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# Original problem situation in TRIZ

**SUMMARY**

The problem, which the inventor encounters while improving the system, is a key source point for the entire process for inventive problem formulation and solving. From the outset TRIZ developed around the problem solving. Tools were developed in TRIZ for identification and solving of problems within the systems. At the same time in TRIZ there is no unity not only in terminology used for describing problem situations, but also in understanding the ontological meaning of this theme.

The present work quotes the analytical analysis of TRIZ tools used for describing the inventive situation. As a result, the author proposed a strict system of terms and models for describing the original problem situation, requirements field and requirement contradiction. Formalizing procedure has been developed for describing the inventive situation with regard to evaluation of level of completeness of describing components, which form the model of inventive situation. Examples are quoted for formal evaluation of completeness of inventive situations description, which demonstrate the mechanisms for transition from inventive situation description to formulation contradiction of requirement and to analyzing them.

## INTRODUCTION

G.S. Altshuller singled out three types of contradictions: administrative, technical and physical contradiction. Each subsequent one is the specification and aggravation of the preceding one. Here is a quotation from the book by G.S.Altshuller: «The very fact of appearance of an inventive problem already contains a contradiction: it is necessary to do something, and it is not known how to do it. Such contradictions are conventionally called administrative ones (AC). There is no necessity to identify administrative contradictions, they are on the surface of the problem. However, the eristic, «prompting» force of such contradictions is equal to zero: they don't prompt us, in what direction it is necessary to look for a solution. In the depths of administrative contradictions there are technical contradictions (TC)… and a technical contradiction, which is correctly formulated, is characterized by a certain eristic value. » [1].

At the initial stage of TRIZ evolution in 1970-ies such a methodological basis of TRIZ consisting of three key notions – administrative, technical and physical contradictions – was quite workable. With time two reasons appeared, due to which the necessity originated to specify these two notions:

- TRIZ application in non-technical spheres, in business and management of enterprises;
- broad spreading of TRIZ requires more exact definitions of the notions used.

In this work we will analyze the existing TRIZ terms for describing original problem situation and will offer an ontological description of them, which is more exact and definite.

The author is thankful to the colleagues, with whom he during the last years discussed the topic of problem statement in TRIZ: A.Kurian, A.Kulakov and A.Trantin.

## THE NOTIONS OF PROBLEM AND ADMINISTRATIVE CONTRADICTION IN TRIZ

G.S. Altshuller used several terms, the meaning of which is similar: problem, inventive situation, inventive problem, administrative contradiction. There are other analogous terms in TRIZ literature: problem situation [2], non-desirable effect, non-desirable situation, original problem. There are other word combinations for the same notion: surface contradiction [3], solver's contradiction [4], original situation.

Table 1 quotes eleven variants of terms, which are close one to another in meaning and which are used in TRIZ and comparative analysis of them is made based on advantages and disadvantages of these terms from the viewpoint of the opportunity to use them not only in technical systems and their correctness from that point of view that at the beginning of analysis it can be unclear, if there is a contradiction in this situation or not.

| Term | Advantages | Disadvantages | Rating |
|---|---|---|---|
| Problem situation | TRIZ term. Not necessarily contains a contradiction. Is applicable to non-technical systems. | Not widely used in TRIZ | **9** |
| Inventive situation (GSA, 1975) | TRIZ term. There is no accent upon the presence of the problem. | The word «inventive» presupposes that there is a contradiction. | 7 |
| Non-desirable situation | It points at the presence of difficulties, but not necessarily due to contradictions | Subjective character of evaluation of non-desirability. | 7 |
| Administrative contradiction | Conventional and widely known TRIZ term. | Is unsuitable for non-technical systems. May not contain a contradiction. | 6 |
| Original problem | The word «original» presupposes the necessity of analysis | The meaning of the term «problem» is too broad and polysemantic. | 6 |
| Original situation | The word «original» presupposes the necessity of analysis | Does not point at the presence of certain difficulties | 6 |
| Source problem | The word «Source» presupposes the necessity of source searching | The meaning of the term «problem» is too broad and polysemantic. | 5 |
| Non-desirable effect | There is no indication of necessary presence of contradictions | Subjective nature of evaluation of non-desirability. Describes a narrow phenomenon. | 4 |
| Inventive problem | Conventional and widely spread TRIZ term. | This term rather relates to a technical contradiction. | 3 |
| Surface contradiction | Can be used for non-technical systems | Points at the presence of contradictions. | 2 |
| Problem | Is understandable intuitively. Widely spread. | Not a TRIZ term, is applied in many meanings. | 2 |
| Solver’s contradiction | - | Not a TRIZ term. Points at the presence of contradictions and subjectivity | 1 |

Table 1. Comparative analysis of TRIZ terms, which describe the Original problem. The term «Problem situation» has the highest rating.

In order to select the most appropriate term it is possible to use one more approach. It is possible to analyze the frequency of used words with regard to all eleven terms, which are quoted in Table 1. The results of this frequency analysis are quoted in Table 2.

| **Words contained in terms** | **Frequency** | **Rating** | **Comment** |
|---|---|---|---|
| **Situation** | 4 | 9 | High frequency, no indication of necessary presence of contradictions |
| **Problem (adj.)** | 3 | 8 | High frequency, but the characteristic is not substantial |
| **Original** | 3 | 8 | High frequency and the characteristic is substantial |
| Contradiction | 3 | 4 | There is an indication of necessary presence of contradictions |
| Inventive | 2 | 4 | Low frequency. The term need not necessarily point at the invention |
| Problem | 2 | 4 | Low frequency. The problem need not necessarily exist. Broad meaning of the term. |
| Non-desirable | 2 | 5 | Contains subjective evaluation |
| Administrative | 1 | 2 | Is unsuitable for non-technical systems |
| Effect | 1 | 1 | Term with broad meaning. Low frequency. |
| Surface | 1 | 1 | Low frequency. Does not reflect the meaning. |
| Of the solver | 1 | 1 | Low frequency. Does not reflect the meaning. |

Table 2. Frequency analysis of words in 11 terms from Table 1. The word «situation» has the highest frequency of use (4 times). The words «problem», «original» and «contradiction» are encountered 3 times each. Such analysis also leads us to the term «Original problem situation».

Based on the quoted analyses, it is proposed to use the word combination «Problem situation» or «Original problem situation» as the desired term. The definitions of these terms will be quoted below.

## ORIGINAL PROBLEM SITUATION AS THE BASIS FOR STATEMENT AND SOLVING OF INVENTIVE PROBLEMS

Analysis of original problem situation can be reduced to three scenarios:

- it is necessary to meet certain problem requirements to the system, however, during the analysis it becomes clear that these requirements can be specified or corrected in such a way that the problem should not appear at all;
- it is necessary to meet certain problem requirements to the system and while performing the analysis it is possible to find the information about known methods for meeting these requirements in the given system;
- it is necessary to meet certain requirements to the system and while performing the analysis it is possible to single out at least one pair of requirements, in which meeting one requirement using known methods does not allow to meet another requirement and vice versa.

Of greatest interest in TRIZ is the third variant, in which the contradiction of requirements is contained in the Original problem situation.

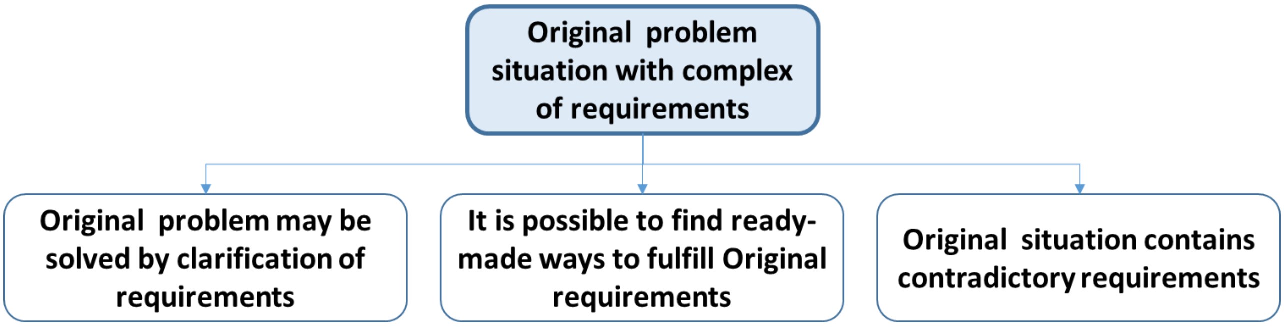


**Fig. 1 Scenarios for transforming a problem situation**

**Problem, problem situation** is a certain objective obstacle, a difficulty on the way from the system AS IT IS to the System AS TO BE, which requires a solution and can be formulated as a question or a set of questions. In contrast to a problem or contradictions of requirements, the problem situation may not contain all possible methods for resolving it. For example, the problem may be analyzed as a set of difficulties associated with improvement of this or that parameter: increase of profits, efficiency and reliability of the equipment functioning, quality of products, etc. In this or that way the problem or the requirements contradiction can also contain the method for solving the given problem, which turns to be inefficient due to this or that reason. For example, based on the quoted problem situations it is possible to formulate the following problem: how to enhance reliability equipment due to increase in stores and doubling without increasing warehouse stock and unused assets of the enterprise.

This or that complex of requirements to the system “AS IS” is described in the original problem situation for the sake of obtainment of a System AS TO BE. Analysis of a problem situation can lead to correction of original complex of requirements, to finding a known method for meeting a whole complex of requirements or to identification of contradictions in a complex of requirements, when the known methods for meeting each requirement separately are used. In the latter case the problem situation transcends to the requirements contradiction.

It is clear from the quoted problem situation analysis and from the proposed definition that with the original problem situation the key notions are «requirement», «contradiction of requirements», «system AS IS», «system AS TO BE». For further structuring and formalizing of the notion «problem situation», it is necessary to structure these notions more precisely. This is done in subsequent sections of the present article.

## SYSTEM OF INTERACTING REQUIREMENTS IN TRIZ

In TRIZ, which is predominantly aimed at the search of requirements contradiction, it is possible to single out two types of contradictions:

- function-and-targeted requirements (motivation requirements, generating energy for further actions) directed at attainment of a certain goal due to performance of certain functions;

- restrictive requirements (certain conditions, which it is necessary to take into account and which should be adhered to in attainment of function-and-targeted requirements).

These two groups of requirements are shown in Fig.2. Restrictive requirements, requirements to interrelations and goals can be related to the general group of non-functional requirements.

These two groups of requirements can form the basis for requirement contradictions within the system: known methods for attainment of certain goal-and-function methods lead to non-fulfillment of other function-and-targeted methods or to violation of restrictions.

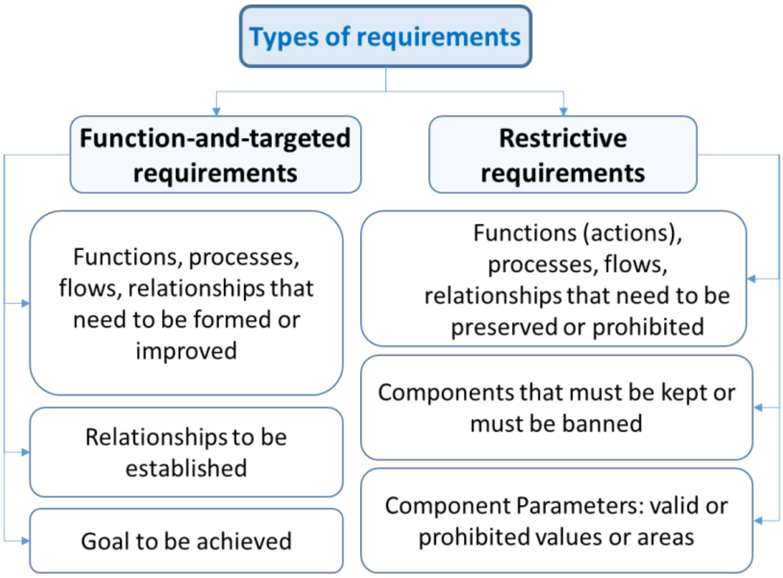


**Fig. 2. Types of requirements: function-and-targeted and restrictive**

It is possible to single out three originals within the system of requirements in TRIZ: requirement of supersystems to the system (for example, requirements of a family to the child: it is necessary to clean the teeth every morning); requirements of the system to a supersystem (for example, requirements of the child to the family: to feed him or her, to provide for a lodging and clothes and to take care of the child); the requirement of “adjacent” systems to the system (for example, requirements of neighbors to the family and to the child: not to make noise, not to break windows).

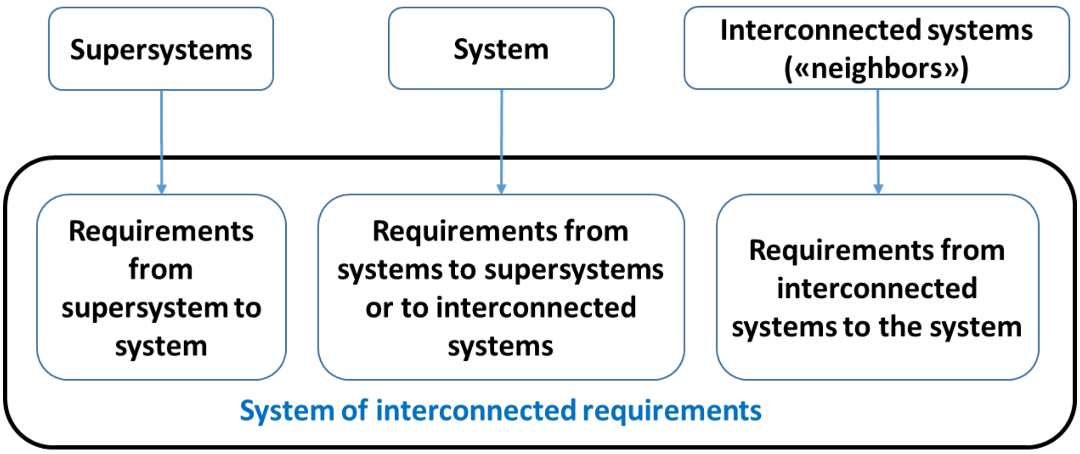


**Fig. 3. Originals of requirements in a single field of interacting requirements. Requirements can be given to different, but interconnected objects**

By way of example let us analyze the system of interacting requirements in design and construction of a certain manufacturing plant. The Customer (supersystem) gives to the manufacturing plant requirements concerning the palette of manufactured products, production efficiency, terms of starting the manufacturing process, conditions of labor of would-be employees, etc. The equipment, which is planned to be used has its own requirements to energy resources and their quality, requirements to temperature and humidity, to shape of the foundation and necessary loads upon it, etc. Also there are requirements coming from the interacting (adjacent) systems: requirements from the adjacent residential estates, entertainment parks, other enterprises. With innovation projects evolutionary requirements can be formulated, which presuppose the improvement of already known parameters of the system analyzed. All these requirements appear to be interconnected and form a single system through objects and processes, which are included concurrently with several requirements. For example, requirements to emissions of chemically active substances into the atmosphere could influence the requirements to chemical durability of the material, of which the roofs of the plant buildings are made.

It is also necessary to take into account dynamic change of requirements system in time and its irregularity in terms of level of significance and mutual influence. The requirements system changes depending upon the phase of life cycle of the systems, which are included with this complex of requirements. For example, requirements to industrial building changed in time from one century to another. Requirements to the system during the manufacturing process, transportation, operation and utilizing change in the course of transition from one phase of life cycle to another. At the same time one system of mutually interacting requirements may include systems, which stay at different phases of life cycle. For example, the edifice is only being built, while the equipment intended for it is already at a given site or being transported, or vice versa, the building is created, while the equipment is only being manufactured. Some requirements may dominate over other; they can also have a higher level of importance than the other requirements. For example, requirements to wind load influence the requirements given practically to all other construction elements of the building. Requirements to higher elements of the building (the roof, the beams, etc.) influence the requirements to lower elements of the building (columns, foundation, etc.), since the parameters of the lower elements of structure depend upon the weight of higher elements.

The system of mutually interacting requirements can be looked upon as an ordinary system using a system operator. It means that the system of requirements has a supersystem, for example, legislation, the laws of nature, etc. Also, there should be subsystems, for example, depending requirements, constituent requirements (components, parameters). The system of requirements has its past and future, it is also characterized by the evolution in time. Correspondingly it can evolve in ontogenesis (evolution of the system of requirements to design of a particular building) and in phylogenesis (system of requirements to constructing buildings in the past centuries is different from the modern system of requirements).

## CONTRADICTION OF REQUIREMENTS TO SYSTEM IN TRIZ

In 1860 F.Engels published a known work «The history of a Rifle» [5]. It is said there in particular in the description of contradictions in rifle evolution: «It was always a great difficulty to connect the shutter with the barrel in such a way so that it might be easy to disconnect it and to install once again, while the connection thereby should be strong enough so that it might endure the pressure of powder gases. There is nothing surprising that under the conditions of imperfection of technology of this time both these requirements cannot be combined: either the parts, which connect the shutter with the barrel, were insufficiently strong and durable or the very process of dismantling and fastening was performed fairly slowly».

In 1959 G. Altshuller and R. Shapiro in their article «Expulsion of a six-wing seraph» formulated and analyzed a collection of cards containing the descriptions of contradictions of system evolution in fairly different spheres: aviation, ship-building, mining equipment, heat generation equipment, etc. It appears that in contrast to a designer, who balances between mutually contradictory characteristics of a machine, selecting them in such a way that the requirements of a particular problem should be fully met, the inventor should break this compromise, should improve (or enhance the quality) of one part of the machine in such a way that the qualities of other parts should not deteriorate. [6]

S.N. Semionov remarked at the TRIZ conference in Novosibirsk in 1984, that the technical contradictions emerge due to the formation of technical requirements, which the society gives to the technical system and the features of the object, which is used in the given device. [7]

In 1994 the author proposed to use the following terms, which are applicable to all systems (not only technical ones): contradiction of requirements as a generalization of a technical contradiction and contradiction of attribute as an analog of a physical contradictions. [8]

It is important to pay attention to the basic difference between a contradiction of requirements (CR) to the system and contradiction of attribute (CA) of an element of this system. In the formulation of CA the element should be different from the system in CR, while the attribute of an element in CA should be different from the change (action), which is introduced into the system, and which is used in CR. Otherwise, the CA will not be different from CR whatever, and the formulation of CA will not yield new ideas. The figure shows a pattern of the model («Sandwich») of association between CR and CA.

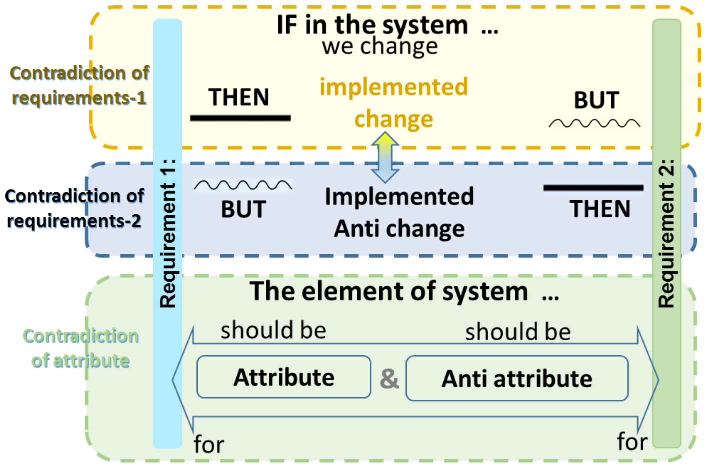


**Fig. 4. Pattern of interconnection of contradiction of requirements and contradiction of attribute as a single cause/effect connection and mutually preconditioned connections (model «Sandwich»)**

Using the formulation of contradiction of requirements in the analysis of the problems enables to integrate TRIZ with such developed technologies of requirements management used in different spheres of human activity. In future this pattern of contradictions and methods of work with them can be integrated into systems enabling to perform requirements management (RMS – requirements management systems) [9]. Requirements management is one of the methods for resolving requirements contradictions.

**Contradiction of requirements (CR)** is a situation, in which this or that change in the system enables to meet one Requirement (Requirement 1) of a supersystem to the system, however, does not enable to meet another Requirement (Requirement 2) to the same system, and vice versa – the opposite change in the system enables to meet Requirement 2, however, does not enable to achieve meeting Requirement 1.

Contradiction of requirements, in which Requirement 1 is met, is called Contradiction of requirements 1 (CR-1). Contradiction of requirements, in which Requirement 2 is met, is called Contradiction of requirements 2 (CR-2).

The following pattern is used for describing contradiction of requirements (technical contradictions):

Contradiction of requirements 1: IF... (Implemented change is indicated), THEN (+ indicate Requirement 1 being improved), BUT (- indicate Requirement 2 being deteriorated).

Contradiction of requirements 2: IF... (opposite change is indicated), THEN (+ indicate Requirement 2 being improved), BUT (- indicate Requirement 1 being deteriorated).

**Contradiction of attribute (CA)** is a formulation of the opposite state of this or that attribute of one element of the system, which is necessary for meeting contradictory requirements to the system. It is possible to formulate several contradictions of attribute for one contradiction of requirements.

Physical, chemical and biological attributes are used for material systems. The wording of contradiction of attribute intended for physical attributes has the following wording: physical contradiction.

Here is the pattern for formulating the contradiction of attribute:

The element of a conflicting pair should possess attribute A, in order to provide for Requirement 1, and should possess attribute "NON-A", in order to meet Requirement 2.

The description of the original problem situation should be fairly complete and informative, so that one might single out and correctly formulate contradictions of requirements and contradictions of attribute.

## GLOSSARY OF TERMS FOR DESCRIBING ORIGINAL PROBLEM SITUATION

Let us quote the definitions of several important notions, which are necessary for describing original problem situation and passing over from these notions to statement of inventive problems and formulation of requirements contradictions.

**Original problem situation** is a situation, which implies that the System AS IS gets this or that complex of requirements for obtainment of a system AS TO BE. Analysis of the problem situation could lead to correcting the original complex of requirements, to finding a known method for meeting a complex of requirements or to identification of contradictions in using known methods for meeting each of requirements separately. In the latter case the problem situation passes over to contradiction of requirements.

**Multitude** – one of the key notions of mathematics, constituting a set, an array of some objects (generally speaking, any) objects – elements of this multitude.

**System** (Greek σύστημα «the whole consisting of parts; unity») – multitude of elements staying in relations and connections one with another, which constitute a certain wholeness, unity and has characteristics, which are related to the system, but not to each element separately.

In contrast to a multitude a system is characterized by the following: its elements stay in interrelations and interconnections, but not simply unified according to this or that feature. Since a system is a multitude, the systems possess all properties and features of a multitude [10]. It means that a subsystem (sub multitude) can exist, one system can be added to or subtracted from another system, the systems may be integrated into supersystems (multitude of multitudes), etc. In particular, since a multitude of all multitudes does not exist, neither can exist a system of all systems (including all possible systems).

**Resource system** is a system, to which no external requirements are given and correspondingly there is no necessity for functions regarding meeting these requirements. Resource systems don't possess any functional-and-targeted features, for example, sand on the beach, electromagnetic field of the Earth, etc.

**Self-organizing system** is a resource system, in which spontaneously (not in keeping with the requirements of supersystems) the processes take place and the flows appear, which are associated with the changes of system elements and the system as a whole in time and in space, for example, swirls, volcano eruptions, formation of stars and planets, etc.

**Functional-and-targeted system** is a system formulated for performing the complex of useful functions and attainment of goals in keeping with the requirements of supersystems and operation principle of the given system. Functional-and-targeted system is formed based on self-organization, natural or artificial selection or as a result of targeted actions performed by one of the supersystems. Biological systems, technical systems, social, financial-and-economic systems, scientific and other similar systems can be referred to functional-and-targeted systems.

**Empty (zero) system (system vacuum)** is a system, which consists of empty multitude of elements. Empty system can be called system vacuum. Since empty multitudes also contain descriptions of these multitudes, for example, «a multitude of horses living on the Moon», «flying lions», the system vacuum should contain a description of what does not exist within this system: physical vacuum, chemical vacuum, biological, social, economic, technical and other kinds of system vacuum (empty systems). In this case an empty system has its characteristics, for example, volume, coordinates in space and in time, shape.

**System of multitudes** (multitude of multitudes, super multitude) is a multitude, all elements of which are multitudes.

**System (complex) of interacting requirements** – is a system of requirements coming from the system, supersystem and adjacent systems, interconnected by common elements and fields of interaction. A system of requirements can be looked upon as a self-contained system within a system operator, which means that one can single out a supersystem of requirements, a subsystem of requirements, the past and the future of requirements system.

**System AS IS** is a system remaining in its source state before the beginning of its being analyzed and transformed into a new system AS TO BE. The model of the system “AS IS” is formed from the system AS IS using some TRIZ models: component-structural and functional models, Su-Fields or El-Fields, description of contradictions or typical pattern of the conflict, etc. Depending upon the selected type of the model, it is later on transformed into the model of the system AS TO BE.

**System AS TO BE** is a system, which is obtained from the system AS IS via transforming it , also based on the model of the system AS TO BE. Model of the system AS TO BE is formed based on the model of the system AS IS via procedures, which correspond to the selected method for transforming models (functional, Su-Field, El-Field, resolving contradictions of requirements and feature, etc.). Transition according to the line "System AS IS" – "Model of the system AS IS" – "Model of the system AS TO BE" – "System AS TO BE" corresponds to the pattern of "TRIZ Model".

**Requirement** is a goal, function, restriction or ratio, which are targeted at this or that object (system) and which should be realized. Requirements may come from supersystems, surrounding systems and the system itself, thereby forming a system (complex) of interconnected requirements.

**Functional-and-targeted requirements** – are requirements, which are targeted at the attainment of the stated goal due to realization of a complex of functions, interrelations within the system and correcting them due to feedback.

**Restrictive requirements** – are requirements, directed at the prohibition or obligatory presence within the system of certain functions, interrelations, components and their parameters. The requirements may be formulated for a certain field of parameter values or by their exact values.

**Function** –is a change, stabilization or measurement of certain parameters of the object of the function (or product) via acting upon it with the agent of the function (tool). Model of the function consists of the agent of the function, action upon the function object and object of the function, the parameter of which is varied. It is also possible to indicate the field of interaction, with the assistance of which the action is performed. "Action" is understood as variation-stabilization, increase-decrease or measurement of this or that parameter, characterizing the object of the function. El-Field or Su-Field can be used as a function model. In the functional analysis they single out useful, harmful, insufficient, excessive, absent and other kinds of functions. Function model does not describe the object of the function before its modification.

**Operation (part of the process)** – is a description of the function performance in time, in which no agent of the function is indicated, however there is an indication of the state of function object before its being modified and the function object, which is modified after operation (process). As it is done with the function, with the process model it is possible to indicate the field, which is used for varying the object parameter. The process consists of a succession of operations. The process describes the variation of a system (or object) parameter in time at the output (exit) of the process as compared to the same system (object) parameter at the input (entrance) of this process.

Fig. 5 shows in the form of a diagram that one and the same system can be described using different models: models of functions, processes, flows or a combination of them.

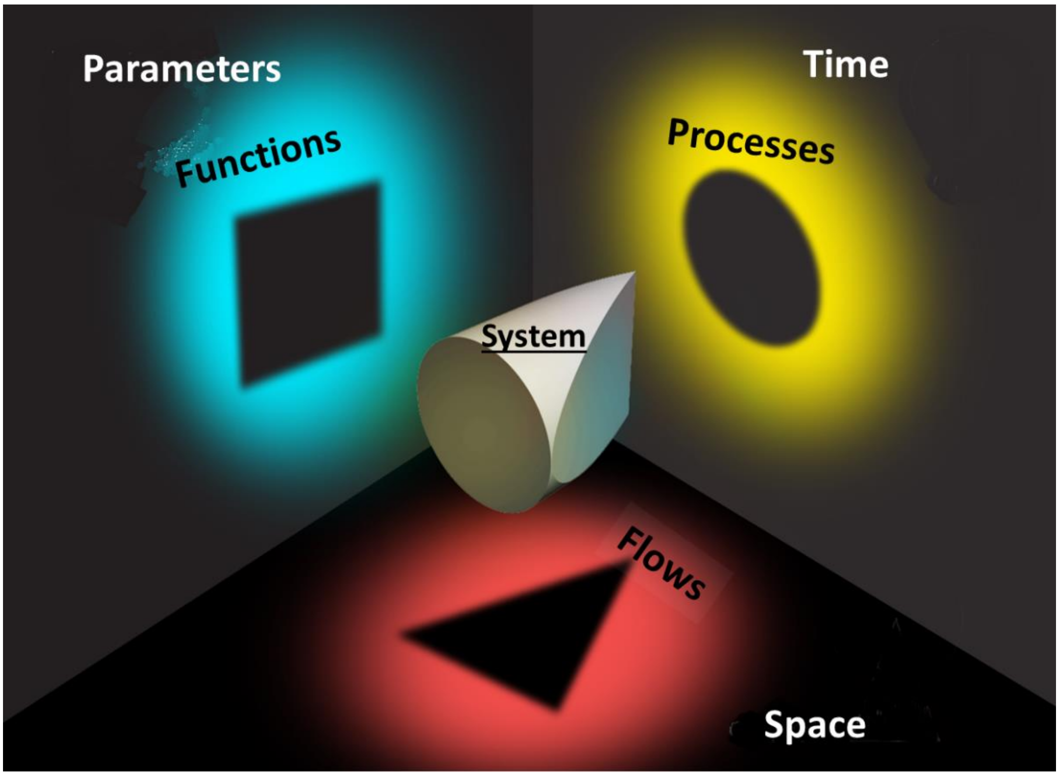


**Fig. 5. Schematic diagram showing that one and the same system could be described using different model: models of functions, processes, flows or combination of them all**

**Flow** – is a private case of a process (of an operation), in which the changeable pattern is the position of the object in space. In contrast to the processes, the flows presuppose that the position of the object in space changes. The flow is a directed motion of parts of substance mass in space, as well as the targeted travel of energy or information. The flow has features of double nature: features of a substance, of which the flow consists and the features of a field, which is formed as a result of targeted motion of substance particles. The flow can be useful, harmful and parasitic. The model of the flow contains static components: source (and capacity of this source), the channel, the receiver (and the capacity of the receiver) and the control system.

**Goal** – model image of the System AS TO BE, which is described in the form of an information image and/or requirements system, and which should be necessarily attained by the subject due to fulfillment of a complex of action programs with feedback. The realization of action programs with feedback is based on fulfillment of complex of functions (processes, flows) and correction of action programs depending upon nearing the set goal or attainment of this goal.

**Target-oriented metric** –is a metric, which enables to identify the degree of attainment of the set goal.

## FORMALIZATION OF THE DESCRIPTION OF ORIGINAL PROBLEM SITUATION

Because of the absence of formalization in the Original problem situation it can be difficult to truly evaluate the completeness and objectivity of this description, which is necessary for identification of inventive problems and formulation of contradictions. In order to single out the main constituents of the description of Original problem situations the analysis was performed of descriptions of Original problems in TRIZ: ARIZ-62, ARIZ-63, ARIZ-64, ARIZ-65, ARIZ-68, ARIZ-71, ARIZ-77 [11]. The evolution of parts of ARIZ, which are directed at the statement of problems took place gradually from ARIZ-62 to ARIZ-77, following the steps and recommendations of the preceding versions of ARIZ. It is possible to single out the main constituent elements of the description of Original problem situations:

- Object of the problem;
- Metric (goal, economic feasibility, required numeric parameter values);
- Characteristics of the object;
- Admissible expenditures and complexity of solution;
- Roundabout way. A more general problem;
- Comparison and selection of problems;
- Supersystems. Comparison with tendencies in branches of industry. External environment;
- Requirements: specification;
- Elements (attributes (features), what can be changed in them, and what can't be changed, product-tool);
- Non-desirable effect (harmful interaction);
- Description of cause/effect connection of elements and non-desirable effect.

Description of a problem situation should be sufficient for analyzing it as well as for singling out inventive problems and solving them. During the analysis and solving the problem situation can be elaborated and augmented.

Structuring these constituents, it is possible to combine a list of basic elements for describing a problem situation. It is possible to propose the following list of elements:

- Object,
- Targeted metric,
- Requirement 1 (function),
- Requirement 2 (function or restriction),
- Ways of attaining requirement 1,
- Ways of attaining requirement 2,
- Element upon which depends the fulfillment of requirement 1 and requirement 2,
- Supersystems.

With each of these elements for describing a problem situation it is possible to evaluate the completeness of information about them according to a five-point scale:

1. No
2. Not clear, if there is or there isn't
3. There are many, but they are not formulated clearly
4. There are many, but it is not clear, which element to choose.
5. There are

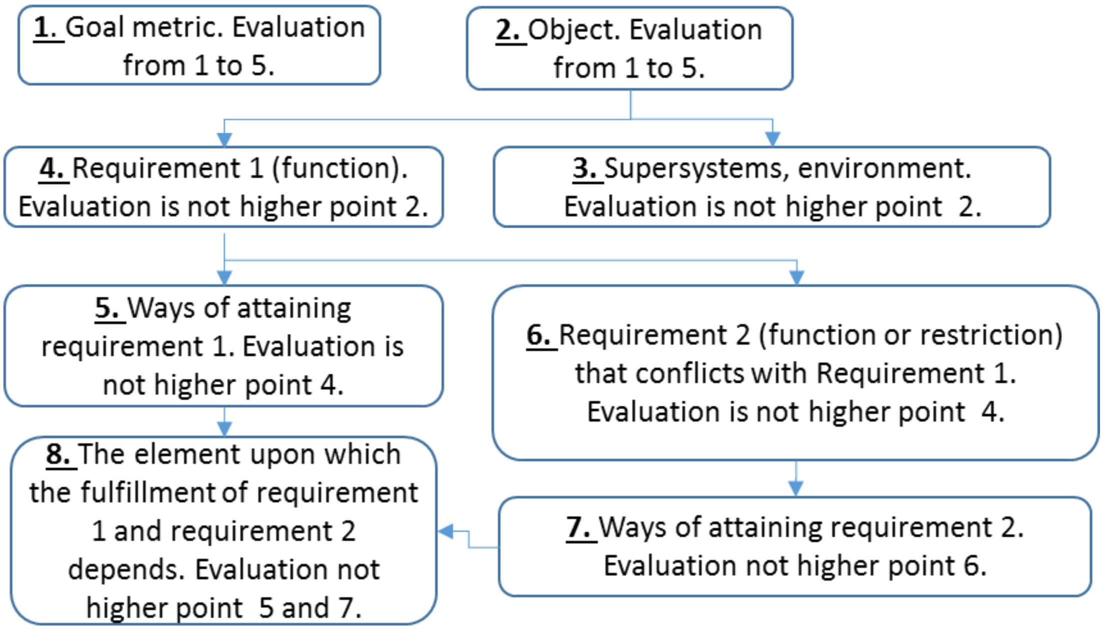


**Fig. 6. Interrelation of evaluations of completeness of information concerning the elements of a problem situation**

Let us quote examples for evaluation of completeness of problem situations description (Table 3).

**Problem 1.** Grinding wheel. Example of formulation of a problem situation.

Grinding wheel badly processes the products of complicated shape with recesses and convexities, for example, spoons. Replacing the process of grinding with another type of processing is unprofitable and rather difficult. The use of lapping ice grinding wheels is in this case too expensive. Inflatable elastic wheels with an abrasive surface are also inappropriate in this case – they wear off too soon. What's to be done?

**Problem 2.** IT company. Example of formulation of problem situation.

IT companies try to create more unique products in order to attract new clients and increase the volume of sales to the current clients. However, the new product costs a lot of money. What's to be done?

**Problem 3.** Sticky tape. Example of formulation of a problem situation.

The wounds are healed with the aid of a sticky tape, but the skin does not «breathe». What's to be done?

| No. | Description elements | Problem 1. Evaluation. | Problem 2. Evaluation. | Problem 3. Evaluation. |
|---|---|---|---|---|
| 1 | Object | 4. Many, but it isn't clear, which one to choose | 3.Many, but not clearly formulated | 3. Many, but not clearly formulated |
| 2 | Goal metric | 3. Many, but not clearly formulated | 2. It isn't clear, if there is or there isn't | 1. No |
| 3 | Requirement 1 (function) | 4. Many, but it is not clear, which one to choose | 3. Many, but not clearly formulated | 2. It isn't clear, if there is or there isn't |
| 4 | Requirement 2 (function or restriction) | 3. Many, but not clearly formulated | 3. Many, but not clearly formulated | 1. No |
| 5 | Ways of attaining requirement 1 | 4. Many, but it is not clear, which one to choose (cannot be higher than line 3) | 1. No | 1. No |
| 6 | Ways of attaining requirement 2 | 3 Many, but not clearly formulated | 2. It isn't clear, if there is or there isn't | 1. No |
| 7 | The element upon which the fulfillment of requirement 1 and requirement 2 depends | 2. It isn't clear, if there is or there isn't | 1. No | 1. No |
| 8 | Supersystems | 4. Many, but it isn't clear, which one to choose | 1. No | 1. No |
| | General evaluation | 62% | 33% | 20% |

Table 3. Evaluation of completeness of description of a problem situation based on the completeness of information concerning the elements of this description.

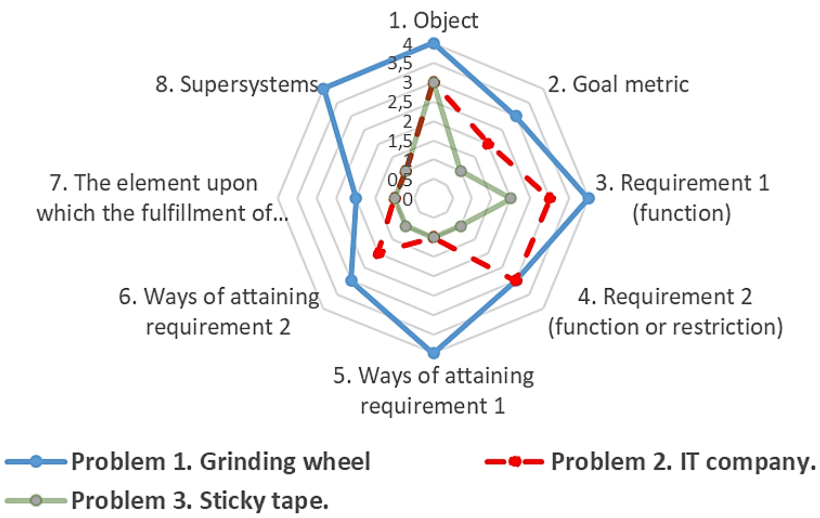


**Fig. 7. Diagram of completeness of fulfillment of Original problem formulation for problems of 1–3**

Fig. 7 shows a diagram of completeness of Original problem formulation for problems 1–3. It is seen from this diagram that problem 1 is described to a greater extent than other problems and problem 3 has the lowest completeness of description. This diagram also shows, which elements of the problem situation are described insufficiently clearly and completely. In the software complex Compinno-TRIZ [12] beside the diagram recommendations are issued concerning the improvement of description of problem situation elements. (Fig. 8).


**Fig. 8. Evaluation of Original problem situation in a software complex Compinno-TRIZ. Recommendations are issued how to improve the description**

The evaluations of completeness of information concerning the elements of a problem situation are interconnected (See Fig. 6). For example, evaluation of the fact that there is a description of Requirement 1 cannot be higher than the evaluation of the Object itself, since if the object is not clear, it is impossible to described the requirements, which this object should meet. Evaluation of the method for attainment of Requirement 1 cannot be higher than the evaluation of the description of Requirement 1 proper. And so on. These interdependencies are taken into account in the software complex Compinno-TRIZ in the module «Problem situation evaluation».

A set of elements describing the problem situation, can be enlarged. For example, it could be augmented with the following elements:

- An opportunity (having required knowledge and information) to set up cause/effect chains between requirements;

- An opportunity to set up cause/effect chains between requirements and features of the element;

- Presence of description of different aspects of analyzing the problem situation (physical, chemical, technical, economic, social, etc.).

Detailed description of a problem situation usually contains exhaustive answers to key questions of describing a problem situation with photographs, descriptions of already tested methods for eliminating the problems, references to documentation, experiments and contacts with experts, which could yield additional information. The growth of completeness degree of Original problem situation description will lead to enhancement of clearness and correctness of transition to requirements contradiction or to a set of such contradictions as well as to the increase in chances to expect that these requirements contradictions will be resolved.

**CONCLUSIONS**

1. The description of the problem to be solved is of fundamental significance for TRIZ. Fairly different terms are used in TRIZ thereby to describe this entity: inventive situation, administrative contradiction, etc. Having analyzed eleven such terms we proposed to use a more correct term in TRIZ: «problem situation» or «Original problem situation».

2. Of greatest interest in TRIZ are such problem situations, which contain system requirements, which are incompatible (controversial requirements), as well as the methods for converting a system AS IS into a system AS TO BE.

3. System of interacting requirements is composed of requirements of supersystems, interacting systems and subsystems. A system of requirements can be analyzed as any other system: let us mention evolutionary analysis, analysis of structure and functions, analysis of supersystems and subsystem, analysis of internal contradictions, etc.

4. Contradiction of requirements relates to any, not only technical systems and therefore is a generalization of the notion «technical contradiction». Contradiction of requirements is associated with the system as a whole, while the Contradiction of attribute – with the element of this system. Contradiction of requirements of the system is associated with the Contradiction of attribute of the element through cause/effect chains. In order to visualize these associations one can, use the model «Sandwich».

5. To provide for a more precise work with the notions of system, supersystem and subsystem it is proposed to consider a system as a multitude, transferring to the system all main features of multitudes. It is possible to single out three types of systems: resource, self-organized and function-and-targeted system types.

6. A system can be described with the aid of three models: processes, flows and functions. There are no functions in resource and self-organized types of systems, however, there is a structure of interconnections between elements of these systems.

7. In order to formalize the description of a Original problem situation it is proposed to use the evaluation of completeness of information concerning problem situation elements using a five-point scale. Such kind of formalization is used in the software complex Compinno-TRIZ.

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