and direction (orientation) ${}_3U^n$.

These relations have the following sets of meanings:

${}_1U^n$ = {parallel, coaxial, perpendicular, symmetrical, top, bottom, right, left, front, rear};

${}_2U^n$ = {internal, external};

${}_3U^n$ = {on l_x , on l_y , on l_z , against l_x, against l_y, against l_z}, where l_x, l_y, l_z - are the Cartesian coordinate axes [17].

The environment of the technical object is described by the following set of components:

$$ {}^kO = \left\langle {}^kO_1, ..., {}^kO_i, ... {}^kO_n \right\rangle , \quad (7) $$

where, respectively: k - the considered level of the hierarchical division of the technical object;

${}^kO_1$ - control objects (human, robot, computer);

${}^kO_2$ - exploitation at all stages of the existence of a technical object;

${}^kO_3$ - interacting (conjugate) technical objects;

${}^kO_4$ - a production;

${}^kO_5$ - a technological process facilitated by a technical facility;

${}^kO_6$ - a product manufactured by means of a technological process into a technical object;

${}^kO_7$ - source of energy;

${}^kO_8$ - modes of operation;

${}^kO_9$ - operating environment [13].

The interaction of a technical object with an environment generates a number of links that determine, in turn, this or that property of the technical object:

$$ {}^kC = \bigcup_{i=1}^{9} {}^9 TO \times {}^K O_i ; \; {}^kC = \left\{ {}^kO_i, i = 1, n \right\} , \quad (8) $$

Description of the properties of a technical object of any level of the hierarchy is a set of triples of the form:

$$Z^i = (I^i, P^i, {}_z P^i), i = 1, n, \quad (9)$$

where *n* is the total number of properties of the technical object;

I^i- the name of the property, $Z^i; P^i = \{P_j^i\}, {}_z P = \{{}_z P_j^i\}$ - the set of parameters and characteristics that characterize the property Z^i [16].

The most important is the "class" attribute, which reflects the interactions of a technical object with the environment in which the property under consideration is manifested [14]. The breakdown of properties by this feature allows them to be grouped into the following main classes: functional, operational, production and constructive properties of the technical object (${}_f^0Z\, {}_h^0Z\, {}_p^0Z\, {}_k^0Z$ respectively).

The main functional properties ${}_f^0Z$ of a technical object are: productivity, speed [15].

The main properties of the technical object ${}_h^0Z$ are: reliability, maintainability, maintainability and ergonomics.

CONCLUSION

Modern onboard information processing system, depending on the tasks assigned, has a complex architecture aimed at parallel measuring processes and increasing tolerance to hardware failures of onboard equipment during its entire service life.

On the basis of a systematic approach to the analysis of a technical object from the standpoint of the problems being solved, systemic TO models as a design and design object, which are the basis for creating a methodology for extracting knowledge, synthesis and modeling of a technical object, are invariant with respect to the introduced levels of division. A lot of basic and auxiliary functions of the technical object were formed, the need for functional analysis for the evolution of a technical object was noted.

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The connection with the generation of auxiliary functions and structure of the technical object is shown, also structure of the object's objectives research tree is determined.

Analysis of prospective systems for processing measurement information clearly shows the trend of using artificial intelligence in such systems and measuring hardware structures depending on the environment and the problem being solved.

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