

## **Managing Creativity for Project Success**

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Technical risk is one leading threat to the cost and schedule targets of new product development projects. Whether the “product” is a physical product, and information technology system, a service, a new business concept, or a hybrid of these, the technical risks frequently become apparent late in development, when difficulties are encountered with prototypes, with scaling up to production, with developing support services, or in other areas that were difficult to analyze or simulate early in the project.

In the past, project managers have consciously avoided all kinds of “creativity” on projects, in the belief that creative problem solutions increase the risk of project failure, since “creativity” has had the reputation for being wild, uncontrolled, undisciplined generation of new ideas that were of limited (or no!) practicality. So they were right—creativity was a danger to the project.

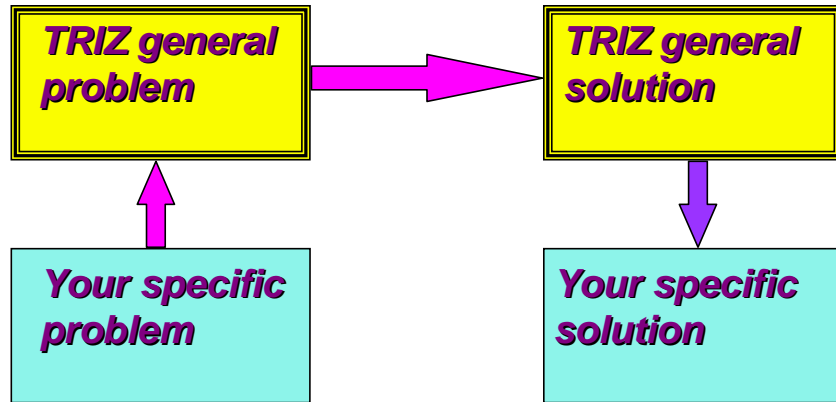
**But creativity can be managed. It can be focused. And it can be the reason that the project succeeds.**

TRIZ is a problem solving method that accelerates the project team’s ability to solve these risk-creating problems (Tate and Domb 1997). “TRIZ” is the acronym in Russian for “Theory of Inventive Problem Solving.” The method was developed by G. Altshuller and his colleagues from the late 1940’s through the 1980’s in the former USSR. (Altshuller 1988) It is now an international science of creativity that relies on the study of the patterns of problems and solutions, not on the spontaneous creativity of individuals or groups. Over 2.8 million patents have been analyzed to discover the patterns that predict breakthrough solutions to technical problems.

TRIZ research began with the hypothesis that there are universal principles of invention that are the basis for creative innovations that advance technology, and that if these principles could be identified and codified, they could be taught to people to make the process of invention more predictable. The research has proceeded in several stages over the last 50 years. The three primary findings of this research are as follows:

- 1. Problems and solutions were repeated across industries and sciences**
- 2. Patterns of technical evolution were repeated across industries and sciences**
- 3. Innovations used scientific effects outside the field where they were developed**

Much of the practice of TRIZ consists of learning these repeating patterns of problems-solutions and patterns of technical evolution, and methods of using scientific effects, and applying the general TRIZ patterns to the specific situation that confronts the developer. Exhibit 1 describes this process graphically.



*Exhibit 1. The TRIZ problem solving method. The arrows represent transformation from one formulation of the problem or solution to another. The pink arrows represent analysis of the problems and analytic use of the TRIZ data bases. The purple arrow represents thinking by analogy to develop the specific solution.*

For example, a powerful demonstration of this method comes from the pharmaceutical industry (Anderson, 1997). Following the flow of Exhibit 1, the *specific problem* is as follows: Tailored bacteria are used to cultivate human hormones, producing a superior product to those refined from animal sources. To produce the product, very large quantities of tailored bacteria cells are cultured, then the cells must be broken open, and the cell wall material removed, so that the useful hormones can be processed. A mechanical method for breaking the cells had been in use at a moderate scale for some time, but the yield was 80%, and was variable. A current crisis was a reduction in yield to 65%, and a long-term problem was anticipated in trying to scale production up to high rates, with yield much better than 80%.

The *TRIZ general problem* at the highest level is to find a way to produce the product with no waste, at 100% yield, with no added complexity. A *general TRIZ solution* formula is “The problem should solve itself.” Another general TRIZ solution is that the pattern of technical evolution is that mechanical devices are replaced by fields. This may seem very general, but it led the pharmaceutical researchers to analyze all the resources available in the problem (the cells, the cell walls, the fluid they are in, the motion of the fluid, the processing facility, etc.) and to conclude that three *specific solutions* had very high potential for their problem:

1. The cell walls should be broken by sound waves (from the pattern of evolution of replacing mechanical means by fields)
2. The cell walls should be broken by shearing, as they pass through the processing facility (using the resources of the existing system in a different way.)
3. An enzyme in the fluid should “eat” the cell walls and release the contents at the desired time

All three methods have been tested successfully, and the least expensive, highest yield method was in production in a very short time.

The “General TRIZ Solutions” referred to in Exhibit 1 have been developed over the course of the 50 years of TRIZ research, and have been organized in many different ways (Domb 1997, 2) (Frenklach, 1998). Some of these are analytic methods, such as

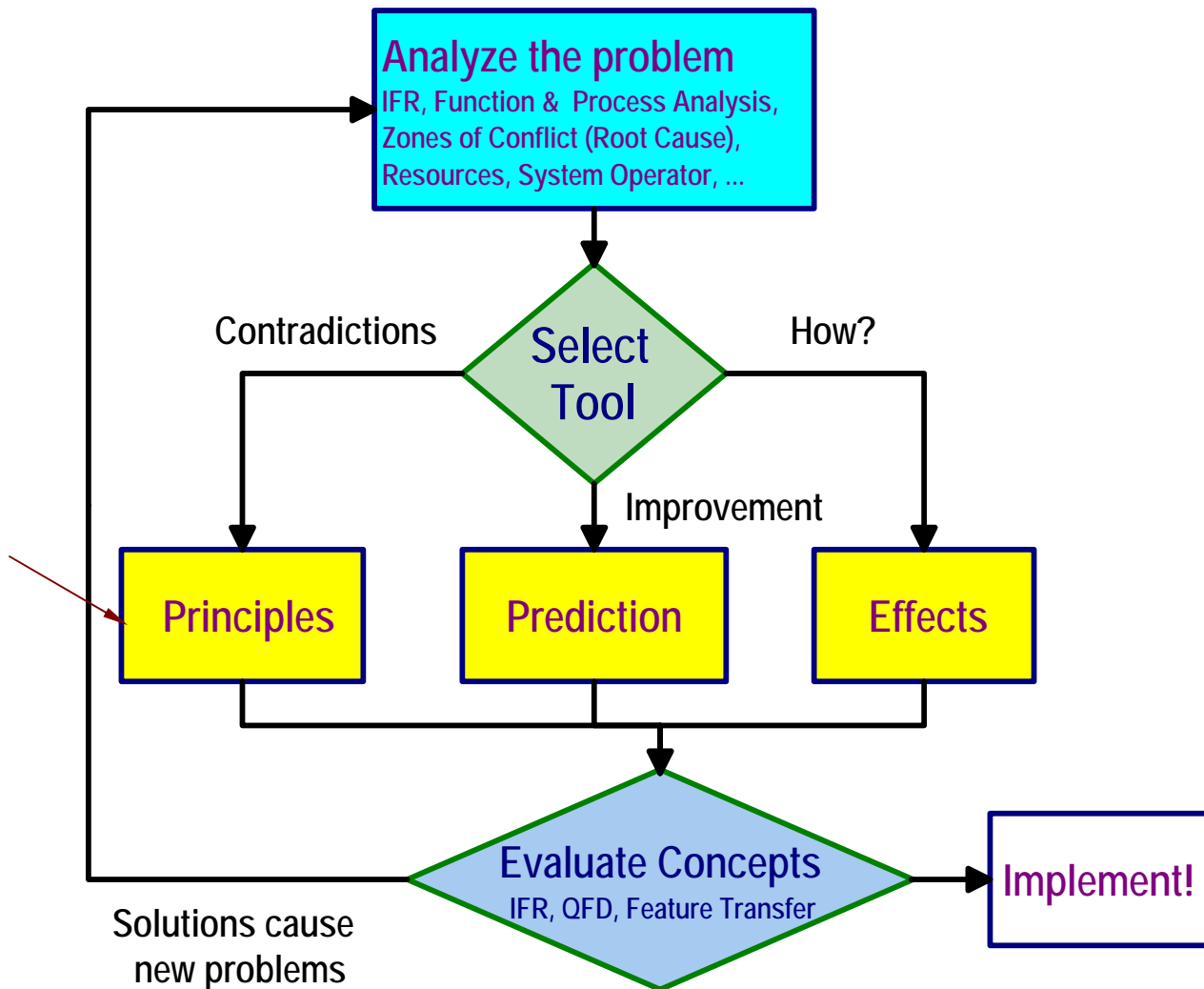
- The Ideal Final Result
- Functional Analysis and Trimming
- Locating the Zones of Conflict (More familiar to Western project managers as “Root Cause Analysis.”)

Some are more prescriptive, such as

- The 40 Principles of Problem Solving
- The separation principles
- Laws of technical evolution and technology forecasting

In the course of solving any one technical problem, one tool or many can be used. A flow chart for problem solving is shown in Exhibit 2.

The 40 Principles of Problem Solving are the most accessible “tool” of TRIZ. (Tate and Domb 1997, Altshuller 1988, Domb 1997, Shulyak 1998) These are the principles that were found to repeat across many fields, as solutions to many general categories of problems. They are used to resolve contradictions, such as those that frequently put new product development projects at risk. (This is the box marked ➔ in Exhibit 2.)



*Exhibit 2. Flowchart for the use of some of the tools and techniques of TRIZ*

TRIZ recognizes two categories of contradictions:

• **Technical contradictions** are the classical engineering “trade-offs.” The desired state can’t be reached because something else in the system prevents it. In other words, when something gets better, something else gets worse. Classical examples include

- \* The product gets stronger (good) but the weight increases (bad)
- \* The bandwidth increases (good) but requires more power (bad)
- \* Service is customized to each customer (good) but the service delivery system gets complicated (bad.)
- \* The automobile airbag should deploy very fast, to protect the occupant (good) but the faster it deploys, the more likely it is to injure or kill small people or out of position people (bad)

•**Physical contradictions** are situations where one object has contradictory, opposite requirements. Everyday examples abound:

- \* Surveillance aircraft should fly fast (to get to the destination) but should fly slowly to collect data directly over the target for long time periods.
- \* Software should be easy to use, but should have many complex features and options.
- \* Coffee should be hot, for enjoyable drinking, but cold, to prevent burning the customer
- \* Training should be thorough and not take any time
- \* The automobile airbag should deploy quickly and slowly.
- \* The automobile airbag should deploy at high threshold and low threshold.

The TRIZ research has identified 40 principles that solve the **Technical contradictions** and four principles of separation that solve the **Physical contradictions**. As in the case of the air bag deployment threshold, many problems can be stated as both physical and technical contradictions. When using the TRIZ research findings, in general the most comprehensive solutions come from using the physical contradiction formulation, and the most prescriptive solutions come from using the technical contradiction. In terms of learning, people usually learn to solve technical contradictions first, since the method is very concrete, then learn to solve physical contradictions, then learn to use both methods interchangeably, depending on the problem.

The TRIZ patent research classified 39 features for technical contradictions. Once a contradiction is expressed in the *technical contradiction* form (the trade-off) the next step is locate the features in the Contradiction Matrix. (Domb 1997, Mann and Domb, 1999) Exhibit 3 shows a piece of the matrix.

Worsening Feature → Improving Feature ↓		Volume of moving object	Speed	Force (Intensity)	Stress or pressure	Shape	Reliability	Object-generated harmful factors	Ease of operation	Ease of repair	Device complexity	Difficulty of detecting and measuring
		7	9	10	11	12	27	31	33	34	36	37
9	Speed	7, 29, 34	+	13, 28, 15, 19	6, 18, 38, 40	35, 15, 18, 34	11, 35, 27, 28	2, 24, 35, 21	32, 28, 13, 12	34, 2, 28, 27	10, 28, 4, 34	3, 34, 27, 16
10	Force (Intensity)	15, 9, 12, 37	13, 28, 15, 12	+	18, 21, 11	10, 35, 40, 34	3, 35, 13, 21	13, 3, 36, 24	1, 28, 3, 25	15, 1, 11	26, 35, 10, 18	36, 37, 10, 19
11	Stress or pressure	6, 35, 10	6, 35, 36	36, 35, 21	+	35, 4, 15, 10	10, 13, 19, 35	2, 33, 27, 18	11	2	19, 1, 35	2, 36, 37
12	Shape	14, 4, 15, 22	35, 15, 34, 18	35, 10, 37, 40	34, 15, 10, 14	+	10, 40, 16	35, 1	32, 15, 26	2, 13, 1	16, 29, 1, 28	15, 13, 39
15	Duration of action of moving object	10, 2, 19, 30	3, 35, 5	19, 2, 16	19, 3, 27	14, 26, 28, 25	11, 2, 13	21, 39, 16, 22	12, 27	29, 10, 27	10, 4, 29, 15	19, 29, 39, 35
33	Ease of operation	1, 16, 35, 15	18, 13, 34	28, 13, 35	2, 32, 12	15, 34, 29, 28	17, 27, 8, 40		+	12, 26, 1, 32	32, 26, 12, 17	

*Exhibit 3. Selected rows and columns from the Contradiction Matrix. The numbers in the cell refer to the principles that have the highest probability of resolving the contradiction. The circled cell is discussed in the example in the text.*

Find the row that most closely matches the feature or parameter you are improving in your “trade-off” and the column that most closely matches the feature or parameter that degrades. The cell at the intersection of that row and column will have several numbers. These are the identifying numbers for the Principles of Invention that are most likely, based on the TRIZ research, to solve the problem: that is, to lead to a **breakthrough** solution instead of a trade-off.

For example, consider the proposal to change the speed of inflation of the air bag, to reduce injuries to small occupants. The trade-off is that injuries in high speed accidents increase. Translating this into the TRIZ matrix terms, the parameter that improves is “Duration of action of a moving object” (Row 15) and the parameter that worsens is “Object-generated harmful effects” (Column 31). The circle in Exhibit 3 highlights the cell at the intersection, that has the notation “21,39,16,22”. These are the identifiers for four of the Principles of Invention.

The principles are usually accompanied by examples from a variety of industries. The design or problem solving team uses both the text and the examples, and examples from their own previous applications, to develop a solution. Consider the application of principle 21 and principle 22 to the airbag example:

### **Principle 21. Skipping**

A. Conduct a process, or certain stages (e.g. destructible, harmful or hazardous operations) at high speed.

- *Use a high speed dentist's drill to avoid heating tissue.*
- *Cut plastic faster than heat can propagate in the material, to avoid deforming the shape.*
- ➔ *Inflate the air bag faster than current practice, so that it is fully inflated when the small person impacts it.*
- ➔ *The de-powered air bag has been proposed as a solution of this type. By using less power, the acceleration of the bag is less, and injuries will be reduced.*
- ➔ *Conversely, smaller bags with higher power would reach full inflation sooner, so that the passenger would be protected from the accident and not injured by the air bag.*

### **Principle 22. “Blessing in disguise” or “Turn Lemons into Lemonade”**

A. Use harmful factors (particularly, harmful effects of the environment or surroundings) to achieve a positive effect.

- *Use waste heat to generate electric power.*
- *Recycle waste (scrap) material from one process as raw materials for another.*

- → *Use the relative motion of the person and the vehicle as part of the protection. Design other parts of the system (seat, dash, side panels) to redirect the moving person to be properly placed for best air-bag protection.*
- B. Eliminate the primary harmful action by adding it to another harmful action to resolve the problem.
- *Add a buffering material to a corrosive solution.*
  - *Use a helium-oxygen mix for diving, to eliminate both nitrogen narcosis and oxygen poisoning from air and other nitrox mixes.*
- C. Amplify a harmful factor to such a degree that it is no longer harmful.
- *Use a backfire to eliminate the fuel from a forest fire*
  - *This again suggests inflating the air bag faster, so that it is no longer harmful by the time the person reaches it.*

TRIZ has 4 classical ways to resolve physical contradictions

1. Separation in time
2. Separation in space
3. Phase transition
  - Solid - liquid - gas - plasma
  - Paramagnetic -Ferromagnetic
  - Others—ferroelectric, superconducting, crystal structure, ...
4. Move to the super-system or the sub-system

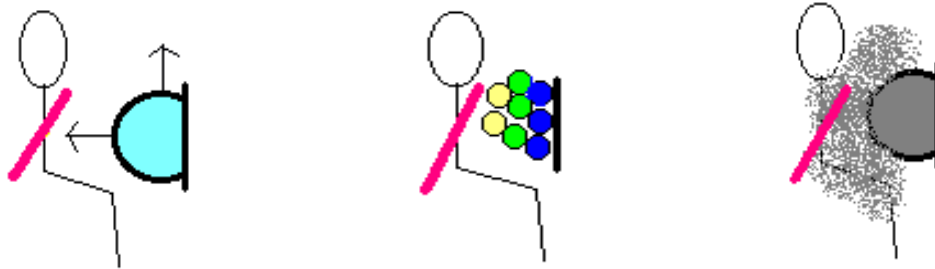
Examination of the 40 Principles shows extensive overlap with these 4 methods, since they are based on the same research on the same collection of innovative solutions to a wide variety of problems. For example, one dominant physical contraction for the air bag system is

- The automobile airbag should deploy at high threshold and low threshold.

Since this is a contradiction, the answer will not be a number—that would be the non-TRIZ way of doing a trade-off. Applying the 4 methods for resolving a physical contradiction will cause us to deal with the *cause* of the problem (air bags cause injuries) and not just with the short-term solution (changing the speed of deployment.)

Applying the first of the 4 ways to resolve the contradiction, *separate the requirements in space* leads to ideas like using a low deployment threshold for a belted, average sized or above driver, and a high deployment threshold for a small driver or unbelted passenger, addressing just the ways to resolve the deployment threshold problem. It introduces problems of sensor and logic complexity, so that the car “knows” where to set the threshold, so it is not a very good solution in terms of ideality. Simple but unpopular solutions, put children in the back seat (separate them in space from the air bag) and have drivers sit as far as possible from the steering column (using pedal extenders, special seats, etc.) are already well known. But this principle it could also lead us to look in detail at the *space* where the problem occurs. Could the shape of the airbag be changed so that it is fully deployed when the short person reaches it? And still protect the average and large person? One of the TRIZ laws of technology evolution states that systems become more segmented, because smaller segments are easier to control. Combining this with

the desire to separate the injury-causing and injury-preventing elements in space leads to a family of designs that use micro-airbags, as shown in Exhibit 4.



*Exhibit 4. The TRIZ laws of technology evolution predict the progression of airbags from single bag, to multiple bags, to a foam or powder protection system. Combining the laws of evolution with the principle of separation of requirements in space leads to breakthrough solutions to the problem.*

TRIZ was developed from the study of patents, but the underlying principles of creativity that were discovered in that research apply to a wide variety of problems. Recent case studies of actual situations include the following:

- **IT Product development.** DelCor Interactives International doubled the value to the customer of their patient interview system for opticians offices by applying the feedback and self-service principles of TRIZ (Domb and Corbin 1998) to the overall product development, and applying the principles of segmentation, “taking out” and “composite construction” to the training and support.
- **School administrators** are finding their creativity has been greatly enhanced in dealing with situations ranging from allocation of the budget for special education to building 5 schools with a funding for 4, to improving racial harmony in the schools. (Hooper 1998)
- **NASA’s Jet Propulsion Laboratory** has made TRIZ a principle technology for planetary exploration. New concepts for an integrated opto-electronic accelerometer, replacement technology for temperature-sensitive batteries, soil chemistry measurement systems, and large space telescope mirrors have all come from their work in the last 2 years (Blosiu 1998)
- **Warranty cost reduction.** Ford used TRIZ to solve a persistent problem with squeaky windshields that was costing several million dollars each year. (Lynch 1997) Previously, they had used TRIZ to reduce idle vibration in a small car by 150%, from one of the worst in its class to 30% better than the best in class. (Smith 1996)

TRIZ reduces project management risk by giving project managers problem-solving tools and, used creatively, problem prediction tools. Using the TRIZ methods can help you solve technical problems, management problems, and resource limitation problems.

## References:

- Altshuller, Genrich. 1988, Translated by Anthony Williams. *Creativity as and Exact Science*. Gordon and Breach, New York.
- Anderson, Wesley; Farrell, Justin, and Tate, Karen, PMP. 1997. "TRIZ Applied to Solving Manufacturing Problems and Improvement." *Proceedings of the 3d Annual International Total Product Development Symposium*, American Supplier Institute, Livonia, MI.
- Blosiu, Julian 1998. "TRIZ and Innovative Design Technology" *Proceedings of the 14<sup>th</sup> Annual GOAL/QPC Symposium*, GOAL/QPC, Methuen, MA.
- Domb, Ellen. 1997 "Tutorial on Contradictions" *The TRIZ Journal*, <http://www.triz-journal.com>, July, 1997
- Domb, Ellen. 1997,2 "QFD and TRIZ/TIPS" *Transactions of the Third International QFD Symposium*, Linkoping, Sweden.
- Domb, Ellen and Corbin, David, 1998. "QFD, TRIZ and Entrepreneurial Initiative." *Proceedings of the 10<sup>th</sup> Quality Function Deployment Symposium*, Novi, MI. Reprinted in *The TRIZ Journal*, <http://www.triz-journal.com>, September 1998.
- Domb, Ellen, and Kowalick, James. 1998. "Applying TRIZ to Develop New Designs for the Future of the Airbag." *Proceedings of the 1998 Society of Automotive Engineers International Congress*, Paper Number 980647.
- Frenklach, Gregory. 1998. "Functional Blocks" *The TRIZ Journal*, <http://www.triz-journal.com>, January, March, April, and May 1998.
- Hooper, Don; Aaron, Kathy; Dale, Holly, and Domb, Ellen. 1998. "TRIZ in School District Administration" *The TRIZ Journal*, <http://www.triz-journal.com>, February, 1998.
- Lynch, Michael. 1997. "Windshield/Backlight Molding Squeak and Flutter (Buzz) Problem." *Proceedings of the 3d Annual International Total Product Development Symposium*, American Supplier Institute, Livonia, MI. Reprinted in *The TRIZ Journal*, <http://www.triz-journal.com>, January 1998.
- Mann, Darrel, and Domb, Ellen. "40 Principles for Business, with Examples." *The TRIZ Journal*, <http://www.triz-journal.com>, September, 1999.
- Shulyak, Lev. 1998. **40 Principles: TRIZ Keys to Technical Innovation**, Translation, with additional material, of the 1974 class notes by Genrich Altshuller, with drawings by Uri Fedoseev, Technical Innovation Center, Worcester, MA.
- Smith, Larry 1996. "Using TRIZ to reduce vibration during idling." *Proceedings of the 12<sup>th</sup> Annual GOAL/QPC Symposium*, GOAL/QPC, Methuen, MA.
- Tate, Karen, PMP and Domb, Ellen. 1997. "TRIZ: Tools for Accelerating New Product Development" *Proceedings of the 1997 PMI Symposium*.