INTELLIGENT SYSTEMS FOR THE CORE OF ANTHROPOCENTRIC OBJECTS AND ITS MODELING

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ABSTRACT
Classification and patterns of computer simulation systems of onboard intelligent systems are presented; these systems provide improvement of knowledge bases of onboard intelligent systems at particular stages of their development. In the computer simulation system of the intelligent information system "The situation awareness of the crew" (the first global control level of anthropocentric object) the presence of a man-operator in the simulation loop is mandatory, and for onboard online advisory expert systems for typical situations of a functioning an anthropocentric object (the second global control level of anthropocentric object), the operator work is simulated by a special a block of situation management.

Keywords: onboard intelligent systems, computer simulation systems for the development of there knowledge bases, algorithms of an activity of an operator.

1. INTRODUCTION

An anthropocentric object is a shell with a great number of macrocomponents implemented in it (the board of the anthropocentric object):

- the onboard measurement devices receiving information from the external world, in which the anthropocentric object operates, and from its onboard world;

- the core of the anthropocentric object in which three global control levels are distinguished: online assigning of the goal (the first global control level), determination of method for achieving online assigned of the goal (the second global control level), realization of this method (the third global control level). In the core the main role belongs to the team of operators (crew);

- the onboard executive devices acting on the external and onboard world.

It is convenient to describe operation of any anthropocentric object by the calculated set of its operation sessions; each of these sessions is characterized by the general goal of the session and the semantic network of typical operation situation in turn, each of these typical situations is represented by the semantic network of problem subsituations of this typical situation. All above are the content of the model "Stage" (another name "General task - global control level" (Fedunov 2010).The model "Stage" is using in the time the development of onboard algorithmic and indication providing of modern anthropocentric objects.

The practice of application and development of modern anthropocentric objects requires the creation of onboard intelligent systems supporting the crew in the course of solution of problems of the first and the second global control levels.

2. STRUCTURE OF OPERATOR ACTIVITY ON BOARD TECHNICAL ANTHROPOCENTRIC OBJECT AND CLASSIFICATION OF ONBOARD INTELLIGENT SYSTEMS OF ITS SYSTEMGENERATING CORE

The activity of the operator (crew) on board the anthropocentric object is represented in terms of the following components (the algorithm of the activity of the operator (the AlAcOp)).

The operator makes decisions on online problem, realizes its solution, and participates in different tracking operations as the element of the tracking system (Fedunov 2002a). All information necessary for operator activity is giving to him on the information-control field (ICF) of the crew cockpit and/or is giving to him via cockpit voice devices. The realization of decisions and participation in tracking operations is performed by the crew via control organs of the ICF. All elements of the operator activity are represent in the integrated way by the graph of operator decisions. The estimation of feasibility of the whole volume of this activity described in operator decisions graph is performed using the computer system "operator decisions graph estimation" (Abramov et al. 2006; Fedunov et al. 2006b).

Let us consider the capability of estimation of the time necessary for the operator for each component of his activity.

Each operator decision is related to one of the following types: π-decisions (perceptive-identification), ρ-decisions (speech-mental), and π-ρ-decisions (heuristic) (Fedunov 2002).

Each π-decision is characterized by the instantaneous reaction of the operator for a certain signal stimulus.

Time expenses of the operator on making such a decision consist of the time spent for detection and recognition of the corresponding signal-stimulus.

These decisions are represented in the operator decisions graph:

(i) by the composition of information or speech message (signal-stimulus) which are necessary for the operator to make decision;

(ii) by the output information: composition and sequence of manual operations necessary for realization of the received decision by the operator.

For the estimation of the time of the perception and the comprehension of the information by the operator the information is represented by the set of the symbols that are indicated on the display of of the ICF. The time estimates necessary for it are introduced into the computer system named "The estimation of the operator decisions graph" from (Fedunov 2002a).

Each ρ-decision is characterized in the operator decisions graph by the following:

- input information including information of the information-control field of the cockpit according to which the operator should make this decision; the composition and duration of speech message, that is used in decision making, is informing to the operator by the cockpit speech device ;
- the decision structure is described by the number and composition of online perception units according to which the decision is made; the composition and sequence of elementary acts of the decision, that had maked, are described in terms of the indication symbols in the displies of the information-control field;
- output information are represented by the composition and sequence of manual operations that are necessary for realization of this decision.

The necessary time for the adoption and the realization of this decision is estimating into the system "The estimation of the operator decisions graph".

Each π–ρ-decision is heuristic. Upon design of the operator activity, it is characterized in the operator decisions graph as follows:

- (i) input information represented by the composition of information in the ICF of the cockpit according to which the operator should make this decision; the composition and duration of speech message, that is used in decision making, is informing to the operator by the cockpit speech device ;
- (ii) the necessary time for the adoption and the realization of this decision is estimated experimentally;
- (iii) output information is characterizing by the composition and sequence of the manual operations that are necessary for the realization of this decision.

The operator activity algorithms that connect with his participation in tracking processes are described in a rather general form at the stage of development of specifications of onboard algorithms. For estimation of the time that the operator had used on the tracking process the following assumptions are maded. It is assumed that the operator is working in discrete-continuous regime. He execution of tracking operations and after they had ended he is occupied with the making and realization of decision (decisions). After the decision (decisions) was realized, the operator comes back to the tracking process again. He eliminates the error of the tracking. This error accumulated in the time when the operator is taking decision (decisions). Time instants of operator diversion to tracking operations cannot break the process of the decision making and the process of the realization of this decision. The time, that the operator is spending on the tracking process, is represented by the dependence $\tau_{track} = f(\tau_{div})$, where τ_{track}.is the time of the removal of the tracking error by the operator, τ_{div}.is the time when the operator is taking decision (decisions). The operator decisions graph can contain several tracking types, each of these types is characterized by the own separate dependence $\tau_{track} = f(\tau_{div})$. The tracking processes can be nested each in other.

Finally, all above elements of operator activity are united by the conceptual model of operator behavior, online change of this model by the operator in the course of his activity requires certain time. This time is characterized by one quantity for all conceptual models.

For the development of the situation control block, whose description will be given below, it is required in the considered typical situation:

- the develop of the operator decisions graph for this typical situation;
- then use this graph to estimate the time that necessary for the operator to realize it;
- separate the semantic component of the operator decisions graph to realized it in the situation control block;
- determine the parameters of time delays for the supply of control signals, that produced in the situation control block, to the particular situation control blocks.

2,1. The example of the development of the fragment of the operator decisions graph.

Let consider the working the operator of the Antr/object (object O-N1) when the object O-N1 meets with the object O-N2. The object O-N1 intends the counter-action to the object O-N2. The object O-N1 have the counter-action of two types: PR1 and PR2. The operator solves this problem on the basis of the information that present him on the disply of the ICF (Figure 1).

If distance D between object O- 1 and O- 2 more D1= const, then operator of the object O- 1 must fix the counter-action PR1. Otherwise operator must fix the counter-action PR2. All of this work the operator makes on background of the spying for the mark (1) on the display (Figure 1).

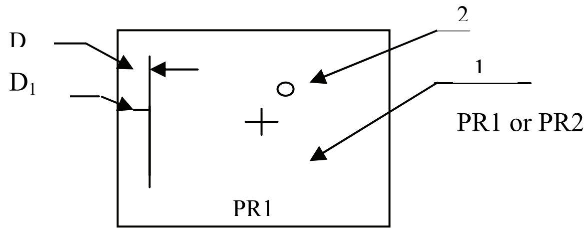

Figure 1: The display on the ICP.
D - the current distance between object O-N1 and the object O-N2.
D1 - const
1 - a cut-off signal PR1 or PR2,
2 - the mark, that is including operator in the tracking process

We compose of the fragment of the graph of the decisions of the operator (the ODG) and calculate on him temporary expanses of the operator for the execution of this work (Figures 2).

There are the following elements of the activity of the operator in the fragment of the ODG. The time for the execution of those elements are took up from (B. E. Fedunov. 2002a).

The AlAcOp-1. The ρ-decision: finding two segments (on the range scale: the segment between O-2 and O-1 - the left scale on fig.1) and the symbol (1) on the indicator. The time for it is 0.4 s. The elementary act of the adoption of this decision: comparison the lengths of two segments (D-0; D1-0). The time for it is 0.7s. The general time for the execution of the AlAcOp-1 is 0.4 + 0.7 = 1.1 s

The AlAcOp-2. The π-decision: finding PR1 in the indicator. The time for it is 0.2 s. The general time for the execution of the AlAcOp-2 is 0.2 s

The time for the realization of the AlAcOp - R1 decision is = 0.5 s.

The time for the realization of the AlAcOp - R2 decision is = 0.5 s.

The temporary expenses of the operator on the tracing process is determined on the approximation of the experimental dependency $\tau_{track} = f(\tau_{div})$:

$\tau_{track} = 0.5 + 0.2\ \tau div$ if $0 \le \tau div \le 1.5$ s; $\tau_{track} = 0.5 + 0.2\ 1.5 + 2\ (\tau_{div} - 1/5)$ if $1.5 \le \tau_{div}$.

The time of the tracing process for the dot 1.1 of the ODG is 0.8 +2(2.3 - 1.5) = 2.4 s.

The time of the tracing process for the dot 2.1 of the ODG is 0.5 +0.2 1.1 = 0.72 s.

The time of the tracing process for the dot 2.2 of the ODG is 0.5 +0.2 0.2 = 0.54 s.

The moment of the passing of the signal on the on-board executive devices from the beginning of the producing of the decision the AlAcOp-1(the delay of the signal) is 2.3 + 2.4 = 4.7 s.

The moment of the passing of the signal on the on-board executive devices from the beginning of the producing of the decision the AlAcOp-2(the delay of the signal) is 1.1 + 0.2 +0.72 + 0.54 = 2.56 s.

On the base of such material the block of situation management (the BSC) is developed for the system of the simulation modeling of the work of the BOSES TS

3. CLASSIFICATION OF ON-BOARD INTELLIGENT SYSTEMS

According to (Fedunov 2010) let us briefly describe onboard intelligent systems supporting the process of solution of problems of global control levels I and II (GLC-I and (GLC-II).

Let us consider the solution of problems of the GLC-I by the crew: online prescribe the current purpose at the execution operation session (online prescribe the typical situation). The motivation for this prescription cannot be formalized completely. The smaller part of these motives is weakly structured, and the larger part cannot be even verbally indicated. For making such decisions the crew uses heuristic π-ρ- decisions. These decisions of the crew are supported by the information from the information model of external and onboard situation. This model are shown the crew on the ICF of the cabin. It is created by the onboard intelligent information system "Situation awareness of the crew"(IIS SAofC) (Gribkov et al.2010).

Problems of the GLC-II, as a rule, are solving by the operator which is using ρ-decisions and π-decisions. This makes it possible to elaborate "onboard online advisory expert systems for typical situations of operation sessions" (BOSES TC) for these problems. BOSES TC supply the crew with the recommendations about the method of the achieving of the prescribed current purpose (problems of the GLC-II) [(Fedunov 1996; Fedunov 2002a).

4. THE CLASSIFICATION OF SIMULATION SYSTEMS FOR TESTING AND DEVELOPMENT OF KNOWLEDGE BASES OF ONBOARD INTELLIGENT SYSTEMS OF THE CORE OF AN ANTHROPOCENTRIC OBJECT.

Development of onboard intelligent systems has the following three stages:

(i) designing of the algorithmic shell of the intelligent system for the problems of the seted domain of a certain class of anthropocentric objects;

(ii) filling algorithmic shell of intelligent system by particular knowledge of the seted domain. As a result, the basic sample of intelligent system had oriented on the generalized (as a rule, most "rich") onboard information environment of anthropocentric objects of this class;

(iii) the adaptation of the basic sample of the intelligent system to the onboard information environment of the particular anthropocentric object of this class.

As a result, the adapted sample of the intelligent system is obtained. At the stages of creation of the basic and adapted samples of the onboard intelligent systems of the anthropocentric object, it is necessary to test and develop their knowledge bases with the help of professional operators. For this purpose the simulation complexes with elements of real onboard systems and full scale information-control fields of the crew cockpit are creating (Fedunov 2002b). The development of these simulation complexes requires large financial and labor costs, and their using for the development of the basic intelligent systems is difficult both due to large duration of work with the basic sample and the limited possibility of the participation of the highly qualified operators. Therefore the computer simulation systems are elaborated for the modeling of the work the onboard intelligent systems. At these systems the work of the crew (operator) of the anthropocentric object simulation with the computer programs in a number of cases.

Two classes of computer simulation systems of are developed on the basis of the technical documentation of the simulated anthropocentric object:

- the simulation system of the GLC-I for the IIS with necessary inclusion of professional man- operator in the simulation loop,

- the simulation system of the GLC-II for each BOSES TC with simulation of the work of the professional man-operator by the situation control block (the computer program).

5. COMPUTER SIMULATION SYSTEM OF FOR DEVELOPMENT OF KNOWLEDGE BASES OF INTELLIGENT INFORMATION SYSTEMS "SITUATION AWARENESS OF THE CREW"

For the onboard intelligent system "Situation awareness of the crew" (IIS SAoC) the specific features of the simulation system are the presence the following components:

- mathematical models of the onboard measurement devices of the anthropocentric object and the onboard digital computer algorithms of the information processing;
- the simulation on the computer display of information frames of the crew cockpit that were designated for the situation awareness;
- the representation of the dynamics of the outward and inward situation;
- the simulation on the computer keyboard of the control organs on the anthropocentric object and its onboard equipment used by the crew in solution of problems of the GLC-I;
- the presence of the real operator in the simulation loop.

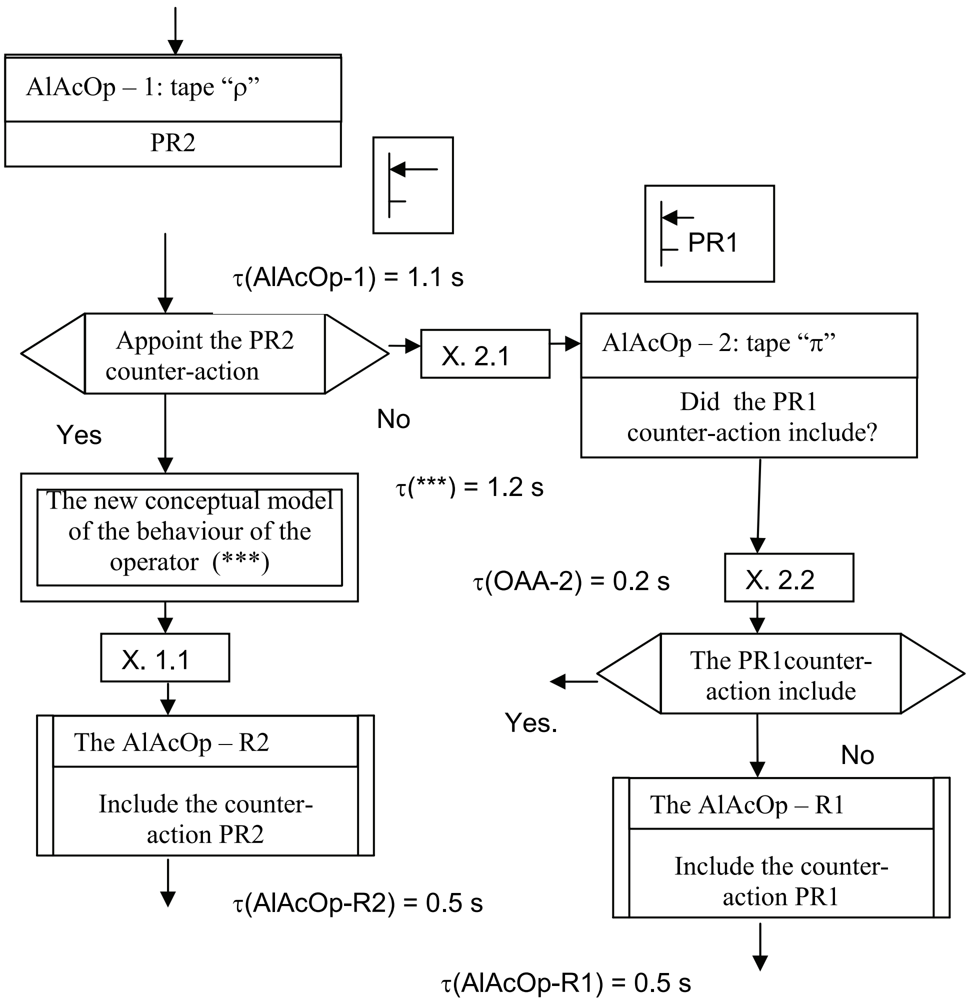

Figure 2: The fragment of the graph of the operator decisions.

That system will be called the simulation systems for the GLC-I. Note, out of the main types of solutions by the crew of problems of the GLC-I are heuristic solu tions follow that the presence of the operator in the simulation loop is mandatory.

Upon simulation by the simulation system for the GLC-I the correctness of assignment by the operator of typical situation, convenience of perception and comprehension of the model of external and onboard environment presented in the ICF are estimated.

6. THE COMPUTER SIMULATION SYSTEMS FOR THE DEVELOPMENT AND THE TESTING OF YHE KNOWLEDGE BASES OF THE INTELLIGENT SYSTEMS PROVIDING THE CREW WITH THE SOLUTION TO PROBLEMS OF THE GLOBAL CONTROL LEVEL II (Romanenko A. V. et al. 2010.

The solution of problems of the GLC-II, where the operator is not assuming heuristic solutions, is executed by the BOSES TS without a participation of the man-operator. The structure of such BOSES TS and the technology of their development were discussed in ((Fedunov 2009).

For the testing and the development of the knowledge bases of the BOSES TS the simulation system for the corresponding typical situation is designed. Here the activity of uhe man-operator is represented by the mathematical situation control block (the BSU).

6.1. The example of the functional blocks of the simulation system for typical situation are shown in Figure 3.

We will not describe all blocks, specified on Figure 3, but will describe only block of the situation management (BSU).The BSU simulates the work of the operator at the choice type situation, in which the operator does not use the heuristic decisions. The BSU is developed on the base of the ODG (shown on the figure 2) with preliminary cut-in in it the estimations of the temporary expenseses of the operator on each his AlAcOp.

The BSU includes itself:

- the choice of the current information for the conditions of the output on the actuated branch of the ODG:

- the definition of the manual acts of the operator in this branch ,

- summing of the temporary expenseses of the operator in the actuated branch of the ODG (from the begining of the actuated branch) for the definition of the delay of the control signal, that was produced in the actuated branch of the AlAcOp - R№*** (where AlAcOp - R№*** is any branch of the ODG on the figure 2);

- a delay of the sending the control signal on the on-board executive devices (the control signal was produced by the actuated branch the AlAcOp - R№***).

For the figure 3 the BSU is designed on the basis the ODG, that shown on the figure 2.

CONCLUSIONS .

The practice of the applications and the developments of the modern anthropocentric objects require the creation of on-board intelligent systems of two classes for its cores:

- intelligent information system "Situation awareness of the crew" (IIS SAofO), that is creating information support of the crew for the online prescription of the current goal of the operation session;
- the onboard online advisory expert systems for typical situations (BOSES TS), that present the crew with the method for the achieving of the current goal of the operation session in real time.

For testing and development of knowledge bases of these systems two classes of computer simulation systems are developed:

- the simulation systems for the first global control level (the simulation systems for the GLC-I) with necessary inclusion of professional man-operator in the simulation loop;
- the simulation system for the second global control level (the simulation systems for the GLC-II) for each BOSES TS with simulation of operation of professional man-operator by the situation control block. The simulation systems for the GLC-II allow to estimate and improve the knowledge base of the BOSES TS without the direct participation of qualified professional operators, and leave this resource for the stage of the development of the adapted BOSES TS.

These simulation systems are being developed on the basis of the technical documentation of the simulated anthropocentric object, that include itself the information about the information and control components about the information-control field, about the onboard measurement devices, about the onboard executive devices and about the composition and structure of the onboard digital computer algorithms.

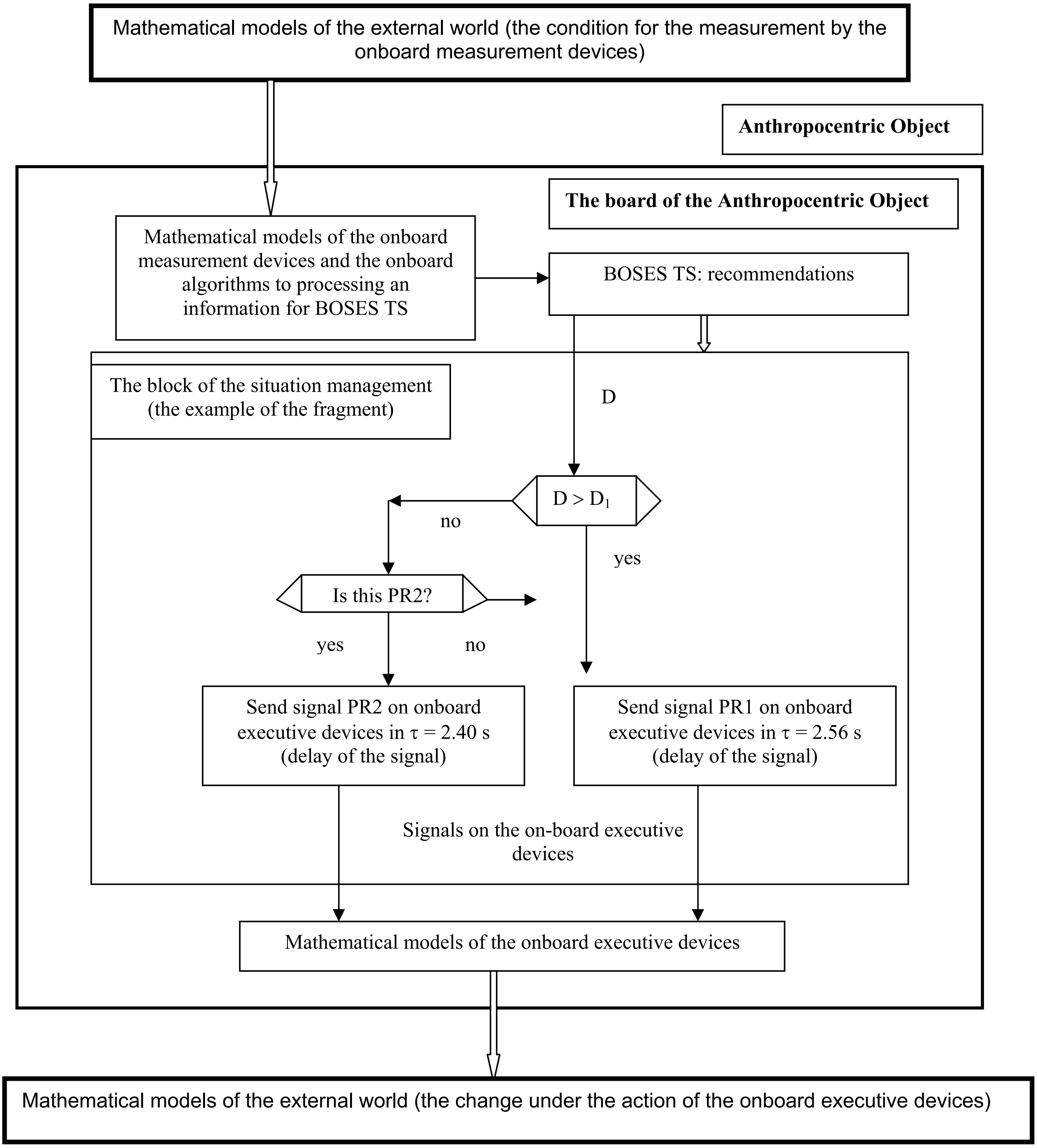

Figure 3: The system of simulation modeling of the work BOSES TS with replacement the Anth/object operator by the block of the situation management

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