

# TRIZ

## for Engineers

Enabling Inventive  
Problem Solving



 WILEY

Karen Gadd



# **TRIZ For Engineers: Enabling Inventive Problem Solving**



# TRIZ For Engineers: Enabling Inventive Problem Solving

Karen Gadd

*Oxford Creativity*



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## About the Author



Karen Gadd has been teaching TRIZ and problem solving with engineering teams from major companies for over 13 years. Her mission is to make TRIZ learning straightforward and the TRIZ Tools easy to use. She has worked on nothing but TRIZ since discovering and learning its power to give us all the routes, to all the solutions, to all engineering problems.

In 1998 Karen started Oxford Creativity to concentrate on developing simple and practical TRIZ problem solving for the European market. Karen has taken TRIZ to major companies including Rolls-Royce, British Nuclear Group, Bentley Motors, BAE Systems, Nissan, Pilkington, Borealis and Sanofi Aventis. Oxford Creativity is now well established as one of the world's top TRIZ companies and has helped to make TRIZ well known and widely used throughout Europe and encouraged top companies to create expert TRIZ teams for innovative problem solving.

Karen studied Mechanical Engineering at Imperial College, and has an MBA from London Business School. After working in strategy and corporate planning in the City of London she returned to live in Oxford and was a tutor at Oxford's Business School the European School of Management ESCP-EAP (based in Paris, Oxford, Madrid and Berlin). From 1995–2002 she was a Governor of Coventry University. Karen's career has been dedicated to creating new enterprises which make a difference – she founded both MUSIC at OXFORD and the European Union Baroque Orchestra and ran both for over ten years and raised millions in corporate sponsorship to make their activities possible. These successful music organisations still flourish. MUSIC at OXFORD transformed Oxford's music scene and is now approaching its 30<sup>th</sup> season of top professional classical concerts. EUBO has celebrated 25 years of launching the careers of talented young musicians and has been so successful in its mission, that there are now former EUBO students in every major professional baroque ensemble in the world. Karen launched Oxford Creativity to make TRIZ accessible to everyone and transform and launch careers of TRIZ enthusiasts and champions. There are now thousands of engineers who have learned TRIZ from Karen and who intelligently daily apply TRIZ to solve difficult technical and scientific problems.

Karen is long married, has four children and three grandchildren and lives happily in Oxford and the Lake District. Karen has recently become a director of the Orchestra of St. John's. Concerts and singing are still her interests and part of her activities, as well as speaking at conferences throughout the world on the success and power of TRIZ.

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My thanks to all the engineers who have taught me, inspired me and worked with me to solve problems with TRIZ. To all the TRIZ teams of engineers we have worked with (but we cannot name for security reasons) whose clever ideas during TRIZ sessions helped us to extend and develop our TRIZ thinking.

My own family of engineers: my father Kenneth Gadd who claims that as an old engineer (contemporary, but unknowing of Altshuller) he represents a generation whose engineering prowess was unmatched by any previous or succeeding generations. All my fellow Imperial College engineers, including my husband Geoff Haines (a middle-aged engineer) and to my son Jonathan Haines-Gadd (a young engineer), and those few members of my family who don't yet work with TRIZ but who have supported me in my championship for such challenging causes – my mother Kathleen Gadd, my daughter Rebecca Haines-Gadd and my TRIZniks of the future, my grandchildren Isobelle, Livia and Freddie.

Most especially, the great Genrich Altshuller – my gratitude and respect for his extraordinary vision to uncover and summarise the world's engineering genius grows with all the TRIZ work I undertake. I have returned to his source material at every stage of my learning, and I strive to merely interpret the power and logic of his TRIZ.

This is what I offer with this book, faithfulness to Altshuller's TRIZ tools and I hope simple, clear innovative ways for understanding and using them. TRIZ requires both right (creative) and left (logical and systematic) sides of the brain to make it work. The only known way to join these two is with laughter and humour and the TRIZ cartoons attempt to achieve this. I have been assisted in this by the wonderful cartoonist Clive Goddard, who has worked with me to create TRIZ cartoons to help show just how much fun TRIZ offers. I hope we have succeeded.

# Foreword

Since discovering TRIZ, Karen Gadd has been an enthusiastic, near-evangelical, promoter of the methodology. She has introduced this exciting modern approach to innovation to many companies, including my own, as well as countless individuals. I am very pleased that she has now captured the essence of TRIZ in this well-written and very readable book, with its colourful and amusing illustrations, making TRIZ accessible to an even wider audience.

TRIZ is a contradiction in terms: it is free thought by numbers; it is a top-down approach to lateral thinking; it is a structured approach to brainstorming. Emerging from post-cold-war Russia, TRIZ is based on an intense and systematic study of all the world's great inventions. All of these can be broken down to be rendered as a combination of simple physical phenomena. There are actually relatively few conceptual solutions to problems (about 100) and 2,500 or so scientific principles. By presenting the designer, or inventor with novel (at times implausible) combinations of principles, new ways of solving problems can be discovered.

Look around you. Mix static electricity and photographic imaging and you have the instant, dry printing of the photo-copier. Mix suction and vortices with centrifugal force and you have the bag-less simplicity of the new generation of vacuum cleaners. The list is endless, as are the possibilities for new inventions.

We don't realise how bounded are our conceptual spaces and how linear our thought processes. We are locked in by past experience, by 'rules' passed down by our teachers, by the 'it'll never work' attitudes of those around us. It is far easier to suppress innovation than to stimulate it. If, like the Queen in Alice in Wonderland, you sometimes believe as many as six impossible things before breakfast, you may be able to get by without TRIZ. Many seemingly impossible things are indeed impossible, but some are not. TRIZ will set you free to explore the world of the apparently impossible.

TRIZ is an essential part of the modern engineer's or inventor's tool kit. This book will not make you an expert overnight, but it will hopefully stimulate your interest and make you want to explore more deeply the world of TRIZ.

Professor Ric Parker, FEng  
Director of Research and Technology  
Rolls-Royce Group

# Introduction

Teoriya Resheniya Izobretatelskikh Zadach = Theory of Inventive Problem Solving

## ТЕОРИЯ РЕШЕНИЯ ИЗОБРЕТАТЕЛЬСКИХ ЗАДАЧ

TRIZ is an engineering problem solving toolkit which successfully summarizes past solutions and successes to show us how to systematically solve future problems. TRIZ comes from Russia, initially and primarily the work of Genrich Altshuller, a great engineer and inventor, perhaps one of the greatest engineers of the twentieth century, whose work helps all other engineers. All good engineers live with both uncertainty and certainty – uncertainty about where to find the solution to the next problem and certainty that a solution will be found. TRIZ enhances and speeds up this process by directing us to the places full of good solutions to our particular problems. TRIZ focuses our problem understanding to the particular, relevant problem model and then offers conceptual solutions to that model. Good engineers reduce wasted time with TRIZ as they head straight for the valid solutions and use their valuable time to define their problem accurately, find all the solutions to that problem and then develop those solutions. TRIZ and other toolkits help in all these various stages of problem understanding but only TRIZ helps in the solution locating stage. The best engineers enjoy complex problem solving and finding new, better innovative solutions – TRIZ enhances their abilities as innovators and just trims out the wasted empty trials and dead ends. TRIZ keeps engineers doing what they do best – solving problems – and takes away nothing but time wasting, brain deadening, complex and irrelevant detail. TRIZ helps engineers power forward to useful and practical answers.

TRIZ is a toolkit – each tool is simple to use, and between them they cover all aspects of problem understanding and solving. The only challenge with TRIZ is learning which tool to use when, and this comes with practice and familiarity. Complete TRIZ algorithms are hard to master, as they set out to cover all problem situations, and are about as useful as an algorithm to help you complete 18 holes in golf. This book takes you through each TRIZ tool in turn and suggests when and where to use them, and offers some simple problem solving flowcharts for each tool. Once each TRIZ tool is mastered, it will become part of your problem solving tool; some you will use everyday and some just occasionally, but they are all useful for engineering problems, and are great thinking tools to help good engineers become great engineers.

In Russian TRIZ is written as above. TRIZ became known and available outside Russia after 1993, although there were some occasional TRIZ activities before that in some Western companies. In the USA there was some resistance to a Russian technique with a strange acronym name, which to most people was incomprehensible and unpronounceable. Some attempts were made to anglicise and rename it as TIPS (Theory of Inventive Problem Solving) – this was not widely adopted and in the USA TRIZ is now pronounced as TREES and in Europe TRIZZZZ.

At my first Altshuller conference in California I was surprised that there seemed to be three TRIZ camps: the Russian, the American and the European, and they didn't seem to be mixing much. (There are now other powerful camps from Korea and Japan). I called my paper TIPSY TRIZ and talked about the western TIPS acronym representing the resistance to Russian thoroughness, the temptation to over-

simplify TRIZ in order to gain acceptance and to break down the initial resistance to this rigorous toolkit. I talked about the UK TRIZ serious successes with major engineering companies, and the TRIZ impact on UK engineering, but at the end I made jokes about trying to problem-solve whilst under the influence of vodka – only the Europeans laughed, the Americans viewed me with disapproval, and the Russians with incomprehension. The paper was mostly about overcoming the difficulties of selling an unknown but brilliant Russian process to Western companies who initially view it with weariness and suspicion, but once familiar with TRIZ are almost always smitten, embrace it with enthusiasm, and how company experts in other toolkits always argue that TRIZ is like ..... and name their favourites. Persuading them that TRIZ is unlike any other toolkit, but complimentary to the others, first involves getting them to use TRIZ to successfully solve problems. This demonstrates that TRIZ covers the parts that no other toolkits even attempt – and that TRIZ is a toolkit for moving from vague problem to defined problem, and then to locating relevant conceptual solutions distilled from all of science and engineering – and that no other toolkit comes close.

I was telling dispiriting stories of how despite its unique power, how hard it can be to sell TRIZ to European companies, and then (I hoped) the more cheering tale of how Oxford Creativity used TRIZ to overcome the problems of getting engineers and engineering communities to adopt TRIZ in the UK. In particular I described our spectacular success in taking TRIZ to Rolls-Royce and the effect of our TRIZ training and problem solving with many hundreds of their engineers. Getting Rolls-Royce to adopt TRIZ took over three years and its introduction was due to TRIZ being initially championed by their R&T director Ric Parker assisted by Dave Knott – a rare prior TRIZ convert earlier, as he had heard a TRIZ lecture some years before and written his most successful patent the next day. With Ric and Dave's help and enthusiasm we overcame the inertia and hostility and TRIZ has been one of their core competence tools since 2000. Since then our other successes have included BAE Systems where even the most experienced and curmudgeonly engineers can be turned around to energetic enthusiasm.

I have always been amazed that, until some small understanding is established, how strong the resistance and inertia to TRIZ can be at a corporate and personal level. This is despite its huge value to engineers, its documented successes, and once accepted and learned, its transforming power on even the most plodding of engineers to think clearly and problem-solve innovatively, quickly and effectively.

Recently whilst teaching a seminar at a college in Oxford University to six technical directors of an international engineering company, we asked them why they had been considering TRIZ with us since 1999 yet ten years later were cautiously allowing themselves a one-day seminar. “We thought TRIZ was either too trivial or too complex for us” came the answer from these clever engineers: all were in desperate need of new solutions, new products and greater understanding of future technologies. After the one day they said TRIZ switched the lights on for them in an area of new technology, where before they had been groping around each equipped with the relatively small torch of their own knowledge and ideas. They have since all learned TRIZ and are working to establish it throughout the company.

The TRIZ tools were developed in Russia by engineers for engineers with thousands of man-years of work (and many women-years). Russia 30-50 years ago was a very different culture to our own and time was not of the essence for them and to learn TRIZ the Russian way was, and is, rigorous, requires great application of thought, with lots of worked examples and at least three months is recommended. This is not practical in Europe today and together with other TRIZ users I have endeavoured to create TRIZ Workshops which do not compromise the thoroughness or rigour of TRIZ but will give an understanding of the best TRIZ tools in days, rather than months.

We have also used TRIZ to solve the essential contradiction of learning TRIZ – how to teach a powerful, set of problem solving tools to engineers and managers who are hard pressed to spare the time. We explain the TRIZ tools and show how to use them after each workshop on their own problems; back at work there needs to be sufficient time and practical application for TRIZ to become useful and effective for problem solving for individuals and teams. Enough experience, and even some small successes in

the real world, as well as solving big problems that matter, and it will become second nature. TRIZ is very much about analogous thinking, so learning TRIZ is a bit like learning to swim or to drive – once we have been taught and have some confidence, to master it and really do it on our own we need to practise and build the skills and confidence to succeed. Then we know we are able to do it again and better – success and improvement will depend entirely on actually doing it ... as often as possible. Nobody will commit to TRIZ until they understand and experience the power and speed of TRIZ to solve problems which will help ensure their company's future – but once committed to using TRIZ every hour invested in TRIZ will repay many dividends for you for ever.

It has been my privilege to teach (with my colleagues in Oxford Creativity) many thousands of really good and clever engineers in the last thirteen years. Almost all engineers seem to me to be very nice and trustworthy people (mostly men in the UK), with many virtues, including hard work, an appetite for understanding everything about the problem from the big picture to the relevant detail, responsible attitudes, a passion for good solutions, a genuine mistrust of trivia or flash quick answers, good humour and a genuine sense of humility.

All of us at OC teach TRIZ in our very different styles and with as much fun as possible. Despite a reputation for full days, hard work and light heartedness, TRIZ classes are acknowledged as enjoyable, useful if exhausting experiences and we hope delegates leave with a great deal to think about and practice. We teach TRIZ in two bites; two days learning the essential TRIZ tools, followed by two days on the TRIZ problem solving process. Over 95% of delegates sign up for the second course, which is encouraging.

This book is a result of thirteen years problem solving, teaching, (and learning) TRIZ. I offer this book in the same spirit as an apprentice had to offer a 'masterpiece' in the hope that he / she could now enter the ranks of their trade accepted by their masters. I hope I offer it in a spirit of humility and I do not offer my way of making TRIZ because I have left TRIZ mostly unchanged, but worked to reveal its simple and powerful logic, assisted by flow charts, pictures cartoons and even jokes.

However I have made one significant new approach and offer two routes for System Analysis – the traditional TRIZ Substance Field Analysis and the five classes of the 76 Standard Solutions and a simpler alternative used by elements of the TRIZ community of Function Analysis and three simple categories of 76 Standard Solutions – how to deal with harm, how to deal with insufficiency and how to detect/measure something. I have taught both in major companies but have only used the second, easier system for many years.

I feel passionately that TRIZ should now be communicated clearly and simply without losing any of its rigour; made simple and straightforward but never, I hope, made trivial. I have always encouraged jokes, fun and laughter when learning and using TRIZ as it seems to make everyone more creative. I was pleased to see that scientific research has shown that the only way to become truly creative in scientific and engineering problem solving is by joining the left side of the brain (alleged to be systematic) with the right side of the brain (alleged to be creative). To make the right side of our brain join up with our left side we have to laugh and see the fun in situations.\*

As in our classes I offer TRIZ tools with jokes and (I hope) humorous stories – not to make light of TRIZ but because I believe this research, which claims the importance and power of humour. I am a great believer in keeping as much fun and enjoyment in life as possible. I hope the cartoons I have commissioned from the wonderful Clive Goddard and the jokes I use here do not offend – I have a very English sense of humour.

Accompanying this book is a website ([www.triz4engineers.com](http://www.triz4engineers.com)) that contains additional material and case studies. There are expanded versions of the 40 Principles and the Oxford Standard Solutions and an Effects database and links to other versions of the TRIZ effects. This website invites TRIZ engineers to contribute their own successes with TRIZ – including case studies – and an opportunity to share problem solving with other engineers.

\*W. Wayt Gibbs, Side Splitting, *Scientific American*, January 2001.

**Part One**  
**TRIZ Logic and the Tools for Innovation**  
**and Clarity of Thought**





## TRIZ Tools for Creativity and Clever Solutions

### What is TRIZ?

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TRIZ is a unique, rigorous and powerful toolkit which guides engineers to understand and solve their problems by accessing the immense treasure of past engineering and scientific knowledge. TRIZ helps us find the surprisingly few relevant and practical answers to our real problems. This is made simple by the TRIZ summary of all the conceptual answers to engineering and scientific problems.

TRIZ is the only solution toolkit which exists so far in the world that offers engineers help beyond brainstorming at the actual *concept–solution locating* and *problem solving* moments. There are wonderful toolkits for understanding problems, with analysis processes for capturing the requirements, analysing the systems, looking at processes and pinpointing actual causes of problems. There are also many rigorous and useful toolkits for the time after problem solving has occurred, including processes for selecting solutions and developing them, with useful ways of evaluating and predicting costs etc.; but for the actual moment of problem solving – the search and capture of the right solutions or new concepts – there is only TRIZ. Until TRIZ the assumption has been that clever engineers and scientists would somehow find the right answers either individually or collectively by brainstorming and using their experience and knowledge.

<b>BEFORE – Preparation for Problem Solving</b>	<b>DURING – Problem Solving</b>	<b>AFTER – Solution Selection and Development</b>
<b>TRIZ and other tool-kits</b> for Requirements / needs capture System analysis Find any root causes of problems etc.	Brainwave ideas Brainstorming Creativity Tools and/or <b>TRIZ</b> <b>TRIZ Conceptual Solutions</b> 40 Principles 76 Standard Solutions 8 Trends all used with relevant <b>World’s Knowledge</b> and <b>TRIZ Creativity Tools</b> including – Ideal Solutions Smart Little People Size-Time-Cost etc.	<b>TRIZ and other Tool-kits</b> for Concept development Concept selection process (such as Pugh Matrix) Successful innovation and new technologies etc.

Use all the available tools for each stage of problem solving

Before TRIZ no one had looked to systematically summarize all the published solutions to scientific and engineering problems and seek similarities, overlaps and patterns. When the founder of TRIZ, Altshuller, examined patent databases he found only 40 solutions to solving contradictions and a total of about 100 conceptual solutions for improving systems and solving problems which can be used together with the 2500 or so scientific and engineering theories (called effects in TRIZ) to solve problems. Together with his TRIZ community Altshuller developed TRIZ as the ‘science of creativity’ derived from all scientific and engineering success and offered a practical problem solving toolkit for engineering systems. The principal TRIZ tools direct us to find all the ways for improving and solving problems in existing systems and processes. They also help us find relevant concepts to develop the next-generation systems, and they offer systematic processes for inventing and developing new products. TRIZ has simple general concept lists to help us solve any problem; these TRIZ solution triggers are distilled from analysing all known published successful, scientific and engineering solutions. TRIZ tools are unique in their power for problem solving but TRIZ also offers simple tools for problem understanding, for system analysis, for understanding what we want, and for stimulating new ideas, creative thought and innovative solutions.

**Who Uses TRIZ and Why?**

For good engineers TRIZ offers the best of all worlds: the individual tools are straightforward, the problem-solving process is systematic and repeatable, and when we move fast with TRIZ we can uncover all the possible solutions and maintain and use our brains at their most creative. Engineers understand TRIZ better than anyone else because it comes from engineering success. It was developed by engineers for engineers, and although TRIZ works well on anything, it seems to work best on engineering problems. When first hearing of TRIZ, however, most engineers resist it, perhaps because it sounds too good to be true; but also maybe because it is new to them, not-invented-here and counter-intuitive to the way they approach problems. Unfortunately TRIZ is also seen as just another part of the overcrowded market in corporate toolkits (which range from excellent to trivial). Taking on a new toolkit makes demands on their brain power, company time and money and other hard-pressed resources, and this requires belief in its efficacy and power. Six Sigma and Lean are both promoted to improve efficiency and deliver cost savings and therefore widely adopted – TRIZ also delivers efficiency and similar cost savings plus innovation, fast problem solving and clear thinking. TRIZ is slowly becoming

recognized as a unique addition to all the other company toolkits, as it supplements and complements them all and fills in their missing essentials – the big hole they all possess of no directed problem solving to relevant solution concepts.

One reason cited for the more hesitant uptake of TRIZ is its perceived complexity. This is a misapprehension, as each TRIZ tool is fairly simple and straightforward and learning the entire toolkit should offer no problems for engineers. TRIZ is quite a large and rigorous toolkit but many of the tools overlap, as TRIZ is designed to suit all types of problem solvers. Part of the genius of TRIZ is that it was developed to allow individuals to build their own, personal TRIZ toolkit which suits their problem solving style best. This is a bit like having a well-equipped gym with a large range of equipment – individuals choose and use only part of that equipment depending on what suits them and which fitness problem they are tackling. The TRIZ Toolkit is much the same – there are tools which have specific purposes and tools which an individual finds suit them well, and which they will use extensively.

### TRIZ and Other Problem-Solving Toolkits

It is big claim to make that TRIZ is the only toolkit which helps engineers locate all the useful solutions to their problems, and understandably this can create some tension with ‘problem-solving experts’ who use the many other wonderful engineering toolkits. These other toolkits have immensely useful guidance to help us find inefficiencies in processes, the root causes of problems, help us understand all requirements, all stakeholders’ perspectives, what everyone wants, and analyse products, processes and systems, and once we have solutions (for solution finding we’re only offered brainstorming) they help us rank solutions. However, none have anything practical to offer for solving problems, and perhaps should not be labelled as ‘problem-solving toolkits’.



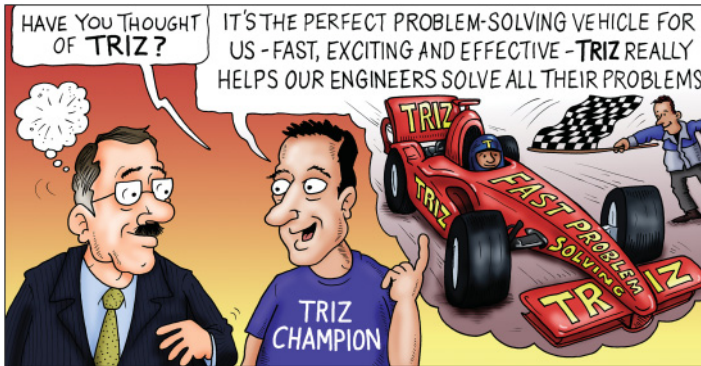
Many good toolkits but none for problem solving

TRIZ is a comprehensive toolkit with simple tools for understanding ‘what we want’ and detailed tools for ‘system analysis’, which are helpful for everything from invention of new systems to improving old ones. BUT unlike any other Toolkits, TRIZ has tools for finding solutions. TRIZ will complement and fill in the gaps (hitherto ignored) of how to actually find concepts to solve problems. The many

## TRIZ for Engineers: Enabling Inventive Problem Solving

engineering quality and production experts who come to learn TRIZ, enthusiastically and thoroughly apply it, and find it is a very valuable addition to whatever toolkit they also use – whether it is Total Quality Management, Quality Function Deployment, Taguchi, Lean, Pugh Matrix, Kepner-Tregoe, 8 Ds, Six Sigma, Value Engineering etc. – especially when they need innovation and want to find powerful solutions.

Other toolkits may offer different and additional benefits such as a more thorough analysis of requirements, or solution selection, but whatever toolkits we normally use TRIZ offers something extra, and powerful and is a good additional toolkit for any engineer.



Only TRIZ helps engineers solve problems

One TRIZ delegate, Jon Theuerkauf, Six Sigma expert and Head of Best Practice for HSBC (Jon is now Credit Suisse's Head of Centre of Excellence), explained 'At the beginning of the TRIZ Workshop I said, "There is nothing new under the sun" as I thought I knew most problem-solving toolkits and was sure that TRIZ would just contain the same tools as all the others. TRIZ showed me something "new under the sun" with its unique problem-solving tools of the 8 Trends, 40 Principles and Standard Solutions. I am impressed and I am not easily impressed.'

### Innovation – Fool's Gold or TRIZ?

Innovation has been in fashion for a long time – and heads up company value and mission statements – and unlike other trendy corporate initiatives has not peaked and faded. Probably because like searching for the philosopher's stone, most companies have never found how to systematically locate useful innovation to achieve its promise of success and hopefully endless future riches; practical, sustained innovation remains elusive to most companies. Corporate culture innovation initiatives often establish the need for innovation, identify innovation gaps and stimulate the desire to close those gaps. There are many innovation departments and consultancies with smart presentations, articles and conference talks telling us that innovation is needed more than ever, especially in difficult times and as the pace of new technologies increases etc. Non-TRIZ innovation toolkits are mostly brain-provocation exercises – helping to create new viewpoints of problems, clearer understanding and provoking ideas by stirring up or helping recall what we already know – and offer innovation by suggesting different combinations of known entities. Companies looking for innovation often keep asking the same questions over and over again ... hoping that it will somehow get different answers (close to Einstein's definition of insanity). Although 'innovation' is blazoned across corporate values, mission statements, slogans and encouraging, motivational material, it is hard to achieve, apart from those companies who have embedded the TRIZ toolkit to deliver technical and business innovation.

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