

DOI: <http://dx.doi.org/10.34069/AI/2020.28.04.46>

Methodology based on coordinate mode principle for interfacing of management systems in case of complex organizational and economic separations

Методология сопряжения управляющих систем для случая сложных организационно-экономических обособлений на базе принципа координируемости

Received: January 23, 2020

Accepted: March 25, 2020

Written by:

Oleg N. Dmitriev¹⁷⁸<https://orcid.org/0000-0003-4514-7519>elibrary.ru: https://elibrary.ru/author_profile.asp?id=3295<https://www.scopus.com/authid/detail.uri?origin=AuthorProfile&authorId=57202382529&zone=>

Abstract

The problem of interface of managing systems in relation to organizational and economic objects-economic entities of legal relations functioning in modern conditions is considered. It is shown that in this conjugation there can be situations with one-level and poly-level organizational separations from sets of different subject dimensions. However, in all cases of coupling, management innovations must be introduced to support the harmonization of interfaced managing systems in a number of aspects. Conceptual versions of interface of managing systems are considered. It is proved that in any case, a certain integration managing super-system is subject to introduction. The methodological expediency of applying the principle of co-ordination to ensure appropriate polysubject self-government with access to the specific typology of optimization problems of integrated managerial decisions is substantiated. The issue of accounting for different levels of intelligence of interfaced managing systems is discussed.

Keywords: coordinate mode principle, coordination, hierarchical management system, interface of managing systems, organizational and economic separation.

Аннотация

Рассмотрена проблема сопряжения управляющих систем применительно к организационно-экономическим объектам – хозяйствующим субъектам правоотношений, функционирующим в современных условиях. Показано, что при этом сопряжении могут существовать как ситуации с одноуровневыми, так и с неоднородными организационными обособлениями из множеств различной субъектной размерности. Однако во всех случаях сопряжения подлежат привнесению управленческие инновации, позволяющие поддержать гармонизацию стыкуемых управляющих систем в ряде аспектов. Рассмотрены концептуальные версии сопряжения управляющих систем. Доказано, что в любом случае подлежит введению некоторая интеграционная управляющая надсистема. Обоснована методологическая целесообразность применения принципа координируемости для обеспечения соответствующего полисубъектного самоуправления с выходом на видовую типологию задач оптимизации интегрированных управленческих решений. Обсуждён вопрос учёта различности уровней интеллектуальности сопрягаемых управляющих систем.

Ключевые слова: иерархическая система управления, координация, организационно-экономическое обособление, принцип координируемости, сопряжение управляющих систем.

¹⁷⁸ Full-doctor in Economics, Professor, Moscow Aviation Institute (National Research University), Moscow, Russia.

Introduction

Now, there is a fairly strong institutional transformation of national economies, their sectoral, regional and smaller components. This also applies to Russia. As a result, there are a sufficiently large number of organizational, economic, institutional or institutionalized separations (Bodrunov et al, 2000; Bodrunov, Dmitriev & Koval'kov, 2002; Demchenko, Dmitriev & Minaev, 2011; Demchenko, 2011). However, they turned out (Dmitriev, 2017a; Dmitriev, 2017b), firstly, to be managerially poorly developed individually, and, secondly, practically not interconnected horizontally or vertically. It was also typical for pseudo-corporate groupings (Mal'ko, 2008; Zuyev, 2014; Dmitriev and Novikov, 2017; Dmitriev and Novikov, 2019a). Therefore, the complex and multidimensional problematic task of the total increase in the level of intelligence of management systems and at the same time their interfacing is very relevant. The components of this task cannot be productively solved as isolated. The indicated pairing should have the correct methodological base, because otherwise one can only expect a late, unlikely and extremely insignificant positive result.

Methodology

Structural interpretation of universal management methodology was presented (Dmitriev and Novikov, 2019b). Design of institutional systems allows interpretation as a local version of management. The results of the study presented below are typical for research aimed at developing the methodological basis. Most likely, there is a right to exist the statement that the development of one of the special methods of performing operations research is considered below.

Accordingly, the methodological basis of the study was as follows:

- system analysis;
- general control (management) theory;
- theory of hierarchical systems;
- optimization theory;
- decision making theory;
- information theory, etc.

Results

Portability assessment of previous studies

Developments in the application of the classical theory of hierarchical systems are conducting for

a long time (Mesarović, Macko, & Takahara, 1970; Mesarović, Macko, & Takahara, 1973).

There are relatively few publications on this topic (Ivanov, 2017; Gimatova, 2003; Oskorbin, Dubina, & Zharikov, 2009; Popovich, 2011; Tsygichko and Popovich, 2012; Veselov, 2006). So, as for the books and monographs, there are only a few works, which began to appear, if the funds of the Russian State Library are recognized as indicative, from the mid-2000s. For organizational structures, we should mention the publications of Bazadze, 2002; Demchenko, 2011.

In foreign fundamental publications, there are the problems of analysis and synthesis of hierarchical systems, however, these problems are mainly presented as indirect.

The author's research in this direction was focused on optimizing the supply of complex technical products, taking into account the interests of a group of entities involved in the life cycle of the fleet (Dmitriev, 2002) and in the preparation of some project proposals for a number of innovative federal targeted programs and projects (Dmitriev and Novikov, 2018a; Dmitriev and Novikov, 2018b). Such developments were also actively used in the formation of the so-called system projects for the corporatization of high-tech enterprises in Russia. (Dmitriev, 2017a; Dmitriev et al, 2013; Dmitriev, 2018).

However, well-known developments extended to horizontal conjugation of managing systems, which, of course, does not allow stating the existence of an exhaustive solution to the problem.

Along with the above-mentioned, a direct author's study was carried out on fundamental methodological issues of analysis and synthesis of mesomicro-level management systems, performed at Moscow Aviation Institute (National Research University) in the first half of the 2000s. Accordingly, the results of these studies were taken into account in the formation of the material described below.

Interface versions of management and managing systems

When considering the problems of interfacing management systems, it is customary to limit oneself to interfacing managing systems, because

interfacing of subjects as a whole in practice is not so common or, in any case, allows separation of managing systems from interfacing.

Very important problem of management efficiency provision is the coordination of functioning of management systems, in case at least one of them influences the other. As a rule, it results in necessity to coordinate management of various subjects by one object of management or to coordinate management in a hierarchical management system. The last case is the most complicated.

It is possible to allocate three following versions schemes of such management systems.

Rigid management sets for subordinate and conjugated systems all indexes of state and managerial decisions (under the list and under the contents) numerical values. The low-priority management systems (for example, management systems of the lower level) execute only functions of realization of the management actions given from the outside, the account and monitoring of these actions, and also of the reached parameters. Such scheme, realizing principles of a so-called administrative-command method, has a number of serious defects. Actually, it can provide efficient management only in the case that, at least, for managing system of the upper level the observability of the object of management will be the same, as for managing system of the lower level. As it is, most likely, unattainable because of backwardness of information infrastructure and low probability of realization of deep decomposed model of object of management, the rather approximate decisions will be accepted, that is in the end incompetent, low efficiency or even irrational. Besides all integrated management systems are influenced by significant number of revolting factors. Managing system of the upper level is obviously unable to trace and compensate or neutralize them, in this connection managing system of the lower level has to secretly conduct the non-authorized actions or to forge indexes of state, or to show deviations on them.

The saved administrative resources, as a rule, are withdrawn by managing system of the upper level or their distribution is completely defined by the highest priority integrated management systems. However, the most serious defect of rigid management is ignoring of optimization criteria of some managing systems, in particular, management systems of the lower level, and consequently, holding back of initiatives and

generally objectively originating conflicts between the goals of subjects of management of various levels. At the same time at severe limitations on resources, small number and backwardness of industrial objects or in extreme conditions when criteria of one part managing systems (for example, managing system of the upper level) have an absolute priority or coincide with criteria of other managing systems, rigid management, at least on all indexes of state, is the only possible scheme.

Localized (or autonomous) management is an antipode of the first scheme and provides delegating of all typical functions of management to the lower level or to each of local management systems. Managing system of the upper level (if it is present) realizes only global assign of a purpose: assigning of composition of indexes of state (and, probably, criterion of efficiency) and assignment of some limitations on managerial decisions (for example, regarding the sources of finance, allowable seller's markets of the certain kinds of production, on quality of production, etc.). A typical example of the scheme of the localized management is non-monopoly production in conditions of the free market. As a rule, such idealized scheme may exist only during short time and only at surplus of resources and also at advancing demand for made production or granted services. Since the moment of saturation of the market, origination of connections or appearance of deficiency of resources, there is a necessity of the coordination of managerial decisions and some indexes of state between developers, suppliers and consumers, maybe even indirectly through competitive relations.

The coordinated management is guided by regulation of managerial decisions and indexes of state, significant only from the point of view of all system of objects of management, for example, national economy. Such regulation may be executed by management actions with the help of acts, normative and technical documents, and by economic measures by the way of different sort of agreements. It is necessary to note that in limiting variants the scheme of the coordinated management includes schemes of the rigid and localized management.

At the coordinated management may coexist conjugated management systems even with greatly distinguishing optimization criteria (or criteria of efficiency). At that all integrated management systems are aimed at reaching of the priority, global purposes, and for them more favorable conditions of functioning as the part of

their vital inputs and/or outputs is provided by powerful endorsements and means of a management system of the upper level, leveling difficulties will be realized. In many cases the role of managing system of the upper level as an organ of assign of a purpose and provision of resources predominates, but criteria of efficiency of managing system of the lower level are taken into account to the full. The degree of a regulation of managerial decisions and indexes of state depends on national importance of eventual results.

There are three kinds of integration distinguished: through, horizontal and vertical. For all these types of integration, we can apply the well-known principle of coordination, which will be implemented as follows.

Through integration, as a rule, is reduced to an integration of several subsystems of one managing system or their functional blocks closed on management by one of subobjects of management (**Figure 1**). In the theory of automatic control the considered case has analog, it is the connected regulation.

It is necessary to distinguish the following situations:

- integrated managing systems have uniform criterion of efficiency K (for example if we consider it as a net profit of the enterprise for its various participants);
- criteria of managing subsystems K_1 and K_2 do not coincide and may be antagonistic.

At uniform criterion K the managerial decision of a kind (it is considered, that the index of state I and managerial decision U are vectors, and

limitations on realization are maintained) will be realized:

$$K(I_1, I_2) \rightarrow \underset{U_i}{extr}; i \in [1,2]$$

Features of management consist in the fact that there exist the next processors (as operators):

$$Processor O_{12} : U_1 \rightarrow I_2 ;$$

$$Processor O_{21} : U_2 \rightarrow I_1$$

and consequently there is a notorious recursiveness:

$$U_1^{opt_1} = \underset{U_1}{arg \ extr} K\{I_1, I_2(U_1^{opt_2})\};$$

$$U_2^{opt_2} = \underset{U_2}{arg \ extr} K\{I_1(U_2^{opt_1}), I_2\},$$

As optimum decision $U_1^{opt_1}$ depends from $U_2^{opt_2}$ and vice versa.

Except for notorious non-optimality of such decision $\{U_1^{opt_1}, U_2^{opt_2}\}$ in general case mutual information interchange between D_1 and D_2 is generally required about is artificially localized subobjects of managements and managerial decisions accepted in their concern. Rationality of finally combined managerial decision essentially depends on a sequence of its development, and also of a priori, hence, ineffective distribution of the limited administrative resources between managing subsystems. If information flows D_1 and D_2 will be distorted or will appear uncertain, even application of a powerful mathematical means for decision of indeterminacies will not allow correcting the situation.

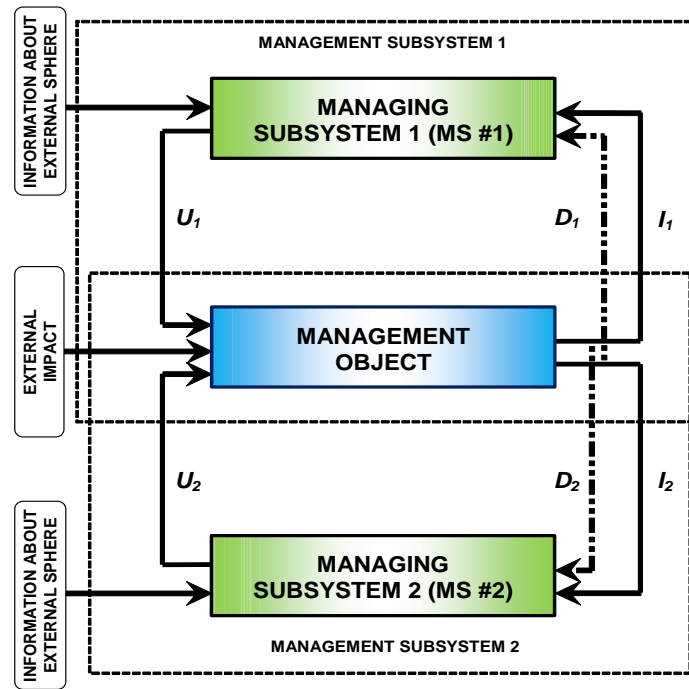


Figure 1. The scheme of subsystems coupling at through integration (hypotetic example)

The unique output implying from a principle of coordination, - merging of managing subsystems, at that their association only regarding preparation of managerial decisions is sufficient:

$$\begin{aligned} \{U_1^{opt}, U_2^{opt}\} &= \\ &= \arg \text{extr } K \{I_1(U_1, U_2), I_2(U_1, U_2)\}. \\ &\quad \{U_1, U_2\} \end{aligned}$$

Besides, the elements appropriate to an estimation of current state of object of management, may be (or remain) decomposed.

If there are criteria K_1 and K_2 , the preparation of a managerial decision is better to be centralized, using the methods of scalarization of optimization criterion, to proceed from a task of vectoral optimization to a task of scalar optimization.

Horizontal integration also may have varieties (**Figure 2**).

If there is uniform criterion of optimization it should be reduced to the scheme of rigid management. Practical acknowledgement of this thesis is frequently observed in real life: only the uniform managing system is capable to provide

an optimal decision of a general and unique industrial task within the framework of which in subobjects the interconnected processes take place, even if the given subobjects are only technologically sequential.

Let us consider a situation when integrated management systems have independent criteria $K_1(I_1)$ and $K_2(I_2)$. Despite of this independence, the subobjects are connected by subsets of indexes of state I_1 and I_2 and I_1^* and I_2^* accordingly. The case is possible, when, for example, I_2^* directly sets parameters of $K_1(I_1)$. Criteria K_1 and K_2 , as a rule, are inconsistent (for example if they represent profit of the supplier and profit of the consumer of production). Experience of an exit from such situation at a decision of an individual task of optimization of the plan of acceptance tests or selective monitoring by criteria of average risk of the manufacturer and the customer is known, but only by superposition of limitations on probability of an error of the first or second sort or application of sequential strategy under the rule (traditionally named criterion) of A. Wald or other rules of stop, that is, at a simple kind of decisions and their trivial connection with criteria of optimization.

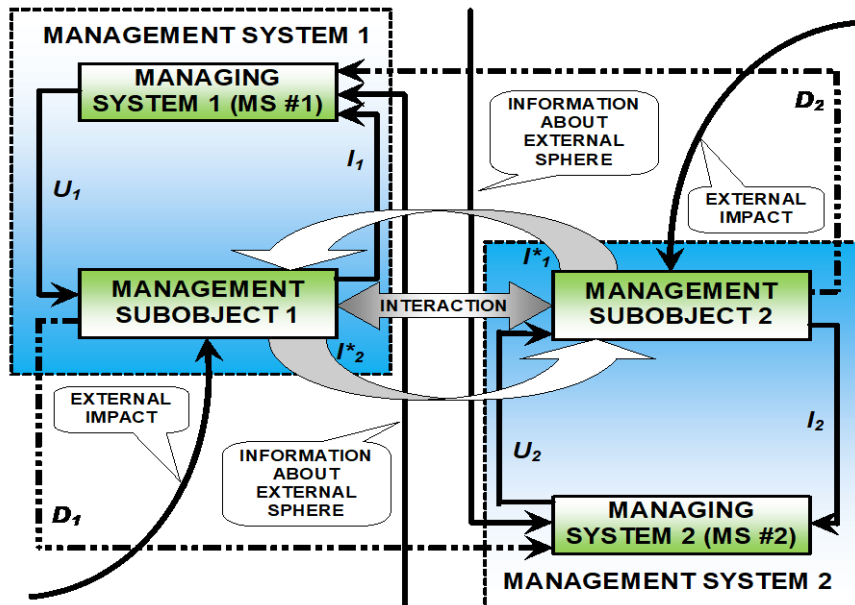


Figure 2. The scheme of subsystems coupling at horizontal integration (hypotetic example)

The important feature of horizontal integration with nonidentical criteria K_1 and K_2 is the fact that, as a rule, there are the managerial decisions U_1 which improve values K_1 and not worsening values K_2 and also U_2 , improving values K_2 and not worsening values K_1 .

If the managerial decision is inconsistently influencing K_1 and K_2 , it is necessary to aggregate these criteria. In organizational aspect it means determination of the compromise decision on elimination of dissents as the first Managing System (MS) – MS#1 and the second MS – MS#2 may not exist without each other.

Individual managerial decisions U^*_1 and U^*_2 , representing subsets accordingly U_1 and U_2 , so, $K_2 \neq K_2 (U^*_1)$; $K_1 \neq K_1 (U^*_2)$ may be as at autonomous management from a condition:

$$U^{opt*}_i = \arg \text{extr } K_i(U^*_i); i \in [1,2]. \\ \{U^*_i\}$$

However the compromise managerial decisions that are even fixed in the form of the agreement should not be considered in a rank of absolute. Really, at contractual delinquency it is necessary to apply sanctions concerning a contractor - monopolist (but only in the limits excluding its liquidation, for example, bankruptcy) and also to prevent its nonsensitivity to privileges and sanctions. Otherwise in practice it may mean self-liquidation. Therefore at elimination of dissents it is necessary to go on the compromise,

providing obviously smaller priority for the infringer and equal possibilities of monitoring over management subobjects.

For the substantiation of compromise managerial decisions there should exist isolated (for example, intermediary or implanted in one or several managing systems) centers of preparation of decisions. It is impossible to exclude a situation when both managing systems will be guided to opposing-parallel work or will agree on the certain specialization.

If there are alternatives of managing systems {MS#1Variant#1, MS#1Variant#2, ...} and/or {MS#2Variant#1, MS#2Variant#2, ...}, and correspondingly, consenting management system 1Variant#1, 1Variant#2, etc. and/or management system 2Variant#1, 2Variant#2, etc. then horizontal integration means also decision making about a choice of the preferable contractor.

In all cases it assumes mutual information interchange about the factors influencing criteria of efficiency.

From the considered procedure of horizontal integration may be seen artificial character and, moreover, adverse effect of planning of increase of manufacture volume separated both from demand, and from available resources of management, and objective character of tendency of origination and balance of

development of interactive (collaborative) objects even if it is not stimulated specially from the outside.

Vertical integration – is the most complicated. At that, it is considered, that there is criterion of optimization (efficiency) of managing system of the upper level K and criteria of two managing systems of lower level $K_{Low,1}$ and $K_{Low,2}$ (Figure 3). Criteria $K_{Low,1}$ and $K_{Low,2}$ inconsistent and insufficiently representative for managing system of the upper level, as otherwise its

existence is not necessary and horizontal integration of managing system of the lower level is sufficient, short of functions of the creditor which bank organization may perform. If we present managing system of the upper level as an organ of management by the way a source of resources, it is necessary to proceed to rigid management, as its resources may be formed only at the expense of alienation of newly created resources of low level management system: for example, deductions from their profits.

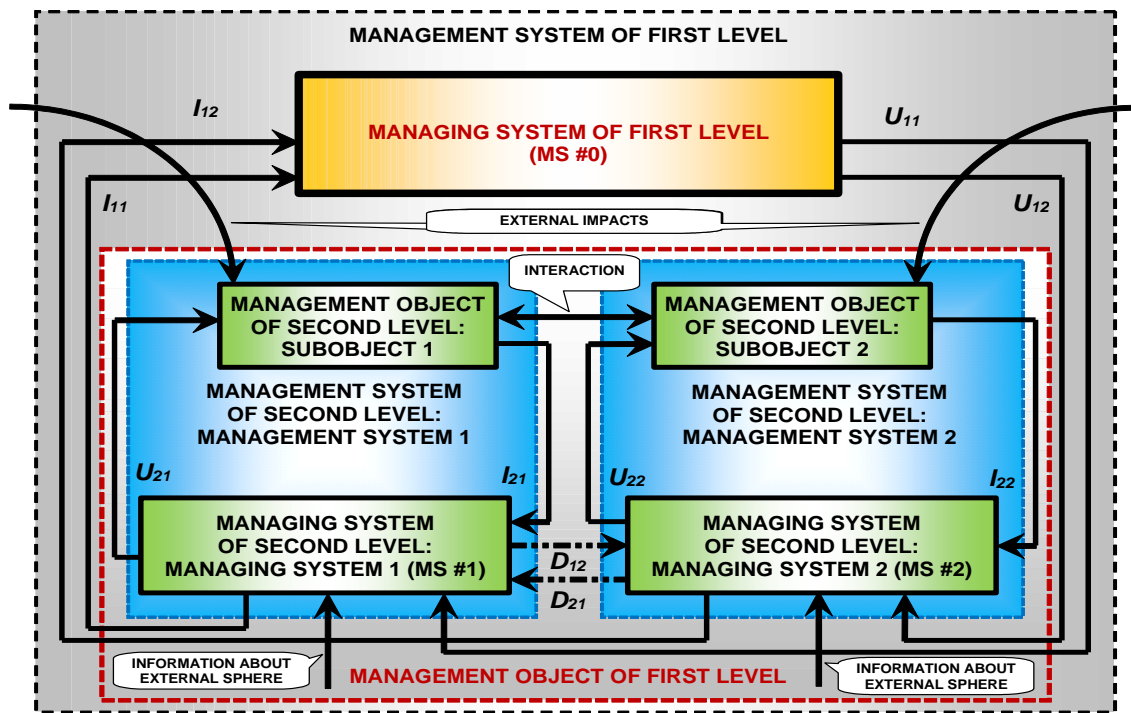


Figure 3. The scheme of subsystems coupling at vertical integration (hypotetic example)

Vertical integration consists in the fact that managing systems MS#1 and MS#2 of the lower level set modified criteria of optimization $K_{Modif,1}(K_{Low,1})$ and $K_{Modif,2}(K_{Low,2})$, and also managements U^{opt}_{12} and U^{opt}_{11} will be realized as follows:

$$U^{opt}_{2i} = \arg \text{extr } K_{Modif,i} (K_{Low,i});$$

$$i \in [1,2]; U_{2i}$$

$$K_{Low,i} [I_{2i} (U^{opt}_{2i}, U^{opt}_{1i})] \text{ not worse } K^{ass}_{Low,i};$$

$$i \in [1,2];$$

$$\{U^{opt}_{11}, U^{opt}_{12}\} = \arg \text{extr } K(U^{opt}_{21}, U^{opt}_{22}),$$

$$\{U_{11}, U_{12}\}$$

where $K^{all}_{Low,1}$, $K^{all}_{Low,2}$ are the allowable values accordingly to criteria $K_{Low,1}$, $K_{Low,2}$.

As the issue of existence of such decision is very complicated, there may be found types of rational values $K^{Rat}_{Modif,1}$, $K^{Rat}_{Modif,2}$, and also U^{Rat}_{21} , U^{Rat}_{22} , U^{Rat}_{12} and U^{Rat}_{11} as follows:

$$K_{Low,i} [I_{2i} (U^{Rat}_{2i}, U^{Rat}_{1i})] \text{ not worse } K^{all}_{Low,i};$$

$$i \in [1,2];$$

$$K_{Upp} (K_{Modif,i}, U^{Rat}_{ji}); i, j \in [1,2] \text{ not worse } K^{all}_{Upp},$$

where K^{all}_{Upp} are the allowable values of criterion K_{Upp} .

From the indicated ratios it is visible, that vertical integration is practically reduced to multicriteria optimizational management task and to determination of area of unimprovable managerial decisions. Depending on superimposed limitations the management task may have a decision either empty, or unique (which is improbable), or by the way of sets of admissible alternatives. Basic difference of the given task from known multicriteria prototypes is the necessity of internal generation of additional rational criteria.

In that specific case, when criteria $K_{Low,1}$, $K_{Low,2}$, K_{Upp} are identical, vertical integration is resulted to in essence more simple version is the optimum resource distribution within the framework of rigid management in compliance with a number of indexes of state of management subobjects, but, probably, not on all.

To exclude compulsion of knowledge of connections $I_{2i}=I_{2i}(U_{2i})$; $i \in [1,2]$ for a system of the upper level, it is necessary to have counter generation and an exchange of information about alternative managerial decisions between managing systems of various levels.

The principle of coordination, as it was already mentioned, is suitable at various priority of managing system criteria of the upper hierarchical level over managing systems criteria of the lower hierarchical level.

Experience in applying development results

The results of interfacing designs for high technology enterprises have proved successful through test and adoption on a large scale and throughout long periods.

In particular, they were used for the following:

- for the design of the cross-industry (the aircraft industry of the USSR – the civil aviation of the USSR) automated system for the collection and exchange of data about the status of aviation inventory ordered and supplied to enterprises of the above two industries, adopted in 1984;
- when doing a work package to design long-term and middle-term projects for supplies of all types aircraft engines and expensive components to maintain the normal operation of the aircraft fleet of the civil aviation of the USSR between 1984 and 1996 with regard to the collection of data as

to the status of aircraft and their components;

- for the design of corporation projects for a number of aircraft industry enterprises and enterprises of some other high technology complexes and industries in Russia between 1996 and 2002 to find out their actual status.

Conclusion

Based on the results of the study, it seems reasonable to make the following conclusions:

- institutional, organizational and economic design and redesign of separation complexes should be based on the application of the apparatus of the theory of hierarchical systems, including modifications of the coordinate mode principle;
- it is advisable to use a scheme of vertical integration of management systems, which provides for the introduction of the first super-system for coordinated management and managing ones;
- when interfacing management systems, it is advisable to focus on systems of the same level of development (for example, interfacing information-advising with each other).

References

- Bazadze, N. G. (2002). *System-technical Methodology of Organizational Design of Management Potential of High-tech Production on Example of Moscow and Moscow Region: Dissertation for the degree of doctor of economics*. Moscow.
- Bodrunov, S. D., Dmitriev, O. N., & Koval'kov, Ju. A. (2002). *Aviation Industry of Russia at Beginning on Boundary of 21st Century: Efficient Management Problems: Part 1st and Part 2nd/ Monograph*. Saint-Petersburg, Russia: Aerospace Equipment Corporation Publishing House.
- Bodrunov, S. D., Dmitriev, O. N., Koval'kov, Ju. A., Manturov, D. V., & Fedorova, O. N. (2000). *Problems, Principles and Methods of Corporatization of Aviation-industrial Complex of Russia*. Saint-Petersburg: Corporation "Aerospace equipment" and Publisher House "Petrovsky and Co".
- Demchenko, O. F. (2011). *Methodology for Mathematics Modelling of Organization Structures of Russian Aviation Industrial Complex*. Moscow: KnoRus.
- Demchenko, O. F., Dmitriev, O. N., & Minaev, E. S. (2011). *Methodology of Identification of Organizational Structures in*

- Aviation-industrial Complex*. Moscow: MAI-PRINT.
- Dmitriev, O. N. (2002). *Intellectual Information Technology of Feasibility Report of Marketing Decisions*. Moscow: Gnom and D.
- Dmitriev, O. N. (2017a). Estimation of Corporatization Expediency of Russian Enterprises in Modern Conditions and Choice of Preferable Organizational-economic Scheme of Corporatization. *Microeconomics*, 5, 22-28.
- Dmitriev, O. N. (2017b). Strategic Problems and Directions of Developing Rehabilitation of Managing Systems of Russian High-tech Complexes. *Microeconomics*, 6, 5-24.
- Dmitriev, O. N. (2018). Application of Principle of Coordinability to Management of Meso-level Organizational & Institutional Split-off's Separations. *Microeconomics*, 5, 37-45.
- Dmitriev, O. N., & Novikov, S. V. (2017). Conception of Managing of Fuzzy Institutional Meso-Level Organizational Separations in Context of Product Projects Internationalization. *European Research Studies Journal*, 20(4B), 3-30.
- Dmitriev, O. N., & Novikov, S. V. (2018a). Economic Assessment of Federal Scientific Programs. *Russian Engineering Research*, 38(4), 326-329.
- Dmitriev, O. N., & Novikov, S. V. (2018b). Concept of Management Interpretation and Aprioristic Convergence Estimation of Innovative Federal Intention Programs. *Innovations*, 4, 63-77.
- Dmitriev, O. N., & Novikov, S. V. (2019a). Unification and Convergence of Hierarchic Structures Such as Organizational Separations and Product Projects at Creation of Recommending Decision Support Systems. *International Journal of Economics and Business Administration*, 7(1), 240-268.
- Dmitriev, O. N., & Novikov, S. V. (2019b). Concept of Organization and Functioning of Integrated Electronic Infosphere of Reporting on R & D Works' Results. *Amazonia Investiga*, 8(21), 87-95.
- Dmitriev, O. N., Yekshembiev, S. Kh., Lubaeva, J. I., Koval'kov, Ju. A., & Minaev, E. S. (2013). *Strategic management concerning corporation (fundamental and applied problems)*. 2nd edition (revised and expanded). Moscow: Kind Word.
- Gimatova, E. E. (2003). *Game-theoretic and multi-criteria management methods in hierarchical production-type systems: Dissertation for the degree of PhD in physical and mathematical sciences*. Moscow.
- Ivanov, A. K. (2017). *Development and Application of Mathematical Models of Hierarchical ACS*. Monograph. Ulyanovsk: UISTU.
- Mal'ko, I. A. (2008). *Organizational Economic Mechanism of Managerial Interaction Between Russian Industrial Enterprise and Its Subsidiary Based Abroad: as Exemplified by a Ukrainian Subsidiary*. Published PhD dissertation in economics. Moscow: Moscow Aviation Institute.
- Mesarović, M. D., Macko, D., & Takahara, Y. (1970). *Theory of Hierarchical Multilevel Systems*. New York: Academic Press.
- Mesarović, M. D., Macko, D., & Takahara, Y. (1973). *Theory of Hierarchical Multilevel Systems*. Moscow: World.
- Oskorbin, N. M., Dubina, I. N., & Zharikov, A. V. (2009). *Problems of Matching Decisions in Hierarchical Systems*. Preprint. Barnaul: Publishing house of the Altai State University.
- Popovich, A. Yu. (2011). *Synthesis of Hierarchical Control Systems: Dissertation for the degree of PhD in technical sciences*. Moscow: Institute for Systems Analysis of Russian Academy of Sciences.
- Tsygichko, V. N., & Popovich, A. Yu. (2012). *Synthesis of Hierarchical Management Systems*. Moscow: URSS-KRASAND.
- Veselov, G. E. (2006). *Applied Theory and Methods of Synergetic Synthesis of Hierarchical Management Systems: Dissertation for the degree of doctor of technical sciences*. Taganrog.
- Zuyev, A. A. (2014). *Organizational Economic Mechanism of Organizational Reengineering of an Industrial Enterprise with Subsidiaries Based in Few Countries*. Published PhD dissertation in economics. Moscow: Moscow Aviation Institute.