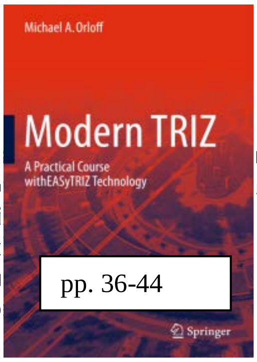

The author of what would be TRIZ m ... rks: „…of course every technical task is individual in its o ... ent has something unique. An analysis shows the possibiliti ... ***of the conflicts in a system an their causes.*** This changes t ... It is then possible to start a creative search for a specific ***ra*** ... no magic formula after all, but there are ***procedures*** that ar ... s”.

5.2 Development of Classical TRIZ

The development of TRIZ began with the initial version of ARIZ (fig. 5.1). Altshuller often stressed that TRIZ organizes thinking as if the experience of all or at least several talented inventors were available. Usually, even the most experienced inventor uses *experience that is based on external analogies*: this means that this task has certain similarities to an older one, i.e., the solution has to be similar, too. *An inventor who knows TRIZ can look much deeper*: there is *such a conflict* in the new assignment that the idea of a solution for an older task can be used that has no external similarities to the new one, but that *contains an analogous conflict*!

The author of TRIZ defined the difference between to concepts of *procedure, method,* and *theory* in the following way:

Procedure – this is a unique and elementary operation. A procedure can refer to the actions of a person who solves a task, as in the „usage of analogies“. A procedure can refer to the technical system of the task at hand, such as „disassembly of the system“, „combination of several systems“. Procedures have no direction: it is not clear in which case this or that procedure is appropriate and when it will function. In one case, an analogy can lead to a solution, in another it can be misleading. Procedures cannot be further developed, although the number of procedures can increase.

Method – is a system of operations that usually contains procedures and foresees a specific order for their usage. Methods are usually based on a certain principle, on a postulate. This is why the assumption that a solution can be found by „releasing the flow of thought from the subconscious“ the basis of brainstorming. The basis of ARIZ is the *principle of the similarity* of conflict models and models for solutions to contradictions. Methods display very limited development and remain fixed in the framework of their initial principles.

Theory – is a system of several methods and procedures that foresees the goal-oriented control of the process of finding a solution to a problem based on knowledge of the laws (models) of the development of complex objects in technology and nature.

By 1985, the highpoint of the development of classical TRIZ, the theory had been shaped for almost 40 years. The author of TRIZ described the development of his theory in the following way.

Stage 1. Work on ARIZ was started in 1946. Incidentally, the concept of „ARIZ“ did not yet exist then. Questions were asked differently then:

It is necessary to study experience gained in creative activities and to focus on the characteristics of good solutions that differ from bad ones. The resulting observations can then be used to solve problems in inventing.

It was immediately clear that solutions to problems in inventing are especially effective when the overcome the technical contradiction (TC) that existed in the assignment. On the other hand, solutions are ineffective when they don't address and or overcome the TC.

But then, a totally unexpected discovery was made: it became clear that even the most experienced inventors don't understand, don't see that the correct tactics to solve problems in inventing should be to investigate the TC step by step, to examine its causes and eliminate them, thereby eliminating the TC itself. When inventors ran into an obviously screaming TC and recognized that the problem would disappear with its elimination, none of them drew the conclusion for the future that had been anticipated. *They maintained the same tactics*, worked on new tasks, sometimes wasted years on the selection of variations, and didn't attempt to formulate the conflict or contradiction that was contained in the problem.

There was therefore no hope to gain something useful for beginners from the experience of great (experienced and talented) inventors: these inventors work constantly with the same primitive method of trial and error.

Stage 2. In the second stage, the problem looked like this:

It is necessary to find a program for the planned solution of problems in inventing that can be used by all inventors. This program should be based on a successive analysis of the task in order to define, investigate, and eliminate technical conflicts. This program does not replace knowledge and abilities, but it does prevent many errors and it offers good tactics for solutions to problems in inventing.

The first programs ARIZ 1958 and 1961 had very little in common with ARIZ 1985. But they had become more precise and reliable with each modification and they took on more and more the character of an algorithmic program. Tables were created with procedures to eliminate TC's (see the latest TRIZ version in appendix 3 *A-matrix for the selection of A-navigators* and 4 *A-navigators* – in the author‘s notes). Patent information and descriptions of inventions became the basis for investigations. Initial seminars were held and experience was gained in the presentation of ARIZ for others.

And again an unexpected discovery was made. It became clear that knowledge was necessary for solutions to tasks at higher levels that exceeds the limits of the inventor's field. *Practical attempts lead to useless experiments in the usual direction,* the use of ARIZ and its tools (procedures, etc.) only improved the process that reached a solution.

It was clear that people are not able to effectively complete tasks of inventing at a higher level. This means that all methods are incorrect that try to activate everyone's „creative thinking" because they are only *attempts to positively organize bad thinking* (Altshuller's words). Stage 2 starts with the development of the idea to provide the inventor with a *helping tool*. It ends with the perception that it is necessary to reshape inventive creativity and thus to *change the technologies of inventing itself.* The program was now thought of as a complete system for solving problems independent from the human subject. *Thinking should follow this system and let itself be directed - then it can certainly become much more talented.* It was also clear that the operations of ARIZ should be compared and contrasted with the objective laws of the development of technical systems.

Stage 3. The formula for the third stage was as follows:

Inventions at a lower level are not creative at all. It is poor creativity to produce inventions at a higher level by trial and error. We need new technologies to solve problems in inventing that enable us to solve tasks at a higher level in a planned way. These technologies should be based on the knowledge of objective laws for the development of technical systems.

Patent information was the work basis, just like in stage 2. But, they were now no longer investigated only to create and introduce new procedures into the table for the elimination of technical contradictions. They were now also used to examine general laws for the development of technical systems.

The most important discovery was the fact that an invention is the further development of a technical system. An assignment in inventing is a form in which people uncover requirements for the development of a technical system. TRIZ teaches inventive creativity with the goal in mind to create effective methods to solve problems in inventing.

A thought is hidden in this definition that may sound very strange: are all extant methods ineffective and should they all be thrown away? People have made great inventions with these „methods“! A modern industry for inventions that produces thousands of new technical ideas every year is based on these methods. What makes them so ineffective? There are the usual, unsubstantiated viewpoints about creativity in inventing, such as: 1) „Everything is arbitrary“; 2) „Everything depends on knowledge and stamina. You have to always try different variations“; 3) „Everything comes from natural abilities“.

Of course, all of these opinions contain a little bit of truth. But, this truth is external and superficial. „Trial and error“ is in and of itself ineffective. However, the modern industry for inventions is organized in accordance with „Edison’s method“: the more difficult a problem is, the greater the number of experiments is and the more people need to take part in the search. Altshuller illustrated his critique of this method as follows: it is clear that the principle of digging remains the same even if a thousand people dig different trenches. A single inventor, a treasure hunter, can work with a good method much more effectively than a „team of mine workers“!

Without TRIZ, an inventor has to make a long and difficult choice between the usual and traditional variations that are part of his field of expertise when solving problems. It is often impossible to look beyond these variations. These ideas then often move in the direction of the psychological inertia vector (PIV). The PIV can be caused by many things. There is always the fear of leaving one’s professional field behind and moving into unknown territory. There is also the fear of producing an idea that appears ludicrous. Of course, another reason can be that the inventor is not familiar with procedures to generate „wild“ ideas.

Altshuller illustrated the „method of trial and error“ with the following schematic (figure 5.2). The inventor starts at „task“ and arrives at „solution“. It is not clear where exactly this latter point is. The inventor creates a certain concept for the search and begins to „throw“ ideas in the direction chosen. These directions are represented by thin arrows. And then it becomes clear that the concept is not entirely correct and that the search has moved in a totally incorrect direction. The inventor then goes back to the departure point of the task, develops a new concept for a search, and starts to „throw“ again with the idea „what if ....?“

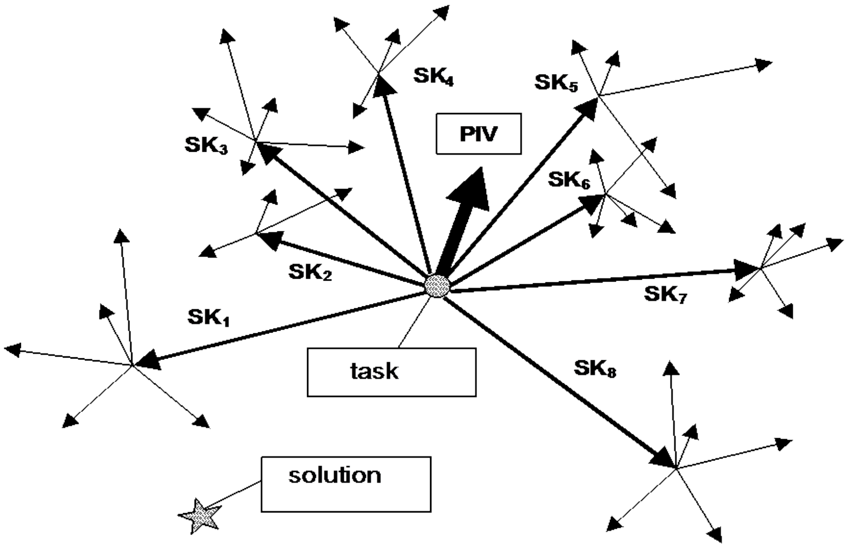

fig. 5.2. Search schematic with the method of „trial and error“

In the schematic, the arrows that move in other directions or even that prevent a solution are the thickest. This is because the attempts are not as chaotic as they initially look. They are even somewhat organized ... in the direction taken by previous experience. This is in the direction of the PIV!

Assignments on different levels differ primarily in the number of attempts that are required to find a solution. But why are 10 attempts necessary for one task, 100 for another one, and 10,000 for yet a third?! What is the *qualitative difference* between them? Altshuller came to the following conclusion (see also section 3.2 *Levels of inventions*).

1. Tasks can differ according to the *content of the knowledge required*. At the first level, assignments and the means to solve them move within the framework of a profession or a field within a profession. At the second level these means come from the framework of the entire field. For example, a task in mechanical engineering is solved using tools and experience from other areas within mechanical engineering. The limits of an entire science hold true for the third level. A mechanical task can be solved based on the laws of mechanics, for example. The fourth level includes means that go beyond the limits of the science in which the problem occurs - a mechanical task can be solved chemically. Higher levels move beyond the limits of modern science. This is why new scientific knowledge or new discoveries can be required for use in solving problems in inventing.

2. Assignments can differ according to the *structure of the interactive factors*. This can easily be demonstrated using the „structural" differences between problems from the first and fourth levels, for example.

The following is characteristic of tasks at the first level:

1) There is a low number of interactive elements.

2) There are no unknown factors, or at least they have no meaning.

3) Uncomplicated analysis:

- *elements that must be changed can easily be separated from those that cannot be changed under the conditions that obtain in the assignment;*
- *the interaction of elements and possible changes are easy to follow.*

4) It is then somewhat disadvantageous when the task needs to be solved quickly.

The following is characteristic of tasks at the fourth level:

1) There is a large number of elements for consideration.

2) The number of unknown factors is high.

3) Complexity of the analysis:

- *it is difficult to separate elements that can be changed under the conditions that obtain in the assignment;*
- *it is difficult to construct a sufficiently complete model of the interaction of elements and of changes.*

4) It is advantageous when a lot of time is available for necessary searches.

3. Assignments can differ according to the *degree of change in an object.* An object (facilities or a procedure) is *hardly changed* in tasks at the first level. It is possible that the value of one parameter is altered, for example. At the second level, an object is changed in a relatively *unimportant way*, for example, in a few details. At the third level, an object is subjected to *meaningful changes*, for example, in its most important components. At the fourth level, it is *changed completely*, and at the fifth the *technical system is also changed* to which the object belongs. This is why a procedure for „transitions" is needed that can transform „difficult" problems into „easy" tasks, such as when quickly limiting the search parameters.

4. ***Nature has not developed heuristic procedures of a high order!*** In the course of human evolution, the human brain has adapted only to solutions to tasks that correspond to the first level.

Even those people who make one or two inventions at the highest level in their lives do not collect and pass on their „high-level heuristic experience". Only those heuristic experiences at a low level have been passed on by tradition: increase - decrease, combine - separate, use analogies, copy, and a few more (see section 4 *Inventive Creativity*). Others were then later added, such as „put yourself in the place of the object of investigation„ (empathy), „think about psychological barriers" etc. (see also the section *Art of Inventing*).

„Heuristics" at this level can be demonstrated to young engineers continuously, but *they won't learn to use them.*! Here the point is that calls to „think about psychological barriers" are doomed to failure because we don't know how to *fight against psychological barriers*. It is also useless to use analogies if it is *not clear in advance which analogies could be appropriate*. This is especially true when there are lots of analogies at hand. Empathy causes nothing but confusion and is even counter-productive when used for a complex object.

This means that our brains have only learned precise and applicable procedures in the course of evolution that can serve to solve simple tasks. Heuristic mechanisms have not yet been discovered - they simply don't exist.

But, they can and must be created!

Let's move to the third stage and to the middle of the 1970's, a time that also represents the temporal middle of the history of classical TRIZ. It was also the beginning of a comprehensive perfection of TRIZ - the discovery of the physical contradiction (PC), the formulation of laws for the development of technical systems, the compilation of the first catalogue of physical principles for the development of great inventions („effects"), and the compilation of the first „standards" (complex procedures).

5.3 Structure of Classical TRIZ

The structure and history of classical TRIZ is shown schematically in fig. 5.3 and 5.4. TRIZ is an example of the realization of the *idea of the concentrated representation of knowledge.* An investigation of the developmental history of TRIZ reveals the following stages:

1) until 1985 - the development of ***classical TRIZ***, essential ideas with conceptual character (supplemented by instrumental aspects) that were published by Genrikh Altshuller;

2) after 1985 - the development of ***post-classical TRIZ***, essential ideas to *„expand"* the theory with detailed presentations, partial formalization, concretization, and a large collection of examples and to *combine* it with other methods, especially with methods of functional and cost analysis and with methods analogous to Quality Function Deployment (QFD) and Fault Modes and Effects Analysis (FMEA).

The most important discovery of *TRIZ* is the fact that a million registered inventions have been made based on a relatively small number of transformations of the original assignment.

TRIZ makes clear reference to the key conceptual components of the organization of every problem and the synthesis of their solutions: ***contradiction, resources, ideal result, rules,*** or rather, ***transformation models***.

In addition, both methods for the solutions to problems were formulated in steps with the help of the concretization and transformation of the original problem and *systems of procedures* were created with TRIZ. This method is described as an ***„Algorithm of Inventive Problem Solving"*** (ARIZ).

With TRIZ, a theory, methods, and models were developed to systematically investigate and solve complicated technical-technological problems ***for the first time in the history of creatively active humanity.*** These problems are characterized by considerable physical and technical conflicts and contradictions that essentially cannot be solved with traditional methods of construction.

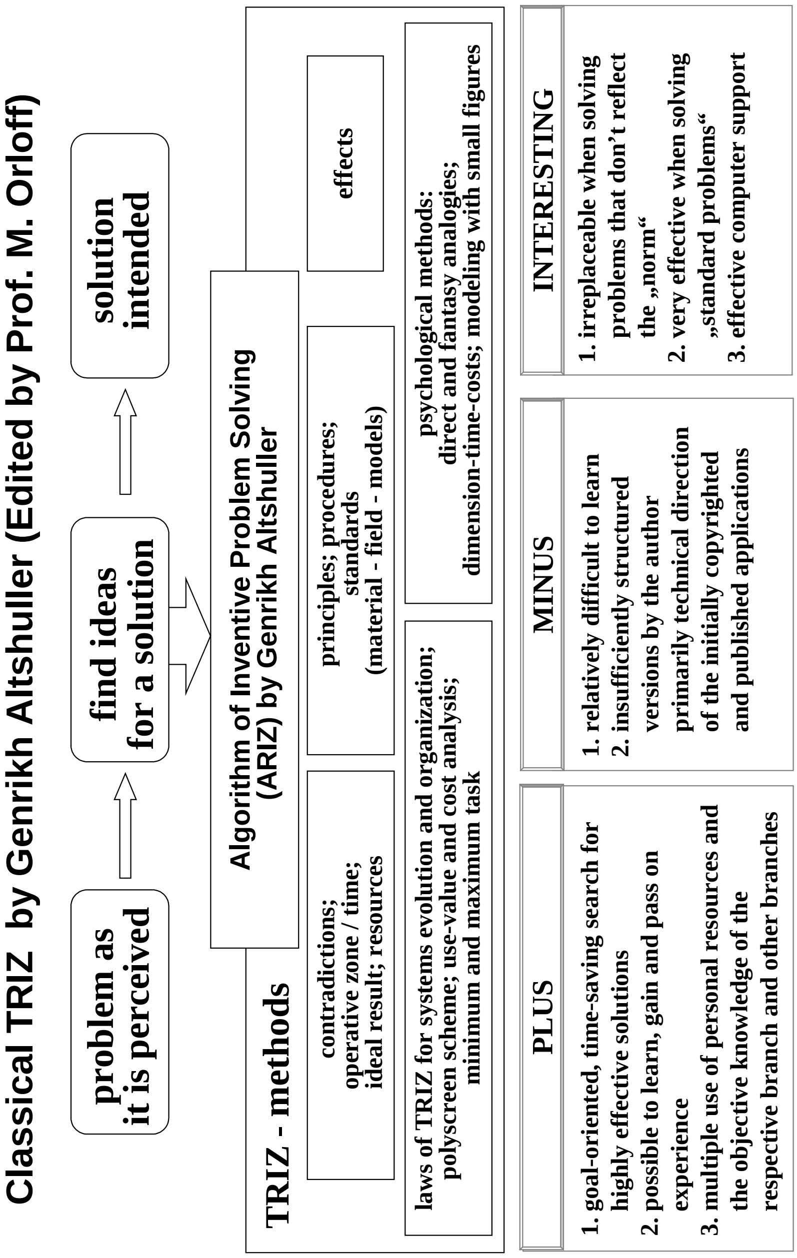

fig. 5.3. Structure of classical TRIZ

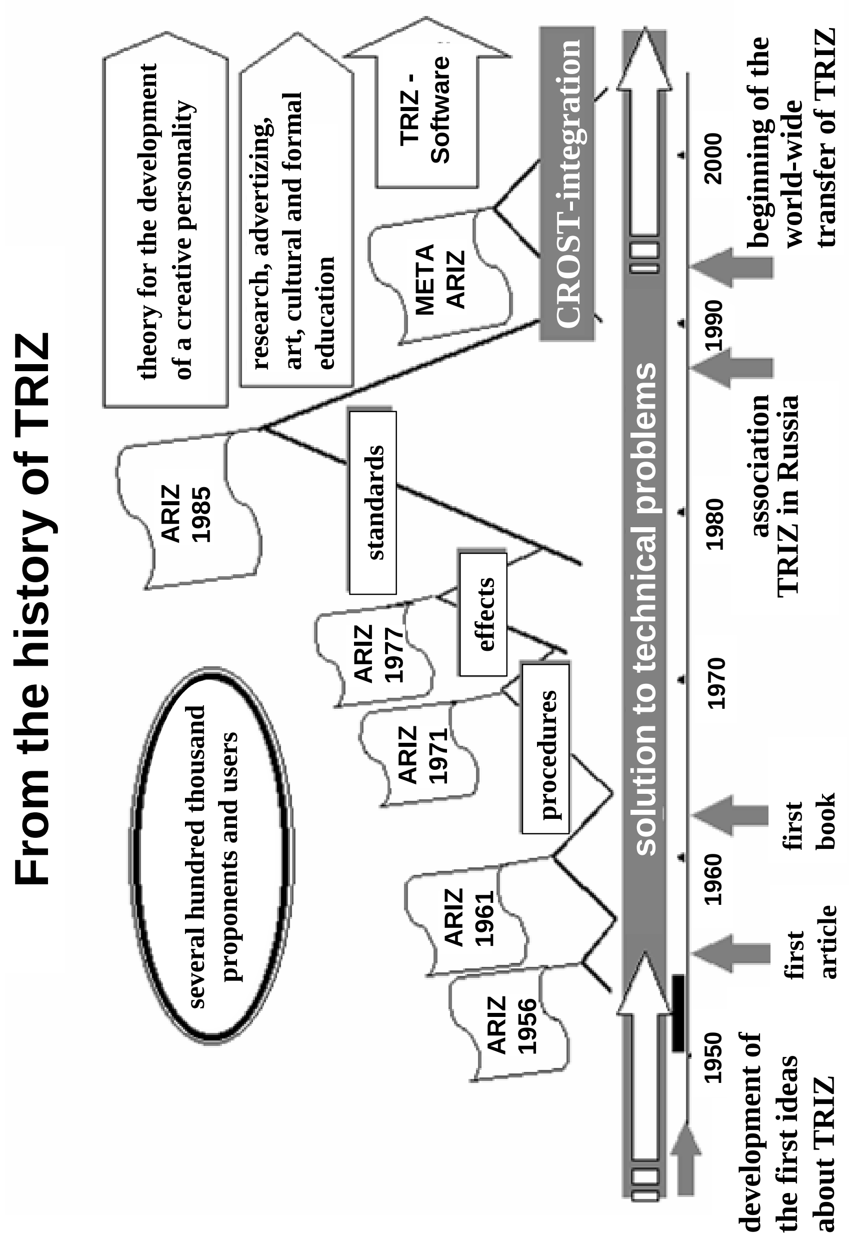

fig. 5.4. From history of classical TRIZ

According to an illustrative definition by Altshuller, ARIZ (and all of TRIZ) is supported by „three primary pillars“ [4]:

1. *The task is processed step by step according to a precise program that recognizes and investigates the physical conflict that has caused the problem.*
2. *Concise information is used to eliminate the contradiction that embodies the experience gained by several generations of inventors (tables of typical task models- procedures and standards, tables for the use of physical effects, etc.).*
3. *There is a kind of psychological scheme for the course of the search for a solution: ARIZ shapes the thinking of the inventor, eliminates psychological barriers, and leads inventors to unusual and courageous ideas.*

Furthermore, it should be noted that most previous books and articles about TRIZ have merely repeated themselves and have shown the value of TRIZ only as a traditional system for solutions to technical problems. This has often lead to misunderstandings about the possibilities and limits of TRIZ.

Above all else, known publications don't mention the existence of many unsolved questions about the „functions“ of creative thinking. For example, this is the case with the largely comprehensive necessity of various intuitive thought acts. They also don't mention that it's not possible *to reach a solution* and constantly use terms like the „algorithm of inventing“ and „transformation operator“. This is why different people who use the methodologies recommended here come to widely disparate results. They don't mention the open-ended (even if drastically shortened) time for the search for a solution when using an algorithm. This is because there are *essentially no-algorithmic acts of thought.*

And finally, if the objective knowledge at hand is insufficient to solve the problem ***and a scientific investigation*** has been made, then even TRIZ has its limits. But, it should be added that TRIZ is also a useful instrument for the completion of a scientific investigation. This textbook shows the author's broad and realistic approach to a theory of inventing that attempts to integrate the highly effective models of TRIZ with traditional methods for an intuitive search as well as comparing and contrasting them.