TRIZ: UNCOVERING HIDDEN TREASURES

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'He that will not apply new remedies must expect new evils for Time is the greatest innovator'. Francis Bacon (1625)

There is nothing more difficult to carry out, not more doubtful of success, not more dangerous to handle, than to initiate a new order of things. For the reformer has enemies in all who profit from the old and only lukewarm defenders in all those who would profit by the new order. Machiavelli (1560)

ABSTRACT

Whilst governments are aware of the need for industries to become more innovative and create various schemes to provide encouragement, very little will come of this unless people have the skills to 'invent'. Whilst some inventions do result from gifted people or by flashes of insight, these are really quite rare. The underlying concept of TRIZ is that innovation can result from logical processes using an abundance of 'treasures' first discovered and developed by the Russian, Genrich Altshuller.

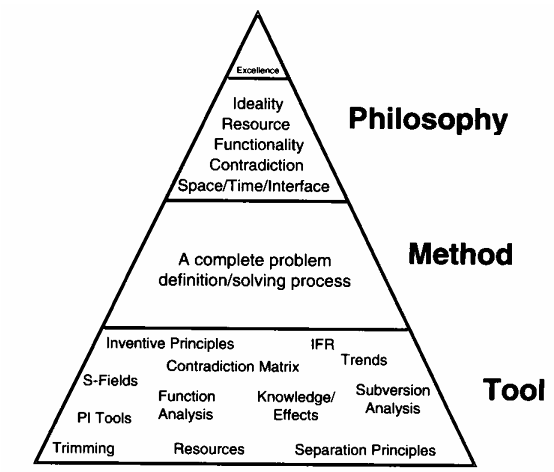
The purpose of this paper is to bring TRIZ to the attention of the reader and, hopefully, lead him on to finding out more about this extraordinary methodology. The understanding and use of TRIZ migrated to the west in the last ten years. Perhaps the time has come for 'the East' to examine its potential.

Although originally created to deal with mechanical problem solving, applications to many other fields are being developed such as electronics, biology, management, sustainable development and environmental problems.

INTRODUCTION

TRIZ (pronounced 'Trreeez') is a Russian language acronym for '***Teoriya Resheniya Izobreatatelskikh Zadatch***': **'The theory of creative problem solving' or 'inventive problem solving'**

It is way of thinking, a philosophy, methods and tools.
Fig 1:



...which makes it clear that it is not something that you will learn in a 20 minute talk. To become proficient in it requires a commitment and long practice. However, remarkable results have been obtained even in one-day introductory sessions.

The purpose of this talk is only to tell you of its existence, how it evolved and to shed a little light on its basic philosophy and methods

TRIZ initially evolved to solve problems with products but recent years work has been done to use it in other fields.

WHAT IS TRIZ?

The ‘inventor’ (or perhaps, ‘discoverer’) of TRIZ was Genrich Altshuller who was born in 1926 and whose his first invention, for obtaining hydrogen from hydrogen peroxide, was filed when he was 14 years old.

As a mechanical engineer, he developed a conviction that there should be a standard method for problem solving that would be:

1. systematic: step by step;
2. a process from broad solutions to specific solutions;
3. repeatable and not dependent upon psychological tools (e.g. ‘brainstorming’);
4. create a body of inventive knowledge for future access;
5. teachable

From 1946-48, he served in the Russian navy as ‘Inspector of Inventing’ and was able to explore this conviction by studying the patents lodged by inventors. This was made relatively easy in that all inventions were owned by the state and the inventor was issued with a single-page ‘Author’s Certificate’. Thus, Altshuller, together with another, Raphael Shapiro, were able to go through 200,000 patents and reduce them to 40,000 for their study.

This not only strengthened Altshuller’s convictions but also enabled him to start developing a process. With a sense of patriotism, they wrote to Stalin explaining how Soviet engineers and scientists could do better. The result was arrest, torture and a sentence of 25 years in Siberia for attempting to undermine the state. (See Machiavelli!).

In 1953, Stalin died and, in 1956, Altshuller published his first article on TRIZ. During the period 1974 - 85, he wrote over 14 books and published in education and the media. For children, there was a regular TV show and a book ‘And Suddenly an Inventor Appeared’. The notion of education for innovation was far ahead in Russia than in the west and it was not until 1985 when two ‘followers’ migrated to the USA, that anyone outside Russia had taken any notice.
Systematic method.

Now the number of people exploring, developing TRIZ is increasing world-wide.

ALTSHULLER’S FINDINGS AND CONCLUSIONS

Levels of innovation

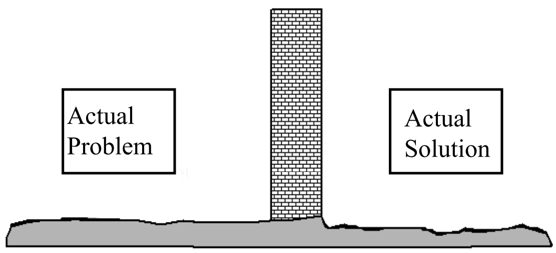
He identified five levels of innovation. The table shows the proportion of these that occurred in the patents that he studied:

Level 1. Routine problems solved by methods well know within a speciality: little innovation . 32%
Level 2. Minor improvements of an existing system inside a technology largely using compromises. 45%
Level 3. Fundamental improvements using methods outside of the industry and resolving contradictions. 18%
Level 4. New principles to perform primary functions mostly through scientific knowledge. 4%
Level 5. Dependent upon a new scientific discovery. 1%

A complementary finding was that 95% of the problems solved in any technology in levels 1 to 3 had already been solved in another!

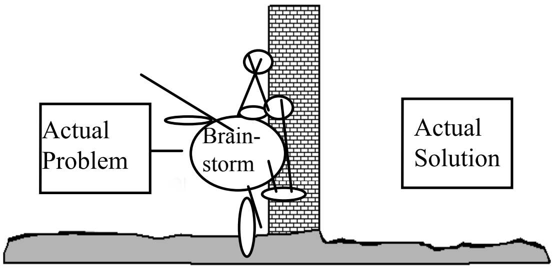
The underlying principle: abstraction

In the most simplistic terms, an actual problem with a solution hidden by the wall.
Fig. 2:

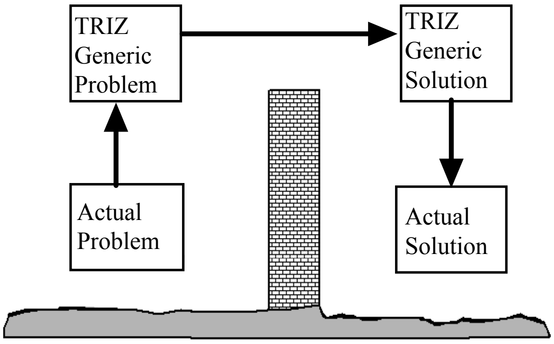


In brainstorming, we set to and chip away at the wall hoping that one idea will lead to another and eventually the brick drops to make a hole big enough to reveal a solution.

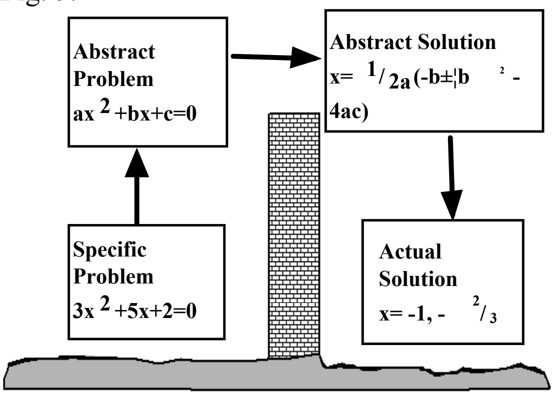
Fig.3:



Altshuller's conviction was that, instead of this 'psychological' method, it must be possible to put the problem into an abstract statement that could then be subjected to certain definable processes. Fig. 4:



The analogue of this is mathematics.
Fig. 5:



..which shows an equation in which we want to find the values of x and y. If we know nothing about mathematics (or have forgotten it), we can 'brainstorm' until we hit upon the right numbers. However, if we take a look at our maths. book, we see that there is a generic statement in symbols that helps solve this problem called a 'quadratic equation'. Put in the values of a, b and c and, hey presto, here is the solution.

Altshuller's' steps are to abstract your problem from its technology and use processes to see what solutions have, with 95% certainty, been already been used in other technologies that you probably know nothing about. This might then lead you to a specific solution in your technology. My use of the word 'might' is deliberate. TRIZ does not have a set of 'equations' to plug into: it is a structure of words and processes. The fundamentals, however, are the same: abstract the problem from reality, follow some principles and knowledge about what has gone before and apply your findings back to your present reality.

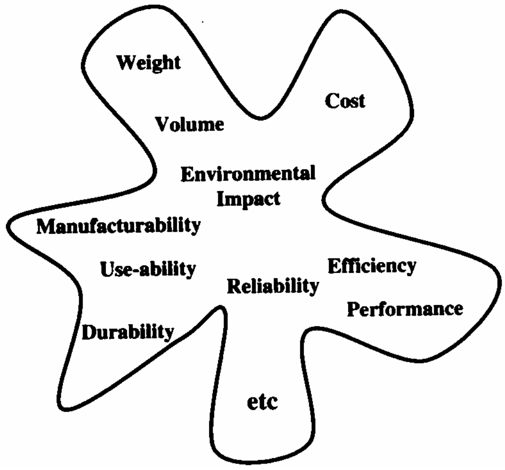
Words are not a precise as mathematical symbols but they are richer:

SOME OF THE PROCESSES

Contradictions

One of the most common type of problem is caused by the competing facts of nature. You want something stronger but that makes it heavier: you use a different material but that makes it more expensive.......

The problem is nicely put as a bag of jelly.
Fig. 6:



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Poke at one of your problems to improve it and another area bulges out and gets worse. Altshuller determined that there are 39 such competing parameters in physical devices.

Table 1.
List of Contradiction Parameters

1. Weight of Moving Object
2. Weight of Stationary Object
3. Length of a Moving Object
4. Length of a Stationary Object
5. Area of a Moving Object
6. Area of a Stationary Object
7. Volume of Moving Object
8. Volume of Stationary Object
9. Speed
10. Force (Intensity)
11. Stress or Pressure
12. Shape
13. Stability of the ObjectÕs Composition
14. Strength
15. Duration of Action by a Moving Object
16. Duration of Stationary of Moving Object
17. Temperature
18. Illumination Intensity
19. Use of Energy by Moving Object
20. Use of Energy by Stationary Object
21. Power
22. Loss of Energy
23. Loss of Substance
24. Loss of Information
25. Loss of Time
26. Quantity of Substance/Matter
27. Reliability
28. Measurement Accuracy
29. Manufacturing Precision
30. External harm affects the object
31. Object-generated harmful factors
32. Ease of Manufacture
33. Ease of Operation
34. Ease of Repair
35. Adaptability or Versatility
36. Device Complexity
37. Difficulty of Detecting and Measuring
38. Extent of Automation
39. Productivity

If you try to improve any parameter, others worsen. ‘Engineering’ is usually, therefore, finding the optimum set of compromises.

By analysing the patents, Altschuller, was able to identify what inventors had done to stop one parameter getting worse at the expense of another and listed the ‘40 inventive principles’.

Table 2.
The 40 Inventive Principles

1. Segment
2. Take Out
3. Local Quality
4. Asymmetry
5. Merge
6. Universal
7. Nested Doll
8. Counterweight
9. Prior Counteraction
10. Prior Action
11. Cushion
12. Remove Tension
13. Other Way Round
14. Curve
15. Dynamize
16. Slightly Less/Slightly More
17. Another Dimension
18. Vibrate
19. Periodic Action
20. Continuity of Useful Action
21. Hurry
22. Blessing in Disguise
23. Feedback
24. Intermediary
25. Self-Service
26. Copy
27. Cheap Disposable
28. Mechanical Substitution
29. Fluid
30. Thin & Flexible
31. Hole
32. Colour Change
33. Homogeneous
34. Discard & Recover
35. Parameter Change
36. Phase Transition
37. Thermal Expansion
38. Enrich
39. Calm
40. Composite

He then drew up a matrix in which both axes are the same: the 39 competing parameters. Where a column and row intersected, he placed the ‘inventive principles’ that he had found had have been used to enable the improvement (on the vertical axis) to be made without making the conflicting parameter, on the horizontal axis, worse.

Fig.7:

	Worsening Feature → / Improving Feature ↓	Weight of moving object	Weight of Stationary Object	Length of moving object	Length of Stationary object	Area of moving object	Area of stationary object	Volume of moving object	Volume of stationary object	Speed	Force (intensity)	Stress or pressure	Shape	Stability of the object's composition	Strength	Duration of action of a moving object	Duration of action of a stationary object	Temperature	Illumination Intensity	Use of energy by a moving object
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1	Weight of moving object		-	15 8 29 34	-	29 17 38 34	-	29 2 40 28	-	2 8 15 38	8 10 18 37	10 36 37 40	10 14 35 40	1 35 19 39	28 27 18 40	5 34 31 35	-	6 29 4 38	19 1 32	35 12 34 31
2	Weight of stationary object	-		-	10 1 29 35	-	35 30 13 2	-	5 35 14 2	-	8 10 19 35	13 29 10 18	13 10 29 14	26 39 1 40	28 2 10 27	-	2 27 19 6	28 19 32 22	19 32 35	-
3	Length of moving object	8 15 29 34	-		-	15 17 4	-	7 17 4 35	-	13 4 8	17 10 4	1 8 35	1 8 10 29	1 8 15 34	8 35 29 34	19	-	10 15 19	32	8 35 24
4	Length of stationary object		35 28 40 29	-		-	17 7 10 40	-	35 8 2 14	-	28 10	1 14 35	13 14 15 7	39 37 35	15 14 28 26	-	1 10 35	3 35 38 18	3 25	-
5	Area of moving object	2 17 29 4	-	14 15 18 4	-		-	7 14 17 4		29 30 4 34	19 30 35 2	10 15 36 28	5 34 29 4	11 2 13 39	3 15 40 14	6 3	-	2 15 16	15 32 19 13	19 32
6	Area of stationary object	-	30 2 14 18	-	26 7 9 39	-		-		-	1 18 35 36	10 15 36 37		2 38	40	-	2 10 19 30	35 39 38		-
7	Volume of moving object	2 26 29 40	-	1 7 4 35	-	1 7 4 17	-		-	29 4 38 34	15 35 36 37	6 35 36 37	1 15 29 4	28 10 1 39	9 14 15 7	6 35 4	-	34 39 10 18	2 13 10	35
8	Volume of stationary object	-	35 10 19 14	19 14	35 8 2 14	-		-		-	2 18 37	24 35	7 2 35	34 28 35 40	9 14 17 15	-	35 34 38	35 6 4		-
9	Speed	2 28 13 38	-	13 14 8	-	29 30 34	-	7 29 34	-		13 28 15 19	6 18 38 40	35 15 18 34	28 33 1 18	8 3 26 14	3 19 35 5	-	28 30 36 2	10 13 19	8 15 35 38
10	Force (Intensity)	8 1 37 18	18 13 1 28	17 19 9 36	28 10	19 10 15	1 18 36 37	15 9 12 37	2 36 18 37	13 28 15 12		18 21 11	10 35 40 34	35 10 21	35 10 14 27	19 2		35 10 21	-	19 17 10
11	Stress or pressure	10 36 37 40	13 29 10 18	35 10 36	35 1 14 16	10 15 36 28	10 15 36 37	6 35 10	35 24	6 35 36	36 35 21		35 4 15 10	35 33 2 40	9 18 3 40	19 3 27		35 39 19 2	-	14 24 10 37
12	Shape	8 10 29 40	15 10 26 3	29 34 5 4	13 14 10 7	5 34 4 10		14 4 15 22	7 2 35	35 15 34 18	35 10 37 40	34 15 10 14		33 1 18 4	30 14 10 40	14 26 9 25		22 14 19 32	13 15 32	2 6 34 14
13	Stability of the object's composition	21 35 2 39	26 39 1 40	13 15 1 28	37	2 11 13	39	28 10 19 39	34 28 35 40	33 15 28 18	10 35 21 16	2 35 40	22 1 18 4		17 9 15	13 27 10 35	39 3 35 23	35 1 32	32 3 27 16	13 19
14	Strength	1 8 40 15	40 26 27 1	1 15 8 35	15 14 28 26	3 34 40 29	9 40 28	10 15 14 7	9 14 17 15	8 13 26 14	10 18 3 14	10 3 18 40	10 30 35 40	13 17 35		27 3 26		30 10 40	35 19	19 35 10
15	Duration of action by moving object	19 5 34 31	-	2 19 9	-	3 17 19	-	10 2 19 30	-	3 35 5	19 2 16	19 3 27	14 26 28 25	13 3 35	27 3 10		-	19 35 39	2 19 4 35	28 6 35 18

Here is a closer view of a specific example.
Fig. 8:

	Worsening Factor->	Weight of Moving Object (1)	Weight of Stationary Object (2)	Length of Moving Object (3)	Length of Stationary Object (4)
	Improving Factor	1	2	3	4
1	Weight of Moving Object (1)			15,8,29,34	
2	Weight of Stationary Object (2)				10,1,29,35
3	Length of Moving Object (3)	8,15,29,34			
4	Length of Stationary Object (4)		35,28,40,29		
5	Area of Moving Object (5)	2,17,29,4		14,15,18,4	
6	Area of Stationary Object (6)		30,2,14,18		26,7,9,39
7	Volume of Moving Object (7)	2,26,29,40		1,7,4,35	
8	Volume of Stationary Object(8)		35,10,19,14	19,14	35,8,2,14
9	Speed (9)	2,28,13,38		13,14,8	
10	Force (Intensity) (10)	8,1,37,18	18,13,1,28	17,19,9,36	28,10
11	Stress or Pressure (11)	10,36,37,40	13,29,10,18	35,10,36	35,1,14,16
12	Shape (12)	8,10,29,40	15,10,26,3	29,34,5,4	13,14,10,7
13	Stability of object's composition (13)	21,35,2,39	26,39,1,40	13,15,1,28	37

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The length of stationary objects intersects with its weight: make it longer (without changing other parameters) and it gets heavier. To remove this conflict, look at inventive principles:

35 Parameter Change
28 Mechanical Substitution
40 Composite
29 Fluid

There are detailed explanations of these words as are the 39 competing parameters. Those who use the principles find that they are relevant to areas other than the original intention such as business and architecture.

The next step is to look to see if one of these generic principles can be applied to your specific problem. It seems that Altshuller believed that this step could be taken without using 'psychological' means but it is more likely that it can be helped by brainstorming may be used or other processes such as de Bono's 'Six Thinking Hats'. The value of the TRIZ is that it identifies a number of specific areas for the search which are most likely unknown to the brainstormers.

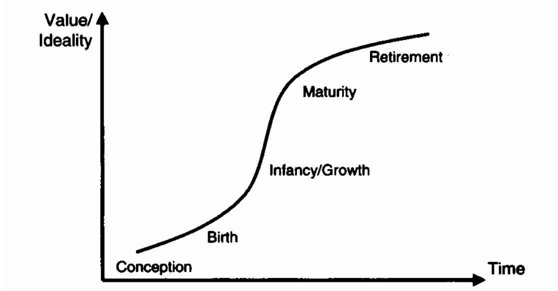
A simple example of the use of this is given in Appendix 1.

A Note on Words and Abbreviations.

The tables of Contradiction Parameters and Inventive Principles are lists of words that, on their own, do not mean very much. However, the meaning of each is documented for the TRIZ user. This is the case for all the TRIZ processes and data bases: there is a operational level' shorthand that points to detailed explanations.

The evolution of products

The 'S' shaped product life-cycle curve is well known.
Fig. 9:



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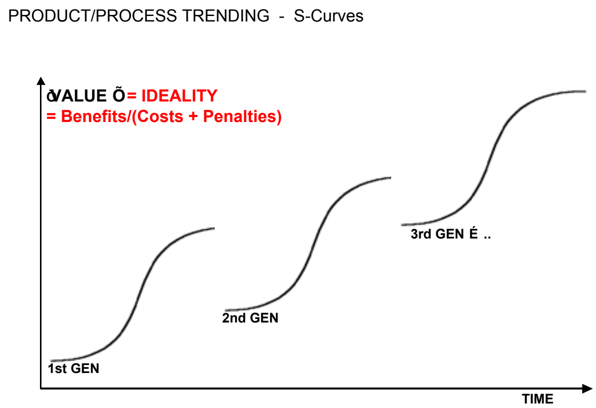
t is also well known that most products die out because they become overtaken by new ones that serve the users' needs better. This new product then goes through a similar life cycle until overtaken by another. Life is a series of S curves. Fig. 10:



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Altshuller discovered, in his patents searches, that the parameters that improve in each successive generation follow similar patterns. In other words, Technological evolution trends are highly predictable and not due to random events.

Another fact discovered by his research was that a major change to the next S curve usually does not come from within the industry making the present product but from outside. It seemed that, the chances of an organisation finding a new principle that meets the primary need of its existing product is almost zero.

A corollary of this might be that brainstorming with only members of one discipline or one organisation is not as effective as bringing in unrelated disciplines with no expertise in what is being brainstormed. However, there is undoubtedly a 'tribal tendency' - very prevalent in most professions - in which only those 'who understand' could possibly be of any use for being included in a project.

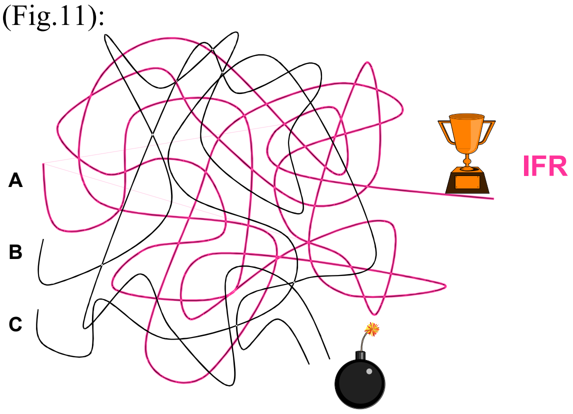
An example of the inevitability of technological advancement is given at Appendix 2. together with a diagrammatic representation of all known trends. Again, the words on this diagramme are not entirely meaningful on their own and reference has to be made to the next level of documentation that explains the meaning of each of them.

Ideality

The evolution, through a series of S curves, discussed above, means that a product is getting better at meeting the user's needs or wants. It is slowly trying to become 'ideal'.

Ideality = $^{\text{sum of useful effects}}/_{\text{sum of harmful effects}}$

Here is a problem. Find the choice of threads A, B or C that will lead you to the prize: the Ideal Final Result (IFR).
(Fig.11):



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The obvious way is to start at the end and work backwards. But there is a tendency of people and organisations to try to solve problems by starting at the present situation rather than their IFR.

Real-life problems are not usually as simple as finding the string but the TRIZ practitioner will first try to determine the ideal final result and then start asking why can't we have it:

What is stopping us achieving it?
Why is it stopping us?
How can you make the 'stoppers' go away?
What do we need to do?
Has anyone done anything like this before?

At each stage the problem is worded, as far as possible, in generic terms: words that describe the present solution are avoided.

However, assuming that we get to the bottom of the list of questions, we are confronted by something quite different -- has anyone done this before in a different technology? How would we know?

This has led to the creation of databases that reveal all the known technologies and their uses:

- Functional: means of delivering key functions. (see ref. 5)
- Compendium of effects
- Searching for knowledge

Other TRIZ processes.

The processes described above are those of 'Classical TRIZ'. Altshuller developed many more ideas - as have those who followed him - such as:

- ARIZ (Algorithm for Inventive Problem Solving)
- SU-Field Analysis
- 76 Standard Solutions
- Separation Principles

THE STATUS OF TRIZ

TRIZ is a set of tools to aid innovation that is still not widely known. The whole 'edifice' of TRIZ is complex and takes a long time to master but the experience of many teachers is that remarkable results can be achieved in quite short courses.

The main barrier to being more widely used comes down to the basic one affecting all thinking tools including Value Management: the widespread lack of understanding of the value of giving time to them. Managers want action!

Another barrier is the majority of education systems based largely on remembering facts and specialising in areas of facts as the person matures. The latest buzzword is a ‘knowledge-based society’ as if it is something new. All that is really happening is that we are getting more adept at storing and accessing knowledge. It might be better if we were aiming at an ‘understanding society’ or a ‘thinking society’.

TRIZ has been taught in Russian schools for many years. There have also been TV series and journals for children. Some schools in the USA have introduced it; Plymouth University in the UK has introduced it to one of their degree courses.

The writer undertook a brief survey of tertiary establishments in Hong Kong to determine the presence of courses on 'Innovation' and drew a blank. The only organisation in Hong Kong that has been offering courses is the Hong Kong Productivity Council.

The word ‘Innovation’ seems largely to be used in connection with entrepreneurial activities in starting up new businesses - largely in electronics and IT. Whether or not any of these devote energies to innovation at the higher levels is not known.

CONCLUSIONS

TRIZ is a means to assist inventive problem solving that has achieved remarkable success in many areas. The ideas are still developing and more people are becoming involved.

Anyone in the area of thinking processes - including Value Management practitioners - must be struck by Altshuller's finding that 95% of ‘new problems’ have already been solved - proabaly many times over. Do we spend most of our time ‘reinventing a wheel’?

It is now appreciated that innovation makes a large contribution to the wealth of a nation and its society but there is little appreciation that those who are asked to innovate must be given the training before they can do it. There is a strong belief that innovations only come from gifted people or by flashes of insight rather than the possibility that it can be learned.

The products of our education still tend to judged by their ability to reproduce knowledge and of doing specialised analyses. Whilst we are beginning to understand that information no longer needs to be stored in the head for examinations, we have not yet reached the point that the people we need for the future need to use their heads in rather different ways. TRIZ is an appealing tool for developing these ways in that it appeals to the ‘ordered mind’ as opposed to the more ‘psychological’ or ‘soft’ methods of creativity.

But a combination of the two -- structured and freewheeling - is probably the best.

Most cultures are based upon ‘experts’ who are skilled at applying in-depth of knowledge of their specialty. But, as de Bono has well put it with ‘lateral thinking’, the depth of the hole of expertise that they are in is of little use for discovering new treasures buried in the adjacent landscape. Closer to home, there is the Chinese proverb that points out that the frog at the bottom of the well only sees part of the sky.

TRIZ, in showing where digging has already happened already, beckons a new way. The word 'beckon' is used deliberately for it is not an easy solve-all: like most good things in life, rewards seldom come free.

REFERENCES & ACKNOWLEDGEMENT

The diagrammes used in this in this paper are taken from books and papers as follows:

1. **'An Introduction to TRIZ'**
   Auth: Stan Kaplan
   Pub: Ideation International 1996.
   (An excellent 'next step' for the reader for further exploration of TRIZ)

2. **'And Suddenly an Inventor Appeared'**
   Auth: Genrich Altshuller
   Pub: Technical Innovation Centre. 1994/2001
   (a wonderful book written for children which has become a classic. A good step for more exploration. It is also now available in Chinese)

3. **'Hands on Systematic Innovation'**
   Auth: Darell Mann
   Pub: CREAX Press. 2002.
   (The book you will need when you start taking it seriously)

4. **TRIZ: The theory of inventive problem solving.**
   Presentation by Dr. Paul Filmore, University of Plymouth 2003.
   Further details from pfilmore@plymouth.ac.uk & www.plymouth.ac.uk/TRIZ

5. **Web sites:**
   Creax http://www.creax.com (extensive resources including a structured knowledge sharing database detailing known means of delivering key functions.)

   Altshuller Institute: http://www.aitriz.org

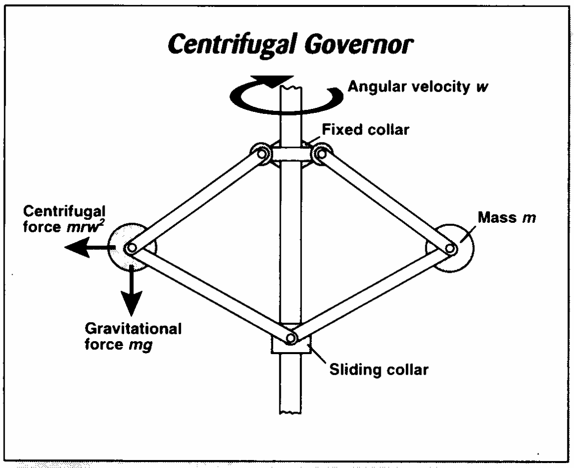
   Ideation: http://www.ideationtriz.com/

6. **Hong Kong Resources:**
   The Industrial Design and Innovation Management Department of the Hong Kong Productivity Council provides TRIZ consultancy services and training workshops.
   matthewd@hkpc.org for further details.

Appendix I

Centrifugal Governor Example

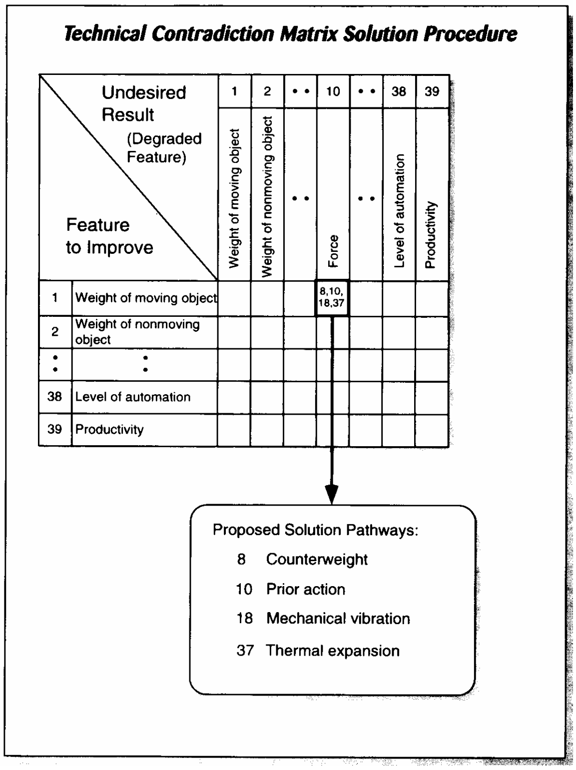
As an example, consider the problem of a centrifugal governor used in early helicopters to control the speed of blade rotation.



The weights must be heavy to create the centrifugal force for the governor to function but weight must be reduced on board a helicopter.

Thus we have a technical contradiction between weight and force.

Referring to row 1 (Weight of a moving object) and, column 10 (Force) of the contradiction matrix, we find recommendations to look at inventive principles numbers 8, 10, 18, 37.



Looking up the detailed description of number 8, we find:

8. Counterweight Principle

a. Compensate for the object's weight by joining with another object that has a lifting force.

b. Compensate for the weight of object by interaction with an environment providing aerodynamic or hydrodynamic forces.

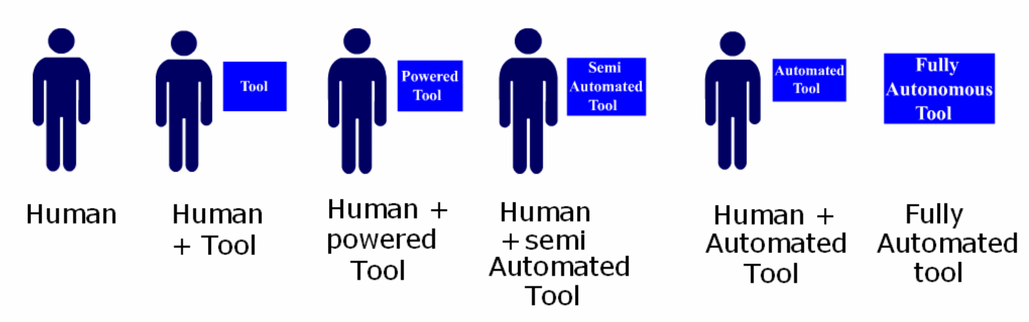
Item b. leads to the idea of replacing the rotating balls by airfoils that provide a lifting force proportional to the angular velocity.

Thus we can reduce the weight without diminishing the governing action and the contradiction is surmounted.

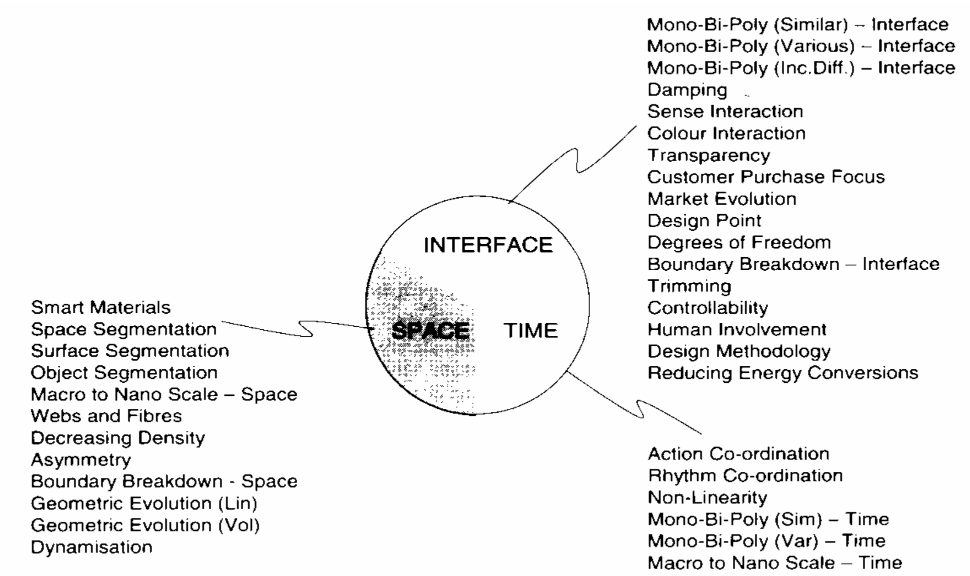
Appendix II

Trends

An obvious example: Decreasing Human involvement.



The set of Trends:



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