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Systematic Innovation

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Issue 3, April 2002

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The Systematic Innovation e-zine is a monthly, subscription only, publication. Each month will feature articles and features aimed at advancing the state of the art in TRIZ and related problem solving methodologies.

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Readers' comments and inputs are always welcome.
Send them to **darrell.mann@systematic-innovation.com**

Normal Curve Contradictions

Introduction

The Normal curve is used in the recording of everything from shoe-size to intelligence, from fertilizer usage to satellite design, medication dosage to missile deployment logistics. The normal curve is close to ubiquitous. In a world of trade-off and so-called optimization, the normal curve is king.

The Normal curve is often useful. Useful is not the same as 'necessary', nor is it the same as 'sufficient', however. The main themes of this article are:-

1) given the importance of 'eliminating contradictions' as a mechanism of evolutionary improvement, the normal curve, being an instrument of trade-off, is not only un-necessary, but usually positively dangerous, and,
2) that even in situations where the normal curve is useful, despite the contrary view of many users, it is never 'sufficient'.

Being a relatively short article, it is not the intention to provide a comprehensive analysis of the pros and cons of normal curves, but merely to highlight some of the dangers they often carry and to suggest ways and means of overcoming these dangers.

The Normal Curve

Figure 1 illustrates a typical normal curve. The curve is a primary mechanism for trade-off an optimization because the manner in which it is usually deployed involves some form of analysis (often mathematically rigorous – in order to ensure 'credibility') of a set of data that is usually inherently incomplete. The data is analysed and simplified to two values – a mean and a standard deviation – which can then in turn be used to plot a normal curve against which all future activities will then build. These two values allow us to state with confidence that 97.4% of customers will be satisfied by the artifacts we construct. Put like that, the normal curve sounds accurate, and not much like the crude approximation it actually is. In the past, we have been able to live with the crudity. Increasingly we now cannot.

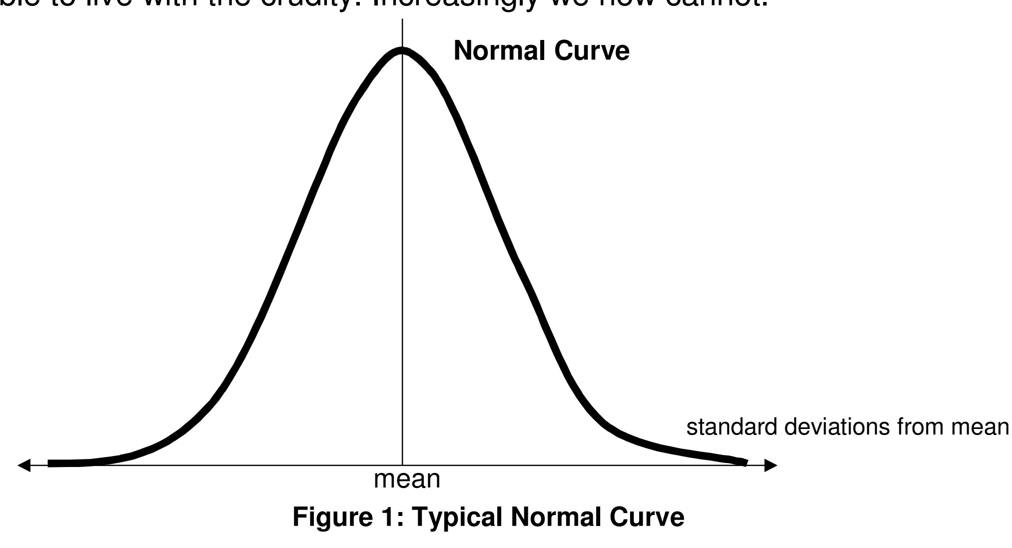


Figure 1: Typical Normal Curve

One of the reasons the normal curve often lets us down is that it encourages trade-off. The normal curve, for example, tells us the ‘average intelligence’ of a population, which in turn directs the people that design television channels – the usual consequence of which is that content gets pitched at a level slightly below the average in order to hopefully allow everyone to understand ‘most’ of the content and ‘not quite’ insult the intelligence of those at the right-hand end of the curve. Net result; most people watch, but few are satisfied. In the longer term, it also takes us into a downward spiral known as ‘dumbing-down’ – content is pitched at a lower level, so people learn less from it, so people get dumber, so the average falls, so the programmers pitch at a lower level, and so on.

Although this might sound like an extreme example, the same thing happens everywhere: the normal curve tells manufacturers that customers with a 16 shirt collar size have an ‘average’ arm length of ‘x’, and hence shirts are made with a length of ‘x minus a bit’ because a shirt sleeve that is slightly too short is not as bad as one that is slightly too long. Net result? Almost everyone is expected to compromise in some way.

The second serious problem with the normal curve is the edge effect. The edge effect involves those poor unfortunates that lie outside the three standard deviations (or increasingly ‘6 Sigma’ thanks to the evolution trend towards higher numbers). These are the ones illustrated in Figure 2 that lie ‘outside the system’. The trade-off and optimization analyses have excluded them as ‘insignificant’. The main problems manifested by this diagnosis are:-

1) another word for those lying outside the system is ‘news’. The media focuses on the ‘out-of-the-ordinary’ – almost by definition what ‘news’ is – because these are the things that interest us. Sometimes, the out-of-the-ordinary can be ‘good news’ (think of stories of exceptionally gifted children, or people that live to very high ages), but more often than not, the focus tends to be on the negative (for example, stories of hospital patients being turned away because there were ‘insufficient’ beds, or the ‘failure’ of a school to allow every student to take every option, or almost any kind of criminal act).
2) A related outcome of this focus on the negative is that it often provokes some form of legislation to cater for the exceptions. The net result of this is an often massive increase in complexity as more and more of the ‘exceptions’ have to be brought into line (in the UK, for example, there were 180 pages of tax legislation in 1918. By 1980, the total had risen to 4000 pages. Or, closer to most peoples work, think about the number of features now added to your copy of Word that you never use – the beast is now almost baroque in its list of features – some so obscure that it is difficult to believe that they were ever asked for by more than one or two customers). This seems to be one of the primary mechanisms underlying the trend of evolution towards increasing complexity. More about this trend and its decreasing complexity half later.

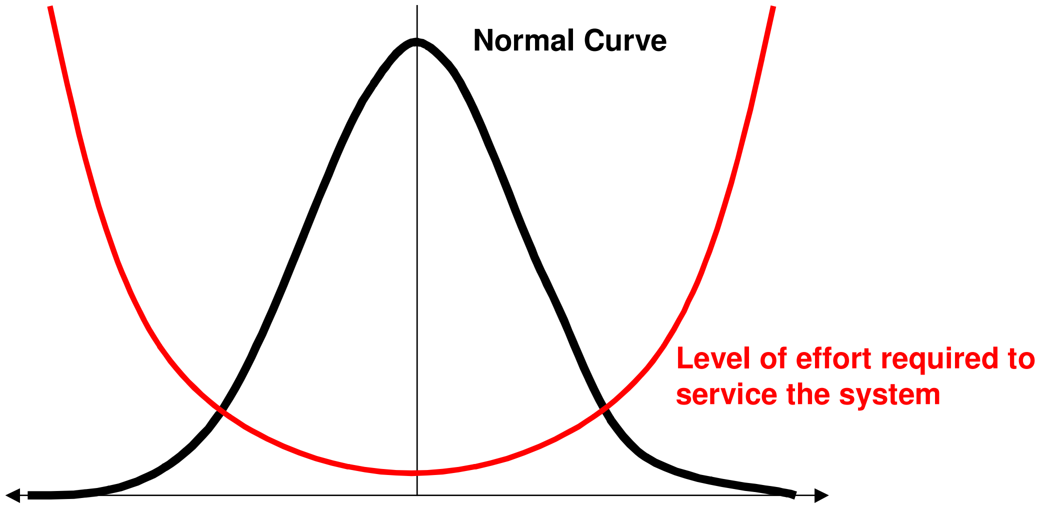


Figure 2: Relation Between Normal Curve and Edge Effect

The Normal Curve and Contradictions

The use of the normal curve as an 'averaging' tool generates the need for trade-offs, which in turn means contradictions emerge. These contradictions come in various shapes and sizes. The most common way of overcoming them involves one of the Inventive Principles associated with segmentation – Figure 3.

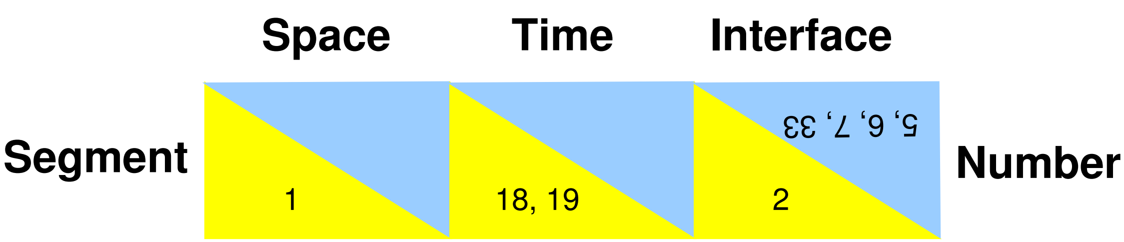


Figure 3: Inventive Principles Associated with Segmentation of Either Space, Time or Interface
(from Reference 1)

Of these, Principle 1, 'Segmentation' is probably the most commonly applied. The most common method of application is to segment the normal curve into a number of different – usually approximately equally sized – areas, as illustrated in Figure 4.

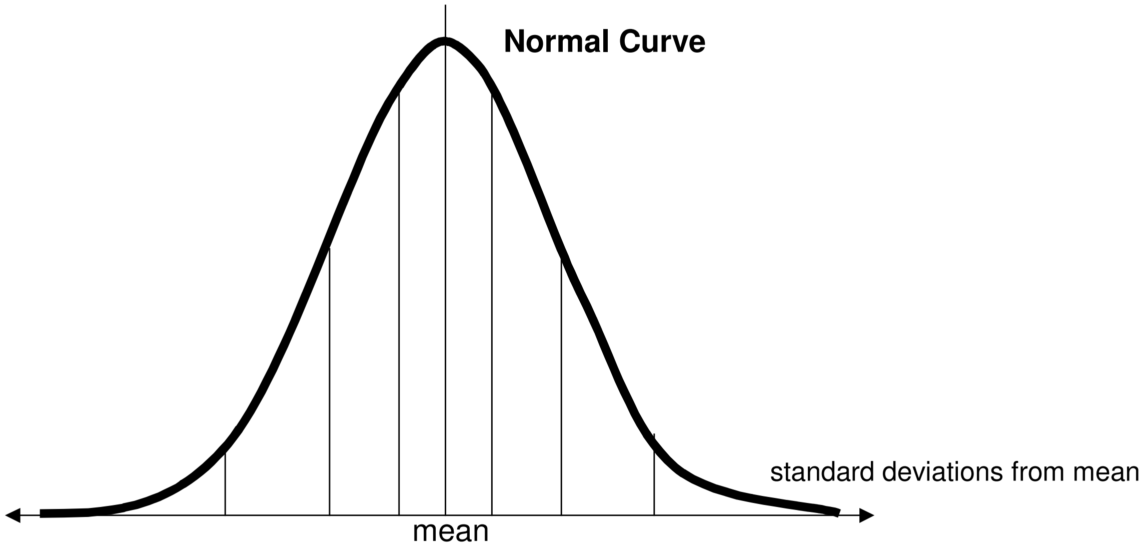


Figure 4: Typical Normal Curve Segmentation Strategy

We see this kind of segmentation activity in the manufacture of shirts in different sizes (and often now different 'fits' – tall, medium, short), the emergence of many niche television channels, different blends of fertilizers, different strengths of medication, and a just about any other area we may care to examine.

In a growing number of cases, this kind of segmentation extends as far as 'segments of one' – products made specifically to match the specific (perceived or real) needs of a given individual. Mass customization is a term commonly applied in this scenario (Reference 2). The worked reported in Reference 2 highlighted the fact that Inventive Principle 1, Segmentation, is indeed the most commonly applied contradiction-challenging strategy in the Mass Customization environment.

The very term 'mass customization' is, of course, itself an expression of a contradiction – by definition, the term means the production of individually customized products or services at the price of products or services produced at mass-production prices.
Successful Mass Customization demands breakthrough innovation strategies. One of the things that becomes apparent when analyzing the use of Segmentation strategies within mass customization is that they rapidly run out of steam. In other words, although they will help *challenge* the contradiction, segmentation alone will not '*eliminate*' the contradiction.

What Mass Customization and other examples illustrate is that Segmentation is a 'strong' Inventive Principle when it has not been applied already. As the Principle is used more and more, however, its beneficial effect begins to diminish to a point where even more segmentation can actually lead to a net reduction in system ideality (because, for example, thinking about a manufacture process, inventory and tooling costs become prohibitive, or, thinking about the TV channel, because the audience is so segmented that no channel is able to attract a critical mass of viewers). This decreasing strength of the Segmentation Principle is illustrated in Figure 5.

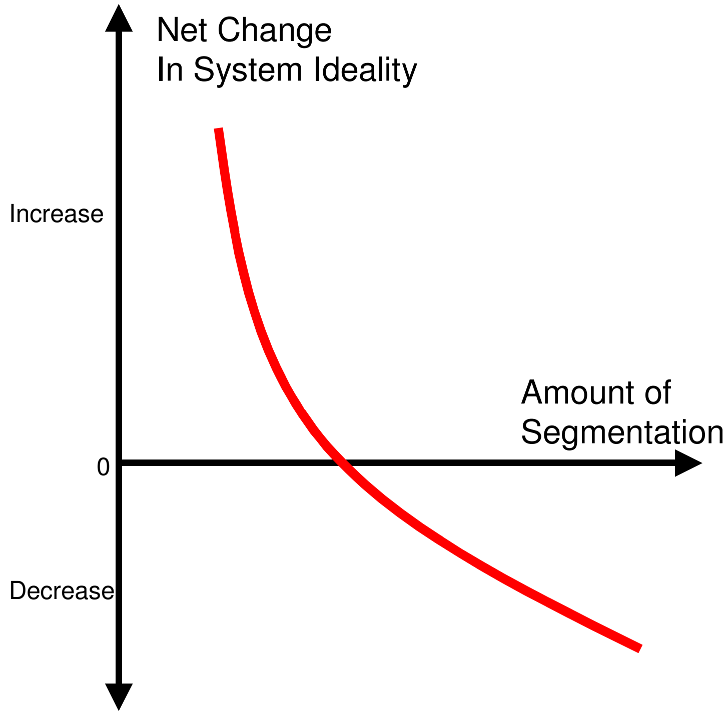


Figure 5: Decreasing Benefit of Segmentation Principle with Level of Application

The figure is intended to illustrate the clear message that, although it may be difficult to quantify (and, moreover that its value may change with time), there is a distinct 'optimum' level of segmentation for a given problem. (Compare this with the similar 'optimum' found within the Mono-Bi-Poly trend – Reference 3.)

In order to continue to challenge the contradictions within a system beyond this point, it is necessary to shift to other Inventive Principle strategies. We now look at how we might identify which of the other strategies are likely to be most beneficial. We begin by drawing an analogy with the segmentation related trends of evolution.

'Segmentation' Trends and Stronger Principles

Our best clue as to which of the other Inventive Principles are most likely to help us when Segmentation ceases to give us any more benefit is the 'Object Segmentation' technology evolution trend. This trend – Figure 6 – highlights not only the increasing segmentation of objects, but the presence of a higher order of jumps that take place from solid (mechanical) to fluid to gaseous to field-based systems. To take one of these higher level jumps as an example, we may see that as we progressively segment a solid system, to the point of maximum achievable benefit, the way to continue to achieve further benefit is to shift from the solid to a fluid and beyond.

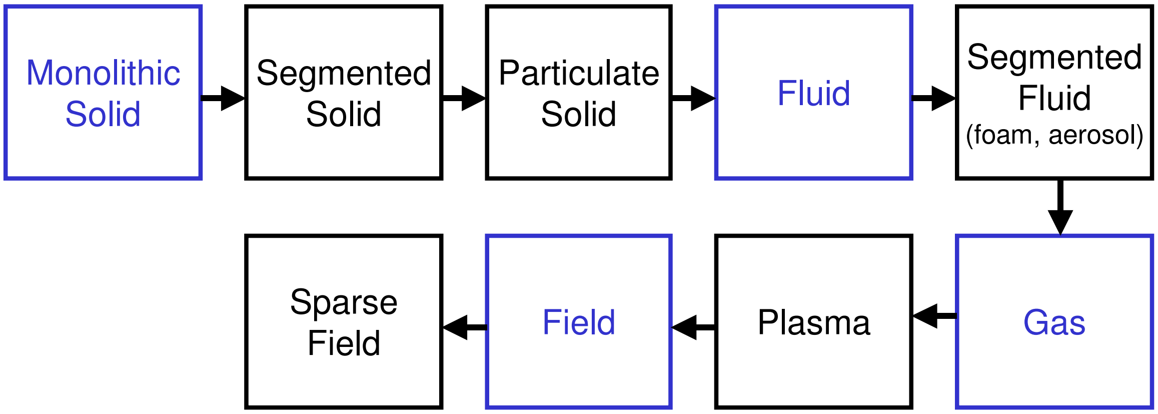


Figure 6: Object Segmentation Technology Evolution Trend

In terms of the Inventive Principles from the Contradictions part of TRIZ, these jumps are presented to users as:-

Principle 35 – Parameter Changes
Principle 28 – Mechanics Substitution
Principle 29 – Pneumatics and Hydraulics

These, then, are the Inventive Principles the TRIZ trends would suggest to us are most useful in solving contradictions once the usual normal curve segmentation strategy has run out of steam.

Physical Contradictions

TRIZ contains a number of separation strategies for helping to challenge physical contradictions. Figure 7 illustrates a typical separation strategy schema.

Separation In Space	Separation in Time	Separation on Condition	Separation by Transition
1,2,3,4,7,13,14,17,24, 26,30,37	1,9,10,11,15,16,18,19, 20,21,29,34	12,28,31,32,35,36,38, 39,40	1,5,6,7,8,13,22, 23,25,27,35

Figure 7: Physical Contradiction 'Separation' Strategies and Related Inventive Principles

Many Normal curve-based situations can be expressed as physical contradiction statements – I want a shirt that is size 16 AND size 18; I want a medication dosage of X AND Y, a TV channel that shows A AND B, etc. Figure 7 illustrates how Principle 1, 'Segmentation' is the most commonly applied means of overcoming this type of contradiction. But solving, for example, the two-size shirt contradiction by making two batches of shirts should not be viewed as a very powerful solution to the contradiction. A far stronger solution – and one that would literally eliminate the contradiction – would be one in which the shirt somehow 'knew' when it was required to be one size and another size, and was somehow able to change itself between the two conditions. In this more ideal situation (note the use of the 'self' word!), segmentation is not going to help. What is far more likely to help is one of the Inventive Principles contained within either:-

- the Separate on Condition or Separate by Transition categories, or
- through combinations of Principles from different categories.

Reference 4 discusses materials and systems which are able to adopt these 'stronger' solutions routes – materials that are fundamentally capable of solving physical contradictions such as shape-memory alloys, thixotropic or auxetic materials.

Conclusions

As stated at the beginning of the article, the main themes under discussion have concerned the belief that the normal curve, being an instrument of trade-off, is not only un-necessary, but usually also dangerous in scenarios where it is necessary to tackle contradictions, and, that even in situations where the normal curve is useful, despite the contrary view of many users, it is never 'sufficient'.

'Segmenting' a Normal curve is one way of tackling contradictions. Figure 5 illustrates the fact that this strategy is helpful only up to a point and thus it cannot be a 'sufficient' strategy. Beyond that point, the remaining contradictions need to be challenged using other Inventive Principles. Other parts of TRIZ suggest what these other 'stronger' Principles are.

References

1) Bridoux, D., Mann, D.L., 'Evolving TRIZ Using TRIZ and NLP', paper presented at TRIZCON2002, St Louis, April 2002.
2) Mann, D.L., Domb, E., 'Business Contradictions 1) – Mass Customization', TRIZ Journal, September 2000.
3) Mann, D.L., 'Hands-On Systematic Innovation', CREAX Press, April 2002.
4) Systematic Innovation e-zine, 'My Dream Suit (I Don't Know What I Want, But I Will When I See It)', Issue 2, March 2002

Humour and Irony

Our previous message that all humour was based on the resolution of contradictions (Figure 1) was challenged this month by a reader who suggested to us that this didn't appear to be the case with irony.

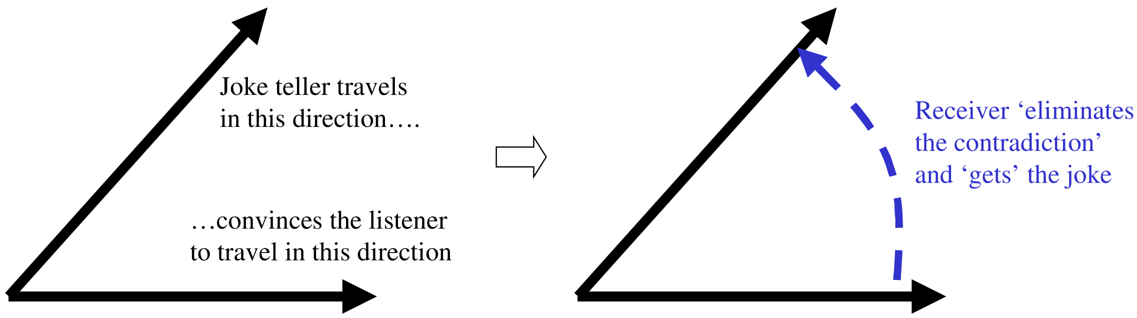


Figure 1: The Importance of Contradictions in Humour

Irony, for those people that don't know (by definition this means 90% of the population of Germany, and 95% of the population of the mid-West states of the US) is when we say one thing but actually mean another. Example; if I tell you that Bradford City are the finest football team in the UK, I will probably be being ironic. Bradford City fans, having suffered probably more than most football fans anywhere in the world, are a particularly world-weary lot and often irony is the only thing that keeps them from crying. Example; the team recently found itself briefly in the Premier Division of British football and playing the likes of proper teams like Manchester United, Liverpool and Arsenal. I had the unfortunate experience of watching Bradford being totally out-played at Arsenal one evening during this period. To say the game was one sided was an understatement of global proportions. After 88 minutes, with only 2 minutes of the game left although the Arsenal goal tally was only 2, the number of shots they had fired on the Bradford goal was over 40. The Bradford attack tally was a very round 0. Then, miracle of miracles we had a shot at goal. Admittedly it was about 10metres wide of the net, but nevertheless it counted as a shot. The immediate reaction of the loyal band of Bradford followers who had traveled over 300Km for the pleasure of watching the game? The chant 'we're going to win 3-2, we're going to win 3-2'. This is Bradford irony.

All the footballing statistics will tell you that Bradford City are anything but the finest football team in the UK. When I describe them as such, it is not so much wishful thinking as heartfelt resignation on my part that they never will be. This is more Bradford irony.

So where is the contradiction?

Well, at first sight it may be obvious that there is a contradiction – I say something and mean something else – the 'humour' is not directly related to it. In fact, the listener is not the intended recipient of the humour at all. Rather, the speaker is the one with the strongest likelihood of a laugh…. That being when the listener doesn't recognize the existence of the contradiction.

And so, looking at Figure 2, irony is also about contradictions, but this time with Inventive Principle 13 ‘Other Way Around’ thrown in for good measure.

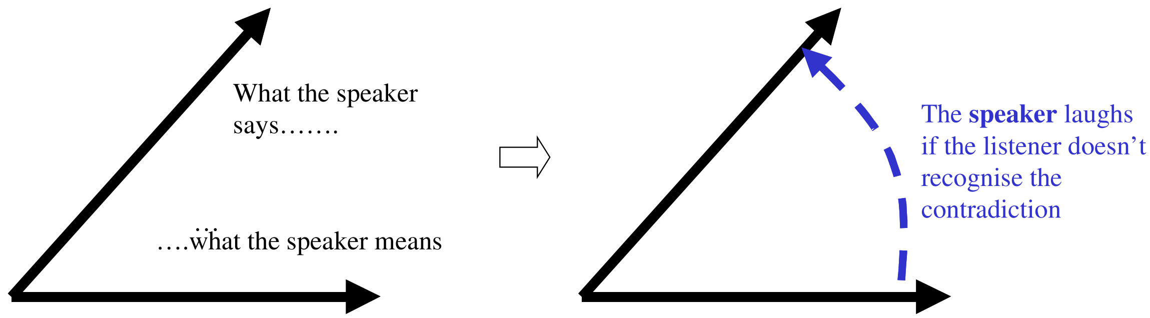


Figure 2: The Importance of Contradictions in Irony

TRIZ and Humour

Oh No, Not Another Principle 13 joke.

Many cartoonists appear to make a career out of making the same joke over and over again. We offer you the opportunity to discover for yourselves who these people are by getting you to think about the use of Principle 13 as a strategy for resolving the contradiction between where the cartoonist sends the reader and where the punchline is (see the Fichte contradiction picture in the previous newsletter).

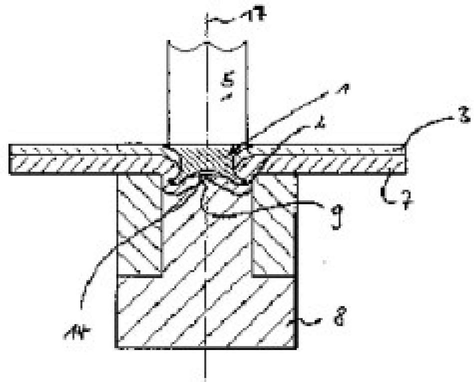
Using Principle 13, the contradiction resolution comes when the punchline lays in the opposite direction to the direction suggested by the earlier part of the joke.

The following cartoon is an example of Principle 13 in action. It comes from a cartoonist who is most definitely not one of those who relies solely on this principle.

Next month: When is a door not a door, and Principle 35.

Patent of the Month

We have a tie for the honour of patent of the month in this issue. Both patents share a common theme (or rather 'word' – self), but are otherwise very different. The first, US patent 6,325,584 granted on 4 December was picked up because it mentions one of our favourite subjects; rivets (is this something we should be admitting to we wonder?), and the creation of a new 'self-piercing' rivet design.



The idea of a self-piercing rivet is not, of course, a totally new idea. From the perspective of ideality, the concept of a rivet that doesn't require the prior need to drill a hole is very attractive. It means production time saving, tool wear reduction, less waste material production and last but not least, an often significantly stronger join.

Apart from the elegance and connection to ideality of the self-piercing rivet idea, our attention was drawn to US 6,325,584 because for the first time it achieves a self-piercing rivet manufacturable from a light alloy like aluminium. The attraction here comes particularly with respect to joining other light alloys. In the past riveting aluminium in a self-piercing way could only be done using steel rivets. Steel rivets however create several problems – higher weight, dis-similar metal corrosion issues, difficulty of recycling for example. The invention uses an aluminium rivet. Prior to the invention, an aluminium rivet would have solved the above problems, but would have been incapable of adequate self-piercing performance. The inventors had to solve a contradiction between the need to improve the strength of the rivet, while at the same time recognizing that the thing stopping them was the need to maintain a certain amount of force to cause the rivet to pierce through the materials to be joined. In other words, they faced a strength versus force contradiction.
The way they solved it (which happens to be consistent with the advice given by the Contradiction Matrix) was:-

"This object is attained with a partially-hollow which is made of light metal and which has a blunt rivet base. The invention is based on the realization that rivet geometries that have proven particularly advantageous for partially-hollow rivets made of steel are not usable for a partially-hollow rivet made of light metal. If the partially-hollow rivet geometries with a chamfered rivet base and a thin-walled rivet shank, which are considered particularly advantageous in prior art, are used for a partially-hollow rivet made of light metal, the problem arises time and again that the partially-hollow rivet made of light metal, shaped in this way, is plastically deformed during the punching operation already, without ever punching through the sheet facing the upper die"

and

3. A rivet according to claim 1, wherein the rivet base front surface includes a concave surface.

In other words, they used Inventive Principle 14, Curvature.

The second 'self-' related patent makes a substantial leap away from the mechanical world of rivets to the highly virtual world of e-mail. The patent in question is again taken from the US patent database. US6,324,569, 'Self-removing email verified or designated as such by a message distributor for the convenience of a recipient' thus describes:-

Methods, articles, signals, and systems are provided for providing email message originators and distributors with default control over message removal at a message recipient's location, regardless of whether the message has been opened. For instance, a self-removing message is designated as such by the message's originator, and a self-removal enhancement is added to conventional message content before the message is transmitted over a computer network toward one or more recipients. At the recipient's location, the message is automatically deleted without additional effort by the recipient, before or after being displayed, according to the originator's instructions unless they are overridden by the recipient. ISPs and other message distributors may identify messages that should be self-removing, and make them self-removing if they are not. Thus, the burden of removing unsolicited email messages is transferred from recipients to the system and the message's originators and/or to ISPs and other email distributors. Security of messages may also be enhanced.

In other words, the inventors appear to have recognized the importance of the receiver (the customer) in the e-mail transmission process, and hypothesized that many people are unhappy to register for many electronic services for fear of the subsequent inconvenience caused by spam mails. From the receiver 'free, perfect and now' ideality perspective, if the mail is somehow able to 'delete itself', the user hassle (perfection preventer) is improved.

While it is possible to argue against some of the logic in the patent (there's a challenge for someone looking to achieve a stronger solution!), the basic ideality and 'self' thinking is certainly an important conceptual strength of the invention.

Both patents use the word 'self' in it's true TRIZ sense – in that they deliver functions without the need for additional resource (okay, not strictly true in the case of the e-mail patent, but then a small increase in complexity in a virtual environment has as close to zero additional cost or harm as to be negligible). Something already in or around the current system is used to deliver the function. As discussed in our 'Ideality and Self' paper at the Bath conference, these self- solutions represent very effective problem and opportunity definitions.

Based on the very high number of patents granted in the last few months featuring the word 'self' in the title, it would appear that this is a message that is increasingly both appealing to inventors and the spur for some very potent innovations.

Best of The Rest

The choice for best of the TRIZ reading of the month for this month should have been difficult given that TRIZCON has just finished and a whole conference of new papers has been presented. Unfortunately, our combined reaction upon traveling back to St Louis airport at the end of the conference was that we hadn't learned an awful lot. Sure, it was great to meet everyone, and yes, we had some great conversations, but, to be honest, there was not a great deal of substance to the papers on show. Hence, our recommendation for the month was relatively easy to make. The shining beacon (present company excepted – we were very fortunate to be able to co-present a number of papers with some very forward thinking people) was very definitely the keynote address given by Professor Linde from the University of Coburg in Germany. The paper – on the TRIZ-inspired WOIS method – presented some of the impressive Coburg research and deployment, and re-presented the very attractive evolution spiral image that we know has helped a number of people to clarify the way they see the dynamics of innovation. Check out the paper if you can.

Elsewhere, we haven't found too much else to recommend to you, TRIZ or otherwise. Someone wrote to us asking for a 'top-ten' business books based on the extensive analysis we have been making during the development of some of our new TRIZ tools for Business. 'Top-tens' are very subjective of course, but in terms of their contribution to our work, we have no hesitation in recommending the following (randomly sequenced) bunch:-

- Charles Handy – The Empty Raincoat (one of the first connections between s-curves and business evolution, and a deeply thought provoking book on quality of work)
- Peter Senge – The Fifth Discipline (seminal book on systems thinking)
- Gary Hamel – Leading the Revolution (business concept innovation bible in the making)
- James Utterback – Mastering the Dynamics of Innovation (one of the books we reference most frequently during our courses)
- Clayton Christensen – The Innovator's Dilemma (one of the others, and a very thought provoking description of how 'good' management practice sometimes leads companies in precisely the wrong direction)
- Rob Rodin – Free, Perfect and Now (not a TRIZ book, but very closely connected to the ideality concept, and a fascinating read. Especially since the book describes a company thriving as an intermediary in the free, perfect and now environment)
- Xxxxx – Defining Moments (excellent book from the nearly always excellent Harvard Business School Press. An examination of right-versus-right contradiction solving. Again not TRIZ, but very TRIZ-like in approach)
- Edward De Bono – Sur/Petition (probably best of the best by Dr DeBono. Certainly from a business concept innovation perspective)
- Joe Pine – The Experience Economy (follow up to the Mass Customization classic – very thought provoking)
- Winslow Farrell – How Hits Happen (something for the people trying to expand the use of TRIZ!)

Remember, we are digesting many books per month still in the process of expanding our TRIZ for business database, so this list is not set in concrete. As we find other good stuff, we'll be sure to let you know.

Investments – 'Negative' Materials

Anyone familiar with the TRIZ trend concerned with 'increasing differences' in systems (see CreaTRIZ trends section or think claw-hammer – i.e. combination of objects that respectively insert and remove nails) will be aware of how systems can often completely flip over to the opposite function or see the introduction of the opposite function.

The **addition** of the opposite function happens in things like the claw-hammer or the pencil with an eraser on the end. In this case it is the idea of mono-bi-poly combination of function plus anti-function that is of interest.

The **replacement** of a system with its negative replica is seen most often in the way markets operate – for example a pop star suddenly shifts from being able to do no wrong in the eyes of the media, to being the subject of a backlash.

The common feature of both of these situations is that given a system delivering a useful function, someone somewhere finds a need or a desire for the opposite function.

This same switch from function to negative function has been present in the materials community for some time at a modest level. Probably the first example of materials exhibiting this positive and negative functional capability comes in the area of thermal expansion. Most materials – particularly metal-based ones – have a positive thermal expansion coefficient, so they expand when heated. Most engineering systems, in fact, are designed to compensate for this expansion coefficient – e.g. bridges are full of gaps to allow the structure space to expand on hot days; overhead electricity lines contain slack to compensate for the shrinkage in cold weather.

In some applications, however, this positive thermal expansion coefficient can be a nuisance and it is very difficult to compensate for the expansion. An example would be holding complex shaped metallic components during machining operations which generate heat – as the components heat, they distort or the thing holding them in position distorts; in either case leading to component damage or out-of-tolerance dimensions. An alloy called cerro-tru was devised to solve this problem. Cerro-tru has a zero thermal expansion coefficient – in other words it does not change shape at all if heated.

The point of this short section of the newsletter is not to delve into the details of cerro-tru, but rather to make the point that when an awareness of a functional capability emerges, it becomes possible to envisage several applications of that function. So, while holding components during machining operations might appear highly specialized, if we think about all those other engineering systems where the designer has compensated (i.e. compromised) for thermal expansion effects, and say, okay now here's a material that means you don't have to make that compromise anymore because it doesn't expand, you suddenly start to see a number of opportunities for contradiction-elimination emerging.

This is not to say that cerro-tru is 'the answer' of course – it is a specialized and therefore rather expansive alloy – merely that materials like it form good compromise-eliminating prospects.

The concept of 'negative' materials – i.e. materials that possess features the opposite of those normally found – is important from a similar contradiction-eliminating perspective. Zero or negative thermal expansion coefficient material properties are but one example. Other emerging 'negative materials' include:-

- Auxetic materials – materials possessing negative Poisson's Ratio. Most materials (certainly most engineering materials) possess a positive Poisson's Ratio. This means that when they are stretched in one direction, they shrink in the other two dimensions. Think of toffee or a rubber band – as we stretch them they become progressively thinner. Auxetic materials on the other hand possess a quality that means when they are stretched in one direction, they actually get fatter in the other directions. Potential applications for auxetic materials include bed mattresses (most mattresses sag over time due to lateral spread caused by our weight; an auxetic mattress becomes more supported the greater the weight placed on them), structural honeycombs (greater impact resistance – e.g. for bicycle helmets), and a variety of constructions which require multi-dimensional conformance (our skin is an example of a naturally occurring auxetic material – think of the stretching and shrinking job the skin around our elbows and knees has to perform).
- Negative permeability/permitivity materials
- Negative viscosity fluids (i.e. fluids that increase in viscosity with temperature rather than exhibiting the normally expected decrease)

Look out for these and other negative material opportunities in the not too distant future.