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Which problem to solve?

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Abstract – The article illustrates some concepts and methods less familiar in the word of "pure engineering" but very usefull in "shattering the mental barriers".
Keywords: Problem situation, Minimum Problem, Maximum Problem,TRIZ, ARIZ, Multi-Screen, STC

I. INTRODUCTION

Solving an engineering problem is usually a routine process by which a professional uses knowledge from his domain and based on previous experience and making a few "trade offs" will solve it, but if the person has a *sudden enlightenment* and propose a completely new system then everybody will agree the fact that the person is a *creative genius*. However the so-called common engineering problems could be solved in a completely different manner, a *creative one*, paying the price of studying a not very known but powerful method, called TRIZ - a Russian acronym, meaning The Theory of Solving Inventive Problem. This powerful method offers not a singular solution but merely a *solution concept* and also high level of creative solutions even when applied to not so complex engineering problems.
Approaching engineering problems begin with a statement: some new Technical System (TS) must be created in order to achieve a purpose, or we must improve such and such a system to get such and such result, or simply we must improve something.
Speaking in terms of Primary Function (PF) we have three situations:
a. PF is not executed because TS does not exist yet.
b. PF is executed partially so the TS must be improved.
c. PF is executed but there is a contradiction between the Useful Function (UF) and the Harmful Function (HF) so the TS must be change to some degree.

II. IDENTIFYING THE PROBLEM

"The real problem to be solved is rarely the same as the problem initially posed."[5] Its frequently happen that the problem arrive to us in a previous incorrect formulation, either because the problem needs clarification or because it is hidden inside the formulation.

"We solve the problems we were taught to solve. School teaches us to solve closed problems. The closed problem formula comprises a clear statement + an approved solving method + the only correct answer. Any sidestep, to the right or to the left of the approved solving method (hence, thinking method!) lowers the mark."[7]
"In real life, one finds, at best, problem situations. And what is a problem situation? A problem situation is a *bunch of tangled problems*, which, as a rule, present us with a lot of uncertainty and lack of definition. Complex interactions and multilevel nature inherent in a technical systems' hierarchy impede our ability to determine the main link in the chain of undesired events. Thus, the issue of problem detection and formulation is the primary challenge to resolving the problem situation."[8]
As Altshuller says [2]: "The process of inventive creativity begins with elucidation and analysis of the invention situation. The invention situation - is any technological situation clearly containing an unsatisfactory feature (the word "technological" is used here in its broadest sense: technical, production, research, everyday use, military) ".
The modality of solving a problem, the quality of the solutions and sometimes even the way it is approached are influenced by both the content and the form under which it is introduced. Here is an example of the way in which the language used influences the attitude of those in the position to solve the problem. It was used by Altshuller [1, p.229] at the TRIZ seminars and tested on a group of highly qualified engineers.
"Let's assume that 300 electrons, in several groups, must jump from one energetic level to another. However, a quantum transfer has already taken place by two groups less than were originally calculated; consequently, each group now has five more electrons. How many electron groups were there in total? This complex problem has not yet been solved."
Everybody's objection was that the problem needs knowledge outside their domain - respectively quantum mechanics and also that nobody had so far been able to solve it. Altshuller then offered to help them by reading a similar problem.

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"To send 300 scouts to summer camp, several buses were reserved; however, two buses did not show up at the required time. Therefore, each bus took five scouts more than was planned. How many buses were sent?"
Obviously, everybody succeeded in solving the problem. When a mathematical problem is considered to have "no solution," the majority of people take this for granted. This is not the case with an inventive problem. "People have tried to solve me, but nothing happened. It is not in vain that smart people believe nothing can be done here."[1,p229]
These observations are one of the reasons why in ARIZ-71, in Step 2-3, the following is recommended:
Describe the conditions of the problem (without using special terms, and without stating what exactly must be thought out, found, or developed) in two phrases using the following format:
a. "Given a system consisting of (describe its elements)."
b. "Element (state element), under conditions (state conditions), produces the undesirable effect (state efect)."[1,p112]
Thus it becomes obvious that not every statement "disguized" under the formulation "it is necessary to solve the problem... such as..." is in fact the enunciation of a problem but rather a mass of information through which we have to see the facts, in certain situations even decide what actually the problem is, and possibly to choose for solving the most appropiate one.
Figure 1 synthesizes the process of passing from the "open" problem, vaguely described by the initial enunciation, to the two categories of problems, minimal and maximal. The term mini-problem should not be confusing. It does not refer to the solution of a "smaller" problem, or to a problem whose inventive solution is of an inferior level . [9]
On the contrary, introducing severe restrictions in the degree of modification of the initial technical system (TS) leads to peculiarly creative solutions. Introducing restrictions leads to emphasizing the technical contradiction (TC) and reduces the risk of trade-off solutions. By restrictions we mean introducing in the conditions of solving the problem supplementary demands concerning the inalterability or simplification of the system in case undesired properties disappear or demanded properties appear. Naturally, this is not always possible, but it is always desirable to start with this approach since, when it is possible, it ensures quality solutions, and, as it does not need major changes in the system, it leads to economic implementations.

III CHOSEN THE PROBLEM

If we are looking in ARIZ 71 Part One we will find:
Choosing the Problem:
Step 1-1: Determine the final goal of a solution.
a. What is the technical goal (what characteristic of the object must be changed)?
b. What characteristic of the object obviously cannot be changed in the process of solving a problem?
c. What is the economical goal of the solution? (Which expense will be reduced if the problem is solved?).
d. What is the roughly acceptable expense?
e. What is the main technical/economical characteristic that must be improved?
Step 1-2: Investigate a "bypass approach". Imagine that the problem, in principle, cannot be solved. What other, more general problem, can be solved to reach the required final result?
Step 1-3: Determine which problem, the original or the bypass, makes the most sense to solve.
a. Compare the original problem with a tendency (a direction of evolution) within the given industry.
b. Compare the original problem with a tendency (a direction of evolution) within a leading industry.
c. Compare the bypass problem with a tendency in the given industry.
d. Compare the bypass problem with a tendency in a leading industry.
e. Compare the original problem with the bypass one. Chose which to pursue.

There are several versions of ARIZ (Algorithm for Solving Inventive Problem) each having been improved due to accumulated data and the solution of more and more complex inventive problems from different domains. In ARIZ 77 Part One we find the following step:

1.2a. Transform the problem by switching to the super-system or sub-system level.
1.2.b. On three levels (super-system, system, and sub-system) transform the problem, having replaced the requisite action (or property) by its reverse. Also in ARIZ 77 the STC (Size-Time-Cost) operator is introduced in Part One of the algorithm, Selection of the Problem instead of Part Two, Define the Problem more precisely. The STC operator is an easy but very powerful tool to use for shattering the mental barriers and overcoming psychological inertia which is very active when it comes to solving inventive problems. Unfortunately, the generation of constructive ideas is not done aleatorily but follows the direction of the inertia vector which more often than not deviates attention from the space of the possible solution to the zone which is familiar to the solver in such a way the greater specialization one has in a certain domain, the easier vicitm he becomes when he less expects it.. The space of quality solutions may be placed in the perimeter of other domains of activity, or other sciences. How does the STC operator function. To illustrate it, here is tep 2-2 from ARIZ 71: Use Operator STC:
a. Imagine changing the dimensions of an object from its given value to zero ($S \rightarrow 0$). Can this problem now be solved ? If so, how?

b. Imagine changing the dimensions of an object from its given value to infinity (S→∞). Can this problem now be solved? If so, how?
c. Imagine changing the time of the process (or the speed of an object) from its given value to zero (T→0) Can this problem now be solved? If so, how?
d. Imagine changing the time of the process (or the speed of an object) from its given value to zero (T→∞) Can this problem now be solved? If so, how?
e. Imagine changing the cost of an object or process - its acceptable expenses - from its given value to zero (C→0). Can this problem now be solved? If so, how?
f. Imagine changing the cost of an object or process - its acceptable expenses - from its given value to zero (C→∞). Can this problem now be solved? If so, how?
To transform the problem by passing to the super-system and respectively the sub-system, another very powerful anf efficient tool is used: Multi-Screening. Why is such a powerful instrument necessary? The answer is :
"Engineers usually think concretely but nonsystemically."[5,p172] In most situations they focus on a single object that needs certain improvements instead of seeing the image in its complexity and this leads to modest solutions wich short term effects.
Multi-Screen Approach is explained figuratively by the necessity to see the full model, the graphic representation of which comprises nine screens as in Figure 2. Certainly many more screens are possible by including elements like:
- Primary Function
- Anti-Function
- Super-Function
- Sub-Function
- Anti-System, etc.

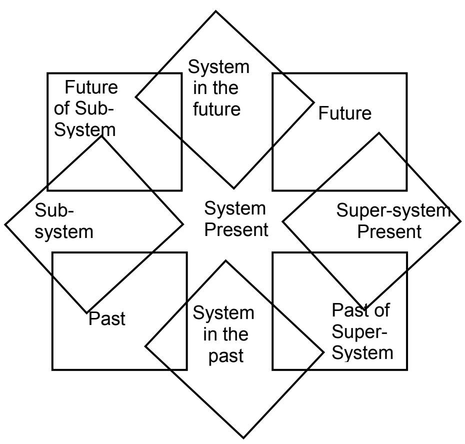
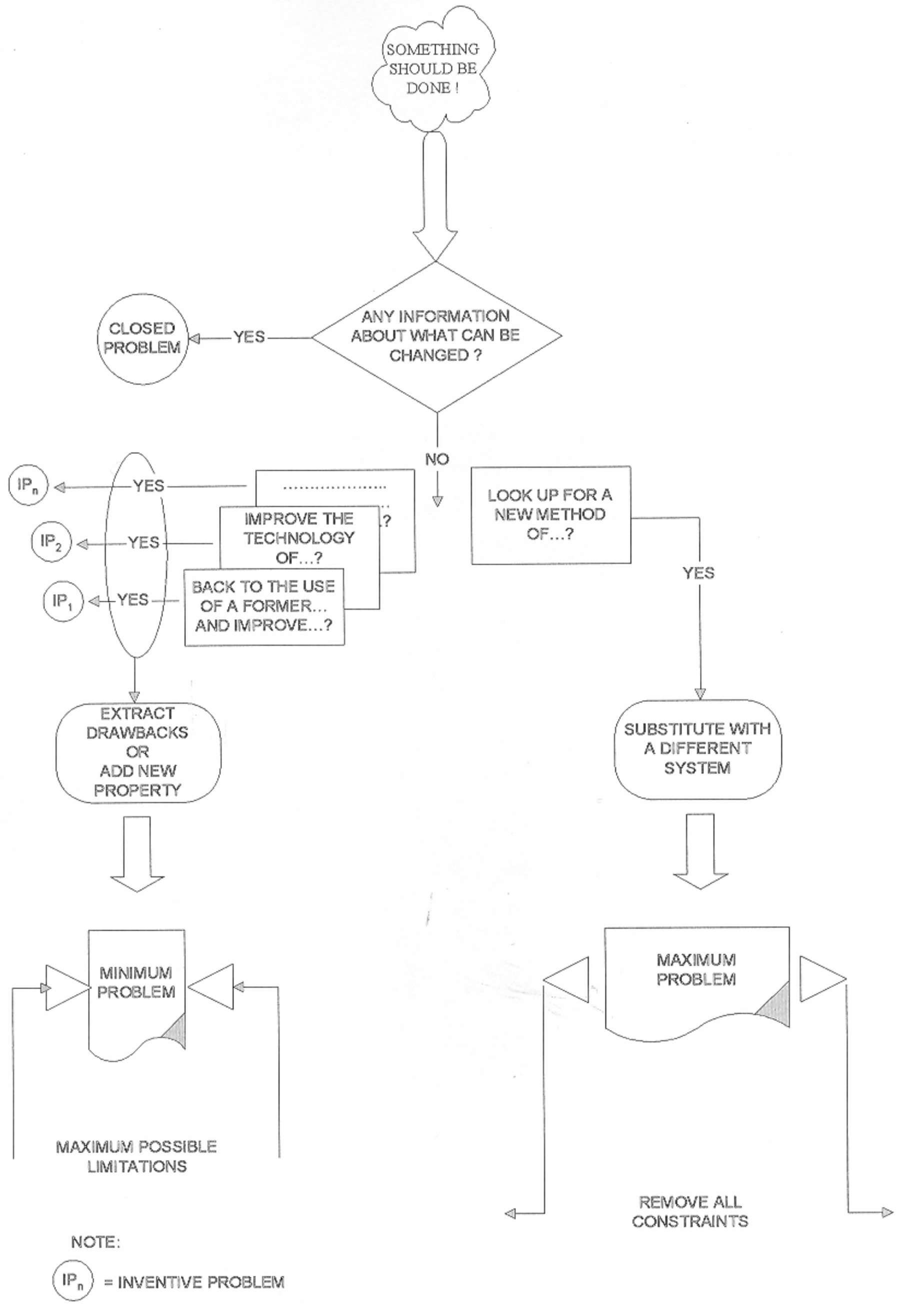


Fig. 2

Let's apply some of these concepts. Air traffic control activities are complex and involve many complex and also expensive systems, like communications systems, aircrafts, airports and buildings, radars, computer networks, meteorological equipments and high qualified personnel. All those systems, super systems and sub-systems work in complex interrelations for achieving the Primary Function of Transport as safely as possible. Let us assume that one is assigned the following task: "Improve the shifts management so that the whole process becomes safer!" Not only is the task vaguely expressed but depending on the recipient of the task, a shift supervisor or some other executive with a background in some technical field, most probably, the same procedures will be adopted, for example, improving discipline, raising the amount of forms to be filled in, checking or re-checking communication lines and so on. Probably some measures will positively affect the working activities but in most of the cases real problems will remain hidden because of the lack of vision. Instead of doing any of the above, one can use the multi screen approach, for example considering instead of the shift activity level, the super-system, which in this case could be the control center, instead of new forms to fill in, using the anti-system which could be a completely new personnel management system in which you don't have to complete forms (!), or another super-system for the communication system where the check is completely automatic. Maybe someone will even dare to approach some fundamental concepts like separation limits (minimal distance in space and time between planes) or the working sector based on considerations about the super-system in the future when the aircraft's speed may become much greater. Such mental exercises imposed by this method will obviously stretch the barriers of the usual solutions and help *anyone* at *any level* to reach high level solutions. Additionally, setting restrictions like using already existent resources in the control center, we can also obtain economical solutions. In some situations using the not so complex tool of the STC operator can also improve the quality of future solutions by stretching the framework of the problem.
"To make a correct statement of the problem it is necessary to consider the evolutionary tendencies of a given technical system"[Altsh. The Innov..p. 83]
"There is a simple method to check whether a problem is stated correctly. Look at identical problem statements in other industries - specifically those industries where problems are stated more precisely, or where the scale of operation is greater." Beeing familiar also with the Laws of Evolution of Technical Systems is important when formulating the problem because it give us the posibility to see the corect tendencies of the evolution of the studied technical system.[9]



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