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Improving Supply Chain Management with TRIZ

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Improving Supply Chain Management with TRIZ

ABSTRACT

Managing a supply chain as a value chain means finding ways to eliminate non-value added activities, processes, and supply chain problems. This paper introduces TRIZ (a Russian acronym for the Theory of Inventive Problem Solving), a structured method to generate innovative solutions for supply chain issues. TRIZ enhances the solution development stage by enabling time efficient and low-cost solutions. Examples and short case- studies from selected industries demonstrate TRIZ applications in the supply chain environment.

Keywords: supply chain, inventive problem solving

Introduction

Supply chain excellence is critical for an organization's growth, profitability, customer satisfaction, and competitiveness. Supply chain is a network of facilities that procure raw materials, transform them into intermediate goods and then final products, and deliver the products to customers through a distribution system. It encompasses procurement, internal transformation, and distribution. Global complexities include multiple stages of suppliers, numerous locations of internal transformation, and many phases of physical distribution.

The Value Chain is a closely related concept to Supply Chain. While Supply Chain includes all processes performed in the chain, the Value Chain incorporates only processes that add value in the chain from customer standpoint. A customer has been determined as the recipient of output of previous process step or the end user of the product or service.

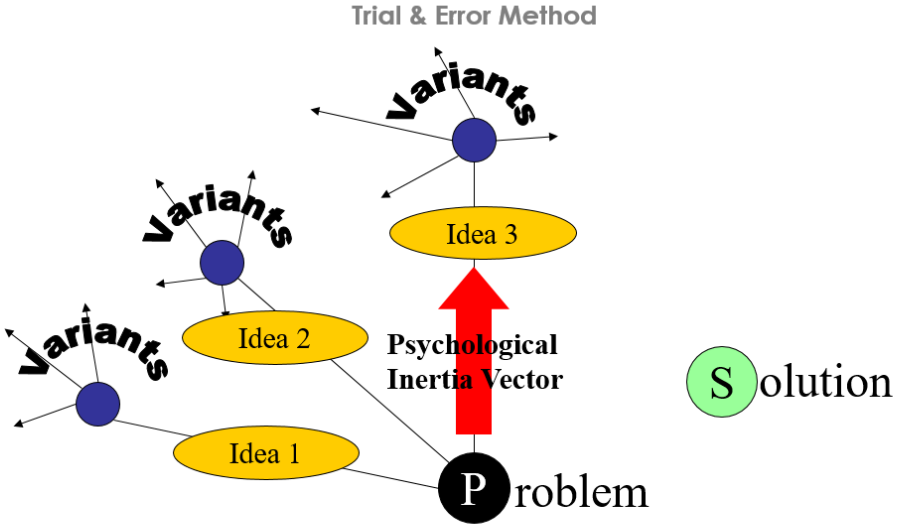
Non-value added steps, activities, or processes may be associated with poor quality, wasted time, information, and costs during: procurement, transformation of raw materials into final products, and distribution of goods or services. Examples of possible sources of waste in a supply chain include rework and/or warranty repairs due to poor quality of products/services; delays in shipments; excessive or insufficient inventory levels; and inaccurate forecasting or scheduling. By resolving supply chain problems and eliminating sources of waste throughout the supply chain, both the supplier and the customer can benefit from time and cost efficiency.

TRIZ: Inventive Problem Solving

Although supply chains have been well studied with operations management, operations research, and other disciplines, psychological inertia can prevent business practitioners from effective resolution of supply chain issues.

Psychological inertia is a force that causes business practitioner’s decisions to be affected by their previous experiences, company’s written or unwritten norms, and current industry practices. As a result, during problem solving, in many cases, a problem-solver (or inventor) uses a trial and error method or simple brainstorming. This approach might or might not lead to the solution to the problem under consideration. Also, this approach can be not efficient in terms of time and other resources spent in funding solution. The solution obtained may not be the best possible solution, and in many cases it’s a solution based on certain compromises (see Figure 1).

Figure 1. *Why TRIZ?*



Source: adapted from #7 I-TRIZ Practitioner Program

Even if the root cause of a problem is determined correctly, existing problem solving methods provide little help in developing solution ideas. For example, success of a solution brainstorming session depends on the past experiences and technical/business knowledge of the problem-solving team members, and utilizes readily available knowledge and subjective intuition. In contrast, TRIZ offers a structured, better organized, and more robust approach to the generation of new, innovative and breakthrough solutions. List of TRIZ tools available for supply chain problem-solving is included in this paper.

Key reasons why TRIZ is effective are as follows:

- The notion of contradictions: All problems occur as a result of conflicts or contradictions among the system attributes. One example of a contradiction is the desire to simultaneously increase product quality and to reduce production costs. TRIZ distinguishes two types of contradictions: functional and inherent conflicts. This paper offers a flowchart for contradiction formulation as the initial point in the supply-chain problem solving. Further discussion of contradictions and their applications in the supply chain environment is based on examples from automotive and aircraft manufacturing industries.
- The notion of ideality: The formula for measurement of solution ideality, demonstrated in this paper, is a ratio of all useful functions over all harmful functions. Systems evolve to increase ideality, which is to increase benefits of using the system and to decrease the system's costs and harmful functions. A solution near the ideal final result in many cases is a breakthrough solution, in contrast to incremental improvement. Resources inside the system are critical for achieving system ideality. Solution efficiency is achieved by identifying and utilizing resources already available in the system, including recognizing

useful functions of currently idle resources. This paper discusses a food industry example of how utilization of idle resources can contribute to more efficient operations.
- The notion of win/win solutions: In TRIZ, there are no compromises. Contradictions must be successfully resolved to achieve an ideal final result. This is the major difference of TRIZ from other problem solving methodologies. In TRIZ, trade-offs are not acceptable. The ideal final result must satisfy both contradicting requirements. The ideal final result is a solution to a problem independent of the constraints of the original problem. TRIZ offers 40 innovative problem solving principles and four separation principles (separation in time, in space, between subsystems and upon condition) to resolve contradictions. Summary of criteria questions for application of four separation principles is reviewed in this paper. Examples of win/win solutions for supply chain problems in automotive industry, such as customer-supplier communication on new product design, corrective actions, and cost of supplier quality audits are also included in the paper.

Thus, TRIZ is a method that enhances the solution development stage, enabling time efficient and low-cost solutions. TRIZ can be used for: supply chain problem formulation; determining an ideal vision of solution; selecting directions for solutions; and evaluating results using the formula for measurement of solution ideality.

In its final part, the paper discusses several short case studies demonstrating applications of TRIZ in the supply chain environment across selected industries. The case studies were developed in the course of the author’s training and consulting activities for local companies. In the case studies, supply chain problem solving involves the use of separation in time TRIZ principle in order to set time lines for inventory management, sales department forecast accuracy, and customer/supplier communication of design changes.

Foundations of TRIZ

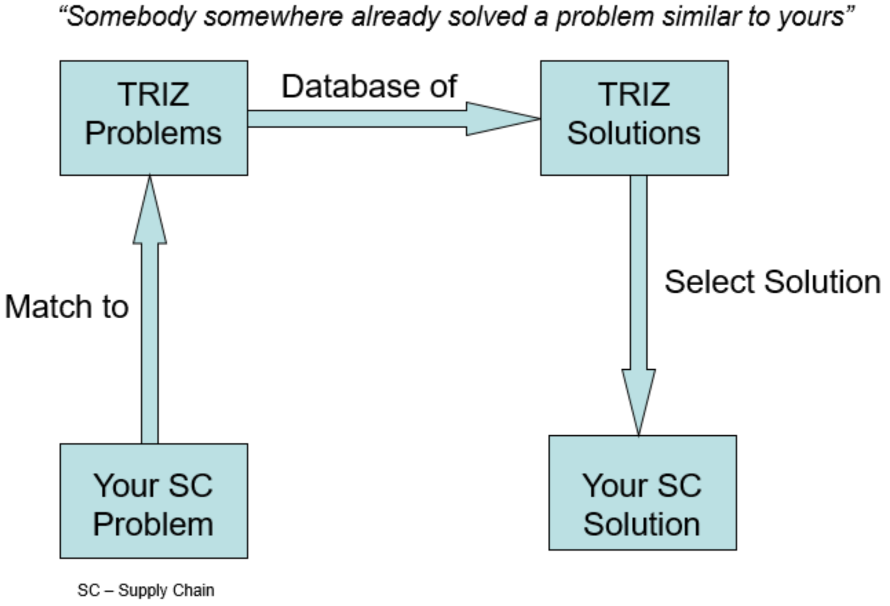
TRIZ is a Russian acronym for the Theory of Inventive Problem Solving. In the Russian language, it is referred to as Teoriya Resheniya Izobretatelskikh Zadatch. Genrikh Saulovich Altshuller (15 October 1926 - 24 September 1998) suggested and developed TRIZ methodology to overcome psychological inertia. His approach was to create a method that will be (quotation) “accessible to anyone, important to learn, and very exciting to work through. We can teach everybody to invent.”

TRIZ is a relatively new methodology, it originated after World War II, in the late 1940s. Genrich Altshuler, the father of TRIZ, was a Russian engineer, scientist, journalist, and writer. He had formal education as Mechanical and Chemical engineer; he made his first invention at the age of 14. Altshuler was imprisoned for political reasons by Stalin, but after 1953 with collapse of the dictatorship, he published 14 books, numerous papers, and taught a thousand of students.

Altshuler and his students spent over 40 years developing, testing in industry situations, and revising different areas of TRIZ methodology. At the present time, TRIZ research is still undergoing by some of his students and students of these students. There is interest in using TRIZ for non-technical applications such as quality improvement, service management, and supply chain management.

TRIZ was developed by Genrich Altshuller as a result of analysis of many thousands of patents. Altshuller recognized a pattern where some fundamental problems were solved with solutions that were repeatedly used from one patent to another, although the patent subjects, applications and timing varied significantly (see Figure 2).

Figure 2. *TRIZ Problem – Solving*



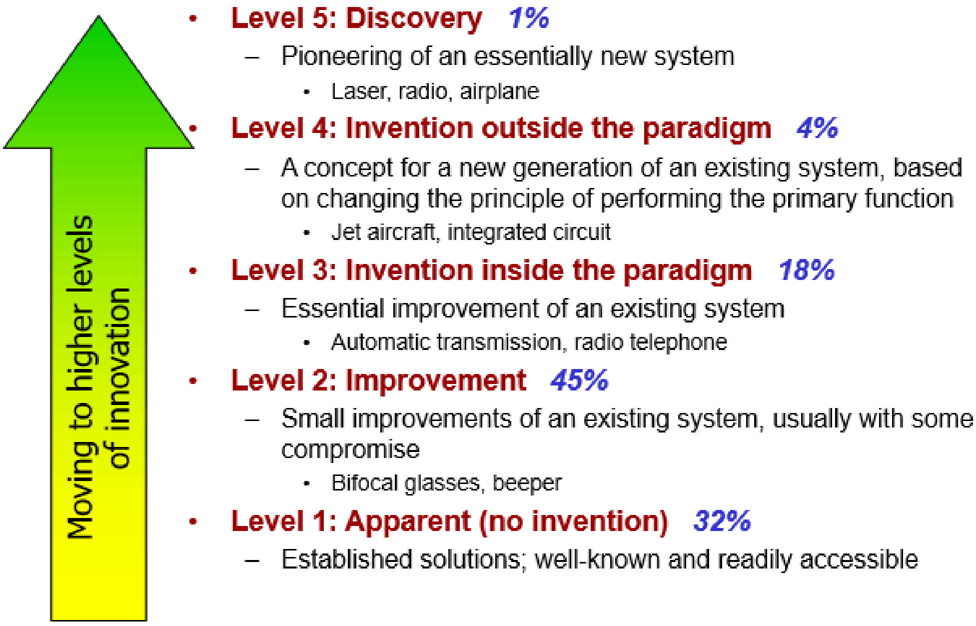
Source: adapted from #7 I-TRIZ Practitioner Program

TRIZ body of knowledge includes:

- 4 separation principles
- 40 inventive principles
- resources and effects
- lines and patterns of systems evolution
- substance–field (Su-Field) analysis
- 76 standard solutions
- algorithm for inventive problem solving (ARIZ)

Selection of a TRIZ tool depends on the level of problem-solving or invention (see Figure 3).

Figure 3. *Levels of Invention*



Source: #10 I-TRIZ Practitioner course

Most of problem solving examples from supply chain case studies later discussed in this paper are at Level 2 Improvement and few are at Level 3 Invention Inside the Paradigm.

The Notion of Contradictions

"The true test of a first-rate mind is the ability to hold two contradictory ideas at the same time," a quotation of F. Scott Fitzgerald, world famous American writer.

The underlying notion of TRIZ is the notion of contradictions. All problems occur as a result of contradictions, that is mutually exclusive requirements. There are two types of contradictions: functional and inherent.

A ***functional contradiction*** is a situation where an improvement in one useful function of a system results in the deterioration of another useful system function.

Examples of functional contradictions are:

- As automobile acceleration increases (improvement), both fuel economy and emissions deteriorate,
- The product becomes stronger (improvement), but its weight increases (bad).

Non-technical examples:

- We improve the capability of our workers (good), then they find jobs elsewhere (bad),
- Exercise is good for you, but takes time and may be relatively unpleasant and/or boring (bad).

Supply Chain Examples:

- Company divides portions of a large scale project among several suppliers to take advantage of the best skills and prices of each (good), but risks quality issues due to poor system integration and teamwork (bad),
- Buying a large number of inventory items provides price negotiation power (good), however, increases value stream waste (inventory holding costs associated with storage, handling, preservation, etc.) (bad).

An ***inherent contradiction*** represents a situation where the same parameter, property, or characteristic of an object or a system should simultaneously operate in two mutually exclusive states.

Examples of inherent contradictions:

- An automobile airbag should deploy fast (to protect an adult passenger), but should also deploy slowly (to avoid injuring a child passenger),
- A wing of airplane should have a large area (to provide lift for take-off and landing), but the same wing should have a small area (to reduce drag and achieve higher speed).

Non-technical examples:

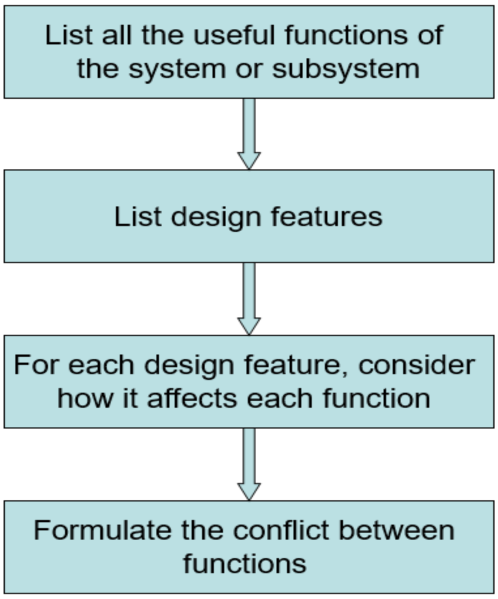
- The office temperature should be very warm to make Sue comfortable and very cool to make Sam comfortable,
- The soup should contain salt to taste good, and should not contain salt to avoid high blood pressure.

Supply Chain Examples:

- Time horizons for sales forecasts need to be long to give sufficient time for production planning (good), and need to be short to reflect changing demand and market conditions (bad),
- Design completion timing is established well before production launch (good), but lacks flexibility to accommodate late changes in customer requirements (bad).

Functional contradictions can be represented and resolved through inherent contradictions. See Figure 4 for steps to formulate a contradiction.

Figure 4. *Problem as a Contradiction*

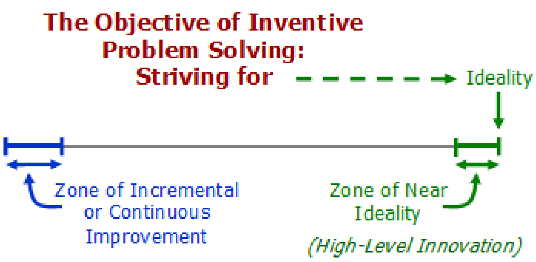


Source: above-mentioned information of this section

Win/Win Solutions and Ideal Final Result

In TRIZ, there are no compromises. Contradictions have to be successfully resolved to achieve the ideal final result. This is the major difference of TRIZ from other problem solving methodologies. In TRIZ trade-offs are <u>not</u> acceptable. The ideal final result must satisfy both contradicting requirements. The ideal final result is a solution to a problem independent of the constraints of the original problem. A solution near the ideal final result in many cases is a breakthrough solution, in contrast to incremental improvement (see Figure 5).

Figure 5. *Ideal Result*



$$\text{Ideality} = \frac{\text{Sum of all benefits}}{\text{Sum of (costs + harm)}}$$

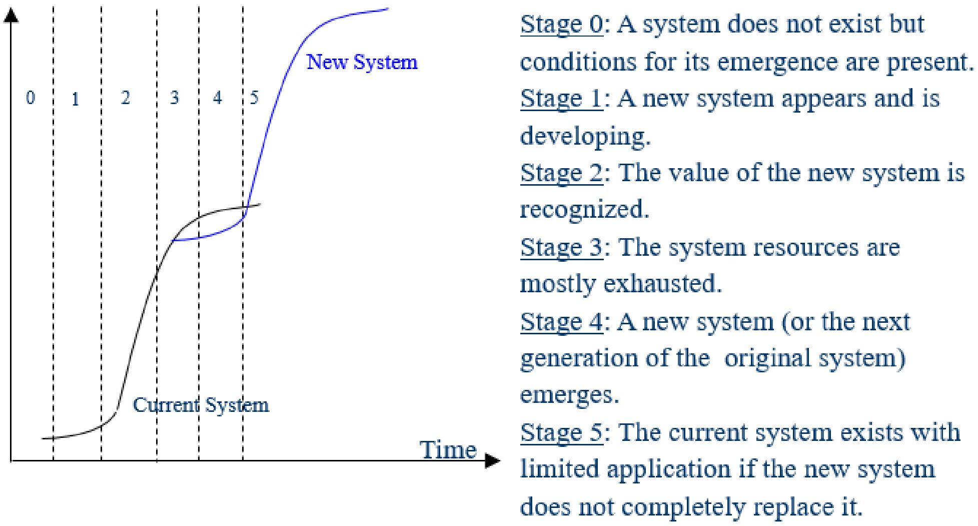
Source: #7 I-TRIZ Practitioner Program

Ideality is measured as a ratio of all useful system functions over all costs or harmful functions of this system. We can increase ideality by increasing useful functions or reducing costs and harms of this system.

The notion of ideality is demonstrated using one of consumer products – a phone. During the evolution of this consumer product, its ideality was improved by minimizing number of parts (the hearing and speaking components joined together), reducing size, improving quality and style, and increasing functionality (added features of voice messaging, speed dialing, external speaker).

TRIZ recognizes that all systems evolve toward increased ideality. The development of a system can be described by an S-curve (see Figure 6). By positioning current system on an S-curve, business practitioner can forecast future development of this system in terms of needed technology, materials, or changes in system design or structure. For businesses, this information can become competitive advantage that allows companies to become first on the market with innovative products, ahead of their competition. For these purposes, TRIZ offers methods such as lines and patterns of systems evolution, substance–field analysis, standard solutions and algorithm for inventive problem solving.

Figure 6. *System Life Cycle*



Source: adopted from #12 Leveraging Success of Six Sigma

Resources in TRIZ

Resources inside the system are critical for achieving system ideality. Smart use of existing resources saves money and eliminates waste. A resource is understood as any type of material, substance, field or energy source that can contribute to achieving an ideal final result. Idle resources inside the system or the system's environment are especially of interest. The usage of already existing, ready-to-use and plentiful resources is not only affordable, but sometimes, free.

Innovative ideas, coupled with the concept of ideality and the efficient use of resources make TRIZ a natural tool to assist teams working on value analysis/ value engineering and Lean Six Sigma.

Fast food, for example, McDonalds restaurants do not have waiters. In fact, the customers themselves perform the waiter functions. Once a customer receives his/her order at the counter, the customer delivers the food to the selected table and then removes the packaging after the meal is finished. The customer becomes the resource for food delivery, and the ideality of the system is increased with reduced overhead costs to the fast food restaurant and additional savings to the consumer.

Another example is a Russian fairytale. Two men, one older and wiser and one younger, went into the forest to hunt a bear. As they walked deeper and deeper into the woods (and further and further from their vehicle), they saw several bears, but they were too small for a trophy hunt. Finally, well away from their vehicle, they found a trophy-sized bear. The older hunter immediately provoked the bear and then both men began running in the general direction of their truck with the bear chasing after them. As they ran, the younger hunter thought to himself, "Why am I letting this bear chase me. I have a gun and I can use it." So the younger hunter stopped, turned around and shot the bear. "You are fool," said the older man. Now we have to carry this bear all the way back to our vehicle! This man had planned to use the bear as a transportation resource. Consider the ideality of this system: no transportation costs, no harmful functions (provided that the bear is slower that the running men) and a completely achieved useful function (the bear is delivered to their vehicle).

Separation Principles in TRIZ

One of key TRIZ tools is Separation Principles. Separation Principles are used to achieve a win/win resolution of an inherent conflict when it is desirable for an aspect (an object, process, parameter, function, or working condition) of a system to operate in different and opposing ways. For example**,** an automobile engine should be tuned (computer set up of fuel ejection timing, etc.) to provide good power and pick-up and should also be tuned to reduce exhaust emissions and provide good fuel economy.

Alternatively, when an aspect of a system should both exist and not exist. For example**,** aircraft landing gear must exist to hold and to transport the airplane on the ground, and the landing gear should not exist to reduce drag and allow better flight characteristics (speed, maneuver).

The purpose is to resolve the inherent conflict by separating opposing requirements:

- in space,
- in time,
- between the parts and the whole,
- based upon a condition.

Separation in Space

To determine the application of the Separation in Space principle, the following questions should be answered:

I. Where does the conflict or contradiction occur?
II. Where do I want this aspect of the system to have property X and where do I want this aspect to have a different or even opposite property Y?

Alternatively:
III. Where do I want this aspect to be present in the system and where do I want it to be absent?

Many people enjoy the refreshing and invigorating taste and aroma of hot coffee. However, a paper cup filled with fresh hot coffee is so hot it may be uncomfortable to hold the cup. This problem may be resolved using the principle of Separation in Space. Apply the question: “Where does the coffee cup need to be hot and where does the coffee cup need to be cold?” The coffee cup needs to be hot on the inside so that the consumer can enjoy hot coffee, and the coffee cup needs to be cold on the outside so the consumer can hold and carry the cup comfortably.

One solution is to separate these requirements in space utilizing an additional insulating paper ring (usually made of corrugated cardboard) as a barrier between the hot cup and hand. The outside surface temperature of the corrugated cardboard is cool compared to the surface temperature of the cup due to the added insulation of the ring. In many instances, it is more economical to change the system locally (add corrugated cardboard), rather than to make changes to the whole system (utilize a more expensive cup design).

Another example is a household refrigerator that is built to address the following system conflict: I want to have freezing temperature to preserve food for long time and I do not want to have freezing temperature for products of immediate use or products that cannot be subjected to very cold temperatures (fruits, vegetables, etc.). Refrigerator design is based on the Separation in Space principle of two compartments: one for freezing temperature and another for cool temperature. Separation in Space principle was applied over the evolution of this consumer product. At first, the freezer was located inside the whole refrigerator, and in following designs the freezer compartment was horizontally or vertically separated from the cool temperature compartment to assure easier access and efficiency.

Separation in Time

I. When does the conflict or contradiction occur?
II. When do I want this aspect of the system to have property X and when do I want this aspect to have a different or even opposite property, Y?

Alternatively:
III. When do I want this aspect to be present in the system and when do I want it to be absent?

For example, a pocket knife should be sharp to cut materials and should not be sharp so it can be safely handled during transportation or storage. The pocket knife allows a user to extract the blade for a cutting job. During transportation, storage or idle time, the blade is safely stored inside the handle. The use of the handle utilizes resources already available in the system increasing design ideality.

A sofa-bed resolves the following contradiction: I want to have a spare bed for occasional guests, but I want to have a sofa when I don't need a spare bed. The separation in time principle resolves this contradiction by transitioning the sofa into the sleeping bed or a couch depending on the need. That is, different properties of this consumer product occur at different times.

Separation between the Parts and the Whole

I. Can an aspect of the system have property X at the system level and a different or even opposite property, Y, at the component level?

Alternatively:
II. Can a system aspect exist at the system level and not exist at the component level (or vice versa)?

Consider the properties of a mechanical chain. A bicycle or jewelry chain consists of individual links that are rigid and strong. Each link is not flexible, however, the chain itself, which is a system of connected links, is flexible.

Internet technology utilizes hyperlink text. It was introduced to address the following contradiction: a computer screen should contain all the explicit information needed for the user, and the computer screen should contain only essential information presented in easy-to-read, user-friendly and organized way. A hyperlink separates the parts from the whole by allowing the system to be user-friendly, while the sub-systems contain explicit, detailed information.

Separation Based upon a Condition

I. Is there a condition where an aspect of the system has property X when the condition exists and has a different or even opposite property, Y, when this condition does not exist (but another condition might be present)?

Alternatively:
II. Is there a condition where an aspect of the system is present when the condition exists, and absent when this condition does not exist (but another condition might be present)?

For example, it is desirable for text on a computer screen to have a small font, so more information can be shown on the screen. It is also desirable for the text on the computer screen to have a larger font to make it easy to read. This contradiction is resolved by implementing a zoom-in and zoom-out feature based upon the circumstances or condition of the user. If the user desires to have an enlarged view, the zoom-out feature is used. If the user needs to closely examine details, the zoom-in feature is applied.

TRIZ Inventive Principles

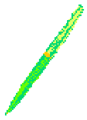
Altshuller recognized that similar fundamental *problems* have been addressed by a number of inventions in various subject matter areas. He also observed that the same fundamental *solutions* were used over and over again, often separated by the passage of many years in time. He reasoned that if the latter inventor had knowledge of the earlier solutions, their task would have been relatively straightforward, and he sought to extract, compile, and organize such information. His original research was summarized in a matrix format consisting of 39 generic conflicting system parameters and 40 inventive problem-solving principles. Altshuller discovered that certain principles had an affinity for certain combinations of system conflicts, so he recommended specific principles for any given combination of conflicting parameters.

Let us consider the following example: A team wants to design a pen that has many colors, but finds that putting more colors into the pen makes the pen too thick and too uncomfortable in the consumer's hand.

In this example, the system property or function the team wants to increase or improve is to make many colors of ink available for the pen user. Using Altshuller's matrix of inventive principles, the team chooses the following generic characteristics: #26 – Amount of Substance (thinking the more colors, the more substance we have), #33 – Convenience of Use (thinking more colors would be so convenient), and #36 – Complexity of the Device (thinking the more colors we add, the more complex the pen design becomes). Also, from the same matrix, the team finds generic matrixed characteristics related to the pen growing too thick and feeling uncomfortable. They choose: #7 – Volume of a Moving Object (thinking that the pen is movable and the volume increases as more colors are added) and #12 – Shape (thinking that it is the shape of a think pen that feels uncomfortable) (see Figure 7).

Figure 7. *Ink Pen Problem*

PEN IS TOO THICK, FEELS UNCOMFORTABLE



WANT MANY COLORS	7. VOLUME OF MOVING OBJECT	12. SHAPE
26. AMOUNT OF SUBSTANCE	15, 20, 29	35, 14
33. CONVENIENCE OF USE	1, 16, 35, 15	15, 34, 29, 28
36. COMPLEXITY OF THE DEVICE	34, 26, 6	29, 13, 28, 15

Source: adopted from #12 Leveraging Success of Six Sigma

In the cells corresponding to both feature to improve, and the degraded feature (undesired result), they find recommended inventive principles and then consider the most frequently used principles.

Most frequent principle here is Principle #15, "Dynamicity":

15a. Make an object or its environment automatically adjust for optimal performance at each stage of the operation

An idea of having a pen with three primary colors and using ink-jet technology to mix the primary colors to print any color at the pen tip.

15b. Divide an object into elements which can change position relative to each other

Create very short ink pens of various colors and stack them upon each other to form the body of the pen. When a user wants a different color, the user simply puts the color he/she wants at the bottom of the stack.

15c. If an object is immovable, make it moveable or interchangeable

Make a pen where a variety of ink cartridges are stored in a large chamber above the user's hand. The user selects the color by sliding this colored cartridge into position inside the thinner chamber where the user holds the pen.

The next step will be the evaluation of potential solutions against ideality criteria.

Examples of the same inventive principle applications in non-technical areas may be found in Table 1. Some solutions developed with this principle may include flexible layouts of offices, flexible pricing policies and organizational structures.

Table 1. *Principle #15: Non-Technical Examples*

15	Dynamicity	***a. Make an object or its environment adjust for optimal performance at each stage of operation***	• Flexible layouts of offices • Service offerings and schedules adjust to better service customers • Self-paced learning • Flexible pricing policies
		b. Divide an object into elements which can change position relative to each other	• Fold-out product labeling provides additional product information • Conglomerate structures in business • A project team which adjusts its members to meet specific needs over the course of the project
		c. If an object is immovable or rigid, make it movable and adaptive	• Flexible organizational structure • Flexible personnel strategy (overtime, temporal workers, etc.) • Highway billboards that change messages by rotating segments or by programming an electronic screen

Source: above-mentioned information of this section

Consider the following contradiction as a demonstration of the use of inventive principles for non-technical applications:
Exercise is good for you, but relatively unpleasant and takes time (bad).
Principle #22*:* "Converting Harm into Benefit" can lead to the following ideas:

Game bike and other gym equipment where work out is combined with playing video games. At present, there are attempts to bring the same approach in the office environment where work out is combined with performing normal office job duties.

Another non-technical contradiction:
We want perfect attendance at work (good), but our flu may infect others (bad).

Suggested principles:
#2: Taking out / Extraction

a. Remove or separate an interfering part or property from an object (*work from home*)

#3: Local quality

a. Change an object's structure or external environment from uniform to non-uniform *(flexible working hours)*

#10: Preliminary action

a. Perform all or part of the required action on the object in advance *(flu vaccine)*

Solving Supply Chain Problems with TRIZ

Situation 1.

Lack of free exchange of manufacturing information within the supply chain cost the U.S. auto industry about $1 billion per year in the early 2000s.

The supplier wanted their quality and design information to remain confidential, but also wanted to participate as a collaborative team with the Original Equipment Manufacturer (OEM).

Solution is based on Separation in Space and Time principles:

OEM has access to supplier's quality and design information only during OEM visits to supplier's site.

Situation 2.

OEM wants their supplier's quality problems to be addressed by finding root cause, but they want the analysis quickly which makes root cause almost impossible to find in the time given.

Applying Separation in Time principle leads to solution:

Immediate response/temporary fix: Interim Containment Actions (segregation) of defective products;

Long-term corrective action: root cause analysis and permanent fix of quality problem.

Situation 3.

OEM wants to have no quality issues in supplied components, but they want significant and active reductions in cost. OEM used to have second party quality audits of their suppliers, but to cut costs eliminated them. OEM requested their suppliers to conduct internal quality audits, which proved to be less objective than audits by OEM.

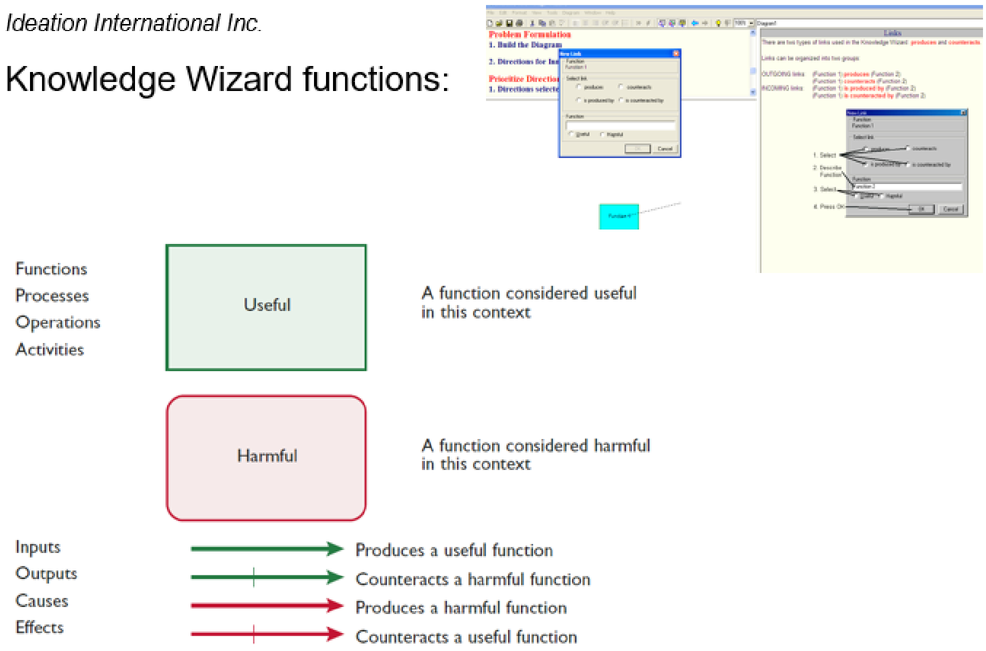
Separation upon a Condition of Short- versus Long–term strategic view of the business:

- Short - term cost reduction: OEM stopped second party audits and laid off Quality Engineers
- Long - term cost increase: Failure Costs (rework/warranty)

The next step will be the evaluation of the approach against ideality criteria.

At the present, due to technology that became available, Inventive Problem Solving is automated and assisted with software packages (see Figure 8):

Figure 8. *Automated Problem Solving*



Source: http://www.ideationtriz.com/software.asp

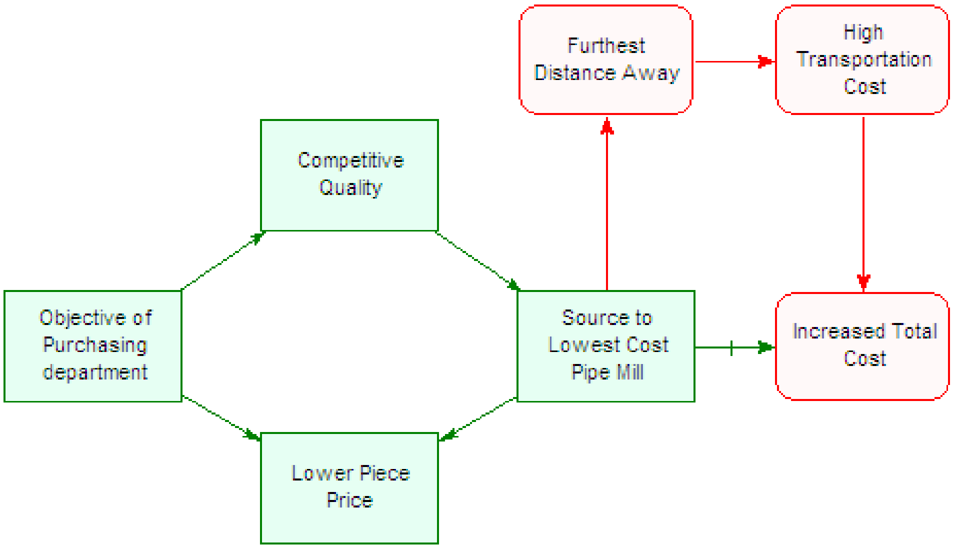
Situation 4.

Lowest cost (similar quality) mill for a pipeline happens to be the furthest away, driving up total cost due to transportation expenses.

Contradiction:
Purchasing meets objectives by sourcing to the supplier with both quality and piece price (good), but the total cost of doing business goes up because of increased transportation costs (bad).

10 ideas for inventive problem solving were identified using the following map (see Figure 9):

Figure 9. *Automated Problem Solving Map*



Source: http://www.ideationtriz.com/software.asp and above-mentioned information of this section

Software direction:
1. Find an alternative way to obtain [the] (Source to Lowest Cost Pipe Mill) that offers the following: provides or enhances [the] (Lower Piece Price), eliminates, reduces, or prevents [the] (Increased Total Cost), does not cause [the] (Furthest Distance Away), does not require [the] (Competitive Quality).

Generated ideas:

Idea # 1:
Change the objective of the purchasing department to focus on total cost, including quality, piece price, and transportation.

Idea # 2:
Change supplier quote to include transportation costs as part of the piece price.

Idea # 3:
Share shipping cost with another company that needs to ship goods to the same area (partial trucks).

Idea # 4:
Use the space inside the pipes to ship smaller items (perhaps from another company) to lower transportation cost.

Idea # 5:
Establish shared objectives between purchasing, engineering, etc. so everyone works together for win-win system solutions.

Idea # 6:
Management from purchasing and engineering exchange jobs (temporal assignment) to get a better understanding of each other's issues.

Software direction:
2. Find additional benefits from [the] (Source to Lowest Cost Pipe Mill).

Generated ideas:

Idea # 7:
Enhance the supplier selection process to include other criteria besides price and quality. Are they good collaborative partners, innovative, etc.? It may be worth the transportation costs to reap these additional benefits.

Idea # 8:
Determine if the mill could build another factory or set up a warehouse in your area**.**

Software direction:
3. Try to increase the effectiveness of the action of [the] (Source to Lowest Cost Pipe Mill) toward reducing the harmful nature of [the] (Increased Total Cost).

Generated ideas:

Idea # 9:
Make arrangements with a company who would like to test tires or truck parts (get high mileage testing quickly) to help subsidise your transportation costs.

Idea # 10:
When trucks ship to your area, they go back empty. Find another company that wants to ship something back, so that the trucks return full.

Productivity of generating solution ideas by problem solvers is obvious.

Conclusions

TRIZ is the most useful at the solution generation stage. The benefits of TRIZ methodology are:

- a systematic and structured approach to concept development that offers advantage of productivity, robustness and repeatability of the innovation process
- low-cost improvement solutions based on ideality principle that uses resources available inside the system

- a breakthrough improvement

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