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In this month's issue:

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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Over The Hump
Getting Beyond The Point Of Maximum Complexity Without Compromising The System

The increasing-decreasing complexity trend uncovered by TRIZ researchers – Figure 1 – is a characteristic well worth keeping in mind during any attempts to use TRIZ to improve a system. What the characteristic is trying to tell us is that there are times during the evolution of a system when the complexity will inevitably rise. Thus, despite all the things that TRIZ will tell us about making use of existing resources, and solving problems by taking stuff away and simplifying what's there, we will not always be able to do it.

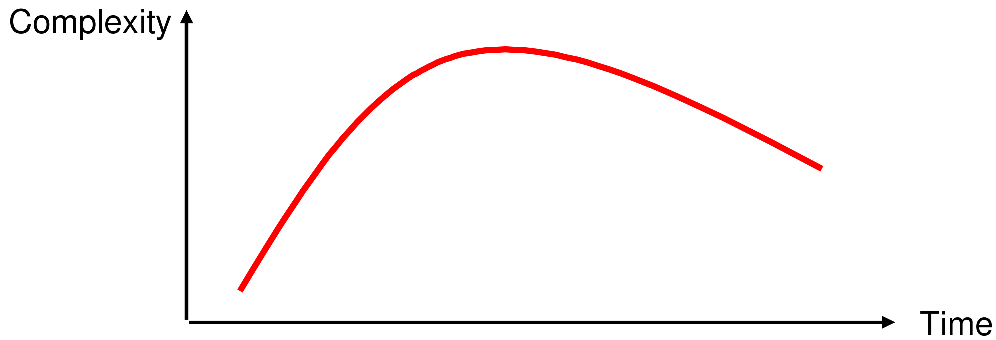

Figure 1: System Complexity Versus Evolutionary Time

We can see an example of a system following the 'increasing complexity' phase of this characteristic with the oft used bicycle saddle case study example (Reference 1). In this case study, we see the basic (uncomfortable) bicycle saddle evolving into a comfortable, more complex design – Figure 2. The designers of the bifurcated saddle successfully solved a very important contradiction. This is the contradiction that says we want the seat to be both wide (to support body load) and narrow (to allow easy leg movement).

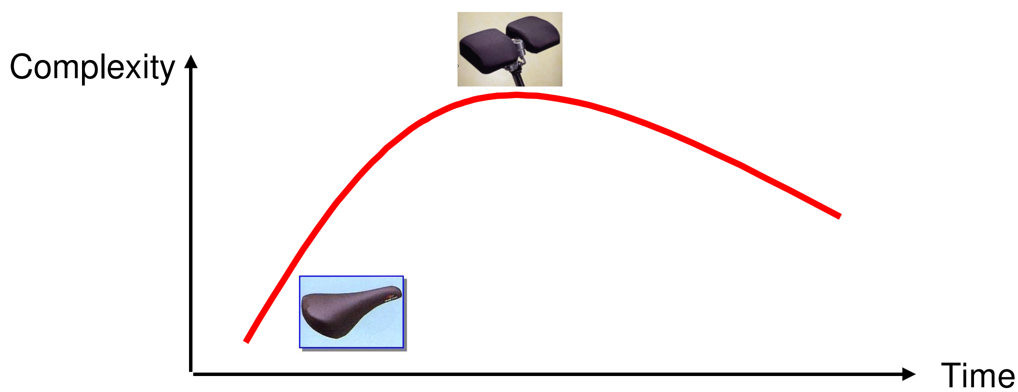

Figure 2: Evolution Of Bicycle Saddle Design

This comfort-related contradiction is undoubtedly an important one in that its resolution serves to improve the main useful function of the saddle. Unfortunately, as can be seen from Figure 2, the improvement has come at the expense of system complexity.

The new bifurcated saddle design has been drawn at a position indicating that it is at a point of maximum complexity. While this may turn out to be imprecise, at this point in time it would appear unlikely that an even more complex design would be likely to succeed on the market. Where the bifurcated design evolves from today, though, is the theme of this article. The design may be seen to be at a critical stage in its evolution. For many potential customers, the design is already too complex and, therefore, too expensive. What the complexity characteristic serves to remind us about in this case is that if we are to truly evolve the saddle design, we need to get 'over the hump'. It would be very simple to reduce the complexity of the design by reverting back to the original design. But, as indicated in the figure, this should be seen as a backward step rather than a forwards one.

True evolution of the saddle – i.e. evolution towards the Ideal Final Result – would take the design over the hump to the question mark highlighted in Figure 3. Only when the design has gone over the hump do we start getting the desired functionality (comfortable load bearing) without the complexity.

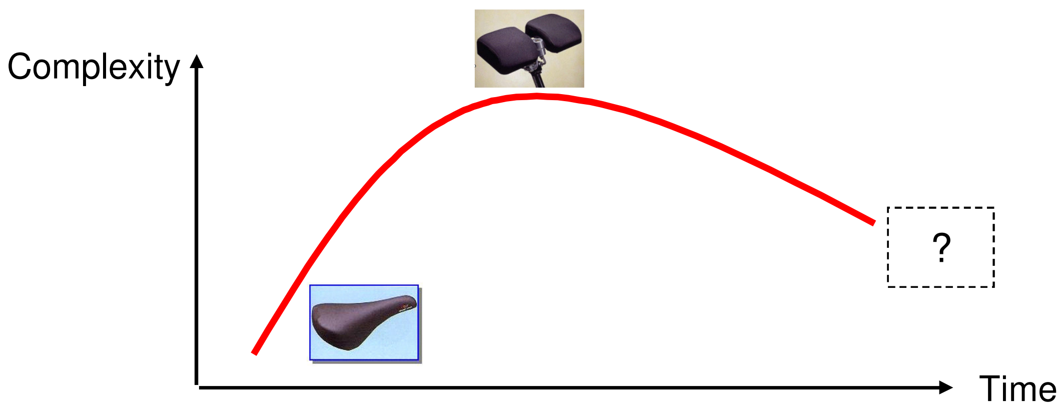

Figure 3: 'Over The Hump' Evolution Of Bicycle Saddle Design

Taking away the specifics of bicycle saddles and looking at Figure 3 from a more general perspective, 'over the hump' design is that which results from solving conflicts between functionality and complexity. The drive to improve function usually takes us to the top of the hump, often at the expense of complexity. Unfortunately, what then happens is that designers spend their time oscillating between the high-functionality/complex design and the low-functionality/simple design – Figure 4.

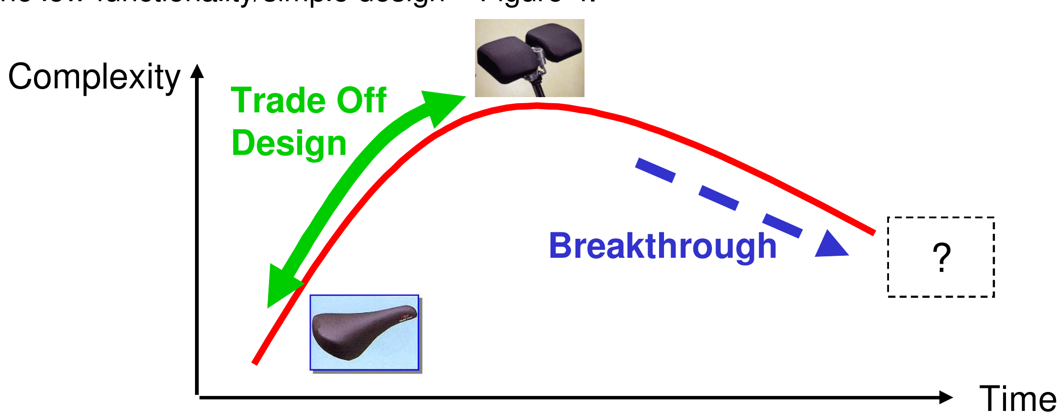

Figure 4: Traditional Trade-Off Based Bicycle Saddle Design versus Breakthrough

True advance beyond the maximum complexity point comes only when designer's look to achieve breakthrough solutions. Breakthrough in this case means specifically solving that functionality-versus-complexity trade-off. The Contradiction Matrix is supposed to be there to help us to see how other people have successfully traveled over the hump in other situations. The new Matrix (Reference 2) does this job rather better than the original classical Matrix (see how many examples of Principles that serve to increase complexity – Reference 3 – are recommended by the Matrix for complexity reduction problems). In too many cases in the original Matrix, the 'best practice' identified by the TRIZ researchers din not always mean traveling over the hump. This is hopefully a problem we have solved during the research behind the new Matrix – since our definition of 'best practice' when a system is at its point of maximum complexity is to achieve a function-complexity breakthrough. Whether you are using the original or the new Matrix (or neither!) the Figure 4 image is always a useful one to keep in mind when we are thinking about delivering genuine 'breakthrough' solutions.

References

1) Mann, D.L., 'Case Studies In TRIZ: A Comfortable Bicycle Seat', TRIZ Journal, November 1998.
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TRIZ And SixSigma –
3) Positioning TRIZ In DMAIC Improvement Schemes

For whatever reasons, the deployment and acceptance of Six Sigma is currently much more widespread than TRIZ at this point in time. With this is mind, it is often necessary to accommodate TRIZ into already present processes rather than trying to do things the other way around. While such strategies might well turn out to be less than ideal, they do at the very least allow TRIZ to be introduced in a sufficiently useful way that we can begin to experience some of the benefits it has to offer. The subject of this article, then, is the exploration of two different levels of TRIZ-SixSigma integration, in which we are seeking to beneficially add TRIZ to an established DMAIC process.

At the first level of integration, the most obvious benefit offered by TRIZ comes during the Improve stage of the Define-Measure-Analyse-Improve-Check cycle. This stage is where SixSigma, like just about every other method outside of TRIZ, features its 'insert miracle here' moment; in this case being the instruction to now go and think of some ways to change the system. The problem definition steps prior to this stage are of course intended to help teams to understand their situation well enough that good ideas will emerge naturally. Unfortunately, the ideas that tend to emerge tend to be based on classical trade-off and compromise lines – moving the problem from one place to another – rather than actually eliminating it. It is the contradiction elimination drivers found in TRIZ that allow us to do a better job of Improving the system.

Figure 1 illustrates a typical form of the DMAIC process. The figure highlights the essential steps of, first, Defining what it is that needs to be measured, then Measuring, and then Analysing the measurements. Crucial during the Analyse step is establishing whether the process under consideration is stable or not. As we know from the work of Deming and his contemporaries, if a process is not stable, then any attempts to improve the process are more likely to make things worse than better. If a process is unstable – i.e. dominated by special cause variation – then the first job is to find and fix the special causes in order to make it stable.

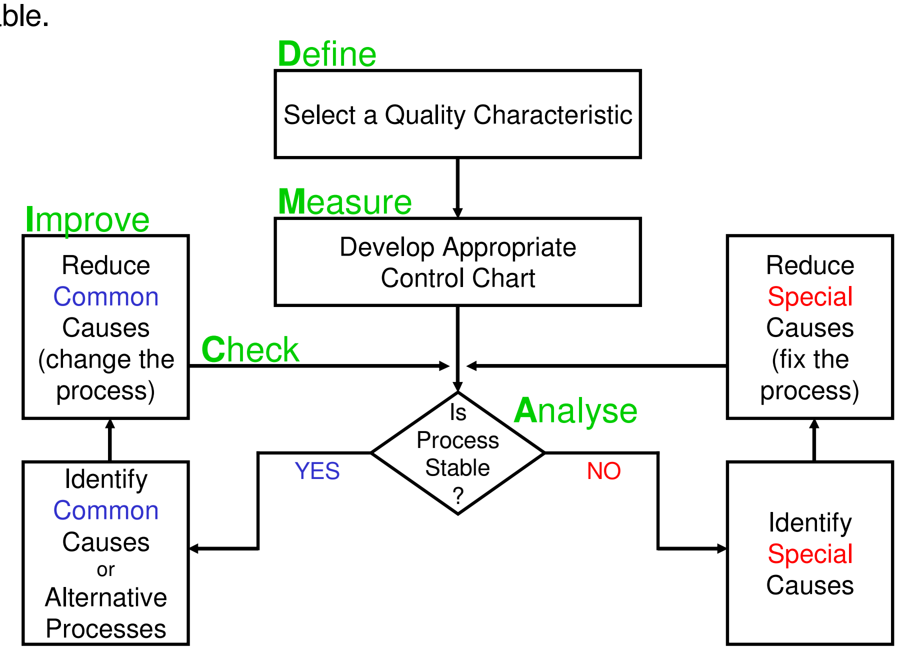

Figure 1: Typical DMAIC Process (from (1))

It is only when we have a stable process that it becomes appropriate to attempt changes to the process. It is only at this stage (noting the comments in Parts 1 and 2 of this TRIZ-SixSigma article series) that we should contemplate the use of TRIZ tools.

Figure 2, then, illustrates how TRIZ might begin to make an appearance in this DMAIC scheme. When we have a stable process that we wish to change (to reduce variation), then TRIZ tells us that there are three basic ways in which we can do this:

1) change to a different means of delivering the intended process functions
2) evolve along one or more of the trends of evolution
3) solve a contradiction

For many process operations, the investment required to move to a completely different means of delivering the desired functions precludes the first option (although when we have used up all of the evolution potential in an existing method, it becomes our only alternative). Usually the easiest method of changing the process comes by the third 'solve a contradiction' strategy. This is because, as illustrated in Figure 2, the earlier DMAIC stages help us to identify what the contradictions are:

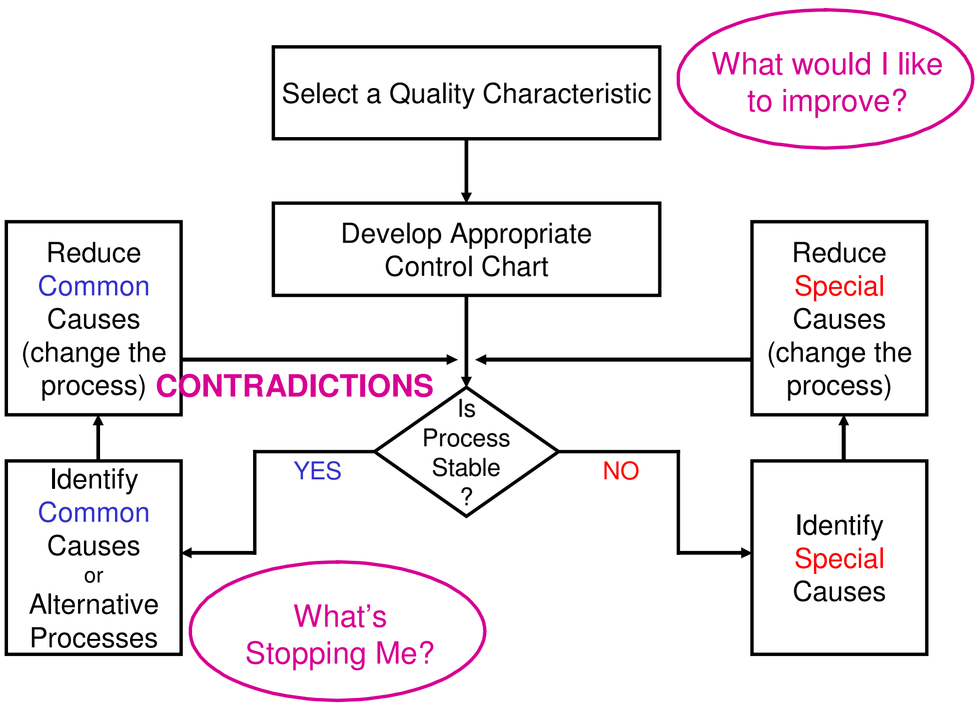

Figure 2: Using DMAIC To Find The Contradictions In A Stable Process

According to the figure, we know what we want to improve in the process from the initial Define activities – when we identified the quality characteristic we wanted to measure. We then get the other side of the contradiction equation by asking our standard 'what's stopping me?' question during the identification of the common cause variation in the system. Having then obtained an improving/worsening pair, we are then in a position to deploy the Contradiction Matrix and Inventive Principles to help guide us towards generating breakthrough solutions.

What this level of TRIZ/SixSigma integration gives us is a very simple way of attaching one of the most effective TRIZ tools onto already established SixSigma practice. Thanks to the Inventive Principles suggested by the Matrix, it now offers users explicit solution directions rather than having them rely solely on brainstorming.

This simple TRIZ integration, of course, misses out much of the problem definition capabilities to be found in TRIZ. It is a great start, but not a great end point. A far more integrated TRIZ/SixSigma process would be looking to integrate TRIZ tools right at the beginning of the Define phase – where we are looking to work out what it is that we should be looking to improve. It is at this stage that we get into all those thorny, difficult questions about what is important to the customer, and how does one part of a system influence others. One of the most common SixSigma failings occurs when a project delivers an apparent process improvement that compromises something downstream of manufacture (like life of the product, or reliability for example). The compromise, in other words, gets shifted out of manufacture into after-sales support. It is only by understanding what it is that customers want and value (and how much they value one parameter over any other), and how one part of a system influences another that we can even begin to claim that we know what the overall system is. When fully integrated into the Define part of DMAIC, TRIZ brings along a raft of other tools – 9-Windows, Resource Analysis, Evolution Potential Analysis, Function Analysis, etc – that all help users to know exactly what it is that the process should be focused on improving.

More about this level of integration in future installments of the TRIZ/SixSigma story. For now, for most, if we can get TRIZ established in the simple way illustrated in Figure 2, we will have made a significant step towards the more ideal process improvement scheme.

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1) Nolan, T.W., Provost, L.P., 'Understanding Variation', Quality Progress, May 1990.

Humour… Is it any wonder…

Is it any wonder that TRIZ is taking so long to take off when we hear stories like that of engineer Caroline Pande in the UK. Caroline entered a BBC design competition earlier this year. The aim of the competition was to design a 'machine capable of carrying out an athletics-style 'triple-jump'. In theory, the competition was about jumping the furthest and 'performance, style, ingenuity and lateral thinking'.

The vast majority of the competitors entering the competition did the expected thing and interpreted the instructions according to the psychological inertia expression 'triple-jump'. Net result: a bunch of highly complex, highly unreliable, mechanical equivalents of a human triple-jumper.

Caroline's solution, on the other hand, involved a solid-fuel rocket to launch a bouncy ball 80m into the air. Perhaps not surprisingly, the performance of this 'machine' was considerably better than the rest of the competition – by almost 2 orders of magnitude in fact.

Despite being assured by the judges that her conceptual solution was acceptable, the judges later decided that they did not want this solution to win the competition. Achieving this when the performance of Caroline's solution was so much better than anyone else's required the construction of an argument that went along the rather silly lines 'it was about a whole host of intangibles such as how much thought had gone into the design'. Caroline's solution, in other words, wasn't complicated enough.

This is surely an example of one of the great paradoxes of simple, effective solutions – they don't look complicated and so everyone assumes that they required no thought. Conversely, a complex solution emphasizes the difficulty of the problem and the 'ingenuity' of the engineer – 'gosh what a difficult problem you just solved'.

Our sympathies go out to Caroline.

Alas it looks like her entry won't be featured in the resulting TV programme. The other, 'valid', entries to the competition may be seen in a BBC show to be screened in January.

Patent of the Month – Quantum Dot LEDs

October 12 saw the publication of US6,803,719, ‘Quantum dot white and colored light-emitting devices’, granted to inventors at MIT. Quantum dot technology is something we have been keeping a close eye on for some time now due to its potential to deliver significant technological advances in a wide variety of applications, from traffic lights to display screens.

The significant advance described in the disclosure is summarized as follows:

Light-emitting devices, in particular, light-emitting diodes (LEDs), are ubiquitous to modern display technology. More than 30 billion chips are produced each year and new applications, such as automobile lights and traffic signals, continue to grow. Conventional devices are made from inorganic compound semiconductors, typically AlGaAs (red), AlGaInP (orange-yellow-green), and AlGaInN (green-blue). These devices emit monochromatic light of a frequency corresponding to the band gap of the compound semiconductor used in the device. Thus, conventional LEDs cannot emit white light, or indeed, light of any "mixed" color, which is composed of a mixture of frequencies. Further, producing an LED even of a particular desired "pure" single-frequency color can be difficult, since excellent control of semiconductor chemistry is required.

Light-emitting devices of mixed colors, and particularly white LEDs, have many potential applications. Consumers would prefer white light in many displays currently having red or green light-emitting devices. White light-emitting devices could be used as light sources with existing color filter technology to produce full color displays. Moreover, the use of white LEDs could lead to lower cost and simpler fabrication than red-green-blue LED technology.

White LEDs are currently made by combining a blue LED with a yellow phosphor to produce white light. However, color control is poor with this technology, since the colors of the LED and the phosphor cannot be varied. This technology also cannot be used to produce light of other mixed colors.

The essence of the inventive steps made in the invention is:

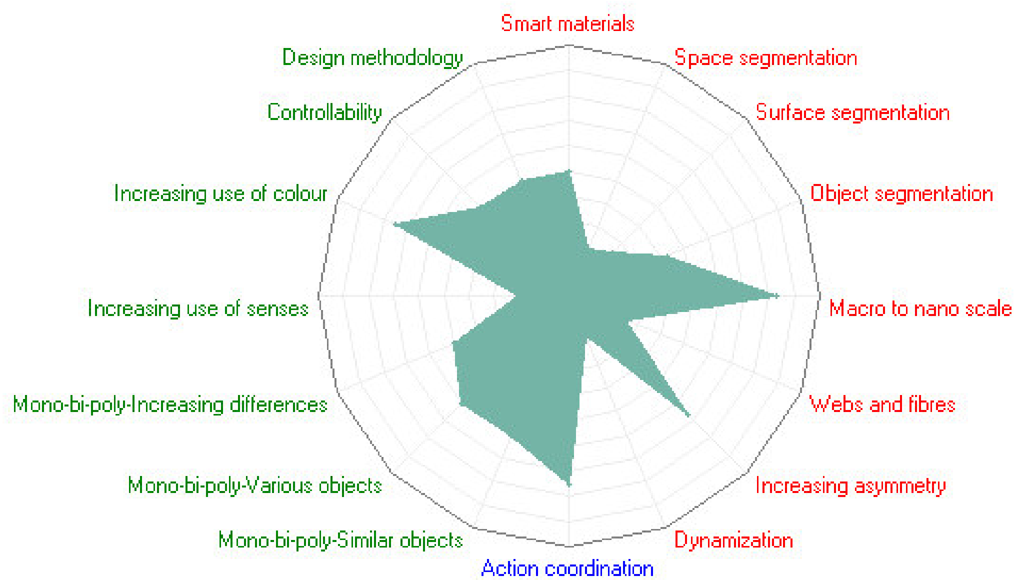
In one aspect, this invention comprises a device, comprising a light source and a population of QDs disposed in a host matrix. The QDs are characterized by a band gap energy smaller than the energy of at least a portion of the light from the light source. The matrix is disposed in a configuration that allows light from the source to pass therethrough. When the QD disposed in the host matrix is irradiated by light from the source, that light causes the QDs to photoluminesce secondary light. The color of the secondary light is a function of the size, size distribution and composition of the QDs.

And:

In a further aspect, the invention comprises a QD composition, in which QDs are disposed in a host matrix. The QDs are, optionally, coated with a material having an affinity for the host matrix. When illuminated by a source of light of a higher energy than the band gap energy of the QDs, the QDs photoluminesce in a color characteristic of their size, size distribution and composition.

All in all, a patent well worth closer examination.

Evolution radar plot for the system is shown here in case anyone is thinking about possibly looking to design a non-infringing alternative:



Conference – Sustainability – Creating The Culture, Inverness, 3-5 November 2004

This conference was attended by around 80 delegates, largely from within Scotland, but also with presenters and representatives from Sweden and Canada. The conference was presented over a three day period with over 40 papers and workshops. We were in attendance for about half of the papers, and to present our own effort – 'Measuring Sustainability – Global Best Practice Scan Toolkit' – a re-casting of the evolution potential concept as a benchmarking tool. A copy of the paper, presentation slides and all of the other conference materials can be found at www.sustainableresearch.com.

Among the many highlights of the conference was the following miscellany of thoughts and case studies:

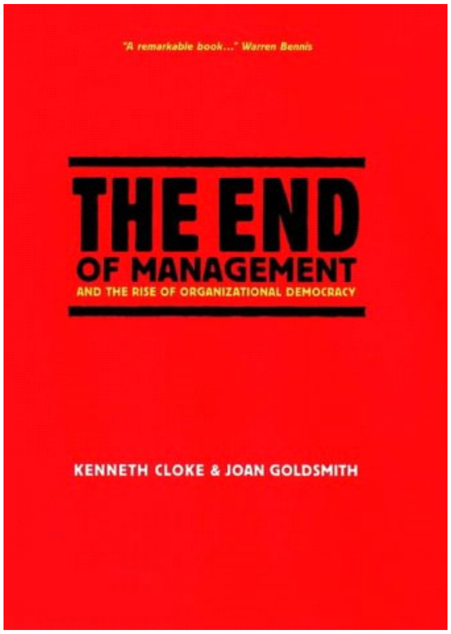
- Wind is a very big theme of life in and around the Scottish Isles; with wind factors of over 50% in parts of the Shetlands (compared to around 30% in places like Denmark – where there is considerable wind-farm activity). Energy costs on the Shetland islands are some of the most expensive anywhere on the planet, especially diesel and petrol. It was very interesting to note how the economic pressures created by such energy costs have acted as a real spur to innovation. Researchers from the island of Unst – the most northerly of the Shetland isles – presented their work to create a local hydrogen-based economy. The main learning point to take from this work is that hardship is the mother of invention – and that people facing a problem to a greater degree than anyone else have the greatest incentive to derive the solutions that will eventually help all of us.
- Sticking with the theme of wind, there was a lot of discussion about offshore windfarms. This was a time for this author to keep his mouth shut, since under just about any rational analysis of obtaining energy by planting wind-turbines 25km offshore would surely conclude that it was not possible to imagine a less ideal method. What with the hazards to shipping, the extraordinarily bad weather that has to be survived (insert mental image of waves higher than even the biggest turbine here), the reliability and maintenance issues, the 45m sea depths and the difficulties of engineering a physical connection to get the electrical power ashore, it is difficult to imagine a more difficult engineering problem. Just because something is difficult doesn't necessarily mean it shouldn't be attempted, of course. On the other hand, when things veer so far into the realm of folly, it is hard to keep a straight face when you hear the amount of money being spent on the behalf of the taxpayer.
- Getting back into the area of useful endeavour, www.nisp.org.uk looks like an excellent resource. NISP is the National Industrial Symbiosis Programme. It's aim is to connect problem owners with solution providers. Very TRIZ-like in its method of operation, the 'someone, somewhere already solved your problem' idea is here presented in the 'one man's waste is another's gold' context. Still early days, but already a very worthwhile place to visit once in a while.
- One of the most saddening papers of the conference was a review of the wildlife statistics for the Shetland Isles. Staggering declines in seabird breeding in the last 5 years were reported alongside details of increasingly pernicious fishing methods being used by man. Microfilament nets, and nets that cheat the mesh-size laws by closing up to a smaller size when dragged at speed through the ocean (effectively an application of Principle 15 which, while certainly help the fisherman to solve a contradiction – I want the nets to be big (legal) and small (catch fish illegally)) –

does little for the smaller fish that support the bird population). Poorly formulated laws and regulations don't appear to help much either. Particularly stupid appears to be fishing quotas that limit the amount of, say, cod catch, so that if a net accidentally catches some cod, the fishermen have to throw them back into the sea. Never mind that the fish are now dead, they cannot be brought ashore. There was a lot of mention at the conference of 'joined-up thinking'. Dumb legislation like this doesn't help anyone. Not quite true; catch brought to shore is easy to measure, while catch in the nets is not and so the legislation is easier for inspectors to check. Unfortunately, just because something is easy to measure, does not mean that it is the 'right' thing to measure. In actual fact, the easier it is, the less likely to be appropriate it is also.

So, all in all, a mixed bag of wonderful success stories, interesting facts and depressing accounts of the damage being done to the environment in the name of economics. It is difficult to see a clear answer to the question of whether mankind will destroy the planet before we are able to save it, but the positives presented at the conference perhaps offer at least a glimmer of hope.

Best of the Month

Another management text recommended this month – from our ongoing research programme. The book in question this time is 'The End Of Management' by Kenneth Cloke and Joan Goldsmith.



The text traces the history of management from the time of slavery through Taylorism and to current paradigms, arguing along the way that the fundamental foundations of 'management' are inconsistent with the 21st Century world. The powerful indictment of current practices is then followed by the authors' thesis that a bottom-up driven democracy is the only valid means of managing the complexities of a global marketplace.

All in all a highly provocative read and a confirmation of several of the discontinuous evolution trend ideas found in the TRIZ business trends. The only real doubt about the book is seeing precisely who it is written for. There is an interesting paradox here in that the book is being sold to a group of people who, the book argues, have little or no place in an organizational democracy. Unless or until that contradiction is solved, the book, alas, is probably doomed to a life in the remaindered vacuum that most management books eventually head towards. In this case, such a fate would be a major injustice.

Investments – d3o

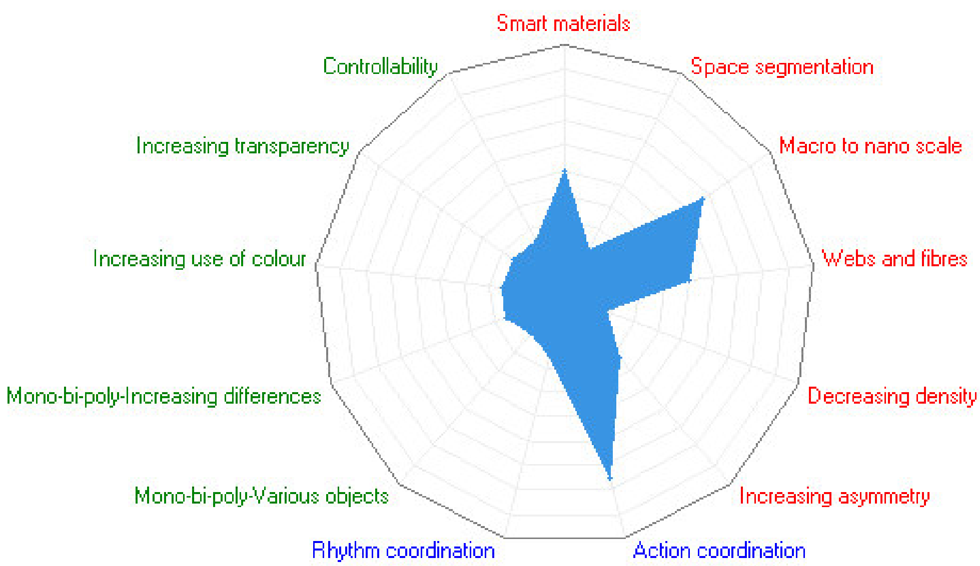
D3o is a company recently set up by Dr Phil Green of the University of Hertfordshire. The company exists to exploit the novel impact-absorbing polymer developed by researchers at the University.

The polymer-based material works using an impact absorbing structure operating at the molecular rather than macro-level. The molecular structure of the polymer in this case is such that the material undergoes an almost complete transformation from a viscous to an elastic state when subjected to impact. The material is thus able to flex at low strain rates, but then becomes an elastic solid at high strain rates.

Initial applications of the material look set to be in sporting and clothing applications, but the company fully expects the applications to extend to heavier duty applications such as automotive suspension bushes. The material is also claimed to possess excellent sound absorption properties.

Check out the d3o website for more details.

In the meantime, here is the evolutionary potential radar plot for the current material system:



Biology – Lionfish (*Pterois volitans)*

According to the space segmentation trend, somewhere there is an advantage in turning a solid thing into a hollow one. Many fish take advantage of an internal cavity in the form of a swim bladder – essentially a means where by the fish is able to take on board an amount of air that permits the fish to maintain a certain level of buoyancy without having to expend any effort.

Also according to the trend, there is likely to be an advantage in turning a single cavity into multiple cavities. At least a step towards such a multiple cavity swim bladder design can be found in the lionfish. The lionfish is a beautiful, slow moving coral reef dwelling fish.

The lionfish's spines are loaded with venom. An injection of venom from a lionfish can be deadly. Lionfish are hunters that like to remain motionless until a favorite meal passes by. During the day, lionfish remain near their hiding place to hunt for their favorite meals such as small fish, shrimp, and even crabs. A lionfish's mouth is large enough to swallow animals nearly as large as its own body.

So how does this wonderful creature make use of a multi-cavity swim bladder? Answer; it has evolved a means of internal muscle structure allowing the air contained in its swim bladder to be squeezed from one end of the fish to the other. Net result: the fish is able to shift its centre of gravity and thus its pitch angle in the water without making any externally visible motion. Net result of that capability is that the lionfish is able to re-orient itself whenever prey passes close by without being detected.

Most life forms have visual senses that are highly responsive to sudden movements. Any fish that has to use tail or fin movements to re-position itself is thus sending out highly visible signals to potential prey. By avoiding the need to make such tail or fin movements, it thus becomes far more likely that the lionfish will be able to make a successful catch.