Physics of Open Systems: Generation of System Knowledge

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ABSTRACT

Information technologies of Physics of Open Systems (POS) automatically generate reliable, theoretical, system knowledge using the data which are collected by the empirical science.

Descriptive technologies begin the production cycle of system knowledge. They create an empirical base of generating system knowledge. Application of these technologies needs participation of subject matter expert. Projective technologies finish the cycle. Their task is to transfer system knowledge to the application area. Specialists of subject area work with projective technologies. Technologies of analytical kernel and constructive component of POS generate system knowledge directly.

Technologies of analytical kernel generate knowledge on the level of system ontology. This knowledge is about organization of the space of senses of the system, semantic organization and semantic activity of the system, semantic forms of all qualitative determinacies of the system whole, completeness, significance, reliability, and applicability of the obtained theoretical knowledge.

Constructive technologies generate knowledge on the level of subject ontology. This system knowledge forms solution resources of the system problems: cognitive schematic descriptions of local and global states of the system; cognitive schematic descriptions of intrasystem mechanisms; and analytical descriptions of dependencies disclosing relations in the inner world of the system.

Keywords: System Knowledge, Ontological Modeling, Communicative Modeling, States Modeling, Solutions Resources, System Ontology.

1. INTRODUCTION

Open systems is being exchanged with environment by substance, energy and information. The fundamental laws still unknown to science define structure, behavior, states and properties of open systems. Complexity of open systems is tightly related with growth of their scale and with heterogeneity of arising structures. Interdependence of heterogeneous components becomes the main problem of understanding complexity.

Natural, social and anthropogenic systems must be considered as open systems. The new scientific ideas, new mathematical structures, new technologies of scientific understanding, which are directed on the reconstruction of global system behavior and rational explanation of both regularities and mechanisms of formation of system properties and states, are needed to overcome the complexity of such systems. *The key question is production of scientific knowledge about open systems.* Solving future global problems depends on the success on this research direction.

As initial presentation of open natural, social and anthropogenic systems their empirical descriptions are being used.

In the empirical description the system is given in actual states. A complete representative empirical description of open system is a unique source of objective information about its natural scale and complexity.

Theoretical knowledge about systems can not be obtained from empirical description by the logical way. For generating system knowledge on the basis of the empirical descriptions the scientific theory is needed. POS is such theory. Scientific understanding and rational explanation of the essence of open systems defined by empirical descriptions are supported by the technologies of POS.

POS is a post cybernetic paradigm of systemology that proposed a new approach to solving problems of cognition, scientific understanding and rational explanation of the complexity phenomenon of open systems [1]. It considers open systems in their natural scale and complexity. It has the deep methodological foundations, adequate metatechnology and its own theoretical apparatus. Its ideas, approaches and methods are implemented in information technologies providing automatic generation of reliable theoretical knowledge on open systems.

Systemological conception and main scientific statements of POS was developed in *St.-Petersburg State Electrotechnical University "LETI"* in 1992-2003 [2-7]. The project "Physics of Systems" has been formed in 2003. The consortium "*Institute of Strategic Developments*" (http://www.isd-consortium.ru) is carrying out works on this project. Authors, developers of technologies and participants of applied approbations of Physics of Systems are the consortium members. The results go through approbation on six directions: computational toxicology, genomics, system biology [8, 9]; theoretical medicine [10-12]; the solar-terrestrial physics [13-15]; safety [16-19]; generation of scientific system knowledge [20-23]; knowledge management [24].

A general review of systemological conception of POS is given in the paper. Within this conception, technologies of POS are considered focusing on problems of scientific knowledge generation on open systems in accordance with their empirical descriptions. On the base of information technologies of POS, process of automatic generation of the complete, reliable, theoretical, system knowledge on the levels of system and subject ontology is described.

2. SYSTEMOLOGICAL CONCEPTION OF PHYSICS OF OPEN SYSTEMS

POS has four levels of organization. *Methodological foundations* define conception of cognition paradigm of open systems in the form of logically complete system of concepts disclosing senses of systemogenesis.
Metatechnology embodied conception of cognition paradigm of open systems at the normative language of constructive expression of their senses.
Constructive theory offered concepts generation methods of systems' normative language, considering these concepts as formal objects.
Information technology was embodied in algorithmic systemology, and its formal objects obtained adequate computable representations.

Methodological foundations

POS is represented in the methodological models, defining a system on levels of vision, cognition, an understanding and explanation of system senses [4-6], fig.1.

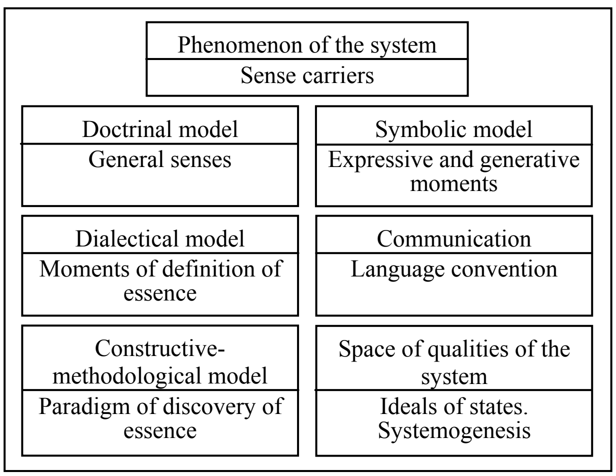

Fig. 1. Methodological foundations

POS, entirely based on the world of experience, builds a philosophical system of doctrines and fundamental concepts about senses and relationship between senses of the system.
Doctrinal model defines a concept of the system through its representations in complete abstract forms of the system senses.
Dialectical model defines doctrines of cognition of the system through basic concepts related by dialectical triads, which form the unified, holistic and hierarchically arranged system of concepts.
Constructive-methodological model sets the sequence of steps of understanding the senses of the system on the basis of measure category and universal principle of symmetrization, creates structural images of the system.
Symbolic model introduce a set of sense relations which are transferring characteristic intrasystem regularities by way of generative and expressive moments.
Communication creates a space of concepts of the system, where the scientific knowledge about the system is expressed by the words of language of systems. Concepts triads stating dialectical relations reflecting an organization of the system in the world of its senses disclose contents of the words of language of systems.
Space of qualities of the system represents the complete space of the system senses and explains all possible actual and potential manifestation forms of phenomenon of the system. Configuration of the space of qualities of the system is being established by mechanisms of systemogenesis which are forming ideals of the system's qualitative determinacies and states of the system.

Metatechnology

Main purpose of the metatechnology is the realization of both ideas and principles of POS in adequate scientific apparatus organized into unified schema of cognition, understanding and explanation of general mechanisms of systemogenesis [3], fig.2.

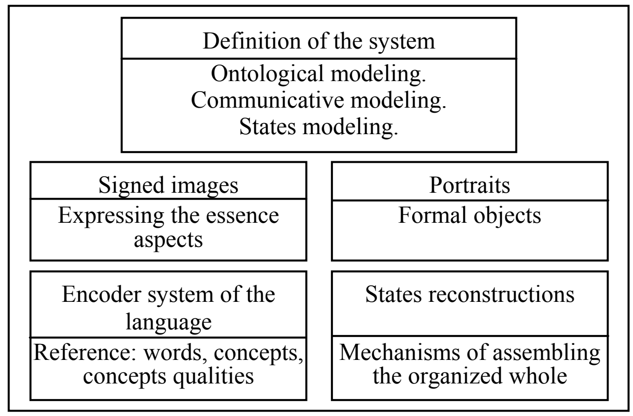

Fig. 2. Metatechnology of POS

In metatechnology of ontological modeling, a sense (pure and external to the subject) of the system, represented by its symbolic model, is transferring into signed images, for which the formalized concepts expressing different aspects of the system essence, serve as means of expression. The sense of the sign transfers into its subject value embodied in formal objects of portraits of the system.
In metatechnology of communicative modeling, the language of systems turns into a holistic theoretical system of scientific knowledge, obtains the status of encoder system defining a complete set of semantic associations between words and concepts of the language of systems, which are introduced at the level of communication. Lexical structure of the language is enriched at the level of reference by both the qualities of concepts and their meaningful estimations generating the constructive definitions of concepts through relations with the objects of portrait images of the system.
In metatechnology of states modeling, the models of states of the system, where the system is represented as an organized whole, are being introduced; the models of rational explanation of the properties conditioned by the system on the whole are being built; the models of mechanisms responsible for formation of the global system properties are being created; the models of properties of every parameter in each concrete actual state are being defined.

Constructive theory

In POS there are three theoretical chapters [2, 21-22].
Theory of ontological modeling creates formal models defining the system in its qualitative features, properties and organization

of the space of its states. The basis of this theory is being formed by the systems axioms and by the principles of systemogenesis which are creating the ideal objects having specific symmetries of forms of system organization. The task of this theory is to establish regularities revealing relations of the ideal objects. These ideal objects and established regularities are implicitly applied to the description of the empirical reality of concrete systems, fig. 3.

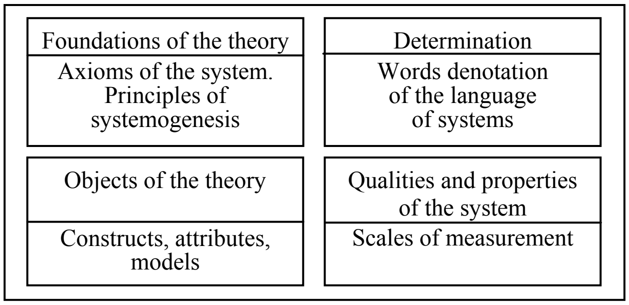

Fig. 3. Constructive theory

Theory of communicative modeling develops the language of systems on the level of determination by way of introduction of measures in semantic space of the system. The language gets ability to distinguish and explain the properties of concrete system, to express the scientific knowledge about the system and to estimate the value and utility of this knowledge.

Theory of states modeling explores the models of states of the system; mechanisms of assembling the states; classes of the states; emergent properties of the system; mechanisms forming a variability of both the properties and values of parameters of the states; attributes of elements of the system organization. For purposes of measuring objects of the theory of states modeling, the measures establishing rules of their mapping onto the special qualitative and quantitative scales are being created.

Constructibility of the theory provides computability of all objects, elements, concepts, qualities and properties, introduced by the metatechnology and proves consistency of the procedures of their calculation.

Information technology

Processes of cognition, understanding and explanation of the essence of concrete systems are realized in the information technology [2], fig. 4.

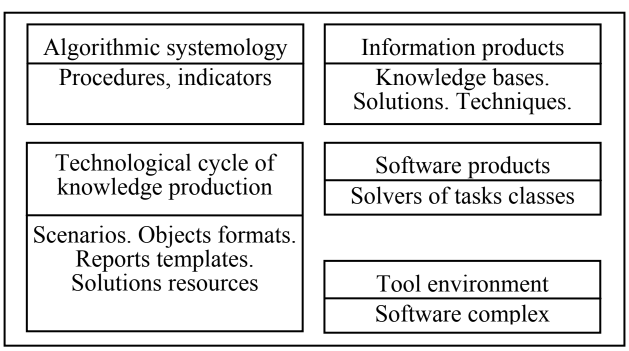

Fig. 4. Information technology

Algorithmic systemology provides computability of all objects of the metatechnology and formal language of the system. On its base the information technology in which the special mathematical methods, effective computational procedures and apparatus of technological indicators are developed is created.

Technological cycle of knowledge production establishes use of procedures of the informational technology in according with the universal scenario of system knowledge's generation. Stages and steps of the scenario create formal objects of the technology which are being mapped in normative formats. The technology defines regulations for representation of the obtained knowledge in the normative documentary reports. Resources of applied tasks' solutions on the basis of the system knowledge are the outcome of the technological cycle.

Tool environment automatically produces the solution of all tasks of producing, formatting and representing the knowledge, creating and providing the solution resources for users. Information technology creates information and software products. It generates the full complete system knowledge about applied problems, forms and represents the knowledge bases, models and techniques of solving system problems on the base of the knowledge. For automatic solving typical system tasks, the technology creates software tools, namely tasks solvers.

3. TECHNOLOGIES OF PHYSICS OF OPEN SYSTEMS

Technologies of POS are represented by the analytical kernel, descriptive, constructive and projective components.

Analytical kernel is the basis of the technologies of POS. In it the ideas, approaches and methods of ontological modeling, communicative modeling and states modeling are embodied. Environment of the analytical kernel undertakes the solving of two tasks: description of the system problems in empirical data and concepts of subject area (*descriptive component*); representation of the system knowledge for solving these problems in forms appropriate for users (*constructive component*) and application of the obtained knowledge for development and estimation of variants of solving the applied problems (*projective component*), fig. 5.

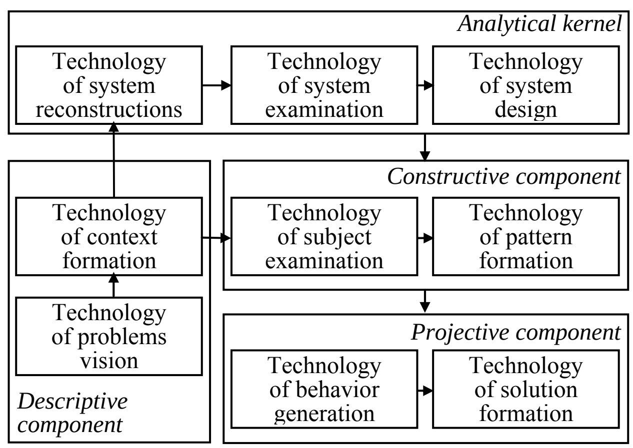

Fig. 5. Components of technologies of POS

Analytical kernel

The technologies of analytical kernel serve as an "intellectual machine" of generation of the system knowledge. It consists from technology of system reconstructions, technology of system examination and technology of system design [1, 20-22].

Technology of system reconstructions generates, organizes, forms and represents an intellectual resource of the system knowledge.

Technology of system examination executes the analysis of sense of the intellectual resource (estimates the scientific system knowledge from the perspective of its reliability, completeness, applicability, significance and actuality) and creates a cognitive resource of the system knowledge.

Technology of system design synthesizes the adequate models of states of the system, researches the emergent properties of the system and generates, organizes, forms and represents a technological resource of the system knowledge.

Descriptive component

Technologies of descriptive component are connected with the analytical kernel by the abstraction channel in which subject representation about the system in its natural scale and complexity is being transferred onto the system level [2, 20].

Technology of problems vision provides creation and application of interfaces at the description of problems in the subject area in the form of system projects. In the subject area the description of each problem includes its isolation, interdisciplinary verbal description, structuring, stratification and organization of monitoring. The problem is being represented as a system project of production of the system knowledge. The problem representation in the form of a system project is related with justification of applicability of the system approach for solving the problem, with estimation of both scale and complexity of the problem, with definition of the size of empirical data which can be represented for solving the problem, and with regulation of data delivery.

Technology of context formation is responsible for transformation of the problem description in the system project into an interpreted normative initial representation of the system (as the object of research); selection and description of measures of the system measurement; and formation of data repository about the system.

Constructive component

Technologies of constructive component are related with the analytical kernel by the channel of concretization, in which system knowledge is being transferred onto the subject level [8, 20]. Constructive component works with the obtained resource of knowledge. It transforms system knowledge generated by the technologies of analytical kernel into the informational, intellectual, cognitive and technological resources of the solutions of applied problems.

Informational resource of solutions is a knowledge being a product of system analysis and of understanding of the empirical fact (defects and quality estimations of empirical description, level of parameters significance, relevance of both parameters and objects of observations in relation to the tasks being solved).

Intellectual resource of solutions is the families of formal models creating a cognitive potential for research activity (system models, models of interaction, estimations of both entirety and completeness of the system knowledge).

Cognitive resource of solutions is a knowledge meant for reasoning and action, has the translation potential, and provides a creation of universally conceptual ways of scientific communication (models, objects, schemas, language of systems).

Technological resource of solutions is an objective knowledge about the system in the whole and in the parts, provides a rational explanation of states of the system and mechanisms of its variability (states, states space).

Technology of subject examination realizes a transformation process of knowledge about states and mechanisms of the system which are expressed by the language of systems, into unified schemas of subject ontology of the system. Knowledge, generated by the technologies of analytical kernel about states and mechanisms of the system is the knowledge about the system's inner world which is not having the subject format. Translating this knowledge into the subject formats requires the application of expression tools able to link the system understanding of mechanisms and states with concepts and representations about both mechanisms and states in the subject area.

Technology of pattern formation uses knowledge resources for choice of the knowledge elements needed for solving applied tasks, reduces the knowledge elements to the formats taking into account the specificity of subject description of the problem on the level of both data and conditions of their obtaining, and offers both the formalized methods of solving problems and the templates of grapho-analytical presentation of the results.

Projective component

Technologies of projective component use the solutions resources in order to create the subject interface [20].

Technology of behavior generation is responsible for: construction of an objective cognitive model of the problem on the base of both its subject ontology and quantitative forms of the system solutions; application of this model for generating behavioral portraits disclosing the system properties through demonstration of its variability in the events, states, space and time.

Technology of solution formation forms the libraries of typical schemas of the solving applied tasks, develops and uses the service-oriented solvers of classes of the applied problems.

4. GENERATION OF SYSTEM KNOWLEDGE

Cycle of generating system knowledge contains four stages. On the first stage the technologies of descriptive component the base for generating system knowledge is being created and the available *empirical knowledge* about the problem (experiments protocols, scientific facts, empirical terms and dependencies) is being formed.

On the second stage the technologies of analytical kernel generate system knowledge. *The system knowledge* includes theoretical models which disclose the essence of the multi-qualitative system and explain its complexity.

On the third stage the technologies of constructive component generate on the basis of obtained theoretical models the system knowledge about regularities, inner organization of systems mechanisms, and also about attributes, properties and cognitive schemas of these mechanisms. The stage is completed by construction of the solutions resources, empirical interpretation of the system knowledge and formation of the subject interface.

On the fourth stage the technologies of projective component use the system knowledge to prepare a solution of the system problem.

System knowledge is generated by the technologies of analytical kernel and constructive component. The techno-cubes having three dimensions serve as images of technologies of analytical kernel.

The first dimension sets the representation of the system (in the whole, in parts and in elements).

The second dimension defines the tasks (cognition, understanding and explanation) and subjects (parameters, relations structures, states and mechanisms) of technologies.

The third dimension discloses steps and key moments of solving the tasks of technologies. The spaces of techno-cubes are filled with knowledge elements for which the normative formats of representation are established.

Techno-cub of system reconstructions

Dimensions of the techno-cube of system reconstructions are set by coordinates "Representation", "Cognition" and "Expression" [2, 6-7, 20], fig. 6.

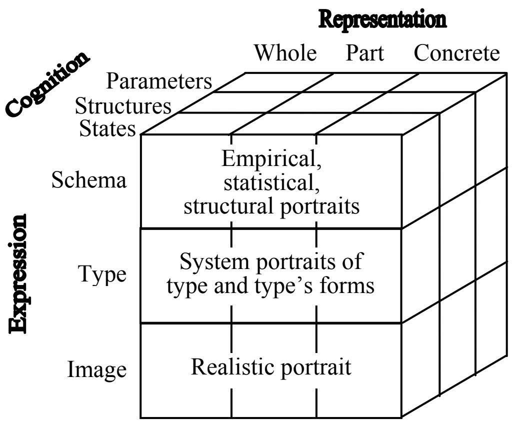

Fig. 6. Techno-cube of system reconstructions

In the "Schema" position the system is represented at the level of both empirical fact and structures of binary relations. In the "Type" position the system is given in semantic forms of all its qualitative determinacies. In the "Image" position the potential of transferring semantic forms of qualitative determinacies of the system onto empirical fact is disclosed.

Technology of system reconstruction automatically produces system knowledge based on empirical description of the system. The empirical description is then transformed into abstract representation of the system in a form of signed connections graph. The graph vertices are parameters of state of the system and its environment. The graph edges are statistically significant binary relationships between parameters. The structure of the binary relationships represents multiplicity of intra-system correlations. The signs of the binary relationships define different forms of behavior of the system through variability of parameters of its state.

The first axiom of POS states that changes in all system parameters are harmonic. Out-of-balance condition of the connection graph shows heterogeneity of the system and its complexity. Connection graph with signs out-of-balance serves as a base for an automatic generation of complete set of *system models* and *models of interaction*.

Each system model determines all system in one of its qualitative determinacies which is formed by the special system-forming mechanism. Complete set of system models determines all qualities of the system. Generation of system models starts with the finding in connection graphs of all *unbalanced triangles*. Resolving lack of balance in the connection graph is realized by finding symmetries of structures of relationships - singletons with the ability to harmonize connections between parameters. A *singleton* is an unbalanced triangle with main axial symmetry and system roles of vertices. One vertex is *special* and identifies one characteristic quality of the system. Two other vertices serve as carriers of system-forming *two-factor interaction*. All singletons with the same special vertex form a *kernel of system model* with preservation of axial symmetry and two-factor relationships of these singletons. The kernel determines a single quality of the system. System model with such a kernel represents the system as a whole in its one quality. The system as a whole in all its qualities is represented by the complete set of system models. This complete set discovers *complexity* inherent in the system.

The models of interaction (*doublets and triplets*) are being generated from a variety of singletons and define all types of structural and behavioral invariants explaining the unity of the multi-qualitative system. Through models of interaction higher symmetries of multi-factorial intrasystem interactions are being manifested.

The result of technology is knowledge on space of qualities of the system consisting of images of family of abstract system models. In this space each system model matches a region in which for the system the type of qualitative determinacy of the system (particular quality of the system) is assigned. Each region covers all variety of manifestations of the assigned type of qualitative determinacy. Conceptual borders in which this type is manifested in different forms and with different intensity determine the structure of the region.

Technology of system reconstruction represents elements of obtained system knowledge in six normative formats (*empirical, statistical, structural, two system portraits and realistic portrait*).

Techno-cube of system examination

Dimensions of the techno-cube of system examination are set by coordinates "Representation", "Understanding" and "Communication" [20-22], fig. 7.

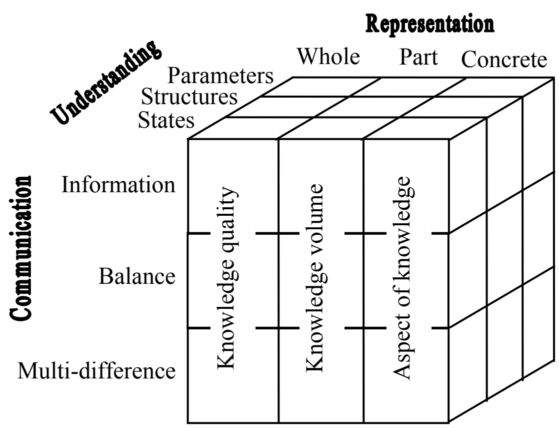

Fig. 7. Techno-cube of system examination

Position "Information" characterizes the empirical fact in its ability to generate a complete reliable knowledge about the system. Position "Balance" explains system models from the perspective of their form, completeness, homogeneity, contrast of idea expression of the system whole in each of its quality. Position "Multi-difference" estimates fullness of actualization of all types and forms of qualitative determinacies of the system.

Technology of system examination assesses generated system knowledge, and constructs on the basis of system models a complete *set of ideal states of the system*. It also maps each region of the space of qualities into the space of attributes and determines set of objects with quality characteristics for this region. The technology works with words, concepts and assessments of the *language of systems*. It uses these objects for expressing properties of concrete systems using generated system knowledge about these systems.

The technology works with different forms of representation of the system: empirical description; complete set of system models; system model of each quality; and complete family of condensed triangles.
The empirical description of the system is assessed based on its sufficiency for generation of complete system knowledge. In the complete system knowledge, heterogeneity of the system is completely revealed: unbalances are resolved, and changes in all parameters are explained by system mechanisms.
The family of system models is assessed by its ability to express completely the organization of the space of system qualities (to define all regions of the space through compact structural invariants isolating the system in each of its quality and to give an explanation to all forms of representation of all qualities of the system through mechanisms determining variability of its states).
The *condensed triangle* is the ultimate concentrated image of the system in a quality expressed by one concrete system model. The condensed triangle serves as an instrument that maps a region of the space of qualities into the space of attributes of the system.
The main purpose of technology of system examination is a transformation of the family of system models into a set of models of the ideal states of the system. Main axial symmetry of a system model allows only two ways of concordance of its signs in agreement with the *first axiom of systems*. Each alternative gives rise to a *model of stereotype of behavior* of the system.
The model of each stereotype is transformed into two models of ideal states of the system in accordance with the i*ndividualization axiom*. This axiom establishes existence of a unique border between high and low values. Complete set of models of ideal states determines the system as a whole with all its possible qualities and all ways of manifestation of these qualities in reality.
The direct mapping of regions of the space of system qualities into its space of attributes is achieved by mapping of the set of models of ideal states on the empirical description of the system. This mapping is achieved by using condensed triangles and special scales of numerical forms of the levels of parameters values.
The technology constructs scales for each parameter in each ideal model. The set of all quantitative assessments of parameters determines *region of ideal* in the space of attributes. This region contains set of objects whose state corresponds to concrete ideal of the system with different intensity of manifestation of qualities of the ideal in reality. A set of such objects forms *cluster of observed objects*.
Joint set of singletons, system models, and models of ideal states form a *complete layout of the system* where senses of the system are revealed in abstract representations. The result of the technology of system examination is knowledge on the quality of the empirical description, the quality of all system and ideal models, and the quality of mappings of regions of the qualities space into the space of attributes of the system.
Technology of system examination represents elements of system knowledge in three normative formats (*quality, volume, aspect of knowledge*).

Techno-cube of system design

Dimensions of the techno-cube of system design are set by coordinates "Representation", "Explanation" and "Attributes" [20], fig. 8.
Position "Qualities" characterizes the system as the whole (in its structural invariants, reconstructions of states, forms of system regularities). Position "Properties" discloses organization of regions of the ideals in space of attributes of the system, and also rules of conjugacy of the ideals and dominants of states of the system. Position "Differences" gives a complete explanation of all actual states of the system separately and its states space.
Technology of system design applies set of clusters of observed objects for construction of *models of actual states of the system*. Each ideal state of the system is realized in different observed objects with different intensity. On the basis of each set of clusters, the technology generates *models of implementation forms of the ideal*. Such model includes cluster of observed objects and assessments of degree of implementation of the ideal in these objects.

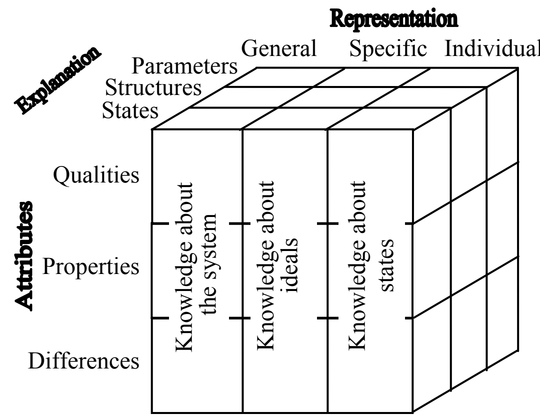

Fig. 8. Techno-cube of system design

The main purpose of the technology of system design is an automatic generation of *reconstructions of actual system states* that are represented in the system empirical description by states of observed objects. In a model of the ideal state, the system has one quality, generated by two-factor interaction that forms the kernel of the system model from singleton with common axial symmetry. In the reconstruction of the implemented state the system is *multi-qualitative* (as a result of that assembly) and is generated by interactions that form the kernel of the model of the reconstruction from singletons of the ideal models.
Each reconstruction acts as a carrier of knowledge about state of the system, considered as the whole, and about emergent properties of the system in this state. The states of the system are revealed in reconstructions by parameters and mechanisms that characterize and determine these states. Each parameter has a set of attributes that are assessed from the position of the system as a whole by special quantitative and qualitative scales. These attributes characterize each parameter by assessments of the level of its value, predetermination of this level, importance, mobility and roughness of parameter.
At reconstruction of concrete actual state each particular system mechanism assists in confirmation or changes this state. The concrete role of each particular mechanism in determination of this state is done by the reconstruction of the observed state. The complete set of reconstructions contains knowledge of all system as a whole and its *emergent properties*. Thus it represents knowledge on limitations and patterns of conjugacy on different qualities of the system in their observed states.
The results of the technology are models of rational explanation of properties of each parameter in each concrete state, properties of the system in whole, properties of observed states of the system, and mechanisms that form changes of each parameter and of global system properties. Technology of system design

represents elements of system knowledge in three normative formats (*knowledge about system, ideals and states*).

Architecture of system knowledge

System knowledge has a three-level structure. The model of open system being investigated is produced at the level of ontological knowledge. Ontology of the system is developed in the four perspectives at the level of axiological knowledge. Each of these perspectives represents a resource of system knowledge. Basis for effective activity in the area of projective, cognitive and analytical applications is created at the level of praxiological knowledge, fig. 9.

Ontological knowledge presents a model of the system in the three spaces: space of qualities, linguistic space, and states space. Model of the space of the system's qualities discovers the complexity of the system in the context of its multi-qualitative essence, each quality of which is unique and homogeneous. Model of the linguistic space describes a language to express discovered senses of the system. Model of the states space constructively defines the system as the whole through the system states and system-forming interactions.

Axiological knowledge presents the system knowledge from the perspective of its value. Information resource of the knowledge represents the system as an empirical reality and, for this representation, contains assessments of the ability to manifest and express senses of the system in complete and final form. Quantitative measures of senses of the system models form the intellectual resource of the knowledge. Cognitive resource of the knowledge contains the sets of elements providing creation of constructively defined formats for cognitive schemas of intrasystem mechanisms. Technological resource of the knowledge gives a variety of assessments specifying the completeness and adequacy of the models of states of the system as a whole from the position of interrelationship between empirical fact and system sense.

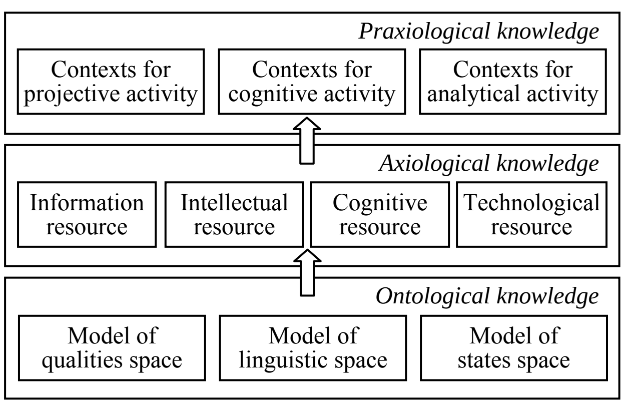

Fig. 9. Structure of system knowledge

Praxiological knowledge provides the opportunity of applying the system knowledge in the science and practice. Contexts for projective activity provide both effective organization of monitoring and formation of complete and representative concrete-subject descriptions of the system. Contexts for cognitive activity serve to the development of elements of knowledge engineering in multidisciplinary subject areas. Contexts for analytical activity represent and structure the system knowledge in the formats that are suitable for solving various types of applied problems.

Ontological knowledge has a two-level structure: knowledge elements and underlying knowledge, fig. 10.

Families of formal constructs (semantic "generators" of the system) are represented at the level "Knowledge elements". Level "Underlying knowledge" contains models of both qualities and states of the system that are produced by the semantic "generators" of the system. At the ontological level, the system knowledge is given by the three components reflecting processes of cognition, understanding and explanation, respectively.

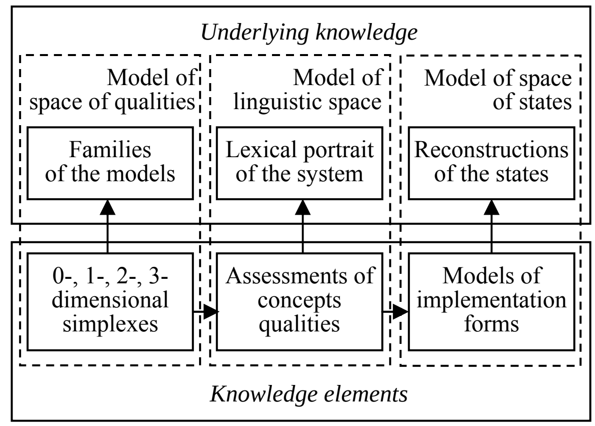

Fig. 10. Ontological knowledge

The first component "Model of space of qualities" discloses the heterogeneity (multi-qualitative essence) of the system through complete families of formal models and models of intrasystem interactions. The families of the models convey a variety of all unique qualities of the system. The models of interactions are represented by simplexes with specific system symmetries that discover mechanisms of systemogenesis.

The second component "Model of linguistic space" provides an understanding of the space of qualities of the system and eliminates the problem of reference for this space through building of the linguistic space. Words and concepts of the language form a lexical portrait of the system. This portrait explicates semantic content of the system. Evaluations of the qualities of concepts link the linguistic and qualities space.

The third component "Model of space of states" sets the conditions, rules and restrictions at formation and change of the system states. Reconstructions of the states represent a reliable knowledge about actual states of the system in the explicit form. The models of implementation forms of the ideals map the space of qualities of the system into its space of attributes. These mappings structure the space of attributes and allow obtaining reconstructions of all possible states of the system.

Axiological knowledge represents the knowledge resources. At this level an underlying ontological knowledge is complemented by assessments of its completeness, significance and reliability, fig. 11.

Information resource represents system knowledge in terms of the category "External". It is created on the basis of the models of the space of system's qualities and also linguistic space. Evaluation criteria are direct characteristics of the objects in qualities space of the system. These criteria are used at two levels of ontological knowledge (knowledge about the empirical fact and knowledge about the system sense of the fact). The levels of manifestation of the senses allow evaluating the system sense of the empirical fact on the basis of the objects of linguistic space of the system. These evaluations show whether the fact can be a carrier of the system sense.

Intellectual resource is formed on the basis of the same models of the system but represents system knowledge in terms of the category "External-Internal". Evaluation criteria directly reflect the system level of ontological knowledge about the space of qualities. At the level of perception of the senses, semes are created; they expand the linguistic space by new senses and evaluations.

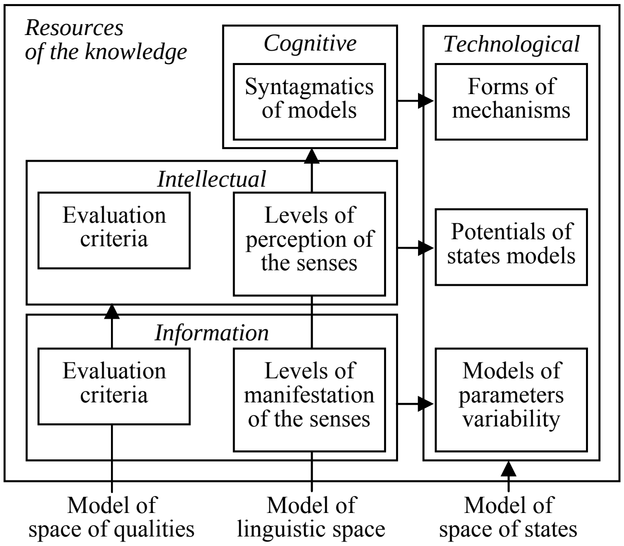

Fig. 11. Axiological knowledge

Cognitive resource characterizes system knowledge in terms of the category "Internal". The purpose of this resource is to understand the underlying mechanisms of systemogenesis. Predicative forms of these mechanisms are obtained in the linguistic model. Tool for this understanding is the criteria of order, which are generated on the basis of the predicative forms. These criteria define syntagmatic relations that discover the senses of intrasystem mechanisms in external formats of representation.

Technological resource represents system knowledge in terms of the category "Internal" in the context of the resource use for explaining the states and behavior of the system in empirical reality. The models of parameters variability contain attributes of parameters, which disclose system function of the parameters in all aspects for all qualities and states of the system taken as the whole.

Potentials of the models of states characterize:

– completion of the synthesis of the system sense and fact (in context of the qualities of the system) through evaluations of features of each quality's manifestation;
– fullness and completeness of states reconstructions, which are reflected in assessments of the influence of:
    - empirical description's defects;
    - limitations related to the effects of the influence;
    - stability of the states.

The forms of mechanisms describe intrasystem processes, responsible for parameters variability and formation and evolution of the states, through attributes of their definiteness, dominance, recessiveness, and reactivity.

Technologies of analytical kernel of POS produce ontological and axiological knowledge. Praxiological knowledge belongs to the technologies of constructive component of POS.

Generation of solutions resources

Technologies of analytical kernel form a level of system ontology [8, 20] (see fig.5). Their task is a production of system knowledge. The system knowledge represents an organized set of formal constructs and their attributes disclosing the essence of the system. This knowledge has an abstract form distracted from concrete reality. It serves as the rational basis for production of solutions resources of the system problems. The solutions resources are the system knowledge designed for explaining the system in interpreted concepts, forms and relations.

The level of subject ontology is formed by technology of context formation and technologies of constructive component. At this level knowledge about the system is given in the forms of empirical and system knowledge, fig. 12.

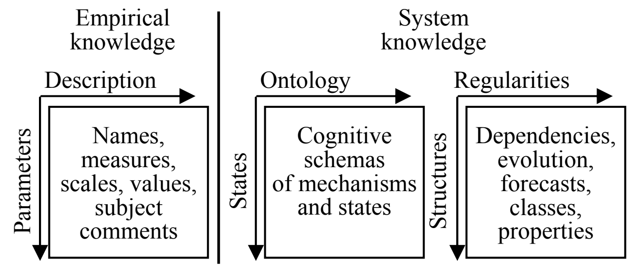

Fig. 12. Production of solutions resources

Along "Representation" coordinate of techno-cubes of system ontology the system is being disclosed in whole, in parts and elements. On the level of subject ontology this coordinate is unwrapped into three coordinates "Description", "Ontology", and "Regularities". Along "Description" coordinate an empirical knowledge about the researched system is fixed. Along "Ontology" coordinate on the basis of the system knowledge the essential world of the system is being disclosed in key concepts and relations and expressed in cognitive schemas. Along "Regularities" coordinate the most significant, necessary and stable relations between parameters, characteristics of their variability and actual and potential states of the system are represented. These relations are external *analytical descriptions* of the essential world of the system.

"Parameters", "States", and "Structures" categories characterize knowledge about the system in external, inner and external-inner forms. Through "Parameters" category, the *description of the system* on the level of empirical knowledge is being introduced. At this level the system and its states are being defined as hypotheses. Through "States" category the system receives *constructive definition* in terms of system ontology. On the level of subject ontology the definition of the system is being unwrapped into *descriptions of its mechanisms and states*, and filled with facts of empirical knowledge, and becomes the concrete-subject representation. "Structures" category establishes rules by which on the basis of the obtained descriptions, the development of regularities determined by the inner mechanisms is being carried out.

5. CONCLUSION

POS in its methodological foundations relies on the following statements:

1. The system is a multi-qualitative unity of the whole;

2. The system in each of its quality is defined in some locality being a part of the whole and simultaneously being a unified whole equipped by this quality in the context of the given part;
3. Behavior of the system whole in each of its locality is dominant;
4. The system in each locality has a two-factor structure;
5. The factors of the system within locality are homogeneous and each of these is being formed by the unique system mechanism;
6. The system in each of its qualitative determinacy is defined by the unique mechanism of two-factor interaction;
7. The system regularities are conditioned by the action of intrasystem mechanisms establishing relations between the parts and elements of the system whole.

The first four statements are directly implemented in the constructs of technologies of analytical kernel. These technologies produce ontological system knowledge about organization of the system considered as a unified whole, define constructs of this whole and explain their roles in forming the whole, its parts and states.

The other three statements obtain concrete form and content in technologies of constructive component. Constructs of these technologies express the given statements in the cognitive schemas of mechanisms and states, and also in the form of formal dependencies, properties and assessments. The solutions resources are the end product of technologies of analytical kernel and constructive component. Elements of the resources form a reliable, understood, checked, system knowledge having the rational explanation which is allowing a subject interpretation.

The solutions resources are being transferred to technologies of projective component (level of applications). At this level, specialists in the subject area work with the solutions resources. Their task is to use these resources in solving concrete, applied problems.

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