Remarks on a Multidisciplinary System Approach Applied to the Socio-Econo-Techno Complexes as the Anticipatory Systems

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1. Abstract

This presentation is devoted to some methodological aspects. However, I know from my experience, that various system research is received reluctantly considering the lack of methodological interpretations. They are very broad problems and at the same time belong to many research branches. Each of these branches has got its own culture of activity. Therefore, specialists representing various research branches, will understand my views in various ways. Therefore, the author presents a suggestion to standardize the procedures and hopes it will be accepted.
The paper presents a certain methodological approach to the possibility of applying the General System Theory in the research on Socio-Econo-Techno Systems. Scientific and social needs of such approach have been discussed. The procedure used in research have been suggested.

2. Keywords

General System Theory, System, Mathematics, Synergistic Effect, Chaos.

3. Introduction

3.1. Confrontation of views

Different views concerning the topic of system research have been propagated. The notion of a system as an object existing in true reality is understood in various ways. There are many publications on the methods of solving problems called system problems. Some of these methods led to obtaining excellent results. Some of the known results have gained almost general approval. Yet, some significant problems which, as it seems, can be considered only by means of system methods still await solution. Therefore, further search is necessary.

The author allows himself to present a certain way of reasoning with no great theoretical aspirations. However, it is a set of methodological remarks of practical use when solving some problems.

Suggestions included in this paper are based on many years' research experience and practice. In spite of serious difficulties in obtaining access to foreign literature the suggestions are also based to a certain extent on world output on the notion of a system. The author should present at least some of the significant publications. It is necessary because views similar to the ones presented by the author have been published for the last few years.

The following publications make the author feel better while presenting his own views: W.E.Hutchinson, ***Making Systems Thinking Relevant*** and Mingers J.,Brocklesby J., ***Multimethodology: Towards a Framework For Critical Pluralism***, as well as Eric Schwartz' ***Control in Non-Artificial Systems. Where does it Come from***? and ***A Proposal for a Holistic Meta-Physical and Meta-Logical Metalanguage*** by the same author citing: Robert Rosen's ***Life Itself. A Comprehensive Inquiry to the Nature, Origin, and Fabrication of Life***.

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The following terms (definitions) of cybernetics suit the author's conception:

„A way of thinking" - (Ernst von Glasersfeld),

„Should one name one central concept, a first principle, of cybernetics, it would be circularity"- (Heinz von Foerster).

The author shares views based on the work of Ernst von Glaserfeld from 1984 entitled ***„Steps in the Construction of „others" and „reality"***. The opinions on „science as a system" expressed in the work of J.K.Klaassen ***„The Sociology of Scientific Knowledge and the Activity of Science; or, Science is a System, Too"*** citing Robert Rosen's ***„Anticipatory Systems. Philosophical,Mathematical and Methodological Foundations."*** The classification of methods presented in M.C.Jackson, P.Keys', ***Toward a System of Systems Methodologies*** should also be mentioned. The suggestion included in M.J.Sirgy, T.F.Mangleburg, 1988, ***Toward a General Theory of Social System Development: a Management/Marketing Perspective*** deserves attention.

3.2. Remarks of the Global Social Situation

One of the latest and most important tasks in world science nowadays is, according to the author, creating methodological bases for conducting global analysis of civilization development. Such necessity derives from the need to conduct a study of prognosis which may serve as the basis for pursuing research on strategic scenarios with a global range. There is a possiblility for reliable results of the analysis to become a premise in determining the strategies of companies dealing with economy on a global scale.

The globalization of markets, finance, competition and products causes the disappearance of frontiers. However, there is a danger. The danger lies in a growing conviction about the effectiveness and veracity of the economic analyses and prognoses. Although they are presently useful tools but it may be an impression at this stage of the global development of the world economy. It is worth noticing that marketing analyses is the main tool of effectiveness. However, this tool is very single-tracked. In addition, the analyses are based on the knowledge of the mentality of people in „Western" culture. The attempts to analyze the communities of other cultures are naive as they are based on our image of these cultures. It is also naive to believe in the possibility of creating „a global village" in „Western" terms (Furet, 1996). Neither should „Western" motivation be considered as identical to the motivation of people of other cultures (Abegglen & Stalk, 1985, Aoki & Rosenberg, 1987, and especially: Fukuyama, 1992).

One of the matters shared by all the inhabitants of the globe may be the joint creation of the system vision of the world. Yet, there is a serious misunderstanding at the bases of the system theory supported by the Western Civilization. We are convinced that it is the consequence of science development in our part of the world. Thus, according to our point of view, it is also the result of „Western" philosophy development. In fact, the system philosophy is entirely unfamiliar to the ways of comprehension of „Western Man." According to (Barrow, 1991) the „West" perceived nature in a linear way and the „East" as a non-linear creation in all its complexity. We should state that the system approach to the perception of the world is present only in the philosophies of the East. Regardless of the historical disputes, it is „them" whose mentality is better prepared for the world being formed now. It is observed in the economy. However, one should not postulate any attempt to change the mentality of the people of the „West" as it is unreal. Nevertheless, we ought to take the existing situation into account. The future depends on the search for common ideals, aims and deals. Searching for qualities which differentiate people in the world scale causes increasing divisions. It also provides false prognoses. Then, such prognosis are the source of politicians' actions, which seem to be more and more irresponsible and threatening for the future of the world. Undoubtedly, we are all slowly becoming aware of the growing necessity for the system perception of the world. This basis should be the common ground for cooperation. It does not mean a decline in competition. Only the undertakings based on global analysis may thus influence the 21st century so it will not be „an age of extremes" (Hobsbawm, 1996).

Therefore, we should conduct research on the influence of current economy and technology developments on the directions of change concerning people in the urbanized agglomerations of the West and in conditions of other types of existence as far as the following aspects are concerned:

- mentality,
- social behaviour within home society and in relation to strangers,
- organization and lifestyles,
- attitude to duties performed so far,
- attitude to ethical and religious standards,
- attitide to tradition,
- attitude to political, ethnic and other problems,
- attitude to knowledge.

3.3. Advice for Scientists

The main advice is for all the scientists to be willing to develop their activity in accordance with social and economic development of the world.

Please, excuse the author for his boldness. As it turns out , the author has spent all his long life in a very closed corner of the world. All this time he has followed the development of science in the world. It seems that it is easier to notice the main tendencies in the course of processes from an imposed distance. The case is similar to sports: it is easier for a careful and competent fan to notice the reasons for wins and defeats watched from a distance than for a direct participant. It seems to the author conceitedly that he is such a competent fan in the field of science development. As far as social problems are concerned, he has experienced those stormy times to his cost.

Despite what is normally thought, scientific circles have always had a great impact on the processes of decision making. Therefore, scientists can have an influence on the direction of changes taking place in the world. Obviously, this influence is executed in the course of a long period of time. Generally, scientific circles rightly identify emerging threats. This is derived from a large doze of objectivity attributed to scientists as well as erudition and external attitude towards matters which lie in the hands of politicians and businessmen. Therefore, the scientists should not only signal the threats but also indicate remedial measures. These measures comprise the scientific research results, which clearly and convincingly indicate the directions of decision making in political and economic matters - decisions which will influence the elimination of threats. Thus, the scientists should firstly change themselves and their circles. Changes should mainly effect the methods of research. The methods should help to obtain results which are currently useful in decision making. The main methodological postulates for research whose results may prove useful in decision practice are the following:

- A multi-disciplinary approach should replace the interdisciplinary research which is supposed to lack competence. Obviously, it requires the solid cooperation of scientists of various specializations.
- A multi-methodological approach - resulting from the necessity of agreement of one definite problem with the views of various schools of science philosophy.

- A multi-model approach - applies various types of models simulating reality. It may also lead to a multi-mathematical approach.

4. Term suggestions

4.1. Anticipatory System

It seems that acceptance of the simplest definition of an anticipatory system is absolutely sufficient to meet the needs of considerations included in this paper. Therefore, it is a system which can anticipate future states of its environment and on the basis of such prognosis it is able to adjust its existence to the changing environment. Such change takes place in order to preserve its existence and carry out its own goals, goals which are the essence of its existence.

Anticipatory system, as any other system, consists of a set of elements (objects - physical , energetistic, informational or abstract) as well as relations (links) existing between these elements. One of these relations conditions the existence of a system as a relatively isolated object. It is a system-formative relation. Elements of the system may also be systems. This is a static picture of a system - its photograph taken at a given moment.

System dynamics is connected with processes which take place in its interior and its environment. As we know, a process is a sequence (set) of succeeding states. Processes are expressed by means of some relations existing between elements. Thus, the analysis of changes taking place in relations is important. Processes may change features of the elements which are not systems but homogeneous objects (physical, energetistic, informational or abstract). Processes may also change features of elements which are called systems.

The essence of anticipatory system is the existence of elements and connected relations which are able to analyse changes in the environment and anticipate future states of environment on this basis. Such elements and relations may in certain conditions exhibit anticipatory abilities or not. It is the very specific type of synergetic effect.

In the anticipatory systems created artificially (technical equipment-machines) we can present this picture in a direct way. In natural systems existing around us (and inside us) precise determination and research of elements and relations exhibiting anticipatory abilities seem impossible. Then, it is necessary to determine some indirect methods. In such case maximization of objectivism in the conducted research is essential. Therefore, we should carefully consider what elements of the research workshop can be based on premises with a low level of objectivism.

4.2. Socio-Econo-Techno System

Human society undergoes very significant transformations under our eyes. Their course is evident for everyone. The course of these processes is observed by scientists representing various fields of science. The results of observation deserve attention and respect. Whereas, the prognosis based on the results of observation do not prove true. There are many reasons for such state. The main reasons include the lack of research cooperation between social, economic and technical sciences.

Now, the global human society is a quickly developing system including mental development, social as well as economic relations and the last but not least relations with technology which deal with the application of a growing number of different types of products which have a significant influence on all kinds of behaviour and social attitude.

According to the author effective prognosis of global society may be carried out exclusively on the basis of analysis which include all the mentioned areas simultaneously. Effective anticipation of social groups and the whole mankind in relation to quickly changing conditions of existence should be taken into account.

5. Methodological Background

We can notice a serious restraint on the influence of the General Systems Theory on science development on the world scale. There are various opinions expressed on this subject. Mainly effectiveness but also reliability of application of this research method are impaired.

W.E. Hutchinson from Edith Cowan University, Churchlands, Western Australia, in his paper „Making Systems Thinking Relevant" wrote (1996):

„...contemporary systems thinking suffers from a number of afflictions caused by the dominance of idealism. This has drawn the systems movement away from practical, problem solving toward introspection and an overindulgence in philosophical analysis. This has led to a neglect of real human behavioural patterns and an over emphasis on how people should behave if they conformed to some perfect model. ..."

and:

„There seems also to be a trend to ignore the concrete world for abstract ones based on stances related to some sociological, political, or philosophical theory"

One of the main goals of the General Systems Theory and Systems Research based on this theory is in my opinion bringing various results of scientific research to their application in practice. I am strongly convinced of the truthfulness of this view. Nowadays, the creation of the theory of chaos commenced a large revolution in the world science. It is not unlikely that there is a possibility to create a totally new description of the reality. There is also hope for a gradual disappearance of barriers between various fields of science. Research on non-linearity of nature phenomena has been carried out. The notion of universality has been determined. The repeatability appearing in the complex systems in the form of fractals has been investigated. These are milestones.

However, it seems that today's research on chaos still remains within the frames of traditional fields of science. Thus, we forget that it is not only a new research method but also a new approach to the perception of reality. Therefore, it is a new philosophy of understanding reality. According to the author there is a clear suggestion to undertake multidisciplinary tasks in which the theory of chaos will serve as the leading research tool. The analysis of the way to obtain results in any traditional branch of science may serve as the justification for such suggestion. For example, separate research is conducted on individuals and a totally different approach is applied in case of research on their community.

The above mentioned remarks seem to have the form of apparently unjustified impressions but let us take a closer look at the scene, where a drama called the „development of science" is performed. We can easily observe that the essential events are not created in the middle of the scene in full light. They sometimes take place in a bashful way as not being considered scientific, which means having rejected rules obligatory in scientific procedures.

The author suggests placing one of the unscientific events taking place just in the middle of the scene. The suggestion is based on a verified genuineness of predictions obtained by means of designing methods. We can observe a huge quantity of technology products around which function effectively and have been created thanks to the designing methods of analyses and synthesis of complex systems. Thus, the author suggests taking the next step and applying the reasoning basis considered as unscientific in the research on chaos. The main reason for this suggestion is the system procedure applied in designing and the methods of combining various fields of science. The evidence of its efficiency can be found in the work performed by professional designers. They are specialists who have always applied some sort of System's Approach in their work intuitively without theoretical premises. Efficiency of practical activity of designers has been justified on the bases of the General Systems Theory. The Design Theory as the basis for Conceptional Preparation of Activity (any activity) has been created. Designers exhibit high methodological discipline. It should be stressed, that desingers comply with these rigours without applying any mathematical tools. Thus, the situation is different than presumed. Mathematical considerations refer only to selected fragments of the whole system or its particular subsystems as there are no mathematical tools which may be used to describe even the simplest technical device as a whole.

On the other hand, during the „Science-Cognition-Consciousness-Cordoba'79" Congress several requirements which should be fulfilled in order to ensure proper development of science were focused on:

- It is necessary to carry out general research, taking into account the multi-level and multi-dimensional reality in natural and social phenomena.
- It is essential to supplement the causal research with theleological considerations including the purposes of phenomena and processes taking place in nature and society.
- Quality research, describing the essence of the phenomena, should complete the results of descriptions and quantity measurements.
- Scientific research should consider the sets of qualities professed by particular groups of people and their type of awareness.

The author will pose the following problem:

- Searching for theoretical and practical applicable fundamentals for analysis and synthesis (designing) the socio-econo-techno systems.

It is an inter- and multidisciplinary problem. The problem composes of the following scientific tasks:

- Creation models of object investigated.
- Description processes defined on the object investigated.
- Creation methods for simultaneous investigation of processes - when every separate process can be investigated with the use of the up-to-day methods according to the practice in separate branch of science.

Solution to the posed problem requires use of different mathematical tools. It generates two new methodological tasks:

- It is necessary to justify the joint use of several mathematical tools.
- It is necessary to consider the permissible range of intuition.

The base for solving the posed task is as follows. All the mathematical branches are connected with by one another by many reasons. There are also branches treated as basic, for instance: mathematical logic, theory of sets and others branches (it depends also on the meaning posed by different mathematicians-philosophers).

For practical purposes, it is possible to treat mathematical branches as languages with sets of symbols, sets of grammar rules and sets of syntax rules. The fragments of reality one can describe with the help of one of those languages. I believe, it is possible, with some dose of intuition, to translate a description in such a manner as one can translate a poem into a foreign language. For this purpose, it is necessary to create a map of mathematical languages from the point of view of its relationships. A simplified proposition of such a map is presented in book (Adamkiewicz, 1983).

6. Suggested Introduction to System Methodology.

6.1. Assumptions

If we are going to conduct scientific research whose results will be presented only to scientists then the simplified description of reality, called a model, may be adopted to the customs ruling in a particular field of science. The model needn't be comprehensible for people outside the circle. In order to find practical application, these models should also be adjusted to the mentality of the decision-makers who will employ our proposals.

In order to meet the needs of research defined as „system research" it is necessary to comply with the following rules while creating the models; these rules may be called the rigours of the system method (Mazur 1976):

- precision rigour concerning precision required in separation of the system from the environment. It is independent on the simplification level in the system model.
- functionalism rigour - the system should be seperated from the environment according to its functions (carried out processes) and not the spacial separation.
- invariability - the definition of the system must remain unchanged in the course of the whole research.
- completion rigour - the division of the system into subsystems must be complete.
- separation rigour - the division of the system into subsystems must be separable.

Taking into account the above mentioned rigours may be simplified by applying the so-called method of generalization during the identification of the system. The method is based on the previous identification of the supersystem which should contain the researched system.

It is also necessary to follow a generally known definition of a system: „System is a set of elements and a set of relations joining the elements inside the system as well as the elements and system as a whole with the environment." It should be added that the elements of the system may be material, energetic, informational, and abstract (for example, the elements of a philosophical system etc.) Among the relations existing between the elements of the system we should also focus on the relation which determines the existence of the system namely, the system-formative relation. The postulate to apply the system definition of the researched object does not require a mathematical approach to the considerations because the verbal description should also be subjected to some logical order. The necessity to apply the above mentioned definition results from the need to combine considerations and results from various fields of science. In order to adopt mathematical approach to further considerations we may suggest a definition based on mathematical logic, for example (Wintgen, 1971).

6.2. Placing the Detalied Sciences in the Global System

The basis for a general view of reality should include awareness of its sytem nature. The perception of the reality as a system should be the bases for the general approach to it:

„Universum" - U, consisting of the cosmos, the globe, nature and the man as its integral part. System U consits of four subsystems:

- **„Physicum Subsystem"** - P, comprising all natural objects determined as „inanimate". The processes taking place in this subsystem are determined by the laws of physics and chemistry.
- **„Biologicum Subsystem"** - B, comprising a great variety of biological objects. The processes taking place in this system follow the laws of biology.

- **„Socium Subsystem" - S, the set of all forms of mental conscience in the corporate sense („Socio") and individual (Psyche"). The Subsystem S appears in the form of behaviour of particular people as well as social behaviour. System S also includes materialized creations of the human mind: laws, external attributes of religious cults, works of art etc. These processes follow the laws of psychology and sociology.**
- **„Artificium Subsystem" - A, comprising all material man-made objects produced by industry or cottage industries. The attempt to describe this system is the System of Instrumental Civilization - SIC** (Adamkiewicz, 1995).

Within the global range the subsystem A more and more tightly covers the area of the U system. The subsystem A has an increasing impact on the S subsystem. It is a natural process of civilization development and therefore it is irreversible. It leads to the question: How does the development of the A subsystem influence the S subsystem? According to the economists and politicians the development of the A subsystem influences only the rise in people's living standard and it is the only aim of its development. But only that? Doesn't the development of A change the mentality of human kind? And if such change takes place, then how? An important initial problem to be examined is the way the subsystem A develops. Another question arises: Are there any critical points within the development of the set after which the set changes into something of different quality?

The division complies with the rigours of system method (Adamkiewicz, 1995b, 1997d). The understanding of the U system as the top-system of all the supersystems may simplify the application of generalization method, namely the identification of a detailed supersystem which includes the system we want to examine.

We can suggest the notion of Instrumental Civilization System - SIC (Adamkiewicz, 1983, 1995,1996) as the introduction to the analyses. As it is the only global approach free of political, religious and national associations known to the author. Introducing the notion of SIC, it was proved, that one of the main features of civilization development is the growing saturation of the creations of human hands and brains. This obvious fact is being analysed only in the context of economic development. Whereas, it influences the mental and cultural changes in the global scale; these changes determine the directions of human civilization and not the growing quantity of products.

On the basis of the above division of reality it is quite easy to define the streams of relations existing between the subsystems of the U system. These streams are essential for detailed research being carried out. It is also easy to determine the system-creative relation as a set of relations which distinguishes the examined system from the environment (the supersystem).
Therefore, at the beginning of every detailed research we suggest defining the U system according to our research needs. It means creating our own U system model which will include those features of the U system and its subsystems, which are important as far as the aim of research is concerned. We are mainly concerned with relations existing between the subsystems of the U system. The main goal of such procedure is the statement concerning simplification level of reality in our research. The next stage is separation of the supersystem from reality. We will determine our examined system in this supersystem. The supersystem as well as the examined system may include various elements of the subsystems of the U system. The choice will depend on the definition of the examined system and the resulting definition of the system-creative relation.

6.3. System Ability to Describe Objects and Processes.

Nowadays, the system way of thinking encounters crisis. Most people reject this sort of world perception. The strongest resistance is among the scientists. If the approach is accepted it serves only as the basis for creating the detailed science based on cybernetics. In order to oppose this anti-system tendency it is necessary to continue the dialogue between disciplines and initiate appropriate research. In order to achieve it we must constantly be aware of many facts which are often hidden timidly in our research work. Some of them are listed below.

The essence of system research is its capability to discover synergetic interaction between elements of the examined object. Such interaction results from cooperation of elements organized in the form of a system (Adamkiewicz, 1997a, 1997b). Thus, we make a methodological error by examining the interaction of any two objects without defining the system in which these elements function. As a result of such research we will in fact obtain information on synergetic interaction. It will be an interaction taking place not only between two elements but the sum of interactions between the elements of the system and cooperation of the examined elements. In this case, we will be unable to generalize the obtained results because the same two elements in another system may show a different level of synergy.

The above reasoning indicates that we should give up all the scientific actions except for those which employ system organization. Still, the system research may also be troublesome. Determining the limits of the examined system may create problems. We should aim at including a possibly large segment of reality within the notion of a system. Then, we deal with a growing number of system elements and even larger number of relations between the elements. This task is usually impossible to perform. According to the author, the only solution is to search for a division of the examined segment of reality which would comply with the essence of system philosophy as far as small sections are concerned. Such division should allow for adjusting the examined segment to the size suitable for research workshop. The author suggests that the idea of the Universum system - U meets such requirements to some extent.

The assumptions of every scientific research are based on intuition or come from practice characteristic of a given discipline of science. Intuition is based on knowledge. Regardless the acquired knowledge the acceptance of assumptions is still an arbitrary act. In the system research determining the limits of the examined system is such an arbirary act. All the philosophers of science from Wittgenstein (and the previous) to Feyerbend (and the following) have dealt with minimization of the intuitive free choice in scientific research. All in all, the proposals concern the employment of intuition exclusively at the introductory stage of research. It is correct providing that a homogeneous object and a homogeneous process are subjected to research. It is essential to „carve" such object and process out of the practical reality by means of „Ockhamm's Razor." It has no connection with the system research.

General suggestions referring to the basic rules for conducting global analyses of civilization development may be resolved into the following postulates which so far have not been considered as scientific by some circles of scientists:

- the analysis should have a system character which means that they should consistently be based on a properly selected concept of system theory by treating the problems integrally and applying the multi-level and multi-dimensional approach. The validity of the multi-dimension approach to scientific tasks is strongly opposed in many fields of science.
- during the creation of the system models or their fragments subjected to research, we should aim at their mathematical representation, at least a simplified one. Applying a mathematical approach needn't lead to obtaining quantity data. The „bigger-smaller" and similar evaluations obtained qualitatively are even more essential. In the field of mathematical approach to scientific research this postulate is not generally accepted either.
- The essential role of the mathematical approach must be completed by including multi-level considerations based on intuition. This postulate is instantly rejected. In fact, the reasons are completely unjustified. As there is a beginning to every research the assumptions of the subject are based exclusively on intuition. Thus, why can't we agree

with incorporating the multi-level approach to intuition between the particular stages of research except for the medieval attachment to Ockham's razor? It is not a brand-new postulate. Some of the outstanding mathematicians (Ajdukiewicz, 1975; Mortimer, 1982) justified the need for such action. The conservatism of professional mathematicians did not allow such views to spread. It is a barrier which exists persistently between a deductive science such as mathematics and all other sciences based on induction which means drawing conclusions from facts coming from the evaluation of the existing reality.

The second postulate dealt with an important empirical fact. The processes of social development including the economic one are not linear (Baumol & Benhabib, 1989, Deneckere & Pelikan, 1986, Drucker, 1980, 1989, Freeman & Perez, 1990, Gleick, 1987, Jenner, 1989, 1991, 1992). Therefore, the course of phenomena depends to a large extent even on slight changes of the initial conditions. Thus, these processes should be considered according to the theory of CHAOS. It is essential to obtain descriptions in order to search for the form of universality in these systems (for example: Feigenbaum, 1980).

7. Synergistic Effect Research

I dare say, this is the most important aspect in the systems research. It was noticed as far back as the ancient times. The ancients formulated the thesis: „The whole is more than the sum of parts". The Synergistic Effect can be easily defined in technical sciences. For example: the collection of all engine parts without giving them an appropriate structure (assembly) is not the engine. In social sciences the problem is not so easy.

In such studies there are two possible wariants:

- studying the system as the whole and then analysing its components after decomposition of the system,
- studying particular components and then their aggregation (summing up) to the whole system.

In the second instance the Synergistic Effect may or not may be detected. However, one cannot be sure that the effect in the whole range has been detected because the essence of the Synergistic Effect lies in the additional relations between the components of the system. These are such relations which are not revealed in the course of studying individual components. Particular components may also show certain new features, which are not revealed in individual components.

Then, the way to search for the Synergistic Effect must always have its beginning in an appropriate definition of the whole system. So the study of components can take place after thorough decomposition of the system into the subsystems.

In my view, only in the course of decomposition of the system, all relations can be detected, and among them also those which constitute the Synergistic Effect. Such relations obviously result from certain features of the components. I am of the opinion that direct search for and study of those features is meaningless because they manifest themselves only within the system as a whole causing exactly the Synergistic Effect. We can presume that these features are of a very complex character and depend on all other features of the component. So, those component features that cause the Synergistic Effect within the system can be studied and defined indirectly. The starting point for such studies should be the previous designation of the relations causing the Synergistic Effect.

On the basis of the presented opinions it appears that the key problem while studying the Synergistic Effect is the competence for detecting all possible relations found within the system. In the systems in question, there is a great number of relations. It is not possible to study all the relations simultaneously. So, it is very essential to classify the relations property and study them in respect of hierarchy. It is inadvisable to carry out such operations intuitively. The error margin can be too large. On the other hand, it is advisable to use the appropriate mathematical models in order to classify the relations and study them in respect of hierarchy.

8. Mathematical Models in Systems Research

8.1. General Assumptions

At the early stage of the General Systems Theory were proposed many models of systems. Later, their application was given up. A widely spread thesis on the inability to describe social phenomena in mathematical terms indicates that teaching mathematics in secondary schools is at a low level. The mathematicians warn that creating mathematical models at early stages of research limits the variety of associations (for example: Wintgen, 1971). However, after having described the field of research in the language of a proper scientific discipline, avoiding mathematical description in the next stages leads to simplification of a problem in a completely free way. We should then advise everyone pursuing the system research at least to attempt to describe the examined object in mathematical terms.

We should especially advise applying mathematical models of systems based on the Theory of Set or also in the notation of formal logic. The aim of the notation is to enable current analysis of relations sets existing between elements of the researched system. Such sets of relations may be noted in the form of matrices, that is in the form of tables. The tables allow for hierarchism of relations having no quantitative data. Such mathematical approach requires abilities acquired in the secondary school. The essential advantage of notation is also the possiblity to cooperate with mathematicians. We should keep in mind that fact that the theory of set is recognized by most mathematicians as the basis for all other fields of mathematics. The axioms (assumptions) of every field of current mathematics are formulated in terms of the theory of set. A mathematician may use another mathematical language to develop the researcher's idea which was initially expressed in the language of the theory of set. An example of such developed programme of mathematical approach to system research has been presented in the papers (Adamkiewicz, 1997a, 1997b).

Mathematical approach employing the Theory of Set allows to describe a system of any degree of complexity. Although it is a general description we can use it to describe an examined system without large simplifications. It is important because social processes are of chaotic nature to a large extent. The research of chaos is possible if it has even the simplest mathematical descriptions of the process (Feingenbaum, 1980, Gleick, 1987, Schuster, 1988, Stewart, 1990).

Creation of the following and more detailed mathematical models of a system must be accompanied by the following simplifications. Thus, it is necessary to make intuitive decisions sequencially between the particular stages of research. Whereas, from the mathematical point of view, the following models may result from each other quite precisely because the particular mathematical languages applied in the successive fields of mathematics result from each other due to common background of the assumptions in the theory of set.

If we are to take up any systems studies, first of all we have to assume a definition of the system which should be strictly obeyed in the course of the whole research process. In my opinion it is not advisable to assume a definition based on a mathematical formulation for the purpose of such general character of the studies. But during the investigation we should think over the type of the set formed of the elements entering into the composition of the system.

The definitions of the sets included in the mathematical set theory are very helpful but it does not mean that we have to describe the whole system by means of a mathematical form. The relations between elements can be arranged by the definitions given in a relations theory but only when we want to make further use of this theory. However, it is not necessary. The relations can be arranged in any way. The various sets of relations will be made. The most essential problem is the identified relations analysis, their classification and hierarchization from the point of view of a significance test. But in this respect it is better to create some mathematical models for particular set of relations.

Where is the whole problem? Well, each system undergoes some processes. [Of course, I omit the investigation of the system being a „dead object", which is enough to describe]. The elements of the system take part in those processes by means of the relations connecting them with other elements and the surrounding reality. So, also the relations undergo certain changes. The changes in each relation are arranged as well in a certain process (I assume that everybody understands the process as a state sequence at real time - particular states need not follow continuously - the sequence may also be of a discrete character).

Comparison and hierarchization of relations are possible only when we are able to present them in a combined form. The most convenient form is, in my opinion, to create the matrices for particular sets of relations. The elements of these matrices, in other word the relations, will be the functions dependent on time or the constants. I would like to emphasize once more that it is not the point to carry further investigations by means of mathematical methods, or means to solve e.g. equations. The point is to form the matrices in which the relations will be seen in an orderly way. Further investigations will be based on logical analysis. The matrices will be treated as data boards. Particular matrices will be compared with one another by means of a time axis, which will be common for all the matrices.

Necessary knowledge of particular mathematical branches resolves itself merely into understanding the essence of this branch, in other words into its language. The operational skill is not indispensable.

8.2. Some conclusions - Outline of Proposed Methodology for Investigations

The proposed research work has an interdisciplinary character. It is evident that such a composed problem is difficult to solve with the help of the consecutive use of the methods belonging to the many disciplines of knowledge (Adamkiewicz, 1983). It seems to be better to reach an original method of investigations. There is a proposition:

- At the beginning it is inappropriate to start up with the mathematical models of the process tested. Early mathematization may cause the loss of important associations.
- The next step will be introductionary formalization of the problem description because of the necessity to escape the subjective conclusions. The best way seems to be the use of formal logic dependencies because of the concurrent possibility to test the description with the help of tautology circles.
- The area of investigations must be treated according to the Chaos Theory because course of such processes depends even on the smallest change of the initial conditions.
- Between the elements of the tested system there are enormous quantities of relations. It is the reason for describing the system investigated as an n-dimensional Riemann's Space.
- The reduction of dimension's quantity can be done by employing relations classification with the help of the Theory of Groups.
- Obtained sets of parameters can be represented by the axes of a Riemann's Space.
- For some cases the next step is linearization of the process description. These equations can be solved with help of the Similarity Theory.

- The linearization description of the problem leads to the use of the Einstein's Indexed Tensor's Notation for solving obtained set of equations describing the mentioned problem.

The above presented procedure was used by the Author for solving some other problems (Adamkiewicz, 1995a, 1995b).

9. Final Considerations

Proposition of the prediction of system features suggested in this paper is based on three independent ways of investigations (Adamkiewicz, 1983, Barrow, 1991).

The first one - are the investigations of the real systems in the real conditions. Then the first question is a relation between a feature of whole system and the same feature of the components of the system.

The second and the third - is the investigation of possibilities to solve a multicriterian problem, when the components of the problem are not comparable to each other - firstly: its measures are incomparable.

The second way - is based on geometrical considerations. If we have a task to investigate many components together it is convenient to describe such a situation as a space with the adequate ("n") number of dimensions. Then the general model is an n-dimensional Riemann's space. Each dimension is suitable to one component, one measure and so on. In this space we can put a tensor. This tensor may be also n-dimensional. In general if we define a general tensor we do not need to define dimensions. In the next step (if needed) we define the measures' tensors. Without the measures' tensors we may investigate the invariants of our task. The measure tensors make a space very complicated. Euklidean laws of geometry are not convenient to such a space. However, it seems to be the only possibility to describe a multicriterian task in mode adequate to reality.

The third way - is an algebraical one. The mentioned geometrical problem was solved by Albert Einstein algebraically on the basis of the Ricci-Riemann's calculus. It is so called the indexed tensor notation.

The use of enumerated mathematical methods is simple. It is enough to understand the general ideas. We define a general Riemann's tensor adequately to our needs then search (or not) for invariants of the problem. Then we define a measure's tensor and in such a way we will obtain an n-dimensional space of our task in curved co-ordinates. Then we put an adequate simplifying assumptions with this end in view - to receive an n-dimensional space with the Euclidean geometry and, if we need, we put the next presumption - and we receive n-dimensional Euclidean space with rectangular co-ordinates.
Yet, on the basis of each two dimensions we can construct a matrix and we can investigate relations between each two components of our task.

10. APPENDIX - The Case Studies

10.1. Modelling in Designing as the Basis for Inclusion of Various Branches of Sciences in the Process of Analysis and Synthesis of the System Tested

The term of a model applies to such a system which can be imagined or materially realized, and which reflects or reconstructs the focused object in such a way that its examination gives us new information about it.

The final goal of modelling process is to obtain a mathematical model. As it has already been stated it is hardly ever possible to identify a mathematical model of the whole object. Therefore, mathematical models are substituted by other models. These models are accurate as far as logic is concerned. Such models are created at particular stages of designing (synthesis) or the analysis. The specificity of systems induces a necessity to look closer at synthesis and analysis on the multidisciplinary and interdisciplinary ground. Therefore, the designers since long ago, have employed the elements of systems approach in their activity. These elements may generally includ:

- The hierarchical decomposition of the designed and analysed objects and processes;
- Carrying out the synthesis from a simplified general conception to details, and not vice versa;
- Including various particular branches of science into the process of synthesis at proper stages.

The synthesis that is designing can be treated as the process of several stages which collects and transforms information and whose products are the models of objects and processes (the designing solutions). The way of obtaining the models of objects used in engineering practice constitute an example of the intuitive adoption of the systems attitude as a natural and psychologically justified creative attitude.

Let us assume that: a detailed notation of a project constitutes a systems isomorphous model with a real system. Isomorphism occurs when a model exists in the supersystem. Furthermore, if we consistently apply the principles of the systems method during the decomposition in the process of analysis and during the aggregation of the models in the process of synthesis (designing), then we can obtain:

- In the process of synthesis (designing) the creation of the hierarchical sequence of models homomorphous with a real object of higher and higher degree of minuteness up to the final objective which is an isomorphous, detailed notation of the construction.
- In the process of analysis (in the scientific research) the creation of a contrary sequence of models of higher degree of abstractness, and of lesser and lesser minuteness.

The creation of both sequences of models should be accompanied by:

- The increase of the formalization of the notation, especially of the models of higher degree of abstractness;
- The decreasing role of the considerations based on intuition.

An ideal situation would be achieved when hierarchical models of a sequence resulted successively from one another. This process of resulting would consist in summing or subtracting the features and the elements, and also in their generalization or decomposition.

Since decomposition (aggregation) will occur not only according to the elements of a system, but also according to the numerous features of these elements, the created set of models will be multiparameters - hierarchical. This set can be represented in the form of a special dendrite (tree). The process in which particular grades of hierarchy result from each other will consist in adding (subtracting) the elements and/or their features.

In order to make the discussed proceeding constitute the basis for solving a posed question, that is for steering the inclusion of various branches of science at different stages into the process of solving a problem, it is essential to make a choice as far as the point of view is concerned according to which the decomposition will be made. The basis for this choice may be only, in the author's opinion, "the generalization method". This principle leads to another assumption: the basis for the choice of the point of view from which the decomposition of a model will be made should be the analysis of the features of a modelled object as the element of a certain supersystem, in which a given object functions.

10.2. The Formation of a System Model for Analysis and Evaluation

The possibility for the formation an applicable system's model of the designing situation and an algorithm for solution the designing problems connected with system designing is presented below. Applying an appropriate method for evaluation of the relations existing between elements of a given system is another important question. The hierarchism of relations is a decisive point to the usefulness of models for real designing processes.

The location of the designed or analysed system in the supersystem or in its marked off subsystem should make it easier to obtain a hierarchical sequence of models. Theoretical circumstances for dissolving the mentioned designing problems one can find, for instance, in the book (Adamkiewicz,1983). It is suggested to consider designing from the point of view of the theory of changes. Thus, the designed system is the one which after being installed in another system, introduces a desirable change. This "another system" is the environment of the designed system.
The introduction of a change in system defined this way may consist only in the following operations:

- the introduction of new elements and/or relations to the system,
- the removal of existing elements and/or relations from the system,
- the reinforcement of activity of existing elements and/or relations,
- the reduction of activity of existing elements and/or relations.

These are the main elements of the process of creating the model of the analysis of relations appearing in the designed system:

- Defining the processes that are to occur in the designed system and reflecting them on the axis of real time as the sequence of states in the system will successively appear (in the course of the whole cycle of the life of the system, its subsystems and elements).
- The mental (abstract) creation of the system of the system states that will consist of the created models of processes.
- Making the hierarchical decomposition of the created system of states (generally, an n-dimensional graph-tree).
- The identification of relations appearing among particular elements of the state's system (states of the system) the successive levels of decomposition.
- Defining the matrices containing the identified relations in reference to various pairs of axes among all the n-coordinate axes in which the system has been presented.

The essence of the mathematical approach consists in presenting the designing situation with the help of a general form of tensor defined in n - dimensional Riemann's space. The tensor constituents will be n - parameters describing the designing situation (the Einstein's indexed notation of tensor). After some appropriate formal simplifications the matrices will be created from each pair of tensor constituents. To this end, axes of representing should be determined:

- A - axis of process states (axis of real time),
- B - strategic interaction in the material sphere,
- C - strategic interaction in the subjective/social sphere

- D - managing subsystems on the operational level.
- F - spheres (domains), in which functioning results will appear,
- G - steering interaction of the operational level on the considered system of states.
- H - axis of the set of SYSTEM PURPOSES REALIZATION functioning.

Real systems generally contain such large numbers of elements and particularly such a considerable amount of relations, that their simultaneous examination is impossible. That is why, stating the Essentiality of Elements and Relations from the considered point of view is a very important constituent of every analysis and systems synthesis (Adamkiewicz, 1983).

10.3. The System of Instrumental Civilisation

10.3.1. Introduction

On the scale of the whole globe a large system as a whole exists. It may have the designation „The System of Instrumental Civilization" [SIC] (Adamkiewicz, 1995c). Main properties of the SIC system, such as social, economical, organisational and technical are independent of the regional differences. The SIC system is still in transformation and develops independently of boundaries. The main problem is the SIC system absorbs more and more resources only for their needs, only for support the self-existence and for the future development. One may think that this great universal system has a great impact on all the people irrespectively of various divisions which exist among people's groups.

10.3.2. Service Focus

The 'Service Focus' is connected with the fact that all people utilize technical systems. So far this regularity has been noticed only in fragmentary way. Politicians do not notice it because they mainly safeguard various divisions. Thinkers and scholars, although proclaiming certain partial truths in that field, do not take this fact into account in a system way (Hickman, 1990; Hicks, 1988). Partially, but only on the basis of intuition, it is noticed by the representatives of big business.
Meanwhile, for instance, in the USA the service sector represents more than two thirds of America's gross national product (GNP), about 75 percent of the U.S. work force, and as much as 90 percent of new employment in this country.

10.3.3. Products in the Life of a Contemporary Man (Adamkiewicz, 1983)

The whole contemporary human activity consists in utilizing various objects while achieving different aims. These objects can be: - people and teams of people, - animals and plants, - materials, - energy, - information, - technical products, - economic and technical systems.
Among these objects technical products play a special role. It is so, because it is characteristic for the contemporary world that the man's surrounding is full of various products.
The avalanche of various equipment serving people devours at increasing rate the material and energy resources of our planet. A natural tendency is, therefore, to create these products in an economical way, which causes that they are not durable and less reliable. This, in turn, results in the creation of complex, more and more complicated organisational-technical systems which make the operation of these products more effective.
In all contemporary considerations the sense of the existence of technical products consists in performing certain roles for people. Yet, this is not the case. There are many more kinds of devices which exist only because there are other machines. Therefore, while analysing the problem in this way, one reflects upon all the relations of General Systems only from one point of view, that is from people's side. The relations that connect that system with people,

societies, are not only the relations which result from human needs and expectations. A significant part of these relations result from the needs of a technical system.

10.3.4. The System of Instrumental Civilization (Adamkiewicz, 1983, 1995c)

I introduced the notion of SIC in order to qualify the relations and their hierarchy among the components of a man's production operation: designing-manufacturing-using. To describe this, I used the simple dependencies of binary mathematical logic. This it not the evidence for truthfulness of the statements. However, the closed loop of logical tautology confirms the correctness of the argument.

On the basis of the presented considerations it appears that on the world-wide scale, the global system of operation (of using all the goods produced) is the supersystem for the global system of designing (designing all the goods produced) and the global system of production (of manufacturing all the goods). So, it should be presumed that the global system of operation influences the designing and manufacturing all the goods. This is simply because people use various goods. By using the goods produced, certain tastes, opinions and even mentality of people and the communities are formed. This refers as well to those people who are involved in designing and manufacturing the goods since people use various goods also in the course of the operation process, that is while designing and manufacturing.

10.3.5. The Logic Description of the SIC

In a certain system S_C in which civilized human communities exist, the processes of development Ω_K are defined, generated and steered by the process of intellectual human activity I_I [see: 1]. These processes cause constant development of the system S_C and change its environment. So far the process $\Sigma\Omega_C$ has caused almost exclusively the quantitative development of S_C the qualitative changes have occurred in a discrete way. Yet, the quantitative changes increasing at present cause the complete qualitative change of S_C which justifies the statement that the process of the growth $\Sigma\Omega_C$ has been nowadays substituted by the process of scientific - technical revolution Ω_R. The basic qualitative change is that the system S_C satisfying human needs has come into existence. It integrates the whole purposeful activity of a human community within its frames. The basic symptom of the origin of such a system is that the SCIENCE has become a productive power, because at present it mainly acts to satisfy the needs not of intellectual hunger. It means that in the long existing system the relation R_C creating the system S_C has appeared. The appearance of this relation was conditioned by the change of the sum of the processes Ω_C into Ω_R.

Let us assume that there exists a certain supersystem consisting of [see: 1]:

U - the set of all technical devices created by man,
W - the set of all products which are not devices, but produced by means of devices,
L - the set of all people who at the present moment have something to do with devices or products,
R_U, R_W, R_L - the set of relations among the elements in the sets U, W, L,
R_{UW}, R_{UL}, R_{WL} - the set of relations among the elements of the set U, W, L,
R_C - the system productive relation.

Let us define this system: The system of instrumental civilization S_C is a system relatively isolated, existing in the discrete (at places continuous) form in the physical reality determined in discrete (at places continuous) way in time and space.

The environment of this system consists of: **N** - the set of all natural physical elements existing in the reality, B - the set of all existing biological elements. In the environment the process of intellectual human activity I_I is determined. System S_C exchanges with the environment: - matter (also biomatter), - energy (also bioenergy), - information (also biological). S_C receives and generates the psychosociological impulses. S_C keeps constant physical contact with man in a discrete way (through its elements). The psychosocial contact is discrete, but its impact on man is constant. In the system S_C there exist: - the general system of designing S_P , - the general system of production S_W , - the general system of operation S_E .

From the considerations presented it results that the general system of designing S_P and the general system of production S_W are the subsystems of the general system of operation S_E .

It seems that according to the considerations presented which concern the general system of operation the name Supersystem of Operation may be proposed. It is equivalent to the System of Instrumental Civilization.

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