Informational and Procedural Description of an Energy-active Control Object Behavior Under Active Threats Conditions

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Abstract

Infrastructure activities and energy-active objects management involves formation and processing of multifaceted information on production and sale of energy resources by its operative personnel system. The synergistic management effect will be achieved thanks to system's emergent property, with formation of an integrated information environment in spatio-temporal dimension, which will reflect "life's multifacetedness" in the context of combining main activity with society's value demands. Activity and decision-making of operational personnel creates characteristics of energy-active object and becomes a reflection of strategically verified cost-value content of its development in general.

Such a motivational reference point manifests itself as acquisition of its information-procedural image (characteristic "portrait") of integrative quality. The activity effect will be reflected in result and state of energy-active object, which are evaluated based on image's parametric information in space-time dimension. Integrative property of management system will be presented as an integration process that will continuously dynamically accompany executive processes that are activated by management influences and become integrated, just like management process. Integrative informational relevance of tactical and strategic assessments of energy-active facility activity and integrated decisions adoption that purposefully affect state and result of activity will be supported.

Keywords

Integration, system, process, risks, decision-making, information technology, energy-active object

1. Introduction

Problem of comprehensive improvement of infrastructure and energy-active object management is defined as need to achieve systematic optimization of problem solving under condition of ensuring sustainable activity and interconnected management of technological and organizational processes, design and research.

This problem is solved during development of management system and with involvement of operative personnel with their practical experience. It is related to the problems of increasing efficiency of infrastructure and energy-active object, scientific and technical levels and quality of management system, which is developing as integrated system. Introduction of new tasks should increase integration synergistic effect.

That is, management system must achieve a higher integration degree at all phases of its life cycle, starting with study of development problems, designing their automated solution as tasks, ending with

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practical implementation as coordinated work of all compatible components (subsystems, sets of tasks) of system.

Therefore, it is necessary to manage the operation of system itself, with an assessment of integration degree by management phases.

2. References analysis

In [1], basics of hierarchical systems intellectual management by operative personnel are substantiated.

Basic principles of systemology and complex systems management are outlined in the works [2-3].

In monographs [4,5,6,7], basics of management theory and decision-making by operational personnel in complex systems under risk conditions and active factors effect on management systems are substantiated.

Work [8] provides an analysis of risks types that may arise during management in hierarchical man-made systems.

Work [9] substantiates systemic and logical-cognitive aspects of managing complex systems in emergency situations. Procedures for decision-making by operational personnel and their problems in making management decisions are considered in [10].

The justification of methods and project control means, which require an integrated approach using data protection and processing theory, interpretation of new data and situations, and management decision- making are considered in [11,12].

Works [14-16] consider management decisions problems in risk conditions and changes in situation under active factors influence directly on management process.

Work [13] provides basics of managing an energy-active facility under risk conditions.

In [17-20], main methods of protecting hierarchical systems from external and internal attacks are revealed.

3. Main research results

In technological structures, it is impossible to manage processes without data selection, their processing, and in case of incompleteness - replenishment due to scientific, engineering, professional knowledge and experience of an expert in structure of decision support system (DSS).

In fact, expert system in decision support system structure has two intellectual components to be applied:

1. Formalized knowledge acquired while processing situations, data, scientific and technical theories and technologies, abstracting cognitive knowledge, logically ordered and recorded in engineering-normative knowledge base, as a basis for supporting and correcting management decisions in the structure of ACS-TP (technological process of automated control system) at the operational level;
2. Scientific-engineering knowledge and personal professional experience of a high-level expert, whose cognitive system, based on creative logical-analytical system thinking, forms abstract structures, which are basis of categorical models of strategic coordination goal-oriented management for the upper level of man-made system infrastructure hierarchy that is affected by active threat factors and targeted information attacks.

3.1. Methodology for object management determination, taking into account operator's nervous system

Subject-oriented information-procedural description of an energy- active facility behavior of infrastructure management under active threats conditions will be described below.

Structural diagram of formation of management object subject-oriented description based on production hierarchical structure and activity cognitive structure and operator's nervous system way of thinking has the form (Fig. 1) and includes following components of information and intellectual technology.

According to the hierarchical system structure, a data exchange interface is built between technological, operational and strategic management layers, which is necessary for intelligent data processing formation and management operations.

The acquisition of expert knowledge by operational personnel in process of working in energy-active units' limit modes is characterized by the fact that expert system performs cognitive intellectual functions, which consist in assessing image of situation and making decisions based on the processed data (CIA $\rightarrow$ACS) (Fig. 1) obtained during process of professional activity at all infrastructure hierarchy levels.

Designation in Fig. 1. ITS – information-technological system, IMS – information-measuring system, ACS – automated control system, MO – management object, CIA – cognitive intelligent agent, $\{F_n\}$– factors of active actions on system, α_{risk}

– risks.Therefore, role of a cognitive intellectual agent person is reduced to the fact that an expert- consultant performs in an active cognitive mode an intellectual operation (IA) of the type:

IA_1 – processes data and knowledge of subject area;

IA_2 – in accordance with target task chooses a scheme, procedure, algorithm and strategy for its solution based on risk factors identification due to action of threats and attacks;

IA_3 – in case of insufficient data and incomplete knowledge, searches for methods of supplementing their knowledge within basic theory management framework, system analysis, logic-cognitive methods of generating ideas and creative solutions;

IA_4 – based on heuristics, generates hypotheses about problem solving schemes;

IA_5 – chooses procedures or algorithms, according to reference models of production system functioning and goal-oriented strategies;

IA_6 – finding the appropriate scheme for problem solving, expert describes problem area in the form of a set of facts and rules (proof, solution) and ties them to target tasks;

IA_7 – fills ES with new knowledge (as basis of ES self-learning process), organizes and formalizes on basis of logical rules and system analysis;

IA_8 – transmits data to operational personnel for decisions formation. On the basis of system approach and cognitive diagrams, appropriate stages of searching for a method of solving management problems in dialog mode are developed with appropriate sequence, for target task and problem situation;

IA_9 – generation of infrastructure functioning strategic and local goals.

In accordance with the target expert tasks, lets highlight management consulting modes (Fig. 2)

R1 − ES mode of client-IA consultation: during operator-intelligent agent (IA) with ES dialogue, problem solution is ensured from subject-oriented area, using formed knowledge base and DB, ES, and situational data of certain reliability level;

R2 − ES awareness mode of one's own essence of cognitive component through self-testing includes decision-making procedures based on logical explanation schemes, scheme mechanisms, proof procedures when solving test problems (self-diagnosis) in production system structure – a system involved in strategic management.

R3 − Filling database and knowledge by expert mode, formation of interface, strategies and dialogue modes (operator – ES – DSS) in the initial and current operation mode.

R4 − Testing mode, when an expert and a knowledge engineer (IAe, IAd) using dialogue and explanatory tools check ES competence to a given level of plausibility and correctness according to the model and a specific interpretation of production situation;

R5 – Working mode with clients at all levels of operational and strategic management hierarchy.

To increase cyber security level, following data processing and selection procedures are used on the basis of intelligent operations using information technology methods (Fig. 2), which, accordingly, is the reason for minimizing risk level in the event of threats complex to infrastructure.

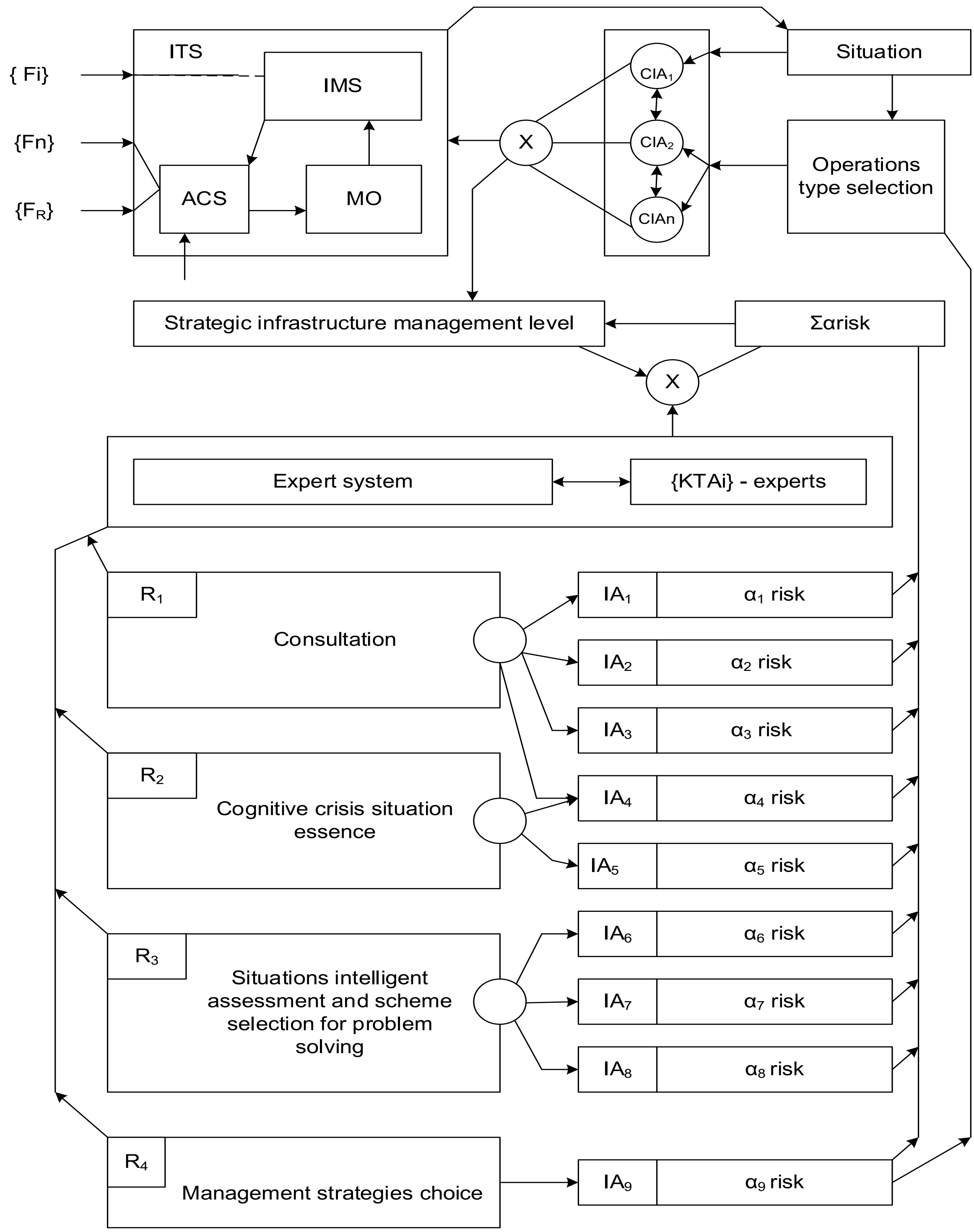

Figure 1: Structural-functional scheme of a set of informational and intellectual operations for management process implementation in countering threats, attacks, and risk conditions

Intelligent procedures of system structuring:

PR1 – extracting knowledge from the expert and operational staff to fill procedural knowledge base;

PR2 – management hierarchy organization for effective operation of production structure based on corporate agreement strategy;

PR3 – submission of requests and knowledge in a form understandable by ES in dialogue mode in access mode according to access level;

The essence of knowledge discovery process by experts consists in procedures for conducting heuristic and logical analyzes of problem area in accordance with target tasks, taking into account the cognitive characteristics of each agent, and formation of system knowledge models that provide situations awareness of their information structure, which is basic for problem solving.

Informational and intellectual knowledge assessment about CIA operation, about effective management processes includes:

PI1 – objects and concepts of subject area for identifying goals, assessing situations, building procedures, decision-making schemes;

PI2 – characteristics of object and situations state (probability of events occurrence, goals significance coefficients, alternatives ranking, identification of advantages signs);

PI3 – comparison indicators of situations in (threat management) mode to establish cause-and-effect relationships between objects and influence degree in objects hierarchy and management structures.

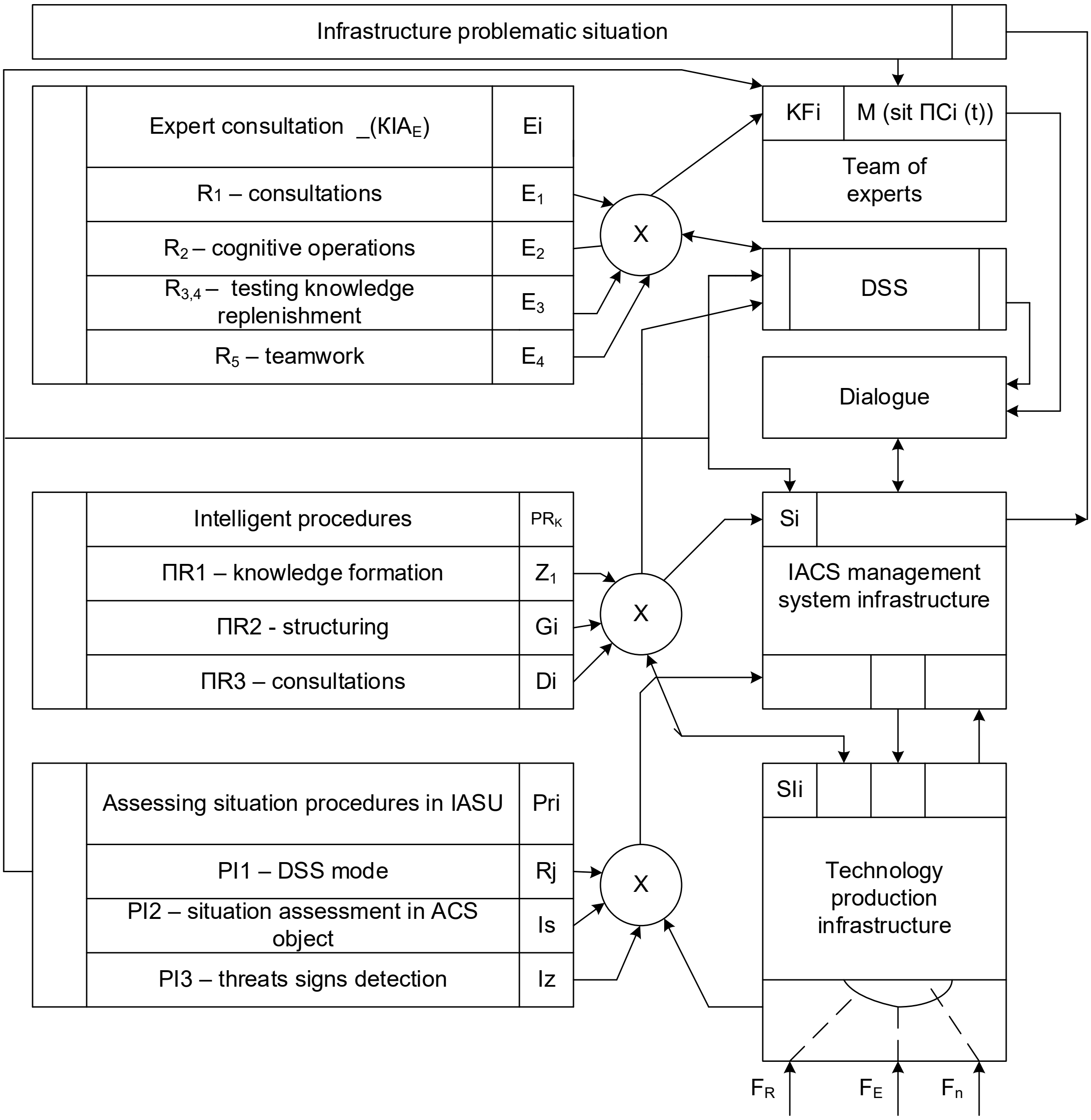

Figure 2: Structural-functional scheme:
a set of informational and intellectual operations for management process implementation in countering threats, attacks, and risk conditions

Accordingly, information ensures preparation of scheme and management process procedure.

VSS_1 – hierarchical management structure, which includes strategic, administrative, operational management and ACS-TP;

VSS_2 – information module that includes strategy synthesis, problem generators, situations identification, data processing unit, logic-mathematical processor, knowledge jams structures, diagnostic system and test generators;

VSS_3 – management object model with aggregated series-parallel connected, active blocks of processing of material and energy resources.

VSS_4 – logical-cognitive model of knowledge organization structure of operator (CIAi) - agent, which ensures decision-making process in hierarchical management system.

3.2. Information and management interaction in infrastructure

The interrelationship of informational and managerial interaction components, respectively, is based on informational-systemic and logical-cognitive procedures that reflect the agent's thinking process in formation and implementation of targeted countermeasures against threats and active attacks on infrastructure.

Let's define basic components of informational-systemic and logical-cognitive activity:

$P\mathrm{R}_{\mathrm{LK}}^{1}$ – generation of target task using operator’s cognitive system based on acquired experience and knowledge;

$P\mathrm{R}_{\mathrm{IC}}^{1}$ – formation of subject knowledge hierarchy for management;

$P\mathrm{R}_{\mathrm{IC}}^{2}$ – creation of knowledge terms subject-oriented field dictionary;

$P\mathrm{R}_{\mathrm{LK}}^{2}$ – strategies generation and procedures of its solving according to tasks purpose;

$P\mathrm{R}_{\mathrm{LK}}^{3}$ – logical-cognitive procedures synthesis for getting out of conflict on the basis of a conceptual model which is based on existing knowledge structure and intellectual agent experience;

$P\mathrm{R}_{\mathrm{LK}}^{4}$ – logical-mathematical procedure development for choosing management strategies, based on a typical procedure and algorithms for solving object management non-standard problems under conflict risk conditions;

$P\mathrm{R}_{\mathrm{IC}}^{3}$ – building a model of structure and a model of states space as well as taking into account space of goals, which is parameterized using operator's knowledge organization cognitive structure;

$P\mathrm{R}_{\mathrm{LK}}^{5}$ – creation of diagnostic system for choice adequacy of decision-making strategies for target management task implementation.

In combating attacks and resource threats system, let’s highlight following IACS levels (Fig. 3.):

1. Strategic management level with problem situation assessment and indication system in (IACS) – an integrated automated control system.
2. Basic components of informational and intellectual activity of management cognitive states and $\left(CIA_4^S\right)$ - $\left(CIA_4^0\right)$ strategic and operational.
3. Cognitive expert's knowledge base (CEKB), which is personally formed by an intellectual agent with a creative way of thinking and intelligence.
4. Blocks (1,2,3), which characterize methods, processes, procedures necessary for assessing situations and expert support.
5. Data flows information processing blocks about dynamic situation in IASU and control object (OC) based on crisis states selection of indicators and limit control modes from mode data.
6. Management risks control block $\left(\alpha_{risk}^{K}(C,U)\right)$ in case of object mode deviation from target area.
7. Expert active consultations formation block for new strategies (ACE – experts) formation.
8. Risk level classification block $\left(\alpha_{risk} C_i \geq \alpha_d\right)$ according to the permissible level.

Accordingly, cognitive and intellectually logical operations are performed by intelligent agents both inside structure of management team and individually:

- $\{CIA_{Ei}\}$ – a team of experts;
- $\{CIA_{Ep}\}$ – an expert with appropriate level of decision-making authority;
- $\{CIA_{U}^{S}\}$ – system management experts team;
- $\{CIA_{U}^{0}\}$ – operational management agents team at IACS;
- $\{IAT_{E}^{SR}\}$ – strategic level experts;
- $\{IF_{ij}(A_{AS})\}$ – team for forming an active attacks complex on infrastructure.

In accordance with target task, let's consider system, information and intellectual operations and their integration while formation of management procedures and countering attacks (Fig. 3).

According to the scheme in Fig. 2. of information-cognitive interaction of IACS and $(IF_{ij}(A))$ - integrated attack system on management process -, two components of risk integration can be distinguished, which, if level is exceeded, lead to accidents:

- logical-cognitive errors in decision-making procedures due to incomplete knowledge and incorrect decisions;
- systemic, logical and cognitive errors in selection of mathematical models of management objects dynamics and structure as well as procedures and algorithms for processing heterogeneous data.

4. Results & Discussion

If take into account that management structure includes an automatic system for implementation of object management process (ACS – TP-ACS) and management operators team (cognitive agents) than behavior of such structure has a high risk of failure under threats influence.

Accordingly, lets provide list of active threat attacks on man-made systems, both internal and external (Table 1).

Table 1
Active threats and attacks on man-made systems

№	Name
1	Threats and information- intelligent attacks on infrastructure destruction
2	Structures of target threat to block technological process
3	Resource attacks to disrupt technological process
4	Information attacks in data transmission network fordistortion
5	Structural attacks on production systemorganization
6	Complex attacks on ACS - TP
7	Attacks on target disorientation
8	Attacks on authority hierarchy
9	Strategic management attacks
10	Attacks on processor systems of ACS control complex
11	Attacks on changing the mode of energy-active objects
12	Information-mental attacks on personnel to change stress resistance and goal orientation
13	Complex attacks on hierarchical management structure and internal conflicts
14	Attacks on complex destruction of man-madesystem

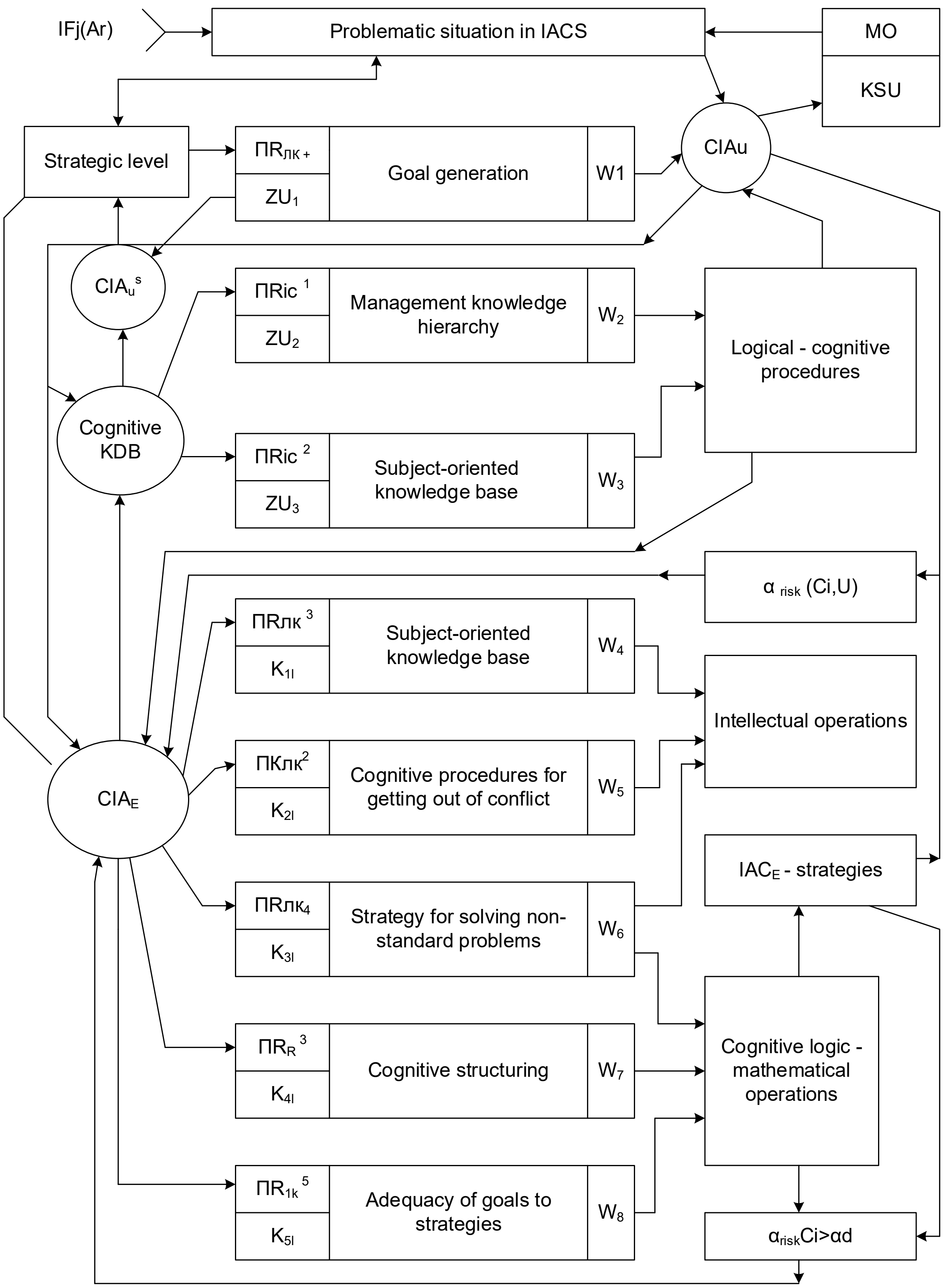

Figure 3: Informational - system structural diagram of combating attacks technology

Strategic management main goal is development of sustainable self-renewing production process methods based on goal orientation, integration, and coordination strategies under active goal-oriented threats conditions.

Let's analyze the negative factors that influence on the functioning and management of an energy active object and infrastructure:

1. Subject-oriented description formation structure of management object based on its production hierarchical structure;
2. The structure of cognitive way of thinking of operator's neural system;
3. To analyze all components of man-made system functioning;
4. Give a source of risks and its impact on the structure of man-made system;
5. Give a source of active factors for functioning and management of the system;
6. To analyze the sources of possible negative attacks on structure management.

So, after characterizing possible negative factors on the management and functioning of man-made system, the risks that affect management and functioning of the infrastructure can be assessed.

Infrastructure integration risk assessment is presented in Table.2.

Table 2

Infrastructure integration risk assessment

№	Component integration	Integration requirements	Integration signs	Informational risks	Structural risks	Resource risks
1.	Goal orientation	<0.55	>0.95	0.8	0.85	>0.85
2.	Structure goals coordination	0.9	0.95	>0.95	>0.95	>0.95
3.	Functional goals coordination	0.9	0.8	<0.15	<0.25	0.1
4.	Goal orientation of structure functioning	>0.85	>0.75	>0.25	>0.2	>0.25
5.	Consistency of management organization	0.9	>0.95	<0.15	<0.1	>0.15
6.	Ensuring management actions	0.8	>0.9	<0.1	<0.15	<0.2
7.	Structure management organization	0.75	0.75	<0.25	0.35	<0.3
8.	Resistance of structure to threats	0.85	0.8	<0.25	<0.3	>0.3
9.	Management mode analysis	0.8	0.75	<0.35	<0.25	<0.45
10.	Integration project team	0.95	0.9	0.15	0.1	<0.2

11.	cognitive level analysis n-system structural integration generalized risks	$\mu_n(CF)$ $(0.7 \div 0.9)$	$\mu_n(Bd)$ $(0.7 \div 0.9)$	$\Pr ob$ $\alpha r_1(0.1 \div 0.9)$	$\Pr ob$ $\alpha r_2(0.1 \div 0.9)$	$\Pr ob$ $\alpha r_3(0.1 \div 0.4)$

5. Conclusion

According to informational and procedural description of target task of infrastructure and energy- active object management, the following was carried out:

- Analysis of literature sources about intellectual management of man-made systems and infrastructure problems, and their resistance to external and internal attacks;
- Problem of infrastructure and energy-active object complex management under complex threats conditions to management is substantiated;
- Role of cognitive intellectual agent on management process in difficult conditions is substantiated;
- Structural diagram of subject-oriented description formation of management object based on production hierarchical structure and cognitive activity structure as well as way of thinking of operator's nervous system is presented;
- Relationship between informational and managerial interaction components, which is based on informational-systemic and logical-cognitive procedures, is substantiated;
- System, information and intellectual operations and their integration in management procedures formation and countering attacks were considered;
- A list of active threat attacks on man-made systems, both internal and external, and an infrastructure integration risk assessment table were given.

Solving the above problems at system, procedural and information levels can help modernize existing infrastructure management and improve their design and management process.

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