A Decision Support System (DSS) for Developing Programs of Scientific and Applied Research and Experiments on the Russian Segment of the ISS

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Abstract

Automation of the main stages in formation programs of scientific and applied research and experiments planned for the Russian segment of the ISS are considered. Computerized decision support tools to rank the results of application examinations for space experiments (SE) based on certain criteria, their importance and feasibility and preparation of the space research program schedule with this multi-criteria evaluation are proposed. In this case, the selection of space experiments for research program and their planning is carried out taking into account financial and resource constraints on the ISS: dimensions and mass, energy consumption, information, available crew time.

As an indicator of the effectiveness of research program may serve degree of achieving the following objectives defined by the preferences of the decision maker, for example:

• maximization of the overall scientific and practical value of the program;
• minimization of the average waiting time of the start of the given experiment;
• minimization of consumption of some of ISS resources.

The developed decision support system "Cosmos" is open to addition of new multi-criteria analysis methods and based on modern Web technologies.

1. Introduction

Performing experiments on board the ISS is a special space flight resource, which can be fruitfully used for scientific and technical purposes. Russian specialists have gained significant experience in research on automated spacecraft and long-term orbital stations. For more than 30 years Soviet and Russian researchers conducted more than 1000 experiments on the physics of weightlessness and space applications on board space vehicles. Varied special scientific and providing equipment was developed.

The experience of previous experimental studies conducted on automatic and manned spacecraft indicates that in the development of such research programs there is an uncertainty both with respect to results of the SEs, and to the resources and the timing of the experiments. This uncertainty makes difficulties for the authorities who have to make decisions on funding of new experimental studies. An objective assessment of applications for SE without access to information about the previously obtained results, the substance of the proposed projects, expertise and scientific authority of the authors without full consideration of scientific and technical priorities and available resources is extremely difficult.

In case of installation expensive equipment on the ISS the need for SE feasibility studies and for comparing most promising areas of domestic and world scientific research greatly increases.

Today we are witnessing rapid growth of computer capabilities that facilitates progress of modern modeling means and information technology (IT). There have appeared new opportunities for synthesis and critical comparison of newest experimental and theoretical data. Extensive use of network technologies provides easy and quick access to information via the Internet. Scientists and experts involved in the preparation, examination and selection of promising projects to be conducted on spacecraft demand a common information environment. This need is natural. Despite rapid development and wide use of IT in various fields of practical activities they are still complementary in the considered domain.

Due to increase in the number of the planned experiments and new proposals an actual problem is increase in efficiency of current procedures regulating formation of mid-term program (MP) of applied research planned, in particular, for the ISS Russian segment (RS) (http://knts.tsniimash.ru) [1,2]. To reach this goal according to the authors it is possible by information and automation of all stages of decision-making [3] about the composition of the AR program and development of the work schedule for its implementation.

On the basis of the designated necessity the Keldysh Institute of Applied Mathematics together with TSNIIMASH proposed a concept of information and automation which is based on the idea of creating a common information environment and a computerized decision support system (DSS) [4] integrated with this environment.

Formation of a common information environment involves incorporation, standardization and unification of necessary information, software and system resources of creative teams, enterprises and companies involved in formation and implementation of space experiment programs. The common information environment offers new opportunities for improving efficiency of the procedure of formation programs for scientific and applied research and experiments in space.

By now:

• prerequisites for informatization and automation of formation of SE programs on the ISS RS have been recognized ;

• practical ways to form a distributed information environment and development of information support from the Russian scientists and professionals involved in the planning and execution of SEs on the ISS RS have been suggested;

• valuable experience to create specialized information resources has been gained [5].

Preliminary analysis of current regulations conducted in order to identify initial prerequisites for informatization and automation of the SE application selection procedure showed the following:

1. Regulations [1,6] allow to formalize the processes of proposals approval (workflow) which could be automated. They contain definitions of entities and their attributes required in the process of automation as well as allow to specify a filtering system based on assumed restrictions, i.e. identify those applications which shall not be considered. They determine the parameters of applications to be considered as evaluation criteria such as scientific significance, feasibility, etc.

2. The basis of the procedure regulated by GOST R 52017-2003 [6] is expert analysis of the application documents. In view of a need to consider many factors when the expertize, the procedure of space experiments selection should be considered as a multi-criteria semi-structured or unstructured problem [3,4].

3. Examined regulatory documentation does not contain an exhaustive list of criteria and ranking rules based on these criteria.

4. At present, information on space experiments is stored as a semi-structured form. The degree of structuring is clearly seen on the website http://knts.tsniimash.ru.

5. There is a need for further normalization of the input information to the level of the attributes which can be considered as numeric or lexical (qualitative) criteria.

6. Two similar objectives are actual:

- Selection of new applications for space experiments on the ISS.
- Decision on continuation or termination of the experiments that are already underway, as well as the formation of the research program optimal according to certain criteria.

7. A tree of indicators to assess space experiments developed by TSNIIMASH includes both numeric and lexical scales. To work with nominal lexical scales without translating them into the additive digital scale it is expedient to use qualitative methods of preferences identification.

2. Methods of solving the problem

There are two different approaches to decision making. The first one is based on the creation of a system of rules by which the system offers a solution. This approach is employed by expert systems. If the problem is structured well, the system of rules is rather clearly defined and objectively correct, the use of these expert systems is appropriate. However, the SE assessment problem under consideration relates to the class of semi-structured, i.e. currently there is no objective and exhaustive list of rules by which one could assess a space experiment. In addition, assessment of SE has both numerical and qualitative (lexical) character. To solve semi-structured tasks one employs systems belonging to another class: decision support systems (DSS). It's worth noting that a common feature of most discussed below methods involved in the decision support system is their dependence on the subjectivity of a decision maker (DM). It is believed that the decision maker has the experience, knowledge and skills which make him competent in the task at hand. This makes oneself evident in the fact that the choice of method and the appointment of its necessary internal parameters are (or at least should be) implemented directly by DM or with his participation. This provision becomes of fundamental importance when the question is making decisions with involvement of a DSS.

Let's compare some of these methods, which will primarily be implemented in the DSS in terms of content, omitting a detailed description thereof, as they were repeatedly set out in the literature [4].

<u>Weighted sum model</u>. In this method a generalized criterion of effectiveness is the sum of the values of indices with weights which are also called coefficients of importance. The coefficient of importance reflects the value of the indicator (its importance) compared with the others.

Advantages:

- Ease of formalization.
- A clear physical meaning.
- Extensive coverage in literature, and availability of proven software tools that implement the method.
- The ability to account for individual representations of the DM about the task when assigning weight coefficients.
- A simple formal procedure (the method of paired comparisons), which facilitates the process of calculating the weights.

Disadvantages:

- Implicit mutual figures compensation which becomes uncontrollable with a large number of them.

• No account of weight coefficients nonlinear dependence on values of metrics (no account of so-called dependence on preferences: the importance of indicators are entered once, and henceforth play the role of parameters).

• Ambiguous criteria space points mapping on the set of possible solutions (alternatives).

Ideal point method. In this method, the vector criterion is considered as a point in the n-dimensional space which coordinates correspond to the figures. The best out of possible solutions is the one in which each of the indicators will achieve the best value. The corresponding point is called "ideal". By introducing the criterion space metric, i.e. having specified the method of measuring the distance between the points, it is logical to assume that best of the two alternatives is the one which is closer to the “ideal” point. It should be borne in mind that the selection of metric can significantly affect the result, and that’s why this step is fundamental. Usually, for the sake of simplicity, the Euclidean distance is used.

Advantages:

• As for the weighted sum, the components of the vector criterion are considered in the aggregate.

• A clear formal statement.

Disadvantages:

• Random metric selection (typically used Cartesian space).

• Non representable distance between two points of an n-dimensional space for n> 3.

• Ambiguous criteria space points mapping on the set of possible solutions.

Median Kemeny. This method is based on ranking of a finite set of alternatives. On the different linear order relationships (different rankings) a measure of rankings proximity is introduced by Kemeny, One ranks the alternatives for each component of the vector criterion and then compute median Kemeny ranking.

Advantages:

• The components of the vector criterion are considered together

• A clear formal statement.

Disadvantages:

• Non representability of median ranking in terms of the content, as it usually does not respond to any of the expert (averaged) rankings.

The method of successive concessions. The essence of this method is as follows. Initially indicators are ranked according to importance. But their ordering is purely qualitative in nature, i.e., no quantitative estimates of the importance are performed. Then the first and most important criterion is selected and the optimal alternative for it is found. After this a concession is assigned, i.e. interval, which can vary the values of the first criteria. In other words, it is determined how much the first criteria may differ from its optimal value (how far it can be worsened). Then the optimization over the second criteria is performed. At the same time the optimal value of the second criteria is searched for with admissible assignment of the first one. Next assignment is determined by the second criteria, etc. The alternative calculated at the end of this multistage optimization is taken as an optimal.

Advantages:

• Meaningful ease.

• Consideration of all components of the vector criterion.

Disadvantages:

• The need for a preliminary ranking of indicators of importance.

• The difficulty of determining the values of concessions.

• The practical infeasibility in case of a large number of indicators.

Strictly speaking, successive concessions are not the method of scalarization of the vector criterion but a heuristic method or a procedure for selecting a "suitable" solution to the multi-criteria problem.

Pareto optimality. This method, considering all the many alternatives discards those that are dominated by at least one alternative. It is believed that Alternative A1 dominates over alternative A2, if according to all indicators (local criteria) A1 is not inferior to A2, and at least one of them is better. The set of non-dominated alternatives is called Pareto optimal, and it is from this one that the solution should be chosen. So the search for solutions in accordance with Pareto optimality gives a set of feasible solutions, not single one.

Advantages:

• The method is mathematically rigorous and understandable to the user.

• Identifies the set of feasible solutions.

• Provides analysis of the decision-makers to focus on making a narrower (or rather less powerful) set of alternatives.

Disadvantages:

• The applicability of the method is limited by the capacity of the Pareto-optimal set (the number of elements must not exceed 7 or 10). If the non-dominated set is of high power, the choice for it is practically unfeasible without the use of special procedures.

Analytic hierarchy process. The method is an extension of the weighted average method. Source vector criterion is not aggregated into a single scalar index, but several milestones that aggregate non-overlapping subsets of components of the vector criterion are introduced. These intermediates are aggregated again to figures new indicators and the process continues until the output of single index which characterizes an alternative solution as a whole. The result is a tree of indicators.

Advantages:

• Allows you to work with vector criterion of arbitrary dimension.

• In the method the procedure for calculating the weights of the criteria on the basis of paired comparisons is proposed.

• Input estimates can be obtained by pairwise comparisons of alternatives.

Disadvantages:

• Do not take into account depending on preferences.

• Do not allow to assess milestones in the lexical scales.

• With a large number of intermediate levels of aggregation loss of data is possible [4].

There are still many other methods of multi-criteria decision analysis: weighted product model, Germeier convolution, Chebyshev distance, Analytic network process (ANP) and many others. There are many methods and it does not seem possible to list them all within this article. However, the authors do not insist on the choice of any one method. The main thing is that the software implementation of DSS contains tools for rapid integration of the methods that are necessary for decision maker.

3. Software tools for decision support

To succeed in decision support and taking into consideration all the risks in the course of development and operation of the system, it is necessary to consider the concept of modern decision support systems and the implementation of these concepts.

The term *decision support system* (DSS) is commonly understood as a tool to make recommendations to a decision-maker on the basis of the ranking of a finite set of alternatives (decisions) or optimizing them for an infinite set. Now a DSS is often interpreted as data preparation tools for a DM. These tools help to create a database (which is usually voluminous and contains complex relationships), to organize a flexible and easy access to them through powerful querying means, receive query results in the form most convenient for analysis, use powerful reporting tools, etc.

DSS is to help solve problems that are traditionally considered as "smart." This diagnosis of problem situations belongs to different fields (medicine, ecology, geology, etc.), construction, and making of political, economic and other decisions. Such problems have always existed, but today, thanks to the development of computer systems, their solution was feasible based on formal methods. The main difficulties were related to the need to address many interrelated factors that affect a solution of the problem, which led to large amounts of data that cannot be analyzed manually. In addition, widespread practical application of the DSS was held back by the fact that not all organizations that would like to use such systems have sufficient resources. Reduction in price of the hardware, emergence of powerful database management systems (DBMS), and software development tools has changed the situation. Now most customers of such systems already have either an existing base of data stored in the computer or financial resources sufficient to its creation. [4]

As it is well known, the distinguishing feature of poorly structured problems, i.e. precisely those that most of all require involvement of DSS is multi-criteria, which means the quality of decisions cannot be measured by a single scalar parameter and one has to resort to a vector criterion. To resolve the difficulties arising in this ranking and optimization of alternatives one has to use informal methods of scalarization based on the judgment of decision-makers.

Current multi-criteria decision support systems are usually divided into dedicated systems and frameworks. The former has the disadvantage that creation of a particular dedicated DSS always requires much time and, accordingly, expenses. In addition, they usually contain hard-coded algorithm, or the structure of solutions of the problem, a that as a rule reflects the system designer`s view on the task rather than the view of the future user. Unlike specialized systems the frameworks are invariant with respect to the subject area. Acquisition of an invariant DSS can be more operationally and financially beneficial, than purchase of a dedicated one. With such a decision one must also take into account the cost of integration of DSS and the controlled system. An exception may be the case when the DSS has been established for a particular application environment and there is no need to solve problems from other data domains. But even in this situation, a dedicated decision support system will not always be better. Thus, a dedicated DSS in the field of economics will require a major reconfiguration and re-writing its parts in the event of changes in the legislation.

Today BI (Business intelligence) systems [4], which are often referred to as DSS are being developed most actively.

In a general sense BI broadly governs:

• The process of transforming raw data into information and knowledge of the business to support improved and informal decision-making ;

• Information technology (methods and tools for data collection) and consolidation of data and facilitation of business users` access to knowledge;

• Business knowledge obtained as a result of in-depth analysis of detailed data and consolidated information.

Now let’s consider some examples of DSS, which allow to issue recommendations for decision-makers.

Expert Choice, Comparion Core. Website: http://www.expertchoice.com/

Purpose: Training and consulting in the field of support for integrated multi-dimensional solutions. There is a version aimed at the alignment of resources.

Super Decisions. Website: http://www.superdecisions.com/. Non-commercial software. It is not currently being developed. The system is based on analytic network process, i.e. generalization of the analytic hierarchy process.

Criterium Decision Plus. Website: http://www.infoharvest.com/ihroot/infoharv/products.asp#CDP30. Multi-criteria decision support system, focused on large-scale problems. It is not developing at the moment.

Ergo, eBestMatch. Website: http://www.technologyevaluation.com/products/decision-support-systems/

It is a multifunctional DSS. Includes statistical treatment. The system is focused on pre-sale inspection.

Decision Lens. Website: http://www.decisionlens.com/. Commercial system. The system is based on the method of analytic networks.

Tables 1 show some characteristics of the DSS presented in the commercial market.

Table 1: Main characteristics of DSS

Name	Paired comparisons	Times Analysis	Sensitivity analysis	Group's assessment	Risk analysis	Web-interface
1000Minds	Yes	No	Yes	Yes	No	Yes
Analytica	No	Yes	Yes	No	Yes	Yes
Criterium DecisionPlus	No	No	Yes	No	No	No
Decision Lab	Yes	No	Yes	No	Yes	No
Decision Manager	No	No	Yes	No	Yes	No
DPL Syncopation	No	No	Yes	No	Yes	No
DSS/UTES	Yes	No	Yes	Yes	Yes	No
ERGO	Yes	No	Yes	No	No	Yes
Expert Choice	Yes	No	Yes	Yes	Yes	Yes
Hiview3	No	No	Yes	Yes	No	No
Logical Decisions	No	No	Yes	No	No	No
MindDecider	Yes	Yes	Yes	Yes	Yes	No
RPM-Decisions	No	No	Yes	No	No	Yes
TreeAge Pro	No	No	Yes	No	Yes	No

As it can be seen from the table, most DSS implements only one method of decision support being promoted by its authors. Furthermore there are few systems oriented at Web technologies. As a result of the analysis of the currently existing DSS it was decided to create a new DSS system named "Cosmos" which is open to addition of new methods for vector criterion convolution and based on modern Web architecture.

4. DSS "Cosmos" development principles

Development of the "Cosmos" system was based on several principles:

The principle of disengagement from developers subjectivity. The system should be flexible as much as possible and adaptable to needs and requirements of a user. At that the customization of decision rules should be performed in the user interface of the system with no need to modify the source code of the software.

The principle of invariance with respect to the subject area. The DSS software should include implementation of a wide range of methods to deal with vector criterion, optimization methods and have tools to identify the user's preferences. Software implementation of these methods is quite laborious, and the methods themselves are not tied to a particular subject area. Therefore, it is advisable to develop a unified architecture of DSS that is capable to operate with any subject area.

The principle of methods multiplicity. There are many methods of decision making. A DSS should provide easy and seamless integration of the required methods, advise the user which method is better applicable in a particular case and why, but do not insist on it.

The principle of decision maker (DM) subjectivity. A DM has the authority and responsibility for decision-making. Solutions offered by a DSS are to reflect the experience, qualifications and preferences of the decision maker. After the initial setup, the results of the DSS are often not satisfied with the decision maker, you need to provide for a procedure of backward chaining, that will explain which preferences have led to the gained result, and what needs to be changed for the result of work to look in a different way.

The principle of friendliness towards the decision maker. To work with the DSS one should not require special knowledge of theory of the decision maker. The interface of the system must demonstrate all of the DM settings and preferences on a minimum number of screen forms. The DSS must include a mechanism for identifying inconsistencies in judgment of a decision maker, and point to them.

DSS architecture that implements these principles is based on frame approach [7]. In this approach, the framework is responsible for the basic behavior, and all the multitude of variable behavior of DSS is released into modules, which are connected via extension points. The DSS frame has the following features:

• provides a mechanism for describing the domain of criteria and parameters of the model domain,

• allows the user to choose methods of decision-making and organizes information exchange between them,

• provides storage, display and editing of the attributes of alternatives,

• provides access control.

Alternatives can be entered by the user in the interface of the DSS, imported and exported from an external system or generated by search optimization techniques. Access control should imply both access to both separate DSS functions and to certain criteria and the individual alternatives.

The other functions of DSS are implemented through the following extension points (sockets) of the framework:

• Writing and editing preferences of a DM.

• Description of the limitations for the parameters of the application environment in order to determine the set of acceptable solutions.

• A description of the acceptable solutions, including relations between the parameters of the solutions and performance criteria of the solutions found.

• Multi-criteria evaluation or alternatives clustering based on input preferences.

• Search for feasible solutions by the chosen method of optimization.

• Data export and import.

When you configure the module in the extension point, one can specify any subset of alternatives and criteria it will be used for.

5. DSS "Cosmos" architecture

The system is based on integration of internal and external resources. External resources are dedicated to the work of external users, whereas internal resources provide the necessary information, analytical and system software.

Figure 1 shows the functional diagram of the DSS "Cosmos" created on the basis of the above principles. The program is implemented in a three-tier architecture. Server database MS SQL Server, an intermediate level - MS Internet Information Server, thin client - Mozilla Firefox. Development was carried out with the use of languages C#, TSQL, JavaScript.

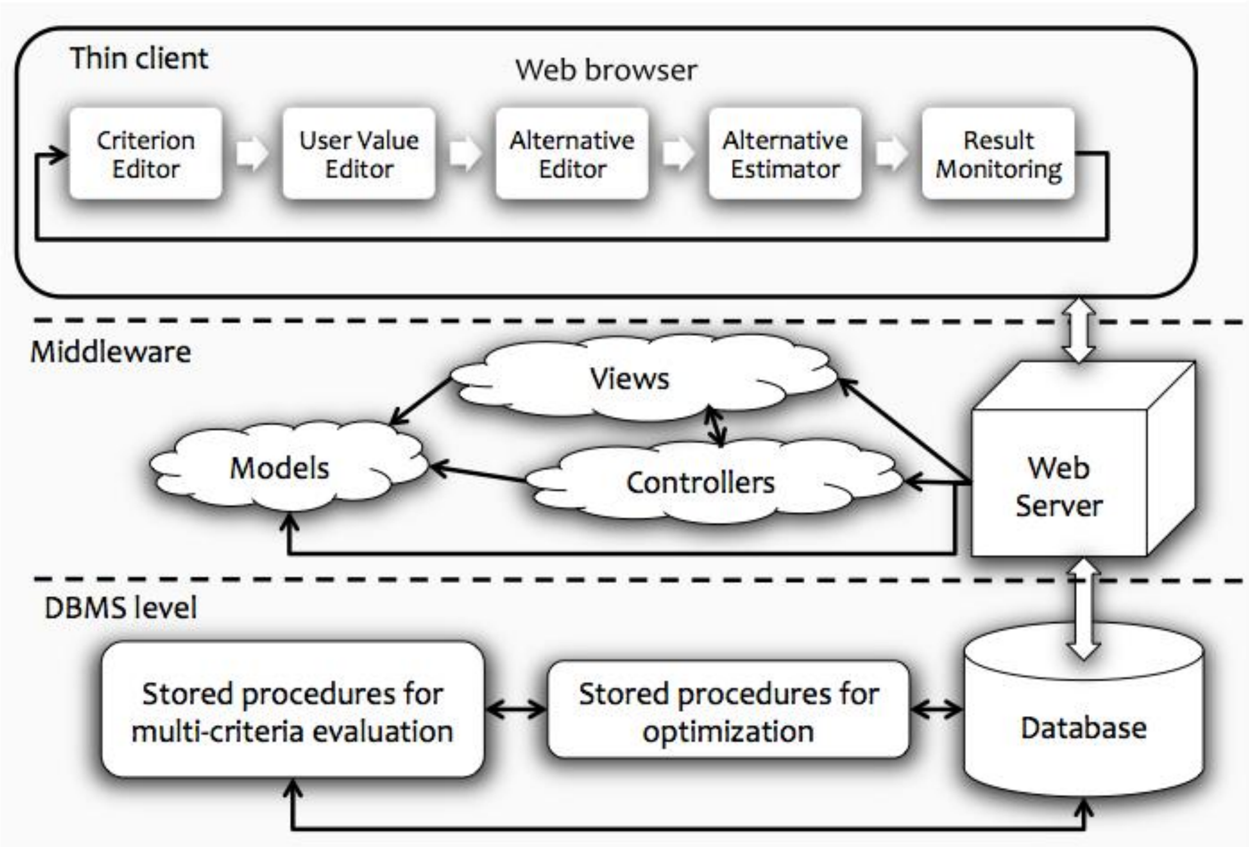


Figure 1: The structure of the DSS “Cosmos” software

Software development is based on the principles of openness to new methods of convolution vector criterion and new methods of optimization. All the sources are placed in the open repository http://code.google.com/p/microgravity/source/browse/.

The database structure is designed so that the system could be configured to meet the challenges of different domains within a common information environment. This ensures uniformity in developing property and DSS use invariance with respect to the subject area.

The following briefly describes the services provided by the system.

6. Ranking of space experiments on the results of examinations

All of the information handled by the system is divided into separate independent tasks. The problem is associated with criteria tree, alternatives and expertises, etc. Besides, access rights are delimited by tasks. Working with a task should start with the input of a vector criterion. Figure 2 shows a portion of the tree of criteria (in Russian) for evaluation of a space experiment in the DSS "Cosmos". The criteria tree can be linked only to one task. Only one criteria tree complies with a task.

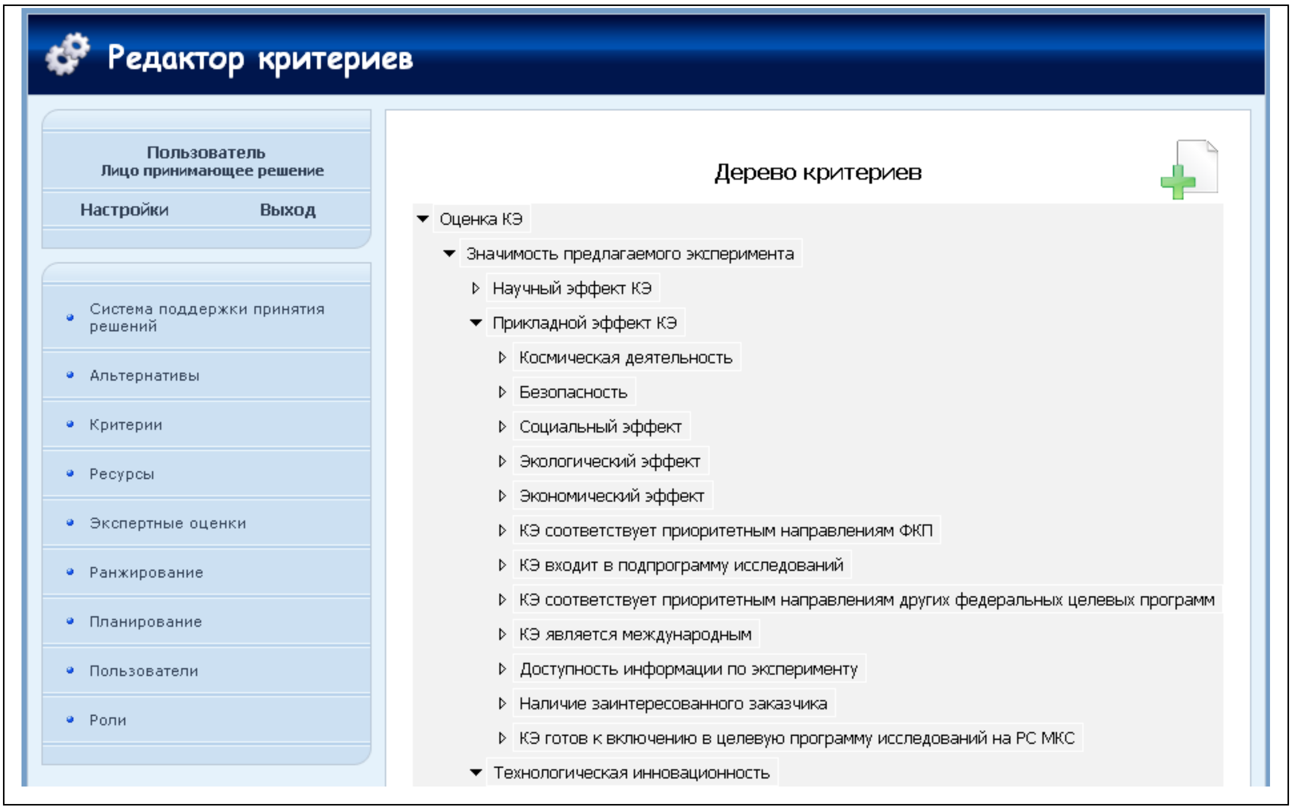
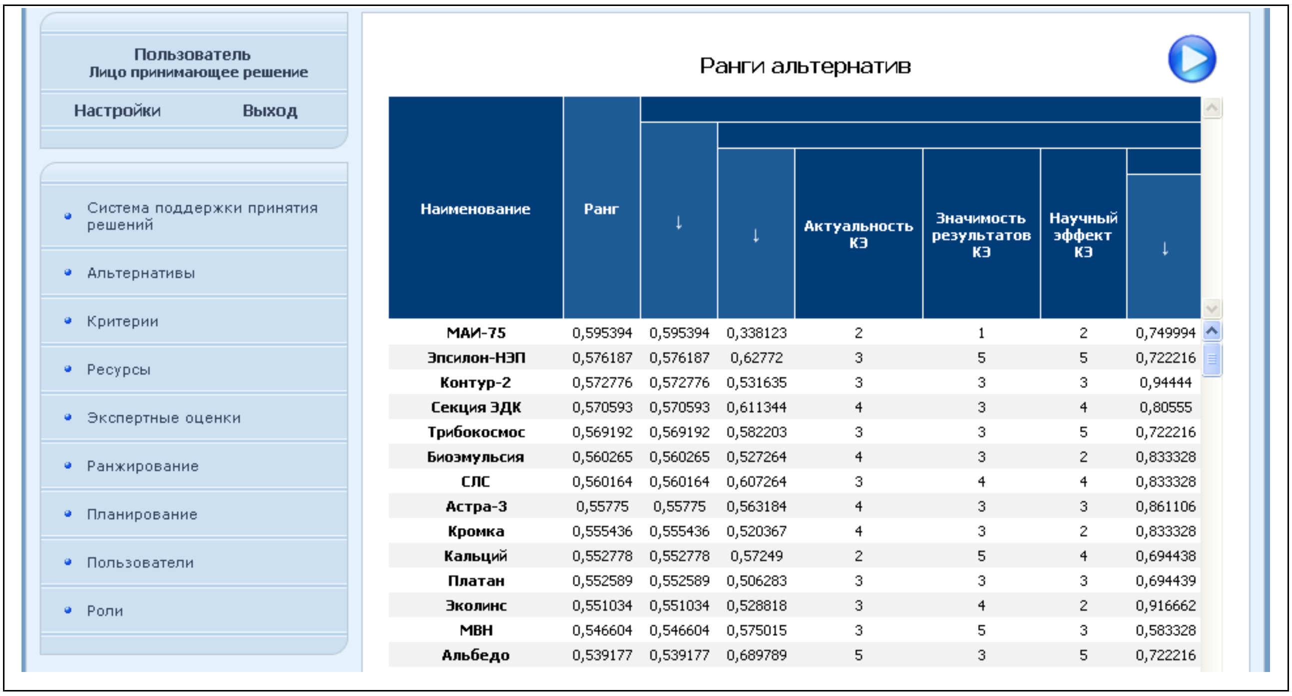


Figure 2: Tree fragment of criteria tree (in Russian) for evaluating SE

For each of vector criterion convolution methods there is a set of parameters describing user`s system of preferences. For example, you can specify to what degree one criterion is more important than the other. And so on for all the combinations of the two criteria. Then before SE ranking experts have to put down their estimates for each of the primary criteria. The values could be selected from the drop-down list.

The ranking procedure itself takes place in the window shown in Figure 3 (in Russian). The digits in left column *Rank* show the corresponding values. The columns marked with the arrows pointing down show the aggregated indexes, calculated over a group of other indicators (their children) to the right of the arrows.



Наименование	Ранг	↓	↓	Актуальность КЭ	Значимость результатов КЭ	Научный эффект КЭ	↓
МАИ-75	0,595394	0,595394	0,338123	2	1	2	0,749994
Эпсилон-НЭП	0,576187	0,576187	0,62772	3	5	5	0,722216
Контур-2	0,572776	0,572776	0,531635	3	3	3	0,94444
Секция ЭДК	0,570593	0,570593	0,611344	4	3	4	0,80555
Трибокосмос	0,569192	0,569192	0,582203	3	3	5	0,722216
Биоэмульсия	0,560265	0,560265	0,527264	4	3	2	0,833328
СЛС	0,560164	0,560164	0,607264	3	4	4	0,833328
Астра-3	0,55775	0,55775	0,563184	4	3	3	0,861106
Кромка	0,555436	0,555436	0,520367	4	3	2	0,833328
Кальций	0,552778	0,552778	0,57249	2	5	4	0,694438
Платан	0,552589	0,552589	0,506283	3	3	3	0,694439
Эколинс	0,551034	0,551034	0,528818	3	4	2	0,916662
МВН	0,546604	0,546604	0,575015	3	5	3	0,583328
Альбедо	0,539177	0,539177	0,689789	5	3	5	0,722216

Figure 3: SE Ranking (in Russian)

7. Assemblage of a research and experimentation program within DSS "Cosmos"

Generalized assessments of SE allow to move to the next phase of work with the system which is drawing up medium-term program of scientific and applied research and experiments on the Russian segment of the ISS (the so-called milestone program). The initial data for the problem are resource constraints and the SE list obtained by processing the expert estimates ranked by the value of the generalized assessment.

Each SE is characterized by a coefficient of utility (equivalent to a generalized assessment in Rank column of Figure 3), duration and resources necessary to carry it out as a different kind of storable and non-storable type. The continuity condition of SE acts (if begun, it is not interrupted before its full completion). To carry out some SE conditions of the processing sequence are set (for example, the experiment *j* can only start after the end of experiments *k* and *l*).

The entire planning period is broken down into discrete components (e.g. days). On board the ISS there is the necessary set of resources of both types. The magnitudes of non-storable resources are taken, which do not change vs. days. The set of storable resources to be spent on the implementation of a selected SE for some period of replenishment is expressed in predetermined time units (e.g., days). The intensity of the stored resources consumption is assumed to be uniform for the entire duration of the experiment. After the end of the next replenishment interval stackable unspent resources are restored to a predetermined fixed value. **Table 2** shows examples of contingent resources the system deals with.

Table 2: Resource of SE

Number	Resource Name	Volume	Period	Resource Type	Discretion
1	Upload mass of cargo (kg)	1000	365	storable	continuous
2	Download mass of cargo (kg)	100	365	storable	continuous
3	Upload volume of cargo (m3)	10	365	storable	continuous
4	Download volume (m3)	1.2	365	storable	continuous

Number	Resource Name	Volume	Period	Resource Type	Discretion
5	Electric Power (kWh)	1200	365	storable	continuous
6	Peak power (kW)	300		non-storable	discrete
7	Seats inside	7		non-storable	discrete
8	Seats outside	5		non-storable	discrete
9	Crew time quota	8	1	storable	discrete
10	The amount of information through communication channels reception (MB)	5	1	storable	discrete
11	The amount of information on the transmission channels (MB)	10	1	storable	discrete

Drafted plan shall satisfy all the resource constraints and be optimized for vector criterion, comprising the following components:

1) The maximum of the total generalized assessment included in the plan of experiments.

2) The minimum of the average start time of the experiments.

3) The minimum of consumption of some of ISS resources.

This scheduling task belongs to a class of multi-objective discrete nonlinear combinatorial programming. The most appropriate method of solving this problem is the implicit enumeration method, based on the local search strategy [5]. This method, although it does not guarantee finding the exact optimal solution, as the experience of its use shows, allows to find suboptimal solutions at an acceptable computational cost. The advantage of this method is its ability to leverage heuristics taking into account the properties of the problem while finding feasible solutions in the certain area around the point. Furthermore, there is an opportunity of using a random mechanism for implementation of the necessary degree of diversity in the initial formation of acceptable solutions, which increases the probability for optimum yield or closer thereto solutions. The resulting suboptimal schedule of the program of experiments in the DSS "Cosmos" can be presented in a Gantt chart. **Figure 4** shows a portion of the initial feasible plan. However, some experiments may not be included in the schedule because ISS resources lacking for all experiments at the specified time period.

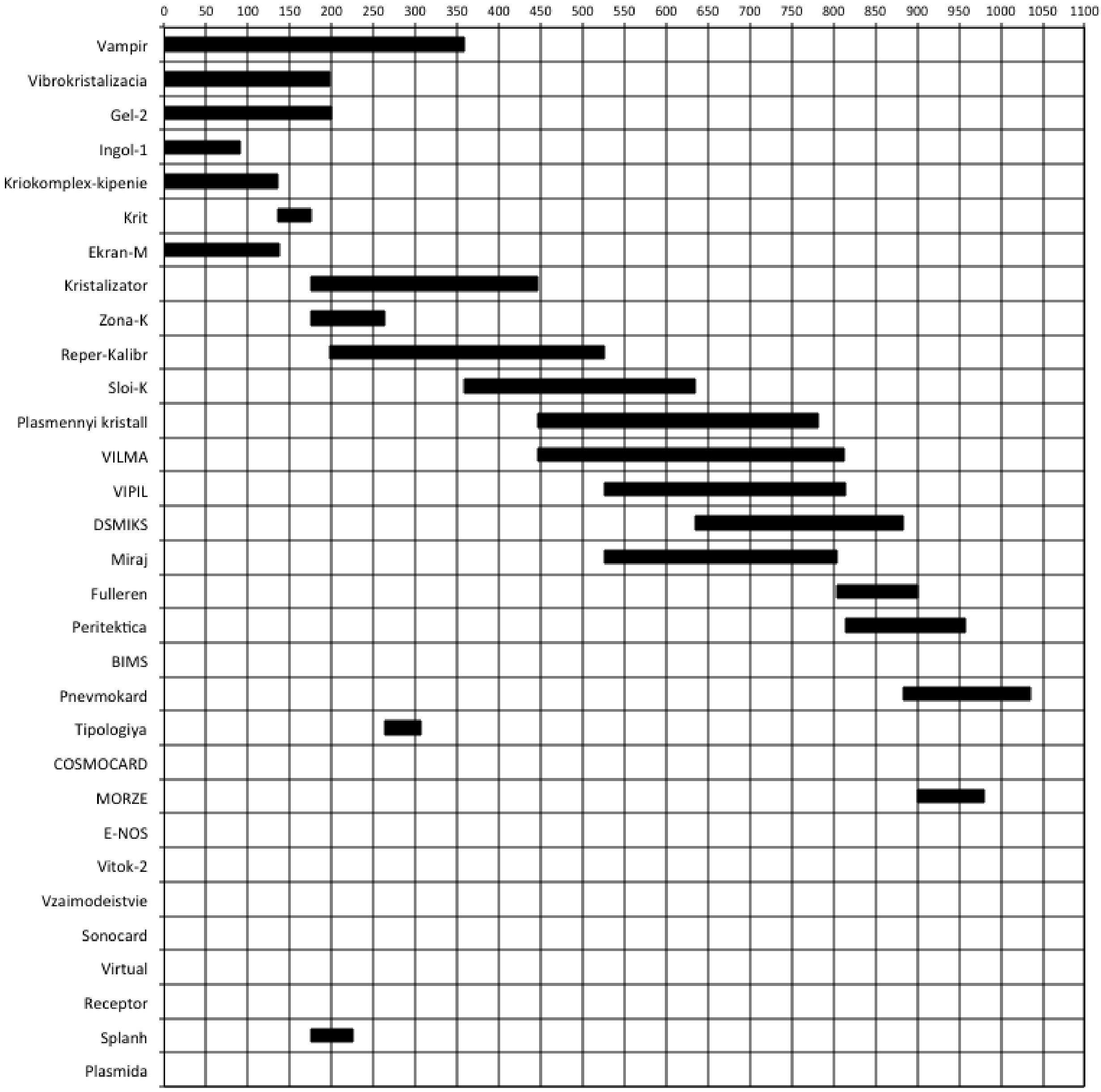


Figure 7: An example of an initial feasible plan

8. Conclusions

In the framework of the created DSS "Cosmos" it was successfully implemented the following:

• effective procedures for entering applications for experiments;

• mechanisms for remote operation of experts involved in the examination of the application documents;

• analytical processing of the results of examinations in the form of ranked lists of SE;

• an original approach to the problem of SE planning based on local search strategy.

The authors hope that the project DSS "Cosmos" will be a dynamically developing system. With use of internet technologies it will be developed a distant expertise, performed via remote access to the information resources of the database containing results of SE. It can serve as a platform for the publication of relevant information for general use by members of the expert community. It is planned to develop a system for the analysis of publications on the results of the SE on board the ISS, analysis and optimization of various programs and projects for further exploration of outer space, as well as for selection, performance analysis and ranking of experts themselves in each subject area.

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