Coordination and Integration of TRIZ Tools

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Introduction

Among the main reasons for the slow dissemination of TRIZ are the following:

- Long learning curve
- Complexity of tools and methods of their utilization

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 degree of 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 instructors and accumulated from one's own experience) and other (mostly tacit) knowledge about how to successfully utilize TRIZ methods and tools.

The first attempt to facilitate utilization of TRIZ was made by G. Altshuller in the mid-1960s when he built an electromechanical version of the Contradiction Matrix with the 40 Innovation Principles. The first ideas for utilizing a computer for TRIZ-based inventive problem solving occurred back in the 1970s[1]. Since then various software packages have been developed, mostly converting various TRIZ tools into electronic format and offering limited value as they still required substantial TRIZ education for effective use. Others offer ways to search for information with various degree of effectiveness [1 - 6].

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[1] *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.*

New approach to TRIZ computerization was introduced in the early 1990s. It was based on the following considerations.

1. The computerization is a part of the automation of human activity. Studies in the history of automation show that the most common mistake in the automation process is the attempt to build machines that copy the human ways of operation. For example, the first locomotives had "legs," the first sewing machines had "hands," etc. History has shown that attempts such as these do not succeed; real success comes only after the old technology (process) is replaced with one that has been invented with automation in mind. In the case of the sewing machine it was the invention of a needle with the hole in the sharp end and the use of two threads instead of one.

2. There are two main issues in every computerization attempt: a) the existing process that has to be computerized and b) available software developer tools. These two issues are connected like two communicating vessels: the clearer and better defined the process, the less sophisticated software tools are necessary for its computerization.

Given the above, the new approach was focused on substantial restructuring of existing multiple TRIZ processes and tools originally created for mental utilization and development of new ones to ensure successful computerization and thus facilitating mass utilization of TRIZ [7, 8].

Analytical and Knowledge-based tools of TRIZ

Classical TRIZ[2] included the following set of tools:

1. 40 Principles & Contradiction Matrix
2. Separation Principles
3. The System of (76) Standard Solutions
4. Effects
5. Patterns/Lines of Evolution
6. Selected Innovation Examples
7. Substance-Field Analysis
8. ARIZ

The first step in restructuring TRIZ was dividing all tools into three groups:

- Knowledge-based – tools offering knowledge extracted from patents and other sources of information representing the best innovation practices (1-6 from the list above).
- Analytical – tools helping to analyze the initial problem situation and formulating directions for solutions (Substance-Field Analysis).

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[2] *TRIZ developed during the 1946-1985 period.*

- Combinations from the first two groups (ARIZ).

This understanding of the existing tools' nature helped identify the main directions for improvement:

- Integration of existing tools to avoid confusion caused by their multiplicity
- Development of "missing" analytical tools to provide complete support of all steps in the problem-solving process, including problem definition and formulation.

One of the results was development of two new analytical tools: Innovation Situation Questionnaire® and Problem Formulator®. The other results included development of the System of Operators – an integrated knowledge-based tool.

Integrating and structuring TRIZ knowledge base

Historically, various TRIZ knowledge-based tools such as the 40 Innovation Principles, the Separation Principles, Effects, and others were developed as independent tools [9, 10]. The expectation existed that older tools would eventually be replaced or absorbed by more advanced and effective tools (such as a complete System of Standard Solutions). As a result, in 1980s many TRIZ schools practically stopped teaching the 40 Innovation Principles providing only brief information about this tool.

Later, it became apparent that excluding the 40 Innovation Principles from a practitioner's "toolbox" had a negative impact on one's practical problem-solving abilities, primarily due to the fact that the older tool had its own advantages, like simplicity. Also, several very effective recommendations from the 40 Innovation Principles were not included in the System of Standard Solutions (for example, "transformation of harm into a benefit"). On the other hand, simple reinstating all 40 Innovation Principles would result in duplication, because in many cases similar recommendations were included in different tools.

All of the problems mentioned above have been resolved through the development of an integrated operational knowledge-based tool (System of Operators) that includes all recommendations contained in the 40 Innovation Principles, System of Standard Solutions, Utilization of Resources, etc. This new System should work with any problem model known in TRIZ: Technical Contradictions, Physical Contradictions, Substance-Field models, etc.

It is also interesting to note that the original Principles were much more specific than the 40 Innovation Principles known today. Many of them had adaptations to specific characteristics they were intended to deal with. For example, the Principle "Segmentation" for the purpose of weight reduction differed from the “Segmentation” used to reduce dimensions [11]. Later, Altshuller withdrew such specifics from the Principles, apparently for the sake of universality and compactness of the Contradiction Matrix. However, this “detailization” can now be reconsidered in the light of the possibility of utilizing computers.

Besides “picking up” (selecting for use) an Operator based on a particular characteristic, it would be useful to do this based on the type of drawback involved or on a desired function. Providing such “entrances” to the System of Operators requires that the Operators be classified according to their possible application. For this, a complete redesign of all existing Operators (Principles, Standard Solutions, etc.), making them much more detailed and specific, can be achieved. This work has been started by Lev Pevzner [12] and proved to be extremely useful. Such “detailization” can be accomplished in two ways: through segmentation of the existing Operators (from the top down); and through the generalization of illustrations associated with each Operator (from the bottom up).

The first TRIZ knowledge-based tool – 40 Innovation Principles didn’t have any structure – just a set. To offset the lack of structure, Altshuller has created Contradiction Matrix to allow selecting from one to four principles from the set for a particular pair of parameters in conflict. The next knowledge based tool – seven separation principles didn’t require any structure because their number was rather small. There were several attempts to increase the number of innovation principles (within TRIZ and outside [13]) with limited or no success, mainly because extended number of principles required certain structure to help with their utilization.

The System of Standard Solutions was the first knowledge-based tool with a structure corresponding with SF-models and certain problem-solving and innovation needs. At the same time, a need to build SF-model prior to selecting an appropriate group of solutions substantially limited its effectiveness as it required extensive training. In addition, this tool was lacking the technical language typical engineer was used to.

Based on the considerations above, a general list that included all Operators derived from the existing Principles, Standard Solutions, Lines of Evolution, etc. was developed. After excluding instances of duplication, a preliminary structure of the Operators was suggested as follows:

Table 1

Main groups of Operators

Group name	**Area of application**	**Example**

Universal	Any	Inversion
Semi-universal or General	Wide	Increasing function efficiency
Specific (i.e., specialized)	Narrow	Increasing convenience

Later, several additional groups were introduced:

- Auxiliary (smart introduction of substances and fields)
- Selected patterns/lines of evolution

Table 2.

Structure of the System of Operators

Group name	**Sub-group name (number of purposes/specific factors were applicable)**[3]	**Number of Operators**	
		Direct	Associated[4]
Universal	Inversion	3	
	Integration	3	
	Segmentation	5	
	Partial/excessive action	4	
Semi-universal (general)	System synthesis (3)	9	
	Increasing effectiveness	8	
	Eliminating harmful effects (6)	30	
Specialized[5]	Improve useful features (12)	91	100+
	Reduce an undesired factor (18)	148	150+
	Improve a system for management/ control (3)	23	25+
Auxiliary	Introducing substances (11)	41	45+
	Introducing fields (3)	18	8+
	Utilization of resources (7)	38	60+
Selected patterns/lines of evolution	Increasing Ideality	12	100+
	Building bi- and poly-systems	16	
	Segmentation	4	
	Developing substance structure	4	
	Dynamization	5	
	Increasing controllability	10	10+
	Universalization	4	6+
	Matching/mismatching	4	

Altogether about 400 Operators have been created (some are not included in the count above, for example over 60 direct and associated Operators for resolving contradictions). Apparently, this

[3] *More detail list is out of scope of this paper.*
[4] *These Operators are linked to the direct ones allowing the user to follow the chains for further detalization of possible solution.*
[5] *Altogether 94 parameters/special purposes, including utilization of various effects*

number can be effectively utilized once stored in professional full scope software[6]. Another structure was suggested for a simplified software or "mental" use.

Using contradiction as a structure for Operators

The following is a well-known TRIZ statement: if one has a difficult problem, one has faced a contradiction. A typical contradiction in most cases could be graphically described on Fig. 1[7]:

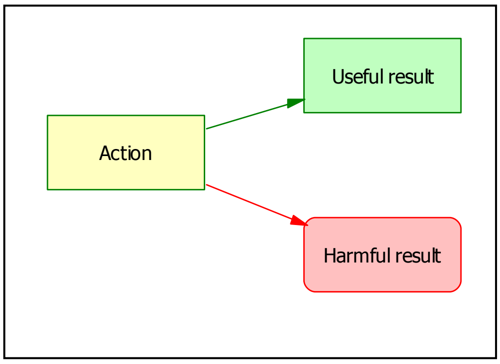

Fig.1. Graphical depiction of contradiction

This graphical depiction of a contradiction is quite convenient because it can be utilized for both types of contradictions known in TRIZ: technical and physical:

- Technical contradiction: An action creates an improvement (useful result) but also causes deterioration (harmful result).
- Physical contradiction: An action should be provided to achieve useful result and not provided to avoid harmful result.

Traditionally, classical TRIZ provides two knowledge-based tools to address the above: a set of several Innovation Principles (from the list of 40) and Separation Principles (4 to 7). However, vast experience of numerous TRIZ practitioners has shown that no matter how desirable it could be, not every contradiction can be resolved, especially when the given system is on its maturity stage and resources for further development within the existing paradigm are practically exhausted [14]. At the same time, it doesn't mean that the situation cannot be improved. Based on the graphical model shown above, the following typical directions for solutions could be identified:
1. Find a way to eliminate, reduce or prevent Harmful result under conditions of the given Action.
2. Find an alternative way to obtain Useful result that doesn't require the given Action (meaning, the associated Harmful result doesn't take place).

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[6] *Innovation WorkBench® software. See more at www.ideationtriz.com*
[7] *Suggested by Alla Zusman in late 1980s. To a certain extent, the underlined idea was similar to the concept of Key element suggested by Boris Goldovskiy in 1970s.*

3. Find an alternative way to the given Action that provides the Useful result and doesn't cause the Harmful result.
4. Resolve the contradiction: the given Action should be provided to produce Useful result and shouldn't be provided to avoid Harmful result.

From the list above, three groups of Operators could be identified: Elimination, Alternatives and Resolution.

For each group, a set of Operators is suggested as in Table 3.

Table 3

Simplified set of Operators

Elimination	**Alternatives**	**Resolution**
• Remove/modify the source of harm • Modify harmful effect • Counteract harmful effect • Protect the subject of harm • Increase the resistance to harm • Eliminate the effect of the harm • Convert harm into benefit • Exclude the subject of harm	• Modify existing way • Mobilize internal resources • Increase effectiveness of the action • Change the principle of Operation • Find additional benefits	• In space • In time • Between the parts and the whole • Based on different conditions

This structure and the limited number of Operators make it easier to memorize and thus to become an element of TRIZ way of thinking in addition to a number of universal Operators and the main TRIZ concepts like Ideality, Contradictions, Resources, System Approach and Patterns/Lines of evolution.

The first extensive knowledge base and new process was developed for Inventive Problem Solving (IPS) [15].

Complete Innovation Platform

IPS is only one of the existing innovation needs. To address all needs and develop a complete innovation and problem solving system suitable for computerization the following steps have been taken:

1. Identifying all needs related to problem solving and innovation and development of a comprehensive set of applications that will address these needs.
2. Development of computer-aided processes for each application.

This approach resulted in development of the following applications and corresponding knowledge – based tools and supported by the family of TRIZ-based software (TRIZSoft®) [16]:

Table 4

Complete Innovation Platform and corresponding knowledge- based tools

Application name	Short description	Knowledge-based tools
Inventive Problem Solving (IPS)	Solving difficult problems and improvements in technical and non-technical areas.	• System of Operators • Innovation Guide (collection of physical, chemical and other effects • Collection of Illustrations
Anticipatory Failure Determination (AFD)	Pro-active process for analyzing, predicting and eliminating failures in systems, products, and processes.	AFD checklists: • Ways to produce harm • Operators for failure prevention/ elimination
Directed Evolution® (DE)	Predicting next generations of products, services and technologies via inventing and developing a comprehensive set of scenarios describing future generations of a system.	• Patterns and lines of evolution (12 patterns and over 500 lines) • Bank of evolutionary alternatives (futuristic concepts for various industries).
Control (Management) of Intellectual Property (CIP)	Evaluation and Enhancement of Intellectual Property (IP) related to proprietary technologies, inventions, patents and patent portfolios	IP checklists: • Invention evaluation (over 35 parameters) • Invention enhancement

Conclusions

1. To facilitate TRIZ dissemination abound the world, computer support becomes an essential productivity tool.

2. Historical attempts to develop software tools were mostly converting various TRIZ tools into electronic format and offering limited value as they still required substantial TRIZ education for effective use.

3. New approach to computerization undertaken by the authors has resulted in restructuring existing and development of new analytical and knowledge-based tools embedded into various professional software packages. Simplified tools could be utilized mentally and/or utilizes via abridged software tools.

Bibliography

1. TechOptimizer, at www.invention-machine.com

2. Goldfire Innovator, at www.invention-machine.com

3. CreaTRIZ, at www.creax.com

4. TriSolver, at www.trisolver.com

5. TRIZ Explorer, at www.insytec.com

6. TRIZContrasolve, at www.ideacore.com

7. Zlotin B., Zusman A. An Integrated Operational Knowledge Base. In TRIZ in Progress, Ideation International Inc., 1999, pp. 114-122.

8. Zlotin B., Zusman A. Theoretical and Practical Aspects of Development of TRIZ-based Software Systems. Presented at conference TRIZFuture 2005. Graz, November 2005.
9. G. Altshuller. Creativity as an exact science. Gordon and Breach, Science Publishers, Inc., 1984. – 319.
10. Altshuller G.S., et al. The Search for New Ideas: From Insight to Methodology. Kishinev: Kartya Moldovenyaska Publishing House, 1989. – 380
11. Altshuller G.S. Basics of the Method of Inventing. Voroneg: Central Chernosem Publishing House, 1964. – 240
12. Pevzner L.H. "A Concept for Development of Micro-Standards for Solving Problems with the Help of a Computer" (in Russian), Journal of TRIZ 1, no. 2 (1990): pp.44 -49.
13. Polovinkin A.I.. Basics of technical creativity, 1988.
14. Zlotin B., Zusman A. Producing TRIZ Solutions: Odds of Success. TRIZCON, 2009.
15. Zlotin B., Zusman A. Managing Innovation Knowledge. In TRIZ in Progress. Ideation International Inc., 1999, pp. 123-140.
16. Ideation TRIZSoft®. At www.ideationtriz.com