Process Innovation

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"5 Whys" On Steroids:
Beyond Repeated Questioning to TRIZ Cause-Effect Models

Part 4 in a series on P-TRIZ

Asking "Why?" is a favorite learning technique of young children, but is it a valuable problem-solving tool? By repeatedly asking why (five is a rule of thumb recommended by Creativity and Problem Solving experts) layers of symptoms can be peeled away, leading to the identification of the root cause of any problem. The claim is that very often the cause of a problem will lead you to another pertinent question.

The usual steps in performing "5 Whys" are:

1. Write down the specific problem. This helps to give an air of formality to the problem and provides a focus for the team.
2. Ask why the problem occurs and write down the answer below the problem statement.
3. If the answer doesn't identify the root cause of the problem, ask why again and write down that answer.

Repeat step 3 until the team agrees that a root problem has been found. Despite its simplicity, the technique proves to be effective. Often, important data emerges in less than five questions. As process improvement experts, the Juran Institute, state in Black Belt training, "All too often problem solving and Six Sigma 'mistake-proofing' efforts are focused on the symptoms of the problem and not the root causes. By asking "5 Whys" teams can move beyond symptoms and tunnel down into the process to find the root cause. Once the root cause is found, it is often easy to put a mistake proofing solution into place." But is it really that simple?

Here is an example:

Problem: Customers are dissatisfied because they are receiving products that don't meet their specification.
1. Why are customers being shipped off-spec products?
 - Because manufacturing made the products to a specification that is different from that which the customer and the sales person agreed to.
2. Why did manufacturing use a different specification to that in the sales order?
 - Because the sales person expedites work on the shop floor by calling the head of manufacturing directly to begin work. An error occurred when the specification was being communicated and transcribed.
3. Why do sales people call manufacturing directly to start work instead of following the

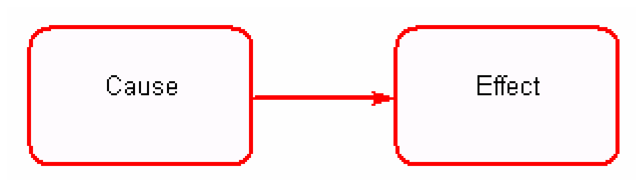
procedures established in the company?
- Because the "initiate build" form requires the sales director's approval before work can begin and this slows the manufacturing process (or stops it when the director is out of the office).
4. Why does the form require the approval for the sales director?
- Because the sales director needs to be continually updated on the sales pipeline for planning with the CEO.

Can we realistically expect Six Sigma practitioners to rely on such a simple method? Maybe this questioning would reveal a solution, maybe not. Every consultant knows that knowing the cause of a problem is 80% towards finding a solution. Sure sounds easy. "5 Whys" may be effective, but can it solve complex problems for which there are no obvious or known solutions?

A complex problem is one in which there are connected, conflicting and counteracting causes and effects. Most process redesign falls into this category. A complex problem is one in which critical domain knowledge needs to be integrated during problem solving if solutions are to be revealed. Root causes are rarely linear where processes are concerned.

TRIZ opens many more directions for questioning

Here is the most basic TRIZ model pattern for "5 Whys":



The model says: There is a harmful Cause, which produces a Harmful effect.

Using the school-child "5 Whys" method, there is only one question: Why does the effect arise? Yet even this simple two-block TRIZ model generates a more interesting line of questioning. From the model, a slew of different possibilities present themselves. Each is called a solution direction.

TRIZ output:
1. Find a way to eliminate, reduce, or prevent [the] (Cause) in order to avoid [the] (Effect).

This solution direction can be applied once the root cause is identified. Here's more:

1.1. Find a way to benefit from [the] (Cause).

The cause leads to a chain of effects. By asking questions about the link between the cause and effect, intermediate effects are identified.

1.2. Find a way to decrease the ability of [the] (Cause) to cause [the] (Effect).

TRIZ has identified that breaking a chain of effects can be a useful solution in its own right.

1.3. Consider the conditions that cause [the] (Cause) and try to change them.

TRIZ prompts us to ask: is there really any such a thing as a root cause? Effects arise as a consequence of the inter-relationships between system functions. In complex situations, eradicating a single root cause would not lead to a substantial system improvement. Life is often more complex than the linear chain of causes and effects implied by the "5 Whys" method.

2. Find a way to eliminate, reduce, or prevent [the] (Effect) under the conditions of [the] (Cause).

Very often, root causes are buried deep in the intricate behavior of a business or technical process. Even if the cause is found, just asking "why" is unlikely to reveal a cause that can be easily eradicated. (This is what is meant by the TRIZ phrase "under the conditions of the Cause".) A possible solution could be to address the upstream effects.

2.1. Find a way to benefit from [the] (Effect).

As you saw in previous articles, everything is both useful and harmful. Asking about the benefits of an upstream effect can lead to novel solutions that a root cause analysis would not reveal.

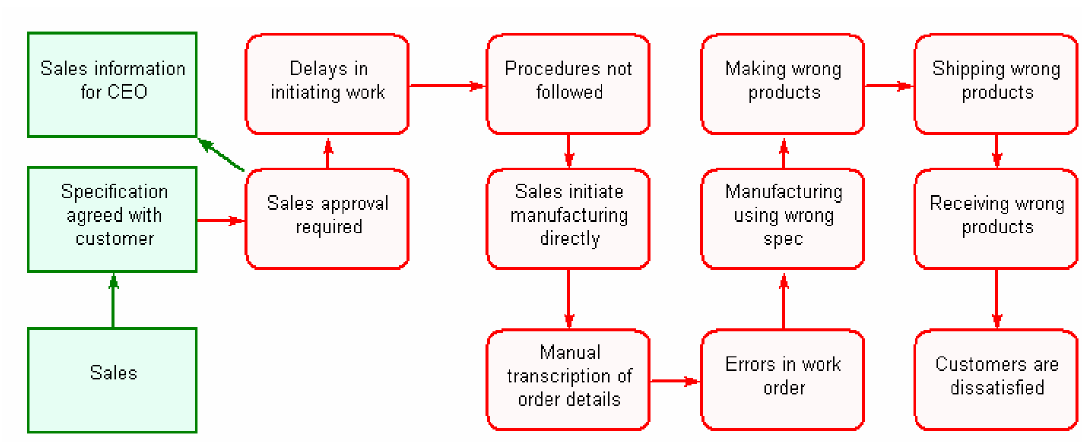
2.2. Try to cope with [the] (Effect).

If a solution cannot be found, we may have to cope with a harmful function in the system. For example, a Catalytic converter is added to a car engine to cope with harmful emissions. At the same time this additional component is harmful as it adds cost and complexity to the engine.

2.3. Consider ways to compensate for the harmful results of [the] (Effect).

Stop this theory! – Let's try it

The Dissatisfied Customers Problem can easily be converted into a TRIZ model as follows:



The output generated from such models (quoted below) is typically used in workshops and brainstorming for possible solutions. In later articles we'll show how it can lead directly to solution concepts.

As you read the output below, a number of obvious solutions will occur to you. See if you can find them. These are unlikely to have emerged just by "looking at" the "5 Whys" script. The example may be trite, but as you will see, there are rather obvious solutions up and down the chain. How many can you find?

1. Find a way to eliminate, reduce, or prevent [the] (Customers are dissatisfied) under the conditions of [the] (Receiving wrong products).

1.2. Try to cope with [the] (Customers are dissatisfied).

1.3. Consider ways to compensate for the harmful results of [the] (Customers are dissatisfied).

2. Find a way to eliminate, reduce, or prevent [the] (Receiving wrong products) in order to avoid [the] (Customers are dissatisfied), under the conditions of [the] (Shipping wrong products).

2.2. Find a way to decrease the ability of [the] (Receiving wrong products) to cause [the] (Customers are dissatisfied).

3. Find a way to eliminate, reduce, or prevent [the] (Shipping wrong products) in order to avoid [the] (Receiving wrong products), under the conditions of [the] (Making wrong products).

4. Find a way to eliminate, reduce, or prevent [the] (Making wrong products) in order to avoid [the] (Shipping wrong products), under the conditions of [the] (Manufacturing using wrong spec).

4.2. Find a way to decrease the ability of [the] (Making wrong products) to cause [the] (Shipping wrong products).

5. Find an alternative way to obtain [the] (Specification agreed with customer) that offers the following: does not cause [the] (Sales approval required), does not require [the] (Sales).

5.1. Find a way to increase the effectiveness of [the] (Specification agreed with customer).

5.2. Find additional benefits from [the] (Specification agreed with customer).

5.3. Find a way to decrease the ability of [the] (Specification agreed with customer) to cause [the] (Sales approval required).

6. Try to resolve the following contradiction: The useful factor [the] (Specification agreed with customer) should be in place in order to fulfill useful purpose and should not exist in order to avoid [the] (Sales approval required).

6.1. Try to apply Universal Operators to circumvent the contradiction.

7. Find an alternative way to obtain [the] (Sales) that provides or enhances [the] (Specification agreed with customer).

7.1. Find a way to increase the effectiveness of [the] (Sales).

7.2. Find additional benefits from [the] (Sales).

7.3. Find a way to obtain [the] (Specification agreed with customer) without the use of [the] (Sales).

8. Find a way to eliminate, reduce, or prevent [the] (Manufacturing using wrong spec) in order to avoid [the] (Making wrong products), under the conditions of [the] (Errors in work order).

8.1. Find a way to benefit from [the] (Manufacturing using wrong spec).

8.2. Find a way to decrease the ability of [the] (Manufacturing using wrong spec) to cause [the] (Making wrong products).

9. Find a way to eliminate, reduce, or prevent [the] (Errors in work order) in order to avoid [the] (Manufacturing using wrong spec), under the conditions of [the] (Manual transcription of order details).

9.2. Find a way to decrease the ability of [the] (Errors in work order) to cause [the] (Manufacturing using wrong spec).

10. Find a way to eliminate, reduce, or prevent [the] (Procedures not followed) in order to avoid [the] (Sales initiate manufacturing directly), under the conditions of [the] (Delays in initiating work).

10.2. Find a way to decrease the ability of [the] (Procedures not followed) to cause [the] (Sales initiate manufacturing directly).

11. Find a way to eliminate, reduce, or prevent [the] (Manual transcription of order details) in order to avoid [the] (Errors in work order), under the conditions of [the] (Sales initiate manufacturing directly).

11.1. Find a way to benefit from [the] (Manual transcription of order details).

11.2. Find a way to decrease the ability of [the] (Manual transcription of order details) to cause [the] (Errors in work order)

12. Find a way to eliminate, reduce, or prevent [the] (Sales approval required) in order to avoid [the] (Delays in initiating work), under the conditions of [the] (Specification agreed with customer), then think how to provide [the] (Sales information for CEO).

12.1. Find a way to benefit from [the] (Sales approval required).

12.2. Find a way to obtain [the] (Sales information for CEO) without the use of [the] (Sales approval required).

12.3. Find a way to decrease the ability of [the] (Sales approval required) to cause [the] (Delays in initiating work).

13. Try to resolve the following contradiction: The harmful factor [the] (Sales approval required) should not exist in order to avoid [the] (Delays in initiating work), and should be in place in order to provide or enhance [the] (Sales information for CEO).

13.1. Try to apply Universal Operators to circumvent the contradiction.

14. Find a way to eliminate, reduce, or prevent [the] (Delays in initiating work) in order to avoid [the] (Procedures not followed), under the conditions of [the] (Sales approval required).

14.1. Find a way to benefit from [the] (Delays in initiating work).

14.2. Find a way to decrease the ability of [the] (Delays in initiating work) to cause [the] (Procedures not followed).

15. Find a way to eliminate, reduce, or prevent [the] (Sales initiate manufacturing directly) in order to avoid [the] (Manual transcription of order details), under the conditions of [the] (Procedures not followed).

15.1. Find a way to benefit from [the] (Sales initiate manufacturing directly).

15.2. Find a way to decrease the ability of [the] (Sales initiate manufacturing directly) to cause [the] (Manual transcription of order details).

16. Find an alternative way to obtain [the] (Sales information for CEO) that does not require [the] (Sales approval required).

17. Consider replacing the entire system with an alternative one that will provide [the] (Sales information for CEO).

17.1. Consider transition to the next generation of the system that provides [the] (Sales information for CEO), but which will not have the existing problem.

17.2. Consider enhancing the current means by which the primary useful function is achieved, to the extent that the benefits will override the primary problem.

17.3. Consider giving up the primary useful function to avoid the primary problem.

Let's transition to the next generation of the system

When a process is re-designed, it's old "As Is" design is discarded, to be replaced by a new "To Be" design. The improvement may be incremental, with only a small number of process steps or participants affected. Or it may be radically different, with little in common with the original design. In P-TRIZ, that's called moving to the next generation of the system.

Did the TRIZ prompt you to find you to find the following solutions?

16. Find an alternative way to obtain [the] (Sales information for CEO) that does not require [the] (Sales approval required).

7.3. Find a way to obtain [the] (Specification agreed with customer) without the use of [the] (Sales).

17.1. Consider transition to the next generation of the system that provides [the] (Sales information for CEO), but which will not have the existing problem.

Solution A: Self service: The customer places their order directly via a Web page accessible to manufacturing. Sales information is automatically generated on a Web-based dashboard for the CEO. And also:

8.1. Find a way to benefit from [the] (Manufacturing using wrong spec).

Solution B: Implement a Returns Process: Return goods can be matched in whole or in parts to subsequent orders that require the specification, reusing returned parts or units. And here's another one:

Solution C: Build-To-Order: Today, such processes are commonplace across a range of industries.

The opposite of why: A Game of Consequences

When attempting to solve a hard problem it is often a good idea to think of things the other way around.

An observed harmful effect does not necessarily lie at the end of the chain, and could have further upstream effects. "5 Whys" can be extended with the idea of the "Game of Consequences" In this game, attendees are asked to elaborate all of the consequences of an effect.

The usual steps in performing the "The Game of Consequences" are:

1. Write down the specific harmful effect. This helps to formalize the harm and provides a focus for the team.
2. Ask what the consequences are and write down the answers. Better still document them in a TRIZ model. (Consequence *produced by* Effect etc.)
3. Vote to select one or more important consequences. Ask for their consequences again and write down the answer.

Keep repeating step 3, fanning out, until the team agrees that the final consequences have been found.

Hint: Stimulate the creativity of the team: When playing the game of consequences, prompting words such as Outcome, Result, Upshot, Event, Aftermath, Final Result, Backwash and Wake, can be used, to generate different types of consequences.

Variants on the game include finding chains of useful consequences from a single harmful function, or chains of harmful consequences from a single useful function. It's not always the case that harmful functions generate harmful effects, and vice versa. Useful functions can have harmful effects, and harmful functions can have useful effects. For example, a car engine is useful, but generates emissions. Emissions as a result of combusting petrol are harmful, but useful to oil companies in making a profit. Hydrogen combustion engines are useful to car manufacturers as the next source of innovation and growth, but harmful to the petroleum industry given its invested capital and asset base.

Consequence chains, like root-cause chains, create the domain knowledge necessary for deep problem solving. As the TRIZ model expands with downstream causes or upstream effects and consequences, TRIZ can generate additional solution directions that are more detailed, prompting effective brainstorming for Solutions. Try it and see. Root causes are not as clear cut as "5 Whys" procedures often imply. Here's an example:

2.4. Consider creating a situation that makes [the] (Effect) insignificant or unimportant.

This direction says: ignore the root cause, find a way to make the upstream effect irrelevant in the overall functioning of the system.

It's not just a chain

Beyond "5 Whys", TRIZ models capture the interplay of causes and effects between the useful and harmful functions in the system, or between the system and the environment or within sub-system components. Processes are systems of interaction between participants. Understanding these causal relationships is vitally important in problem solving.

A root cause is rarely the only factor that needs to be resolved if a system is to improve. Multiple effects can emerge from a single function. Multiple effects can converge amplifying a useful, or harmful, function. Self-reinforcing loops exist in any complex problem, hence the popularity of systems dynamics (SD) models. TRIZ models, while not quantitative like SD models, can nevertheless capture the essence of these situations. Traversing the network of interplays identifies the critical-chain, a term borrowed from the book of the same name by Eliyahu Goldratt, author of the business novel, *The Goal.* These interconnections generate contradictions in the model.

A contradiction exists in a system when, in attempting to improve one parameter of the system, another parameter you care about deteriorates. For example, if we attempt to make a product stronger by making it thicker, it also gets heavier. If we use higher quality materials, the cost goes up, and so on.

The typical engineering approach to dealing with such contradictions is to trade-off, in other words, to compromise. While compromise may be useful in some situations, and may contribute to minor incremental improvements, compromise cannot be considered to be innovation. If we need to provide significant new value to customers in a product or service, compromise in the re-design of the process providing the product or service is unlikely to yield answers. In contrast to a compromise, an invention is an idea that surmounts the contradiction, moving both parameters in a favorable direction. This is the viewpoint taken in TRIZ. TRIZ practitioners are obsessive seekers of solutions that resolve contradictions.

In TRIZ mythology there is a story about the difficulty of construction of large buildings upon permanently frozen ground. Piles are driven into the permafrost to form a foundation. Piles need to be pointed at the bottom so that they could more easily penetrate the ice. On the other hand, for maximum load bearing capacity and resistance to settling, piles must be blunt. Hence a contradiction: the piles should be both pointed *and* blunt. The presence of a contradiction is good evidence that a hard problem needs to be resolved.

The solution to the pile-driving problem was to include a hollow chamber in the pointed pile and fill it with a wire, concrete rubble, and an explosive charge. After the pile was driven to its final position the charge was detonated, forming a blunt footing. This is an instance of the TRIZ inventive principle of 'separation in time': the pile is pointed while being driven and blunt when carrying load. TRIZ is littered with such creative solutions. They emerge from the directions generated by TRIZ models.

Innovators solve problems by focusing upon the useful parameters of a system that, if increased, would enhance it substantially, but also, the harmful aspects that, if left unchecked, would lead to a contradiction. Contradictions are significant, for if eradicated or reduced, directly or indirectly, they contribute to the development of a breakthrough solution. Avoiding compromise is central to problem solving and innovation. Tradeoffs—strength versus weight, reliability versus cost, service-quality versus resource and output versus input—are not the same as an inventive solution that creates new value. Inventive solutions only emerge by exploiting useful effects and eliminating harmful effects.

In classical TRIZ there are a core set of 40 principles[1]. Each is a solution to a contradiction. These classical TRIZ solutions remain important, but in modern TRIZ, there exists a more comprehensive set of TRIZ operators[2]. This expanded set of abstract solutions greatly expands our ability to reveal root causes and find practical solutions.

Resolving contradictions

In our sales example above, the following contradiction was identified by TRIZ:

> 13. Try to resolve the following contradiction: The harmful factor [the] (Sales approval required) should not exist in order to avoid [the] (Delays in initiating work), and should be in place in order to provide or enhance [the] (Sales information for CEO).

This would not have been identified using “5 Whys”. Let’s see what solutions are prompted by a couple of simple TRIZ solution patterns.

TRIZ abstract solution: Separate the irresolvable by condition: How might I separate the system conditionally to allow it to be one way under one condition and a different way under another:

Concrete solution: Sales approval not required for orders less than $X.

TRIZ abstract solution: Separate the irresolvable perceptually: How might I make the same system seem different to different users?

Concrete solution: When the sales director is out and cannot sign orders he must give his hat to someone else who is perceived to carry his authority by the manufacturing teams.

Do these solutions seem obvious to you? So why didn’t you think of them right away? Solutions when revealed may seem “obvious” but would they have emerged from reading the “5 Whys” transcript?

TRIZ is often criticized for appearing to generate obvious solutions. It’s almost as if some folks believe that answers must be complex and that any methodology is worthless unless it provides complex solutions. The fact is:

- Trivial problems don’t need TRIZ. If the answer is easy, so be it.
- Hard problems are rarely if ever solved using trivial methods like “5 Whys”
- TRIZ often finds simple solutions to hard problems
- TRIZ has been used to find sophisticated solutions to deep-seated problems, even to invent the next generation of a technology

A problem in Project Management would not be solved by asking 5 Whys

[1] Altshuller, G., “40 Principles Extended Edition: TRIZ keys to innovation,” Technical Innovation Centre, April 2005

[2] http://www.ideationtriz.com

A large project is an example of a complex system. Such systems contain self-reinforcing harmful loops. For example, large projects have large program scope. This creates a high risk environment which needs to be managed in detail. This creates the need for detailed planning, which often results in frequent program reviews, leading to frequent re-direction of the project, which causes slippage, which extends the program duration and increases the size of the project. The problem is well reported in the literature. For example, it is described on Page 75 of the book *Developing Products in Half the Time*. Such knowledge can be easily converted to a TRIZ cause and effect (Useful - Harmful) model (Figure 1).

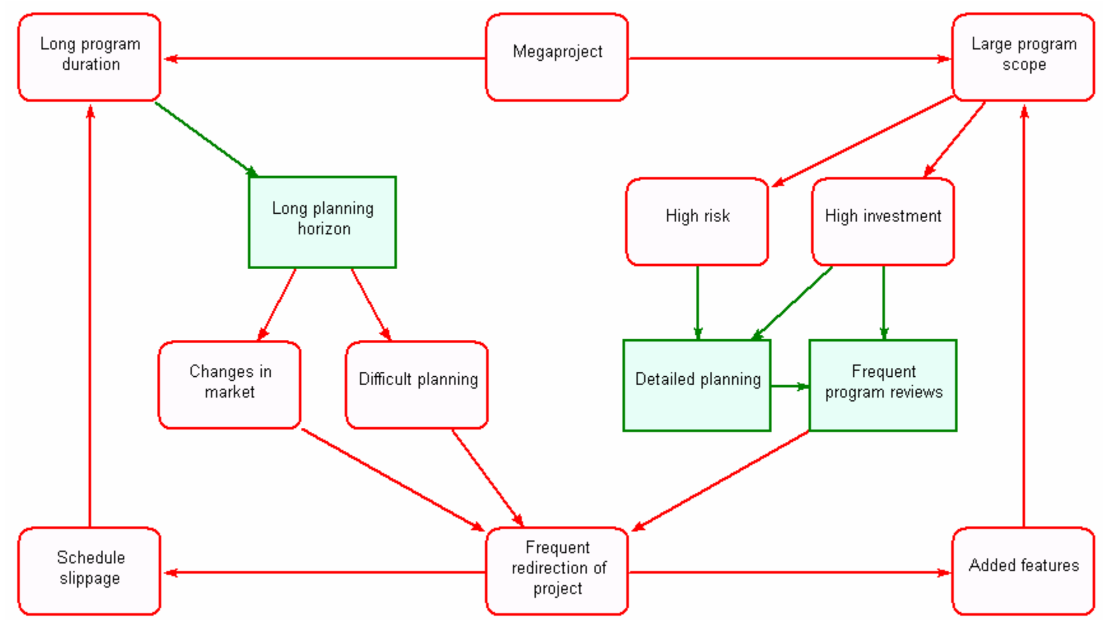


Figure 1 – TRIZ Model for the Self-Reinforcing Nature of Mega Projects

From this model, TRIZ can generate an exhaustive set of strategies for probing and questioning why mega projects are so problematic.[3] These strategies for coping with large projects would not emerge from a simplistic "5 Whys" analysis. The irony is however that the "5 Whys" technique could well be useful in developing, refining and elaborating the TRIZ model itself.

No single source will inform on all aspects of TRIZ

Henry Ford once said, "I have heard it said…that we have taken skill out of work. We have not. We have put a higher skill into management, planning and tool building, and the results of that skill are enjoyed by the man who is not skilled." Before the car assembly line, labor cost to manufacture just one car was 160 hours. By 1908, that had fallen to 12 hours and by 1916 to 1.5 hours. The result: Ford's labor cost in 1916 was $52.73 per car, against $190.87 for competitors not using the assembly-line innovation. This increase in productivity translated into lower prices for consumers. Pre-Ford, a car cost $3000. By 1908 the price had dropped to $950, and 1916 to $280. As a result, Ford's market share rose sharply, from zero in 1907, to 56% in 1916. And, Ford's investors were very happy. Profitability rose from nothing in 1907, to $30M in 1914 and to $60M in 1916.

[3] This example and the strategies generated by TRIZ were documented in part 2, "P-TRIZ Formulation", http://trizmethods.blogspot.com

Ford had eradicated what TRIZ methodologists call a contradiction, in Ford's case between labor cost and productivity. Ford achieved this using an inventive principle, the conveyor belt metaphor. It exists in TRIZ today as an abstract solution and can be observed in numerous innovations across many industrial sectors.

Modern versions of TRIZ are the result of decades of analysis, by hundreds of scientists and inventors, of millions of worldwide patents and related sources of knowledge, across all engineering disciplines. Hundreds of patterns of *invention* and technological *evolution* have been extracted and codified. This knowledge has been incorporated into procedures that guide innovators and problem solvers toward breakthrough solutions, direct the evolutionary path of development and help anticipate future limitations or roadblocks. Today, TRIZ practitioners report that dipping into this knowledge base encourages thinking and prodding at technical systems until solutions to deep-seated roadblocks are identified, problems that limit a product from developing along a desirable line of evolution in a market.

Typical steps in a TRIZ analysis

- Agreeing the problem and the perspective from which it should be solved
- Collecting information about the system, the problem and its environment
- Enumerating all of the system, sub-system and super-system resources
- Describing the functioning of the system, past, present and future
- Uncovering the root causes of the problem, and its downstream effects
- Revealing the interdependence between system functions and root causes
- Identifying the central resources that could play a role in the solution
- Formulating possible sub-problems to be solved
- Selecting the most promising directions for solving the problem
- Refining and strengthening these directions leading to solution concepts
- Evaluating recommended operators corresponding to problem type
- Translating abstract solution patterns into concrete solutions
- Applying operators and analogies to refine directions for problem solving and idea generation
- Adding new ideas into the cause-effect models of both the problem and solution
- Recognizing and iterating over sub-problems
- Recognizing and solving subsequent problems created by the solution direction
- Iteratively improving the solution by repeating this process
- Summarizing concept description and protecting intellectual property

To conclude

Most of the problems we now are required to solve in business and technical fields involve complex processes in which solutions are masked by myriad interconnected symptomatic factors. It's rarely as simple as asking "5 Whys".

While "5 Whys" can help in developing a TRIZ model, it's only when that model is analysed, using TRIZ formulation, that solutions begin to emerge. When matched to a comprehensive set of abstract TRIZ solution patterns, teams can more readily find real world solutions to complex real world problems.