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ARIZ - solving Non-Typical Problems

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Abstract – This article illustrates some tendencies in the field of Non-Typical problem solving methods, mainly the current tendencies in TRIZ and its development OTSM.

Keywords: TRIZ, ARIZ, Technical Contradiction, Minimum Problem

I. INTRODUCTION

In a prophetic allegation made in one of his most important works published in 1984, Altshuller says that: "TRIZ enables us today to solve inventive problems on the level of organization of mental activity that will be the norm tomorrow" [2].

More than 20 years later in a seminar in Vinci (Italy), in March 2007, Nikolai Khomenko used the following statement attributed to Albert Einstein: "The problems that exist in the world today cannot be solved by the level of thinking that created them" to answer the question: "Why do Non-Typical Problems appear?" and he further quoted Peter Drucker, one of the greatest specialists in management in our century who said that "Knowledge-worker productivity is the biggest of the 21st century management challenges" and also that "Making knowledge workers productive requires changes in the basic attitude - whereas making the manual worker more productive only requires telling the worker how to do the job." Knowledge workers should be able to solve Non-Typical Problems otherwise they could be replaced by computers the same way that manual workers were replaced by machines. Non-Typical solutions require non-typical ways of thinking; typical Solutions appear first as solutions for Non-Typical problems.

In the 21st century instead of production equipment the most valuable asset will be knowledge workers and their productivity so we will need new methods of solving Non-Typical problems.

The common point implied in both Altshuller's assertion and Khomenko's demonstration is the idea of "inventive creativity" - all this trial and error, "enlightenment," "happy coincidences" are not an end in themselves but a means for developing technical systems [2]. As an engineer involved in the solving of inventive problems Altshuller discovered that "the solution of inventive problems turned out to be strong if it overcame the technical contradiction contained in the problem presented to it, and weak if the Technical Contradiction was not revealed and eliminated."[2]

Even talented inventors failed to notice this fact and therefore they couldn't apply it in their further activity and struggled for years before understanding that first of all they had to search for the contradiction contained in the problem under study.

Years of study and practice lead Altshuller to the conclusion that "neither knowledge, nor experience nor ability can serve as a reliable basis for the effective organization of creative activity … If the "price" of a problem is 100,000 trials no one can solve it in isolation" [2].

For solving a "high level problem" [9] knowledge from the most varied domains and a holistic vision are necessary. What happens in reality is that people use primitive criteria of selection of the variants guided only by "old concepts and personal experience" [2].

Starting from the observation that inferior level inventions are lacking in creativity and superior level inventions achieved by the trial and error method are mediocre, Altshuller sets himself the task of devising "a new technology for solving inventive problems, which would permit one to solve problems of higher levels according to a plan" and "based on knowledge of the objective laws of development of technical systems"[2].

We mention the postulates of classical TRIZ below with the purpose of enabling a comparison with the new developments in TRIZ which, achieves more formalised instruments and predictable results based on new grounds certified through practice:

Postulate of Objective Law of System Evolution - systems evolve not randomly but according to objectives laws which could be discovered and applied for problem solving.

Postulate of Contradiction - system evolution should be considered as arising, intensification and resolution of external (between a system and an environment) and internal (between components of a system) contradictions of the system.

Postulate of a Specific Situation - each stage of evolution of a system takes place in a specific environment (context, situation) which influences the evolution (transformation) of the system and provides specific resources.

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One of the stereotypes about creativity is that there must be generated as many ideas as possible and then the best ones should be selected. Altshuller showed that in spite of the fact that by using a morphological box we can produce a large amount of ideas, analyzing it takes a lot of time even if we have some objective criteria.
The common engineering practice asks for a trade-off among the parameters by a process known as optimization, e.g.: capacity-consumption, degree of integration-dimension, power-signal quality, etc.
TRIZ, by its methods introduces breakthrough solutions that would maximize both parameters; see Fig.1 [11]
Some concepts need to be specified:
Typical Problems are problems solved by applying Typical Solutions. These are well known to professionals. Learning these solutions is provided by professional education. Non-Typical Problems are problems that cannot be solved by the application of Typical Solutions which were discovered, before the appearance of TRIZ, by the trials and errors method, a time consuming process, inefficient and less predictable. Non-Typical Solutions are very often refused by the community to the extent that the more productive breakthrough ideas the evolution of instruments for problem solving allows to deliver, the more resistance, both the instruments and the ideas, are faced with. This is a paradoxical situation arising from the very essence of the TRIZ solutions.

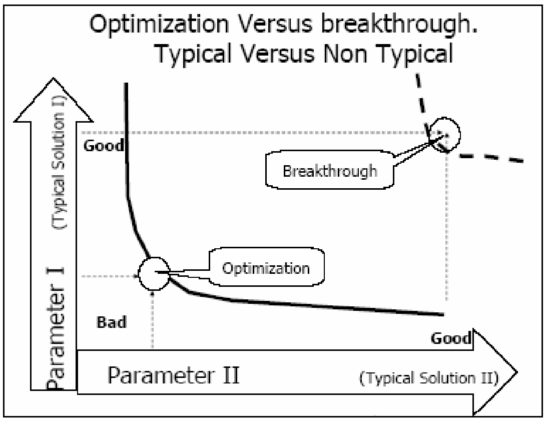

Fig. 1

The overall view of Altshuller was not to look for ideas but to develop them step by step according to the objective laws of engineering system evolution. Experience accumulated along the years showed that the main factor that makes a problem difficult is the lack of methodology for:

- problem understanding
- problem identification
- getting concept solutions
- objective evaluation of the concepts

none of these being related to the studied domain [11]. Altshuller recognized the fact that the "Trial and Error Method today is considered as a synonym for Creativity. To increase productivity of intellectual work a scientific approach should be applied..."[qtd. in 11] so he started his scientific research in 1946.
ARIZ as the main tool of classical TRIZ for Non-Typical Problems integrates different TRIZ instruments like Systems of Standard Solutions, the Law of System Evolution, Pointers of Effects and the Matrix of Technical Contradiction [9].
TRIZ does not search to solve all the non-typical problems one meets but develops instruments by the use of which the latter are changed into problems that can be solved by the already known methods. A major problem that arises is how the canonical form of a complex non-typical problem should look and what the typical procedure for solving the problem should be. The aspect that is common to the process of solving problems from the most different domains is changing the description of the problem with the description of the problem solution.

II. ARIZ - STEPS OF THE METHOD

Classical ARIZ contains nine main stages. In spite of the apparently sequential spread of the stages, the actual application of the algorithm is not a linear process but one that takes into account the results obtained during the process. Before enumerating the ARIZ steps we specify that:
ARIZ is an instrument to aid thinking but not a replacement for it, "the algorithm was developed for humans and therefore it must consider specifics of both the human thinking process and human psychology" [1].
1. Analyzing the Problem - the main purpose of this part is the transition from the initial situation to a description clearly formulated and very much simplified, already dealt with in [10]. The main sub-stages are:
- formulate the mini-problem
- define the conflicting elements
- describe graphic models for technical contradictions
- select a graphic model for further analysis
- intensify the conflict
- describe the problem model
- apply the inventive standards

2. Analyzing the Problem Model
3. Formulating the Ideal Final Result and Physical Contradiction
4. Mobilizing and Utilizing Substance-Field Resources
5. Applying the Knowledge Base
6. Changing or Substituting the Problem
7. Analyzing the Method for Resolving the Physical Contradiction
8. Capitalizing on the Solution Concept
9. Analyzing the Problem-Solving Process

III. ARIZ HISTORY

The first version was ARIZ-56 which got its name after the year when it was issued, all subsequent versions complying with this type of notation. It is worth mentioning the steps of this first version of the algorithm [5] in order to trace its complex evolution:

I. Analytical stage
1. Choose the problem
2. Determine the main part of the problem
3. Discover the important contradiction
4. Determine the direct reason of the contradiction

II. Operation stage
1. Research examples of typical solutions in nature, technique, and the environment.
2. Search for the solution by a change in the system, sub- or super-system, or the environment.

III. Synthesis stage
1. Introduce changes in the system stipulated by functions.
2. Introduction of the functionally caused changes in the methods of using the system
3. Check applicability of principle to solve other technical problems.
4. Evaluate the solution

ARIZ-59 brings new elements to better structure the respective algorithm, a set of tools including operators, data base, and a new, important step - the statement of the Ideal Final Result [7].

Added experience drives the algorithm from a "method of inventing" towards a "science of invention" and ARIZ-61 will be a much improved version ARIZ-64 which brings a section about "Clarifying and verifying the problem statement" while with ARIZ-65 "the first limited contradiction table is introduced" [7]. ARIZ-68 introduces special steps for "handling psychological inertia," extended knowledge base and 35 Inventive Principles revealed by systematic analysis of patents.

ARIZ-71 incorporates extra rigor, concepts like the operational zone, the STC (Size-Time-Cost) [10] psychological operator. The chain of improvements continues with ARIZ-75 which can work with the "Pattern of Technological Evolution, substance-field transformations, and compiled guides of effects"; ARIZ-77, contains the prototype of the physical contradiction on a micro-level. "Beginning with ARIZ-82, a paradoxical process of specialization/generalization begins. In technology, ARIZ is targeted specifically toward the solving of difficult non-typical problems and the development of new standard solutions. At the same time, ARIZ gains some universal features as it is applied to the solving of scientific problems, problems in the arts, etc." [7].

ARIZ-85C was the last version in whose elaboration Altshuller was directly involved.

IV. EXPRESSING CONTRADICTION

Before talking about one of the most promising developments of TRIZ, TRIZ-OTSM, we will briefly present the "core" of classical TRIZ and, of course, of ARIZ as the beneficiary of all its instruments: the Technical Contradiction expressed by the next canonical form [4]:

A technological system for <purpose of the system> contains <list of the most important parts of the system>

- Technical Contradiction 1: describes a state of the system and the associated useful and harmful effects

- Technical Contradiction 2: describes an opposite state of the system and the associated harmful and useful effects.

It is necessary with minimum changes to the system to obtain <the required result>.

Let's have a simple example:

"In the activity of air traffic control a minimum distance between the airplanes must be maintained, both vertically and horizontally. These distances influence the number of working sectors in which the controlled area is divided; sectors divide the space in map-like horizontal regions and also in vertical levels.

TC1 – If the sector area is too great, the traffic controllers have difficulties in doing their jobs and the level of safety is low but the control center needs less people for doing the job and also less radio frequencies for communication with airplanes.

TC2 – If the sector area is small, the activity of the controller is easier and the safety is high but more small sectors are needed which implies more people for the control activity and also more radio frequencies for different sectors.

It is necessary with minimum changes in the structure of the activity (same number of frequencies and people) to insure the same safety level."

Remember that a Technical Contradiction appears when the introduction or increasing of the useful effect or the elimination of the harmful effect causes the deterioration of the whole system or part of it; this functions as an indicator of the fact that we deal with a Non-Typical Problem. At this point ordinary thinking chooses a trade-off but this is not the case with ARIZ.

This canonical form placed in classical ARIZ under the name of Formulating the Mini-Problem [11] represents a real step aside from the usual way of engineering thinking because it blocks the "path toward trade-offs" [6] by introducing additional requirements in obtaining the required result.

V. OTSM - THE NEW TRIZ TECHNOLOGY

In agreement with Altshuller's desire expressed in July 1997 together with the permission granted to N.Khomenko of using the term OTSM for further developments of TRIZ, we mention that OTSM is the Russian acronym for General Theory of Strong Thinking. Altshuller opened this path in the 80s as a consequence of the many solicitations coming from a host of domains regarding the necessity of a TRIZ approach that should be accessible even to those who do not benefit from an engineering training.

Two major improvements were brought by N. Khomenko. One is the Network of Contradictions as a Canonical Form to describe Non-Typical Problems and the second one is the Problem Flow Networks Approach which is a Canonical Procedure to transform the Initial Problem Description into a Canonical Problem Description. OTSM comes with a new way of thinking about problems, of dealing with challenges, and this way, besides being more logical and creative, is also by far more rapid, more effective and more organized than all the other traditional problem-solving methods.

In the March 2007 seminar, two reasons were offered by N. Khomenko for developing Problem Flow Networks Approach: one is that "complex, non-typical multidisciplinary problem situations are often presented as a network of various problems" and second is that the solving process is "a flow of knowledge about the problem and potential solutions, as well as a flow of research needed to be done to solve the problem." [11].

We mention the evolution of two of the important concepts in classical TRIZ: the System Operator (Multi-screen approach in [10]) - becomes the ENV (Element-Name-Value) Model in OTSM. One or several Features are associated to each element that is taken into account during the problem solving process. These Features are characterized by Feature Name and Feature Value as shown in Fig.2.

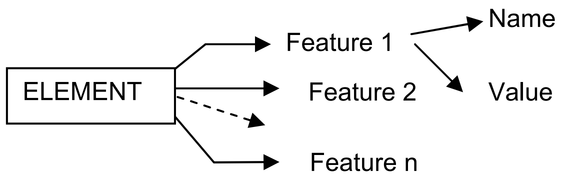

Fig. 2

The following is the canonical form of the ENV model for depicting a contradiction.

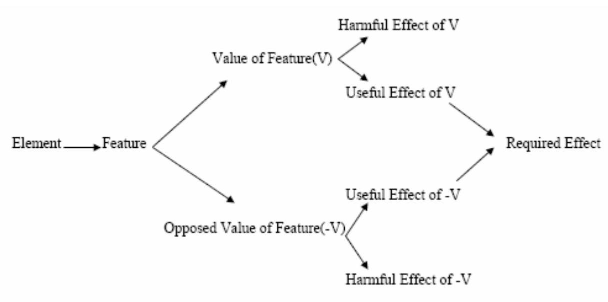

Fig. 3

To put it differently:

TC1 - If there is V then Harmful Effect < > of V but Useful Effect < > of V

TC2 - If there is -V then Useful Effect < > of -V but Harmful Effect < > of -V

Required Effect: It is necessary with minimal changes of the system to < > without degrading < >

The so-called "Hill & Tongs Mainstream" Model (Fig.4) [11] of Classical TRIZ becomes the OTSM Fractal Model of Problem Solving Process. (Fig. 5) [11]

The Complete ENV Model offers the solver of the problem a holistic vision of the system involving both brain hemispheres and breaking the usual mental barriers by adding to the old System Operator which already contained descriptions of Level of Hierarchy, Levels of Opposition and Time, the Levels of Generalization, Probability, and Objectiveness and also the most surprising dimension for science Imagination which contains : the Variation of Value, the Impossible-Possible dimension, and Broken Cause-Effect Links.

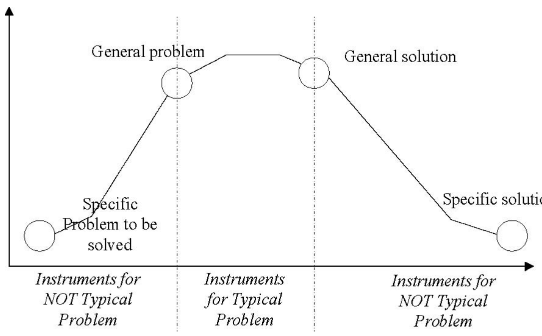

Fig. 4

The use of TRIZ involves a genuine mental revolution having at its centre the notion of contradiction. Stages of the algorithm when analysis proceeds with the help of professional knowledge alternate with stages meant to render conscious mental phenomena which are normally unconscious, moments of reflection or the surprising idea that the best solution is the elimination of the necessity to solve the problem at all. This situation may arise once the function of the new system is defined.

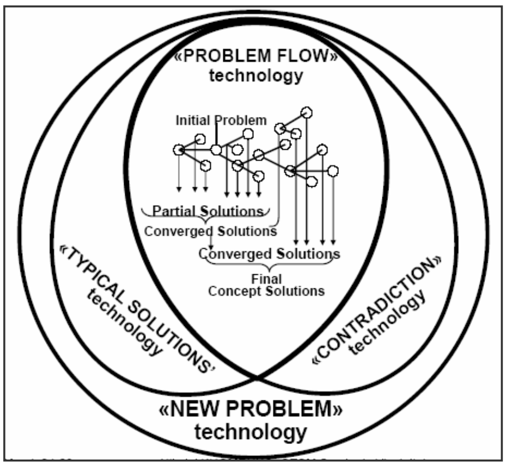

Fig. 5

ARIZ practice disclosed the difficulty solvers face in defining the function of a system. OTSM-TRIZ solves this difficulty by using a three-step algorithm:

1. the generation of a common language model of the Function
2. the generation of a Verb-Noun model of the Function
3. the generation of the ENV model based on Four Verbs for the description of the Function. The canonic form used in the analysis of the problem is:

What value of What Parameter of What Element we must Change in order to ... KEEP/CHANGE/ INCREASE/DECREASE).

During the Vinci seminar, when asked to determine the function of a pen, the participants, engineers and inventors, came up with the following answers: *to write, to transmit information, to draw signs on paper, to hold ink*; but since no part of the pen directly interacts with the information in a person's brain these cannot be considered acceptable answers. The real function was obtained after using the 3-step algorithm and the Law of Completeness which specifies the structure of the Minimal System:

1. OTSM ENV Function Definition
2. Product
3. Tool
4. Energy for the Tool to Change Product
5. Energy Source Flow through the system
6. Engine
7. Transmission

The verb-noun model of the functions arose: Control of the flow of ink from inside the pen to the paper. Evidently Ink is the product and the Capillary is the Tool so the Function is: the Pen by itself Moves Ink from one point to another.

The list of problems specific to complex multidisciplinary Non-Typical problems represents the raw material for constructing the OTSM Network of Problems and the result is a Semantic Network which is analyzed by the rules of OTSM-TRIZ. Establishing relationships between problems and partial solutions is very important, this being an indicator of a contradiction and confirming another major improvement of OTSM-TRIZ.

VI. CONCLUSION

TRIZ is no longer a method; it has evolved into a THEORY which lies at the basis of several methodologies.

TRIZ-OTSM allows today's scientist to meet the challenges of the 21st century, one of the biggest being the increase in productivity obtained by capacitating the knowledge-workers to solve Non-typical problems. But a change in attitude and mentality is just as necessary as developing professional knowledge in one's field. This change of vision is just another revolutionary aspect of TRIZ-OTSM.

The new directions of evolution brought by OTSM are tied to the task of making possible the analysis of complex multidisciplinary problems, one of its major achievements being the possibility of working with networks of problems and contradictions.

This approach allows for a planning of the strategies for designing new systems on several temporal levels: the systems meant to be implemented at the present moment, the systems for tomorrow, and the systems for the future, permitting also to control the process of innovation within an institutional background.

REFERENCES

[1] Altshuller, Genrich. *The Innovation Algorithm*. Technical Innovation Center, Inc. Worcester, MA, p. 123, 2000

[2] Altshuller, Genrich. *Creativity as an Exact Science. The Theory of the Solution of Inventive Problems*, pp. 266, 40, 42, 43, 1984

[3] Kosse, Vladis. *Solving Problems with TRIZ an Exercise Handbook*. Ideation International Inc. 2004

[4] Salamatov, Yuri. *TRIZ: The Right Solution at the Right Time. A Guide to Innovative Problem Solving.* Insytec B.V., 1999

[5] Savransky, Semyon D. *Engineering of Creativity. Introduction to TRIZ Methodology of Inventive Problem Solving.* CRC Press, 2000

[6] x x x *Tools of Classical TRIZ*, Ideation International Inc. 1999

[7] Zlotin, Boris and Zusman, Alla. ARIZ on the Move, <http://www.ideationtriz.com/paper_ARIZontheMove.htm>

[8] Ivanov, Gennady and Barkan, Mark. Process Management Using Systemic Thought Process: Identification and Formulation of Creative Tasks

[9] Coşer, Mircea. "Patents in the Framework of TRIZ", *Buletinul Universității "Politehnica", Seria Electrotehnica, Electronica si Telecomunicatii*, Tom 50 (64), 2005, Fascicola 2, 2005, pp. 34.

[10] Coşer, Mircea. "Which problem to solve?", Buletinul Stiintific al Universității "Politehnica" din Timisoara, *Seria Electrotehnica, Electronica si Telecomunicatii*, in print.

[11] Coşer, Mircea. "Destroying Mental Barier - Agents' Method", Buletinul Stiintific al Universității "Politehnica" din Timisoara, *Seria Electrotehnica, Electronica si Telecomunicatii*, in print.

[11] Khomenko, Nikolai. "OTSM and some of its instruments: First acquaintance", *OTSM Seminar in Vinci*, Italy, March 24-28, 2007.

[12] Coşer, Mircea. "TRIZ - a short presentation," *Buletinul Universității "Politehnica", Seria Electrotehnica, Electronica si Telecomunicatii*, Tom 48 (62), 2003, Fascicola 1, 2003, p. 89.