2 Original Concepts

The list of standard methods – this is some kind of inventor's desk reference book, but a special kind of reference book: the inventor must treat it as a base that is necessary to replenish yourself from the new technical and patent publications.[29]

Genrikh Altshuller

2.1 Contradiction

PRIMUS INTER PARES
First among peers (Lat.)

2.1.1 Definition of Inventive Problem

The notion of *"contradiction"* is the most fundamental and central of TRIZ concepts. Another important concept is that of *"transformation model"*.

A contradiction exists where certain system properties prove to be incompatible, or inconsistent, or contrary to the purpose of the system.

Definition of "**Inventive Problem**"	**"Inventive Problem"** (Inventive Assignment) – a problem containing *a contradiction* in the form of incompatibility of requirements and-or properties which are appeared through an irregular development of parts of the system or of the given system and its surroundings and which possesses no adequate methods and means to solve the problem situation.
Addition 1 to definition	Resolution of problem-based contradictions requires application of special creative models and methods to constructively reorganize available professional knowledge and/or acquire new knowledge with a view to synthesize an efficient idea.
Addition 2 to definition	Resolution of the contradiction is an indispensable condition of removal of the relevant inventive problem.

[29] According to Altshuller, G. S. (1973) *Algorithm of Invention*. – From Russian: Г.С.Альтшуллер (1973) *Алгоритм изобретения. – Москва: Моск. рабочий, с.141-177*

DOI 10.1007/978-3-642-25218-1_2,

Example 2.1. Original Issue in Problem P1. Moscow Kremlin Stars.

Architects wanted Moscow Kremlin Starts to be big. However, with an arm span of 5 meters, the star has a large wind area (surface exposed to the wind). This means that strong frontal wind can break the star or its support, and throw the star off the tower. Towers have a height of 60-70 meters.

The star is very heavy, weighing in at about one and a half tons. An attempt to strengthen the construction with additional elements to reinforce its structural integrity by definition increases the star's weight, which is undesirable.

The original problem can be shortly formulated as follows: structurally, the star must withstand exposure to strong winds. This is a *general contradiction* which can usually be "framed" by asking the question: *"What can we do to…?"* It is naturally assumed that we do not know.

Indeed, at the time when they came up with the architectural idea, designers of Kremlin Stars did not have a ready answer to that question.

Example 2.2. Clarification of the Issue in Problem P1. Moscow Kremlin Stars.

The key to solving this problem lies a more detailed definition of contradictions inherent in the original problem situation.

In this case, the star must be large and, consequently, must have a *large surface area*, so that it can be seen from a great distance; on the other hand, an increase of the surface area of the star increases its windage and reduces its resistance to strong winds, and, accordingly, detracts from *reliability* of construction. This is a typical *standard contradiction* where one factor (which is usually placed, or named, first) requires improvement, while the other factor either deteriorates concurrently with improvement of the first factor, or hinders such improvement. Both developments are unacceptable, and must be prevented.

The original contradiction may also be escalated using the following formulation: the star *must* and *must not* be large – for different reasons! This is a *radical contradiction* where incompatible or, to be more precise, directly opposed requirements are imposed on one and the same property.

2.1.2 General Contradiction

General Contradiction	**General Contradiction** (in classical TRIZ this contradiction is called *administrative*) is a systemic requirement which merely reflects the general need to attain a certain property (or state) or remove an obstacle preventing the system from operative as desired.

Problem 2.3. "Clever" Gate (beginning). Not too far from the downtown area, in the south-west of Berlin, there is an agricultural experimental field run by the Free University (Freie Universität Berlin) – a plot of land with an area of about 20 hectares planted with potatoes, wheat, strawberries (!) and many other things.

The field consists of smaller sections, fenced in by inconspicuous but very durable wire, with small barns housing sheep, horses, pigs and cows. A real "natural" pastoral nook complete with dirt roads and tracks, roadsides covered with wild bushes and grasses, and even a small bog with nocturnal frog choir presentations.

A place which enjoys unflagging love and devotion on the part of many local residents. Entrance fee: zero.

Incidentally, in Germany such "natural" places are very few and far between – all roads and paths leading to houses are covered with asphalt or tiled. And every house strives to present, in a somewhat theatrical fashion, fabulous fusion of human residence with Nature, and has a well-tended flowerbed. Flowers, many different flowers, are everywhere, as are manicured lawns, shrubs and trees!

Well, with all this talk about cleanness and flowers, I cannot help myself and not tell you a totally "irrelevant" story. Incidentally, this story also contains a "general contradiction" that we can discuss or, better yet, use as the title of this example.

Example 2.4. General Contradiction: How Do We Keep It Clean?

fig. 2.1. No comment…

I was amazed (fig. 2.1) to see, amid a huge mountain meadow, a post carrying a notice to the effect that visitors are kindly asked to clean after their dogs so that other people can walk around and lie down without running the risk of stepping into… well, you know… Right under the notice there was a small box filled with disposable plastic bags that one could use to pick up "pet products", and next to the post there was a big box where one could dump those products. The big box was firmly embedded in the ground, and its lid was weighed down with a heavy brick to prevent it from being accidentally opened by the wind.

Naturally, the solution of the general contradiction described in this example does not boil down to "provide the box and the bags and display a polite notice." The solution is to accustom people to cleanness from childhood. Unfortunately, it does not work for all people…

Problem 2.3. "Clever" Gate (continued). But let us get back to the Free University experimental lot. It can happen that by some miracle a particularly curious animal may escape. Meanwhile the gates that people use to enter and exit the plot may remain open, and the animal may find itself in the middle of a street with cars zooming by, next to an underground line (U-Bahn) which – in this particular place – runs above ground.

What can we do? - Ah, there it is, the general contradiction!

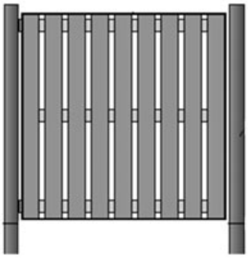


fig. 2.2.

We can fit the gate door with a spring – OK, not bad. We can use a weighted cable – that is a good one, too! We can install a special mechanism – but then it will lose its "rustic" charm. Alright, can we make a "clever" gate that would close ITSELF, and that no animal, however smart, would be able to open?

Let us take a closer look at the situation (fig. 2.2): normally, a gate hangs on hinges, on a small post, and - when closing - is stopped by another post. The gate hangs vertically, and without external influence can stop in any position between "opened" and "closed".

Apparently, the *general contradiction* does not indicate the possible solution – which, indeed, remains unknown.

So the question "How do we make a simple self-closing gate?" remains.

Problem 2.5. "Clever" Platform. Two large (2 m x 2 m) sheets of glass are joined in a vacuum chamber. The sheets are very thin – less than 1 mm. They are placed horizontally. A robot with almost 100 "suction-cup fingers" puts the first sheet on the lower metal platform, then grabs the second sheet, turns it over and raises it from below to the underside of the upper platform. The upper platform must "capture" and hold that sheet. The robot then extracts its "tentacles" from the chamber, and the chamber is closed. In the past, such platforms used to hold onto the sheets "by suction": they had openings and channels through which the air was pumped out until the pressure became lower than residual pressure inside the chamber.

At this point we need to explain the situation in more detail (fig. 2.3). The sheet must adhere to the platform uniformly throughout its entire surface area. Then the upper platform slides down (see the arrow) until the distance between the two sheets becomes about 100 microns. The horizontal position of the lower platform is adjusted (see two thin arrows) so as to align certain markers placed on the sheets. Then the upper sheet is pressed to the lower sheet.

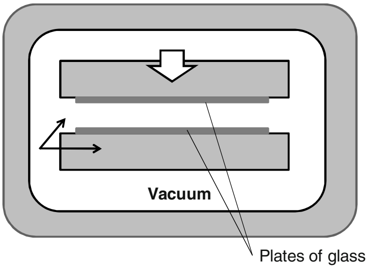


fig. 2.3. Problem: how do we keep a sheet of glass under the upper platform in a vacuum chamber?

The sheets are glued together, because epoxy adhesive is applied to the upper sheet in advance along an outline tracing locations of future monitors (the lower sheet houses liquid crystal fields).

Finally, the chamber is depressurized, and atmospheric pressure "fine-presses" the sheets into a monolithic construction. This is one of the technologies used to manufacture liquid crystal displays for computer monitors and television sets. The resultant monolithic sheet is cut into individual monitors.

General contradiction: how do we ensure that the upper sheet holds onto the platform after deep vacuum is created in the chamber (i.e. after the air is pumped out, and holding "by suction" becomes impossible)?

Problem 2.6. Tricks and "Illusions". Here is a simple task[30]: three glasses are placed on the table at distances exceeding the length of a table knife (fig. 2.4).

We need (general contradiction!) to use the glasses and the knives to construct a "bridge" so that an imaginary "ant" would be able to travel from one glass to another, and so that the bridge would be sturdy enough to hold, for example, a glass of water.

This is a game problem meaning that there is at least one solution. In general, as long as we are dealing with tricks and "illusions", it is important to recall one of the fundamental TRIZ systemic analysis postulates: if a phenomenon exists, all resources required for its realization are available.

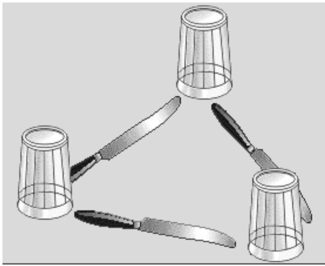


fig. 2.4. Problem: how do we build a "knife bridge" that will join the glasses?

This is true for puzzles, too, except that puzzles may have only one solution based on a very subtle secret which is very difficult to discover. You need to *know.* And sometimes it may be impossible to figure out (reinvent) the solution! (Do you agree, by the way?)

2.1.3 Standard Contradiction

Standard Contradiction **(1)**	***Standard Contradiction*** (in classical TRIZ: *technical contradiction*) – binary (of 2-factors) model which reflects incompatible requirements between *two different functional features* of an object (or several conflicting objects).
Standard Contradiction **(2)**	***Standard Contradiction*** – 2-factors-model in which one of the factors corresponds with and supports the most important feature of the system (positive *Trend-factor* or *Plus-factor*) while the other factor does not correspond this feature or counteracts it (negative *Problem-factor* or *Minus-factor*).

[30] This problem was published in 1913 by Yakov Isidorovich Perelman (1882-1942) – outstanding Russian pedagogue; Edward de Bono (b. 1933) – renowned psychologist and educator, developed a series of instructive versions of this game in the early 1960-es

fig. 2.5. "Innovative" leaf transportation devices!

Problem 2.7. "Short Arms".

In autumn, when cleaning fallen tree leaves, we face a problem: to carry the leaves from the heap to the compost pit, we have to resort to "complex" devices – carts, shovels or pitchforks – which are often not readily available.

Of course, we can try and *grab* as much as possible, but that usually does not work – our arms are "too short!

Maybe that is why the "cleaners" in fig. 2.5 had to come up with some really weird leaf transportation devices!

Let us present the standard contradiction (SC) in different notation systems.

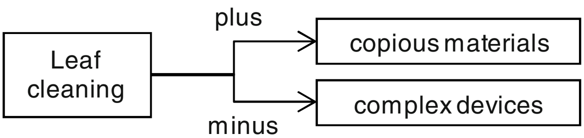
Option 1 (Text): Cleaning fallen leaves involves the need to move large quantities of "material", but devices normally used to do that are complex and inconvenient.

Option 2 (Formula): Leaf Cleaning ► Copious Material **VS** Complex Devices

In this option, we have used a special sign (►) meaning that the situation (process, state, action, object, etc.) is "modeled" as a contradiction. Its choice is completely arbitrary, and it can be replaced with any other sign.

The sign **"VS"** is an abbreviation of the Latin (and English) word ***versus*** meaning *against*, *with respect to*, *in comparison with.*

Option 3 (Graphic): All three options represent an *informal* standard contradiction (we use the epithet "informal" because this contradiction does not use any TRIZ models).



We also say: informal contradiction is not *reduced* to TRIZ models.

Other options are available, too. This is not the point. The point is we have singled out, from the description of the problem situation, the "main" conflicting properties (demands, states, actions, etc.).

Problem 2.8. That's a Lotta Line!

fig. 2.6. Mooring at Key West, Florida

I made these shots in October 2006, when our cruise liner *Majesty of the Seas* was nearing the isle of Key West, the southernmost point of the USA and the State of Florida, a place that Ernest Hemingway[31] visited over and over again, a place where he lived for many years.

I was filled with the thrill of anticipation, as I was about to step over the threshold of the house of Hemingway who was one of my two most favorite writers when I was a young man (the other one being Jack London[32]). In the year when I turned 18, I won the boxing championship of Minsk, Belarus, among light middleweights, scoring the remaining points that I needed to be awarded my first sports rank (to be followed by Candidate Master of Sports and Master of Sports – but I never got those, as I dedicated all my time to work and study (at that time I was doing an evening correspondence course).

fig. 2.7. The vessel is successfully moored

---

31 Ernest Miller Hemingway (1899-1961) – well-known US writer, 1954 Noble Prize winner, author of "Farewell to Arms", "For Whom the Bell Tolls", "The Old Man and the Sea" and other works.

32 Jack London (1876-1916) – well-known US writer, author of "The Sea-Wolf", "Martin Eden" and numerous short stories about courage, fidelity, will to live and win; my favourites are "White Fang", "A Piece of Steak", "The Mexican", "Grit of Woman" and "Love of Life"

Both writers went in for boxing, and wrote many wonderful stories related to box. And now I was going to have a meeting which would surpass even my wildest dreams…

But first things first! First we need to moor, and mooring involves delivering several lines (one of those is marked with an arrow in the photo) from a height of about 20 meters to the berth below. This is what three sailors are doing (see the circled area in fig. 2.6, a and b). But therein lies a contradiction:

Line ► long **VS** heavy, sailors are not strong enough to swing it, especially from above, so that it reaches the berth

All the energy being applied is consumed by the line! Have you maybe remembered the thin-line problem from the kindergarten described in the author's other book, *ABC-TRIZ*?!

Problem 2.9. On the Way to a New Automotive Era: Electric Car. Many electric car models have been suggested over the 100+ years since the first such cars were designed – and even broke speed records outstripping the first cars equipped with internal combustion engines! Did you know that? Amazing, is it not?

However, even today the main problem persists: low efficiency and high weight of the onboard accumulator batteries and excessive power losses.

Standard contradictions – possible variants:

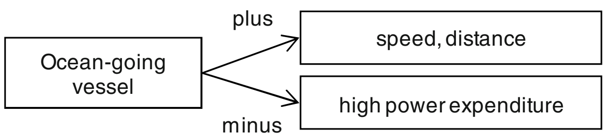
1) Electric car ► time in motion between battery recharges **VS** power expenditure;

2) Electric car ► time in motion without battery recharge **VS** excessive weight due to heavy battery;

3) Electric car ► time in motion without battery recharge **VS** power losses at every stop, for example, at a crossroads, if the engine is left running.

Problem 2.10. Back to the Future! It is a well-known fact that ocean-going vessels use up huge quantities of fuel and have to "carry about" fuel stocks instead of more payload. Also, the higher the speed, the higher the fuel consumption rate. Naturally, intensive fuel consumption results in intensive environmental contamination (ocean water).

Standard contradiction (it is truly "standard" for all means of transportation!):



Problem 2.11. Lord of the Wheels. In section *3.6 The Invisible in the Obvious*, discussion of Problem 30 referred to the fact that the Honda U3-X scooter can move in any direction!

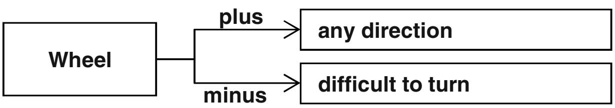
fig. 2.8.

Literally in any direction: to change direction, the rider can stop and start moving, for example, at right angles to the previous direction… without ever turning the wheel! How can this be?

In known prototype scooters, such change of direction clearly detracts from comfort of operation, as the rider has to twist his or her body like a circus contortionist to make the steering, or main, wheel move along a rounded transitional trajectory.

Conversely, with Honda U3-X the rider only has to lean his or her body in the required direction (fig. 2.8)!

There arises the following informal standard contradiction:



It is easy to see that in all such situations there are two different properties at war (fig. 2.9):

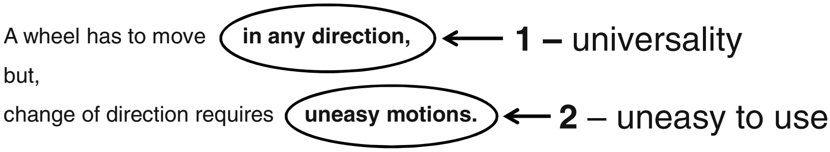


fig. 2.9. Standard contradiction for standard prototype scooters at the time when they turn

A similar conclusion can be made for any standard contradiction, for example, for the "mooring line" model (fig. 2.10):

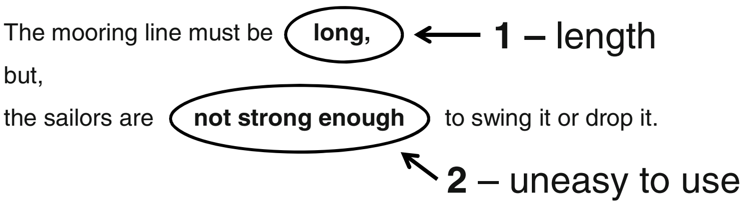


fig. 2.10. Standard Contradiction for the mooring line

Problem 2.12. "Clever" Mailbox.

fig. 2.11. These are not birdhouses – these are mailboxes!

Private residences are fitted with mailboxes (fig. 1.11). This is Long Island, New York. And this is very traditional for America. What can we do to enable the owner to learn that there is mail in the box without leaving home?

You can define the standard contradiction by yourselves. Very soon you will develop a taste for building similar conflict situation models.

Still, take a closer second look at this short section, compare your versions with those suggested by the author – and maybe yours will prove to be more accurate, and will better approximate the nature of real-life conflicts inherent in the situations described, the contradictions existing in these prototype artifacts.

Write to me about your models.

2.1.4 Radical Contradiction

Radical Contradiction (1)	***Radical Contradiction*** (in classical TRIZ: *physical contradiction*) – binary contradiction model in which contrary, excluding one another, requirements are being requested from one and the same feature of one and the same construct (component, resource, function, effect, condition etc.).
Radical Contradiction (2)	**Radical Contradiction** – binary two-factor model where the first factor reflects one demand ("plus-factor"), and the second factor reflects the other demand ("minus-factor") so that both factors represent the same property of the same construct (*component, resource, function, action, state, etc.*), but are incompatible.

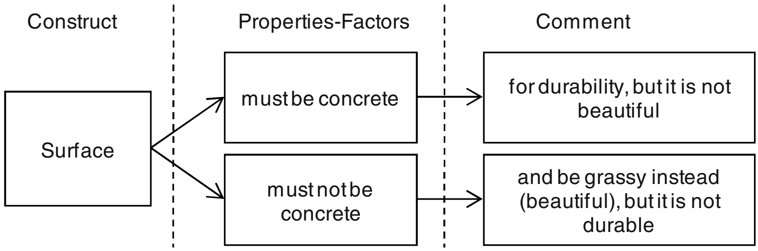
Problem 2.13. Parking Lot. Large parking lots, such as those found next to exhibition centers and shopping malls, often look quite depressing – huge gray concrete or asphalt fields. People would definitely find it more pleasant and useful to have, instead, grass fields – better yet, grass fields dotted with trees! Alas, heavy cars would soon grind the grass into the ground and eventually turn those fields into dirty wastelands covered with weeds.

General contradiction: How can we improve the external appearance of parking lots?

Standard Contradiction: parking lots must have *durable coating* over the soil, but because of that they *look bad*, they *overheat*, and they *get overrun with rainwater, so that sometimes you cannot get to your car without wetting your feet.*

Radical Contradiction: the parking lot must *be concrete* to bear the weight of the cars, and it *must not be concrete* (or: it must be grass) to look beautiful, not overheat, and have better rainwater removal properties.

Graphically, this conflict can be presented as follows:



Radical contradiction formula (variants):

"concrete" **VS** "non-concrete",
"grass" **VS** "non-grass",
"durable" **VS** "non-durable",
"beautiful" **VS** "non-beautiful".

Note. If you found a solution outside of the TRIZ universe, or knew an efficient solution for the start, present it using TRIZ models.

Problem 2.14. Bridge Across a Navigable River. Radical contradiction: the bridge *must be* to join the banks so that pedestrians and vehicles can cross the river, and the bridge *must not be* so that vessels with high masts and decks can navigate the river. (See note to the previous problem.)

Problem 2.15. Ads on the Bus. Would you trade places with the passengers of this bus pretending to be an airplane (fig. 2.12)? I would not – the windows are "painted over". They probably can see nothing from the inside?!

Now, that is a truly radical contradiction:

the ad *must be* on the bus, particularly when it is so impressive – an airplane rolling along the street with its landing gear legs propped against the wheels of the bus will DEFINITELY draw stares from the amazed onlookers! –

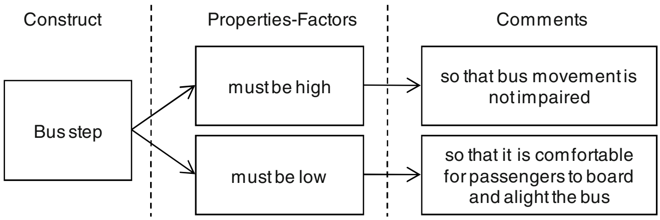
fig. 2.12. Airplane-Bus "hybrid"!

and it *must not be* on the bus, as the situation where you cannot see the sights on a sight-seeing tour is unacceptable!

Who wants to ride around the city "inside a suitcase"? So, you decide: Do you want to see things through a small porthole (at best) – or through large bus windows?

Problem 2.16. Comfortable Bus Step. How can you keep passengers comfortable when they are boarding and alighting the bus, especially when they carry heavy suitcases or travel with a baby carriage? You cannot lift boarding platforms to the bus-floor level at each bus station, now, can you?!

Radical Contradiction:



Formula: The step must be "high" **VS** "low", or
the step ▶ "high" **VS** "low".

Problem 2.17. Like a Fairy Tale! You probably remember a clever (you might even say "inventive") girl which managed to comply with the king's demand to come before him "neither dressed nor naked, neither on horseback nor in a cart, neither by path nor by road"...

Incidentally, the fairy-tale lassie successfully dealt with a SET of radical contradictions!

Try to create formulas and graphic models for those contradictions.

Problem 2.18. Memory Eternal. What can be a symbol of remembrance – of "memory eternal"? It is important because people continue to live in us and through us while we remember them. They continue to live in the new generations while representatives of such new generations remember their families, their history, their motherland. This is the only way to preserve and pass on memories which hold together national identities, families and religions. To refuse to remember is to change or lose one's identity.

With time, monuments decay and fall apart. Memories, on the other hand, can be preserved forever while their carriers remain alive and pass on to their heirs things that need to be remembered. So what is the most "adequate" symbol of memory eternal?

Informal radical contradiction: the symbol *cannot (must not* – according to the laws of Nature) *be* eternal, as with time any "physical object" is destroyed, and it *must be* eternal to remind us about things that should not be forgotten.

Here is a more formal presentation: symbol ▶ "eternal" **VS** "non-eternal".

Problem 2.19. Sun Beds. And now back to the sea! These people are sun-bathing on board the Star Princess (photo by the author: Miami, 2007) – hundreds of sun beds (fig. 2.13) are set on deck each morning, and taken away each evening. But how and where do they go? The photo clearly shows that they occupy a lot of space!

Therein lies a radical contradiction:

sun beds ► "much space" – for use
VS "little space" – for storage.

How do we resolve this contradiction?

Problem 2.20. Window Washer. Here is a seemingly simple task: how do you wash a window if it does not open so that you are able to reach each and every spot on the pane from the outside? Well, you could always make, say, a special rod with a curve. But that may cause another problem: the rod may become too complex.

fig. 2.13. Here everyone has a place under the sun!

Accordingly, we have the following *general contradiction:* what can we do to wash (whether on a one-time basis or repeatedly) window panes from the outside?

We can also construct a *standard contradiction*:

> *the rod makes it possible to wash the window both from the inside and for the outside, **but** the construction of the rod may become too complex.*

Last but not least, we can proceed to formulate a *radical contradiction*:

> *the rod must be outside the window (to wash the window pane from the outside) **and** it must not be outside (as this is physically impossible).*

In the last two variants, we have named specific obstacles preventing the use of the main property of the rod to enable completion of the main useful function of the entire operation – namely, to wash the window panes (both from the inside and from the outside).

We can you visualize these models (fig. 2.14).

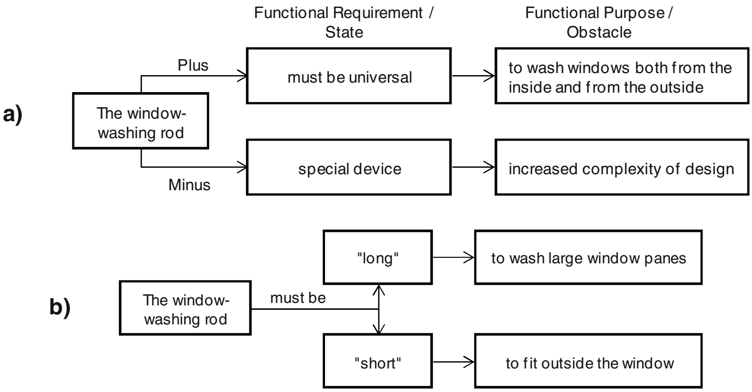


fig. 2.14. Graphic representation of informal Standard (a) and Radical (b) Contradictions for the "Window Washer" example

Also, to avoid psychological stereotyping, we recommend that the word "rod" be replaced with some conventional name for the future construction. For example, we can call it a "washer". Thus we finally formulate the trend that can be used to search for an idea for the solution: we need a "washer" that can wash windows from the inside and – importantly! – from the outside, and is not too complex!

Problem 2.21. Makeyev Missiles[33]. In the early 1960-es, with the commencement of construction of nuclear submarines, it turned out that to enable installation of more powerful missiles it would be necessary to build huge submarines.

Naturally, the missiles could still be transported in horizontal position (fig. 2.15), but before the launch they would have to be rotated and placed vertically on their launching pads.

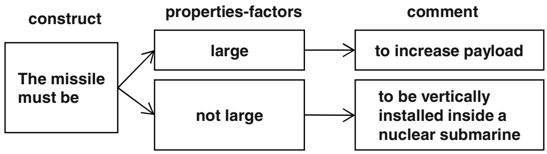
This, however, would necessitate time-consuming pre-launch preparations and exclude the possibility of submerged salvo launches.

fig. 2.15. 11FM Missile (1950-es)

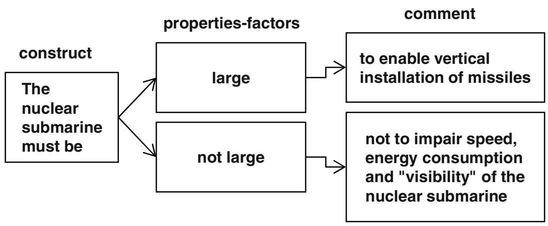
The length of 11FM, the first one-stage sea-launched missile, was slightly more than 10 meters, its range – less than 200 km. The dotted line in the drawing separates the missile's engine (1) from its fuel tank (2).

To extend the range to 2,000-3,000 km and increase the payload, the missile would have to have two stages. Unfortunately, an attempt to add a second stage without changing the missile's construction would increase its length to more than 16 meters. As a result, the missile would simply not fit inside the submarine.

Radical contradiction with respect to the missile:



Radical contradiction with respect to the submarine:



Which solution would you choose if you were the "Commander-in-Chief": a submarine of unprecedented height or a missile with inferior parameters?

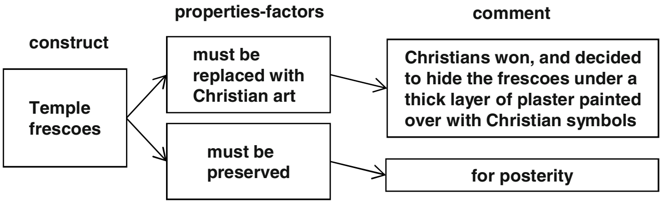
---

33 Viktor Petrovich Makeyev (1924-1985) – outstanding Soviet rocket designer, creator of the Soviet submarine-launched ballistic missiles design school

Problem 2.22. Time is Powerless! The temple in Philae, Egypt, was built approximately in the 3^{rd} century BC, and used to glorify Isis, a Pharaonic goddess. In the 6^{th} century AD, Christians converted it into a church.

Question: what would you do to try and preserve the beautiful frescoes inside the temple for posterity in the hope that one day justice would prevail?

Radical contradiction:



Problem 2.23. Art and Craft of Ice. One evening during a workshop that I gave in Harbin, China, in February 2008, my translator and good friend Sung Siandung (whom I called by Russian name Aleksey – according to the long-standing tradition and, naturally, with his consent) invited me to the famous ice festival.

A 1 km^2 plot was filled with magnificent works of art created of ice by sculptors from all over the world. Replicas of the London Tower Bridge, the famous Notre Dame de Paris, the Athens Acropolis, a mosque, an Orthodox Christian church and many other buildings were towering above the square covered with myriads of color lights (fig. 2.16 – color photos are presented at www.eastytriz.com).

Ice sculptures were made of large ice blocks ("bricks"). Each such "brick" had dimensions of 25 x 25 x 50 cm and weighed almost 30 kg. The builders must have used several hundred thousand "bricks"! But neither any single one sculptor, nor all of them together for that matter, would be able to manufacture enough "bricks" to build, say, the Acropolis!

How was that grandiose construction site supplied with building materials? What did the organizers and participants invent?

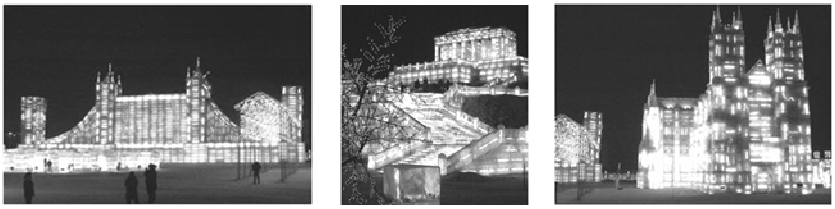


fig. 2.16. Harbin Ice Sculpture Festival in "miniature"

Radical contradiction:

"bricks" ► "many" – approximately 1.5 million **VS** "few" – the sculptors cannot make about 20,000 "bricks" needed for a relatively small sculpture, and then build it over a reasonable period of time.

2.2 Transformations

2.2.1 Transformations Pyramid

TRIZ continues to evolve. Today it still exists as a theoretical *background*, an empirical substantiation, a proto-theory. We still have to walk the long and winding road leading to the creation, within the structure of Modern TRIZ, of in-house "algebra" and "systemology" or, maybe, proprietary "systemogenetics" and "nanotechnologies". Ahead of us lie breathtaking discoveries whose fruits will need to be cemented through value- and purpose-oriented synthesis.

Besides, Modern TRIZ currently relies on proto-models awaiting future structuring, algorithmization, expansion and development.

In a first approximation, TRIZ models[34] can be presented within a single structure as a "pyramid" (fig. 2.17). The general principle underlying this pyramid is that the "lower" models can be regarded as more detailed versions of the "upper" models. The "upper" models, in turn, can be regarded as meta-models, or "capsules" containing the "lower" models.

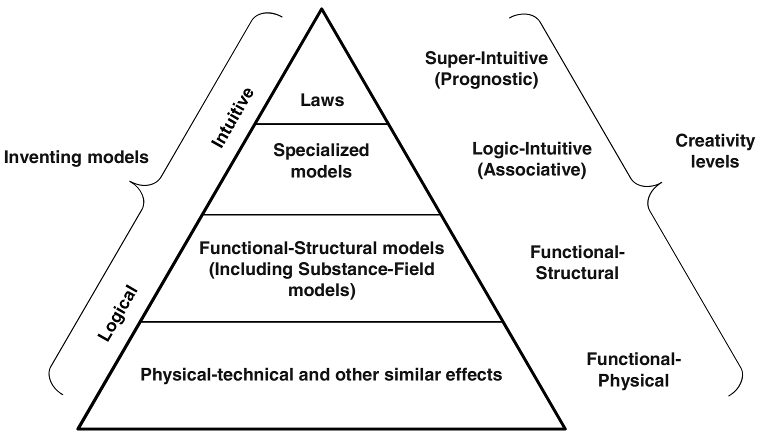


fig. 2.17. Pyramid of the TRIZ-models of transformations

Next to the pyramid are the "names" of these levels from the viewpoint of the role played by logic (left hemisphere), intuition (right hemisphere) and "super-intuition" (according to P. V. Simonov[35]), and their interactions. Each level assumes the dominating position depending on which type of model is in use. All

[34] M. Orloff (2006) *Inventive Thinking through TRIZ,* sections "Classical A-Studio Invention Navigators", "Strategy of Invention" and "Art of Invention". – Springer Verlag

[35] Academician Pavel Vassilyevich Simonov (1926-2002) – outstanding Russian neurophysiologist, biophysicist and psychologist, creator of the "information-need" approach to behavioural and creative studies.

levels of the pyramid are transfixed by three systemic entities which hold the pyramid together – and which we intend to explain at higher levels of Modern TRIZ training.

These notions are best introduced after there has emerged a relatively numerous and qualitatively diverse community of theorists (scholars) and practitioners (users). It should also be noted here that specialized models – which we are going to tackle in the following sections – are the simplest in terms of understanding and practical application.

2.2.2 Specialized Transformations

Here we intend to deal with the purely empirical aspects of the notions "transformation" and "transformation model". The algorithm which can be used to extract models from individual artifacts is presented in the section "Extracting".

Problem 2.24. See the Invisible in the Obvious (beginning). What do these things have in common: health insurance, a safety belt in a motor car, and a fuse installed in your apartment and protecting all electric devices and wiring from short circuits and overloads?

Let us look at the Main Useful Function (MUF) of each system and see what critically important and creative things have been introduced into it in comparison with systems that do not have such function.

Example 2.25. Insurance System. Let us assume that a certain individual (let as call him Mr. N) is not paying the relatively small annual or monthly insurance premium, and is not a member of any insurance program. Then it so happens that Mr. N finds himself in need of prolonged special treatment. Accordingly, to restore his health, Mr. N has to find a sizeable amount of cash to cover these unexpected expenses. Naturally, Mr. N will have to pay all treatment costs by himself. And what if he does not have the required amount?

So, in this case the MUF is health insurance. And Mr. N has failed to use this function.

Let us imagine an opposite situation where Mr. N is a member of an insurance program. The program would cover all his medical costs! Let us also assume that the annual premium that Mr. N would have to pay is € 3,000, that the required course of treatment costs € 60,000, and that the tr eatment cannot be delayed or replaced, say, with a vitamin course. Therefore, all insurance program members contribute relatively small amounts to create a massive cash fund which can be tapped if any of them needs significant assistance.

Yes, insurance is a truly valuable invention!

Example 2.26. Safety Belt. It is a well-known fact that safety belts save numerous lives in car accidents – which occur when the driver becomes exhausted, or fails to notice a patch of ice or promptly react to an animal jumping into his headlights out of nowhere. Safety belts also help us win the war waged, both against themselves and against all others, by irresponsible individuals which violate traffic rules.

Rules where virtually each paragraph is written in blood. And what? See information in Problem P4.

So safety belts are a really useful invention! The MUF of the safety belt is to help the person survive a dangerous unpredictable situation which unfortunately may occur through somebody else's or his (alas!) fault.

Example 2.27. Fuse Guarding Against Short Circuits or Overloads. A short circuit happens when live wires come into direct contact. This generates an electrical charge resulting in overheating and inflammation of insulation and other nearby objects. A network overload may lead to inflammation from overheating of, or damage to, electrical devices.

Fuses installed throughout the house immediately cut off power supply and discontinue the charge when there is a short circuit, or the permissible aggregate load is exceeded. After the problem has been remedied, the fuse is restored to its working condition.

This invention has saved innumerable devices, houses, and lives.

So, a question for Trivial Pursuit aficionados: name the creative model which is common for all these three situations!

Problem 2.24. See the Invisible in the Obvious (solution). All three problem situations in Examples 2.25 – 2.27 relate to events which may occur in the future. The MUF *in advance* takes certain measures designed to *mitigate the negative impact of such events*.

It brings to mind a Russian proverb: if I knew where I would fall, I would put some straw there to cushion the blow! Wait, why not use a *cushion*? Interestingly, the *creative model* used in all three situations is called "previously installed cushion"! In TRIZ this model is represented as follows:

Previously installed cushions	Increase the relatively low security of an object with safety measures in advance.

The "specialized" principle underpinning the model can be used to find efficient solutions in situations where you need to protect yourself in advance from developments which are possible, yet undesirable. All other "specialized" models are defined similarly.

Clearly, the *technical implementation* of the principle in all three systems is completely different:

- cash fund in an insurance program;
- safety belt activated when the body moves with certain acceleration (try to rapidly lean forward in your car while your safety belt is fastened – even when the car is not moving – and the belt will arrest you progress!);
- fuse activated when the intensity of the current which runs through it exceeds a certain predefined level.

Now let us identify the differences between creative solutions used in these situations and artifacts.

Example 2.25 (supplement). Insurance System. The TRIZ creative principle used here is called "segmentation".

Segmentation	a) disassemble an object into individual parts; … c) raise the degree of disassembly (reduction into parts) of an object.

Clearly, the overall insurance benefit paid upon the occurrence of an insured event is divided into small contributions paid by individual members of the insurance program.

Example 2.26 (supplement). Safety Belt. Several more creative models are used here, and one of them is called "mediator".

Mediator	a) use another object to transfer or transmit an action; b) temporarily connect an object with another (easily separable) object.

This basically is a direct description of the "creative technique" implemented in the invention called "safety belt".

Example 2.27 (supplement). Fuse Guarding Against Short Circuits or Overloads. For the sake of illustration, in this case we can demonstrate several (but not all!) transformation models making up the "composite creative picture" of this apparently simple solution.

Copying	a) use a simplified and inexpensive copy instead of an inaccessible, complicated, expensive, inappropriate, or fragile object

Indeed, the fuse is like a switch which terminates electric current under certain conditions. The fuse, therefore, copies and directly implements the switch function.

Inexpensive short-life object as a replacement for expensive long-life object	replace an expensive object with a group of inexpensive objects without certain properties, for example, long life.

Previously (and in many systems currently) structurally simple and inexpensive fuses were made of easily fusible materials, and were destructible and expendable. As a result, the live wire within the fuse melted and broke when the current exceeded a certain threshold value sufficient to destroy it.

Transform damage into use	a) use damaging factors, especially damaging influences from the environment to achieve a useful effect

In this case, strong current which could potentially damage electrical devices installed in the house effectively "commits suicide" by destroying its own circulatory system (the fuse).

> The minimal primary objective of TRIZ training and self-education is to learn to *see the unobvious* – see transformation models – in any artifact, in any situation where positive (or, sometimes, negative) changes have already occurred, or may occur in the future.

fig. 2.18. A sun beds pyramid!

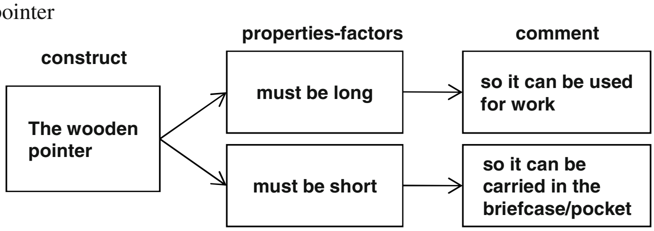
Let us look at more examples.

Problem 2.18. Sun Beds (solution).
The solution of the radical contradiction in this assignment is provided by the special construction of the sun bends which makes it possible to stack them up one on top of the other (fig. 2.18). As a result, the sun beds occupy as little space as possible!

Example 2.28. From Wooden Pointer to Metal Pointer. A wooden pointer is usually about 1.0-1.5 m long (fig. 2.19).

fig. 2.19. Wooden pointer

Let us formulate the following radical contradiction:



Solution of the problem: metal telescopic pointer (fig. 2.20). Such pointer can be extended to 1.0-1.5 m, but when collapsed, it fits inside a briefcase or even in a jacket pocket.

fig. 2.20. Metal telescopic (extensible) pointer

There are two leading, dominating transformations here. For now, we will name only one of them: make an object of several parts, each part inserted inside another! Have you noticed that this solution is in principle very similar to the solution of the sun bed problem?

Example 2.29. Shooting Tower. This military solution[36] presents interest to us only in connection with examination of the creative model objectively realized in it (fig. 2.21). We are not posing or discussing questions related to its functionality or efficiency.

fig. 2.21. Elevating tower used to launch… no, not arrows – missiles!

fig. 2.22. Matryoshka doll.

In the opinion of the manufacturers, one of the intended uses of the tower is to destroy enemy tanks with self-guided missiles.

It is assumed that the tower can be covertly delivered to, and deployed in, the operative zone (in a forest or on broken terrain), unexpectedly assume the firing position, and attack the enemy.

The mast of the tower is made in the form of a telescopic construction. Thus, we already have three artifacts sharing the same key idea for resolving the main contradiction "be large VS be small" by using a similar approach – a transformation model which in TRIZ bears the name of "Matryoshka", or "nested doll".

Matryoshka (nested doll)	a) an object is inside another object that is also inside another, etc.; b) an object runs through a hollow space in another object.

Let us look at more examples.

Problem 2.13. Bridge Across a Navigable River (Solution).

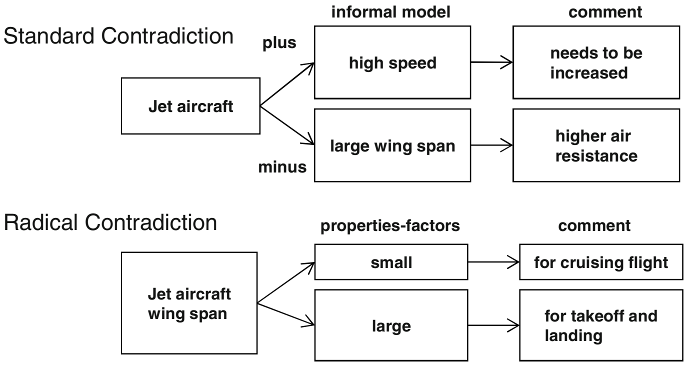
One of the known solutions involves the use of a draw bridge. In other words, the construction is no longer static, as is now incorporates a dynamic component.

fig. 2.23. Palace Bridge in Saint-Petersburg

[36] MSLP, or Missile Stand Lifting Platform, is an antitank system designed by the Danish company Falck Schmidt Defence Systems.

During one (longer) time interval, the bridge is "closed", and is used in accordance with its main useful function, linking the banks of the river so that it can be crossed by pedestrians and vehicles, and during another (shorter) time interval it is "opened" for the passage of high vessels.

Example 2.30. B-1 and Tu-22M3 Bombers[37]. At one time designers of jet aircraft faced the following contradictions:



Solution-invention: use of variable-sweep wings!

In fig. 2.24,a B-1 is preparing to land, and the wings are unswept (spread out).

In fig. 2.24,b B-1 is performing a high-speed flight, and the wings are swept (pressed to the fuselage).

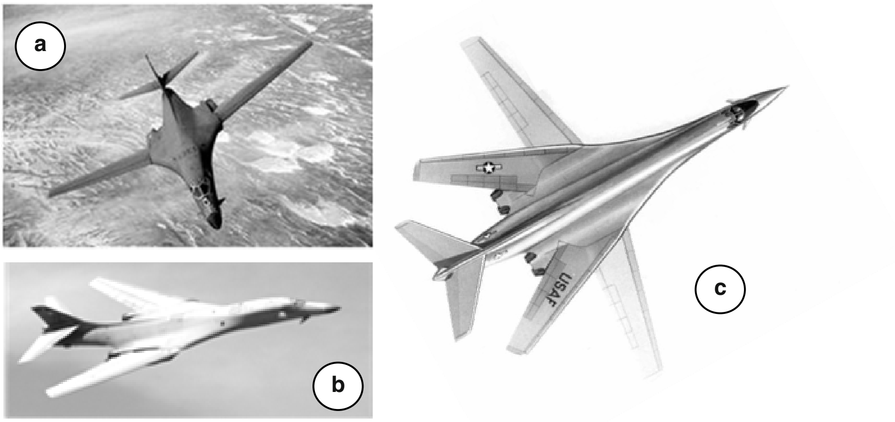


fig. 2.24. B-1 – currently (2010) the only US combat aircraft with variable-sweep wings.

[37] The Rockwell International B1 Lancer bomber has been used by the USAF since 1986; the Tupolev Design Bureau began to design the Tu-22M3 (Backfire-C) bomber in 1974; the Soviet Air Force started to use it in 1984 (officially, in 1989)

The schematic representation of wing sweep variation in the Tu-22M3 aircraft is shown in fig. 2.25.

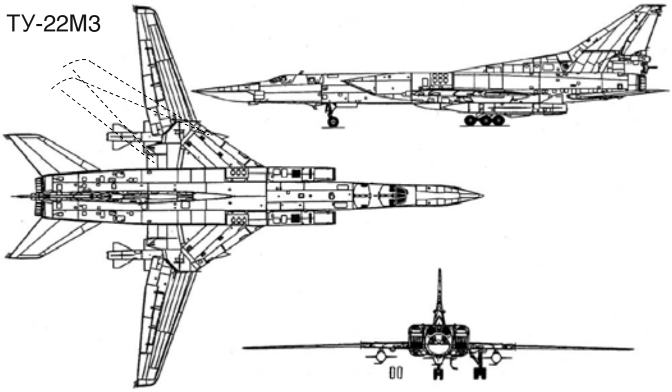
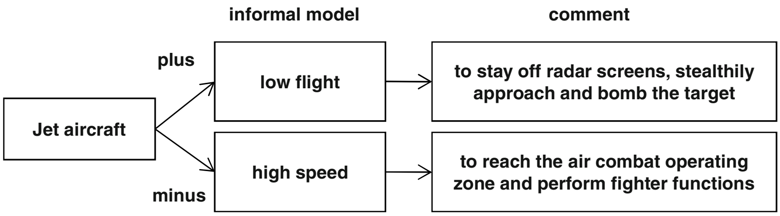


fig. 2.25. Variable-sweep wings of the Tu-22M3 aircraft

Example 2.31. Su-24 Attack Aircraft[38]. In the 1960-es, the Special Design Bureau headed by P. O. Sukhoi[39] was instructed to create a multi-purpose jet aircraft meeting certain opposing requirements which can be represented in the form of the following standard contradiction:



The key TRIZ principle underlying the solutions in Examples 2.13, 2.30 and 2.31 is called "dynamization".

Dynamization	a) the characteristics of an object or an environment are changed to optimize every work procedure; b) disassemble an object into parts that are moveable among each other. c) make an object moveable that is otherwise fixed.

[38] The Soviet/Russian Sukhoi Su-24 (Fencer) aircraft has been used by the Soviet/Russian Air Force since 1975; its production was discontinued in 1993

[39] Pavel Osipovich Sukhoi (1895-1975) – outstanding Soviet aircraft constructor and designer, one of the founders of the Soviet jet-propelled and supersonic aviation

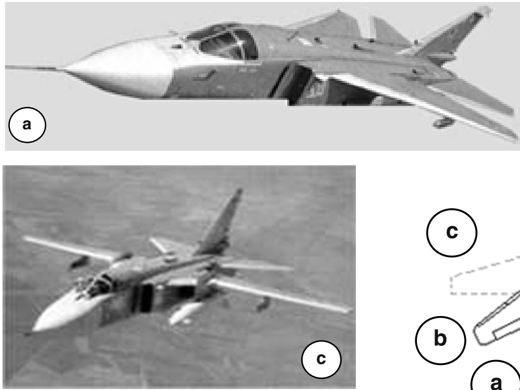


fig. 2.26. Su-24 bomber with variable-sweep wings

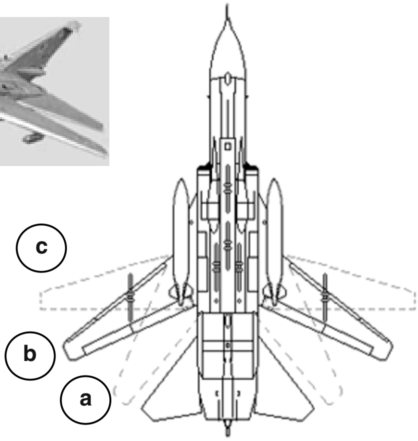
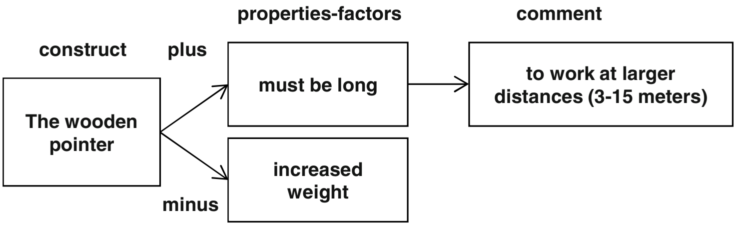


fig. 2.27. Su-24 three wing positions

And in conclusion, let us "transform" the telescopic pointer to illustrate other transformation models.

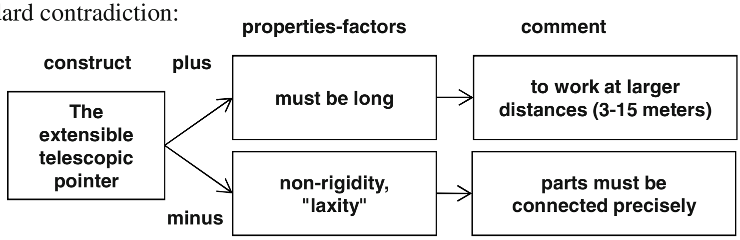
Example 2.32. From Telescopic Pointer to Laser Pointer. Let us assume that we need a pointer, say, 3-5 m long. Clearly, a wooden pointer of that length – even if it could be manufactured – would be very heavy.

Standard contradiction for this example:



For this problem, TRIZ suggests a solution based on the "counterweight" model – even though for distances of 2-4 m we still might use a collapsible pointer (I once saw such pointers in a military school – they were sectional and consisted of many links, like fishing rods) or a telescopic pointer based on the "dynamization" model.

With the dimensions specified, the telescopic pointer encounters the following standard contradiction:



Even a cursory inventory of the TRIZ arsenal shows that this contradiction is best resolved by the "replacement of the mechanical matter" model – *a) replace mechanical structure with optical structure.* And *voila* – many speakers use laser pointers (fig. 2.28).

Specialized transformation models were the first TRIZ tools to be designed – and will be the first to be learned.

fig. 2.28. Laser pointer

2.3 Operative Zone

The Operative Zone (OZ) is one of the fundamental TRIZ notions.

Figuratively speaking, OZ is the *hypocenter of the problem*, unlike the *epicenter of the problem* which refers to external manifestations of the problem represented, in particular, in the form of contradictions.

This metaphorical definition can be explained with the following simple scheme (fig. 2.29).

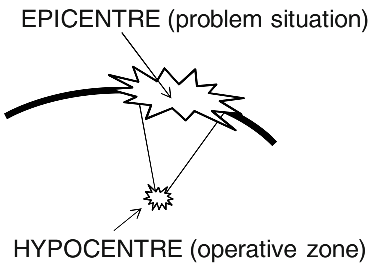


fig. 2.29. "Epicenter" and "hypocenter" of the problem

The earthquake starts in the *hypocenter* because of the shifts or other changes that occur to the Earth's crust at some depth.

The *epicenter* is defined as the area where those subsurface changes manifest themselves on the surface of the Earth. In other words, "invisible" processes evolving in the hypocenter are the cause of the "visible" observable problems (destruction and other catastrophic consequences) that we see in the epicenter.

When analyzing a problem situation within the TRIZ framework, we formulate models of the problem (or multiple problems) in the form of contradictions. Problems (regardless of the form of their presentation), conflicts, contradictions – all these are things that lie on the surface, in the "epicenter".

But what causes those contradictions? What subsurface processes create problems, conflicts, contradictions? What elements act as "initiators" or participants of those subsurface processes?

The common answer to all those questions can be located within the operative zone – the "hypocenter" of the problem situation.

The formal definition of the OZ gives only a marginal idea of this notion. To master it, you need to accumulate ample practical experience. Still, we will use examples provided in the following sections to review situations where identification of the OZ is a relatively straightforward and intuitive process.

In the simpler examples, the hypocenter and the epicenter may be deemed to be virtually the same, as the relevant contradictions directly reflect the conflict between the properties inherent in OZ elements.

<table>
<tr><td>Definition
"Operative Zone"</td><td>Operative Zone (OZ) is the totality of system components and, in some cases, system environment elements which are directly related to, and lead to the emergence of, the contradiction.</td></tr>
<tr><td colspan="2">OZ is perceived as a certain functional/structural model reflective of the composition of, and the connections and interactions between, the elements within a certain modeling system (language).</td></tr>
<tr><td>"Occam's Razor"
- addition to OZ definition</td><td>OZ consists of elements which are necessary and sufficient to fully describe the processes (as well as the causes and consequences) leading to the emergence of contradictions.</td></tr>
<tr><td colspan="2">The necessity condition sets forth the requirement in accordance with which the OZ consists of such elements that, if even one of them is excluded, it will make it impossible to fully describe the processes (as well as the causes and consequences) leading to the emergence of contradictions.
Such OZ description is a priori non-excessive and, therefore, minimally complicated.</td></tr>
<tr><td>"Hypocenter of the problem"
– addition 2 to OZ definition</td><td>For relatively more complex systems, OZ delineation (location and structuring (modeling)) often involves development of several intermediate models, and for each such model it proves possible (or necessary) to find an even "deeper" OZ.</td></tr>
<tr><td colspan="2">If there are several successively linked OZs, any of them can be regarded as the epicenter for a "deeper" OZ which, in turn, is the hypocenter for the previous, more "superficial" OZ.
Any OZ can have, as its epicenter, reformulated contradiction models related only for those processes and consequences that occur in such OZ. Those contradictions reflect the requirements posed by the superior OZ to the "deeper" OZ.
The "deepest" OZ can be defined as the primary OZ-hypocenter for the entire system, entire problem situation, specific problem, conflict or systemic contradiction under analysis.</td></tr>
<tr><td>" Dynamiztion of OZ"
– addition 3 to OZ definition</td><td>Creation of a chain of operative zones (or creation of a functional/ structural model of any OZ) can be regarded as a dynamic process evolving not only "depth-wise" (determination of the "hypocenter of the problem"), but also "width-wise", with the final result depending on the composition and source of resources used by the model.</td></tr>
<tr><td colspan="2">OZ models can widely vary in terms of composition, structure and processes depending on the selected aspects of analysis, with type of resources by which core analysis is being performed and the nature of anticipated change (Ideal Functional Model) being the most critical aspects.</td></tr>
</table>

Example 2.33. Operative Zone in the Construction of Moscow Kremlin Stars

Let us recall the standard and radical contradiction as they are defined based on the description of the problem situation:

Standard Contradiction: the star must have *large surface area* so that it can carry many lamps and be visible during the night; however, this increases windage and reduces *reliability of construction* when it is exposed to strong winds.

In this case, there are two conflicting properties: *area* (of static object) and *reliability*. Such conflict is normally present in virtually all problem situations: something needs to be reinforced or developed – but such reinforcement of development detracts from another aspect (property). There emerges a general trend (direction towards the goal, and the goal *per se*) where the desired solution is synthesized subject to the following requirements: the first property (*plus factor*) must be improved, while the second property (*minus factor*), as a minimum, must not be impaired.

The **radical contradiction** is also quite simple to build – it is a set of conflicting requirements related to one and the same aspect (factor, parameter, element): the *area* must be *large* (so that many lamps can be installed throughout the surface of the star), and it must be *small* (ideally, equal to "zero", so that the wind cannot bring pressure to bear on such "zero" surface).

In this case, the operative element is the entire frontal surface of the star. The opposing requirements (attainment of different parameter values and, consequently, of different properties) are posed to the "area" of that surface: it must be *large* and *small*. The critical parameter here is the measurable surface area.

These contradictions are "informally" presented in the table below (fig. 2.30).

<table>
<tr><th>Problem P1. Moscow Kremlin Stars</th><th colspan="2">Standard Contradiction</th></tr>
<tr><td rowspan="5">A large star on a tall tower can be damaged by strong wind.</td><td>(+)-factor</td><td>(-)-factor</td></tr>
<tr><td>Large surface area, so that the star can be seen from a large distance</td><td>By large area, the star could be destroyed with a strong wind</td></tr>
<tr><td colspan="2">Radical Contradiction: The star must have –</td></tr>
<tr><td>a large area to house many lamps</td><td>a small area to weather a strong wind</td></tr>
</table>

fig. 2.30. Moscow Kremlin Stars' OZ contradictions

Operative Zone: the OZ is represented by the entire construction, as the hypocenter and the epicenter (in this simplified description) are the same. The OZ consists of the following elements: the star and the support in the form of a pointed summit (spire) of the tower. To put it simply, the problem in the OZ arises because strong frontal winds create significant pressure on the star, and the star, or the support, or the junction between the star and the support can break.

It is necessary to change the composition of construction elements, or the structure of one or several elements, so as to eliminate the existing contradictions.

2.4 Invention

The notion of "inventive problem" in TRIZ was defined as a problem whose efficient (acceptable) solution still awaits to be created because obvious solutions would be unsatisfying or they do not exist and would be impossible to obtain by using existing professional methods.

It is the emergence of contradictions in the course of evolution of all systems that is the source of problems and problem situations. Contradictions are eliminated by inventing efficient ideas which change the operative principle and/or the construction of the system. Such construction change promotes the system to a new qualitative level, and creates a set of properties which are free of the original problem and related contradictions.

Definition of **"Invention"**	**Invention (inventive idea, inventive solution)** – idea that abolishes the contradiction and thereby the problem containing that contradiction.
Effectiveness – "system" addition 1 to the definition "Invention"	The inventive idea excels itself by its high effectiveness due to the following preferences: 1. clears the problem which hinders the system's development; 2. creates the object with new properties that are necessary for higher systems; 3. opens the opportunity for a further development of the system and-or of the surrounding systems; 4. usually solves the problem with the least amount of means (resources) possible; 5. requires the least amount of small changes within the system itself or within bordering systems.

The characteristic of the idea's effectiveness is in its core, according to addition 1, a complex of important demands on the quality of the inventive idea.

Let us consider the notion of "invention" using one of our first benchmark inventions – the Moscow Kremlin Stars.

Example 2.34. Moscow Kremlin Stars. The Secret of Invention!

In the absence of a solution inventing system, such as TRIZ, all we really can rely on is professional knowledge and talent of the designers. And for the Kremlin Stars this talent created a truly wonderful solution! Solution which today we will use to learn to invent.

The key idea of the solution is to turn the star into a… wind vane (fig. 2.31)! To that end, the axis of the support is displaced relative to the star's axis of symmetry so that one part of the star has a larger surface area than the other. Then strong wind will have to do useful work, turning the star so that it positions itself with its "side" – its shorter arms – towards the wind. The stronger the wind, the more sustainably will the star be fixed in this "correct" – safest – position! This means that *harmful impact has been made useful.* And this is exactly how inventions are created in TRIZ! Another principle which was actually used when inventing vane-stars is the principle of *asymmetry.*

And now let us review this solution as if it had been made according to TRIZ. In Modern TRIZ such modeling is called *reinventing*. Reinventing is the fundamental method to practice inventing thinking which can then be used to solve any problems of similar or even higher complexity.

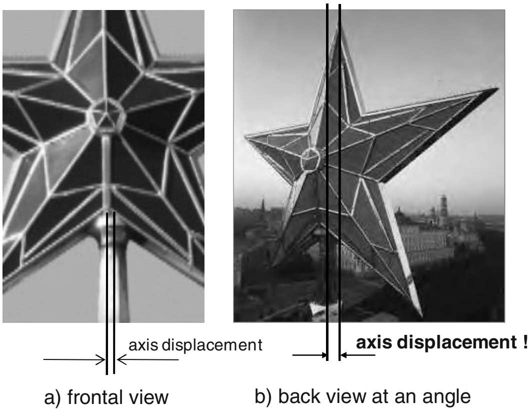


fig. 2.31. Ideal solution – the construction PROTECTS ITSELF!

fig. 2.32. You do remember what a wind vane looks like – and how it works?

Example 2.35. Reinventing of Moscow Kremlin Stars According to TRIZ

To resolve such contradictions, TRIZ has a wide gamut of 40 models, such as "*inverse action*", "*copying*", "*dynamization*", etc. To select the models suitable for the given situation and given contradiction, a special table [40] – A-matrix[41] – is used.

To solve the problem under consideration, we use, in A-matrix, two factors from the standard contradiction: the first factor corresponds to the positive objective of problem solution – the star must have a large surface area, which corresponds to A-matrix plus-entry Number *18. Surface of the Fixed Object;* the second factor corresponds to minus-entry *04. Reliability*, as it is reliability of the star that deteriorates as its size and surface area increase.

At the intersection of Line 18 and Colum 04 of the A-matrix we find a cell containing the numbers of transformation models – 01, 09, 17 and 24 – which statistically have been frequently used in practice to solve contradictions represented by Factors 18 and 04. The notation form used is: 18 **VS** 04.

To generate an idea, we need to look up descriptions of these models in a special As-Catalog, and attempt to interpret them as they apply to solving the problem at hand. In this case, the highest "creativity" potential is displayed by Navigator *24 Asymmetry: (a) change the form of the object from symmetrical to nonsymmetrical.* Objectively, there is also Navigator 07 *Dynamization*: (c) if the object is im-

---

[40] See also: M. A. Orloff (2006) *Inventive Thinking through TRIZ.*

[41] The terms "A-Matrix" and "A-Catalog" were suggested in honor of G. S. Altshuller by the author of this book in his first textbook – a TRIZ summary based on the works of Genrikh Saulovich Altshuller: M. A. Orloff, A. M. Shirokoff (2001) *Contradiction. Invention. Development. Selected Pages from Classical TRIZ.* – Minsk: Modern Knowledge Institute– 210 p. (in Russian)

mobile, make it mobile, motive. Application of these transformation models yields an idea which leads to the following wonderful solution: make the star in the form of a "wind vane" (fig. 2.32)!

A quick test of the solution shows that all contradictions are removed! The design does not become more complex, and there emerges a "bonus" useful effect – we save energy, as the wind does all useful work by itself, turning the star into the safest position. Accordingly, the solution objectively implements yet another model, *21 Transform Damage into Use.*

Now we can supplement the brief description of the problem, as presented in fig. 1.30, with a more detailed one incorporating the solution (fig. 2.33).

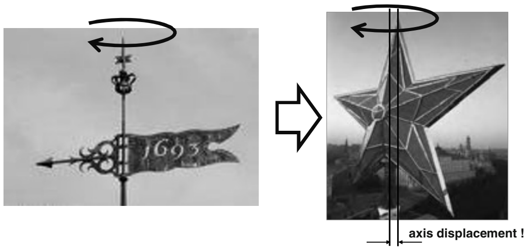
<table>
<tr><td>Problem P1. Moscow Kremlin Stars</td><td colspan="2">Standard Contradiction</td></tr>
<tr><td rowspan="4">A large star on a tall tower can be damaged by strong wind.</td><td>(+)-factor</td><td>(-)-factor</td></tr>
<tr><td>Large surface area, so that the star can be seen from a large distance</td><td>By large area, the star could be destroyed with a strong wind</td></tr>
<tr><td colspan="2">Radical Contradiction: The star must have –</td></tr>
<tr><td>a large area to house many lamps</td><td>a small area to weather a strong wind</td></tr>
<tr><td>Time: 1936</td><td colspan="2" rowspan="2">
</td></tr>
<tr><td>Solution: the stars are made in the form of wind vanes. Axis of rotation (axis of support) is displaced relative to the axis of symmetry of the star.
TRIZ Models: "Asymmetry", "Dynamization", "Transform Damage into Use", "Copying"</td></tr>
</table>

fig. 2.33. Brief presentation of solution for Problem P1. Moscow Kremlin Stars

Reinventing of this invention is presented in a standard blank (to work in the class without software EASyTRIZ™) shown in fig. 2.34.

Additional examples of similar application of dynamization and asymmetry models are provided in fig. 2.35-2.37 (all photos are made by the author).

So, you have learnt initial TRIZ concepts: contradiction, transformation model, and invention.

Now we will proceed to an in-depth review of these and other TRIZ notions. In doing so we will – as you may have already noticed – rely, to the extent possible, on real-life artifacts. This entire course will be accompanied by practical examples similar to that of Moscow Kremlin Stars (fig. 2.34).

We wish you success – and yes, perseverance! – in mastering "easy" TRIZ!

TREND

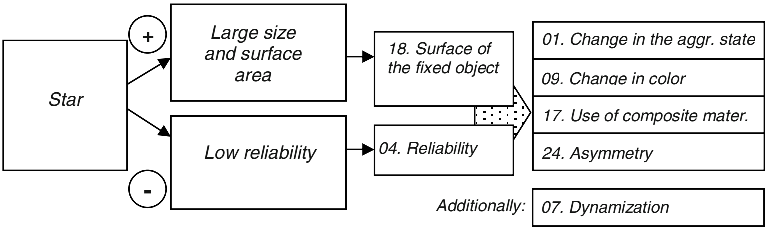
The main Moscow Kremlin Stars are large – more than 5 meters tall. Each star weighs 1 ton or more. All stars have large surface area and, consequently, large windage. As a result, in high winds there is a risk that they may be thrown off their respective towers. PROBLEM: how do we redesign the stars to make them reliable and resistant to strong wind?

REDUCING

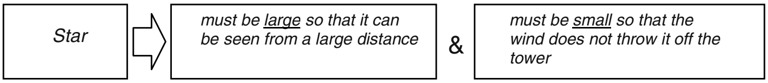
FIM: X-resource, together with available or modified resources, and without making the object more complex or introducing any negative properties, guarantees attainment of the following **IFR**:

[*the star is reliably steady in strong wind*].

Standard (Technical) Contradiction



Radical (Physical) Contradiction



INVENTING

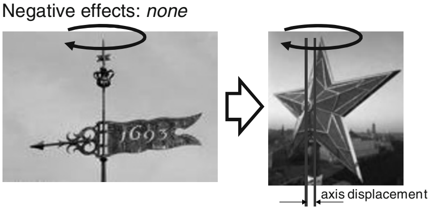
Key model: 24 Asymmetry – a) move from a symmetrical shape of an object to an asymmetrical one. What does a "nonsymmetrical star" resemble? A wind vane! So turn the star into a wind vane! This is a clear case of application of Model 07 Dynamization*.*

ZOOMING

Have the contradictions been removed? – Yes. – ~~No~~.

Super-effects: *the wind ITSELF aligns the star with its own direction. The solution objectively implements Model* 21 Transform Damage into Use*, as the stronger the wind, the better it keeps the star in a position where its smallest section "cuts through" the air flow, while its largest section "rides with" the air flow. The design is simplified. No energy is consumed.*

Negative effects: *none*



BRIEF DESCRIPTION

To simplify design and reduce energy expenditure, Moscow Kremlin stars are designed so that their axes of rotation are displaced relative to their axes of symmetry in accordance with Navigator 24 Asymmetry*; model* 07 Dynamization *is also realized.*

fig. 2.34. Reinvention of the Moscow Kremlin Stars

fig. 2.35. Rotation of the star on the Troitskaya Tower of Moscow Kremlin

fig. 2.36. Rotation of the coat of arms on the tower of the Museum of History in Moscow as viewed from the Alexander Garden

a) view in the morning from the Palace Square; the fountain is to the left

b) view in the evening from the fountain opposite the main entrance; the Palace Square is to the right

fig. 2.37. Rotation of the ship wind vane on the spire of the Admiralty Building in Saint-Petersburg
(two positions of the wind vane with different wind directions)

Technical solutions used in the making of the Kremlin Stars inspire admiration, and can serve as examples of inventive brilliance and audacity. These solutions are simple and highly efficient. Some of the photographs provided are made by the author. And one more thing: the same principles – "dynamization", "asymmetry" and others – that can be extracted from these solutions are used in other constructions, for example, in the rotating "eagles" towering above the Museum of History in the Red Square in Moscow, and in the ship-shaped wind vane on the Admiralty Spire in Saint-Petersburg. All photographs are dated July 2009.

http://www.springer.com/978-3-642-25217-4

Modern TRIZ
A Practical Course with EASyTRIZ Technology
Orloff, M.A.
2012, XVI, 449 p. 456 illus., Softcover
ISBN: 978-3-642-25217-4