Editor's note: Kraev's Korner was first published in the newsletter of the Altshuller Institute, www.aitriz.org, in 2005. Val Kraev is the Chief TRIZ Officer of the Technical Innovation Center in Worcester, MA USA, www.triz.org, and has contributed several very valuable case studies to the TRIZ Journal. Our thanks to the Altshuller Institute and the Technical Innovation Center for letting us reprint this educational series. Lesson 1 and the introduction appeared in the October issue of the TRIZ Journal.

KRAEV'S KORNER
Lesson 2 - Levels of Innovations

Dear Subscribers,

I would like again to thank all of you who sent me messages with proposals, wishes and ideas related to our TRIZ Studies after the first lesson. Your participation and interest was very helpful for preparation of the second lesson's material.

In this lesson we are talking about levels of innovations and starting to solve problems in Practical Work which resemble our everyday life. The Practical Work contents is in two parts: "quiz" and "home problems". The quiz section's main goal is to repeat the theoretical material and "home problems" that relate to training in using TRIZ tools. Home problems basically don't require other special knowledge and can be solved with application of the usual materials that we can find in our home. Hopefully solving these problems will be useful for your TRIZ-training and application in usual life.

As before, please, send me any questions and comments at: kraev@triz.org

Valery Kraev

LEVELS OF INNOVATIONS - LESSON 2

Before our talk about innovation or more precisely invention, let's understand what it means. As mentioned in our first lesson, analysis of a large number of patents reveals that not every invention is equal in its inventive value. G. Altshuller proposed five levels of innovations:

Level 1. A simple improvement of a technical system: Requires knowledge available within the trade relevant to that system.
Level 2. An invention that includes the resolution of a technical contradiction: Requires knowledge from different areas within the industry relevant to the system.
Level 3. An invention containing a resolution of a physical contradiction: Requires knowledge from other industries.
Level 4. A new technology is applied which contains a resolution of contradictions with better approach to Ideal Final Result: This new technology includes a breakthrough solution that requires knowledge from different fields of science.
Level 5. Discovery of a new phenomena or substances: This new knowledge provides for the development of new technologies with utilization of the new phenomena, resolving existing contradictions with better approach to the Ideal Final Result

With problems of the first level, the object (device or method) does not change. At the second level, the

object is changed but not substantially. At the third level, the object is changed essentially and at the fourth, it is totally changed. In the fifth level, the entire technical system is changed in which this object is used.

A very important point, the TRIZ methodology claims that if there is no technical contradiction then it is not an inventive problem (not a TRIZ problem). Therefore, if there is resolution of a technical or physical contradiction during problem solving then it is invention.

Officially, the invention is a creation of a new technical idea and the physical means to accomplish or embody it. To be patentable, an invention must be novel, have utility, and differ from what skilled users might expect (http://usinfo.state.gov/products/pubs/intelprp/glossary.htm#top). Therefore, an invention legally protected by a patent should meet three requirements: novelty, utility and non-obviousness.

"Novelty" is one of the three legal criteria by which patent applications are assessed. It requires that the claims in a patent must be totally new, i.e. for an invention that was previously unknown and unavailable to the public when the patent application is filed. This criterion is the same for US Patent and Trademark Office (USPTO, http://www.uspto.gov/index.html) and World Intellectual Property Organization (WIPO, http://www.wipo.int/portal/index.html.en). USPTO and WIPO are government organizations that make the final determination for applied patent proposals as to which are inventions and patentable and which are not inventions.

"Utility" is another of the USPTO criteria by which patents are assessed. It requires that an invention must be useful and industrially applicable to be patentable. In WIPO, the same or similar requirement is phrased as "industrial applicability».

"Non-obviousness" is the third legal USPTO criteria by which patent applications are assessed. In the WIPO the similar requirement is known as "Inventive Step". Non-obviousness and Inventive Step is one that would not have been obvious to a person skilled in the art at the time the application for a patent was filed.

As we can see, the criteria of TRIZ to invention by resolving the problem's contradiction are more definitely and strongly in comparison with USPTO/WIPO criteria. Nevertheless, these criteria are corresponding to each other and this correlation is shown in table below.

TRIZ AND INTERNATIONAL INVENTION'S CRITERIA

TRIZ Invention Criteria	USPTO Invention Criteria	WIPO* Invention Criteria
Technical & Physical Contradictions	Novelty	Novelty
Contradictions Resolutions	Non-obviousness	Inventive Step
Ideal Final Result	Utility	Industrial Applicability

* - World Intellectual Property Organization. The UN agency, headquartered in Geneva, that administers most IP treaties and that holds periodic conferences to revise them

In fact, the same problem can be solved by obtaining the inventive solutions from the different TRIZ levels. Let's look around at our home and take well-known home appliances for our analysis. I would like to start stove in the kitchen.

Electric stove with electrical spiral cooking surface, which produces heating, is a basic appliance. These stoves appeared in homes after the wood and gas stoves. These new stoves were very progressive devices because they have a higher level of safety, do not smoke, use available electricity and was less expensive. There was just one serious disadvantage, the first electrical stoves heated slowly in comparison with gas stoves. Future inventions were related to overcoming this disadvantage.

	A **first level invention** related to modification of basic electrical stove was the "Rapid" stove. This appliance had high a temperature heating spiral with heating rate 10-12 seconds. This was a significant improvement in comparison with basic element which needed 30-60 seconds. However, the typical electrical stove heating spiral element was not changed. Just the electrical parameters and the spiral shape were modified.
	**The second level** of invention is "Hi Light" electrical stove. At this level, the heating element in comparison with initial design is distinctly changed. Hi Light electrical stove uses a heating device in shape snake-like strip produced from a high-ohmic alloy. The heating rate is faster, 4-7 seconds and the radiated heat is uniformly proportioned on all working area. New heating element is changed in both shape and material. Such modification allows for solving the technical contradiction between oven's parameters of heating rate and power density. But if previous "Rapid" heating element with diameter 150-180 mm consumes power at 1-1.5 kW then heating element of High Light needs 1.5-2 kW.
	The **third level** of invention for the electrical stove can be a halogen appliance**.** Halogenous electrical stove provides heating by using the high-temperature spiral with integrated halogen lamp that has a quartz gas-filled tube. The lamp shines with a bright red light and produces strong heat. This electrical oven and its heating element have a big power; therefore heating element is instantly being heated and promptly cools down. In this device, physical contradiction for heating element has been resolved and instead metal spiral the gas filled spiral was used. We can see changes of the heating element on the physical level.
	In the **fourth level** of invention the stove is an induction appliance**.** In this appliance, the heating element is totally modified. The Induction electrical stove is an advanced development. Under the operating area, an induction coil and powerful electric generator are presented. These components are quickly creating a varying electromagnetic field. Due to changes of electromagnetic field atoms of crystal lattice of an alloy, from which the pan is made, start an oscillating motion, heating predominantly the bottom of the pan. The induction's effective area heats only the pan and the coil remains cold. So that boiling soup will not become attached to glass surface. The direct heating

	allows economy of both time and electric power. Certainly, burner will not work, if there is no pan on it. To apply an induction heating, it is necessary to use a pan with a magnetized bottom manufactured with ferromagnetic alloys (of cast iron or a special steel).
	In the **fifth level,** the electric stove is totally changed and absolutely new physical phenomena are used for cooking. It is a microwave oven with other principle of operation with direct action on the food without application intermediate container. The microwaves inside the oven permeate into the food from different directions, heating molecules of water, fat and sugar. Heat permeates promptly but only inside the food. The microwaves used for cooking can pass through glass, paper, plastic and china but do not permeate through metal. In usual state, molecules of food and liquid contain negative and positive particles that rotate slowly. During cooking with microwaves, this motion is expedited creating heat. The end result is that heat is generated in the food. The cooking in a conventional oven is realized by molecular actions, but the microwaves do it faster, because they permeate into food directly and decrease the cooking time.

Some other examples for solving problems at different inventive level are represented in the table for washing machine, TV set and phone set.

Examples of innovation levels

	LEVEL 1 Compromising Design	**LEVEL 2** Resolving the technical contradiction	**LEVEL 3** Resolving the physical contradiction	**LEVEL 4** New Technology	**LEVEL 5** New Phenomena
Washing Machine	Washing Machine with Vertical Drum	Washing Machine with Horizontal Drum	Washing Machine with Double Drum	Cavitational Ultrasound Washing Machine	Field Cleaning Machine (forecast)
TV Set	Electromechanical TV	Mono Cathode-Ray Tube TV	Color Cathode-Ray Tube TV	LCD/LED TV	Three-Dimensional TV
Phone Set	Two-Piece Hand Phone	One-Piece Hand Phone	Telephone and Fax Machine	Radio Wireless Home Phone	Mobile Cell Phone

The five-level classification, described above, has been applied to already known examples and solutions. It was relatively clear how to determine which innovation's level corresponds to known different solutions. And then another question appears: can this classification be used not only for description of known solutions but during development process of new, unknown proposals?

Here is an example. Let's imagine that we have an assignment from a customer for the development of

a new lamp. It is necessary to propose new designs for a lamp that would be better than the current commercial one. The specific technical result can not be indicated in requirements specification, but customer would like to get better and cheaper lamp than existing one. It is typical situation for practical innovation activities. So, having knowledge of the five innovation levels, we can start the development of our new lamp with the use at least three scenarios: conventional engineering improvement of existing lamp, development of new designs with application existing principle of operation and finally, creation of new lamp generation with new physical principle of operation. It is clear, that the first approach corresponded to the first innovation level and allows getting the new optimization of the lamp's designs with some improvement to the qualitative parameters over the existing lamp.

If our customer wants to increase lamp qualitative level by more than 100%, we should use second and third project scenarios corresponded to 2-5 levels of innovations. Therefore, if we wish to greatly improve parameters of our product then optimization cannot help us and we need to find methods and materials to resolve contradictions that do not support this improvement.

Hence, five-levels of invention classification can be used in practical activities for comparative assessment of innovation proposals that are generated for solving problem.

Often a customer reluctantly accepts substantial changes to his existing system. He perceives that for solving a problem it is necessary to change something in the existing system, but he tries to implement these changes minimally to facilitate prompt introduction. Nevertheless it is possible to offer solutions of the problem for all five levels. The first three levels change the existing system insignificantly with minimal modifications and so these design proposals are accepted for manufacturing more easily. The fourth and fifth level of the proposals can be accepted as prospective solutions for the next step of introduction and may be patented by the customer.

Knowledge about the five levels of innovation is a useful tool in the prognosis and development of a specific system, as it can define volumes of change of this system at each stage of evolution.

It is reasonable that strong solutions, which resolve contradictions without compromise, require special technologies for their finding, because these solutions are not the obvious ones. Previously, solving problems that had conflicts or contradictions were accepted an unreal process and such problems were solved by compromise or were not solved at all. We will be interested in just such problems with contradictions and our goal is to get knowledge and practice for resolving these contradictions. In our next our lesson, we will discuss contradictions, their finding, formulation and resolution.

SUMMARY

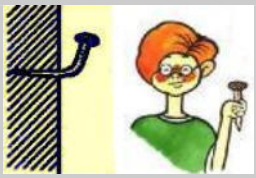
Thus, summarizing this lesson, one can say that TRIZ proposes five levels of innovation. These levels allow us to estimate the development state for existing technologies and products. We can use this knowledge in our creative work to predict the step by step development of new directions for existing technologies and products.

PRACTICAL WORK

Quiz. Please, determine what kind of level of innovation the following objects have:

Film Photo Camera Mechanical Clock Vacuum Cleaner

Could you propose the fifth innovation level for each of these devices?

“THREE HOME PROBLEMS FOR TRIZ APPLICATION”	
	“Nail Problem” Very often we to have to use a simple nail in a wall as hook for hanging clothes. However such hook starts to rotate in the hole and does not hold clothes. What is it possible to do?
	“Box Problem” The simple wooden boxes in a cabinet or desk badly slide on support. What is it possible to offer for solving this problem?
	“Refrigerator Problem” In order to avoid extra consumption of the electric power it is useful to know if the door of the refrigerator is closing tightly. How to test contact between door’s seal and housing?

Please, send any questions and comments to: kraev@triz.org