Ideation TRIZ Roots and Differentiations

Introduction

From its inception, TRIZ as a science has been driven by the practice of innovation. All improvements, enhancements and advancements to TRIZ described below have resulted from our accumulated, extensive experience as TRIZ practitioners (involving more than 5,000 problems) and educators (more than 6,000 students have been taught). The main objectives for the advancements were as follows:

- Overcome the weaknesses of the methodology (see below)
- Explore new areas (including non-technological ones) for applying TRIZ
- Enhance the existing tools and develop new ones
- Make TRIZ appropriate for mass use and education
- Enhance the theoretical base of TRIZ and link it with other sciences

According to these objectives, we have divided the descriptions of these advancements into two chapters:

A. TRIZ Philosophy and Theoretical Base
B. TRIZ Tools and Applications

We have also divided the entire TRIZ history into three distinguishable eras, as follows:

Classical TRIZ	TRIZ as it underwent development led by Genrich Altshuller in the former Soviet Union (from the mid-1940s to the mid-1980s).
Contemporary TRIZ. Phase 1 (Kishinev era)	TRIZ during *perestroika* in the former Soviet Union (from the mid-1980s to the early 1990s).
Contemporary TRIZ. Phase 2 (Ideation era)	TRIZ as it penetrated the Western world (beginning in the early 1990s to 2005).

These approaches are used for the following purposes:

- To draw the most complete picture possible of contemporary TRIZ.
- To emphasize the achievements that we believe are vitally important for disseminating TRIZ throughout the world, and which we readily share with anyone interested in providing value to their customers and friends.

TRIZ Philosophy and Theoretical Base

Assumptions and definitions of Classical TRIZ

We define the Classical TRIZ era as a period that started in the mid-1940s, when Altshuller began his research on creativity. He undertook a new, scientific approach to the process of generating inventive ideas. This approach was based on the utilization of the accumulated knowledge of human innovation as documented in the patent library and revealed in the history of technology. Among the basic discoveries he made along the way, the most important are:

- Any technical system develops according to certain patterns
- The patterns of evolution for different systems have much in common
- The patterns of evolution can be unveiled through researching the evolutionary history of a system (for the area of technology, this evolutionary history is contained in the patent library)
- Based on these discovered Patterns of Evolution, universal methods for searching for new ideas can be developed

For over four decades, Altshuller led all development in TRIZ. In the mid-1980s he stopped working on technological TRIZ, judging that this part of TRIZ was complete. At the same time, Russian *perestroika* finally allowed TRIZ to be utilized for commercial purposes, and the first TRIZ customers came into being as a result. The need to better serve their customers forced various TRIZ schools and individuals to start adjusting TRIZ to the new requirements. The commercialization of TRIZ meant that there was no longer a free informational exchange. We believe that this was the beginning of new era in TRIZ.

The main accomplishments during the Classical TRIZ era that could serve as a foundation for further development can be summarized as follows:

In the area of basic concepts:

- Revealing and utilization of the Patterns of Technological Evolution
- Ideality as the main target of a technological (engineered) system's evolution
- The emergence and escalation of contradictions in the process of a system's evolution; revealing and resolving contradictions in the process of solving problems.
- A systemic (multi-screen) approach
- A structured and systematic (step-by-step) approach to the problem-solving process.
- Utilization of formal problem models

- Transfer of knowledge (concepts) through the development of an innovation knowledge base.
- Utilization of "operators" (principles, standard solutions, etc.) derived from the best innovation practices, to direct the problem-solving process.
- Direct utilization of methods for reducing psychological inertia

In the area of tools and education:

- 40 Innovation Principles and Contradiction Table
- ARIZ
- Separation Principles
- First system of Patterns of Evolution
- Substance-Field Analysis
- Standard Solutions
- Selected Innovation Examples
- Effects
- Course elements for the development of a creative imagination
- Life strategy for creative individuals

The most important result of the Classical era is that Altshuller set out to develop a method that would help technical individuals handle difficult technological problems. In fact, he accomplished much more than this, revealing the basic patterns and principles of evolution and creativity that are applicable to any field of human activity requiring creative solutions. He also succeeded in systematizing these patterns and principles, making them available for wider use. However, TRIZ remained half-science, half-art, requiring extensive education and practice as well as exceptional commitment.

Ideation TRIZ

Revision of assumptions and basic concepts

As mentioned earlier, the commercialization of TRIZ in the former Soviet Union, followed by the marketing of TRIZ in the United States and worldwide, forced us as a united group of TRIZ professionals to begin working on transforming TRIZ into a methodology suitable for mass utilization. The first step was to articulate the main limitations of Classical TRIZ, which are as follows:

- Insufficient rigorousness of TRIZ tools (i.e., many analytical skills required for successful application of TRIZ tools had not been transformed into documented rules, algorithms and recommendations).
- Only a limited amount of the TRIZ knowledge base had been documented and was available for study and use.
- Each tool had been developed separately.

- Problems of different types had to be treated differently — there were no clear recommendations for which tool should be used for what type of problems/situations.
- The tools did not support all stages of the problem-solving process. For example, problems had to somehow be pre-formulated in TRIZ terms before the tools could be applied.

As a result of the above limitations, TRIZ was characterized by the following:

- Considerable education (from 100 to 250 hours) was required to effectively utilize TRIZ.
- Extensive practice (from 1 to 5 years) was required to become self-sufficient in applying the methodology.
- Making TRIZ available for mass utilization posed an insurmountable challenge.

Work on lifting these limitations required that certain assumptions be revised that were inherent to Classical TRIZ and which hindered its dissemination, especially in the Western world. These assumptions were analyzed and reconsidered, with the following results[1]:

Classical TRIZ	**Contemporary TRIZ**
TRIZ is a "stand-alone" methodology; it has nothing in common and cannot collaborate with the Trial-and-Error method and its psychology-based enhancements.	TRIZ must absorb the best of other techniques, and must work together with other related techniques.
Everyone should become creative.	Everyone should be taught to solve creative problems. The educational process should be supported by appropriate tools (including software tools).
The development of technological TRIZ is complete; everyone involved with TRIZ should work on the development of creative individuals.	Technological TRIZ is in an early stage of development and must accommodate the needs of the customer.
People need inventions. Invention is always better than a conventional solution, and a high-level invention is better than a low-level one. The main mission of TRIZ is to allow people to invent at the highest levels.	Orient the development of TRIZ toward the high market value of solutions.
TRIZ has been developed, and must continue to develop, based on the knowledge embodied in patents.	TRIZ should develop based on patents, on the history of technology (as a history of implemented inventions), and on the

[1] *Revision of Classical TRIZ assumptions*. TIRG, 1999, Appendix 6.

(Documented patents were a valuable resource that significantly facilitated early TRIZ development).	experience being gained by TRIZ professionals.
The evolution of technology is governed exclusively by the Patterns of Technological Evolution. Follow these and you will always be successful.	Two processes guide the evolution: generation of new ideas capable to change products and processes, and selection of the best ones by the market.
The Patterns of Evolution must be based exclusively on high-level inventions.	Patterns of Evolution should reflect all steps of the evolutionary process including the ones required drastic changes and incremental ones as well.
TRIZ should focus on revealing and resolving contradictions, that is, concept development.	TRIZ must support all steps of the problem-solving process, including problem definition, formulation (reformulation), evaluation, and planning for implementation.
While solving a problem, an individual must look for the one, near-ideal solution (global ideality).	Target an exhaustive set of solutions, then select the best ones based on local resources (local ideality).
Focus on changing the way people think rather than on supplying people with appropriate working tools.	Orient the development of TRIZ on both tools and changing the way people think.
Ignore the psychological issues associated with the creative process.	Integrate psychological issues into the problem-solving process to help people adopt new ideas.
TRIZ is based on the world patent library and thus is suitable for any country or group of people.	TRIZ must be adjusted to various cultures and mentalities.

Additional basic concepts accepted for Ideation TRIZ

The revised assumptions allowed the list of basic concepts accepted by Classical TRIZ (see the section above entitled *Assumptions and definitions*) to be extended in the following manner:

- Contemporary TRIZ is a living science and is continually developing.
- A comprehensive approach to the enhancement of systems within the entire range of complexity (including small improvements to parts and assemblies of an existing system, and the development of the generation of a system) and over the lifetime of a system (from concept development through engineering, implementation and exploitation).
- The complementary nature of the "human" and "machine" ways of being creative, combining the verbalized creative processes implemented in software and the intuitive processes inherent to the human mind.
- The two main directions in TRIZ development:

  - A way of thinking that provides an individual with the means to enhance his/her personal creative capabilities.
  - A science that provides an individual with a set of working tools and processes to support the creative problem-solving process and assure successful results.
- The different ways by which TRIZ can be introduced: through educational institutions and through the adoption of TRIZ by industrial companies.
- Conditioning the growing TRIZ market via development of a range of tools suitable for different groups of potential customers, from customers having only slight interest in TRIZ to those ones wanting to become TRIZ professionals. Different and gradual (if necessary) TRIZ implementation through:
  - The utilization of well-defined (and simplified, when necessary) TRIZ-based processes and tools.
  - Learning the TRIZ methodology (at various levels of depth) to increase the efficiency of using TRIZ tools.
  - Professional utilization of TRIZ.
- Applying the TRIZ theoretical base and problem-solving experience to other domains, including non-technical ones (business, management, politics, markets, etc.).
- Utilizing TRIZ as the basis for developing creative education methods to teach conventional subjects.
- A complete restructuring of TRIZ for computerization purposes.

Basic directions established for research and development for the period 1985-2005

The following basic directions for research and development have been established and followed for over two decades:

- Theoretical base of TRIZ, in particular:
  - Axiomatic foundation of TRIZ
  - Revised and extended system of Patterns/Lines of Technological Evolution
- Appropriate analytical tools (methods, processes, etc.) and knowledge-base tools to help control the evolution of technological systems (including problem solving)
- New approaches to TRIZ computerization
- New applications
- Theoretical foundation and practical methods of applying TRIZ to the evolution of non-technical systems (business, management, political, etc.) and problem solving
- New approach to evaluation and enhancement of intellectual property (IP)
- Solving scientific problems

- Applying a TRIZ approach to the creative teaching of conventional school disciplines

Enhancement and new development of TRIZ tools

The need for enhancement

The utilization of TRIZ tools for solving real-life problems began almost in parallel with their development. All useful approaches, rules and recommendations were immediately tested by the TRIZ author, G. Altshuller, and then by his students and colleagues. Every time he developed a new tool, Altshuller intended that the new tool would be more powerful than the existing ones and would be able to replace them. For various reasons, however, this did not happen.

The sequential introduction of new tools prompted the following questions about their use: "Which tool is most effective for which situation?" "Is it necessary to learn all the tools?" As practical results in applying the tools accumulated, it became evident that each tool had a different effectiveness depending on the level of solution, the required time to learn and use the tool, and the advantages and limitations of the user. As a result, a great deal of time and effort was required for a TRIZ practitioner to be able to confidently apply numerous tools.

Another consideration is that concept development (idea generation) was always in the main focus of Classical TRIZ. Most of the tools mentioned above (Innovation Principles, Separation Principles, Standard Solutions, Effects, etc.) represent sets of recommend-ations for changing a technological system within which a problem resides in a way that will cause the problem to disappear. It was also shown that each of these tools works with a specific problem model (for example, the Contradiction Table is used with problems that have been formulated in terms of conflicting parameters or technical contradictions; the Separation Principles work well with problems formulated as Physical Contradictions, etc.). However, the highest challenge was to reformulate (i.e., remodel) the problem to a format where *any* tool could be applied. Although two other Classical TRIZ tools – ARIZ and Substance-Field Analysis – were intended to help one build a problem model or to transform a problem into one that could be described by a typical (standard) model, the successful solving of real-life problems required extensive experience.

As mentioned earlier, newly developed tools were tested on real-life situations. This was carried out in a limited fashion, however, due to the lack of practical application for TRIZ at that time. When *perestroika* opened up a market for TRIZ in the former Soviet Union, the need for the organization and advancement of these tools became significant. This need became even stronger in view of the inevitable introduction of TRIZ to the Western world.

Enhanced and newly developed tools

The first attempt to develop a road map for the utilization of TRIZ tools was made in 1985[2]. This attempt was later enhanced (Fig. 1). Starting in 1991, the following developments related to TRIZ tools were carried out in parallel:

- Enhancement of existing tools based on accumulated practical experience
- Embedding existing tools into a typical problem-solving process
- Structuring and adjusting the existing tools to better fit this process
- Integration of existing tools to avoid confusion caused by their multiplicity
- Development of "missing" tools to provide complete support of all steps in the problem-solving process.

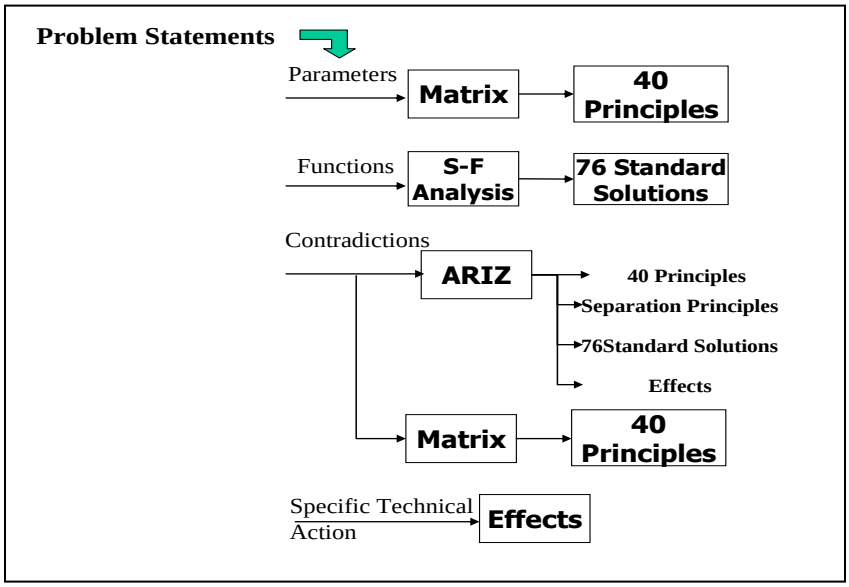

Fig. 1. Classical TRIZ Tools Map

This extensive work has resulted in the following accomplishments:

- All Classical TRIZ tools have been divided into two groups: analytical and knowledge-base tools.
- The Ideation Problem-Solving Process has been developed and includes the following steps:
  - Problem definition and documentation
  - Problem formulation
  - Identification and categorization of Directions for Innovations
  - Development of solution concepts

[2] *A method for solving real-life problems*, presented at the TRIZ conference, Petrozavodsk, 1985.

- Evaluation and planning of implementation

- New analytical tools have been developed to support the missing process steps, as follows:
  - The Innovation Situation Questionnaire® (ISQ)® is used to facilitate the understanding and documenting of the problem-at-hand
  - Problem Formulation is used to analyze a problem and develop an exhaustive set of potential Directions for Innovation
- Enhancement of the following existing analytical tools:
  - ARIZ
  - Substance-Field Analysis
- Development of a new integrated knowledge-base tool called the System of Operators.
- Development of a streamlined, unified process and integrated process by which all types of problems can be treated in the same way (Fig. 2).

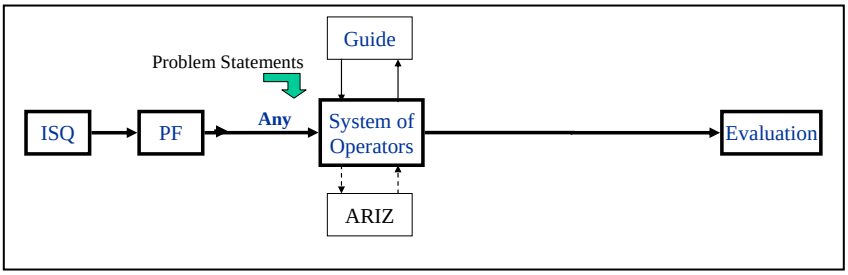

Fig. 2. Ideation TRIZ Tools Map

TRIZ based software

As mentioned above, among the main reasons for the slow dissemination of TRIZ are the following:

- Long learning curve
- Complexity of tools and of utilizing the methods
- Psychological barriers
- Lack of full-scale implementation to prove the effectiveness of TRIZ

The long learning curve is necessitated by the large amount of knowledge that must be acquired from various sources and through substantial practice before becoming a successful practitioner. TRIZ has many tools of various complexity, yet there are no clear rules as to which tools should be applied to a particular case. Typical TRIZ knowledge includes numerous examples and illustrations learned from others and accumulated from the TRIZ practitioner's own experience that serve as analogies in the problem solving

process and other (mostly tacit) knowledge about how to successfully utilize TRIZ methods and tools. The counterintuitive nature of TRIZ forces people think "outside the box"—that is, look in directions that are out of their zone of familiarity and are therefore usually defined by psychological inertia. Although certain discussions about the use of computers to address some of the problems discussed above took place in the late 1970s,[3] by the mid-1980s it had became obvious that TRIZ could greatly benefit from computerization.

Since the wide-scale introduction of computers, the computerization of human activities has provided various benefits, including expediting numerous processes and increasing their accuracy (such as calculations), and enabling new types of activities (such as searching for information or buying goods on the Internet).

One of the most important benefits of computerization is that it has enabled people to perform activities that, before computers were available, had been the prerogative of professionals. There are many examples of simple and effective software enabling millions of people to engage in new and amazing activities, such making their own presentation slides using PowerPoint or communicating via e-mail using America Online.

The natural way to invent and solve creative problems was always achieved through trial and error, and was especially effective when applied by gifted inventors. The methodology encompassed in TRIZ removed the first step from this "human" approach. TRIZ has little in common with the natural human methods of creative thinking; rather, it is an invented method that allows one to achieve the same results as can be achieved with "natural" creative thinking, but in a more effective and controlled way.

Similar to TRIZ, TRIZSoft® is the next invented application by which similar results can be achieved as with TRIZ but in an even more effective and controlled way. In fact, solving problems with TRIZSoft is an alternative way of inventing that is parallel to both "natural" creative thinking and "manual" TRIZ.

Given the above, the computerization of TRIZ is a logical and inevitable step in the further evolution and wide dissemination of TRIZ.

The first attempt to automate TRIZ was made by G. Altshuller in the mid-1960s when he built an electromechanical version of the Contradiction Table with the 40 Innovation Principles. The first ideas for utilizing a computer for TRIZ-based inventive problem solving occurred back in the 1970s. During the late 1980s and early 1990s, as far as we know, several teams of TRIZ specialists tried to develop such software products. *Invention Machine* software, based on Classical TRIZ and currently marketed in the USA, was developed in Minsk. The Novator Company in Moscow developed prototypes for two inventing software products: *Edison* and *Novator*. A team led by Professor Zaripov in Tashkent developed a software prototype for synthesizing new technological

[3] In 1978, in correspondence between Zlotin and Altshuller, a project was discussed outlining the development of a computerized, TRIZ-based system that would allow users to find inventions in patent libraries through a TRIZ analysis of a situation. For various reasons this project was never started.

systems through the combination of various physical effects. Other attempts were made as well, with low to moderate success.

To support the problem solving process, the main modules of the software should perform the following functions:

Module	Functional Description
Innovation Situation Questionnaire®	Collection and reorganization of information about the situation and the system facilitating the creative process.
Problem Formulator® and	Visualization and automated generation of a practically exhaustive set of directions for innovation (solutions).
System of Operators	Automated process of suggesting operators (recommendations) with statistically proven relevance to the selected directions for innovation prompting idea generation.
Concept development	Consolidation of ideas into concepts
Evaluation	Evaluation of obtained ideas and their enhancement using selected patterns of technological evolution

New ideas, solutions, concepts, etc., may be found in any stage of the problem solver's work; the Ideation Problem-Solving Process supports this in the following ways:

- Filling out the ISQ often helps change the user's point of view, reminding the user of information he/she had not previously linked to the problem. This activity, as well as structuring the information about the problem, sometimes helps the user find the solution even in this early stage.
- Working with the Directions for Innovation formulated by the software sometimes allows for the revealing of new approaches not previously considered; sometimes these problems are easy to resolve.
- Applying the operators and examples/analogs for problem solving is the major stage for revealing new ideas.
- Improving ideas and solving secondary problems by applying operators and lines of evolution prompts new ideas and solutions, as well.

In addition to the above, the software generates a list of ideas and a full report of the problem solver's work.

Based on considerations above we have developed a suite of TRIZ based software as follows:

Inventive Problem Solving (IPS):

- Eureka on Demand – introductory level software
- Ideation Brainstorming (IBS) – medium-level software

- Innovation WorkBench® (IWB®) – professional level software4
- Knowledge Wizard (KW) – professional level software for non-technical problems

Software for IPS support the following steps of the innovation process:

Process Steps	IPS Software			
	Eureka	**IBS**	**IWB**	**KW**
Problem definition	N/A	System Approach	Innovation Situation Questionnaire	Innovation Situation Questionnaire
Problem formulation (modeling)	Function modeling	Function modeling	Problem Formulator	Problem Formulator
Idea generation and concept development	Limited set of operators	Limited set of operators and resources	Complete system of operators	Set of operators for non-technical problems
Evaluation of results	N/A	Formulating consequent tasks	Evaluation and enhancement of obtained ideas	Evaluation and enhancement of obtained ideas

Other software supports the Anticipatory Failure Determination (AFD®) application:

- Ideation Failure Prediction
- Ideation Failure Analysis

Also, the following two software products are in development:

- Directed Evolution® software
- Intellectual Asset Management software

New directions for Ideation research and development

The main objective for the next decade is transforming TRIZ from problem solving methodology into the theory of controlled evolution of artificial (man-made) systems (transition from TRIZ to Directed Evolution™).

We also continue our work in the following directions:

- Complete innovation solution system for R&D

[4] A new version of the IWB software, IWB 2005, has recently been released.

- Integration with other business, quality and knowledge management systems like Six Sigma, Stage Gate, etc.
- Evolution of organizations
- Methodology for scientific problem solving (SPS)
- Building specialized knowledge bases (chemical, health care, business/management, etc.)
- Development of software for DE, SPS and IP evaluation and enhancement

Conclusions

1. Ideation TRIZ becomes a combined marketing offering with the following differentiations from classical TRIZ :
   - Integration with other effective approaches to creative problem solving and control of technological evolution like Osborn's brainstorming and Miles value Engineering approach
   - Focusing on refined Innovation knowledge
   - Utilizing a unified and integrated process by which all types of problems can be treated in the same way
   - Targeting exhaustiveness of possible solutions following by selection of the best one based on local resources and specific requirements
   - New analytical and knowledge base tools (Innovation Situation Questionnaire, Problem Formulator, System of Operators) developed to achieve full support for problem solving process
   - Development of new TRIZ-based applications (Anticipatory Failure Analysis, Directed Evolution and IP evaluation and enhancement) providing a complete coverage of all innovation and problem solving needs for an enterprise.
   - Development of step-by-step processes for each application
   - Development of a suite of software tools TRIZSoft® to support all applications with the possibility to be customized for specific industries
   - Continuous research and advancement
   - Business model developed including education, software, project based workshop and coaching/facilitation
   - A turn key solution for TRIZ institutionalization (TRIZ system)

2. The main theoretical objective for the next decade is transforming TRIZ from problem solving methodology into the theory of controlled evolution of artificial (man-made) systems (transition from TRIZ to Directed Evolution™). Under this objective we care working in the following directions:

- Expanding TRIZ in non-technical areas (science, arts, business, management, etc.)
- Creation and continuous updating the Bank of Evolutionary Alternatives™ containing predictions related to the most general areas of human life (energy, automobile, housing, healthcare, medicine, computers, etc.).