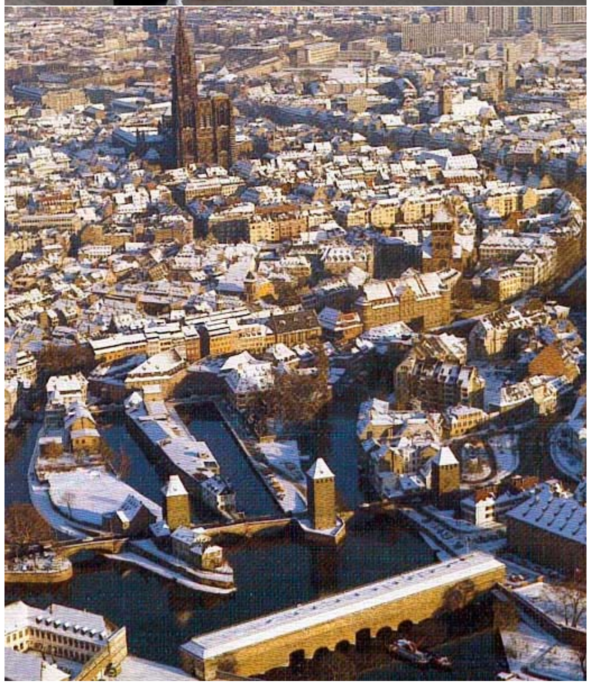
Advanced MASTER
in
Innovative Design

Module 4

INSA STRASBOURG



THEORETICAL GROUNDING AND PRINCIPLES OF TRIZ

...The problems that exist in the world today cannot be solved by the level of thinking that created them...
attributed to Albert Einstein

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objectives of the course

- **Understand** the fundamental differences between TRIZ and conventional approaches to inventive problem solving.
- **Practice** contradiction formulation and 40 Inventive Principles.
- **Learn** about Three basic concepts of OTSM-TRIZ and their corollaries.
- **Understand** the basic principles and inventive problem solving process applied for various TRIZ methods.
- **Realize** the scope of usage of the 40 Inventive Principles and formulate their limitations.

course contents

1. INTRODUCTION
2. 40 INVENTIVE PRINCIPLES
3. THREE BASIC CONCEPTS
4. Mental Inertia & Creative Imagination
5. Problem Solving Process
6. APPLICATION OF TRIZ KNOWLEDGE

overview of the session's program

Day One: INTRODUCTION; Case example "Wire spool"; Learners' specific cases.

Day Two: 40 INVENTIVE PRINCIPLES; Case examples; Work on specific cases.

Day Three: THREE BASIC CONCEPTS; Case examples; Work on specific cases.

Day Four: Mental Inertia & Creative Imagination; Work on specific cases.

Day Five: PROBLEM SOLVING PROCESS; APPLICATION OF TRIZ KNOWLEDGE
Presentation of case study results; Summary of the course.

Module 4: Theoretical grounding and principles of TRIZ

INTRODUCTION

...It is not the problem that breaks you down, it is the way you approach it... (ancient wisdom)

- **Why is it difficult to solve problems?**
- **The Key Task of the problem solving process**
- **about TRIZ**

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invention is...

...Each invention is a road through the 'impossible'.

Generally, 'impossible' signifies only 'impossible by existing means'.

The inventor must find a new concept, and then the impossible *becomes* possible*...*

G.Altshuller

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Shape of the Earth

Is it possible to prove that the Earth is spherical without using any devices? Aristotle* (384-322 BC) did it.

How did he prove this fact?

* an ancient Greek philosopher, a student of Plato and teacher of Alexander the Great

lost spacecraft

A spacecraft is “lost” in outer space. There is no radio signal, however the approximate location in space is known. Several photographs were taken of that area in space.

How does one trace the spacecraft faster?

why is it difficult to solve problems?

Please discuss in a team and compile a list of the causes.

Note the most important causes first:

1. ______________________________
2. ______________________________
3. ______________________________
4. ______________________________

…………………………………………………………………………………….

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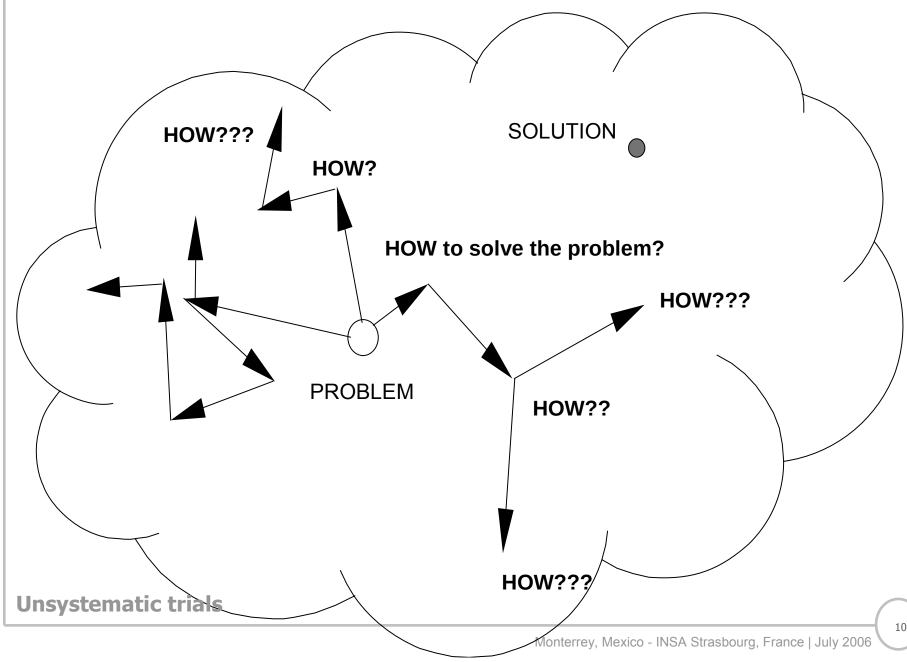
how do we look for the solution to a problem?



Unsystematic trials

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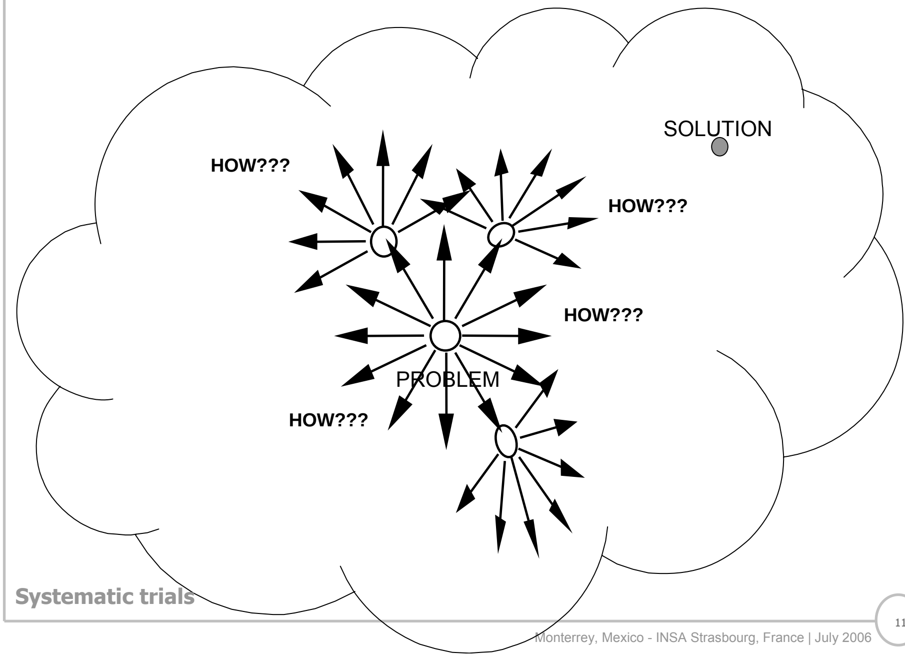
how do we look for the solution to a problem?



Systematic trials

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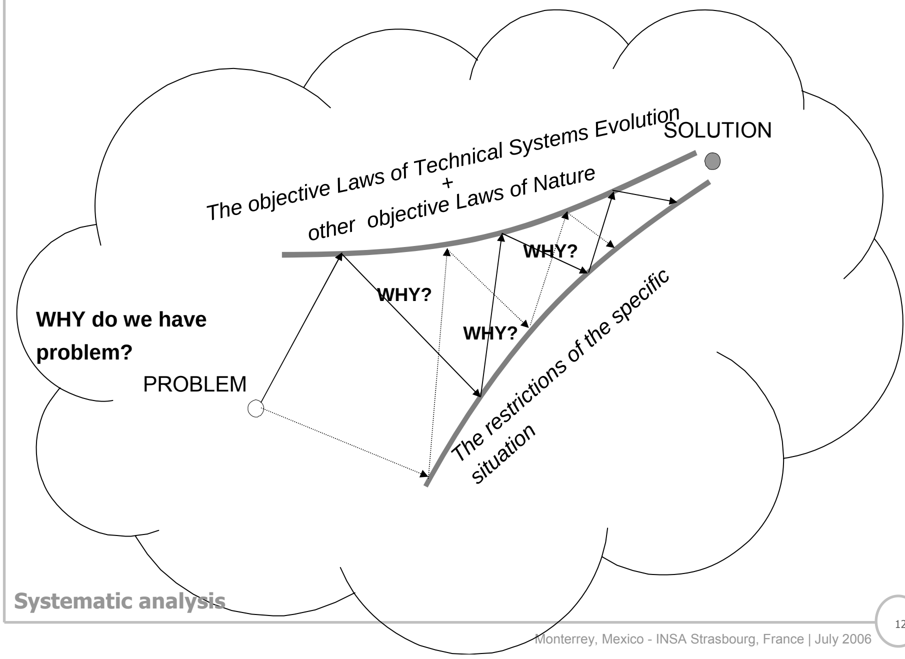
how do we look for the solution to a problem?



Systematic analysis

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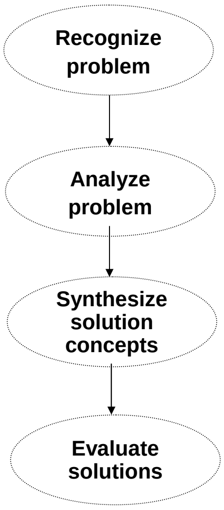
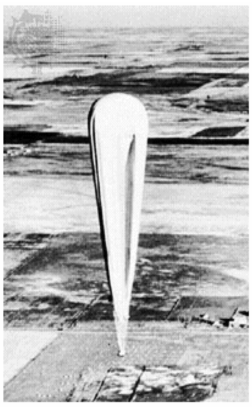
how do we look for the solution to a problem?



DIFFERENT STRATEGIES:

- **Unsystematic Attempts**
  - **HOW to solve the problem?**
    Guessing the Answer. Trial and Error
- **Systematic Attempts**
  - **HOW to find a solution?**
    Search for Solutions.
    Intensified Trial-and-Error process
- **Systematic Analysis of the problem situation**
  - **WHY do we have a problem?**
    Developing the Solution.
    Reduced area of research.

Auguste Piccard* balloon



Ascent of a Piccard balloon
Credit: UPI--EB Inc.

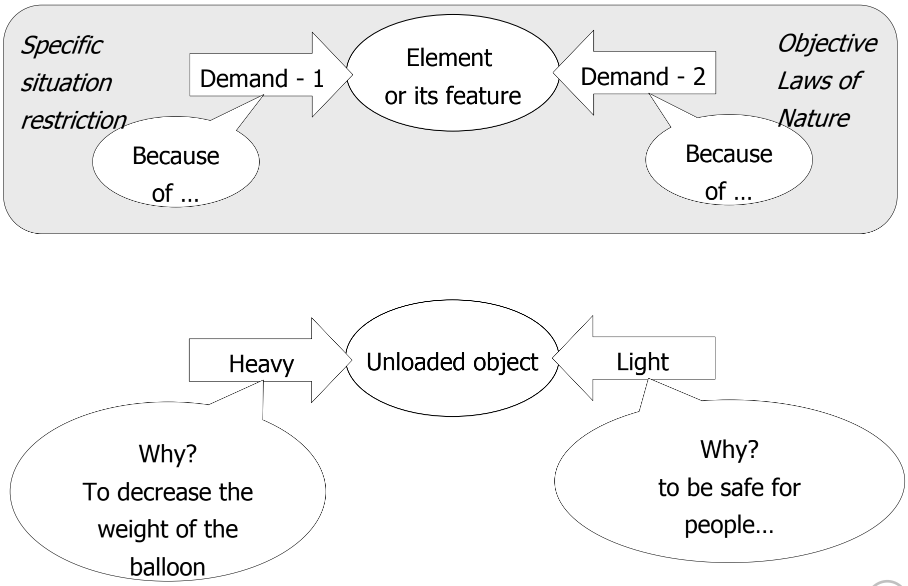
On May 27, 1931, Piccard and Paul Kipfer reached an altitude of 15781m, where the atmospheric pressure is about 1/10 that at sea level. In order to ascend it is required to unload something. However, unloading something above cloud level was unsafe for people on the ground.

What should be done?

<The unloaded object> must be <heavy>,
in order to
<decrease the weight of the balloon system>,
BUT
<the unloaded object> must not be <heavy>,
in order to
<be safe for people>.

* physicist, aeronaut, balloonist, hydronaut

Auguste Piccard balloon



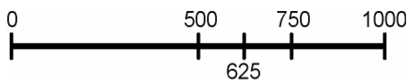
how to find a number?

Task: You must find an integer in the range from 0 to 1000 as quickly as possible.

What should be done?

Let us use a simple rule:
- *for each step, it is necessary to subdivide the section of numbers into equal sections.*

Pattern of questioning*: Is the unknown number less than the middle of the section?*

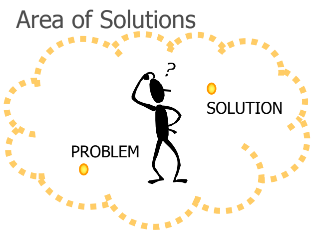


1. Is the unknown number less than 500? – Yes / No
2. Is the unknown number more than 750? – Yes / No
3. Is the unknown number less than 625? - Yes / No.

…………………………………………..

At step #**11** we will know the unknown number. **Guaranteed!**

why do we have difficulties?



How to <reduce the Research area into the Solutions Area>
without <considerable trial and error
and mental inertia restrictions>
without <degrading the power of the solution?>*

THE KEY TASK **of the problem solving process**

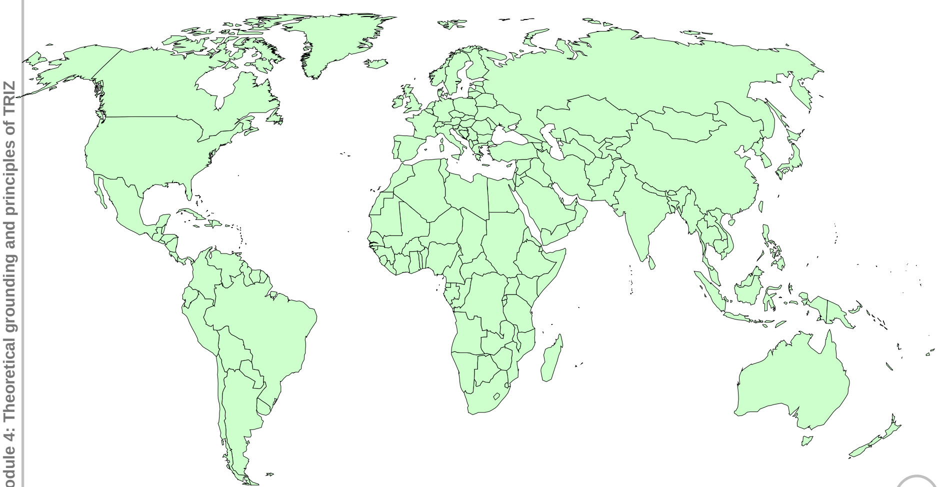
It is necessary to sort out carefully and systematically all possible and impossible concepts, **because** <it is quite possible to miss useful solutions>; <it is necessary to overcome mental inertia>.

But it is necessary to exclude a careful, systematic and exhaustive search, **because** <it is required to reduce the expense of the solution>; <we do not have the time, knowledge and other possibilities necessary for estimating all solution concepts>.

*© N.Khomenko. 1997-2001. Materials for seminars: OTSM-TRIZ: Main technologies of problem solving, "Jonathan Livingston" Project.

how to find a city?

different strategies



summary

- The difficulty of developing a solution concept is based on the limits of available resources of time, knowledge, and mental inertia restrictions.
- In order to make the transition from unsystematic attempts to the systematic analysis of the Problem Situation it is useful to ask strong WHY questions (i.e. Why do we have such a problem?) instead of HOW to perform the solution.
- In order to develop a strong conceptual solution the problem solving strategy has to reduce the research area for each step of analysis instead of enlarging the number of variants.

about TRIZ

"TRIZ is a tool for thinking but not instead of thinking".

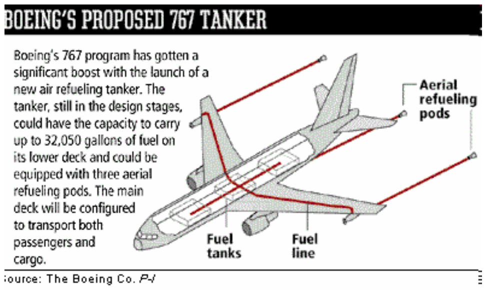
G. Altshuller

T eoriya	**- Theory of**
R esheniya	**- Inventive**
I zobretatel'skih	**- Problem**
Z adach	**- Solving**

Some companies using TRIZ

- Avon
- BMW
- Boeing
- Borden
- Case
- Caterpillar
- Clorox
- Daimler-Chrysler
- Datacard
- Delphi
- Dial
- DuPont
- EDF
- Electrolux
- Eli Lilly
- Ford
- Fujitsu
- General Motors
- Heidelberg
- Hilti
- Hitachi
- Honeywell
- HP
- IBM
- Intel
- ITT
- Johnson & Johnson
- Kimberly-Clark
- Kodak
- LG
- Lockheed Martin
- McDonnell Douglas
- Motorola
- NASA
- NEC Electronics
- Pfizer
- Pilkington
- Proctor & Gamble
- PSA Peugeot Citroen
- Raytheon
- Rockwell
- Rolls Royce
- Samsung
- Sanyo
- Sara Lee
- Shell
- Siemens
- The Gillette Co.
- Toyota
- USPO
- Xerox
- 3M

Boeing



Boeing declares a 1.5 billion USD profit due to this solution.

Samsung

September 2001: Samsung recognizes “an inventive solution concerning the head of a DVD drive, developed using TRIZ, brings 91.2 million USD to the company ”.

Some projects where TRIZ has been used*


- International Space Station
- Self-heating container
- Trident missile
- SeaWolf submarine
- Cassini satellite
- Prius hybrid car
- Heat dissipation of Intel chips
- Intel board assemblies
- Lockheed Launch Vehicle
- Pluto Fast Flyby
- Delta Launch Vehicl
- Fuel Cell
- Large LCD and PDP displays
- E Ink and OLED displays ...

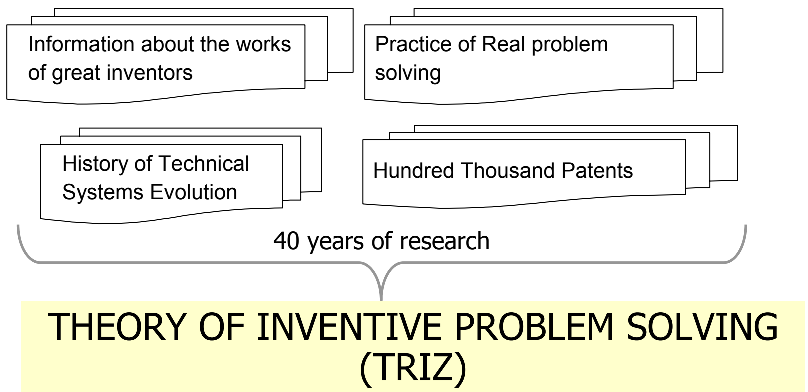
Source: Silverstein, D., N. DeCarlo, and M. Slocum, Insourcing Innovation: How to Transform Business as Usual into Business as Exceptional. 2005: Breakthrough Performance Press. 175.

TRIZ is…

… a tool, … a method, …a theory…

Theory of Inventive Problem Solving (TRIZ) is a domain of science that explores the *mechanisms of technical systems evolution* in order to develop applicable *analytical methods* and *problem solving techniques*.

where does TRIZ come from?



The objective laws
of Technical Systems Evolution

- Analytical methods
- Problem solving techniques
- Useful Knowledge base

history and background

Module 4: Theoretical grounding and principles of TRIZ

First stage: "..it is necessary to study the experience of great inventors and *extract typical features of powerful solutions* in order to differentiate strong thinking."

Second stage: "..it is necessary to build a *program that performs step by step systematic analysis of the problem*, discloses, studies and overcomes technical contradictions. The program does not replace the knowledge and capacities of the inventor but provides useful problem solving tactics."

Third stage: "..it is necessary to obtain a *Theory of inventive problem solving*. This theory enables the resolution of high level problems in a systematic way. The theory has to be based on the knowledge of objective Laws of Technical Systems Evolution."

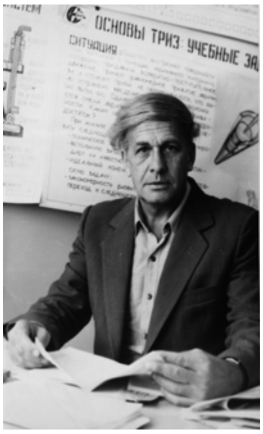
Fourth stage: TRIZ evolves into the *Theory of Technical Systems Evolution* (TRTS). Knowledge of TRIZ spreads widely in the former Soviet Union. TRIZ starts to be applied for different non-technical systems.

Fifth stage: First publications on the Theory of Creative Personality Evolution (TRTL). Several TRIZ+ directions evolve. Worldwide spread of TRIZ.

Current stage: Application of TRIZ Concepts for non-engineering activities in the former Soviet Union.

Application of TRIZ techniques and methodologies for engineering system development worldwide.

1940
1950
1960
1970
1980
1990
2000
2010



"...Behind the specific theories of evolution, the general theory was clearly revealed step by step, which we temporarily named the **General Theory of Advanced Thinking**..."
[G.Altshuller, G.Filkovsky. Actual state of TRIZ. Baku, 1976]*

* http://www.trizminsk.org/h/5300700.htm

Levels of inventive solutions

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Problems of different levels differ by the amount of trial-and-error needed to find a solution.

Why does one problem require 100 trials, and another 1,000 more?

Level One: A problem, and the means of solving it, exists within the area of one profession.

Level Two: A problem, and the means of solving it, exists within the area of one industry.

Level Three: A problem, and the means of solving it, exists within the area of one science.

Level Four: A problem, and the means of solving it, exists outside the boundaries of the science where the problem originated.

Higher sub-levels of Level Five: A problem, and the means of solving it, exists outside the boundaries of contemporary science.

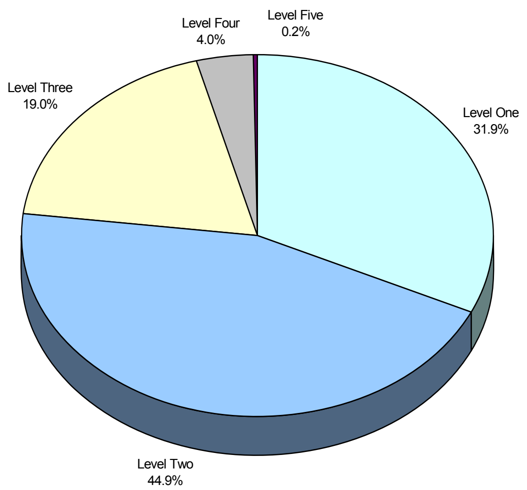
*G.S.Althsuller, 1969, 1973. THE INNOVATION ALGORITHM: TRIZ, systematic innovation, and technical creativity, Moscow.

Levels of inventive solutions

	Level of the solution	Number if trials or variants are considered	Where did the solution come from	Percentage of patents in this level
I	Apparent solutions	A few	The narrow specialized field	~32%
II	Improvement	Dozens	A single branch of technology	~45%
III	Invention inside paradigm	Hundreds	Other branches of technology	<19%
IV	Invention outside paradigm	Thousands to tens of thousands	From science – little known effects and phenomena of physics, chemistry and geometry	3-4%
V	Discovery	Hundreds of thousands to a million	Beyond limits of contemporary science	<0.2%

*G.S.Althsuller, 1969, 1973. THE INNOVATION ALGORITHM: TRIZ, systematic innovation, and technical creativity, Moscow.

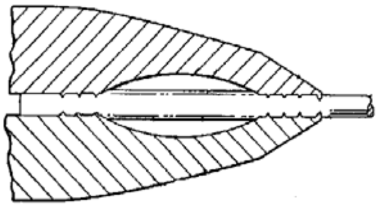
Levels of inventive solutions



first level - routine solutions

First level solutions do not consider contradictions. They are not inventions (from a TRIZ point of view). However, these solutions may be patented.

Pliers which have an increased gripping capacity due to a pincer point at the tip and a center groove located inwardly from the tip. The center groove allows for a workpiece to be deformed and therefore implicates resistance to possible shearing on separation of the workpiece from the tool. Yet the pliers possess a greater control and sensitivity when grasping very small objects, including flat sheet material, due to the pincer point on its tip.
US Patent 5572914



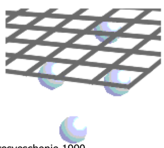
second level - trivial inventions

Contradictions may be considered; no knowledge required from another field of technology.

To check that a container is air-tight a tank containing liquid is used . If the container is not air-tight, we will remark bubbles after adding the liquid .

But if we have a lot of containers and tanks, the operator can miss the bubbles. How do we keep bubbles near the surface of the liquid? One attempt was to cover the surface of the liquid with glass, but this changed the level of the liquid.

Cover the surface of the liquid with a special grid. The bubbles were caught between the cells of the grid. [A.c.1193478]



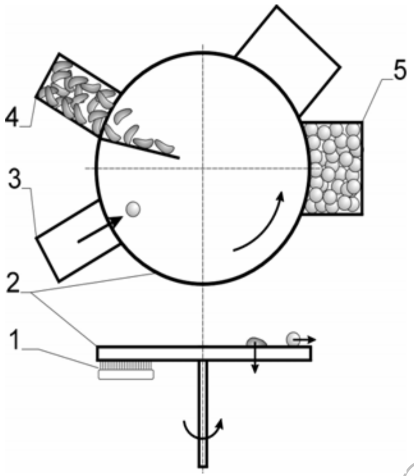
Salamatov Y.P. How to become of inventor: 50 hours of creativity. Moscow, Prosveschenie 1990.

third level - non trivial inventions

Contradictions are resolved by applying knowledge from another technological field.

A rotating disk is used to separate non-spherical particles from balls of the correct shape. It is proposed to install brushes under the disk. The brushes and the disk are made from dielectric materials. The brushes and the disk rub against each other.
As a result, the disk takes an electrostatic field and non-spherical particles stick to the disk. Balls are rolled faster under the action of centrifugal power.
[A.c.539517]

1. Brush
2. Disk
3. Feeder
4. Non-spherical particles collector
5. Balls collector



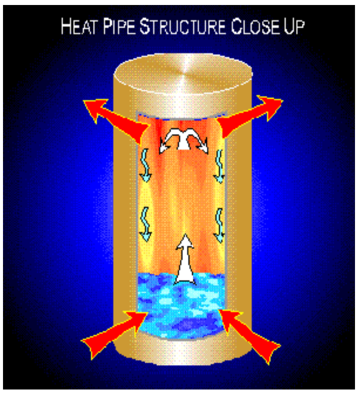
Salamatov Y.P. How to become of inventor: 50 hours of creativity. Moscow, Prosveschenie 1990.

fourth level - great inventions

Contradictions are resolved using well known scientific knowledge (physical, chemical and other natural effects).

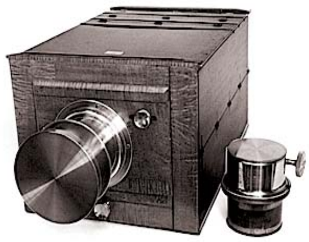
A heat pipe is a device that can quickly transfer heat from one point to another without needing any energy input. Heat pipes are often referred to as the "superconductors" of heat as they possess an extraordinary heat transfer capacity with almost no loss.

US Patent 3229759
Grover 1/1966



fifth level - pioneering inventions

Scientific knowledge is required to solve the problem. Contradictions are resolved using recently discovered scientific effects and phenomena.



Large Folding Box Camera, 1855, Inventory nos 92,724; 71,055; 95,583.

New system forms a new field of engineering systems:

airplane *(aviation),*
radio *(radio electronics),*
computer *(information technology);*
laser *(quantum optics)...*

structure of classical TRIZ

Theoretical basis	Methods	Techniques / Tools	Knowledge base
The Laws of Technical Systems Evolution	Algorithm of Inventive Problem Solving (ARIZ)	Principles for Physical Contradictions Elimination	Repository of descriptions the solutions obtained with TRIZ
	Contradictions analysis	Principles for Technical Contradiction Elimination (40 Inventive Principles + Altshuller's Matrix)	Collections of advanced inventions
	Su-Field Analysis	Standard Approaches to Solving Problem (76 Inventive Standards)	Pointers to effects: • physical • chemical • geometrical
	Function and Cost Analysis/TRIZ-enhanced	Function and Ideality Modeling (convergence)	Lists of substance-field resources most frequently used in inventive problem solving
	Methods for Creative Imagination Development (RTV)	- Modeling with Little Creatures; - Size-Time-Cost Operator (Dimensions-Time-Cost operator); - "Golden Fish" operator;	Repository of ideas drawn from science fiction literature
	Methods of Research problem analysis	Analysis of Inverse problem	TRIZ-based Software and database
	Multi screen scheme of strong thinking		

Brief history of TRIZ

...The thinking is talented when it works according to the laws of the external world...
G.Altshuller

1946 - 20 year old research officer of the Patent department (Caspian Navy) started to develop a methodology of Inventive Problem Solving.

1956 - first publication about the future methodology for Inventive Problem Solving in issue #6 of journal "The Problems of Psychology".

1961 - first book about methodology for Inventive Problem solving (50 000 copies)

1971- first regular Public University of TRIZ was established in Baku.

1981 - more than 300 TRIZ Centers in the former Soviet Union. Most TRIZ Centers were public and non profit.

1984 - first book in English translated from Russian G.S.Altshuller, CREATIVITY AS AN EXACT SCIENCE

1989 - International TRIZ Association was created in the former USSR.

1990 - first issue of Journal TRIZ (in Russian).

1994-2003 - several books about TRIZ were translated, written, and published in English, in German, in French, in Spanish, in Japanese, in Korean, and other languages...

summary

- **TRIZ is a theory that aims to study the Objective Laws of systems evolution and to propose new technologies for improving the problem solving process.**
- **TRIZ generalizes the worldwide experience of inventors and great thinkers and systematizes some useful techniques and knowledge for problem solving purposes.**
- **Instead of trying to find multiple solutions as quickly as possible, it is useful to analyze the reasons of the problem situation in order to reduce the research area, to overcome mental inertia and to satisfy conflicting requirements.**

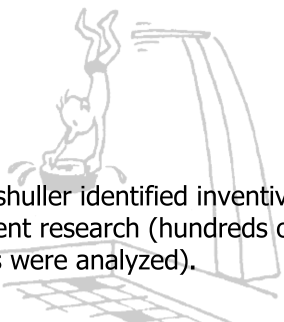
40 INVENTIVE PRINCIPLES

***Inventive Principles:* a problem solving technique that is helpful for dealing with Technical Contradictions.**

- Inventive principles operate with technical contradictions defined as the condition whereby *improvement* of one system characteristic results in the *degradation* of another.
- Inventive principles give general recommendations on how to change the analyzed system to eliminate contradictions.
- Inventive principles consist of a list of 40 principles with sub-principles, and a contradiction table[1] to identify useful principles for formulated contradictions.

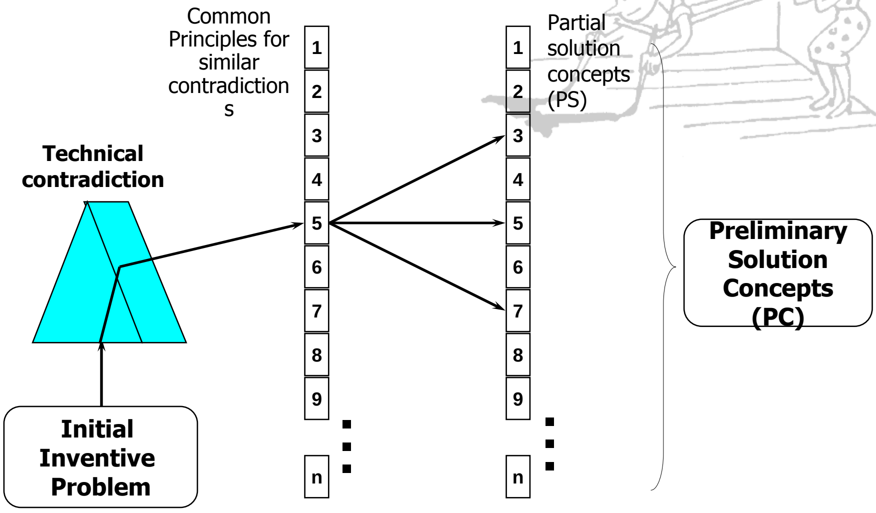
[1]The Contradiction Table (**Altshuller's Matrix**) is a 39x39 matrix formed by placing these system characteristics in rows (under the heading "Feature to Improve") and columns ("Undesired Result").

Background



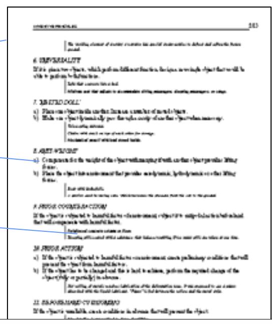
- G.S.Altshuller identified inventive principles based on his patent research (hundreds of thousands of patents were analyzed).
- The first list of inventive principles using the contradiction model was published in 1961. The first contradiction table was introduced in 1964.
- The final list of 40 inventive principles was published in 1973.
- In order to reduce the shortcomings of Inventive principles, the system of 76 Inventive standards was developed .

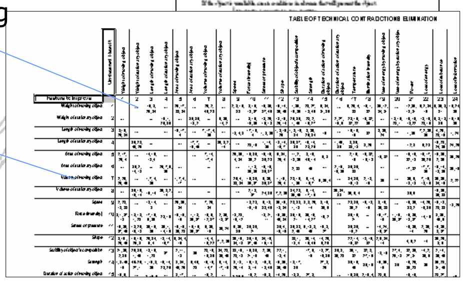
How does it work?

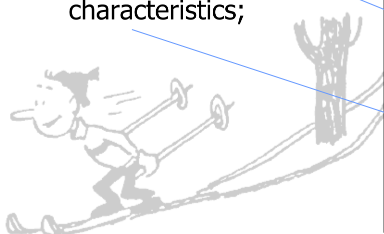


Structure of 40 Inventive principles

- List of 40 principles;
  - more than 80 sub-principles;
  - dozens of examples;
- Contradiction table
  - 39 generalized engineering characteristics;

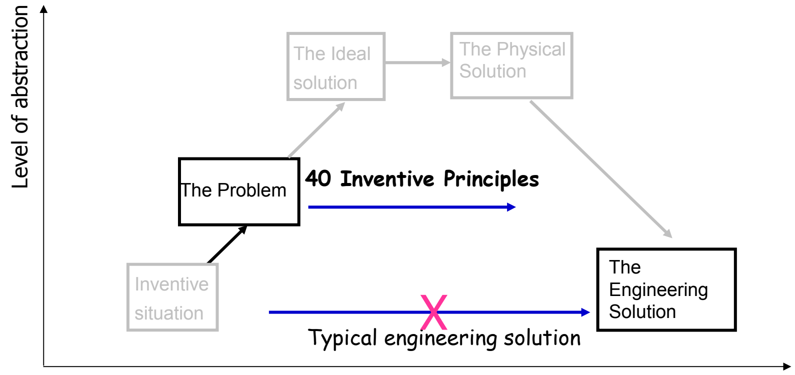






Field of application

Inventive Principles can be applied to synthesize solution concepts at level 2-3 and as a part of express-analysis of the problem situation.



practice: laser cutting

Image: http://www.cuttingedgelaser.com/images/pic-laser.jpg

During laser cutting of a metallic tube the droplets of melted metal stick to the inner surface of the tube.

It is necessary to propose a solution concept in order to remove the hardened droplets from the inner surface of the tube.

What should be done?

G.I.Ivanov: 1994: *THE FORMULES OF CREATIVITY OR HOW TO LEARN TO INVENT.* Prosveschenie, Moscow. P. 78

Problem analysis

Recognize problem

A. Describe **the need** for improving the existing system in accordance with Multi-screen analysis results. Why is it difficult to satisfy the needs using known methods?

B. Summarize the difficulties of using a known method in the form of a **contradiction**. Describe the **mini-problem particularities**.

Analyze problem

C. Define the conflicting elements (**Product** and **Tool**) for the formulated contradictions. Choose **one contradiction** for further analysis

D. Reformulate the chosen contradiction as the following: *It is necessary to improve the parameter A <indicate>, in order to satisfy demands <indicate>, BUT the parameter B <indicate> gets worse.*

E. Identify the parameter that it is **necessary to improve "A".** Respectively, identify the parameter that **gets worse "B".**

F. Find a cell in the Contradiction Table (Matrix) which is the intersection of column and row in accordance with the selected parameters.

Synthesize solution concepts

G. Apply the **list of Inventive Principles**.

H. Interpret the recommendations of the Inventive Principles to gather the **Partial solution concepts**.

A. The need to improve an existing system

Laser cutter main function: *to separate* parts of the tube
Anti-system main function: *to connect* parts of the tube

before super-systems: 1. Air (low t^0, low P) 2. Heavy Support 3. Other machines 4. Gravity forces 5. Old production process	**super-systems:** 1. Air (t^0, P, humidity) 2. Support of machine 3. Other machines 4. Gravity forces 5. Production process	**After super-systems:** 1. Air (t^0, P, humidity) 2. Support of machine 3. Other machines 4. Gravity forces 5. Efficient Production process
***Before system*:** Mechanical cutting system	**Laser cutting system**	***After system:*** *"Laser cutting+" system*
before sub-systems: 1. Cutter (saw) 2. Metallic tube 3. *Filings* 4. Electricity 5. Actuators 6. Control sub-system	**sub-systems:** 1. Laser beam 2. Metallic tube 3. STICKY DROPLETS 4. Electricity 5. Actuators 6. CNC sub-system	**After sub-systems:** 1. Laser beam 2. Metallic tube 3. *Free droplets* 4. Electricity 5. Actuators 6. CNC sub-system

A. the need to improve an existing system

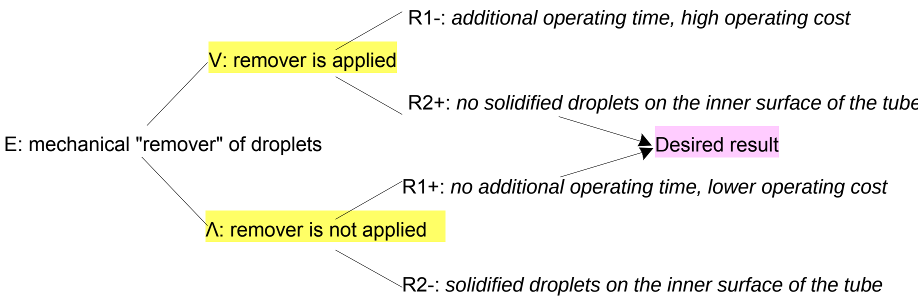
Why is it difficult to satisfy the needs using known methods?

- The hot droplets of metal stick to the inner surface of the tube during cutting.
- The chips did not stick to the surface of the tube with the previous system (mechanical cutter).
- An additional operation is required to “unstick” the droplets from the inner surface of the tube (in order to remove solidified droplets).
- It would take time and additional operating costs if a mechanical remover were used to “unstick” the droplets (the known method).
- Ideally it would be preferable if the droplets of melted metal *did not stick to the inner surface* of the tube.

B. known method leads to contradictions

Describe the mini-problem particularities

The technical system: <laser cutter> for <separating parts of the tube> consists of <laser beam, metallic tube and sticky droplets, electricity supplying system, actuators; CNC control sub-system>.



Desired result: It is necessary to achieve *<no droplets on the inner surface of the tube without additional operating time and while lowering the operating cost>* with minimal changes of the system.

C. Product and Tool

Choose one contradiction

The **Product** is the element that needs to be processed (manufactured, moved, changed, improved, protected from a harmful influence, revealed, measured etc.) according to the problem conditions.

The **Tool** is the element that directly interacts with the product (e.g., mill rather than a milling machine; fire rather than a burner).

Product: sticky droplets

Tool: mechanical remover

Laser cutter main function: *to separate* parts of the tube

TC-1: If there is <**a mechanical remover**>, then <*there are no solidified droplets on the inner surface of the tube*>, but <*there is additional operating time and a high operating cost*>.

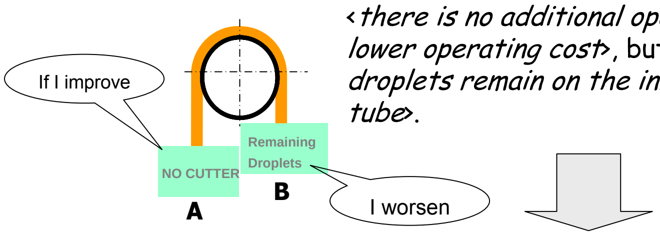
TC-2: If there is <**no mechanical remover**>, then <*there is no additional operating time and a lower operating cost*>, but <*solidified droplets remain on the inner surface of the tube*>.

D. reformulate the chosen contradiction

Product: sticky droplets

Tool: absent mechanical remover

If there is <**no mechanical remover**>, then <*there is no additional operating time and a lower operating cost*>, but <*solidified droplets remain on the inner surface of the tube*>.

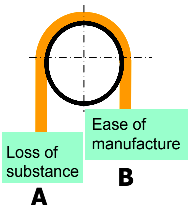


*It is necessary to improve the parameter **A** <no mechanical remover>, in order to satisfy the demands <no additional operating time and a lower operating cost>, however, the parameter **B** <solidified droplets remain on the inner surface of the tube> gets worse.*

E. identify the parameters

according to analysis list of	**according to generalized 39 features**
the parameter to improve **A**	
<no mechanical cutter>,	*23. Loss of substance* *39. Productivity*
the parameter that gets worse **B**	
<solidified droplets remain on the inner surface of the tube>	*32. Ease of manufacture* *26. Quantity of substance*

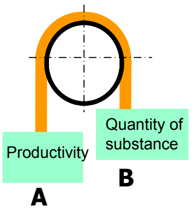
F. find a cell in the Contradiction Matrix



15. DYNAMICITY

34. REJECTING AND REGENERATION OF PARTS

33. HOMOGENEITY



35. CHANGE OF PHYSICAL AND CHEMICAL PARAMETERS

38. STRONG OXIDIZERS (STRONG OXIDENTS)

G. apply Inventive Principles

To which element of the system should the recommendations of the Inventive principles be applied?

First: to conflicting elements (1) sticky droplets and (2) mechanical remover

Second: to nearest super-system of conflicting elements (1) tube; (2) laser beam; (3) air; etc.

Third: to far super-system (1) Gravity forces; (2) Others machines; (3) Production process;

15. DYNAMICITY

34. REJECTING AND REGENERATION OF PARTS

33. HOMOGENEITY

35. CHANGE OF PHYSICAL AND CHEMICAL PARAMETERS

38. STRONG OXIDIZERS (STRONG OXIDENTS)

H. gather Partial solution concepts

Direction of inventive solutions (**brief IFR**): <Droplets of melted metal> itself, without an additional cost <do not stick> to the <inner surface of the tube> within <laser cutter operating time>.

15. DYNAMICITY

____

34. REJECTING AND REGENERATION OF PARTS

____

33. HOMOGENEITY

____

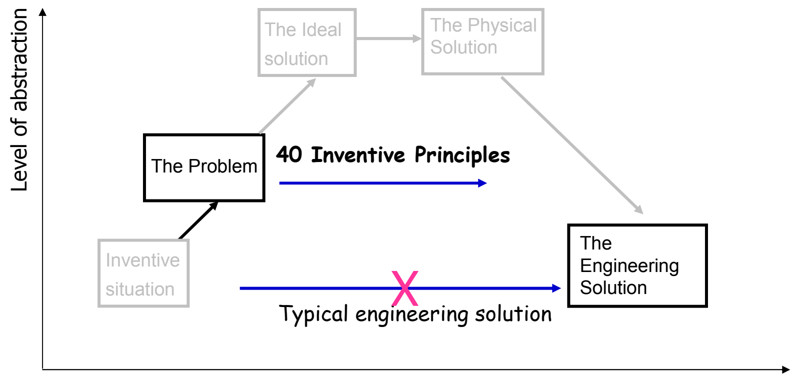
35. CHANGE OF PHYSICAL AND CHEMICAL PARAMETERS

____

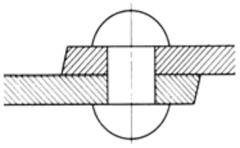
38. STRONG OXIDIZERS (STRONG OXIDENTS)

____

From solution concepts to the solution



practice: riveted joint



It is necessary to rivet two flat plates in order to make the riveted joint.

If the rivet is deformed enough, the plates are well fixed, but cannot work as a joint. If the rivet isn't deformed enough, the plates are movable, but they aren't adjusted enough.

How should the rivet joint be manufactured ?

Problem analysis

Recognize problem

A. Describe **the need** for improving the existing system in accordance with Multi-screen analysis results. Why is it difficult to satisfy the need using known methods?

B. Summarize the difficulties of applying a known method in the form of a **contradiction**. Describe the **mini-problem particularities**.

Analyze problem

C. Define the conflicting elements (**Product** and **Tool**) for formulated contradictions. Choose **one contradiction** for further analysis

D. Reformulate the chosen contradiction as the following:
It is necessary to improve the parameter A <indicate>, in order to satisfy the demands <indicate>, BUT the parameter B <indicate> gets worse.

E. Identify the parameter that it is **necessary to improve "A".** Respectively, identify the parameter that **gets worse "B".**

F. Find a cell in the Contradiction Table (Matrix) which is the intersection of column and row in accordance with the selected parameters.

Synthesize solution concepts

G. Apply the **list of Inventive Principles**.

H. Interpret the recommendations of the Inventive Principles and gather the **Partial solution concepts**.

A. the need to improve an existing system

_______________ main function: <_______________>
Anti-system main function: <_______________>

before super-systems: 1. 2. 3. 4. 5.	**super-systems:** 1. 2. 3. 4. 5.	**After super-systems:** 1. 2. 3. 4. 5.
***Before system*:**		***After system:***
before sub-systems: 1. 2. 3. 4. 5.	**sub-systems:** 1. 2. 3. 4. 5.	**After sub-systems:** 1. 2. 3. 4. 5.

A. the need to improve an existing system

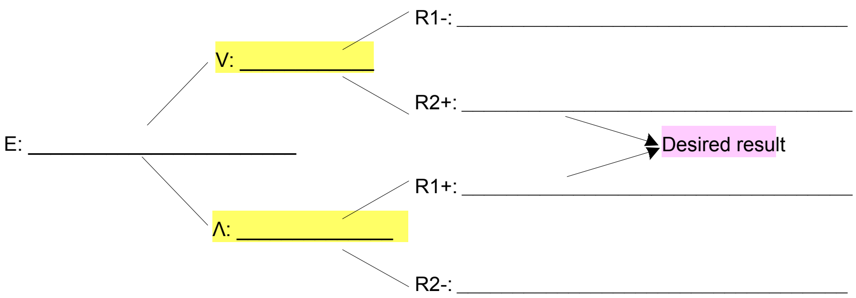
Why is it difficult to satisfy the need using known methods?

- ____
  ____
- ____
  ____
- ____
  ____
- ____
  ____

B. known method leads to contradictions

Describe the mini-problem particularities

The technical system: <________> for <_____________> consists
<____
____>.



Desired result: It is necessary to perform <_____________________
____>
with minimal changes of the system.

C. Product and Tool

Choose one contradiction

The **Product** is the element that needs to be processed (manufactured, moved, changed, improved, protected from a harmful influence, revealed measured etc.) according to the problem conditions.

The **Tool** is the element that directly interacts with the product (e.g., mill rather than a milling machine; fire rather than a burner).

Product: ______________________________

Tool: __________________________________

__________________ main function: __________________________

TC-1: If there is <______________________________________>, then
<____>, but
<____>.

TC-2: If there is <______________________________________>, then
<____>, but
<____>.

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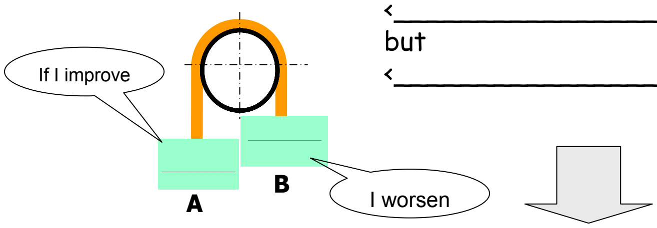
D. reformulate the chosen contradiction

Product: ________________________________

Tool: ___________________________________

If there is <______________________>, then
<____>,
but
<____>.



*It is necessary to improve the parameter **A** <______________________>,*
in order to satisfy demands <____________________________________>,
however,
*the parameter **B** <____>*
gets worse.

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E. identify the parameters

according to analysis	**according to generalized list of 39 features**
the parameter to improve **A**	
<___________________>,	___. ____________________
	___. ____________________
the parameter that gets worse **B**	
<_____________________>	___. ____________________
	___. ____________________

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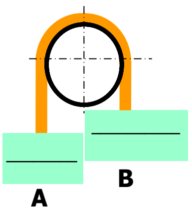
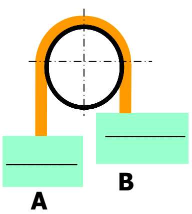
F. find a cell in the Contradiction Matrix



___. ____

___. ____

___. ____



___. ____

___. ____

G. apply Inventive Principles

To which element of the system should the recommendations of the Inventive principles be applied?

First: to conflicting elements (1) ________________ and (2) __________________

Second: to nearest super-system of conflicting elements (1) __________; (2) ____________; (3) ____________; etc.

Third: to far super-system (1) ____________; (2) __________; (3) ________________;

___. ______________________________________

___. ______________________________________

___. ______________________________________

___. ______________________________________

___. ______________________________________

H. gather Partial solution concepts

Direction of the inventive solutions (**brief IFR**): <_______________> itself, without an additional cost <_______________________> inside <_______________________> during <______________________>.

___. ______________________________________
____

___. ______________________________________
____

___. ______________________________________
____

___. ______________________________________
____

___. ______________________________________
____

THREE BASIC CONCEPTS*

How do we look for the solution to a problem?

1. Idea of Objective Laws of Systems evolution

- Objective laws of systems evolution exist.
  These Laws can be discovered, studied and purposefully applied for problem solving without resorting to a search for variants.

2. Idea of Contradiction as a problem cause

- During their evolution the systems overcome the contradictions between objective restrictions and specific situation limits.

3. Idea of Particular situation conditions

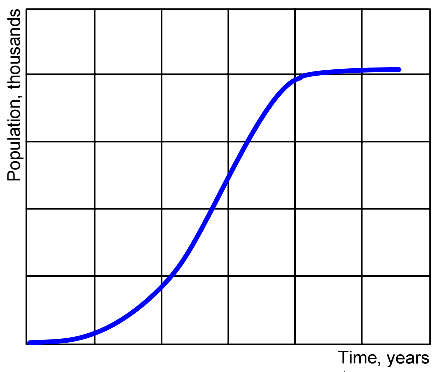
- Every problem can be solved only for particular situation conditions, using available resources.

*© N.Khomenko. 1997-2001. Materials for seminars: OTSM-TRIZ: Main technologies of problem solving, "Jonathan Livingston" Project.

LAWS OF SYSTEMS EVOLUTION: an example

Logistic equation:

Life curve of systems



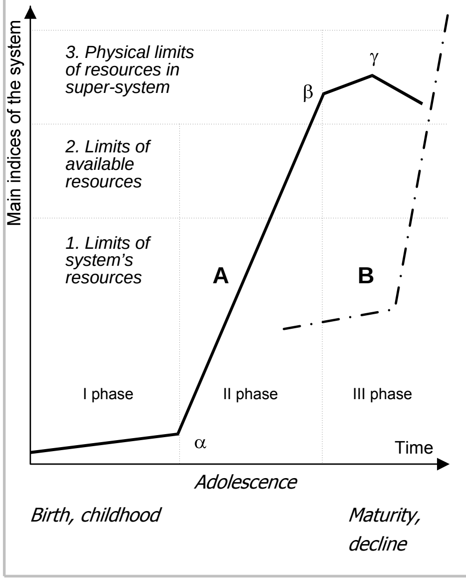
$$P(t) = a\frac{1+me^{-e/\tau}}{1+ne^{-e/\tau}}$$

The logistic equation as a model of population growth was introduced by Belgian mathematician Pierre-Francois Verhulst (1804-1849) in 1838 .

Verhulst derived his logistic equation after he had read 'An essay on the Principle of Population' of English demographer and political economist Thomas Malthus (1766-1834) .

The logistic equation was introduced to describe the self-limiting growth of a biological population.

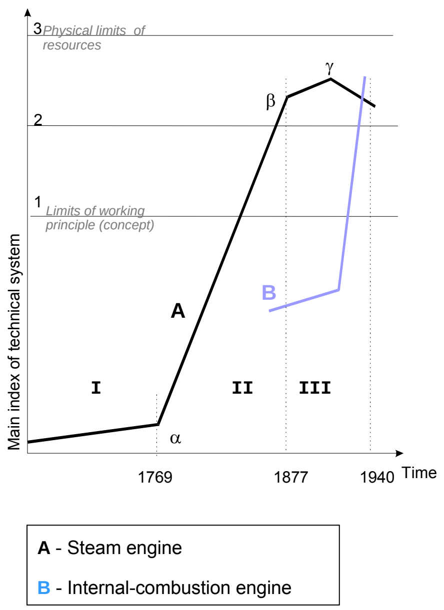
Life curve of technical systems



- **Growth curve**
- **Sigmoid curve**
- **Logistic curve**
- **S-curve**
- **Pearl Curve**

It is useful to depict a system's position on an S-curve in order to take a decision about the direction of problem solving.

S-curve of heat engines evolution

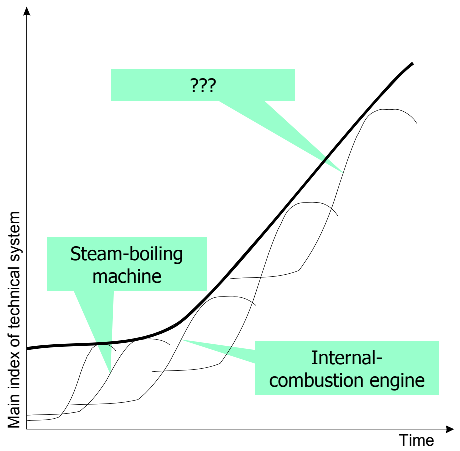


Phases of evolution:

I. birth, childhood;
II. adolescence;
III. maturity and decline.

- What phase is the system currently in?
- What form of creative thinking is required?
- How do we know when the rules of survival have changed?

Combination of S-curves



Several evolution curves for technical systems with different working principles.

Why does "system 2" replace "system 1" ?

Increasing Ideality

During their evolution the technical systems tend to improve the ratio between the SYSTEM PERFORMANCE and the EXPENSE required to achieve this performance.

$$I = \frac{\sum P}{\sum E} \quad \begin{array}{l}\text{(performance)} \\ \text{(expense)}\end{array}$$

Useful for practice*:

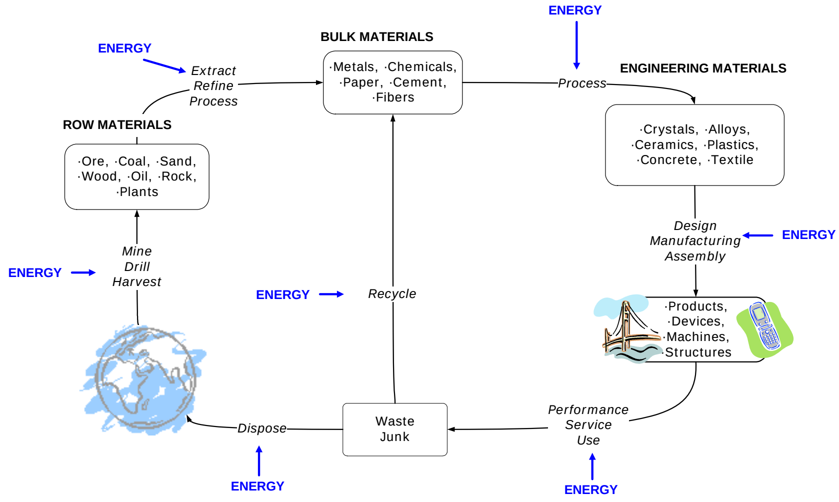
Ideal machine – there is no machine, but the required action is performed.

Ideal process – there are no energy expenses and no time expenses, but the required action is performed (self-acting control).

Ideal substance – there is no substance, but the function is performed.

*G.S.Altshuller: 1979. CREATIVITY AS AN EXACT SCIENCE. Sovietskoe radio, Moscow

definition of expenses (substances, energy)



Original presentation source: "Materials and Man's Needs," National Academy of Sciences, Washington D.C., 1974

Module 4: Theoretical grounding and principles of TRIZ

classic system of
Laws of Technical Systems Evolution

Laws of Technical Systems Evolution describe fundamental, firm, and repeating relationships of system elements and the external environment during their evolution.

- *law of System Completeness*
- *law of Energy Conductivity in systems*
- *law of Harmonization*

o law of Dynamics Growth
o law of Increasing Substance-Field Interactions
o law of Irregularity of the Evolution of a System's Parts
o law of Transition from Macro- to Micro-level
o law of Transition to the Super-system

✓ LAW OF INCREASING IDEALITY

Module 4: Theoretical grounding and principles of TRIZ

CONTRADICTION AS A PROBLEM CAUSE

During their evolution systems overcome the contradictions between objective restrictions and specific situation limits.

Practical conclusion for problem solving:

A powerful solution must overcome one or several contradictions.

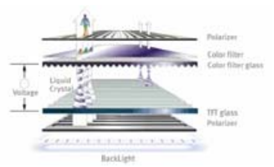
Brightness of LCD panel:

Backlight lamps

V: high brightness
- R1-: short lifetime of panel
- R2+: *adequate brightness of panel*

Λ : low brightness
- R1+: *adequate lifetime of panel*
- R2-: insufficient brightness

R2+ and R1+ → Desired



types of contradiction models

Administrative contradiction (initial situation)

we know what is required, but we do not know how to achieve that.

Vacuum cleaner produces a lot of noise (>60dB).
How to reduce the noise's level of a vacuum cleaner?

Technical contradiction

we know how to achieve the required result, but it will make the system worse.

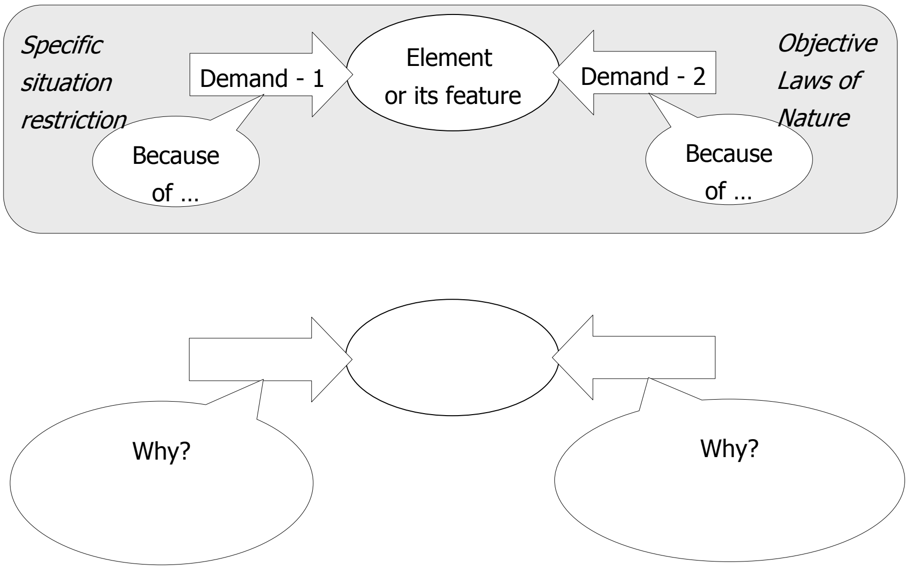
TC-1: If there are <few damping materials>, then <the suction power is sufficient>, but <the noise level is high>.
TC-2: If there are <added damping materials>, then <the noise level is low>, but <the suction power is not acceptable; dimensions of the vacuum cleaner are large, temperature of the fan-motor increases>.

Physical contradiction

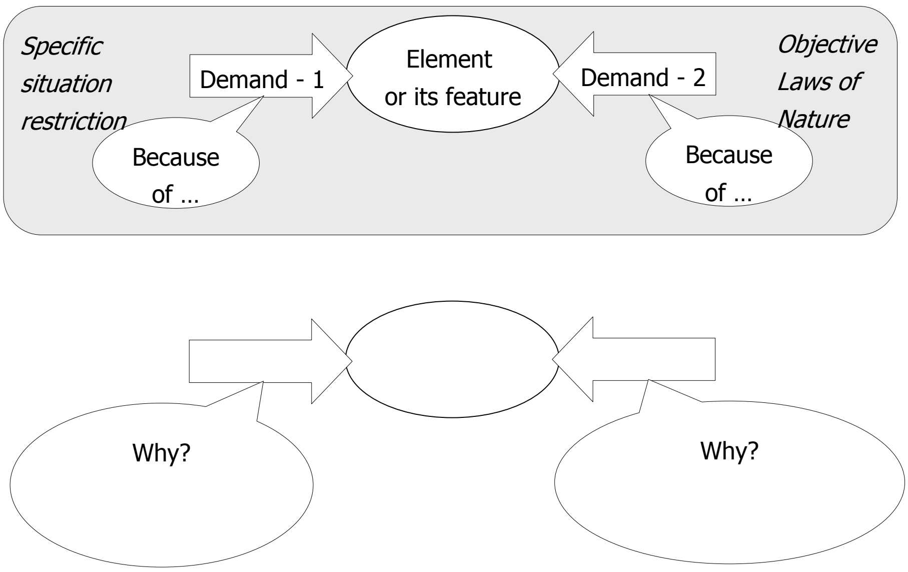
we know what is required and how it has to work but we do not know the working principle.

<Air flow> has to be <small and laminar>, to <decrease noise>
<Air flow> has to be <large and turbulent>, to <provide effective suction>

shape of the Earth



lost spacecraft



PARTICULAR SITUATION CONDITIONS

Every problem can be solved only for <u>particular situation</u> conditions, using available resources.

Practical conclusion for problem solving:

A powerful (useful, breakthrough) solution uses, first of all, the resources available in the conditions of its particular situation.

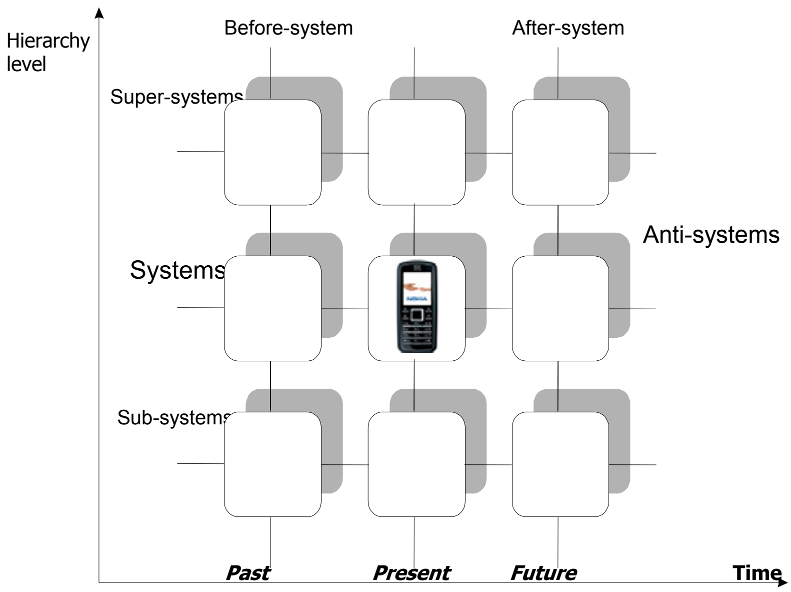
SUBSTANCE - solid, liquid, gas, plasma substance.

FIELD - mechanical, acoustical, thermal, chemical, electrical, magnetic, electromagnetic fields, etc.

SPACE - empty space, artificial and natural void, permanent or temporary void.

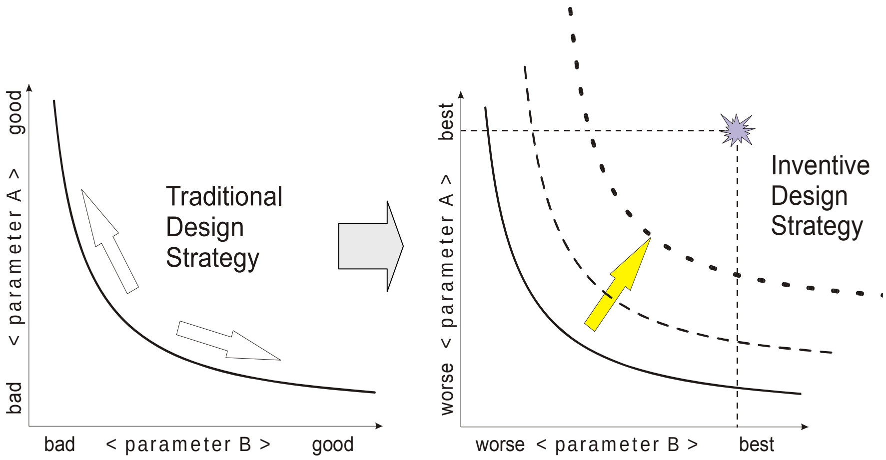
TIME - time before problem occurs, time of conflict, time after conflict.

Multi-screen thinking (how to look for resources?)

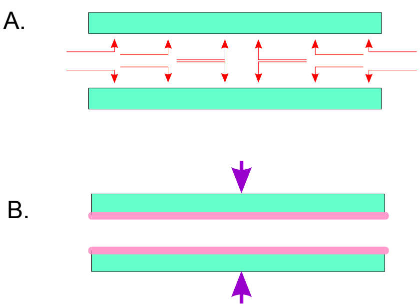


inventive vs. robust

...Nature of innovation is to discover what you don't know...



Welding of two glass plates



In order to assemble two glass panels hot air is used to heat their surfaces. It is necessary to detect precisely when the surfaces begin to melt ("flow point") and to push them together at this moment.

It is necessary to propose a device that detects the melting moment of the entire surface with a high degree of accuracy.

G.I.Ivanov: 1994: *THE FORMULES OF CREATIVITY OR HOW TO LEARN TO INVENT.* Prosveschenie, Moscow. P. 107

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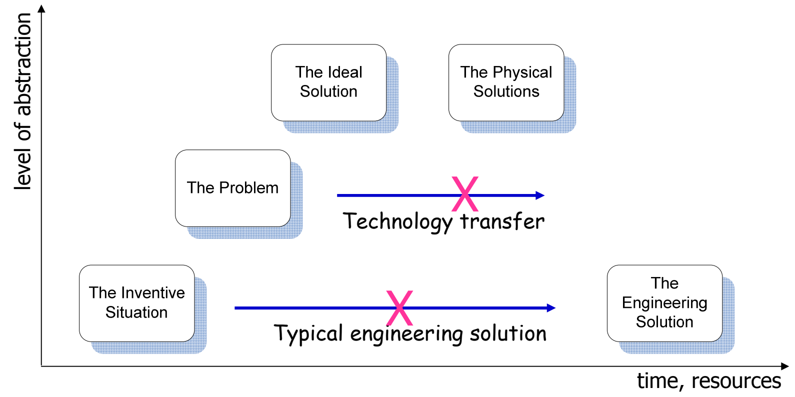
process of solving an inventive problem

Future State of System = Actual State of System + Changes



Summary

- **TRIZ is a theory that aims to use the objective laws of systems evolution in order to improve the problem solving process.**
- **A principal feature of talented thinking is the ability to easily "travel" between system, super-system, and subsystem levels as well as between past, present, and future stages.**
- **The problem solving process might by subdivided into 5 stages:**
  1. Initial situation analysis: to extract a problem;
  2. Problem definition stage: to formulate the problem as a contradiction;
  3. Ideal Final Result definition stage: to fix the problem solving direction and to disclose the physical contradiction;
  4. Physical solution development: to develop feasible ideas;
  5. Engineering solution development: to develop a practical solution out of feasible ideas.

Mental inertia & creative imagination

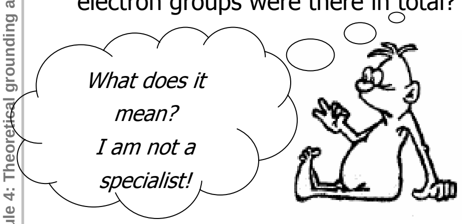
Psychological barriers include several layers:

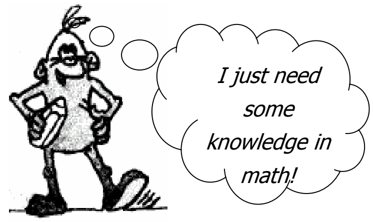
- the specific terms;
- well known typical solutions from professional practice;
- nonflexible viewpoint of the problem situation;
- desire to obtain a solution as soon as possible…

complicated by words

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?

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?





Source: G.Altshuller: 1999, THE INNOVATION ALGORITHM: Worchester, Massachusetts: Technical Innovation Center

mental inertia…: how to apply words?

Instead of names and terms it is helpful to use the *functional "name"* or general description + key feature

Specific name / term	**Function / feature**	**"name"**
Water-purification filter	To clean water	"Cleaner"
Sulfuric acid		
Book		
Hammer		
Chair		
Computer display		
Mobile phone		

Module 4: Theoretical grounding and principles of TRIZ

function definition

How do we define the function of a system?

1. Describe a function using common words and expressions
   pencil – to write, to draw

2. Reformulate the defined function in accordance with the pattern:
   <verb> + <subject/noun> + <..additives/object..>
   <draw> <letters>; <supply> <ink>

3. Reformulate the defined function according to the pattern:
   <change> + <features (values)>
   <change> <color>

Module 4: Theoretical grounding and principles of TRIZ

mental inertia…: anchor

It is necessary to anchor a boat in open sea. However, the seabed is stony and level. A classic anchor doesn't work properly.

What should be done?

*A.V.Podkatilin. Basics of Engineering creativity: Moscow 1997.

…and creative imagination

Whatever a human being can imagine, others can make reality.
Jules Verne

What are the applicable approaches from TRIZ to scaffold creative imagination and overcome the limitations of mental inertia?

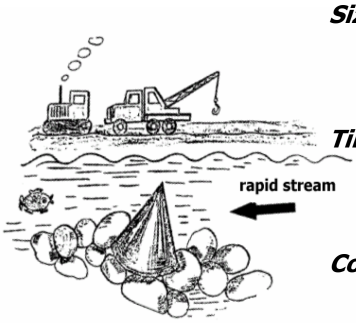
- Multi-screen scheme of talented thinking
- Size-Time-Cost operators
- Simulation with Little Creatures
- “Golden Fish” operator…

The creative imagination approaches do not work in isolation! They are efficient in combination with analytical methods, techniques and knowledge base.

size-time-cost operators

What would happen to the problem situation, the features of objects and its environment if we were to increase or decrease the values of an object's parameters by many times (by 10, 100, 1000 times)?

It is necessary to remove a 3000 kg metallic cone from a river. The river has a stony bed and a fast current. What should be done?



Size:

- increase it from its real size to infinity step by step AND/OR
- decrease it from its real size to zero step by step;

Time (operation or conflict time):

- increase it from its real time to infinity step by step AND/OR
- decrease it from its real time to zero step by step;

Cost (operation):

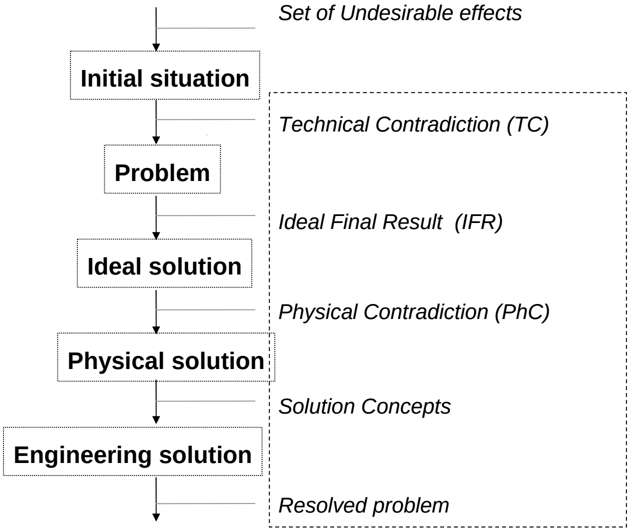
- increase it from its available cost to infinity step by step AND/OR
- decrease it from its available cost to zero step by step.

*A.V.Podkatilin. Basics of Engineering creativity: Moscow 1997.

PROBLEM SOLVING PROCESS

1. Initial situation analysis:
   to extract a problem.
2. Problem definition stage:
   to formulate a problem as a contradiction.
3. Ideal Final Result definition stage:
   to fix the problem solving direction and to disclose the physical contradiction.
4. Physical solution development:
   to develop feasible ideas.
5. Engineering solution development:
   to develop a practical solution out of feasible ideas.

Flow of problem analysis



* G.S.Altshuller, [1975]. PROCESS OF SOLVING AN INVENTIVE PROBLEM

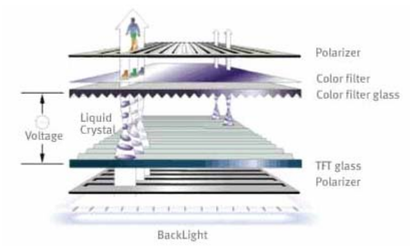
How to increase brightness of a LCD display?

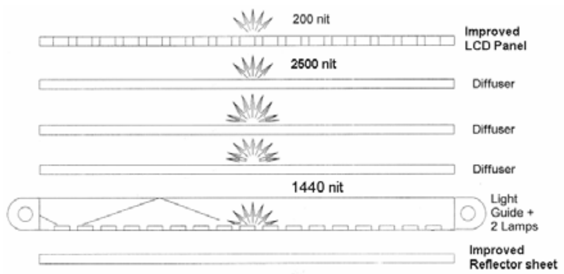
Initial situation:

To backlight liquid crystal displays fluorescent lamps are applied. For displays larger than 12", in order to improve the brightness of the display, two lamps are installed on both sides of the display. In order to improve the homogeneity of the backlight a set of special sheets are applied.

It is necessary to improve the brightness of the LCD display by 20%.

What should be done?



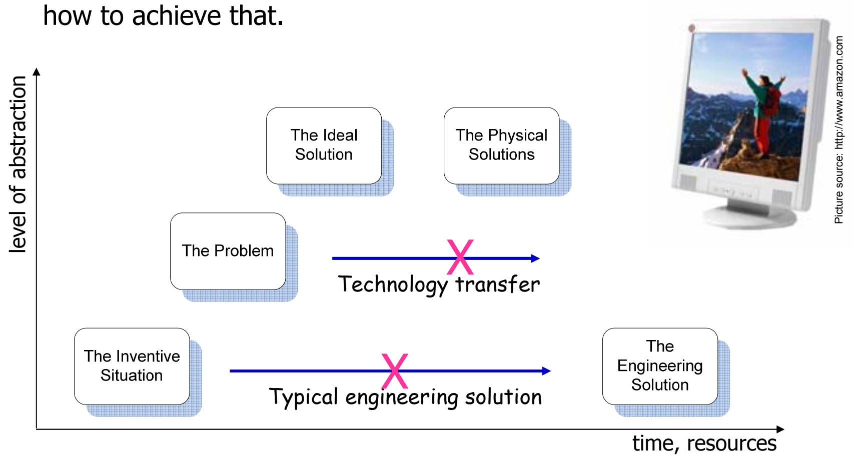


Initial situation

Discontent is the first necessity of progress.

Thomas A. Edison

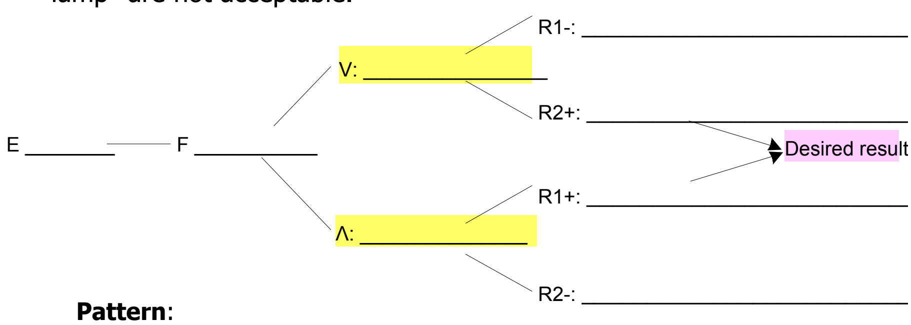
The problem situation is recognized when there is no known method for satisfying needs. We know what is required, but we do not know how to achieve that.



Problem definition

We fail more often because we solve the wrong problem than because we get the wrong solution to the right problem. Russell Ackoff

Some typical (known) engineering solutions such as "install a brighter lamp" are not acceptable.



Pattern:

TC-1: *If there is <**V**>, then <**P1-**>, but <**P2+**>*

TC-2: *If there is <**Λ**>, then <**P1+**>, but <**P2-**>*

Problem situation description

Main function of LCD panel:

____

The technical system: <LCD panel> for <____________________> consists
<__________________, __________________, __________________,
__________________, __________________, __________________>

TC-1: If there is <____________________>, then
<__________________>,
but <____________________________________>.

TC-2: **If there is <____________________>, then**
<__________________>, but
<____________________________________>.

It is necessary* to
<____> with minimal
changes of the system.

* desired result

What to do with contradictions?

1. **IDENTIFY the elements that are responsible for the contradiction:**
   ____________________ (Product); ________________________ (Tool)
2. **CHOOSE one contradiction that corresponds to the main function of system efficiency <__________________________>:**
   ____
   ____
3. **INTENSIFY CHOSEN CONTRADICTION:**
   ____
   ____

Problem model

...A problem well stated is a problem half-solved...

(1) *Conflicting pair:* <____________________> and <________________________>

(2) *Intensified Conflict:* <____________________________________> do not <___________________________>, but they do not <___________________>.

(3) *Problem:* It is necessary to find such an **X-element** that <_____________________> do not <____________________________>, and <_____________________________________>.

What is an Ideal solution?

Think of the end before the beginning.
Leonardo Da Vinci

Ideal machine – there is no machine, but the required action is performed.

Ideal process – there are no energy expenses and no time expenses, but the required action is performed (self-acting control).

Ideal substance – there is no substance, but the function is performed.

Simplified pattern for Ideal Final Result (IFR):

X-element, *itself, without harmful side effects*, eliminates

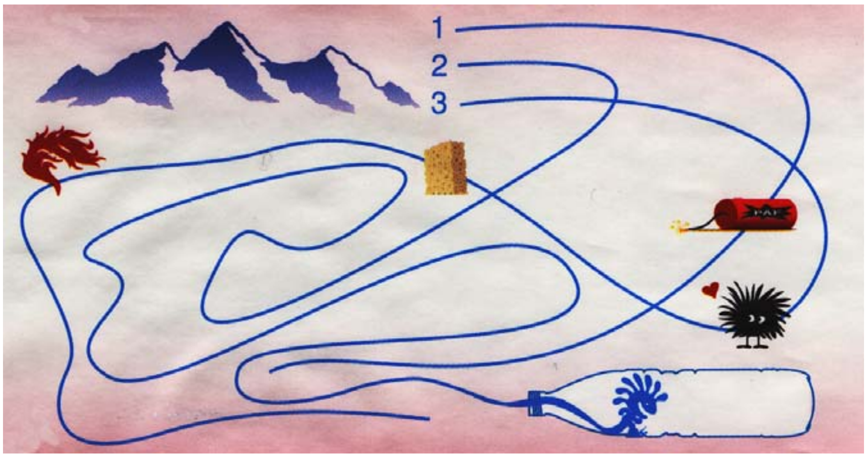
<*indicate the harmful action*>

and keeps the ability to provide

<*indicate the useful action*>.

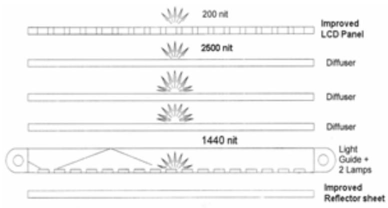
Ideal Final Result

How do you start such a puzzle?



What is a Physical solution?

Description of concepts (ideas) which answers the formulated contradiction and does not conflict with laws of Nature.



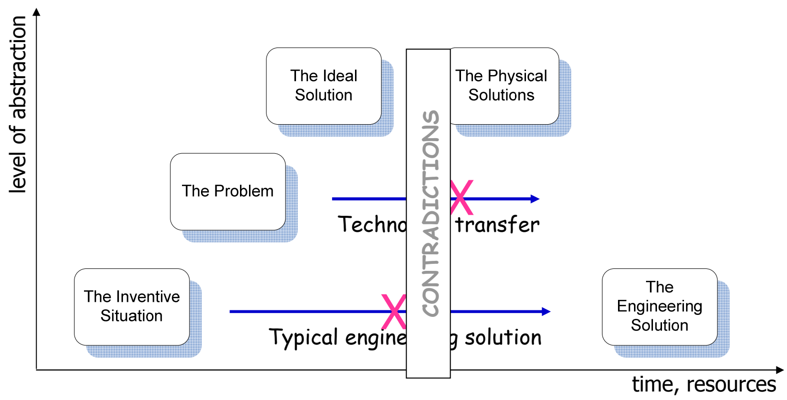
What is an Engineering solution?

The only difference between a problem and a solution is that people understand the solution.
Charles Kettering

Detailed description of concepts (ideas) which answers the formulated contradiction and does not conflict with specific situation restrictions.

summary

The contradiction model is applied to reduce the research area effectively and to take into account all major restrictions.



The direct route isn't always shorter!

APPLICATION OF TRIZ KNOWLEDGE
(Engineering problem solving context)

CONCEPTUAL DESIGN

Define Problem: Problem statement benchmarking; Quality Function Deployment (QFD); Product Design Specification (PDS); Project planning; *Contradiction analysis; knowledge about Laws of Technical Systems Evolution; Function-Ideality modeling*.

Gathering Information: Internet; Patents; Trade literature; *Knowledge base; Scientific literature; Multi-Screen Scheme of thinking.*

Concept generation: *Contradiction analysis; Substance-Field modeling & 76 Inventive Standards; Algorithm of Inventive Problem Solving (ARIZ); knowledge of Laws of Technical Systems Evolution; Knowledge base (including Pointers of effects);*

Evaluation of Solution Concepts: *Laws of Technical Systems Evolution; Special 76 Inventive Standards; ARIZ.*

embodiment design: Product architecture; Configuration Design; Parametric design.

detail design: Detailed drawing and specifications.

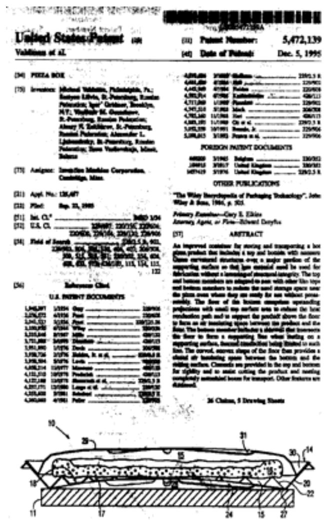
TRIZ is not...

- It is not a universal panacea for any problem.
- It is not a replacement for professional knowledge.
- It is not software.
- It is not a “magic wand”.

* © N.Khomenko. 2006. Materials for seminars: OTSM-TRIZ. “Jonathan Livingston” Project.

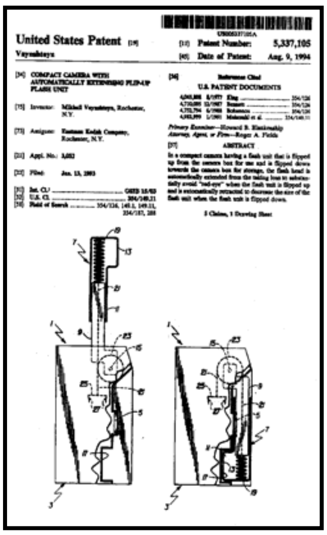
Example of a patent: Pizza box


United States Patent
Patent Number: 5,423,477
Date of Patent: Jan. 13, 1995


United States Patent
Patent Number: 5,472,139
Date of Patent: Dec. 5, 1995

*Denis Cavallucci. 2001 “La méthode TRIZ : introduction”. © L.R.P.S.

Example of a patent: Flip-Up flash


United States Patent
Patent Number: 5,337,105
Date of Patent: Aug. 9, 1994

*Denis Cavallucci. 2001 “La méthode TRIZ : introduction”. © L.R.P.S.

typical structure of a project team

- *Team leader to manage the project.*
- *TRIZ experts*. Requirements: previous consulting experience of minimum 4 years, experience in teaching TRIZ is a plus.
- *Experts in the particular problem situation:*. Requirements: previous engineering experience of minimum 3 years, experience in new product development is a plus, motivation to solve inventive and innovative problems, awareness of competitive products.
- *A professional physicist* (optional) (or an engineer with a degree in physics). Requirements: a wide background in different branches of physics, used to working in a corporate environment, familiar with engineering, motivation to solve inventive and innovative problems.
- *Marketing specialist* (optional). Requirements: familiar with the marketing of engineering products and with the situation of the Customer's market, engineering degree is preferable.
- *It is preferable to have the possibility of inviting external experts.*

comparison of various TRIZ-techniques

(rough estimate*)

40 Inventive Principles

• for practical mastery: two-day course + 10-20 hours of practice

• duration of resolution process - several working hours.

76 Inventive Standards

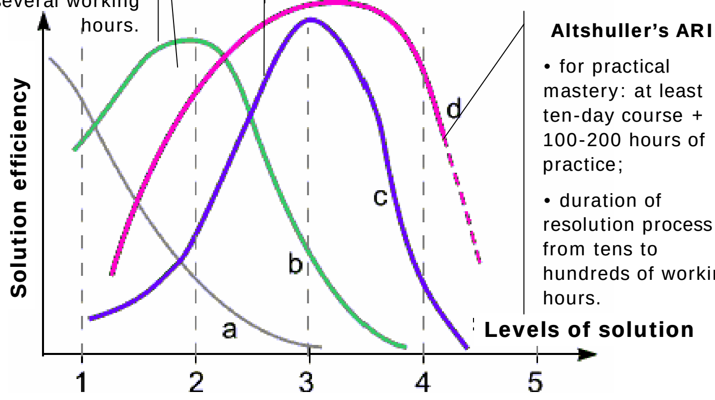
• for practical mastery: three-day course + 25-30 hours of practice;

• duration of resolution process - several working hours

Altshuller's ARIZ

• for practical mastery: at least ten-day course + 100-200 hours of practice;

• duration of resolution process: from tens to hundreds of working hours.



* G.S. Althsuller, et al. 1989, SEARCH FOR NEW IDEAS: FROM INSIGHT TO TECHNOLOGY. Kartya Moldovenyaska Publishing House, Kishinev.

SUMMARY

Advantages	Limitations	In comparison with non-TRIZ techniques

references

1. G.S.Altshuller: 1969, 1973. ALGORITHM OF INVENTION, Moscowskiy Rabochy, Moscow
2. G.S.Altshuller: 1979. CREATIVITY AS AN EXACT SCIENCE. Sovietskoe radio, Moscow.
3. G.Altshuller: 1997, 40 PRINCIPLES: TRIZ Keys to Technical Innovation. Translated by Lev Shulyak and Steven Rodman. Worchester, Massachusetts: Technical Innovation Center. 141 pages, ISBN 0964074036
4. Zlotin B., Zusman A., Altshuller G., Philatov V.: 1999, TOOLS OF CLASSICAL TRIZ. Ideation International Inc. 266 pages, ISBN 1928747027
5. G.S.Altshuller: 1986; 1991, TO FIND AN IDEA: introduction to the theory of inventive problem solving, Nauka, Novosibirsk. (Ru)
6. DARING FORMULAS OF CREATIVITY. 1987. Karelia, Petrozavodsk. (Ru)
7. G.I.Ivanov: 1994, THE FORMULES OF CREATIVITY OR HOW TO LEARN TO INVENT. Prosveschenie, Moscow. (Ru)
8. N.Khomenko: 1997-2006. Materials for seminars: OTSM-TRIZ: Main technologies of problem solving, "Jonathan Livingston" Project.
9. D.Kucharavy: 1998-2006. Materials for seminars: TRIZ Techniques, OTSM-TRIZ Technologies Center.

links

- Journal TRIZ (USA) (En) http://www.triz-journal.com/index.html
- The Altshuller Institute (En) http://www.aitriz.org/
- OTSM-TRIZ Technologies Center (En/Ru) http://www.trizminsk.org/eng/index.htm
- The Official Foundation of G.S.Altshuller (En/Ru/Fr/Ge/Sp) http://www.altshuller.ru/world/eng/
- The Thinking Approach (En) http://www.thinking-approach.org
- TRIZ Home Page in Japan (Editor: T. Nakagawa) (En/Jp) http://www.osaka-gu.ac.jp/php/nakagawa/TRIZ/eTRIZ/
- Asociacion Mexicana de TRIZ AMETRIZ http://www.mty.itesm.mx/dia/centros/cidyt/ametriz/
- ETRIA European TRIZ Association (En) http://www.etria.net/
- TRIZ France (Fr) http://www.trizfrance.org/
- TRIZ INSA Strasbourg (Fr) http://www.insa-strasbourg.fr/triz/
  Master's Degree Specializing in Innovative Design
  (En) http://www.insa-strasbourg.fr/masteres_specialises/conception_innovante_en.php
- Jonathan Livingston Project - ОТСМ-ТРИЗ (Ru) http://www.jlproj.org/

~~**TRIZ method ?**~~

"The methods of TRIZ"

or

"TRIZ methods"

The End

...Intellectuals solve problems,
geniuses prevent them...

attributed to Albert Einstein

;-)