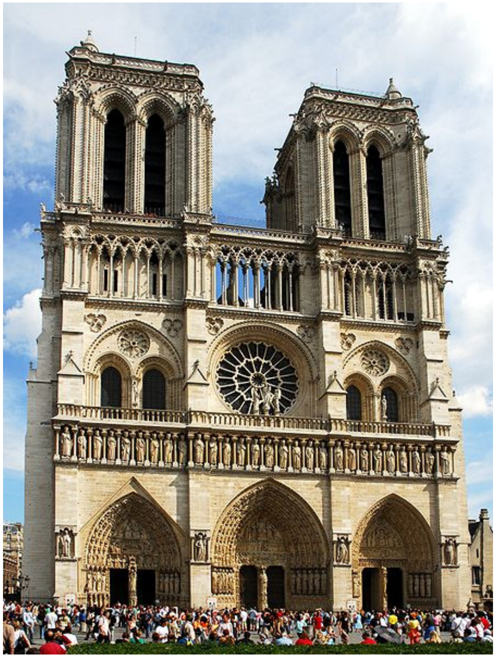
1 Fundamentals of Classical TRIZ

1.0 Why do we need to know the foundations of applied theories?

One frequently hears the following statement: “We are experts, we don’t need any theories…” This opinion is understandable in part. In relatively simple situations it is quite possible to succeed by a simple selection of the available versions and accepting those which provide satisfactory operation and help to achieve some objectives.

On the other hand, we are frequently unaware of the fact that the tools we use in our everyday professional activities are often based on certain theoretical models and assumptions. Thomas Kuhn describes many such facts in his famous book *Structure of Scientific Revolutions*. Kuhn shows that often in science history, theories and their tools have been created on the basis of not quite realized and not quite distinctly defined premises. Kuhn calls these basic theoretical premises paradigms. Realizing and correcting these premises led to serious changes in scientific notions and the creation of new, more effective tools.



Notre Dame Cathedral in Paris
Author Jerome Dumonteil
(www.wikipedia.org)

One can hardly imagine that the Notre-Dame Cathedral in Paris or the Riga Dome Cathedral in Latvia could have been built on the basis of trial and error without a theory.

It is the same with cars. Imagine for a second that only “empirics” who renounce theory, mathematics, physics and accident-prevention rules work in the design-engineering departments of Mercedes and create cars by the trial-and-error method. How many years or even centuries would it take them to create a new model?

It took several centuries of research, experimentation and theoretical generalization for modern cars, aeroplanes, electronics, cinema and musical instruments to have been made possible. All that work resulted in the appearance of rules for empirics, which significantly increased the productivity of mental creative labour. It is remarkable that people using those rules often renounce the possibility of creating similar rules for inventors who create the new in any sphere of activity – technology, business, art etc.

Even poetry, music and architecture have their rules theoretical generalizations. These rules, and typical solutions, are studied by future professionals. For example, today any schoolchild can solve quadratic equations and draw a linear perspective, whereas not long ago these things were considered very creative and not formalizable by means of rules.

In 1991, at the World Fair EXPO-91 in Plovdiv, Bulgaria, I had the chance to meet a violinist named Johann. We were demonstrating the first versions of the “Invention Machine” software product, designed to support engineering problem solving. It was the world-first TRIZ-based software created at our research lab. “Invention Machine” really helped engineers in their everyday practical work. It is just this software product that made TRIZ popular in the world.

An attractive guy approached our exhibition stand and asked why our company was called the “Invention Machine Laboratory”. During our conversation it became clear that Johann was a specialist not only in music but also in artificial intelligence and that he had done the same work in music as that done by G.S. Altshuller in technology. Johann had identified and clearly defined the principles of creating music of one or another genre, integrated them into a system and developed a software program that allowed anyone to enter a sequence of several notes, indicate the parameters of a desired piece of music to a computer, which, after having performed the routine work, played the created music. As the computer's co-author, one could listen to the obtained piece of music and improve it to your taste. Johann had invented a simple language which allowed even those who could not play a musical instrument and could not read music to use that system.

Johann's company was called the "Computer Music Laboratory" and his software was called "Composer". He gave me a cassette with recorded pieces of music created by different people using his software product. It included variations on popular musical themes in different genres as well as new melodies. I used to listen to this music with delight until I lost the cassette during one of my numberless trips. It is remarkable that many of my friends, including some professional musicians, also enjoyed that music.

Later I read about experiments where computer-composed and man-composed pieces of music were compared. An auditorium of musicologists was asked to listen to pieces of music and guess whether they had been composed by a computer or by a person. Professional musicians failed to pick out the computer-composed pieces.

We can draw one important conclusion from these episodes and examples. Creative activity is not something unmodifiable or stagnant. What yesterday seemed creative work looks as routine today. And what yesterday seemed an unachievable dream requiring a huge creative effort is being done today by the new generation of creators employing new professional technologies.

1. 0.1 The notion of creation is akin to the notion of Horizon

Today, that tree on the horizon seems to be at the uppermost point of the Earth. Tomorrow, after we have got to that tree and sat in it its shade, we will see that the horizon (the uppermost point of the Earth) has moved away and a new, even more beautiful landscape has opened up before us.

The same is happening to creative work. Today, many musicians and composers are already using software products like that created many years ago by the violinist Johann from Bulgaria, just as many engineers are using some TRIZ tools in their practical work and are solving problems which remained unsolved for years in machine building, nanotechnology or microelectronics.

An interesting tendency showed itself in the example of the large number of people engaged in professional study of Classical TRIZ. Initially, they attended TRIZ courses for creating inventions necessary for protecting their dissertations or for solving complicated problems within projects in which they took part. With time, some of them began to teach TRIZ it their organizations, which increased their TRIZ competence. Problems which had previously seemed creative were beginning to look routine. Very often their objectives were becoming more and more complicated. Their creative energy found a way out though attaining those objectives.

At present, traditional advertising specialists meet with competition from colleagues armed with the knowledge of TRIZ application in advertising. Creating an advertising product which would help to significantly increase the sales of products and services of your clients is not at all a simple creative job. Competition is particularly strong in advertising and results are easy to check: a growing sales volume means that the advertising campaign has been properly designed and conducted.

Igor Vikentiev , one of my advanced TRIZ colleagues engaged in the development of Advertising Theory and creating effective methods for practical application, wrote a book entitled *Advertising Principles*. The book has been republished many times and today it is a desk book for many advertising specialists.

It is natural that the book is actively criticized by competitors – traditional ad-makers who insist that creating an advertising product by some methods is impossible and that an ad-maker must always be in the throes of composition to produce a new, original advertising product. However, the desired result is not always achieved. That is why the new generation of ad-makers and advanced professionals buy the book and attend I.V. Vikentiev's workshops. The thing is that his approaches significantly increase the probability of obtaining a positive result, which means a higher probability of conducting a highly effective advertising campaign within a scheduled time frame. Using the TRIZ-based method of conducting advertising campaigns ensures the sustainable production of good results and helps to win in the competition with those who do not admit that TRIZ is a very practical and effective theory.

Elena Novitskaya is a professional graphic designer. She has inventively revised the 40 TRIZ principles and is using them extensively in her work. She has a wide choice of customers. It is necessary to say that Altshuller's 40 principles are the most popular TRIZ tool in the world, but few people know that in 1986, G.S. Altshuller expressed regret concerning the years he spent revealing and integrating those principles and removed them from the arsenal of TRIZ tools.

High competence in TRIZ means that a specialist knows the theoretical foundations and can use them as an applied tool; this helps his company to obtain a steady profit and high results in the field of innovation and increases the chances of success for his company or organization under keen competition.

Why am I so interested in the examples concerning my colleagues from the advertising sphere dealing with the application of TRIZ elements in non-technical fields?

Igor Vikentiev is not an advertising specialist by education. When the USSR economy collapsed and many engineers lost their jobs, those who knew TRIZ began to use its tools for solving problems related to the organization of advertising business and in those niches of products and services where a new labour market was emerging.

In-depth knowledge of the fundamental principles if Classical TRIZ not only ensures the effective application of its tools, but also allows new tools, adapted to specific needs, to be created as necessary.

If experts, creating their tools by the trial-and-error method and without any theoretical generalization, face a situation when their tool does not work, they need to make a fresh start.

If, on the contrary, theoretical generalization has been made, it often, though not always, strongly facilitates the creation of new tools for new applications and the correction of existing theoretical principles. Classical TRIZ and its tools have been created in the same manner by studying the experience accumulated by many generations of inventors.

Thus, we can draw the conclusion that applied scientific theories significantly increase the probability of obtaining a desirable result at a lower cost and at a better quality of an obtained product or service. These theories may serve as the basis for the creation of new tools for everyday practical application. These tools are studied by future specialists in the course of their professional training.

The trouble is that all professionals, future competitors, learn about much the same tools during their professional training. This considerably reduces the competitive advantages of specialists and companies. At present, to win a competitive struggle, one needs to develop and improve the skill of increasing the effectiveness of work while solving so-called creative problems. All professionals are taught to solve problems by standard methods. By far, not all of them can work with non-standard problems. It is, however, just an effective method aimed at defining and solving non-standard problems that offers a tangible competitive advantage. And it is where a deep knowledge of Classical TRIZ comes to the rescue.

Using a good applied theory we do not seek a solution to a problem by the trial-and-error method, but do it systematically, creating, step by step, a solution to a respective specific situation.

The knowledge of theory for building various tools increases the level of professional training and facilitates the effective modification of existing tools or the creation of new ones as and when necessary. That is why more and more universities all over the world are considering a possibility of introducing serious Classical TRIZ and OTSM courses into their academic curricula. A good applied theory turns the solving of complicated, non-standard, so-called creative problems into routine, thereby opening up new vistas for higher-order creative work and for work on more complicated problems. The creation horizons are being expanded, offering new opportunities for efficient creative work.

The notion of creation is akin to that of the horizon and applied theories are cars which allow us to reach new horizons much faster than we could do on foot, and to move to new, still more interesting creation horizons.

1.1 Introduction for teachers and companies

We live in a rapidly changing world. The speed of changes and the appearance of novelties are growing abruptly. It is not easy to orientate oneself in this world. Knowledge quickly gets out of date and new knowledge appears. The situation in the world and in the regions of the countries around us is also changing, as well as economic conditions. Cultures are integrating. Today, it is not enough, as it was previously, to master one specialty, learn typical professional solutions and use them all through one's life…

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TRIZ has been evoking much discussion since the moment it appeared in 1946–1949. First, it arose as an invention-creating METHOD. At that time, creating such a method was believed to be impossible. At that time, the ability to invent was considered a gift of nature. You can either invent if you are endowed with such a gift, or not if you have no such gift. Nevertheless, in 1949 the method was created and tested on very complicated problems. The solutions obtained through the use of this method won a grand-prix at an inventors' competition. In addition, the method was also tested on other problems and yielded steady results. The authors of the method – Genrikh Altshuller and Raphael Shapiro – wrote a letter to Stalin reporting the achieved results. Instead of encouragement, they were arrested and sentenced to 25 years of Gulag punishment. Genrikh Altshuller served his term of imprisonment in the Arctic Circle, working in the Vorkuta pits, while Raphael Shapiro was sent to the south of Central Asia, near Karaganda.

Shortly after Stalin's death they were given their liberty. Raphael Shapiro withdrew from development and research while Genrikh Altshuller continued his work on the method and began spreading it among engineers. The method was being gradually improved and turned into a clear ALGORITHM, which, over the course of time, was given the name the Algorithm of Inventive Problem Solving (ARIZ).

By that time, public opinion of the invention METHOD had started to change for the better. The method proved its effectiveness. It began to be studied and used by different people who, just as Altshuller, obtained excellent results. Skeptics changed their opinion and began to admit that a method of inventing the new could exist, but that referring to it as an ALGORITHM was too strong!

Nevertheless, ARIZ continued to develop and training courses for those wishing to master it began to be organized more and more often. That promoted a more active ARIZ development. The participants of ARIZ workshops kept in touch with the Altshuller and sent him difficult-to-solve problems. Altshuller applied ARIZ to problems analyzed by his followers, revealed the weak points in the algorithm and created new ARIZ versions. As a result, there appeared two figures in the ARIZ name which denoted the year of issue of a given version: ARIZ-64, ARIZ-74, ARIZ-77, etc. Workshops were becoming more and more popular and new ARIZ versions were being produced more and more often, sometimes several versions a year. As a result, letters denoting the version number were introduced into ARIZ names in addition to the figures.

For example, in 1982 several versions were created: ARIZ-82 A, ARIZ-82 B, ARIZ-82 C, ARIZ-82 D.
Each new version had been checked on test problems before Altshuller distributed it. The collection of test problems was permanently growing; it included problems which were impossible to solve using previous ARIZ versions.
There began to emerge schools of inventors, where ARIZ was taught not only by Altshuller, but also by people who had received training from him. By the mid 80s there existed about 300 invention schools where training was organized on different levels and with different frequency.

As time went on, the hypotheses proposed by G.S. Altshuller and Raphael Shapiro in their very first article, dedicated to the foundations of the invention method's creation written shortly after their liberation from the labour camps and published in 1956, found confirmation. Over 30 years were spent verifying the ideas described in the article, during which time new ideas were obtained as well as theoretical foundations underlying ARIZ. All those achievements were integrated into a single theory and tools for use in the everyday engineers' practice. In the mid 70s, the theory acquired the name of the Theory of Inventive Problem Solving (TRIZ).

By that time, public opinion had already accepted the idea of the possibility of creating an invention ALGORITHM, but had begun to deny the possibility of creating an articulate invention theory. It is necessary to say that in the late 80s and early 90s, the possibility of creating an Invention Theory was beginning to be recognized, but TRIZ was denied as a theory. G.S. Altshuller's and I.M. Vertkin's research into the history of innovation implementation by people who changed the world proved that the delay in recognizing innovations is characteristic of all cases regarding the introduction of weighty innovations: aviation, the railway, space travel and many more had to follow the same path to recognition. Today, the recognition of TRIZ as a well-knit and practically effective system is prevented by many factors, the main one being the lack of reliable information from primary sources created by G.S. Altshuller himself.
Popularity is being gained for the simplified and abridged versions of the simplest tools of Classical TRIZ. At workshops, neither the theoretical foundations of Altshuller's Theory nor its most important and basic tool – ARIZ – are considered. The information about Classical TRIZ is diluted with numerous "improved" versions of the "modern TRIZ". Many of these TRIZ versions are far from what could be called an applied invention theory. Judgements about TRIZ are very often based on these compilations rather than on primary sources. It is interesting that as early as 1985, at the first presentation of the research into the history of innovation implementation by creative people of the past and present, Altshuller himself predicted that the events would take this course after his death. That research proved that there exist steady regularities of events which accompany the introduction of new ideas, whether it be within the limits of a separate company or organization or on the scale of humanity scale.

Meanwhile, a new stage of TRIZ development and dissemination started in the mid 80s. TRIZ development logically resulted in new ideas. For example, it became clear that further development of TRIZ required the creation of a strong foundation underlying three new theories.

The first theory should deal with the evolution of those systems that the improvement of which is the job of creative people and different kinds of inventors. G.S. Altshuller called it the Theory of Technical System Evolution (the Russian acronym is TRTS). Because of the historical circumstances, he narrowed the name of this theory and restricted himself to technical systems. Different people (Boris Zlotin, Alla Zusman, Igor Vikentiev, Vyacheslav Yefremov, Igor Kondakov, Yury Salamatov, Igor Vertkin, Natalya and Alexander Narbut and many others) were engaged in TRTS development. Their works formed the basis of the recent versions of the Classical TRIZ tools.

Systems are developed by people – inventors and creators – so it was necessary to understand where the people who changed the world came from and how they managed to introduce their ideas despite the resistance of their contemporaries. G.S. Altshuller and I.M. Vertkin scrutinized the biographies of about 1000 such people whose names had become the history of humanity. It emerged that the biographies of most people who lived in different historical periods of human history and in different regions of the world have certain similar features. Many of them faced similar problems while working on their inventions and ideas and while implementing them. It is important to note that similar problems occurred not only in the life of engineers, but also in the life of painters, doctors, researchers and businessmen (for example the Federal Express history). The analysis results were presented in the form of a business game: "External Circumstances versus Creative Person". It is a kind of problem collection which describes typical problems arising in the life of Creative People irrespective of their occupation, time and place of residence. This research work formed the basis of the second theory, which needs further development. Altshuller and Vertkin called it the Theory of Creative Personality Development (the Russian acronym is TRTL).

The evolution of Classical TRIZ proved that its theory and practical tools are applicable not only to technical systems. Such a hypothesis arose at the early TRIZ creation stages. However, the practical confirmation of this hypothesis required several decades of application of TRIZ tools and theory by different people engaged in research activities in various fields, such as physics, botany, chemistry, various production and financial applications, business applications and different kinds of social problems of different scale, advertising and many others.

Many of Altshuller's followers started applying TRIZ to various problems, including those arising in their private life. There arose a question why some people could and others could not apply TRIZ to various situations. Not only engineers but also representatives of other professions such as advertising specialists, businessmen and research workers were beginning to attend TRIZ schools. Banks, exchanges and government organizations were beginning to resort to the services of specialists. There arose another question connected with the first one: how to teach all those people to effectively use the Classical TRIZ tools in their fields of activity. While searching for answers to those questions, new ideas came to Altshuller which formed the basis of the theory named the General Theory of Powerful Thinking (OTSM). He started to develop those ideas in the mid 70s. In the mid 80s, Nikolai Khomenko was involved in OTSM development.

By the mid 80s, many more people had accepted the idea of creating an Invention Theory. However, both the idea of developing a General Theory of Powerful Thinking (OTSM), as well as the Theory of Creative Personality Development (TRTL) faced strong resistance even in the environment of TRIZ specialists.

The OTSM evolution caused further development of Altshuller's basic ideas and gave an impetus to the creation of a comparatively articulated theory of powerful thinking. This theory formed the basis for the appearance of tools for dealing with complicated interdisciplinary problems containing tens and hundreds of sub-problems from various areas of knowledge. Examples of problems with such an amount of complexity include: managing the sustainable development of a region with hundreds of thousands or even millions ofinhabitants; setting up a company or business based on permanent and effective creation and the introduction of innovation ideas; the creation of research centres capable of changing pioneer heretical ideas into an ecologically safe and profitable business for society.

OTSM provides users with the tools for dealing with various kinds of knowledge. It helps them effectively assimilate knowledge from different areas, including new areas of human activity. That is why a group of researchers from the former Soviet Union selected OTSM as a basis for building new pedagogical tools capable of improving the effectiveness of the educational system in teaching adults and children to deal with problems. For example, one such tool was Alexander Sokol's approach to the simultaneous teaching of foreign languages and OTSM-TRIZ basics. This approach, called the Thinking Approach, is founded on the idea that language is one of the tools used for solving the vital problems of man and in order to master and make the best use of this tool it would be advantageous to know at least the basic approaches to problem solving in general.

Let us look again at the history of Classical TRIZ and see what transformations it underwent during its evolution (see Figure 1).

First, there appeared a METHOD comprising a small number of steps. Then supplementary methods started to appear. In due course, those supplementary methods began to integrate into a system – an ALGORITHM which increased their application effectiveness – ARIZ. ARIZ evolution revealed some fundamental applied theoretical statements which were presented in the form of an applied scientific THEORY – TRIZ. The evolution of the theory proved the necessity of developing several other theories which must serve as a basis for a new TRIZ.

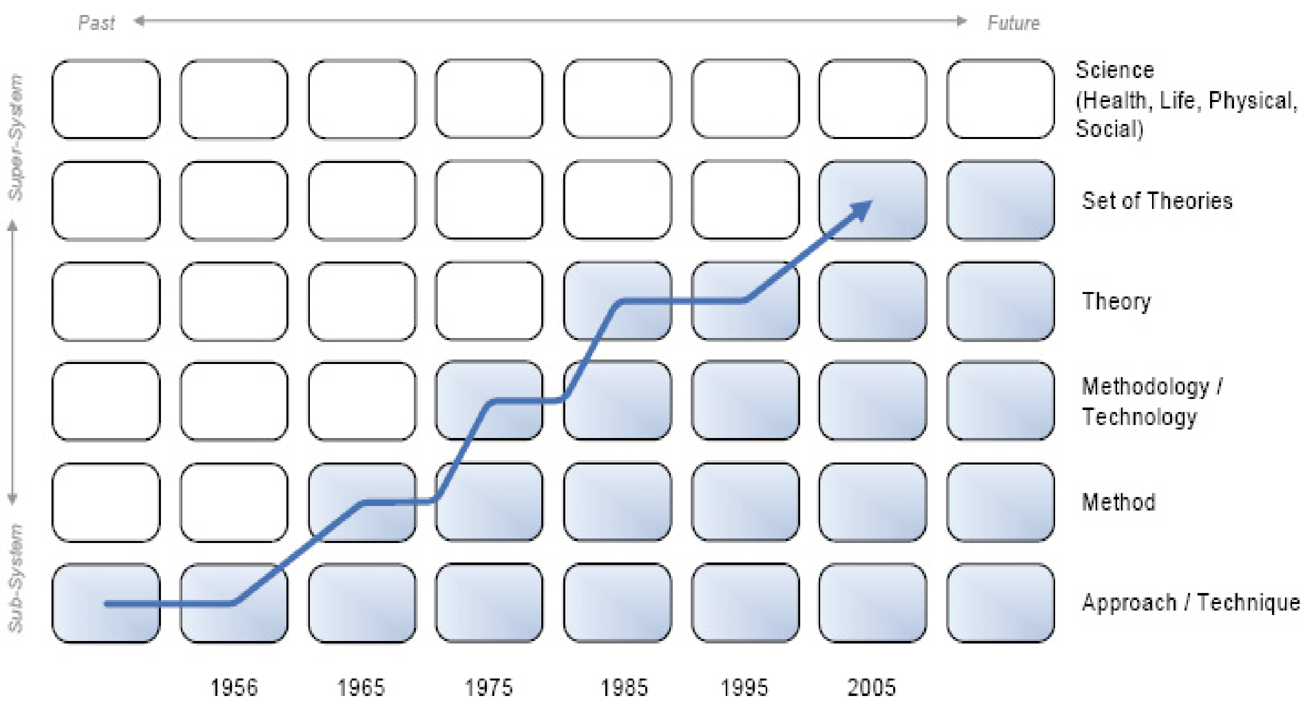

Figure 1. The evolution of Classical TRIZ

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Altshuller thought that the system of theories needed a new, more suitable name, but no new name has appeared so far. Therefore, the formed system of theories is still called Classical TRIZ, which causes some misunderstanding while talking to people interested in TRIZ but unacquainted with its history. As Classical TRIZ acquired popularity in the world, its various modifications began to appear. They are generally strongly simplified and abridged. A reverse process is likely to start – moving away from the already achieved objectives back to special methods and algorithms.

Some of the Classical TRIZ evolution branches produced interesting approaches. For example, an interesting approach and a useful method, named Directed Evolution, was created in I-TRIZ. The main authors of this approach are Boris Zlotin and Alla Zusman. Analysing this and other branches of Classical TRIZ are not within the scope of this work.

Classical TRIZ has repeatedly proved its effectiveness. TRIZ and its tools have been used for solving various problems starting with relatively simple ones (technical) and finishing with all sorts of complicated social problems.

People who come to know TRIZ sooner or later start wondering why it all works so effectively. We will try to answer this question in the next sections. For a better understanding of how and why TRIZ works, it is necessary to go thoroughly into different aspects of Classical TRIZ. Nevertheless, even the most perfunctory knowledge of TRIZ and its theoretical foundations allows people of different professions to cope with many of the problems they encounter in their professional and private life. This is just what makes Classical TRIZ and OTSM attractive to people engaged in the sphere of education.

Research has been conducted and OTSM-TRIZ elements have been used in pedagogy and education for over 25 years so far. Individual special methods have been created as well as complex systems used in education and pedagogy. Using those methods, we are ready, right now, to start developing creative and thinking abilities in children aged 2 or 3 and guarantee a positive result. Most of the pedagogical OTSM-TRIZ tools are represented by games and various kinds of creative activity. Children who began to assimilate creative thinking methods based on OTSM-TRIZ are already grown and have children of their own. It is interesting that they themselves are beginning to work with their children using new, modern methods or creating their own methods if the need arises.

This fact is worth noting: high-quality, in-depth comprehension of OTSM-TRIZ not only improves the application efficiency of the existing tools for dealing with complicated non-standard problems, it also allows the prompt creation of needed tools if those available do not cope with a problem.

The current OTSM-TRIZ is in fact a construction set composed of various tools which are united into a required system according to respective rules. These rules constitute the theoretical foundations of OTSM-TRIZ to be mastered for a better understanding and for solving problems arising in the educational system. That is why we are starting with the theoretical foundations. You should not be afraid of the word “theoretical”, because the theoretical foundations of Classical TRIZ and OTSM are in effect applied tools of a higher generalization level. That is why they work where the existing standard tools of professionals and experts of all kinds cease to work.

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We live in a rapidly changing world. The speed of changes and the appearance of the new are growing abruptly. It is not easy to orientate oneself in this world. Knowledge quickly gets out of date and new knowledge appears. The situation in the world and in the regions of the countries around us is also changing, as well as the economic conditions. Cultures are integrating. Today, it is not enough, as it was previously, to master one specialty, learn typical professional solutions and use them all through one's life. New knowledge and new tools for working with this knowledge appear even within one specialty. It is difficult to foresee how the world is going to look in several decades. It could be said that this problem is solved by life-long learning. To better outline the problem, let us use one of the Classical TRIZ tools – aggravating the problem situation to an absurd extreme. This method allows basic roots to be identified within a problem, leaving for a time the remaining particulars for subsequent analysis.

Let us imagine that we have created the best, the most advanced training course and begun teaching a group of students. Some days later, the students successfully defend their graduate papers and get diplomas. But when they leave their educational institution it becomes clear that the most advanced skills and knowledge they got while studying became hopelessly outdated during the training period. Real life changed during that time and required new skills and knowledge.

The situation is really challenging and many educators are really at a dead end! What should they teach to students in this rapidly changing world if knowledge becomes obsolete by the end of a training course?

The Third Millennium, G.S. Altshuller's unfinished novel, describes a fictitious school where not narrow specialists are trained but generalists capable of deriving the knowledge necessary for resolving vital situations.

Problems are also changing. Typical professional solutions are becoming useless. What is to be done?

We think that G.S. Altshuller's ideas exposed in his fantastic novel are worth our attention. We have to teach our children about living in a world about which we ourselves know very little. Today we cannot provide our children with standard tools for solving problems which are unknown to us. What we can do is teach them to create tools for effectively solving those future, unknown problems. This is proved by the applied experience of Classical TRIZ and OTSM. Probably it is not enough. Neither Classical TRIZ nor OTSM can replace special knowledge in various subject areas. However, we think that the skill of dealing with the knowledge about problem situations is one of the fundamental subjects of the educational system of the future. And we must start creating this future right now.

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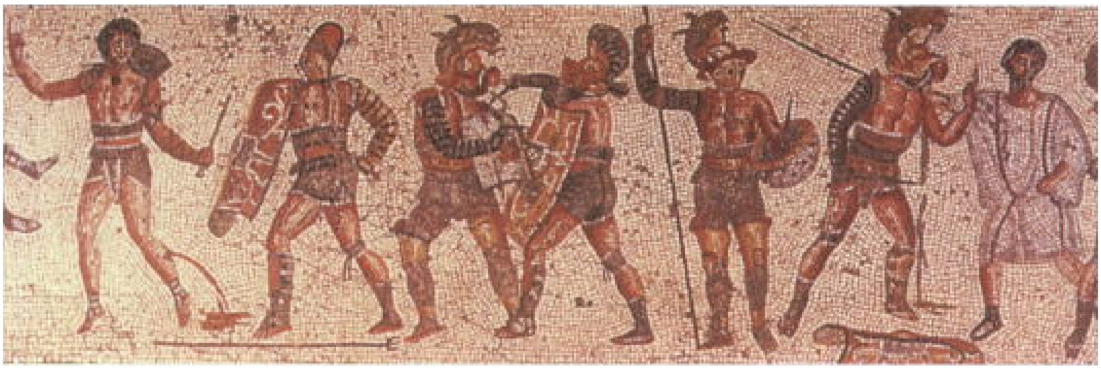
1.2 Introduction to TRIZ for students

Nowadays, it is difficult to find somebody who has never played a computer game, at least once in his life. A significant number of computer games is offered, and differ from each other in their plots, graphic levels, sound quality… and in their AIMS of winning in the virtual world.
But how can these people solve a real problematic situation and become a winner in the real life?
In our electronic book we will discuss these questions. The physical and emotional feelings of gambling, astonishments which appear as a result of new discoveries, victory triumph will be familiar to you because everything begins from games and real life demands considerable efforts…

... The Roman Empire, the Rom centre, the Coliseum arena. The bright son appears over the tribunes. You have a short, fighting sword and a light, consistent shield in your hands and feel with your shoulder a shoulder of your fellow-soldier in the compact, locked file of fighters. With the slight press of the button everything goes in motion. The tribunes cry with excitement! The dozen thousands of hands are risen up. In the opposite side of the arena dust is mounted up from the furiously rushed, fight chariots of the enemy. And your team knows how to turn these hateful chariots down and to achieve a victory over the stronger enemy!



(source: The Ancient City: Life in Classical Athens and Rome di Peter Connolly e Hazel Dodge)

Of course, it is only a game …

... The modern, supersonic, combustion ramjet. You have a hand wheel of this high-powered machine in your hands. The roar of the engine makes you push yourself in the seat and feel acceleration physically. The takeoff strip flashes downwards and is changed by the beautiful Earth view. The horizon is marked by tender, pastel tones and above you can see endless space darkness. You find yourself in face to face contact with this miraculous, iron bird. With the slight movement of your fingers on the control

(source NASA Photo ID: EL-1997-00146 AND Alternate ID: L96-924)

box and you make the rocking wings move. The plane turns, drifts down and flies up again. You feel yourself like a hero. The professional pilots who operated planes throughout their service life express their admiration about such training stimulators.

Probably, it is a game as well…

Modern role playing games (RPG). You play a computer game not alone, not even with a couple of your friends… The dozen hundreds and even million of players are involved in the game! Their presence can be filled physically as a shoulder of the fellow soldier in the Coliseum arena. In addition to high-powered acoustics, nice and quick graphics and special effects the game interactivity appears. The plot development depends on the players and their actions. The play appears to be like life. The situation can change quickly and in these conditions it is necessary to take responsible and non-standard solutions. The plot roles can be different: household, travel, politics, new business development, child's upbringing, social life, economy…

Is it a game as well?

These examples are linked by the astonishing feeling of reality, the power feeling over the computer, the possibility to get new skills and also diverse levels and aims of these tools in the world experience.
And it is not necessary at all that games, plots and images which were illustrated above coincide with your favourite.
It is more necessary to understand the core of a game correctly.
We would like to emphasize the following points in these image pictures.
Our amazing, changeable and manifold world demands new knowledge about tools, modelling and management skills during its development.
In the Middle Ages only a few scientists could add, subtract, divide and multiply figures which exceeded by its amount the number of fingers in both hands:

XLIX * XLI = ?

And the reason lies not in presence or absence of intelligence, but in solution of non-standard problems. The roman system of calculations was time-consuming and uncomfortable and even more complex for difficult, untypical calculations. With the invention of Arabic figures and of the decimal system it becomes easier to study arithmetic. And nowadays, everyone can study it, if he wishes. It is even more important to find with a methodic approach the correct direction while solving inventive, i.e. non-standard problems. Nowadays, everyone can learn it, if he wishes.
The double calculation system makes even computers work more effective…

The tool and the fundamental knowledge and models where this tool is found play here a crucial role.

This book is written with the aim of sharing our knowledge about TRIZ and of learning how to use TRIZ tools in order to solve non-standard problems. In the following two pages we give an overview of some basic questions.

What?

This book is about TRIZ – a theory of solution of non-standard tasks. This theory gives the basis for the creation and the appliance of solving tools for complex, non-standard problems. It differs from other theories by its universality – this approach is applied in any subject areas, though it does not substitute special knowledge. At the same time it is instrumental because it suggests using concrete rules during a problem solution.

What is a Non-standard problem?

For example, the following task which was posed 50 years ago was solved with the help of TRIZ by its inventor, G.S. Altshuller:

It is necessary to develop a fire resistant, heat-protective suit. It must provide safety protection from high temperatures (100 ^{0} C) in a fire point and also have a self-contained breathing system to survive poisonous gas produced by combustion. Materials capable to resist to high temperatures have been already invented. And the systems of self-contained breathing have been also found. What causes then a problem? The case is that it is almost impossible to work in this heat-protective suit because it is equipped with two systems: the self-contained breathing system and the system of heat protection. And one should bear in mind that it is also necessary to carry tools and sometimes to evacuate injured people…
The question is how to decrease the weight of the heat-protective equipment?

(fonte: Photo Contest Entry, color, Mar. 1981, "Air Force Fire Fighters" VANDENBERG AIR FORCE BASE, CALIFORNIA (CA) UNITED STATES OF AMERICA (USA), autore AIRMAN MELODY A. WEISS

If reformulate this problem in accordance with one of TRIZ tools, one can guess how we can solve this problem:
If the self-contained breathing system will be excluded, then the heat-protective device will be easier, but it will be impossible to work because the breathing system is not provided. If the system of heat protection is excluded, then it will be possible to locate the self-contained breathing system. But how we can provide heat protection?
It is necessary to create the heat-protective suit which will provide a fireman with air and gives him necessary heat protection, using the accessible technologies and materials.

The task remains non-standard, until the method of solution is unknown.
One of TRIZ tools was applied in order to solve this problem: **it was necessary to change and to combine systems so that its advantages remained and its disadvantages disappeared.**

Applying this general rule to the concrete problem with the heat-protective suit, we can give the general description of the problem solution: it is necessary to combine two subsystems in one system in order to provide breathing and heat protection.

According to one of TRIZ tools the formulation of this problem gives a concrete direction how to solve this problem: we should think about the connection of two subsystems in one main system in order to decrease the weight of the heat-protective suit.

It was suggested to use liquid oxygen for the system of heat insulation and cooling at a temperature of minus 183°C. Liquid oxygen which vaporizes and transfers into gas cools the heat-protective suit. It takes heat from this suit and when liquid oxygen is heated, it can be also used for the breathing system. As a result, not only the weight of the heat-protective suit will be reduced, but also firemen can stay longer in the dangerous zone and the comfort during their work is also improved. As a result of this invention extra benefits appear: such a heat-protective suit could give a fireman the possibility to do his work up to a temperature of 500 ° C.

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It is the best possible solution, isn't it?

The main idea of TRIZ refers to the observation that our world evolves according to objective laws, which can be explored and implemented in practice. And the creative processes are not exceptions because we have some rules for them as well.

As a reader, you can briefly make an acquaintance with TRIZ, when you read this introduction. You can see the animations which reflect the core and the history of this theory and go deeper into reading and studying this training aids. It is up to you to decide.
Your knowledge will be turned into skills and attainments, when you will feel the effectiveness of this method with the tip of your fingers. You will realize the effectiveness of TRIZ firstly during the solution of some training tasks and the lectures of your teachers and then, in real-life experiences. And from your efforts not only the course of the game will be changed as in the above described plots, but also the course of life will be changed. And you will feel yourself like a winner not only in a game, but also in real life.

Who?

Whatever is your age or profession, for sure you have already realized in your life that we live in a world of problems and we spend a lot of time trying to overcome them.
The book is written with the help of the programme *Lifelong Learning* and is intended for people of different ages and professions. You can read it by yourself or with the help if the lectures of your teacher; hopefully, this will be just the starting point of a deeper study of TRIZ and its powerful instruments.

Where?

The printed form of this book will appear in the countries of all the project partners in several different languages: English, French, German, Italian and Latvian. You can print this book or read it on this website. Here you can find information about conferences, seminars, books, magazines and forums. It does not matter with what you begin your acquaintance with TRIZ. The more important is the result, which you can achieve. At least, the part of the result which some companies achieved as a result of its appliance of TRIZ in practice: *ABB, Ford, Boeing, General Motors, Samsung, Chrysler, LG, Eastman Kodak, Peugeot-Citroen, Exxon, Siemens, Procter & Gamble, Digital Equipment, Xerox, Hewlett Packard, Motorola and many others…*

When?

If you do not have five spare minutes for the beginning of your acquaintance with TRIZ, then you can read about it during your lectures and conferences, travels on public transport and waiting for a doctor's appointment. You can suggest solving an interesting task during a party with your friends. That will animate your party and explain how the chaotic search for a proper variant differs from the meaningful solution which you will be able to acquire to that time to a certain degree.

Why?

In order to improve the quality of Your life: to achieve a professional success, improve one's social position and to increase material benefits.
In order to become special: to see the world from another side, do not scare an unknown and to find solutions which you can find in comparison with others who are not capable of obtaining any solution.
In order to gain satisfaction from seeing that impossible becomes possible, from helping and making somebody happy. You also feel satisfaction from acquiring skills about which you have had no notion.

We will be glad to see you in your circle- among people who not only seek for answers to difficult questions, but who find them self-confidently. Do not loose your time dear reader! We wish you success and cool solutions!

1.3 TETRIS OTSM[1]—TRIZ glossary-solution

1.3.1 Problem.

1.3.1.1 Typical Problem.

Definition:

Typical problem is a problem that is typical for certain domain of human activity, there for in this domain typical solutions for that kind of problems are well known.

Theory:

One of Sub-Function of Altshuller's ARIZ (ARIZ 85-C) is transformation of a non typical problem description into typical one. Then we can use typical solutions of TRIZ or/and typical solutions from domain where this kind of problems are most typical and well known.

1.3.1.2 Non Typical Problem (see: Innovative (Problem) Situation).

In the border of OTSM-TRIZ Non Typical Problem

1.3.1.3 Innovative (Problem, Inventive) Situation.

Definition:

Innovative situation is a situation we would like to change but typical well known solutions could not be helpful for certain reasons.

Theory:

Some innovative situations arise due to some undesirable phenomenon that should be eliminated or decreased. More generally we consider Innovative situation as unsatisfactory situation of many kinds: we would like to change something but it is not possible for certain reasons or changes we are going to make lead us to a conflict with other shareholders participate the problem situations. Sometimes Innovative situation arise when we have to explain unknown phenomenon that appear in nature, scientific research, manufacturing and business process of an organization etc. Any kind of contradiction between a natural phenomenon and contemporary scientific knowledge could be also considered as an innovative situation: it is necessary to think on new paradigms capable to resolve contradiction between real life phenomena and actual scientific theories.

Even more generally: any kind of unhappiness with status quo we could not change within modern stereotypes and typical solutions we could consider as an Innovative Situation.

1.3.2 Solution

1.3.2.1 Typical Solution.

Definition:

A well known solution of a typical problem presented in general form. Used by many professionals who learn typical solutions during their professional education and throughout their professional experience.

General solutions should be adjusted for a specific situation. Then typical solution became implemented solution (See: Implemented Solution).

1 At the beginning of 1980s more and more people started applying TRIZ not only to engineering problem solving but to different kinds of problem, even in their private life. That is why Altshuller started writing in his articles and manuscripts that TRIZ had to be transformed into the General Theory of Powerful Thinking. OTSM is a Russian abbreviation for the theory and at the same time the name given by Altshuller himself. As our research was provided under his supervision and he approved of our results, in July 1997 Altshuller granted N. Khomenko a permission to use the name OTSM for his research. This was done under the condition that every time the name was going to be used, its history had to be explained. That is why this comment appears here.

1.3.2.2 Non Typical Solution.

Definition:

Solution that is unknown for professionals who are working on the problem (innovative) situation. See detail: Innovative (Problem) Situation.

1.3.2.3 Line of Solutions.

Definition:

In the framework OTSM-TRIZ problem solving Process (See: OTSM-TRIZ Models of a Problem Solving Process) we distinguish several main lines of non typical problem analysis. Line of solutions show how appear implemented solution out of initial description of non typical Innovative (problem) Situation (See: Innovative (Problem) Situation).

Theory:

The Mile Stones system of several lines was developed for educational proposes, but it is also helpful for avoiding some misunderstanding between members of a problem-solving team as well as between an OTSM-TRIZ coach and his customer.

Here we deal with one line of analysis of a problem situation - that of building a solution that is used in practice here and now – in specific conditions.

These are the requirements for the Solution Line which are in our opinion the most important ones in terms of the OTSM-TRIZ problem solving process:

The Line must be coordinated with the entire complex of lines of analysis of a problem situation and synthesis of solution on the basis of the models of Classical TRIZ proposed by Altshuller [G.ALTSHULLER.: Process of Solving an Inventive Problem: Fundamental Stages and Mechanisms. April 6, 1975. (http://www.trizminsk.org/c/126002.htm)].

The Line must not depend of the used tools of problem analyzing and solving, in order to provide flexibility of its use for various tools of problem solving.

The Line must not depend on those areas of knowledge to which the problem pertains, in order to be universal and subject-independent.

The Line must be simple and understandable by experts in the problem area even without a specific knowledge of the problem solving technologies, in order to use a team of experts-specialists in narrow fields and to communicate in one conceptual language.

Model:

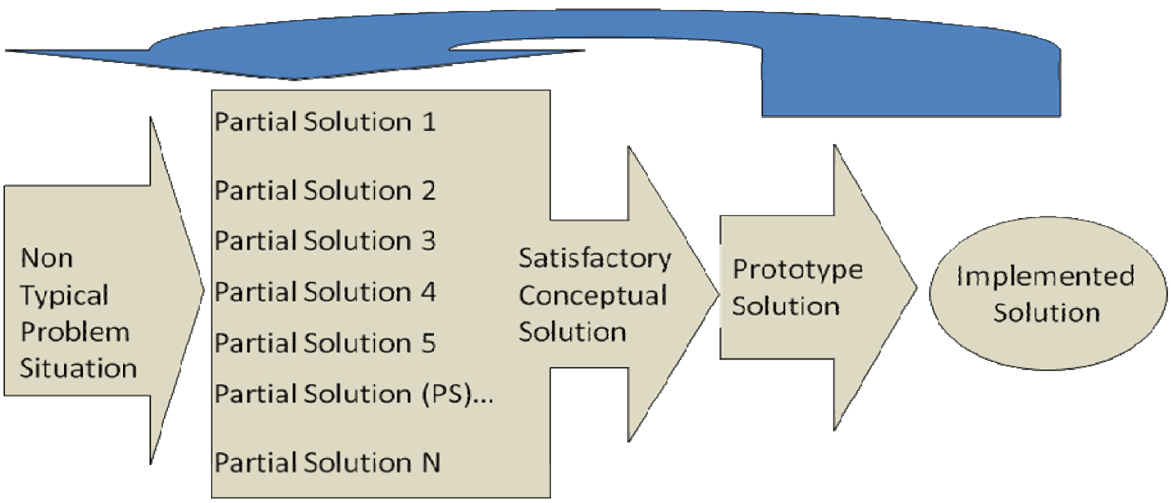

Figure 1. OTSM-TRIZ Line of a Solution.

Theory:
During OTSM-TRIZ problem solving process we use typical solutions of a certain specific domain of knowledge or TRIZ typical solutions and techniques to obtain Partial Conceptual Solutions (PS) or Partial Solutions (See: Partial Conceptual Solutions). Each Partial Solution could be presented as a hypothetical system. Those hypothetical systems (PS) could be converged according TRIZ rules of system convergence and produce new partial solutions. As soon as we obtain Satisfactory Solution (See: Satisfactory Solution) we can switch from conceptual solutions stage to implementation stage and developed Prototype and Implemented Solutions (See: Prototype Solution and Implemented Solution).
During implementation of a satisfactory conceptual solution (Stages of Prototype and Implemented solutions) some new problem situations could arise. In order to correct satisfactory conceptual solutions with respect to those newly born problems OTSM-TRIZ problem solving process could be applied. These iterations should be used until corrected satisfactory conceptual solution will be implemented with appropriate quality.
Most specialists who encountered a problem situation have a strong conviction that the more solution concepts (ideas) are developed in the course of problem analysis, the better for the project. At the same time here and now – in specific conditions – one solution is being used. We consider this solution, embodied here and now - specific material objects; specific actions performed by people or a method and theory that are being used in practice – a final goal of problem-solving and call it Implemented Solution
In other terms generating a high number of conceptual solutions is to be considered a waste of time end efforts and should be avoided in order to increase the efficiency of the innovation process.
An exteriorly obvious idea is often seen as a novelty even in the environment of professional problem solvers. At the same time, those who regularly deal with problem analysis and problem solving know that while analyzing, one often comes across multiple solution ideas. Those ideas are often indistinct, are not filled with specific knowledge. Often and often those ideas have numerous disadvantages, having at the same time something positive in the context of solving a specific problem. Such ideas, described in the form of a set of their positive and negative properties within the framework of OTMS-TRIZ, are called Partial Conceptual Solution or Partial Solutions (PS).
Nevertheless, in the course of the work on a problem, these Partial Solutions gradually concretize, integrate with one another forming a more concrete outline of a further Implemented Solution. This kind of solutions, forming a system of Partial Conceptual Solutions, is called Converged Conceptual Solution (CCS).
The difference between Converged Conceptual Solution and Partial Conceptual Solution consists in that:

- Converged Conceptual Solutions are more concrete and are close to reality unlike very indistinct Partial Conceptual Solutions, which are rather fragments of fairytales than solutions to be used in real life.
- Converged Conceptual Solutions are created in such a way that positive properties of different PCS are summed up and multiplied producing a synergetic effect, while the negative properties of the same PCS decrease and eliminate one another.
- Converged Conceptual Solutions are now evaluated not only by their positive properties, but also by the disadvantages inherent in them and by the negative effects they may cause when realized. To reveal these negative, undesirable effects, mental experiments and computer and full-scale simulation of individual CCS are carried out.
- Converged Conceptual Solution includes Partial Conceptual Solutions as constituent elements. Moreover, other CCS may figure in the capacity of CCS elements.

As a result of CCS integration with one another and with PCS, there appear CCS which may have undesirable properties and effects, but the summary level of their negative, undesirable properties and effects is much lower than the produced positive properties and effects. Such solutions look quite acceptable. This testifies to the fact that we have obtained a new type of solution, which we call Satisfactory Conceptual Solution.

The distinctive features of Satisfactory Conceptual Solution as compared with Converged Conceptual Solution are:

First of all it is the fact that the desirable integral – positive - effect considerably exceeds the negative - undesirable – effect, which is so small that in some specific conditions of a specific situation it is quite possible to reconcile oneself to it.

While there may be dozens of PS and CCS, the number of Satisfactory Conceptual Solution rarely exceeds 5 or 6 (it may amount to 10-20 together with variants.).

Description of Satisfactory Conceptual Solution is more specific and concrete than PS and CCS. It is concrete to such an extent that it is possible to pass to the selection of necessary materials and components and to start development and manufacture of prototypes.

All so far described processes occur in the heads of problem solvers. The obtained ideas are checked with the aid of mental experiments, tracing and sketching, and computer simulation. Sometimes, in order to check some PCS and ICS, full-scale experiments are carried out before selecting or rejecting the obtained ideas for manufacturing a prototype or experimentally checking its efficiency. The selected Satisfactory Conceptual Solutions embodied in a prototype and tested experimentally with a positive mark are called Prototyped Solution.

After passing to work on Prototyped Solution, the situation changes basically. So far, we have dealt mainly with mental simulation and mental experiments. Now a full-scale experiment with physically existing models is of first importance. At this stage, a transition to idea realization, to its embodiment in specific forms starts: mechanisms, constructions for engineering systems; organization, groups of people, organizing various events, law provision of various formalities, etc. are for problems from the business sphere.

Though at the implementation stage we are dealing mostly with material embodiment of ideas, we, nevertheless, encounter some problems, the solution of which requires mental experiments, analysis and generation of additional Conceptual solutions. In other words, we need the same mechanism of problem solving which helped us obtain Conceptual solutions accepted for prototyping.

After the tests have been carried out, the problems have been solved and a decision to pass from a prototype to implementation stage has been taken, we face once again the situation, when it is necessary to solve the arising problems. And we can use once again the mechanism of obtaining a Conceptual solution, which we used in order to obtain solutions suitable for prototyping. In a general case, prototyping of some additional conceptual ideas may be needed.

Thus we can describe in a general form the process of work on a problem from an initial situation till a solution introduced in practice. It will comprise three stages:

Mental simulation of a problem situation in order to obtain a conceptual solution.

Full-scale simulation or experimental check of conceptual solutions obtained at the stage of mental simulation in order to obtain a well-tested material prototype of the conceptual solution.

Implementation of a finalized prototype and its wide use in real life situation for which it is designed.

This is just one of the most general schemes of OTSM-TRIZ presenting different approaches to the process of transformation of Initial Problem Situation Description to a concrete production of Implemented Solution (material or non-material) or actions in accordance with some plan.

We call this scheme Line of Solution:

- Initial Problem Situation Description, - without an acceptable solution.
- Conceptual Solution (Partial, Converged and Satisfactory conceptual solutions), - description of a solution, accepted for prototyping or implementation.
- Prototyped Solution, - tested prototype accepted for implementation.
- Implemented Solution, - Desirable result performed and accepted.

Initial Problem Situation Description is usually indistinct. It is not always clear what are the aims and what means are allowed to use. There is only a description of some disadvantage – some Undesirable Effect, of something to be eliminated or changed.

Implemented Solution is a specific product that eliminates the initial problem situation. This problem may be of various kinds:

- Material, for instance, some electronic devices, mechanical machines or buildings.
- Nonmaterial, for instance, theories and methods, some feelings of a spectator examining a picture or other work of art.
- Actions already performed in accordance with a certain plan in order to achieve some aim or actions, which achieved that aim.
- Combination of the above-mentioned products.

OTSM-TRIZ approach is aimed at providing a transition from the Initial Problem Situation Description to a Conceptual Solution. This is the main designation of this approach and its niche in the problem solving process. At the same time, since certain problems occur often enough both in passing to Prototyped Solution and in passing to Implemented Solution, one can say that the OTSM-TRIZ approach is applicable to all stages of problem solving – from Initial Innovative (Problem) Situation Description to Implemented Solution. Just like mathematics is used for estimating and evaluating concepts, for calculations necessary for creating a prototype, and for calculations needed in transition from a prototype to Implemented Solution. Just as in case with mathematics, the OTSM-TRIZ approach may be used in all sorts of specific problems arising due to some undesirable phenomenon or unsatisfactory situation in order to obtain conceptual ideas on how phenomenon could be decreased (eliminated) or undesirable situation could be changed.

Classification of the main types of solutions used within the framework of OTSM-TRIZ approach to the problem situation analysis:

1. **Initial Problem Situation Description -** description of something undesirable without an acceptable solution how to eliminate it.

2. **Conceptual Solution -** description of a solution accepted for prototyping or implementation.
2.1. **Partial Conceptual Solutions** – appears as a result of the analysis stage of a problem solving process.
2.2. **Converged Conceptual Solution -** appears as a result of the synthesis stage of a problem solving process
2.3. **Satisfactory Conceptual Solution** or just **Conceptual Solution – Converged Solution** that passed test of mental experiments or computer simulation and was accepted for prototyping or implementation.

3. **Prototype Solution -** tested prototype accepted for implementation.

4. **Implemented Solution -** result of problem solving that is performed and accepted.

1.3.3 Models for representation of Elements of Innovative (Problem) Situations

1.3.3.1 ENV Model

Theory:
OTSM based ENV model is one of the two most important models for understanding both theories and their instruments for efficient problem solving: Classical TRIZ and OTSM.
So what is an ENV model? What for it was introduced and how this theoretical model could be used for everyday life practical needs?

Definition:
ENV means: Element – Name of a property – Value of the property, or for the shorter - ENV.

Theory:
The ENV model is dedicated to formalize description of elements of a problem situation to be analyzed. This is one of functions of Classical TRIZ System Operator (SO) (see: System Operator) as well as Advanced System Operator (ASO) developed in the course of transition from Classical TRIZ to OTSM. System Operator of Classical TRIZ became a component of an Advanced System Operator and ASO in turn included into OTSM ENV model as one of its component.
The use of the ENV model could simplify the understanding of many nuances of Classical TRIZ and how practical instruments work. Moreover, it makes the educational process more logical and transparent. All classifications we apply in the context of OTSM-TRIZ based problem solving process is based on the ENV model, as well as all instruments of Classical TRIZ and OTSM are underlying by this model. This is helpful also when needs arise to integrate some particular Instrument of Classical TRIZ or OTSM with some other instruments for intellectual work, such as Six Sigma, Taguchi method, QFD, various tools for strategic planning and project management, Knowledge management and various computer system for knowledge processing, Neurolinguistic Programming (NLP) and many others. This is one more reason why this model Appear in OTSM-TRIZ: Simplification of integration OTSM-TRIZ with various complementary instruments for intellectual activity of a human and computer support for human thinking.
Three main functions of OTSM ENV model:

- Formalize descriptions of elements involved into innovative situation.
- Simplify education by making transparent links between all theoretical models and practical instruments of OTSM-TRIZ.
- Simplify integration of Classical TRIZ and their instruments with other complementary instruments were created to support intellectual activities of human and computer.

Three main components of ENV model:

- Element.
- Parameter.
- Value.

Example:
In the context of our everyday life we use just simplified version of the ENV model (Figure 2: Model “Element-Feature”.). When we describe an “apple” to someone who has never seen an apple before or when we explain to foreigners the meaning of the word “apple”, we say that it is a fruit; hard enough; that could be green, yellow or red; usually sweet enough but not too much; round or oval; it grows on trees etc. for many common cases it is enough and convenient for communication on any other subject we have in reality or in our imagination. This is a model Element- Property.

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Model:

Name of an element and list of its features.

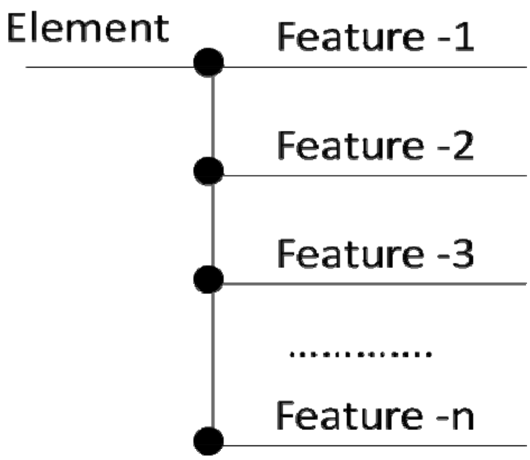

Figure 2: Model "Element-Feature".

Theory:
However, to overcome mental inertia and resolve problem (innovative) situation efficiently it is better to use a more detailed model where feature is split into Name of a property and Value of the property presented as a name of a parameter and value of the parameter.
Please, pay attention that in the context of OTSM-TRIZ we consider feature as a synonym for: parameter, variable, property, characteristic, etc. In other words everything that we use to describe certain Element and that could be presented as a Name and set of its Values.

Model:

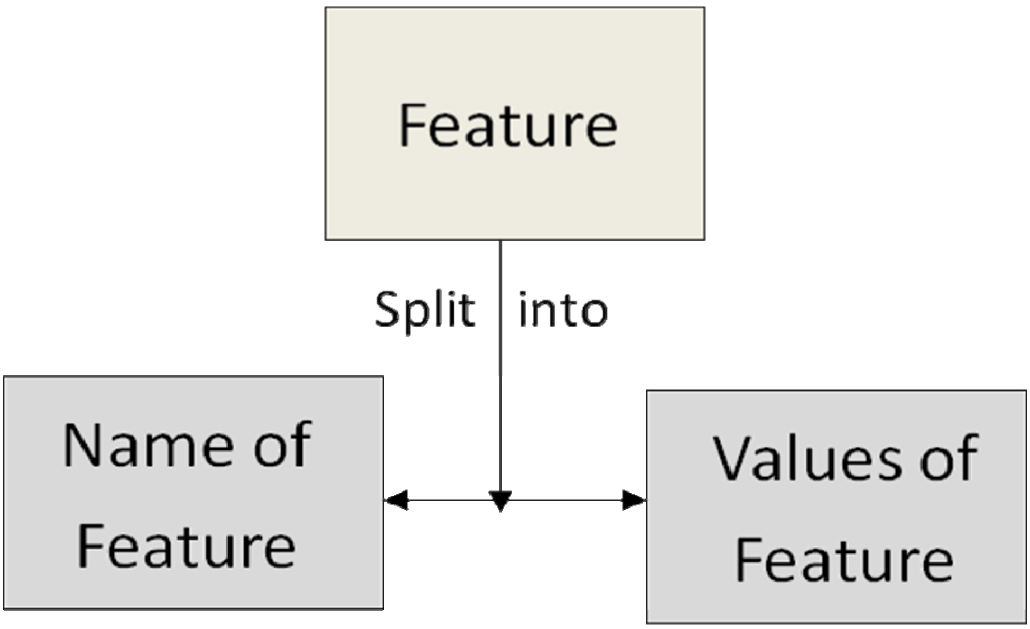

Figure 3: Feature Split into Name of a Feature and Value of the Feature

Example:

Element: Apple - could be viewed as a set of important parameters: Kind of Plants; hardness; color; level of sweetness; shape; kind of plant it growing on etc.
Each of these parameters could have a specific value: Kind of Plan has value – Fruit; hardness has value – hard enough; color could have several values - Green, Yellow; Red; level of sweetness has a value – Sweet enough but not too much; parameter shape has a value – Round or Oval; plant were it grows – Tree.

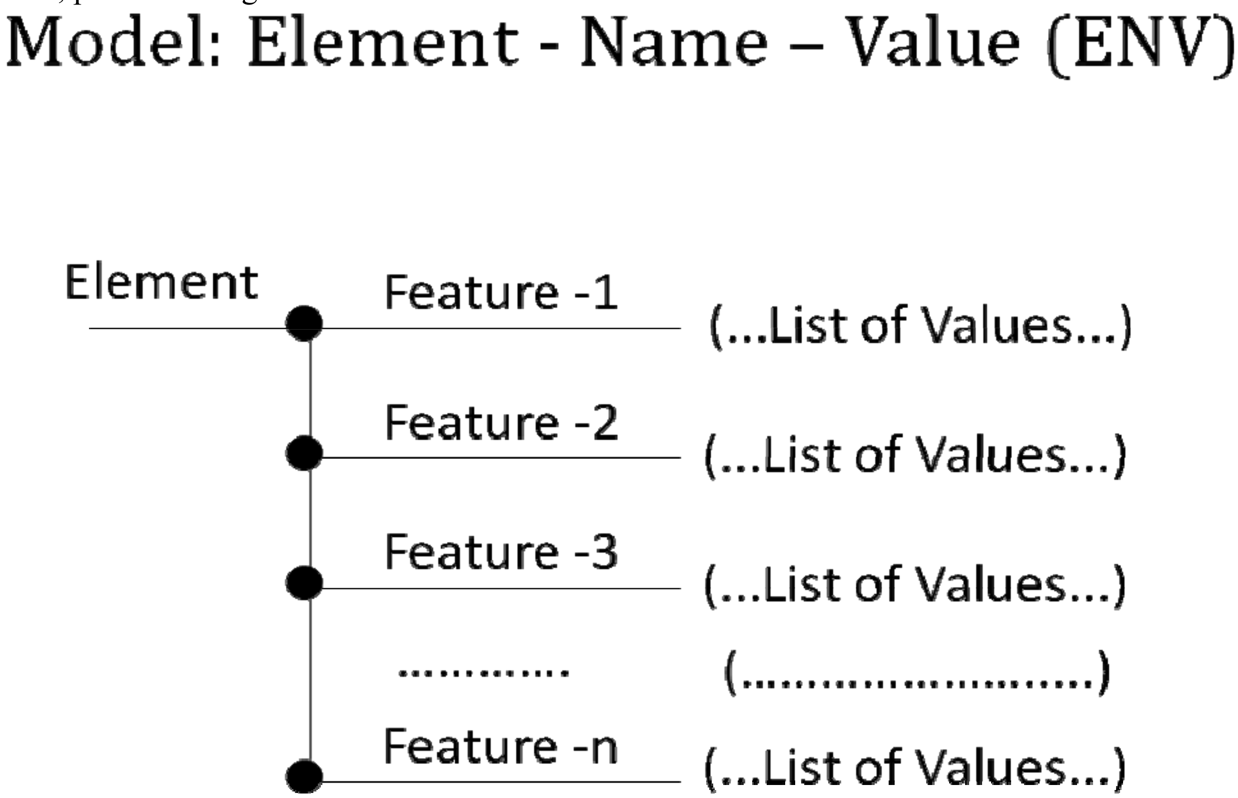

Figure 4: General Model: "Element-Name-Value" (ENV)

Theory:
In order to be meaningful, each of the parameters used to describe a certain object must have other possible values in some other elements of the world. In other words when we say that the property "color" of an "apple" can assume the values "red, yellow and green", we provide an useful information if other objects in the world can assume different colors (e.g. purple, orange, blue etc).
ENV model should be viewed as a multidimensional space of parameters. This perception of ENV model brings many advantages that help increasing the level of formalization in the course of work on solving complex interdisciplinary problems.
The Classical TRIZ concept of Contradiction shows us exactly what parameters of what elements must change their values, and Convergence Rules introduced into Classical TRIZ by Igor Vertkin [Igor Vertkin. Механизмы свертывания технических систем.] could help us transfer those features to other component of a system and increase ideality of initially given system.
Using the ENV model for teaching Classical TRIZ in order to describe various elements (components) supports the clarity of the explanations, helps understanding what those elements have in common and how we can distinguish those elements (components) from each other.
Last but not least. Notion of Element as well as Parameter and Value are not something absolute but relative. In some specific case Red color could be treated as an element to be improved

in term of its property: dissemination on the colored surface (possible values: uniform; spots; lines, circles) or in a saturation of the red color (possible values: High saturation, medium saturation, low level of saturation, saturation as a sunset sky or saturation as a dark red rose etc.). This relativism is based on the Specific Situation Axiom of Classical TRIZ and helps implement this theoretical axiom as a very practical instrument to destroy mental inertia and develop satisfactory conceptual solutions.
For Classical TRIZ simplified ENV model described above is perfectly suite. However for most advanced applications and complex problems it is necessary to study Fractal Structure of an ENV model.

1.3.3.2 Element (component)

(See also: ENV model)

Definition:
In the context of OTSM-TRIZ we consider as an Element everything we can think of. It does not matter if it is substantial or non substantial, if we could not touch or feel by our sensors directly or indirectly as well as any of imaginary things we can find in fairy tales and fiction stories and novels.

Example:
Examples of real world elements: Trees, grass, human, animals, technical systems.
Example of models which have been used or are still in use in scientific representations of the World: Phlogiston, Relativity Theory, Objective Laws of nature, Mathematics etc.

1.3.3.3 Parameter (variable, synonyms: property, feature, characteristic, etc.)

(See also ENV model.)

Definition:
In the context of OTSM-TRIZ a parameter always belongs to a certain Element and has at least two different values.

Examples:
Element: Color
Parameter: Saturation
The parameter can assume different values: red as a Summer Sunset, or red as a dark red rose, or red as a tomato, or red as Flamingo.

Element: Statement
Parameter: Truth
The parameter can assume two values: True and False.

At the same time, Truth as an element can be characterized by a set of parameters. For instance: parameter Level of truth: Completely True, partially True, absolutely Not True. Parameter Time when something could be true or not: existing of Phlogiston was considered as a truth before Thermodynamics Theory was initiated, and today Phlogiston is considered as Not True.

1.3.3.4 Value

(See also: ENV model)

Theory:

Each Parameter (variable) that belongs to a certain Element can assume a limited set of values among the possible values which can be associated to that Parameter (starting at least from two different values to an infinite set of values).

1.3.3.5 System Operator (multi screen schema of powerful thinking)

Theory:

System Operator (SO) or, as Genrich Altshuller named it, Multi-screen Schema of Powerful thinking, shows the model of powerful thinking in the course of problem solving process (Figure 5: System Operator or Classical TRIZ Multi-screen Schema of Powerful Thinking.). Learning this model and develop appropriate skills to use it in practice is a core of Altshuller's educational program. For this purpose ARIZ was created. Altshuller often mentioned that ARIZ is a multi screen schema of powerful thinking presented in the form of line of analysis of a problem situation. It means that ultimate goal of ARIZ education is learning the most efficient way to use System operator for problem solving.

Model:

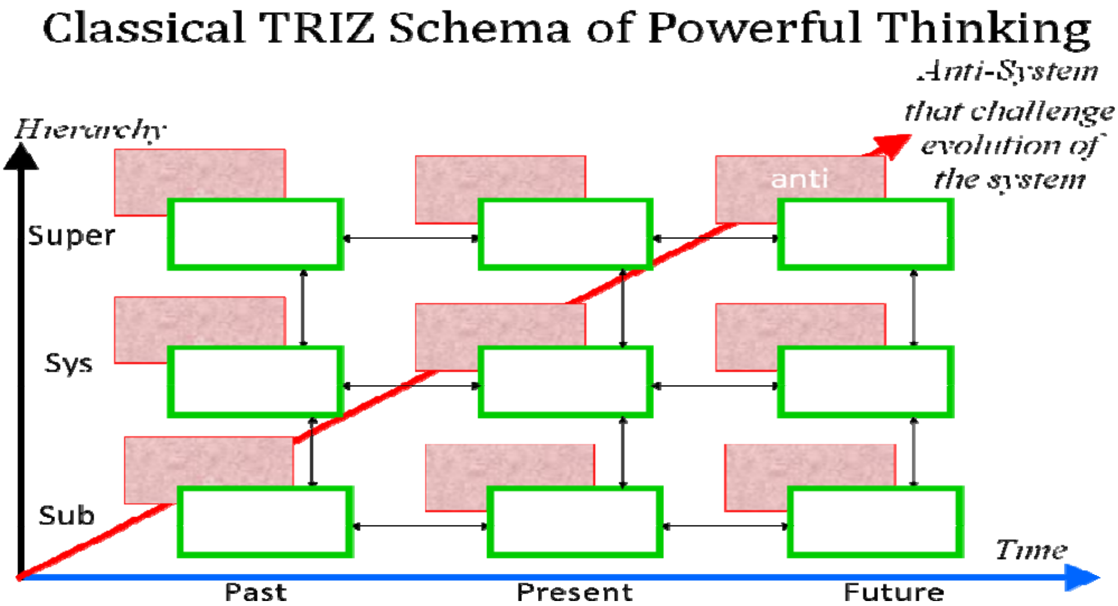

Figure 5: System Operator or Classical TRIZ Multi-screen Schema of Powerful Thinking.

Theory:

System operator could be seen as a three-dimensional parametrical space:

Dimension of Hierarchical level of System: Whatever is the element we are taking into account (System), it is always possible to consider its constituting parts (Subsystems) as well as the environment it belongs to (Supersystem);

Dimension of Time: whatever is the time interval taken into consideration for a certain analysis or description (Present), it must be considered as a phase of a sequence, therefore with a Past and a Future;

Dimension of Anti-Systems: whatever is the property of an element taken into consideration, this dimension suggests looking to the opposite values of the same property (anti-property); similarly, a combination of anti-properties characterizes an anti-system.

For practical needs it is useful to treat each of these three dimensions as a composition of several dimensions. For instance, in practice we often faced with a situation that one Element be-

longs to several hierarchies of systems. Live bag in the car belong to dashboard or doors or steering wheel and at the same time its belong to a safeties system of the car.
Another example: depending on the specific situation we can consider Time dimension as a historical time (if we study evolution of certain systems), as a process time (while analyzing a chain of events, even with their cause-effect relationships), as a life cycle of an element of a system or in terms of speed and acceleration if these variables are relevant for the specific situation.
The System operator can be used as a tool by itself with different functions within the problem solving process. For example, during the preliminary stages of the problem solving process, while looking for roundabout problems whose solution allows to obtain the same overall goal, a multi-screen view helps orienting the thought from cause prevention to effects compensation or mitigation, as well as a means to change the scale of the solution space in order to avoid psychological inertia. Besides, while looking for resources, the System Operator helps focusing the attention on every relevant aspect of the system and its environment, by analyzing any time stage at any detail level with a systematic approach.
Using ARIZ helps understanding what kind of time dimension of Classical TRIZ Multi-screen schema of Powerful Thinking is most suitable. While using System Operator directly, for instance for Resource Analysis on step 2.3. Of ARIZ-85-C or for understanding initial innovative situation, it is necessary to distinguish clearly System operator for Element and System operator for System. What is a difference?
In order to use SO in the System context we have to clearly formulate function of a system to be considered. As soon as the Function is identified we automatically identify product of the system. Based on Product and Function we can identify subsystems: Tool, Transmission, Engine and Control Unit for technical systems.
In the course of Classical TRIZ evolution Altshuller came up with the conclusions that some more dimensions should be introduced to a classical SO. However he did not find a graphical representation to present several more dimensions in the Classical SO.

1.3.3.6 OTSM-TRIZ Models of Problem solving process.

Introduction:

The OTSM-TRIZ problem solving approach can be represented by a number of models which clarify its structure and peculiarities.
Together with the ENV model, the following models constitute the essence underlying all the instruments of Classical TRIZ and OTSM-TRIZ as well.
One of the very first idea on improving problem solving process was about change the fundamental stereotype that was and still is very popular and underlying all Creative Problem Solving Methods: it is necessary to generate as more various unusual ideas as possible and then select the right ones which could solve our specific problem. Until now this stereotype (paradigm) dominate in the domain of problem solving. Genrich Altshuller formulated and exaggerated a contradiction that this paradigm arises: the more various solutions we generate the more time we will need to spend for evaluating satisfactory solutions that suit our specific inventive (problem) situation. Out of this contradiction there appears the Ultimate Goal for Classical TRIZ: create a problem solving method that will generate just one solution but this solution will be a satisfactory solution for a specific problem (innovative) situation.
We should mention that all models described below were dedicated to get orientation in order to develop more precise instruments based on those models. However all of those models could be used as instruments for practical needs.

1.3.3.7 "Funnel" Model of a TRIZ based problem solving process.

Theory:

Out of the Ultimate Goal of a method capable to generate just one solution as an outcome of the process, the first general idea about problem solving process appears: the "Funnel" model. Large input at the beginning of a problem solving process to observe and analyze initial problem (inventive) situation and narrow output in the end of a problem solving process that shows us satisfactory solution. Problem solving process should be located inside this "Funnel" and prevent a problem solver from useless trials and errors. We should say that this model still has not been accomplished at 100% but great achievements on this way were done by Altshuller and his followers. In the course of Classical TRIZ evolution and its transition to OTSM "Funnel" model appears in this form (See: Figure 6: "Funnel" model of a Problem Solving Process.)

Model:

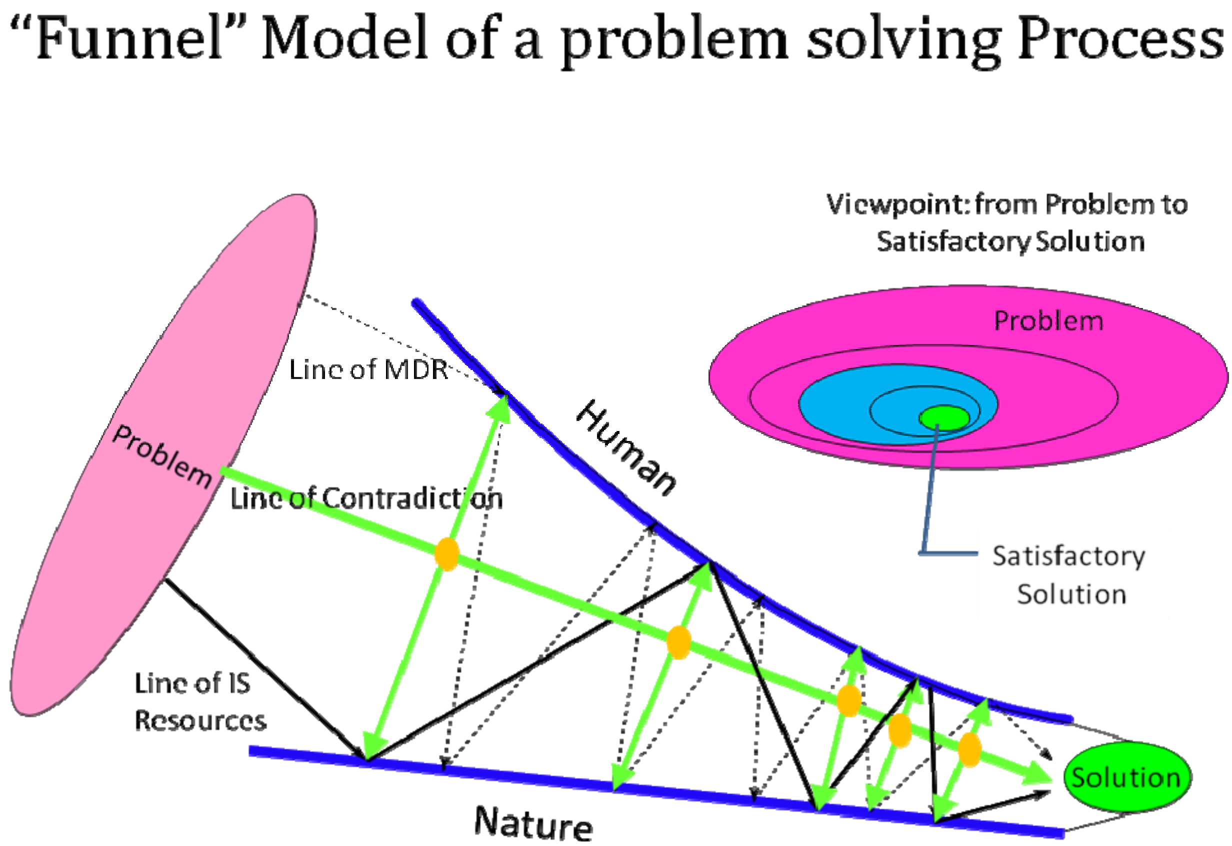

Figure 6: "Funnel" model of a Problem Solving Process

"Funnel" models is used today mostly for educational purposes to explain in general what is happening in the mind of professional OTSM-TRIZ expert in the course of a problem solving process.

We could say that each stage of the process and each specific instrument pushes a problem solver through the Funnel tunnel with his problem in very particular way.

So when you will learn TRIZ, you should pay specific attention to the question: "In which way the instrument I'm using follows the Funnel Model? How could we narrow the area of analysis in order to avoid useless trial and errors but obtain satisfactory solution by discovering the deep root of a certain problem and eliminate it?

In other terms the problem solving process should be intended as the construction of the identikit of the solution: each step is finalized to the definition of suitable Values of the relevant Properties of the system elements constituting the solution to the inventive problem we are dealing with. It also means that the problem solver should avoid "guessing" the solution while the process is still in progress: all the clues should be collected systematically in order to restrict the domain of possible solutions.

1.3.3.8 "Tongs" Model of modern OTSM-TRIZ

Theory:

Historically this was the first practical model of the problem solving process proposed and implemented at the very beginning of TRIZ evolution (See: Figure 7: Simplified "Tongs" Model of TRIZ based Problem Solving Process).

The tongs model suggest avoiding the generation of possible solutions starting directly from the Initial Situation. Besides, the first step should be to identify and describe precisely the Most Desirable Result (MDR); then, a comparison between the actual situation with the available resources and the MDR brings to the identification of the barriers preventing from the achievement of the MDR itself. According to the TRIZ theory, any barrier can be described and modeled in terms contradictions. The conceptual solution must be thus generated as the way to overcome the contradictions underlying the current system.

Model:

Ovals on the Line of Contradictions could be viewed as "Tongs" Models at the Figure 6: "Funnel" model of a Problem Solving Process. Same for the "Hill" Model – ovals on the left slope of the "hill" (See: Figure 9: "Hill" Model of a TRIZ based Problem Solving Process.)

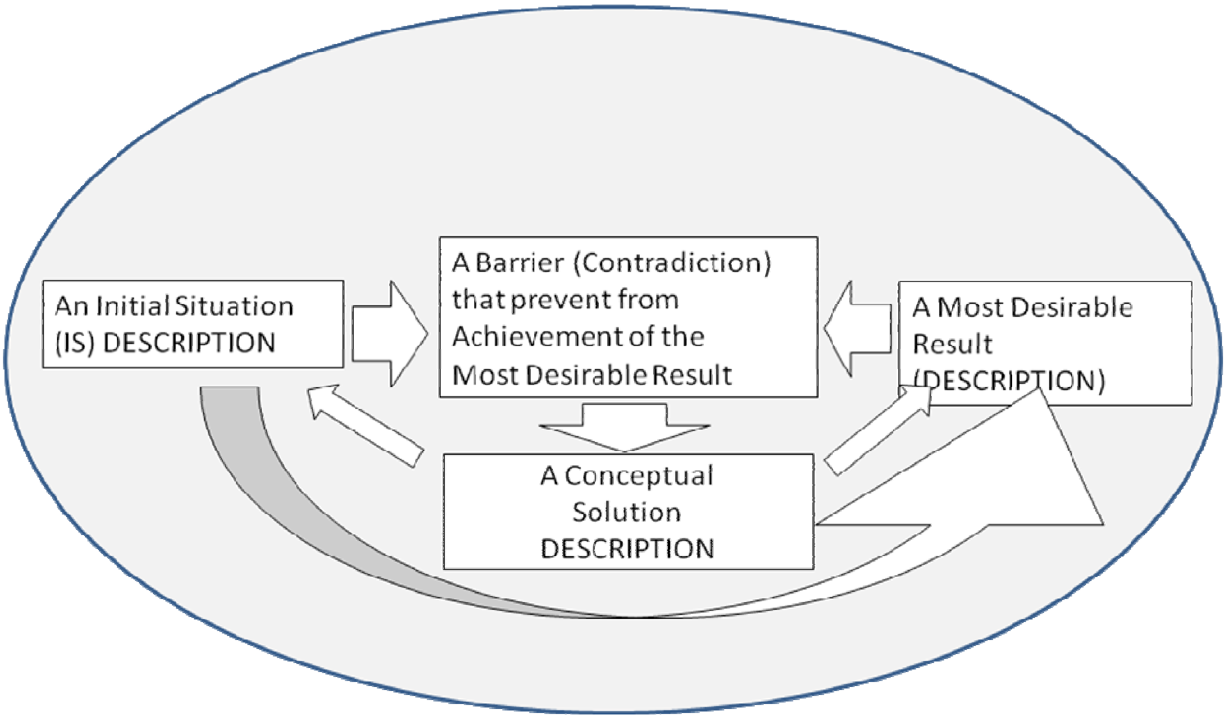

Figure 7: Simplified "Tongs" Model of TRIZ based Problem Solving Process

1.3.3.9 "Hill "model of Classical TRIZ

Introduction:

In the middle of the 70s a new model of the problem solving process was proposed by Genrich Altshuller. This next model is underlying all the following ARIZ modifications until ARIZ-85-C. Eventually this model got the name of "Hill" Model of a problem solving process. "Tongs" model appear in the "Hill" model on the left slope of the "Hill" as one of its component.

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Theory:

The Hill model states that the first part of the problem solving process consists in a generalization of the problem through an abstraction process with the aim of transforming a non typical problem into a standard model of a problem. Two are the main types of problem models according to the TRIZ theory: an unsatisfactory interaction between two elements of our system (i.e. an insufficient or a harmful function identified through a Su-Field model) or a contradiction

After building a general model of a problem, TRIZ instruments bring to the identification of candidate models of solution to be finally contextualized in the specific situation according to the available resources (right part of the hill).

Hill model not only help use "Tongs" model more efficiently, but also to introduce one more important novelty in the problem solving process: the transition between different levels of generalization. In the beginning of problem solving process we reformulate the problem several times according to the rules of the "Tongs" model, but every time we increase the level of generalization. This abstraction process leads us to a more general description of a problem and as a result of this generalization it is easier to find a direct analogy between problems that look very different.

Example:

For instance two famous problems that is very popular in the modern TRIZ world are problems on Hydrofoil that is destroyed by capitation effect in the water and a problem on preventing oranges from eating by apes. At the beginning this two situations looks absolutely different. But after using "Hill" model and generalizations we obtain the same model of problem for both initial innovative situations: Two objects and harmful interaction between them. Altshuller's System of standard inventive solutions proposed in this case use mediator that is modification of one of the substances or mixture of both. This was one of main functions of ARIZ modifications before ARIZ 85-C: Generalize initial situation description and use TRIZ typical solutions or any other available for you. In other word it means transformation of non typical problem into one of well known typical problems. This dramatically increases efficiency of instruments based on Classical TRIZ. However new classes of problems appear very quickly: problems that could not be transformed into typical problems. What should be an efficient model of problem solving process for these complicated problems? As an answer to the question ARIZ-85-C appeared. This version of ARIZ starts new S-curve of Classical TRIZ based instruments for problem solving and eventually lead us to a new model of problem solving process that appears in the course of Transition from Classical TRIZ to OTSM: Problem Flow model of OTSM.

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Model:

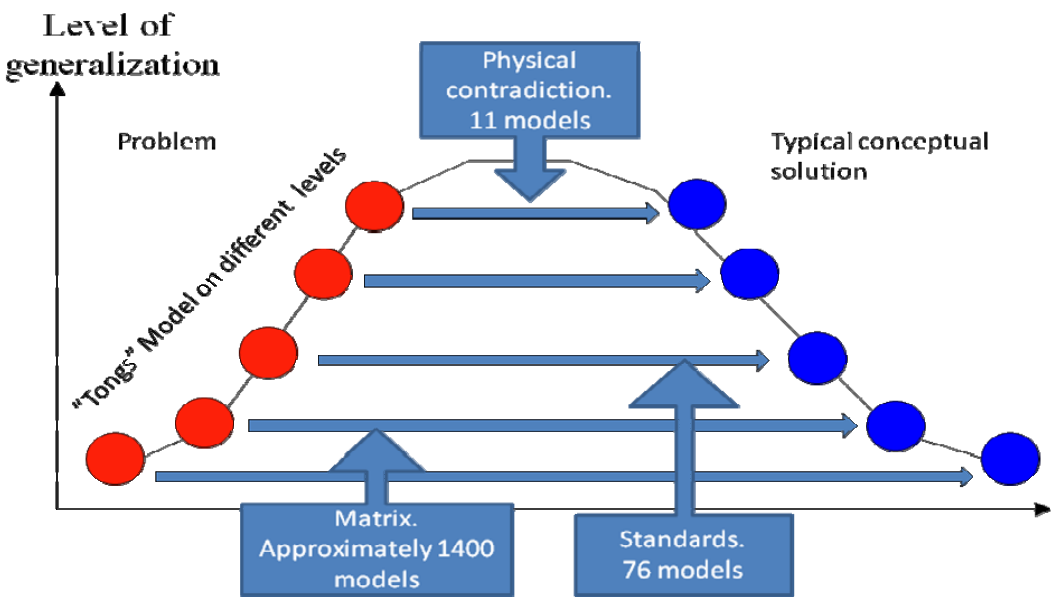

Figure 9: "Hill" Model of a TRIZ based Problem Solving Process.

1.3.3.10 "Contradiction" model

Introduction:

Consider now a set of design problems, the requirements of which concern two evaluation parameters denoted EPI and EPII. A point in figure *10 left* represents a solution of these problems. These solutions are mapped with a set of technical alternatives the elements of which are known by the designers. These solutions are described by a set of design parameters. Evaluation parameters are functions of design parameters. Let's call EPI-dp and EPII-dp the set of parameters that influence the values of EPI and EPII respectively. EPI-dp and EPII-dp are defined by the set of technical alternatives.

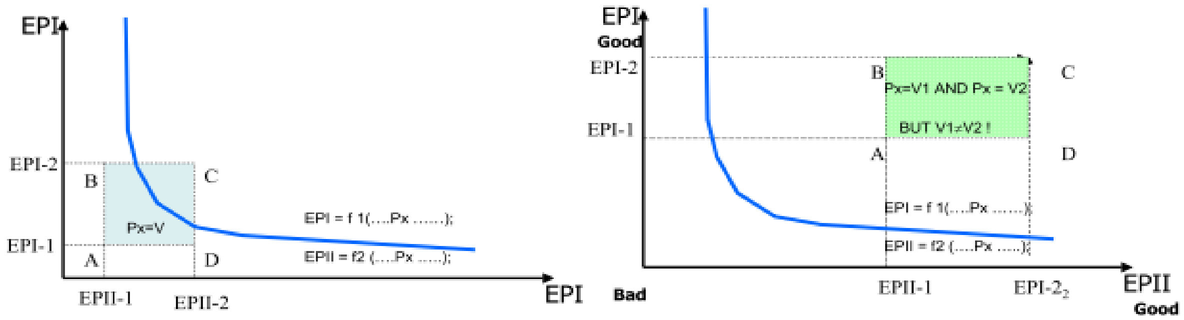

Figure 10: left "Optimization situation", right "Innovation situation"

In the first situation the requirements targets EPI and EPII values to be within the range [EPI-1, EPI-2], [EPII-1, EPII-2] respectively. Thus a solution fits the objectives when EPI and EPII define a point inside the rectangle ABCD in figure 10 left. If there are no common design parameters between the evaluation parameters (i.e.: EPI-dp∩EPII-dp=Ø), they are independent and there is no problem to reach any point in the rectangle ABCD. But when at least one design parameter influences both evaluation parameters EPI and EPII, they are dependent. This dependence relation constraints the area of feasible solutions in the evaluation space; it is represented by a curve in figure 10 left. When the situation of the relation between the parameters overlaps the requirements area like in figure 10 left, finding a solution can be considered as an

optimization problem. On this example the common parameter is called Px and each value V of Px defines a point of the curve. The problem is then to find the values of Px that allows the evaluation parameters EPI and EPII to fit jointly the requirements. We can then enter a decision process by adding preferences about the pairs of evaluation parameters.
Let us now consider a second situation as summarized in figure 10 right: the only difference with the previous situation is that the targeted area for the evaluation parameters is not overlapping the area of possible solutions defined by the design parameters. The relation between the evaluation parameters due to the technical known solutions and natural law or laws that drive links between parameters remains the same. Thus there is no way to get a solution by using this model of relation between the evaluation parameters and a new paradigm is required in which the relation between them overlaps the requirements. Two main approaches, which can be performed in synergy, may be used to perform this overlapping. The first attitude consists in changing our values about the preferences and keeping both the set of technical alternatives and the structure of the system. The second method consist in changing the set of technical alternatives and the structure of the system by expanding knowledge and inventing what is called in TRIZ language non typical solutions. As an output of this process new curves between the evaluation parameters are generated. If they overlap the preference area we come back to an optimization situation.

Theory:
The previous examples concerning the relation between Evaluation Parameters can be generalized and stated the following way: the fact that two evaluation parameters are linked means that at least one common parameter both of them depend on does exist. These common parameters have to be disclosed in order to develop new technical alternatives and finally new structure of the system. Thus in our example the fact that EPI and EPII are linked means that at least one common parameter Px the evaluation parameters (EPI and EPII) depend on does exist. The reason why it is impossible for the evaluation parameters to fit the requirements in the framework of existing models is the following: in order to fit jointly a pair (EPI, EPII) of the evaluation requirements Px should take two mutually exclusive values; let's call them V1 and V2. Moreover once taking into account partial elements of the preference structure the situation can be described at least by three dilemmas. Let's illustrate this point through the previous example. We assume that the preferences elements are:
in the range [EPI-1, EPI-2], the higher EPI value the better
in the range [EPII-1, EPII-2] the higher EPII value the better.
The three resulting dilemmas TC1, TC2 and PC become:
TC1: when EPII value is good from the requirements point of view then EPI is bad.
TC2: when EPI is good from the requirements points of view then EPII is bad.
PC: when Px value equals V1 then TC1 holds whereas when Px value is V2 then TC2 holds.
The PC dilemma concerns a choice between two mutual exclusive values of a parameter that leads to two options TC1 and TC2 that are unfavorable from the requirements points of view.
Classical TRIZ system of contradictions has just 3 types of contradictions (administrative, technical and physical): TC1 and TC2 are named *technical contradictions* (a contradiction between two evaluation parameters of a system) whereas the underlying contradiction PC corresponds to the concept of *physical contradiction*.

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Model:

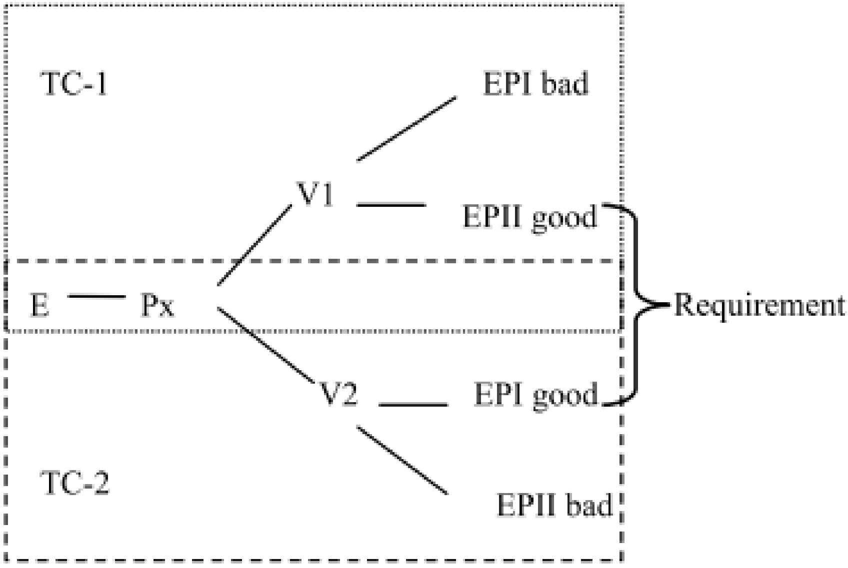

Figure 11: OTSM-TRIZ basic's system of contradictions

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