

Common Ground – Integrating The World’s Most Effective Creative Design Strategies

Darrell Mann
Systematic Innovation

Abstract

The paper examines the broad range of methods, tools and strategies available to designers and attempts to distill the best of each in a bid to generate a coherent, ‘systematic creative design’ philosophy. Although using the Soviet-originated Theory of Inventive problem Solving, TRIZ as its foundation, the proposed design method also encompasses elements of, amongst others, QFD, Design for X, Value Engineering, Axiomatic Design and Robust Design. The paper describes the ongoing process of integrating these methods and reviews their deployment on a broad spectrum of real engineering design case studies.

Introduction

The world of creative design is currently served by a range of tools, methods and strategies that many might conclude is bewilderingly large. Their individual and combined effectiveness and usability is similarly a matter of concern for many designers and design managers. Taking a broad sweep across the complete menu and matching them to the different essential elements of the design process – here segmented as definition, generation, evaluation and capture – a study conducted specifically for the paper has concluded that there is also a considerable mismatch between the importance and the efficacy of the tools available to support each stage. The primary objective of the work carried out for the paper, then, has been to establish ways and means of resolving some of these issues.

In reviewing a range of tools that encompasses QFD, Robust Design, Axiomatic Design, Design For X, TRIZ, Value Engineering, Kansei, FMEA, Multi-Criteria Decision Analysis, and a host of lesser others, the paper suggests that there is a large and potentially confusing surplus of assistance in the design process areas of definition, evaluation and capture, and a distinct dearth in the area of generation – with many of the methods reliant on brainstorming when the ‘now generate some ideas’ part arrives.

Whether these tools, methods, strategies and philosophies can be integrated together to form a sum greater than the sum of the individual parts has been a matter of some debate. What does appear clear from the analysis carried out, however, is that there are opportunities for the creation of a unified, confusion eliminating, higher level system embracing and distilling the most effective qualities of all. For the sake of providing this higher level system with a label, the paper proposes the term ‘systematic creative design’.

Further analysis has revealed that TRIZ is the only one of the considered methods to explicitly tackle the idea generation part of the design process. The paper discusses TRIZ in this context, and reports the finding that its effective deployment offers significant opportunities for a more systematic creative approach on condition that the earlier definition process is conducted in a manner that takes best advantage of the opportunities afforded by TRIZ. In other words, the distillation of best design practices that form a significant part of TRIZ show that the most effective design solutions start from a distinctly different definition than has traditionally been the case.

While it was far from clear that any designer would actually want a seamlessly integrated creative design system, what emerged from the study conducted for the paper was their desire to be able to

mix and match an array of methods to suit both individual taste and the demands of a particular design task. The paper describes the process of assembling just such a system.

This paper is divided into three unequal parts. The first part describes ongoing work on the development of TRIZ as the core of an integrated systematic creative design 'system'. The second, longest, part of the paper examines how the main 'other' creativity tools, methods and philosophies have been integrated into this TRIZ-based 'systematic creative design' picture. To varying degrees all of these other tools, methods and philosophies are shown to have something to enhance the efficacy and efficiency of TRIZ. The final part presents a review of recent case study examples of the current integrated system being used to tackle real-life design challenges in a way that fundamentally achieves a stronger outcome than would have been possible without the integrated methodology.

TRIZ – Ongoing Evolution

The future of TRIZ (Altshuller, 1988. Salamatov, 1999) has been the subject of significant discussion in recent times (Savransky, 2000, Vertkin, 2001). Opinion differs as to whether it is still at the beginning or has reached the limits of its evolutionary potential. The conflict can be both understood and resolved if TRIZ is recognised as a just a part (albeit an important one) in a much bigger system. For the sake of providing this bigger system with a label, the term 'systematic creative design' is proposed.

TRIZ places great importance on the existence of evolutionary S-curves. In these terms, the difference between the s-curve for TRIZ (actually, bearing in mind the different TRIZ proponents and variations, such a TRIZ s-curve should be seen as the average of a cluster of subtly different s-curves) and an average curve that might be constructed for 'systematic creative design' is illustrated in Figure 1.

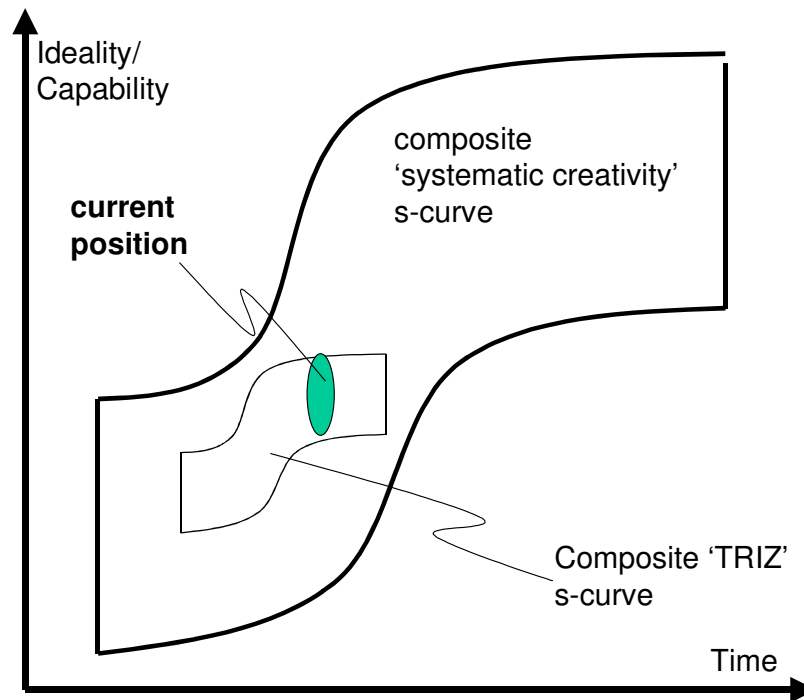


Figure 1: 'Systematic Creative Design' Evolutionary S-Curve

The conflict between 'is TRIZ a mature system or an immature one?' is thus explained by the point marked on the figure illustrating the current evolutionary state. The point suggests that TRIZ is at the mature end of its evolutionary potential (thus concurring with Vertkin's comment that 'there

hasn't been a single new concept introduced into TRIZ in the last 12 years'), but that TRIZ and the current position are still at the relative beginnings of the over-riding 'systematic creative design' curve.

In terms of systematic creativity it is evident that there have been many new concepts emerging in the same period. This paper discusses the emergence and integration of some of these concepts as they build on the four philosophical pillars of TRIZ – evolution towards increasing ideality; maximum use of existing resources; the importance of function; the systematic elimination of contradictions as a fundamental evolution driver – and their distillation into a complete problem definition/solving process and wide-ranging selection of tools (Figure 2).

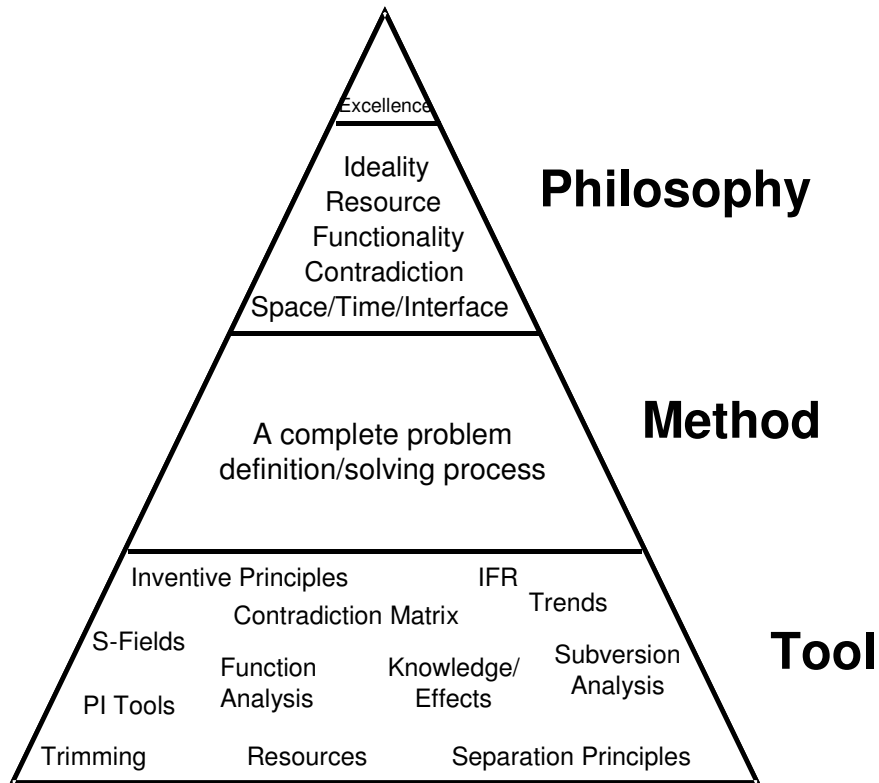


Figure 2: TRIZ Philosophy/Method/Toolkit Hierarchy

The idea that TRIZ is one s-curve (system) inside a bigger system for now called 'systematic creativity design' emerges from the concept of recursiveness in systems. Recursiveness as discussed in the Viable System Model, NLP and other emerging texts on, not just creativity, but all system evolution is an example of a concept which has not previously existed in classical TRIZ. The current prevailing view is that recursion will be an important element in the successful realisation of a 'systematic creative design' s-curve.

The idea of TRIZ representing one s-curve inside a higher order s-curve explains the s-curve figure constructed by Savransky, which suggests that the next stage of 'TRIZ' evolution (but actually to give some credit to the mass of other creativity research outside the current scope of TRIZ, 'systematic creativity') will involve the integration of different methods.

Examining, now, ongoing work on the development of TRIZ it is possible to show that, although the system is relatively mature, there is still scope for significant improvement and extension.

If Vertkin's statement about the absence of new concepts in TRIZ in the last 12 years is correct, it should not be taken to also mean that there has been no new work in TRIZ over the same period.

The success of www.triz-journal.com, for example, should provide ample evidence of the spread and expansion of TRIZ in recent times.

Much of this 'new' work on the other hand may be seen as refinement and re-arrangement of knowledge that is largely the same as that extracted through early TRIZ analysis of scientific and patent databases. One of the consequences of this is that TRIZ tools like the Contradiction Matrix and Inventive Standards are often inadequate (Mann, 2002a) and in some cases fail to handle certain types of problem altogether. One of the underlying problems discovered here is that the world has moved on significantly since the original analysis was conducted. One manifestation of this progress is that the Matrix, for example, often sends users looking to solve software or electrical problems in directions that are significantly different to those being used by the most successful inventors of the last 15 years. The world was a much more 'mechanical' place when the initial analysis was happening.

An extensive programme of work was instigated at the beginning of 2000 to begin to rectify this situation. A team of researchers is now undertaking a patent-by-patent analysis of invention disclosures over the period 1985 to 2000. The aims of this research are to:-

- update the Contradiction Matrix in terms of both its form (updating the list of 39 parameters for example) and content. Initial results suggest that in several key contradictions, inventors are now using significantly different strategies to those of their pre-1985 predecessors.
- identify the emergence of new Inventive Principles
- identify the emergence of new trends of evolution. In this regard, it is believed that at least ten trend patterns not previously found in TRIZ have been uncovered.
- identify the emergence of new Inventive Standards.
- generate upgraded versions of the psychological inertia tools based on incorporation of external tools and findings from psychology research.

In line with an increasing tendency for individuals and organisations to not patent their good solutions, and in order to extract strong solutions from fields not involved in patents (e.g. architecture, business/management, industrial design), a programme of systematic search of other knowledge sources has also been initiated. The overall idea is to ensure that users can be offered access to the most effective solutions from wherever they occur.

Evolving 'Systematic Creative Design'

The decision to base a 'systematic creative design' method around TRIZ was made in line with the comprehensive range of problem solving strategies contained within the method. It was noted that, where most other methods relied upon brainstorming techniques during the idea generation stage of a problem solving process, TRIZ had successfully identified a wide ranging array of much more systematic strategies. The decision to base the systematic creative design method on TRIZ was further justified because awareness of the problem solving tools within the method causes users to define problems in often considerably different ways than they would normally. Beyond that decision, it was clear that several other tools, techniques and methods still had much to offer to enhance the TRIZ process. The other available methods that the research has indicated are best able to complement and help deliver the higher order systematic creative design model are those shown in Figure 3.

To varying degrees all of these other tools, methods and philosophies may be represented as systems with their own series of s-curves. Rather than attempt to position such s-curve approximations relative to TRIZ, the paper focuses only on their role in serving the higher order systematic creative design s-curve development. All of these additional methods have already been

the subject of some form of work to explore the benefits of integration with TRIZ. The paper now briefly reviews such work and projects how and why such integration should progress in the future.

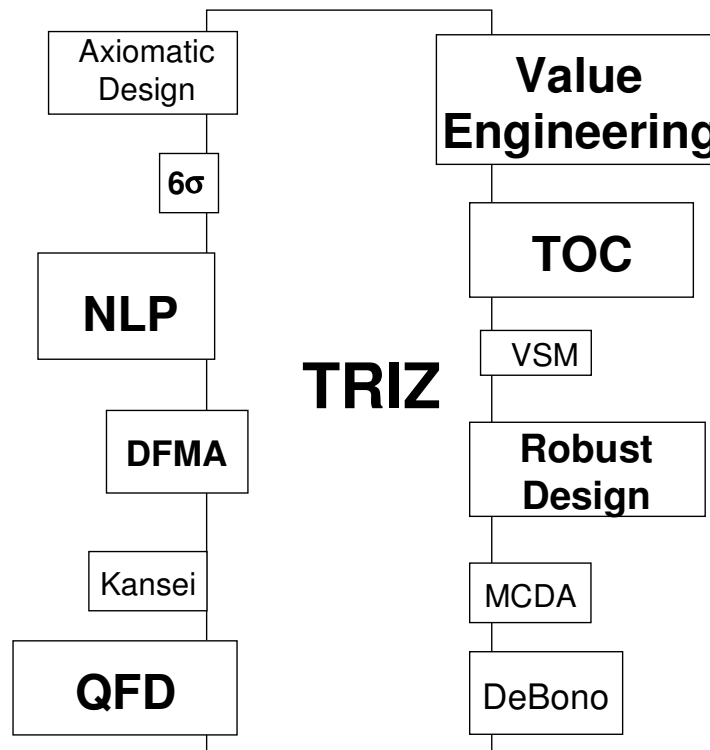


Figure 3 Integration of Innovation Tools

TRIZ and Function Analysis/Value Engineering

The function analysis/value engineering methodology initially developed by Miles (1961) is probably the method most closely linked with and integrated into TRIZ. Park (1999) is probably the first text to talk about both function analysis and TRIZ in the same place (albeit the understanding of TRIZ is woefully inaccurate). It does not make any mention, for example, of the simple but profound conceptual addition to function analysis made by TRIZ – that of using the function analysis to describe the harmful, ineffective and excessive functional relationships in a system as well as the useful ones drawn in classical function analysis. This simple shift in thinking transforms a method that is useful into one that offers an extremely effective means of both modelling complexity and defining problems. Dewulf and Mann (2001) describe how the current TRIZ addition to function analysis is being further evolved by incorporation of new concepts such as modelling of system attributes, time-variant problems and transition between problem definition and the selection of the most relevant tools to help solve the problem. Of all the methods considered, the integration of function analysis/value engineering into TRIZ is to date the most comprehensive and complete. Future evolution thus looks set to occur at the detailed implementation rather than conceptual level.

TRIZ and QFD and Robust Design

The integration of the ‘holy trinity’ of TRIZ, QFD and Taguchi methods was the subject of Terninko, Zlotin and Zusman (1997). Theoretically, the three complement each other very well; QFD is about capturing the voice of the customer and translating it into design specification; TRIZ is about generating solutions that fit the specification; and Taguchi/Robust Design tools are about optimising the implementation details of the solutions offered by TRIZ. The practice is currently seen to be some considerable distance away from the theory for the large majority of users. The biggest problem encountered by users involves the usual failure of QFD to accurately capture that customer voice. Customers are frequently unable to describe what it is that they want other than in

terms of 'better' than the thing they already have. Few if any customers would ask for a digital camera given a conventional film camera and a request for ideas on creating a better solution. This is an area where TRIZ – and particularly the technology trend prediction elements – is emerging as a more effective start point than QFD. Integration of QFD and Robust Design techniques into TRIZ looks set to continue. At least one significant conceptual level integrative step remains unexploited at this point in time. That step sees its roots in the inadequate ability of TRIZ to handle problem non-linearities. The strengths of Robust Design in this area and their integration into TRIZ is the subject of Apte and Mann (2002).

TRIZ and Design for X (DFX)

Design for X, and more specifically the most developed of the X's, DFMA shares the same problem as a good number of the other tools and methods described here, in that it contains what can be seen from a TRIZ perspective as the 'insert miracle here' moment. DFX is very good at defining problems and even better at quantifiably evaluating solutions, but between the two, it offers users little more than the suggestion 'now generate some ideas'. That being said, the method does have something to add to TRIZ. The already mentioned solution evaluation capabilities – basically providing a framework allowing users to benchmark manufacture and assembly times for an object and thus provide quantified improvements between 'before' and 'after' situations – are a useful addition, as are the questions developed within DFMA for identifying whether parts are actually needed in a system. This part of DFMA is closely linked to the 'trimming' trend ideas contained in TRIZ. Combined together, a problem solver is offered a more comprehensive list of questions to ask when considering the simplification of technical (or indeed business) situations. There appears little scope for additional high level conceptual integration between TRIZ and DFX. The creation of combined DFMA plus function analysis plus trimming tools appears to offer benefits in terms of use-ability.

TRIZ and Axiomatic Design (AD)

The integration of AD and TRIZ has already been discussed by Mann (1999). TRIZ can be used to show that the AD 'axioms' have some very meaningful exceptions, and that they are thus not axioms, but nevertheless, axiomatic design still offers designers a series of useful rules to help define and achieve 'good design'. The likely future complementarity between AD and TRIZ currently appears to be restricted to the incorporation of these 'useful rules' into the solution evaluation part of TRIZ, although the AD scheme for correlating the functional requirements of a system to the selected design parameters to the subsequent method of manufacture may offer some additional benefits to TRIZ.

TRIZ and Viable System Model (VSM)

Stafford Beer's Viable System Model emerged from the study of organisation structures and resulted in two very important conceptual findings. The first involved the identification of five essential elements that a system had to contain if it were to be 'viable'. The second involved the idea of recursiveness – and the discovery that the five element viability test still applied at different hierarchical levels of consideration of a system organisation structure. Mann (2001a) describes how this first finding contradicts the TRIZ definition of 'system completeness' and how it ultimately therefore provides a stronger definition of completeness than TRIZ (interested readers might also like to examine CREAX (2002) – which provides an alternative perspective on the Law of System Completeness). The second concept of recursion is still only just being introduced into TRIZ (and the higher order 'systematic creative design' system proposed in this paper), and is believed to offer significant scope for fundamental conceptual evolution of systematic creativity.

TRIZ and Multi-Criteria Decision Analysis (MCDA)

There are a growing number of available methods for enabling problem solvers to make legitimate, recordable and reproducible 'apples versus oranges' comparisons between different systems.

Several such techniques – most notably the logarithmic scaling techniques of Lodge (1981) – offer the potential to enhance the solution evaluation aspects of TRIZ. Software implementations of integrated TRIZ/MCDA can be expected to appear in the very near future.

TRIZ and Six Sigma

As described by Domb (2001), Six-Sigma is more a decision than a method. At a detailed level, there are a number of potentially useful tools and techniques contained in (but not necessarily created by) Six Sigma. These tools centre mainly around the process of problem measurement, and specifically variants of Shewhart/Deming based statistical process control techniques. They offer the potential for some small beneficial advance once incorporated into the problem definition elements of TRIZ.

TRIZ and Theory of Constraints (TOC)

The process of integration of Eli Goldratt's Theory of Constraints into TRIZ has also begun (Mann, Stratton, 1999). The Theory of Constraints matches TRIZ in its recognition of the importance of defining and eliminating contradictions and while it offers less in terms of strategies to overcome contradictions, it does offer the Evaporating Cloud tool which does offer increased richness in terms of increasing problem understanding and entry points for breaking the contradictions. Related to this, but also a much more important area where TOC can be expected to enhance TRIZ comes with its emphasis on modelling causes and effects inside systems. This area looks set to be the main conceptual enhancement to TRIZ, but several other important TOC ideas (identification of bottlenecks, strategies for overcoming bottlenecks for example) can be expected to find their way into future TRIZ/ 'systematic creativity' models.

TRIZ and De Bono

The work of Edward De Bono is both extensive and widespread in its use. Many of the strategies identified or uncovered by DeBono have direct equivalents in TRIZ – for example the idea of working back from an ideal rather than working forward from the known solution (albeit DeBono has nothing as extreme as the Ideal Final Result strategy in TRIZ), the importance of function, the need to shift from either/or to win/win thinking, the trend for systems to evolve in a manner which sees complexity increase before it can decrease, and the concept of psychological inertia and tools to overcome all exist in some form in both pieces of work. Elements of Dr DeBono's work that have no direct equivalent in classical TRIZ include the Six Thinking Hats™ concept, water logic versus rock logic and the 'flowscape' tool, the 'po' operator, and 'sur/petition' concept. The thinking hats concept – and specifically the idea that different modes of thinking are treated very differently in the human brain and so should be segmented – is particularly useful in the context of applying more complete TRIZ processes like ARIZ to more potent effect (Mann, 2001b).

TRIZ and NLP

Although instigated more recently than TRIZ, Neuro-Linguistic Programming has evolved from a very similar philosophical startpoint. Both TRIZ and NLP have been built on the study and abstraction of 'excellence'. In the case of TRIZ, the global scientific and patent databases provided the basis of method development; in the case of NLP it was cognitive science research into linguistics, psychology, cybernetics and anthropology. Both have sought to study 'creativity' from the perspective of modelling known successful creative personalities. Latterly, NLP has drawn additional knowledge from psychotherapy – including Gestalt and Hypnotherapy. Perhaps these latter two extensions have tended to draw NLP away from the mainstream somewhat, and certainly exploitation of NLP in business or scientific practices for example is practically non-existent in most fields of endeavour. This is undoubtedly a pity as NLP offers significantly greater richness than TRIZ in many areas. Initial research to understand the areas of common ground and opportunities for mutual benefit (Bridoux, Mann, 2002) between TRIZ and NLP have highlighted a significant number of high level concepts that exist in one or the other but not both. By way of a

simple example, Reference 20 discusses the 9-window or ‘system operator’ scheme in TRIZ and how NLP can be used to extend its essentially two-dimensional space and time perspective into a third dimension which might be called ‘interface’ or relationship. Figure 4 illustrates this new three-dimensional operator as an example of a concept that does not exist in either TRIZ or NLP, but emerges purely from the integration of the two. The benefits of this integration are discussed in more detail in Mann (2001c).

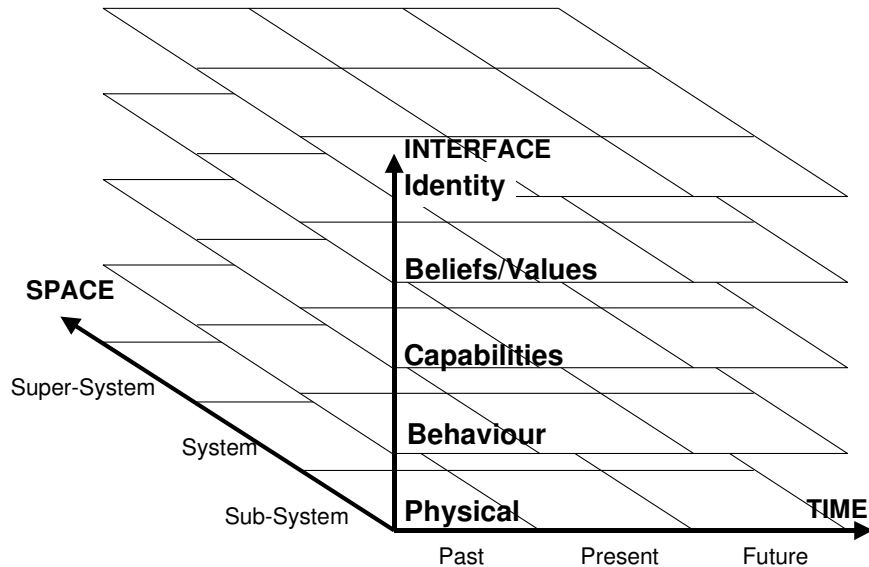


Figure 4: Extension of TRIZ System Operator into 3-Dimensions Using NLP

The integration of TRIZ and NLP tools, methods and philosophies (both rightly claim to feature such hierarchies of application) is very much at the beginning of what may be expected to be a long and fruitful road, along which several important conceptual advances can be expected to emerge.

TRIZ and Kansei

As TRIZ extends further towards industrial design, architecture and the arts it becomes apparent that issues like aesthetics are not well handled by current models. The idea that it is possible to systematise those elements of design that relate to the things we describe as ‘x-factors’, ‘the mysterious wow’, and other labels implying that we don’t understand what makes one design better than another one, is positively offensive to some. Kansei engineering on the other hand represents an attempt to achieve exactly this kind of understanding of why people prefer one artifact over another one. Kansei is undoubtedly also at the beginning of its evolutionary potential. It is already possible to embody a number of Kansei principles and strategies into a tool integrated into the TRIZ/’systematic creativity’ framework, but too soon to speculate on whether the integration of the two will create new high level conceptual benefits. All that can be said with any degree of certainty, is that TRIZ is weak on aesthetic issues and that Kansei is currently the best available tool to explore as a suitable foundation for integration.

Review of Case Study Applications

A number of publications have been published in the last two years describing the application of the evolved systematic creative design method to a broad spectrum of problem and opportunity situations. Notable amongst these studies are the following:-

Wind-Turbine Design – Mann (2002b) summarises a study to try and overcome the inherent inability of commercial wind-turbines to operate in very high wind conditions. The paper describes how the key to successful design in this situation is the fundamental need to depart from traditional

design trade-off design paradigms. The paper suggests that the wind-turbine is incapable of operating in high wind conditions because current design practices force the designer to find a compromise between two conflicting requirements; on the one hand to make the turbine strong, and on the other, to be able to make it light. The paper highlights a situation definition process which first seeks to find the ‘root contradiction’ (as opposed to root cause – which requires substantially more data and drives users towards optimisation rather than innovation) of the problem, before applying a range of the contradiction-elimination strategies uniquely contained within TRIZ.

Evolution of Bearing Systems – Mann (2002c) reports the application of TRIZ-based technology trend prediction methods to identify the evolutionary limits of existing bearing and lubrication system design paradigms. The paper then goes on to explore the unused evolutionary potential contained within the trends in order to identify future design opportunities and match them to current and anticipated future shortfalls of bearing systems as may be seen from the perspective of their end-users.

Process Design Applications – Mitchell (2002) and Winkless (2002) respectively report the systematic creative design capability being applied to coated paper and food manufacture process applications. Both cases build on the importance of functional modelling and root contradiction analysis as key problem definition stages. The two papers then show the deployment of conflict elimination and trend evolution strategies to overcome limiting contradictions within those processes.

Design for Sustainability – Mann and Jones (2001) discuss the application of hierarchical space-time-interface modelling strategies, and the deployment of trend prediction and resource maximisation tools to derive novel design solutions to a variety of mobile power generation equipment challenges. The paper concludes by suggesting that far greater levels of sustainability may be achieved through more holistic design approaches.

Consumer Goods – Mann (2002d) examines the application of the systematic creative design process to the paradigm-shifting conception of novel consumer products in which aesthetic requirements play a significant role in determining the success of one design solution over another.

Further Ahead

We have speculated here that TRIZ is but one component of a higher level creativity capability we have chosen to label ‘systematic creative design’. We believe that it is fundamental to the evolution of such a ‘systematic creative design’ model is that it will emerge – initially at least (as detailed by Savransky (2000)) – from the integration of the different tools, methods and philosophies that currently exist.

There are several emerging creativity models that have not so far been explored in the context of their place in a bigger ‘systematic creativity’ picture. These include game theory, chaos theory, spiral dynamics and general periodicity. Work to explore the relevance and potential benefits of integrating these models into the TRIZ-based model described here (or, indeed, the other way around) has barely begun at this point in time.

In the meantime we all have problems to solve, and opportunities we wish to explore in inventive ways. Some people may want just a few tools or strategies to help them, others may be looking for a higher level start-to-finish process, and still others are looking for a higher level creativity philosophy from which they hope everything else might emerge. In other words, we are all different, work in different ways and want different things. There is currently no single ‘creativity’ entity that will satisfy every individual desire. If there ever is, one thing it will have to encompass is due recognition of individual difference, and (to introduce a TRIZ concept) be self-adapting to

accommodate those differences. At a practical level, this might simply mean that person A likes DeBono, TRIZ and QFD, while person B uses NLP and TOC and doesn't like TRIZ and that both can still work effectively together. The aim of the systematic creative design framework is to achieve this kind of flexibility. As with a 'systematic creativity' s-curve, it is still early days. Our hope is that we've at least realised a framework that offers users the prospect of tangible benefit now.

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