

Problem Formulation

Background

The System of Operators and the other knowledge-base tools mentioned above help in solving problems that have been formulated in some manner (either right or wrong). When used with a complex innovation situation with many inter-related problems, rather than with a single problem, the efficiency of utilizing the System of Operators can become close to zero. Although some Operators incorporate certain changes into the problem statement (as mentioned in the section entitled “*The Operator as a creative recommendation for system transformation*”), they cannot address multi-faceted, multi-hierarchical situations or systems in their entirety.

At the same time, it is widely known that a well-formulated problem is a problem that is nearly solved. Often, by reformulating the problem, the solution becomes obvious or is more easily obtained than with the initial problem statement. Breaking up a complex and unclear innovation situation into a set of individual, well-defined problems is a key to a successful problem solving.

The fact that the same problem situation may have multiple problem statements is rooted in Mr. Altshuller’s multi-screen model of creative thinking¹ or the so-called “systems approach.” According to this approach, any system has a hierarchical structure that includes subordinate sub-systems and at least one higher-level system to which it, in turn, serves as a sub-system. Very often the links between the system, sub-systems and super-systems are rigid enough to ensure that a change in one part of the system causes substantial changes (either positive or negative) in adjacent systems and sub-systems, in particular:

- A breakdown in one part of the system can cause undesired consequences in other parts of the system, and in the system as a whole
- An undesired situation in one part of the system can be eliminated by changing a different part of the system.

As a result, one problem can be addressed in different – and often very diverse – ways, that is, the assertion can be made that every problem has more than one way by which it can be approached.

Example:

Suppose we are faced with the problem of how to increase the speed of an airplane. This problem can be approached from various standpoints, such as: increasing engine power, improving the aero-dynamics of the airplane body, etc. At the same time, we can formulate this problem at a higher system level by addressing the purpose we wish to achieve by increasing the airplane’s speed. Obviously, we want to increase the speed so that the flight-time will be reduced. But at the same time, a commercial airplane belongs to the super-system named “transportation.” In this case, we should consider the other systems that contribute to the overall time spent in taking a trip, including the time required to get to the airport, check in, wait for an available gate, pick up luggage, etc.

¹ G. S. Altshuller, *Creativity as an Exact Science* (Gordon and Breach Science Publishers, 1984), 117-123.

Continuing in this manner, we can change the problem statement to consider, for example, reducing the time spent on the ground rather than in the air. This change seems even more reasonable from the standpoint of resource availability for system improvement: it may very well be that there is a physical limit to the increase in speed that can be achieved, however, the ground service systems have much in the way of resources by which improvements can be made.

In the course of their work, many TRIZ specialists have been in situations where a customer has spent an enormous amount of time trying to solve the wrong problem, and the TRIZ specialist succeeds because he/she offers a different approach.

Example:

Refined and processed nickel is usually supplied in granular form in the shape of small pellets. To produce these pellets, molten nickel is dispersed into water by being dropped from a substantial height. The drops of molten nickel are cooled by the air as they fall towards the water, becoming somewhat hardened in the process. Upon entering the water, they completely harden and solidify.

This approach works in principle but, in practice, as multiple drops of nickel are released simultaneously, their mutual proximity creates a localized thermal hot zone, which inhibits each drop from cooling. As a result, the metal hits the water at a temperature that is much higher than desired. Thermal shock results, which fractures the metal, producing a significant quantity of unusable nickel powder.

To recover the powder, the manufacturers attempted to introduce it into the furnace together with the nickel ore. In this case, however, the nickel powder burns up before it reaches the molten nickel surface, due to the high temperature and oxygen blasting. The problem was to find a way to protect this powder from burning.

After finding several solutions to this problem, the problem statement was changed. It was clear that attempts to improve the powder utilization process did not constitute ideal solutions because the root cause of the problem was unresolved: i.e., the problem of producing the powder in the first place. Moreover, an additional harmful result of this root problem was that a certain number of the pellets fractured not during production but later, as they were being transported to the customer. This resulted in customer dissatisfaction. Focusing on the nickel production process itself rather than on the utilization of powder allowed a solution to be found that rendered the problem of powder utilization non-existent.

In this case, the problem statement was changed due to experience, TRIZ intuition, etc. The challenge we faced, then, was in transforming this intuition into a well-defined process that can be followed by anyone.

The actual development of the Problem Formulation process began around 1985. The following well-established methods and techniques were taken into consideration (shown in historical order):

1950s Functional analysis developed by Larry Miles to describe a product/process in terms of its hierarchical system of numerous useful



functions

- 1960s** Fishbone diagram developed by Ishikawa Kaoru to describe a process in terms of cause-effect relationships
- 1960s** First chapter of ARIZ (in early versions) developed by G. Altshuller to identify problems formulated on higher and/or lower levels of system hierarchy, which might replace the initial (and sometimes unsolvable) problem statement
- 1970s** Chapters in later versions of ARIZ devoted to changing and/or replacing the initial problem statement with a more promising one(s) in those situations where the initial problem statement can not be resolved
- 1970s** Multi-screen model of creative thinking developed by G. Altshuller based on the systems approach and which encourages the problem solver to consider the whole system rather than focus on the sub-system associated with the problem
- 1970s** Altshuller's concept of conflict, including its graphical representation
- 1970s** Practical experience accumulated by Boris Zlotin and other TRIZ specialists in changing/replacing the initial problem statement by a more promising one
- 1980s**

Problem Formulator™ development

The Problem Formulator™ is an analytical tool that encompasses the problem formulation process². It can be used manually or with software support. The process includes two steps: building a cause-effect (event) diagram; and the formulation itself. Accordingly, the associated software tools include two main modules. A brief history of the development of the Problem Formulator is as follows:

- 1985-1987** Boris Zlotin and Alla Zusman develop the first step-by-step process for analyzing a given problem statement, restoring the initial innovation situation and identifying potential directions for innovation.
- 1989-1991** Alla Zusman offers an integrated graph of useful and harmful functions/ effects/events, formulating eight key questions for identifying the links between useful, harmful and correcting functions/events, identifying contradiction (key) nodes, and introducing standard frames for problem statements that fit all possible problem situations. This

² John Terninko, Alla Zusman and Boris Zlotin. *Systematic Innovation; An Introduction to TRIZ* (CRC St. Lucie Press, 1998), 47-64.

technique was included as a chapter in ARIZ –SMVA 91³.

- 1992** Sergey Malkin's group began developing a software module for the automatic generation of problem statements and building of graphical models. They suggested introducing specific link words reflecting useful and harmful relationships, in order to allow the software to identify the function type and built a corresponding mathematical model.
- 1993** Development of a Navigator – a system that assists one in building the graphical model using a set of questions and a pre-determined work scenario. Patent application filed.
- 1994-1996** Various users practice with the Problem Formulator.
- 1996:** U.S. Patent No. 5,581,663 issued.
- 1996-1997** Development of a Problem Formulator for Windows-95. New features introduced: an additional link (“hinders”), extended lists of standard problem statements including formulated contradictions, the ability to edit graphical features.

The development of software capable of formulating problems related to an innovation situation had always been a formidable task, and represented a challenge similar to the classical problem in the area of Artificial Intelligence (AI), where a machine must be able to recognize a meaning presented in text form. However, we could avoid solving this long-standing problem by utilizing some elementary patterns found in structural linguistics. Thus it was discovered that automated problem formulation can be provided via the following procedures:

- Divide all text elements into two types:
 - Invariants, that is, elements that do not change during the formulation process and thus do not need to be “understood” by a machine. These elements contain specific information (functions, actions, effects, events, and other statements) related to the problem situation.
 - A limited number of changeable, standardized elements (link verbs) that describe the relationships between the invariants and that can be recognized (and acted accordingly upon) by a machine.
- Define the minimum amount of standard link verbs that will allow any situation to be described (so far, four such link verbs are sufficient, and further research is directed toward improving the quality of the descriptions that can be made, with the possibility of reducing the number from four).
- Visualize the relationships between invariants with the help of graphical images of link verbs (various types of arrows).

³ Boris Zlotin and Alla Zusman. “Problems of ARIZ Enhancement,” *Journal of TRIZ*, vol. 3, no. 1 (1992), in Russian. See the English translation on the scientific channel of our web site, www.ideationtriz.com.

- Develop rules and algorithms for transforming the graphical description of a problem/system into a set of relevant problem statements.
- Adjust the available knowledge-base tools according to the automatically formulated problem statements.
- Develop a navigator to direct the process of building the graphical model by presenting the user with a set of relevant questions.

The output of problem formulation is a set of individual problem statements. Once these problems (i.e., problem statements) are identified and elucidated, each of them usually represents a distinctive direction towards a group of solutions. One of the most surprising results of working with the Problem Formulator is the discovery that the meticulous process of building the graphical model allows a nearly exhaustive set of problem statements to be formulated. This in turn can reveal quite promising approaches that might be non-obvious even to experienced professionals. Often, once a new approach is spelled out, the solution is straightforward.