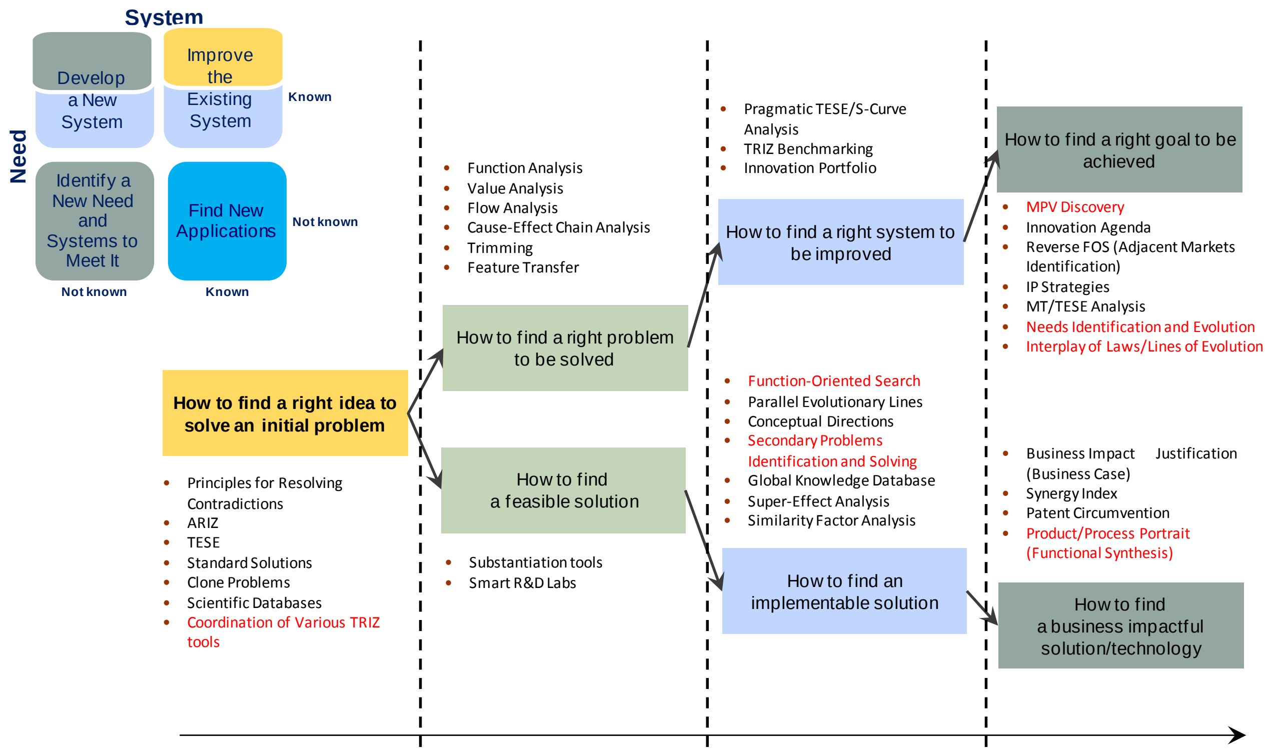
High-Priority Directions (HPD) for TRIZ Development



Framework for the Identification and Selection of HPD

Integration of TRIZ Tools Based on a Unified Language for Knowledge Presentation and Transformation

Objectives

a. To enable the seamless flow of information between all steps of engineering system analysis and problem solving within an integrated software tool, so that the user does not have to alter knowledge representation form between steps
b. To allow for the possibility of tight coupling and interoperation between TRIZ software and computer-aided design and mathematical modeling software systems

Background

The main deficiencies of the original TRIZ tools

1. Multiplicity of tools; additional confusion due to different translations from Russian; necessity to change forms of knowledge representation in transition between steps of the analysis (which requires high qualification in TRIZ). Indeed, we see in the Project roadmap groups of tools that use the following languages:
   - Mostly parameters and/or properties (Benchmarking, S-Curve Analysis, Feature Transfer)
   - Mostly functions (Function Analysis, Trimming, Standard Inventive Solutions)
   - Combination of parameters and functions (Function-Oriented Search, Engineering & Physical Contradiction Resolving, Scientific Database Application, ARIZ)
   - Free-form (Trend Analysis)
   - Mixed parameters and functions plus natural (Flow Analysis, Cause-Effect Chain Analysis, Clone Problem Application)
2. Given that a) TRIZ is intended mostly for engineers, and b) that engineers commonly use CAD software, it appears reasonable to presume that the rapid spread of TRIZ may be achieved by incorporating it into a software package which may be plugged into such or similar systems.

3. To avoid this, we should switch to a unified language of knowledge representation, and only in this case it would be possible to automate the process of constructing TRIZ methodology models.

4. This unified language should enable bidirectional data exchange between the TRIZ module and CAD software. The language of parameters best fits this requirement. For one thing, parameters and their numeric values naturally fit into CAD. Also, as we can see from the list above, the majority of TRIZ tools either already use this language to some extent (sometimes implicitly) or may be switched to it fairly easily.

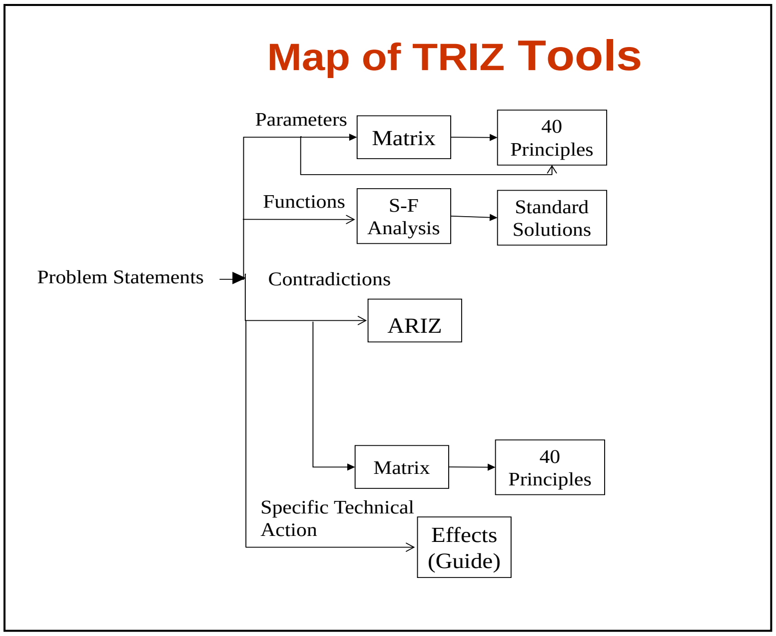
c. It should be noted that this refers to the **internal language** of the software module implementing the combination of TRIZ techniques. "On the surface" it should not be visible because it is not particularly convenient for the human user. All information input and output for the user should be represented in a language as close to natural free-form as possible.

Attempts to improve the situation to date

One of the first attempts to coordinate utilization of TRIZ tools was suggested at the Petrozavodsk TRIZ Conference in 1985 (Zlotin, Zusman; see a simplified diagram below). This diagram, however, has improved the situation just to a degree, so later on, the following directions have been developed:

- Classification of tools and its main elements
- Integration of existing knowledge-based tools, with introduction of uniform structure and step-by-step utilization
- Development of additional tools for problem definition, formulation, etc.

- Replacement of complex tools with new ones offering acceptable efficiency
- Development of software capable of storing accumulated TRIZ knowledge (examples, case studies, etc.) and guiding the user step-by-step



During the period 1989-1999, the following findings were obtained (selective list, for more detailed information see references):

1. Tools have been divided into two groups:
    - Knowledge-based tools
    - Analytical tools
2. For each type of tools basic universal elements, structure, and rules for utilizations have been identified.

Knowledge-based tools

1. For elements of knowledge-based tools, (inventive principles, separation principles, standard solutions) unified basic element "operator "has been introduced defined as a recommendation to change the system for the purpose of resolving the problem.   The name was borrowed from math and G. Altshuller (operator DTC (dimensions, time, and cost)) and math.
2. Operators were divided into several groups by the size of area of application:
    - Universal (could be applied to any system/need)
    - General (applicable to wide classes of systems)
    - Specialized (applicable to specific systems/needs, like reduction of weight or cost reduction)
    - Additional group included auxiliary operators (similar to standard solutions from class 5) on how to introduce substances and fields in the most ideal way.
3. Extending number of operators over 400 with the possibility to come up with practically unlimited number of new operators for various specific purposes.
4. Numerous number of operators' chains (sequential use of a number of operators) were built to guide the user from more general to more specific recommendations (like reducing weight by strengthening parts bearing the main load- strengthening via introducing mechanical stress- using physical effects associated with elastic properties of materials, etc.)

Analytical tools

1. For analytical tools, the following basic elements have been introduced:
    a. "Factor" as a general name for function, parameter, condition, object, property, etc.
    b. Factor evaluation (positive or negative) depending on the user's objectives
    c. Two types of standard connections between factors: "produces" ("contributes") and "counteracts"
    d. Describing the situation in the form of a graphical cause-effect relationships between related factors
    e. Creating a graphical model of a contradiction suitable for both technical and physical contradictions and formulating three basic mini-problems (alternative, elimination and resolution) on the basis of this model.
    f. Creating a technique for building graphical cause-effect diagrams with automatic transformation of the diagram into an exhaustive list of directions for solutions/innovations

2. Technique for building graphical cause-effect diagrams was developed with automatic transformation of the diagram into an exhaustive list of directions for solutions/ innovations

In recent years, based on the model described in item 7, short lists of operators for all three mini-problems have been identified for mental application (with participation of Dr. Ron Fulbright, chair of informatics at the University of South Carolina Upstate, which offers an accredited TRIZ course).

Software development

Developed software for problem solving, embedding all operators, graphical diagramming, questionnaire for problem definition, and other elements of the process supporting all steps necessary for problem solving, from problem definition to the implementation plan.

For more detailed information on the findings see references.

Expected results

We expect that individuals or groups interested in the given subject will do the following:

1. Study the results mentioned above
2. Test the efficiency and other attributes (like simplicity, etc.) of the tools developed (both with and without software)
3. Identify pluses and minuses of the given approach and offer further improvements, including:
    a. Unified language of knowledge representation, including "vocabulary" and "syntax," e.g., words may include "object," "parameter," "value," "change," as well as Boolean operators and parentheses. Hence, statement "/Object 1//change/(/value 0/, /value 1/) □ /Parameter 1/ □ /Object 2/" with appropriate value substitutions may be a representation of function like "water heater heats water from 20 □ C to 100 □ (/Object 1/ /c 1/) /Parameter 2/) □ /Object 1/), with appropriate value substitutions would represent the technical contradiction, "if water heater has large surface area, then it rapidly heats water, but it is also very heavy."
    b. Rules for constructing models for all steps of the methodology using a unified parametric language.

Participants of these studies will receive all papers and free software.

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Participants of these studies will receive all papers and free software.

Addressing Secondary Problems

Objective

Provide effective recommendations to address secondary issues (possible side effects and other drawbacks associated with the potential solution) while solving problems with TRIZ.

Background

Any more or less serious invention cannot be implemented without solving a number of secondary problems which grow dramatically with the level of invention. In Classical TRIZ, though, limited consideration was given to this subject. Certain attempts to address secondary issues were made, for example, step 7.4 in ARIZ-85C [1] which recommended thinking about sub-problems that could appear during further development; and in 76 Standard Solutions, Class 5, how to apply standard solutions [2] was introduced. Unfortunately, these recommendations were of limited help for the following reasons (not in any particular order):

- Absence of specific instructions/ tools on how to unveil and handle secondary problems
- Even comprehensive TRIZ courses were not long enough to pay proper attention to the last parts of ARIZ.
- Typical training case studies lacked detail about the real system (situation) prohibiting formulation of secondary problems.
- For the majority of students, training case studies were outside their professional expertise, making revealing secondary problems on their own very difficult.
- Today, most typical short TRIZ courses, at best, include one of the abridged versions of ARIZ from which these parts are usually omitted.

At the same time, the importance of addressing secondary (subsequent) problems has been increasing with the widening practical (professional) application of TRIZ. In fact, the higher the level of the obtained solution, the wider the range of subsequent problems (in numbers and complexity) which must be resolved to ensure successful implementation. In the absence of clear recommendations, TRIZ practitioners are left to handle secondary issues to the best of their abilities. In most cases, however, their experience in this area is not well documented, or is rather tacit than explicit, which renders it impractical for dissemination.

The first specialized instrument to address situations with numerous and often sequential secondary problems was suggested by Vladimir Gerasimov and Simon Litvin in the mid-1980s [3]. This technique recommended a number of sequential steps based on functional analysis and function ranking (primary, auxiliary, secondary, harmful, etc.).

The most recently known attempt to address the issue above was made during the development of the Innovation WorkBench® software [4] that was intended to support the TRIZ-based Inventive Problem Solving process, including handling of subsequent problems as a part of the "Evaluate Results." section The first step included an attempt to identify the most typical secondary situations:

- Problems arising in the process of realization of high level inventions. As a rule, their implementation takes a long time because of unresolved secondary issues [5].
- Issues arising from adapting known engineering solutions to the specifics of the current situation – coordinating with other systems' elements, new environment, requirements, etc.
- Unintended consequences – issues associated with the fact that in the majority of cases, short and long term results of changes are rather opposite, where changes that bring positive results at first produce unexpected problems later.
- Various issues arising as a result of changes dictated by the system environment and its evolution (improvements, optimization, etc.)

As a result, various instruments were suggested to address these issues [6].

For more detail information on the findings see references.

Expected results

We expect that individuals or groups interested in the given subject will do the following:

4. Study the results mentioned above
5. Test the efficiency and other attributes (like simplicity, etc.) of the tools developed (both with and without software)
6. Identify pluses and minuses of the given approach and offer further improvements

Participants of these studies will receive all papers and free software.

References

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Analogy-based Solution Search

Objective

Develop new TRIZ problem solving tools that are based on deep non-obvious analogies between solutions from different industries and areas of science

Background

One of the major challenges of classical TRIZ is a contradiction: the solution should be disruptive in order to assure significant improvement of the product/process; however, the solution should already be proven in order to reduce the time of implementation. Using remote analogies resolves this contradiction and changes the innovation paradigm by offering already existing solutions or technologies rather than inventing new ones. Industries face similar engineering challenges, but these similarities are not readily obvious, because the industries where they appear may be completely different from each other. In industries where these challenges are more critical, more resources (manpower, capital, and time) are allocated to address them. Correspondingly chances to identify effective existing solution in these areas are higher.

There are two analogy-based tools in the modern TRIZ toolbox – Clone Problems and Function-Oriented Search (FOS). The Clone Problems approach was developed by G.Altshuller in 80-s [1] and was further developed by S.Litvin in 90-s [2]. It is based on deep non-obvious analogues among solutions that address the same physical contradiction. A serious challenge of Clone Problems is the necessity to form a special database of typical physical contradictions and corresponding solutions. That is why this very powerful problem solving tool is not popular in the TRIZ community and cannot be effectively taught within TRIZ education. There is a need for further development of the Clone Problems approach in order to make it more instrumental and acceptable.

Function-Oriented Search (FOS) was developed by S.Litvin and his colleagues beginning in the late 80-s [3-5]. FOS has become one of the most powerful TRIZ-based problem solving tools in the world today. The main idea behind FOS is bringing an already existing technology from a very remote but functionally similar area of science and engineering as a solution to the problem in the initial area which requires an innovation. The specific tools of FOS are function generalization, function-leading areas identification, similarity index identification, adaptation problems, etc. [3-5].

There are two major advantages of FOS when compared with traditional inventive problem solving, including contradiction resolution. First, the FOS derived solution is, by definition, an existing technology. One does not need to prove that a corresponding technology will work - it does work in a function-leading area. Second, FOS is bringing solutions from remote industries to help solve problems for the entire world with the knowledge of the entire world, which facilitates the idea of practical open innovation. It is easier to find functional analogues using modern search tools, like Google, because of the intensive use of functional terms in the world patent collection and product registers. However, in different industries and areas of science the same function is usually described in very different terms. Another challenge lies in the identification of the proper leading areas for each typical function. These challenges require further development of the FOS approach.

Moreover, Clone Problems and FOS are just two possible analogy-based problem solving tools. There are some other intrinsic features of products and technologies that may provide a basis for other analogy-based problem solving tools. For instance, an action principle of the system (its basic physics, chemistry or biology) may play a role in such a basis. Another possible analogy is the one between absolutely different products with different functions and action principles, but addressing the needs of a similar market niche or group of consumers.

Expected results

- Practical recommendations and algorithms for Clone Problems application.
- Clone Problems database.
- Leading Areas database.
- Practical recommendations and application algorithms for action principle-based analogies.
- Practical recommendations and application algorithms for market niche-based analogies.
- Other possible kinds of analogy-based problem solving tools.

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Transition from Business Challenges to Technical Problems

Objective

Develop effective tools and recommendations for connecting companies' business challenges with underlying technical issues.

Background

The ultimate goal of innovation is to maximize business growth and profitability within the constraints of available resources. That is why there is no demand for any invention or innovation if it doesn't address some business need. Executives of industrial companies are operating with business categories such as annual revenue, profit margin, market potential, market share, return on investment, etc., in mind. The business success of industrial companies, however, depends heavily on the efficacy of their products and technologies. Unfortunately, there is no direct connection today between business challenges and underlying technical problems.

There is a serious gap between business consulting companies which usually address business issues and technology consulting firms and R&D departments that are dealing with technical problems.(this should be one paragraph, but the formatting is not permitting it)There is an obvious need for effective methodological tools and corresponding providers t capable of connecting business challenges to specific technical problems of products/processes.

Classical TRIZ didn't possess these kinds of tools at all. In modern TRIZ several tools were developed to address this gap. Among these tools are Main Parameters of Value Discovery, Innovation Agenda, Adjacent Markets Identification, Combined Analysis of Market Trends and Evolutionary Trends, etc.

The Main Parameters of Value (MPV) Discovery is a tool/technique that connects business challenges and technical problems []. Main Parameter of Value is a key attribute of a product/service that is hereto unsatisfied and important to the purchase decision process. MPV Discovery is based on such TRIZ tools as Function Analysis and Evolutionary Trends. Applying these tools allows, instead of the subjective results of market surveys (Voice of the Customer - VOC), the identification of objective function-based parameters of the product (Voice of the Product- VOP).

The MPV approach opens new horizons for connecting business problems with technical ones. However, this technique requires further development. Some of the questions that should be addressed are:

- How to select the main parameters out of multiple candidates?
- How to prioritize MPVs?
- What are the differences between MPVs in Business-to-Consumer and Business-to-Business industries?
- How to measure/evaluate some qualitative MPVs, like Convenience, Indulgence, Brand, etc.?
- How to combine VOC and VOP?
- How the super-system evolution in time effects the MPVs for the system?

Expected results

- Practical recommendations addressing the issues of the MPV approach.
- Practical recommendations and algorithm for the Combined Analysis of Market Trends and Evolutionary Trends.
- Other possible TRIZ-based tools connecting business challenges and technical problems.

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Identification of High-Potential Innovations Based on Analysis of Needs and Wants

Objective
Develop a tool for identifying the most promising new products, technologies, and services using knowledge of the evolution of needs and wants.

Background
One of the most vital applications of TRIZ is helping businesses identify and prioritize the best innovation opportunities. TRIZ tools used for this application – different product and technology forecasting approaches based on laws/lines of TS evolution and S-curve analysis [2, 3, 6, 13] – are associated with one or all of the following major shortcomings:

- Lack of specificity (recommendations are often too general to be actionable)
- Variability of results (different experts using the same tools arrive at different conclusions)
- Difficulty in discovering unspoken and latent needs
- Inability to predict new needs

It is suggested that the aforementioned tools and approaches be augmented by other analytical tools – presently absent in TRIZ – that take into account the evolution of needs and wants.

The bulk of the inquiry in the evolution of needs and their influence on the evolution of technology has been conducted outside TRIZ[1]. Most researchers in this area share the following basic concepts and understandings:

- There are needs and there are wants. A need is something one must have, cannot do without (e.g., water). A want is something one would like to have, but can survive without (e.g., a cake).
- The same object can satisfy a need for one person and a want for another (e.g., a mobile phone may be the former for an executive and the latter for a homeless person).
- Yesterday's want becomes today's need (e.g., a personal car in suburban America).
- The same technological object can satisfy several needs (e.g., a Rolex provides for both time keeping and conveyance of social status).
- Some needs are explicit while others are latent (satisfying the latter often leads to new and rich market opportunities).
- Some needs are permanent (e.g., human need for oxygen), while others are emerging (e.g., bleaching of private parts).
- Some needs beget new technologies (e.g., the need to kill fast-moving animals and humans led to the invention of various weapons for hunting and war), and some new technologies give rise to new needs (e.g., proliferation of digital social networks and databases led to the increased vulnerability of privacy).
- There are individual needs and those of groups (e.g., families, work teams, businesses, societies).

[1] In 1980, Genrikh Altshuller initiated a study of the evolution of needs (both at individual and societal levels). One of the goals was to understand how evolving needs translate into the emergence and development of products, technologies, and services. That study, carried primarily by Igor Vertkin and Victor Fey in the period 1980-1984, yielded some theoretical and practical results (e.g., the prediction, among others, of consumer DVRs with a "skip-commercial" capability; first personal DVRs were introduced in 1999). However, due to certain historical circumstances, those results have not been made available to a wider TRIZ community. Perhaps, they should be now reviewed, revised, if necessary, and published. In 2005, Vladimir Petrov presented a paper [9], in which he hypothesized some similarity between the trends of evolution of needs and those of TS.

This, of course, is not an exhaustive list of concepts and hypotheses concerning the evolution of needs; more can be found in literature. However, none of the existing theories of needs and their evolution can be used to reliably identify new high-potential innovations.

Expected results

1. Classification of needs[2]
2. Databases of individual and group needs[3]
3. Trends of evolution of needs and wants[4]
4. Indicators of the level of need satisfaction
5. Method (algorithm) for the identification of all vital unsatisfied existing needs associated with a given TS
6. Method (algorithm) for the identification of all vital latent needs associated with a given TS
7. Method (algorithm) for the identification of new needs
8. Method (algorithm) for the translation of needs into functional and physical models

Developing all of the items on this list may take years, but any meaningful advancement even along some of them would markedly enhance the state-of-the art.

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[2] Are existing classifications – e.g., Maslow's – sufficiently instrumental?
[3] Needless to say, such databases should be continually updated.
[4] Potentially, matching the laws/lines of evolution to the vectors of evolution of needs

Development of Products and Processes from Scratch

(Additional)

Objective

This proposal describes the inventive situation (IS) which requires the performance of a certain function where the existing way of performing this function is not feasible within the limitation imposed on the IS. The examples of such an IS are well-known in TRIZ – for instance, unloading of tar from a tank car, or trimming of the marine sluice guiding system. The essence of such an IS is the search for a new way of performing a function.

Background

The known TRIZ approaches for development "from scratch" are all based on finding a suitable known system, called a "Prototype," which already performs the required function in some known way. Once the Prototype is found, existing TRIZ tools are applied to evolve the Prototype to a point where the requirements of the IS are satisfied. A Function-oriented Search (FOS, [1]) is commonly used for finding the Prototypes. In some (arguably) rare cases when it is not possible to find a single Prototype, the approach is to construct a composite Prototype using features of a existing systems.

The approaches described above work only if a Prototype is found, but this is often not the case. In the case studies referred to in the Introduction, none of the known ways of transferring partially solidified fluid (in the tar unloading case) or guiding a ship (for the sluice challenge) are anywhere close to fitting the limitations of the new IS. The solution cannot be obtained by improving an existing system; a completely new system has to be invented. In spite of the fact that such an IS is quite common and its solution usually revolutionizes technology, its analysis and solution methods have not yet been adequately developed in TRIZ. One reason for this is that such ISs contradict the very "stepwise" approach of TRIZ, according to which even the strongest and breakthrough solutions are achieved gradually and step-by-step. How can one step when there is no "ground?"

Expected results

The proposed research topic consists, therefore, in the development of a new, or the adoption of an existing TRIZ technique for the analysis and solution of the IS in which none of the known or constructed ways of performing a function can be used as a Prototype.

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