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TRIZ:
A Useful Tool For DFMA Innovations

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TRIZ: A Useful Tool For DFMA Innovations

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TRIZ, pronounced "trees," is a relatively new tool to the engineering tool kit. Created in Russia by Genrich Altshuller over a fifty-year period, it was not until the 1990s that English versions of his work became available. Through the analysis of four hundred thousand Russian patents, by hand, Altshuller sought to identify the specific characteristics that every engineer strives to optimize in their designs. Thirty-nine were found. By examining these individual characteristics, Altshuller was then able to identify forty specific principles that engineers use to optimize these characteristics. Perhaps the most powerful tool for systematic innovation available on the planet today, many turn away from it because the possible permutations and combinations of a forty by thirty-nine matrix are daunting. Software, like it has done for DFMA, has simplified many of the time consuming mechanics of executing TRIZ. And, like DFMA, once one has experience with the technique, one can cut to the quick with good rational thinking.

Evolution Of Innovation Tools

Prior to 1970, there were but a handful of formal innovation tools on the planet. Yoga and meditation had been around for centuries and were scoffed at by most engineers and scientists. The go to approach was "brainstorming."

The first formal innovation tool was created in England in the 1960s by Edward de Bono, Six Thinking Hats®. This tool was geared to extracting the most valuable thinking from folks that were assigned to a common task. One's background, and level in the company hierarchy, skewed the outcome of pure brainstorming. DeBono defined a method whereby everyone thought along the same lines at once, using a single hat. Then, the next hat was used. And, so on. Giant global corporations tried the process. It was useful and gained traction. This tool has stood the test of time and is one of the predominant tools in use today.

The next group tools were all analogies to each other. Psychiatrists had been using inkblot patterns with their clients for centuries. Would a set of "ink blot like" images or short phrases spur some non-linear thinking? It turned out to be the case. Osborn's List was born. By the end of the 1980s, several tools had been developed along this same line of thinking. "Creative Whack Pack" was the most notable among them. A deck of cards with four suits, each suit posed questions along the same line of thinking and asked participants to react to the phrase on each card.

Industry demand for innovation enablers was low. The focus was on time-to-market, low product cost, assembly and manufacturing efficiency, and strong quality control. These bodies of knowledge were all convergent, innovation is divergent.

By the end of the 1990s, most companies had achieved great control over their processes and the competitive advantages that were gained by the early practitioners were now neutralized. What then? What would be the next basis of competitive advantage? Innovation!

Thought leaders saw it coming and much writing began, but industry demand was not yet sufficient to motivate venture capitalists and entrepreneurs to start creating tools yet. There simply was not enough ROI. As always, there are some exceptional risk takers. Companies and folks that bet they could make a living from the front 3% of industry that had already achieved their desired levels of convergence years before the bulk of industry. Quietly, two companies were developing software whose underpinnings were based on a new and largely unknown approach named TRIZ (pronounced "trees."). These two companies, Invention Machine and Ideation International, were developing the equivalent of manufacturing's PDM/PLM systems for engineers and scientists. Instead of dealing with parts and their assembly methods and routings, these systems dealt with lines of thinking and bodies of knowledge and learning that preceded parts. Both companies are still main players today, but this paper is not about their story. It is about TRIZ.

DFMA practitioners should already see the similarity to the work of Boothroyd and Dewhurst. Originally a manual method for the thinking person to help structure their thought processes, the complexity quickly became great enough that software bettered the clout of the tool. So was the same for TRIZ.

Since the 1990s, some three hundred tools have been created to help foster innovation. Like all emergent markets, many new products fail and few succeed. So has been the case with innovation tools. Like DFMA has stood the test of time, so have most of the tools whose underpinnings were based on TRIZ. Today, next to the USPTO Patent Database, TRIZ is the most used innovation tool by industry.

Where Did TRIZ Come From?

Back in 1946, a group in the Soviet Navy in the Caspian Sea area was assigned to inspect inventions and determine their utility. The "Invention Inspections Department," saw a great cross section of new capabilities created by inventors and companies in the U.S.S.R. Within this department, most new things crossed the desk of Genrich Altshuller. A systems thinker, Genrich began casually observing patterns of things that worked and things that did not work. On his own initiative, he began to study the subject.

A long story that is well documented in literature, can be boiled down to a few short sentences. Innovation does not have to be unstructured, it can be systematic. Not all patents are innovative, but patents that are innovative have common principles that made them innovative. These principles can be extracted from patents and generalized. Generalized approaches can then be applied to new problems and adapted directly in the context a new problem to generate specific and innovative solutions to that problem.

Altshuller dedicated his life to the analysis of patents in the Soviet Union to cull out the set of innovative principles that cross technical domains, and to identify the design conflicts that lead to the innovation that solved them.

After screening about 200,000 patents over a number of years, Altshuller identified 40,000 of them that were innovative and set about the more detailed study of that group. Completing this work in the late 1960s, Altshuller identified that there were about 39 generic design characteristics [Figure 1] that technologists try to optimize.

Figure 1
Characteristics That Technologists Optimize

1. Weight of moving object
2. Weight of nonmoving object
3. Length of moving object
4. Length of nonmoving object
5. Area of moving object
6. Area of nonmoving object
7. Volume of moving object
8. Volume of nonmoving object
9. Speed
10. Force
11. Tension, pressure
12. Shape
13. Stability of object
14. Strength
15. Durability of moving object
16. Durability of nonmoving object
17. Temperature
18. Brightness
19. Energy spent by moving object
20. Energy spent by nonmoving object
21. Power
22. Waste of energy
23. Waste of substance
24. Loss of information
25. Waste of time
26. Amount of substance
27. Reliability
28. Accuracy of measurement
29. Accuracy of manufacturing
30. Harmful factors acting on object
31. Harmful side effects
32. Manufacturability
33. Convenience of use
34. Repairability
35. Adaptability
36. Complexity of device
37. Complexity of control
38. Level of automation
39. Productivity

And, there were about 40 generic solutions [Figure 2], "inventive principles," that resulted in the optimization of these generic design characteristics. "TRIZ" was born.

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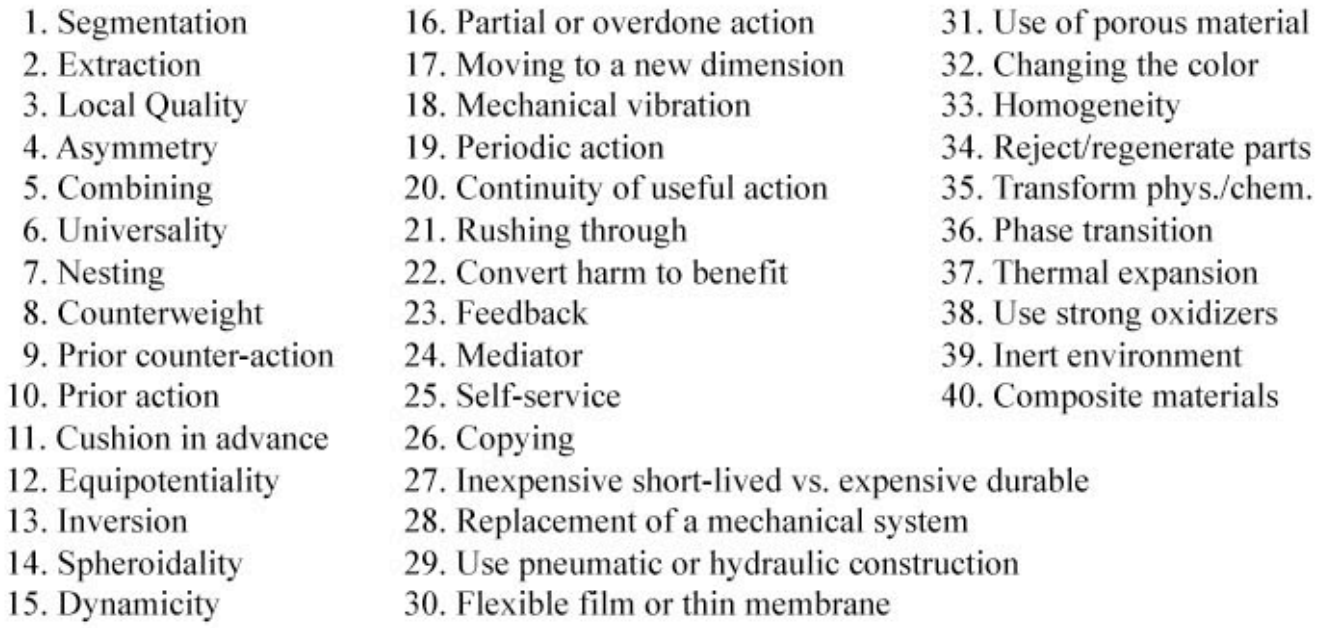
Figure 2
Inventive Principles For Eliminating Technical Contradictions



1. Segmentation
2. Extraction
3. Local Quality
4. Asymmetry
5. Combining
6. Universality
7. Nesting
8. Counterweight
9. Prior counter-action
10. Prior action
11. Cushion in advance
12. Equipotentiality
13. Inversion
14. Spheroidality
15. Dynamicity
16. Partial or overdone action
17. Moving to a new dimension
18. Mechanical vibration
19. Periodic action
20. Continuity of useful action
21. Rushing through
22. Convert harm to benefit
23. Feedback
24. Mediator
25. Self-service
26. Copying
27. Inexpensive short-lived vs. expensive durable
28. Replacement of a mechanical system
29. Use pneumatic or hydraulic construction
30. Flexible film or thin membrane
31. Use of porous material
32. Changing the color
33. Homogeneity
34. Reject/regenerate parts
35. Transform phys./chem.
36. Phase transition
37. Thermal expansion
38. Use strong oxidizers
39. Inert environment
40. Composite materials

Based on the study of empirical data from patents, "Teoriya Resheniya Izobreatatelskikh Zadatch" is translated as "a methodical way of examining inventive situations and developing numerous solution concepts by utilizing all available solution spaces."

Reducing TRIZ's Complexity

Having defined the basic tenants of systematic innovation, the next task was to portray the results in a practical framework. The number of possible combinations that one had to think through was mind-boggling. However, it stands to reason that not every solution approach applied to every possible problem. As Altshuller was going through his analysis of innovative patents, he had observed that at most a handful of possible solutions applied to a given design problem. In fact, with a bit of an eye test, the likely solutions to a given problem could be portrayed in a matrix. The "Contradiction Table" was born.

Step back and think for a moment. Isn't it true that whenever a design problem occurs that some type of "trade-off" has to be made? What is a trade-off? A trade-off is the improvement of one design parameter to the degradation of another design parameter. That is usually the case in engineering practice. For design to be optimized, manufacturing/producibility usually has to be sub optimized. And, vice versa. Numerous other examples exist, mechanical vs. electrical, etc.

However, it is not always the case. Achieving optimization of a parameter does not necessarily have to degrade another parameter. Isn't that also true of DFMA, much of the time? Perhaps the most brilliant outcome of the TRIZ methodology is the systematic ability to optimize one parameter without degrading another.

The Contradiction Table is a 40x40 table that pits trade-offs against each other on the X and Y axes. In the cells that intersect, Altshuller listed the handful of specific possible solutions (out of the 39 total possible solutions) that will optimize the design without degrading either of the conflicting parameters.

That said, even the Contradiction Table is ornery to the novice or early intermediate practitioner. It is a natural to be software-enabled.

When TRIZ first arrived in the USA in the early 1990s, it was said that it could take as much as three to six months to become proficient in the technique. Today, most practitioners estimate that proficiency can be achieved in three weeks. Becoming a Six-Sigma Black Belt takes longer and millions have done that. Becoming a Black Belt Systematic Innovator is likely well worth the investment.

TRIZ In Practice

Many TRIZ-based innovations are not identified to TRIZ as the enabler. Those companies that have mastered it, or whom hire outside experts to apply TRIZ when they arrive at untenable trade-offs, consider it a competitive advantage.

One of the better-known examples is the new plastic water bottle that has hit the market in the past five years. Originally bottled water came in a fairly thick and rigid cylindrical plastic bottle with a large cap. A few years back, squishy crinkly water bottles with a larger top than bottom and small caps hit the market. While having about half the mass (and half the cost) of the original pure cylinder, these bottles did not leak nor slip through one's hands. And, they had half the environmental footprint too. These water bottles were actually a secondary application after TRIZ was used to improve the design of traditional beakers and flasks used by chemists in laboratories. After TRIZ-based innovation reduced the likelihood of beakers slipping tor breaking in the hands of scientists and robotic handlers creating HAZMAT situations, it was pretty easy to port the solution to water bottles. What is the equivalent of the beaker problem at your company, or in your company's product line? TRIZ may be just what you need!

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A Note About The Author: Bradford L. Goldense NPDP, CMfgE, CPIM, CCP is president of GGI. Founded in 1986, the consulting-market research-education company is recognized across the major *industrial continents for expertise in R&D, advanced and product development, innovation, and the metrics that drive corporate performance. Mr. Goldense has worked with 200 of the Fortune 1000 and over 500 global manufacturing locations. GGI is based in Needham, Massachusetts.*

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