Evaluation system for the Russian Academy of Sciences: Objectives-Resources-Results Approach and R&D Indicators

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Abstract - **In the present paper we are describing Semantic dictionary as a part of the RAS Evaluation system, subsystem for RAS decision-makers and experts, Objectives-Resources-Results approach to the system design, and a stage-indicator table.**

1. PREFACE

In February 2008 the First Russian Academic Programme was adopted by the Government of the Russian Federation as a fact of the public interference in the area of science. The Programme introduced assessment for institutional academic activities, including science and educational ones. The Programme consists of six parts including the RAS Programme as a principal part of the first one. The Russian Academy of Sciences (RAS) took a decision to create an Evaluation system for providing the assessment of the RAS academic activities within the framework of the RAS Programme.

The RAS Programme embraces 88 subject areas of basic research arranged according to 9 sections:
- Mathematical sciences (include 5 areas);
- Physical sciences (9 areas);
- Technical sciences (12 areas);
- Computer sciences and information technologies (9 areas);
- Chemical sciences and material sciences (6 areas);
- Biological sciences (12 areas);
- Earth science (13 areas);
- Social sciences (14 areas);
- Historical sciences and humanities (8 areas);

We would like to note, that development of methods of scientific performance assessment as well as creation of the system of monitoring, analysis and assessment of scientific activities results are provided for within the section "Computer science and information technologies".

The RAS Programme was developed under Federal law (August 23, 1996 № 127-FZ "On science and state scientific and technological policy"). The law makes provision for program-oriented financing in science. Every RAS Programme is adopted by the Government of the Russian Federation for a period not less than 5 years. The first RAS Programme was adopted for a period of 2008-2012, i.e. its life-cycle makes 5 years. It is expected, that after its termination the second RAS Programme should be adopted, etc.

Thus the Evaluation system being developed in the Russian Academy of Sciences should continue its operation after the termination of the first RAS Programme in 2012 as well. However, in 2013 a new list of the goal-oriented indicators and other indices might be specified for the second RAS Programme.

The temporal stages of the RAS Programme monitoring and assessment is much longer than the RAS Programme life-cycle. These stages should resemble monitoring and assessment stages of EC framework programmes: ex-ante, mid-term, and ex-post [1].

In 2007 design and development of the Evaluation system of the Russian Academy of Sciences started. In the previous paper presented at ATLC'07 [2] we described clarification tools of the RAS Evaluation system. In the present paper we are describing Semantic dictionary as a part of the system, subsystem for RAS decision-makers and experts, Objectives-Resources-Results approach to the system design, and a stage-indicator table.

2. RAS EVALUATION SYSTEM

The RAS Evaluation system has to provide the assessment for the RAS Programme on the basis of indicators and other indices in:
- R&D sphere;
- Innovation sphere;
- Educational sphere.

The RAS Evaluation system is meant for data acquisition and processing on basis of which indicators and other indices are calculated then. In course of their usage the list of goal-oriented indicators may be modified. This makes the specific feature of Evaluation systems.

In consequence of possible modification of the list it is essential to provide for the development of instruments for those systems adaptation to such modifications in the process of Evaluation systems design.

We would also like to emphasize that Evaluation systems relate to category of long-term information systems which tend to evolve in the course of time. The very key factor affecting the evolution of Evaluation systems in the course of time is modification of the goal-oriented indicators list after beginning of their usage.

In other words, it is known that after some period of time Evaluation systems have been under operation the list of goal-oriented indicators could become dramatically modified.

It is important to note, that one of the principal goals of the RAS Evaluation system creation is calculation of indicators and other indices meanings. Modification of the indicators list in the majority of cases won't affect the purpose of the RAS evaluation that is support of the processes of formation and management of the RAS Programme in line with network diagram of the Programme realization as well as processes of its monitoring and assessment in compliance with network diagram of its assessment.

It is necessary to specify indicators in course of Evaluation systems creation. Their verbal, most common description is usually not enough. Our experiments and research with development of publication activity indicators showed that it is feasible to specify several indicators which differ in sense and calculated meanings on basis of the only one verbal description [3].

It is also important to take into account specified conditions of Evaluation systems usage in process of indicators specification. Sometimes document describing service conditions contains information on duration of Evaluation systems usage and on primary causes of indicators list modifications (e.g. transfer to execution of the next RAS Programme or correction of the ongoing one).

As compared to the version 2007 of the RAS Evaluation system now we are adding new subsystem. The main function of the subsystem is to provide information on the implementation of ongoing RAS Programme to address management needs. This information will be provided to RAS decision-makers and experts by new subsystem to support assessment of the RAS Programme intervention according to its results.

Hereinafter, the following terminology is used to describe the results of the RAS Programme:

- 'outputs' are knowledge presentation forms directly produced as a consequence of the RAS Programme intervention (publications, conference papers, patents, prototypes, etc.) according to the similar definition from the report [1],

- 'outcomes' are objective-oriented results which are compared to the RAS Programme-oriented purposes according to the similar definition from the GPRA [4], and

- 'impacts' are the long-term socio-economic changes the RAS Programme intervention brings about according to the similar definition from the report [1].

New subsystem for RAS decision-makers and experts consists of three functional modules to represent in future the RAS Programme resources, results, effectiveness, and efficiency using indicators and other indices:

- statistical module represents indices in interactive tabular forms for RAS decision-makers,

- diagram module represents indices in static graph forms for RAS decision-makers,

- module of Semantic dictionary represents indicators and other indices by query in tabular and graph forms for RAS experts.

The module of Semantic dictionary also serves as an instrument of adaptation of the RAS Evaluation system to goal-oriented indicators list modifications. Its developers are of activity.

4. OBJECTIVES-RESOURCES-RESULTS APPROACH

The main objective of the RAS Evaluation system is to provide an assessment of the RAS Programme according to three perspectives:

- RAS institutional levels,
- Subject classification of the RAS Programme, and
- Activity-based structure of the RAS Programme.

From three above-listed perspectives the RAS Evaluation system should support an assessment of the RAS Programme resources and results, as well as (see Figure 1):

- the RAS Programme consistency which means relationship between objectives and resources,

Since developers are aware about next modifications of the goal-oriented indicators list in advance, an attempt to design architecture of the RAS Evaluation system capable of reducing expenses on its redesign has been made.

In the next section a functional subsystem for users as decision-makers and RAS experts will be briefly described. In the subsystem instruments of the RAS Evaluation system adaptation to the goal-oriented indicators list are provided for in advance. However, expenses on its redesign in case of the list modification will depend on amount of works on development of algorithms and programs for new indicators calculation.

3. SUBSYSTEM FOR DECISION-MAKERS AND EXPERTS

planning to include a procedure describing new indicators and their relations with new programs of their meanings calculation as well as those information resources, which are exploited in course of indicators meanings calculation into the module.

Three above-listed functional modules should represent indicators and other indices for the RAS Programme resources, results, effectiveness, and efficiency in institutional levels, subject classification and activity-based structure.

The pilot variant of the RAS Evaluation system should provide an assessment at four institutional levels:

- Macrolevel - the Russian Academy of Sciences as a whole;
- Mesolevel - Institutes of the Russian Academy of Sciences;
- Microlevel - Research teams of the institutes;
- Nanolevel - Scientists and engineers.

Classification of the first RAS Programme includes 88 subject areas of basic research arranged according to 9 sections given in the first paragraph of the paper.

The activity-based structure of the first RAS Programme includes 4 types of activities:

- R&D subprogrammes and projects financed at the expense of the RAS institutes funds;
- R&D subprogrammes and projects financed at the expense of the Presidium of RAS;
- Analytical, information and contributory projects;
- Infrastructure projects financed at the expense of the Presidium of RAS.

For instance, meanings of the patent activity indicator could be calculated for the first RAS Programme as a whole, for every Institute, subject area of the basic research and types

- effectiveness which means relationship between results and objectives, and

- efficiency which means relationship between results and resources.

When implementing the RAS Evaluation system, developers needed a classification scheme for indicators capable of supporting an assessment of the RAS Programme. Development of the scheme was based on the Objectives-Resources-Results Approach. Its main idea is as follows: the classification scheme for an assessment of the RAS Programme should cover its objectives, resources, and results, as well as relationships between them, i. e. consistency, effectiveness, and efficiency. But for all that each indicator

integrated into the scheme is linked to one, two, or all of the three above-listed perspectives for which the RAS Evaluation system is able to calculate its meanings and to extend them.

indicator of the patent activity at all the three perspectives and to extend them according to institutional levels, subject

For instance, the RAS Evaluation system will be capable of calculating meanings of the above mentioned classification, and activity-based structure of the RAS Programme.
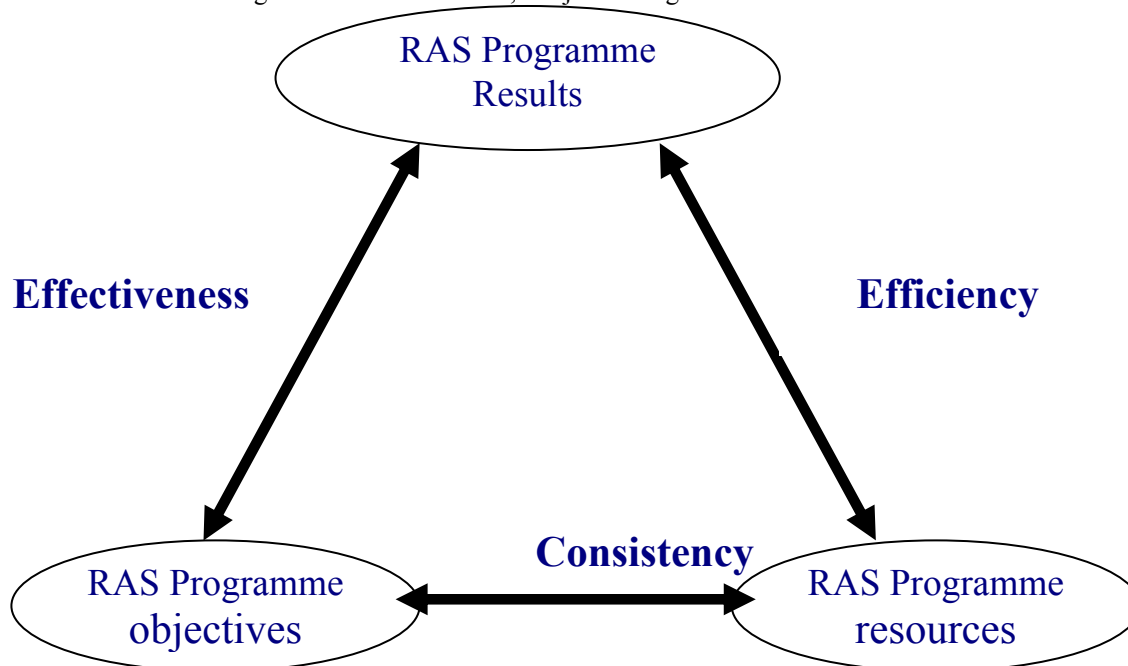

Figure 1. Relationships between objectives, resources, and results.

5. SEMANTIC DICTIONARY FOR RAS EVALUATION SYSTEM

At the moment the classification scheme is integrated into the module of the Semantic dictionary. Every entry of the dictionary includes parameterized definition, examples of indicators variants illustrating its substantial meaning and links to the other entries. The definition of each entry in the Semantic dictionary may also contain links to description of information resources of the RAS Evaluation system, variants of indicators meanings calculation algorithm and parameters defined in compliance with some normative documents (see Figure 2).

Let's illustrate importance of the links to description of information resources by the following example. The RAS Evaluation system may store publications of various types (books, reviews, scientific articles, conference papers, etc.)

In the description of information resources the full list of available publications types is given. Availability of the link to the description in the indicator entry allows user to view all the types and simultaneously only those of them relating to this entry. Moreover, when calculating indicator's meanings user will have an opportunity to choose exactly those of publications types he needs for indicator's meaning calculation. For instance, when calculating meanings of publication activity indicator, its entry as a query will provide option for the type "book". As a result, meanings of the indicator will be calculated for this type only.

As an example of a link to parameters defined in compliance with normative documents a value of the age limit outside of which a person has a status of a young scientist may serve. As regards links to variants of indicators meaning calculation algorithm, its example may be illustrated by citation index: its meanings essentially depend on duration of citation period considered.

We'd like to note, that inclusion of parameterized definitions into dictionary entries particularly distinguishes it from other types of semantic dictionaries. A review of them is given in [5]. Our approach to entries construction helps to reduce risqué of ambiguous understanding of substantial meaning of an indicator. Moreover, if an indicator possesses several meanings, each of them correlates with a particular set of parameters and links in the entry which specifies the meaning, i.e. its concept.

In 2008 in process of the RAS Evaluation system design developers from our Institute -Resources-Results Approach (see Figure 1). At the same time the developers used basic data about three above-listed perspectives - institutional levels, subject classification, and activity-based structure of the RAS Programme. Experience of designing the RAS Evaluation system prototype in 2008 showed that there was a strong need applied Objectives in the classification scheme further development as it hasn't classified assessment indicators and other indices for the following 3 items: programme objectives, consistency, and effectiveness.
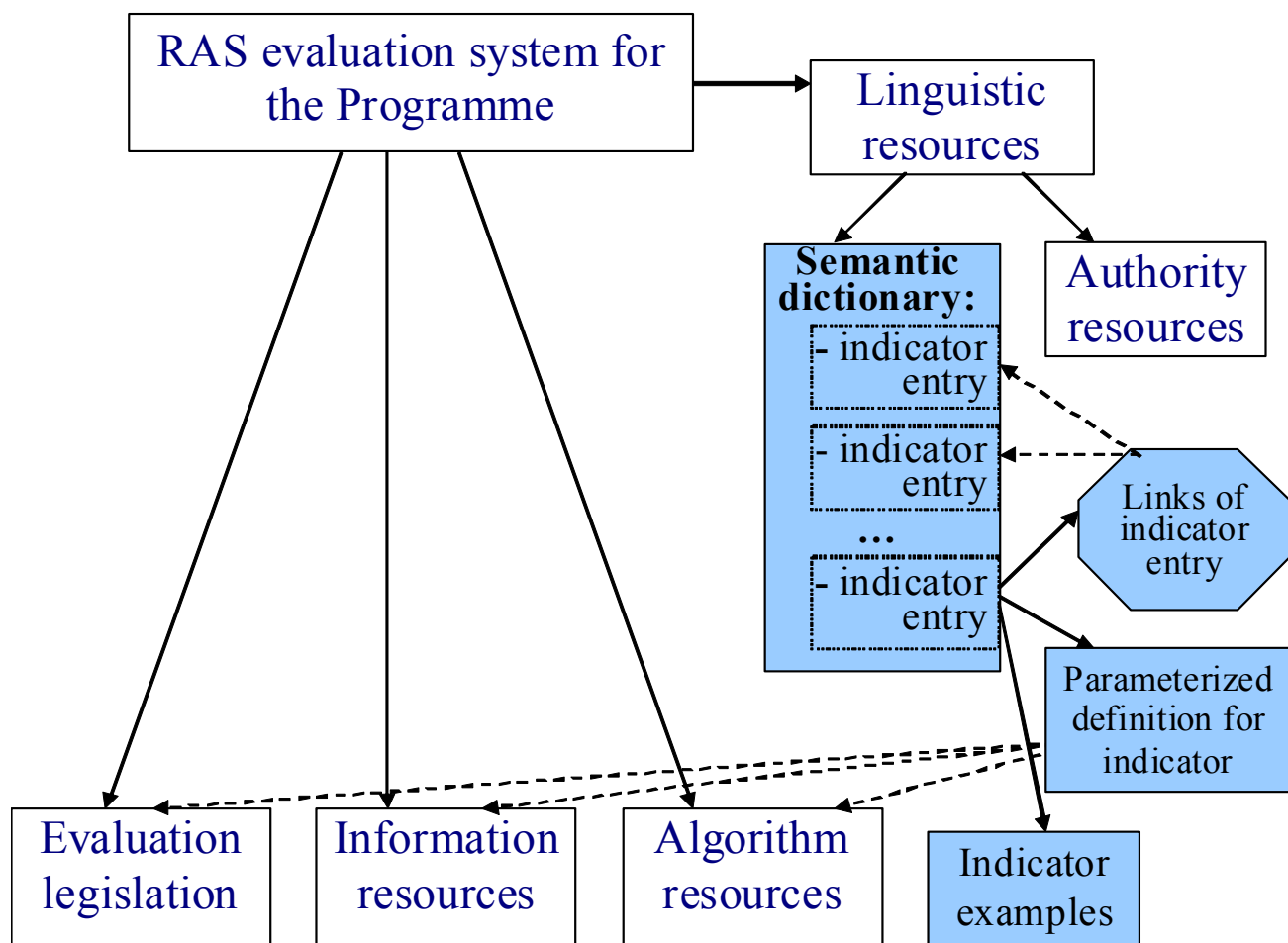
Figure 2. Links of the Semantic dictionary to other components of the RAS Evaluation system.

As a result of the Objectives-Resources-Results approach usage indicators and expert evaluations were divided into 6 categories - for assessment of the RAS Programme objectives, resources, results, consistency, effectiveness, and efficiency (see Figure 1).

Now the classification scheme covers all 6 categories of indicators and expert evaluations within the Semantic dictionary of the RAS Evaluation system. It was integrated into the dictionary providing implementation of two stages of indicator meanings clarification [6]. A need in the functional module of the Semantic dictionary arose due to specific situation of those indicators emergence and their original ambiguity. Emerging indicators lacked definitions, examples of usage and application, etc. To solve the task of taking into account all the existing and potential, expected indicators it

Hence, at the moment the classification scheme includes 4 general types of indices, as follows: indicators, criteria, parameters, and expert evaluations. Figure 3 represents a fragment of the updated classification scheme (version 2009)

6. STAGE-INDICATOR TABLE

In addition to the scheme expansion a necessity in bringing in correspondence temporal stages of the RAS Programme assessment with indicators and other indices has emerged. Developers of the RAS Evaluation system used the temporal stage and substage definitions according to the report [1]. The

was suggested to create a dictionary that could be completed by new indicators when expanding the scheme.

In the paper [6] top level of the classification scheme was described. It included five types of indices:
- Indicators (evaluations calculated on basis of information resources of the RAS Evaluation system);
- Characteristics (indices of infrastructure and personal resources);
- Criteria (indices for decision making);
- Parameters (data, that are specified outside the RAS Evaluation system, for example, funding data);
- Expert evaluations (results of an independent examination attached to evaluation forms and reports).

In the current version of the system amount of the types is reduced, since characteristics are considered to be a subcase of indicators (see Figure 3).

in which two types of indices are given with their subtypes: indicators and expert evaluations. Each type is divided into 6 subtypes. They were formed as a result of usage of the Objectives-Resources-Results approach (Figure 1).

network diagram of the RAS Programme assessment consists of the ex-ante, mid-term, and ex-post stages. The ex-post stage consists of the three substages covering different time horizons: short, medium, and long terms.
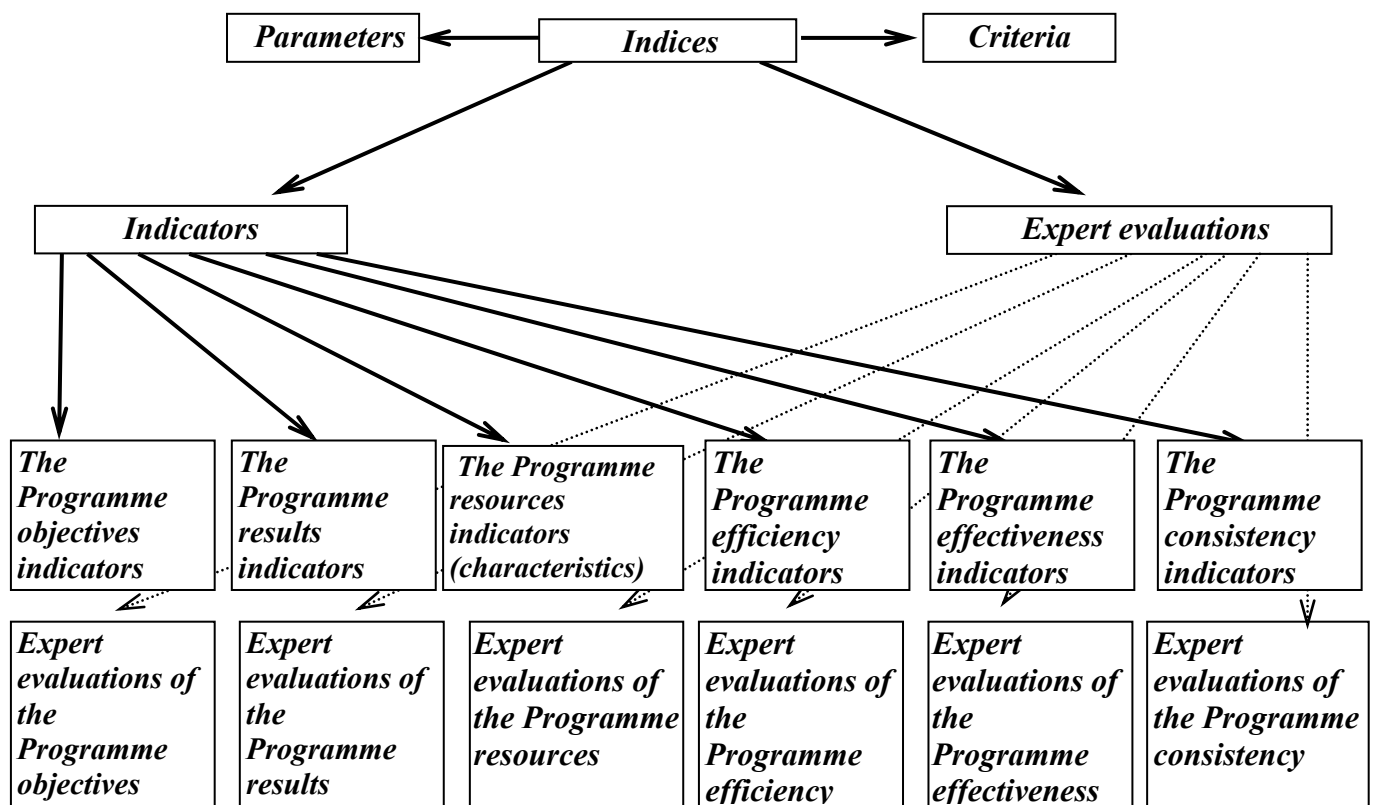
Figure 3. Fragment of the updated classification scheme.

The short term evaluation (1-2 years after the RAS programme termination) is meant for the following purposes:
- analysis of the RAS Programme outputs and outcomes,
- the RAS Programme management issues (e.g. efficiency of administrative procedures),
- the RAS Programme design issues (e.g. accessibility and flexibility of instruments, barriers to participation, etc.).

The medium term evaluation (after 4-7 years) is intended for following purposes:
- analysis of the RAS Programme outputs and outcomes,
- the RAS Programme design issues (e.g. effectiveness of instruments),
- analysis of participation (combining qualitative and quantitative aspects, e.g. research networks analysis, impacts on the behaviour of researchers, etc.).

The long-term evaluation (after > 10 years) is intended for an assessment of impacts.

Developers of the RAS Evaluation system suggested to use special stage-indicator tables for a description of correspondence between temporal stages and substages of the RAS Programme assessment with indicators and other indices for the following items: the RAS Programme objectives, resources, results (incl. outputs, outcomes, and impacts), consistency, effectiveness, and efficiency (see table 1).

For each list of indicators and other indices table cells are filled up as follows: if the list contains any of the indicators or indices for a stage & item cell, then symbol "+" is to be put in the cell; otherwise, symbol "-" is signed down, or the cell stays without filling (it's a brief form of the table). In order to fulfill the analysis of the indicators and other indices in more detail relevant sublists are given in the cells (it's a complete form of the table).

Items	Objectives	Resources	Results			Consistency	Effectiveness	Efficiency
Stages (substages)			Outputs	Outcomes	Impacts			
Ex-ante								
Mid-term		+	+	+				
Short term ex-post		+	+	+				
Medium term ex-post								
Long term ex-post								

Table 1. Stage-indicator table.

The brief form of the table given was filled on the basis of the indicators and other indices list defined in the first RAS Programme as a whole. The stage-indicator tables may be designed for the RAS Programme as a whole as well as for every Institute, four types of activities carried out within the framework of the RAS Programme, etc.

It is planned to exploit the tables when discussing functions' specifications of the RAS Evaluation system with decision-makers, including the Semantic dictionary structure. These tables are clearly presenting the degree of "covering" by indicators and other indices of the RAS Programme objectives, resources, results, consistency, effectiveness, and efficiency for every stage of an assessment

7. CONCLUSION

Thus the RAS Evaluation system was modified according to the Programme requirements. Firstly, the system was supplemented with one more principal functional module, namely, the Semantic dictionary. Secondly, this new module is linked now to legislation, information and algorithm resources of the system. It means that each indicator under study can be viewed from several perspectives, i.e. its definitions, links, and other relevant information is available in the Semantic dictionary, its place and relations in the hierarchy of the classification scheme. Finally, the RAS structure has been separated from the Semantic dictionary structure. Now the latter is more stable than the annually modified RAS structure. The RAS Evaluation system allows us to calculate an indicator for the RAS as a whole and to consider it in different perspectives that are given by institutional levels, subject classification, and activity-based structure of the RAS Programme.

The description of the subsystem for RAS decision-makers and of the Semantic dictionary given illustrates up-to-date stage of the RAS Evaluation system development.

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