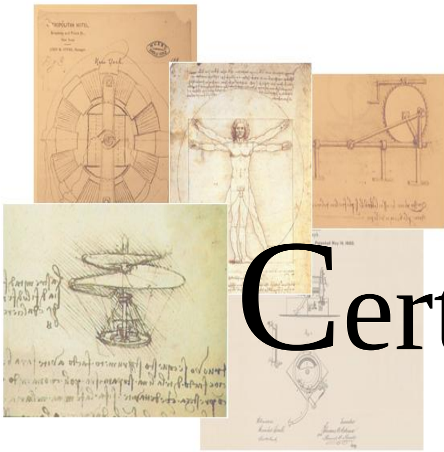


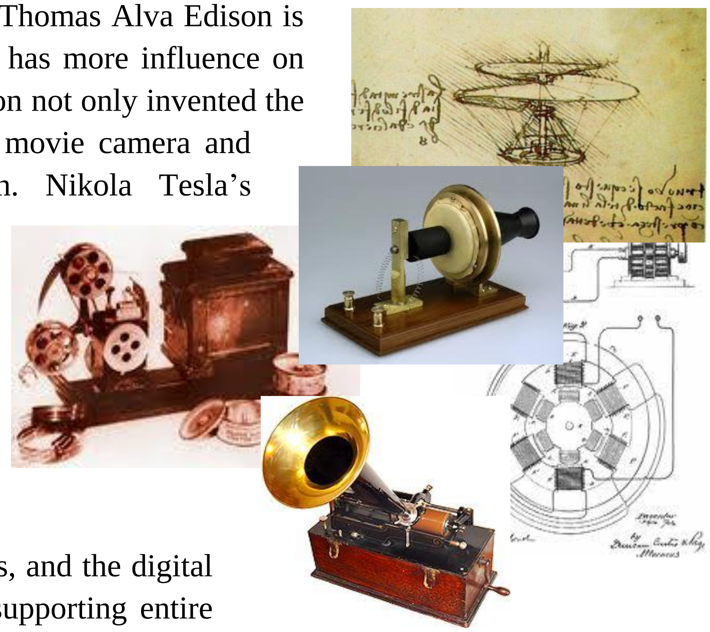
Certified Innovation Professional

Lesson 1

Introduction to TRIZ, ITRIZ, and the Five Levels of Invention

1. Great Inventors

Leonardo da Vinci (1452 – 1519) imagined flying machines similar to helicopters, hang gliders, and parachutes hundreds of years before their time. Alexander Graham Bell's invention, the telephone, changed human communication and is now an indispensible personal device with over 5 billion in use. With 1093 patents, Thomas Alva Edison is the most prolific American inventor and has more influence on modern life than any other inventor. Edison not only invented the light bulb but also the phonograph, the movie camera and pioneered electrical power distribution. Nikola Tesla's inventions in alternating current power distribution and three-phase electric motors enabled the electrification of everyday life and industry, making the 20th century as we know it possible. With over 3000 patents, Yoshiro Nakamatsu holds the record for the most number of patents. Dr. Nakamats holds patents in floppy disks, CDs, DVDs, and the digital watch, all of which are key inventions supporting entire industries.



How valuable would it be if you could know the innovative concepts these and other inventors have used and could employ those concepts to any object or system you wished to? What if there was a way to condense human invention down to something that could be taught? What if we could teach people how to *innovate on demand*?

2. TRIZ and Genrich Altshuller

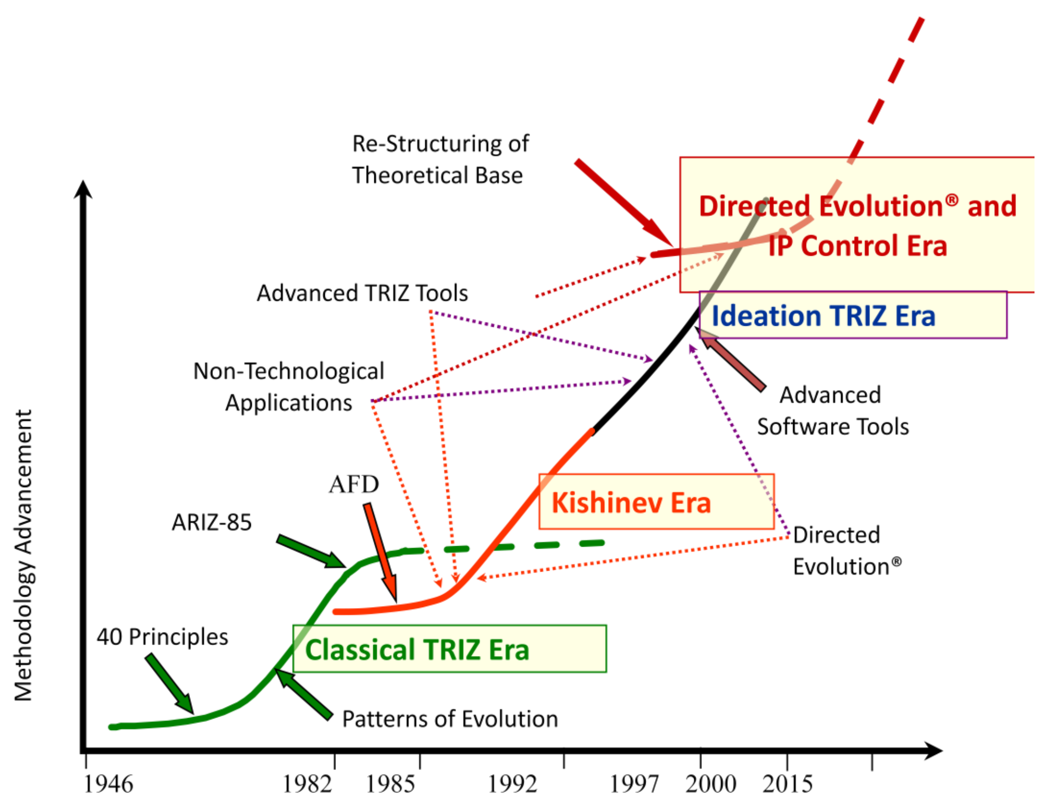
In an effort to discover generic rules for innovation, Russian engineer, inventor, and scientist, Genrich Altshuller, began studying patents and technological evolution in 1946. By the 1970s he had become the intellectual leader of a group of Russian scholars and practitioners involving themselves in the study of problem solving, invention, and innovation. Collectively this effort is called TRIZ (pronounced "trees") which is a Romanized acronym for the Russian phrase Teoriya Resheniya Izobretatelskikh Zadatch meaning "the theory of inventor's problem solving."

TRIZ has been in continual development since 1946 and has proceeded to the present along several different lines, each under the direction of Altshuller's students and colleagues. TRIZ was largely unknown to the Western world until the translation and publication of some of Altshuller's work in English in the 1980s. With the collapse of the Soviet Union in the late 1980s and early 1990s, many TRIZ colleagues moved to other parts of the world where they have continued work in TRIZ. Consequently, since the early 1990s, knowledge and use of TRIZ has spread all over the world.

TRIZ encapsulates a set of methodologies, knowledgebase, and a set of tools to assist efforts in system analysis, problem formulation, and idea generation. The overall goal of TRIZ has been to develop and refine an algorithmic approach to invention and innovative problem solving that could be understood and used by anyone.

3. TRIZ/ITRIZ Timeline

As shown in the following graph, the early period, called the *classical TRIZ* era, began in 1946. Over time, researchers have developed more tools and methodologies expanding the applicability of TRIZ. The *Ideation era* (ITRIZ) began in 1992 and continues today. A major addition in ITRIZ is a set of software tools to help practitioners perform system analysis and idea generation. The software, together with structured training materials seeks to "bring ITRIZ to the masses."



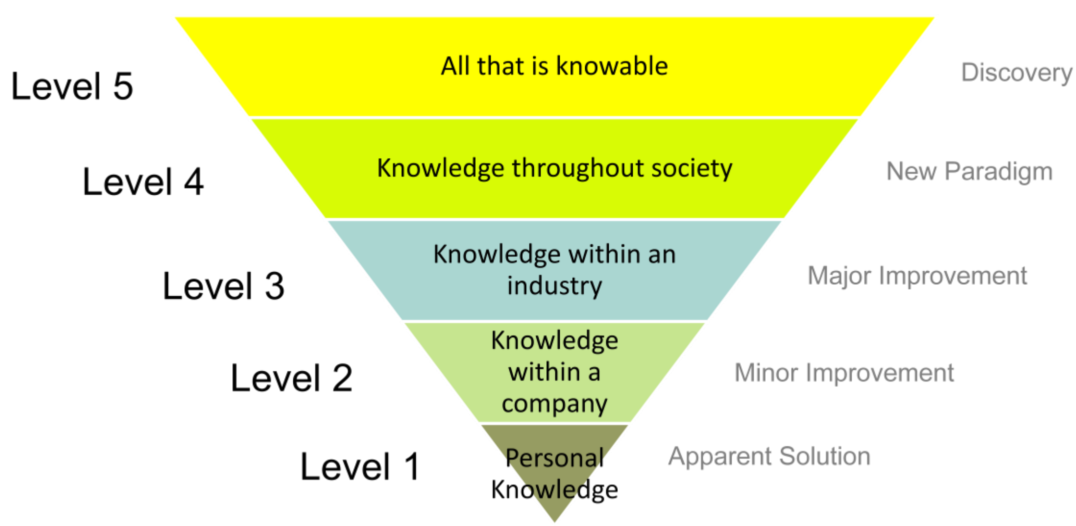
4. The Five Levels of Invention

Based on his study of patents and technological systems, Altshuller proposed that five levels of invention exist:

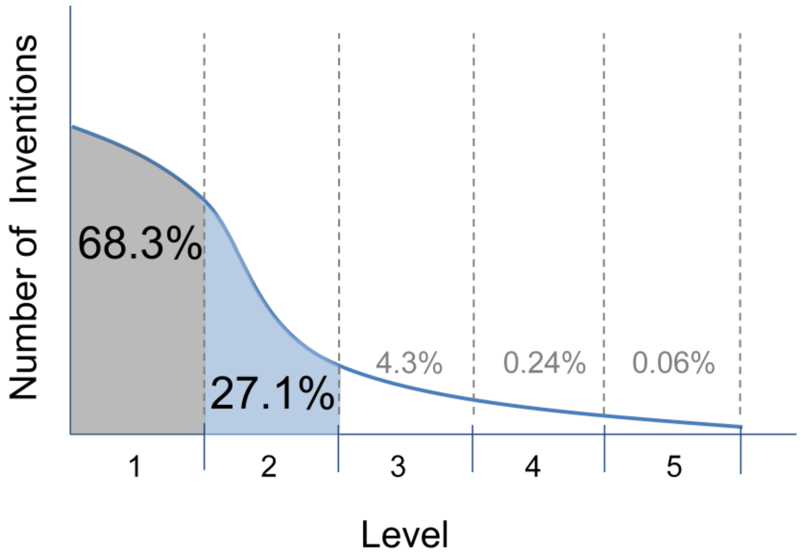
- **Level 1 –** Apparent Solution
- **Level 2 –** Minor Improvement
- **Level 3 –** Major Improvement
- **Level 4 –** New Paradigm
- **Level 5 –** Discovery

Level 1 inventions are obvious and apparent solutions involving well-known methods and knowledge requiring no new invention of any consequence. *Level 2* inventions constitute minor non-obvious improvements to a system, using methods known within the domain of discourse but applied in a new way. *Level 3* inventions involve fundamental improvements to a system involving methods known outside of the domain. This involves applying an idea to the domain that has never been used in the domain previously. *Level 4* inventions entail the development of an entirely new operating principle and represent radical changes. *Level 5* inventions represent a rare scientific discovery or the pioneering of a totally new industry altogether.

Naturally, lower-level inventions are easier to come by. One reason this is true is because of the amount and kind of knowledge required for each kind of invention as shown in the following graph:



Paradigm-altering new scientific discoveries do not happen very often. However, people solve millions of routine, simple problems (Level 1) every day. In fact, over 99% of inventions are Level 1, 2, or 3:



5. The Definition of Innovation

The Merriam-Webster dictionary defines *innovation* to be the act of introducing something new[1]. With Level 1, 2, and 3 inventions, the "new" aspect rarely refers to a new creation, but rather a new application of something that already exists. By "new" we usually mean "different." Innovation entails a *refinement*, meaning a contrivance to improve[2]. Therefore, we define *innovate* as follows:

innovate: an incremental improvement of an existing object or system

[1] "Innovate." Merriam Webster Online, Internet site located at http://www.merriam-webster.com/dictionary/innovate and last accessed on August 27, 2010.
[2] "refinement," Merriam-Webster Online, Internet site located at http://www.aolsvc.merriam-webster.aol.com/dictionary/refinement and last accessed on August 27, 2010.

6. The Principle of Ideality

Since, by the term *innovate*, we mean the improvement of an *existing* system, inherent in any innovative effort is analysis of the existing system under study. A basic tenet of TRIZ and ITRIZ is that all systems can be viewed as collections of desirable features (called *useful functions*) and undesirable features (called *harmful functions*). This is a way of modeling systems different from other kinds of systems analysis. However, this method is particularly successful at helping identify areas of a system that need to be improved.

The ratio of useful functions to harmful functions yields a relative measure of a system's *idealilty:*

$$\text{Ideality} = \frac{\text{useful}}{\text{harmful}}$$

A perfectly ideal system would be one with no undesirable features at all. In the real world, no such system exists. However, a system's ideality can be increased by either increasing the useful or by decreasing the harmful. Since innovation seeks to incrementally improve a system, any innovative improvement should increase the ideality of the system.

7. Patterns of Evolution

The tendency for systems to continually increase in ideality is a general trend applicable to all technological systems and was readily identified by Altshuller. However, this was not the only trend that Altshuller discovered. Altshuller identified 8 general patterns in system evolution:

- **Increasing ideality**
  Systems evolve in the direction of increasing ideality. Ideality can be defined as the ratio of all of a system's useful features to all of its harmful (or undesired) features. Therefore, we can increase a system's ideality by increasing its useful features, reducing the harmful ones, or both.

- **Building bi- and poly-systems**
  As technological systems evolve, they tend to improve by being integrated into supersystems. This can be accomplished through transformation into a bi-system (the combination of two systems, either identical or different) or into a poly-system (the combination of more than two systems).

- **Segmentation**
  As technological systems evolve, they tend to improve through various kinds of segmentation. A segmented system is more adjustable, more flexible, and more effective. Segmentation assumes the establishment of new relationships between elements, and thus new resources for system improvement.

- **Developing a substance's structure**
  As technological systems evolve, they tend to improve by developing the structure of a material (or substance). As a result, the structure becomes more heterogeneous in accordance with the heterogeneous distribution of forces, energy, substance flows, etc.

- **Dynamization**
  As technological systems evolve, they tend to improve by becoming more dynamic. They gain greater flexibility and variety to adapt to a changing environment and to satisfy multiple requirements.

- **Increasing controllability**
  As technological systems evolve, they tend to become more controllable and capable of changing to satisfy multiple needs. This is the complement to *Dynamism* because greater system flexibility requires more controllability.

- **Element universalization**
  As technological systems evolve, they tend to become more universal and multi-purpose in order to provide convenience and satisfy multiple needs. This tendency is accompanied by increased dynamism, because increased universality requires increased flexibility and "adjustability."

- **Matching and Mismatching elements**
  As systems evolve, they tend to proceed through the following stages: First, the system and its subsystems match each other, their super-systems and the environment. Various system parameters become equal, coordinated, proportional, or mutually-dependent. Second, mismatching is introduced. Parameters are changed to eliminate harmful effects and obtain additional useful effects. With mismatching, various system parameters become differentiated, independent, and opposite, Third, dynamic matching-mismatching allows system parameters to change as conditions vary in order to provide optimal results. With dynamic matching-mismatching, system parameters become more controllable.

Think of an object or system that you use every day. Now consider the history of that system. How has it changed over time from when it was first invented or introduced? No matter which object or system you examine, you are sure to observe at least one of the above trends in its development.

8. ITRIZ and Ideation International, Inc.

Following the collapse of the Soviet economy, many TRIZ experts moved to other parts of the world. In 1992, entrepreneur Zion Bar-El moved a group of Altshuller's colleagues to the West and created a new company named Ideation International to commercialize TRIZ. The Ideation team has continued to evolve and develop TRIZ technology since this move and this work is referred to as ITRIZ (for Ideation-TRIZ).

ITRIZ is the most comprehensive of the post-Soviet lines of TRIZ development and is the result of over 65 years of the study of human innovation. Today, over 2,000,000 patents have been analyzed, an extensive knowledgebase has been compiled, and several methodologies have been developed: inventive problem solving (IPS), anticipatory failure determination (AFD), intellectual property protection (IP), and directed evolution (DE). This course involves IPS.

9. ITRIZ Operators

Fundamental to ITRIZ is the database of over 400 *operators*. Each operator encapsulates an innovative concept gleaned from the study of the patents and technological evolution. The purpose of the operators is to suggest potential improvements to the system under study. Not every operator applies to every system and vice versa but operators serve as aids to facilitate brainstorming. The goal of the brainstorming effort is to identify an incremental improvement to an existing system. In a full-scale analysis, dozens of operators (maybe hundreds) will be considered. Some operators stimulate several ideas, some none. Typically, by the end of an analysis, several dozen ideas for potential improvements are identified. Subsequent in-depth analysis narrows done the list for actual implementation.

There will be much more about operators later in the course., but an example of an operator is the *Add-A-Marker* operator:

Add-A-Marker

Consider adding a marker that can become the source of an easily detected field.

This operator captures the notion that, in some situations, it is advantageous to add an easily detected object or substance. An illustration of the application of this operator is the addition of radioactive dye to a person's blood stream. Unaltered blood does not show very well on an x-ray but with the dye added, blood flow can be easily seen on x-rays facilitating diagnosis of circulatory problems with minimal invasion of the body.

Another example is the *Preliminary-Action* operator:

Preliminary Action

Consider completely or partially performing a needed activity in advance.

This operator captures the concept that sometimes it is better to perform an action ahead of the time it is actually needed even if the action is only partially completed. An example of this concept in practice is building demolition by implosion. For several weeks, or even months before the day a building is imploded demolition teams prepare the structure by removing some, but not all, supporting elements. In some cases, members are partially cut to insure they perform as desired during the implosion. The team is partially demolishes the building before the implosion event to insure a more controlled and effective implosion.

A third example is the *Upside-down or inside-out* operator:

Upside down or inside-out

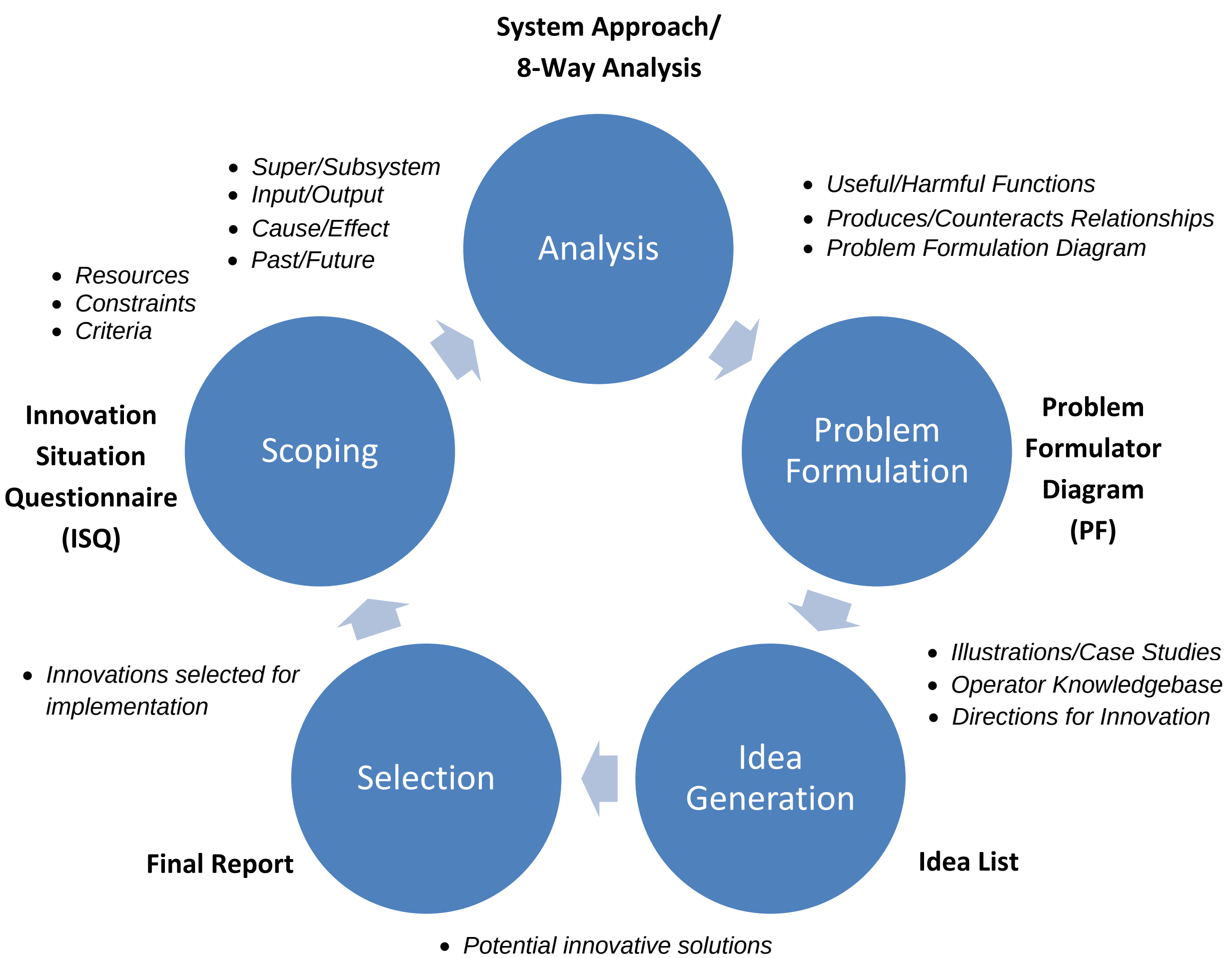
Consider turning an object, system, or process inside-out or upside-down.

This operator suggests thinking about inverting some portion of the system. Of course, there are many ways to “invert” things in a system. An example of this operator is dipping a complex part into a vat of paint rather than attempting to spray or brush the paint in a traditional manner. With a sufficiently complex part, highly irregular surfaces may prevent spray or brush-applied paint from adequately covering the entire part as desired. Submerging the part allows the paint to penetrate into crevices insuring proper coverage.

When considering innovations to a system, a practitioner uses the operators to stimulate ideas. The operators are essentially a catalog of innovative concepts used by prior innovators. By collecting these into a single knowledge store, ITRIZ enables us to “stand on the shoulders” of innovators that have come before.

10. The Basic ITRIZ Methodology

The ITRIZ knowledgebase is so extensive, the only way to effectively employ it is to approach a project systematically and methodically. The following depicts the basic ITRIZ methodology:



Scoping

In the scoping phase, one defines the system and the problem to be studied. The Innovation Situation Questionnaire (ISQ) assists by posing questions to be answered by subject matter experts.

Analysis

In the analysis phase, a tool called the 8-way analysis helps identify the most important aspects of the system being studied. In this phase we also begin to identify the useful and harmful aspects of the system.

Problem Formulation

A problem formulator diagram (PF) captures useful (desirable) and harmful (undesirable) aspects of the system being studied and their interrelationships. Diagramming the system exposes areas of the system, called *contradictions*, which are areas most needing improving via innovation.

Idea Generation

In the idea generation phase, systematic application of ITRIZ operators to the contradictions stimulates innovative ideas and generates possible solutions.

Selection

In most cases, dozens, if not hundreds, of potential ideas are generated in the brainstorming idea generation phase. Careful analysis of each potential idea facilitates selection of one or more for implementation.

11. Summary

ITRIZ is the modern extension of a 65-year effort to understand the evolution of technological systems and how humans innovate. Begun in the Soviet Union in 1946, the classical TRIZ era covers the period of time from 1946 to the fall of the Iron Curtain about 1990. Many important discoveries were made during this period such as the Lines of Evolution, the Five Levels of Invention, and the Principle of Ideality. After the Soviet economy collapsed, TRIZ scholars fled to all parts of the world taking knowledge of TRIZ with them. This facilitated a global awareness of TRIZ and began a post-Soviet era of continued development. Ideation International, Inc. was created in 1992 and houses several of Altshuller's original collaborators who have continued to develop TRIZ into the modern era, which is now called ITRIZ. ITRIZ features a methodology and toolset that can be taught to anyone and is the subject of this course. The ITRIZ knowledgebase represents a distillation of human innovative thought and can now be used by practitioners to innovate on demand.