Using TRIZ To Overcome Mass Customization Contradictions

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ABSTRACT

The Mass Customization concept carries with it inherent contradictions between versatility and user benefit versus productivity or cost. Traditional trade-off and compromise based business approaches offer little to help overcome these contradictions. Thus, while many organisations are beginning to recognise the need for Mass Customization, few actually know how to tackle the issues involved in turning the concept into profit-making reality. The paper discusses how systematic innovation methods are beginning to be used to successfully to overcome rather than accept the trade-offs and compromises often held to be inherent. Case study examples include design of mass customized bicycle seats, shoe products, novel room lighting solutions and home-customisable food products. The paper ends with a discussion of these and other disruptive contradiction-breaking technology solutions in general.

INTRODUCTION

> *"Customers, whether consumers or business, do not want more choices. They want exactly what they want – when, where and how they want it"*
> *'Do You Want To Keep Your Customers Forever' Harvard Business Review, Mar-Apr 95*

The concept of Mass Customization – the economically viable creation of products tailored to the specific needs of individual customers – carries with it inherent contradictions between versatility and user benefit versus productivity or cost. Traditional trade-off and compromise based business approaches offer little to help overcome the contradictions. Thus, while many organisations are beginning to recognise the need for Mass Customization, few actually know how to tackle the issues involved in turning the concept into profit-making reality.

The recent introduction of systematic innovation methods into the Design for Mass-Customization (DFMC) environment looks set to change this picture. Central to these new methods is the Theory of Inventive Problem Solving, TRIZ. TRIZ consists of a series of tools and strategies developed through over 1500 person years of research, and the study of over two million of the world's strongest patents.

The key findings of TRIZ research in a Mass Customization context are:-

- that the strongest problem solutions are the ones which successfully challenge the contradictions usually accepted as fundamental
- that there are only a very small number of inventive principles available to successfully eliminate contradictions for either technical or non-technical problems
- that technology and business evolution trends are highly predictable, and highly consistent with Mass Customization

The paper builds on pioneering work on application of TRIZ to Mass Customization problems (1), and describes how a TRIZ-based systematic innovation methodology has been developed and is now being deployed to generate innovative new solutions across a variety of mass customization problems. The paper will discuss the methodology through a number of exemplar case studies. These will include the application of TRIZ tools:-

- to the design of inherently customized bicycle seat designs
- in a DFMC project in the shoe industry
- to the design of novel room lighting systems
- to 'home-customizable' food product innovation

We begin, however, with a brief overview of some of the main TRIZ tools and strategies for those unfamiliar with the method.

TRIZ Basics

TRIZ provides means for problem solvers to access the good solutions obtained by the world's finest inventive minds (2, 3). The basic process by which this occurs is illustrated in Figure 1. Essentially, TRIZ researchers have encapsulated the principles of good inventive practice and set them into a generic problem-solving framework. The task of problem definers and problem solvers using the large majority of the TRIZ tools thus becomes one in which they have to map their specific problems and solutions to and from this generic framework.

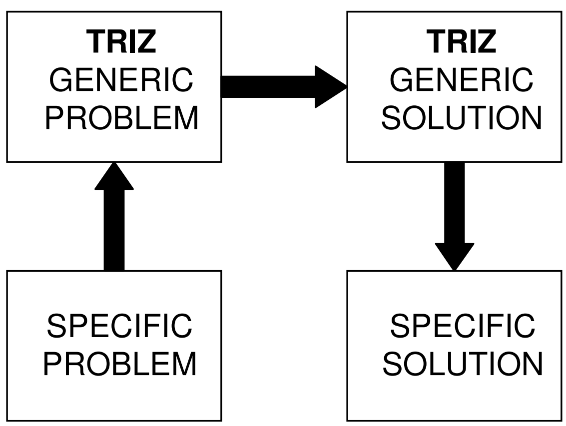

Figure 1: The Basic TRIZ Problem Solving Process

By using the global patent database as the foundation for the method, TRIZ effectively strips away all of the boundaries that exist between different industry sectors. The generic problem solving framework thus allows problem owners working in any one field to access the good practices of everyone working in not just their own, but every other field of science and engineering.

Successful use of the various TRIZ tools requires an approach dissimilar to other creativity methods. Reference 4 discusses the four paradigm shifts – Contradiction, Ideality, Functionality, and Use Of Resources – most commonly observed as important in a TRIZ usage context. We review those elements briefly here:

Contradictions/Inventive Principles

The Contradictions part of TRIZ is constructed on a comprehensive analysis of patents in which the inventor has successfully 'eliminated' design contradictions other design methods assume to be inherent. In using the patent database as a foundation, the analysis has inevitably been dominated by engineering solutions, and so there is an inevitable degree of extrapolation involved in applying the tool to other solutions. Nevertheless, previous research has demonstrated that the exact same solution strategies – or 'Inventive Principles' - apply in non-technical (5) and biological (6) situations. Preliminary work relating the Principles to mass-customization problems seems to further bear out the relevance and scope of the original TRIZ research.

To date, TRIZ researchers have uncovered just 40 Inventive Principles usable by problem solvers to help overcome contradictions. The main message from the TRIZ findings is that there are ways of eliminating contradictions and therefore we should actively seek them out.

Without apparently any knowledge of TRIZ, the acute importance of breaking compromises in a mass-customization environment was first recorded by Stalk et al in Markets of One (7) in an article describing the paradigm breaking performance of companies like Schwab, Southwest Airlines and Home Depot after they successfully broke contradictions in their market sector – Figure 2 – see also TRIZ analyses in (8).

	(%) Industry average growth '88-'95	(%)Compromise-breaker growth in same period
Securities Brokerage	90	520
US Domestic Airlines	80	370
Home Improvement Retailing	40	1500

Figure 2: Breakaway Growth Examples from Schwab, Southwest Airlines and Home Depot (7)

Ideality/Ideal Final Result

TRIZ founder, Genrich Altshuller, identified a trend in which systems always evolve towards increasing 'ideality' and that this evolution process takes place through a series of evolutionary paradigm shift characteristics (2, 9). A key finding of TRIZ is that the steps denoting a shift from one paradigm to the next are predictable and have been under-pinned by the uncovering of a number of generic technology evolution trends. This finding may be expected to play a significant role in helping organisations to predict the future evolutionary potential of any given system or sub-system.

The essential paradigm shift between a conventional design approach and the TRIZ approach is that while traditionally, problem solvers start from the knowns of today, the concept of Ideality, employs a strategy in which the problem solver is asked to envisage the 'ideal final result' situation – in TRIZ terms that situation where the function is performed without any cost or harm – and to then use that as the basis from which to work back to a physically realisable solution. This philosophy is illustrated in Figure 3.

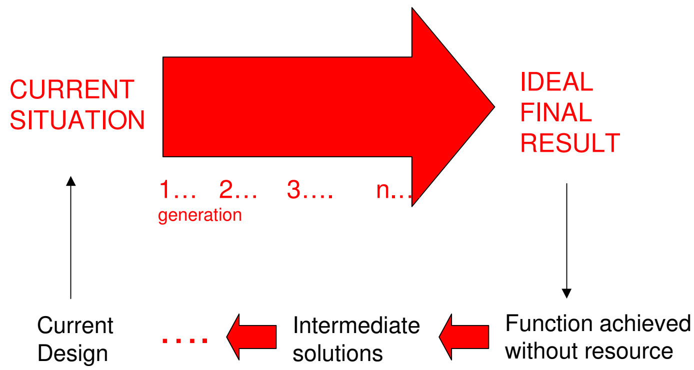

Figure 3: Proposed 'Ideality-Based' Improvement and Evolution Strategy

As well as offering a successful evolution strategy and real problem solutions, the method also provides a considerable amount of valuable long-term strategy definition data. We concentrate our view here, however, on two simple parts of the tool with particular relevance to the subject of mass customization:

The first comes from the definition of Ideal Final Result (IFR) as 'achieve the function without (additional) resources'. This definition is intended to suggest the concept of the existing system '*solving the problem by itself'*. The key word here is SELF. Self is a very important word in a TRIZ problem solving context, and the idea of solving problems without complicating the system denotes a powerful step towards increased ideality. Reference 10 discusses the subject in more detail, but of particular interest from a mass customization perspective are solutions that, for example, self-adjust, self-adapt or self-orient themselves to individual customer desires.

The second part emerges from the (usually qualitative) equation used to define the 'ideality' of a system:-

$$\textbf{Ideality} = \Sigma\textbf{Benefits}/(\Sigma\textbf{Costs} + \Sigma\textbf{Harms})$$

For it is in this equation that we see one of the fundamental contradictions of all business problems – the fight between delivering the good things on the top of the equation versus wishing to reduce the cost element at the bottom of the equation. Actually, the fight usually centres around customers – who generally speaking want the benefits – versus the supplier, who generally speaking wants to minimise costs. Of course this fight differs according to a variety of factors – most notably market maturity – but the top-versus-bottom contradiction analogy will be useful to us in this discussion.

Functionality

Although the functionality aspects of TRIZ owe a significant debt to the pioneering work on Value Engineering, the method of defining and using functionality data is markedly different; sufficient at the very least to merit discussion as a distinct paradigm shift in thinking relative to traditional occidental thought processes. Three aspects are worthy of particular note:-

1) The idea that a system possesses a Main Useful Function (MUF) and that any system component which does not contribute towards the achievement of this function is ultimately harmful. In a heat exchanger, for example, the MUF is to transfer heat to the working medium; everything else in the system is there solely because we don't yet know how to achieve the MUF without the support of the ancillary components. (Systems may of course perform several additional useful functions according to the requirements of the customer.)
2) In traditional function mapping, the emphasis is very much on the establishment of positive functional relationships between components. TRIZ places considerable emphasis on plotting both the positive and the negative relationships contained in a system, and, more importantly, on using the function analysis as a means of identifying the contradictions, ineffective, excessive and harmful relationships in and around a system. Function analysis thus becomes a very powerful problem definition tool.
3) Functionality is the common thread by which it becomes possible to share knowledge between widely differing industries. A motor car is a specific solution to the generic function 'move people', just as a washing powder is a specific solution to the generic function 'remove solid object'. By classifying and arranging knowledge by function, it becomes possible for manufacturers of washing powder to examine how other industries have achieved the same basic 'remove solid object' function. '*Solutions change, functions stay the same*' is a message forming a central thread in the TRIZ methodology: People want a hole not a drill.

The emphasis TRIZ places on functionality demands that engineers and scientists adopt a much more flexible approach to the way in which they look for solutions to problems. The age of the specialist is coming to an end; it is no longer sufficient for mechanical engineers to only look for mechanical solutions to their problems when someone from, say, the chemical or software or social or political, etc sectors may already have discovered a better way of achieving the function being sought – Figure 4. This is again important in a mass-customization context.

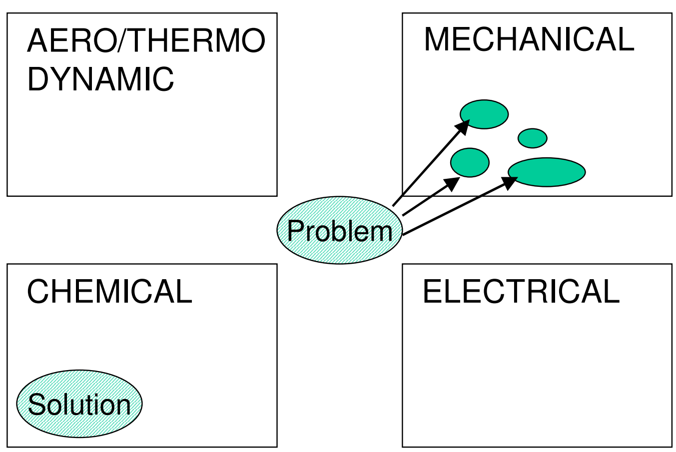

Figure 4: Solution Spaces

Use Of Resources

While the previous three pillars of TRIZ could undoubtedly have been uncovered anywhere where the researchers showed the dedication shown by TRIZ researchers, the 'resources' pillar is probably uniquely Russian. Resources relates to the unprecedented emphasis placed on the maximisation of use of everything contained within a system. In TRIZ terms, a resource is *anything in the system which is not being used to its maximum potential*. TRIZ demands an aggressive and seemingly relentless pursuit of anything –

objects, information, time, energy, attributes, etc – in (and around) a system which are not being used to their absolute maximum potential. Discovery of such resources then reveals opportunities through which the design of a system may be improved. In addition to this relentless pursuit of resources, TRIZ demands that the search for resources also take due account of negative as well as the traditionally positive resources in a system. Thus the pressures and forces we typically attempt to fight when we are designing systems, are actually resources. By way of an example of this 'turning lemons into lemonade' concept, Russian engineers often think of resonance as a resource. This is in direct contradiction to most Western practice, where resonance is commonly viewed as something to be avoided at all costs. TRIZ says that somewhere, somehow, resonance in a system can be used to beneficial effect. In effect, resonance is a potent force lever capable of amplifying small inputs into large outputs. Resonance is currently being used to generate beneficial effects in a number of new product developments from vacuum cleaners, paint stripping systems on ships (firing a pulsed jet of water – existing resource! – at the local resonant frequency of the hull), and in helping to empty trucks carrying powder-based substances more quickly.

CASE STUDIES

1) Bicycle Seat

A simple example should serve to demonstrate the key mass customization benefit-versus-cost contradiction in action: Any customer going into any bicycle shop in the world is likely to be surrounded by a plethora of different bicycle saddle designs, all of which are pretty well designed using the same design rules and trade-offs that have been around for over a 100 years. From a mass-customization context, picking up the quote at the beginning of the paper, there is probably too much choice and too few options. The basic trade-off is one of benefit versus cost. Figure 5 illustrates the basic choices on offer – either cost or benefit via a range of different degrees of compromise (denoted by the hyperbolic 'constant paradigm' curve)

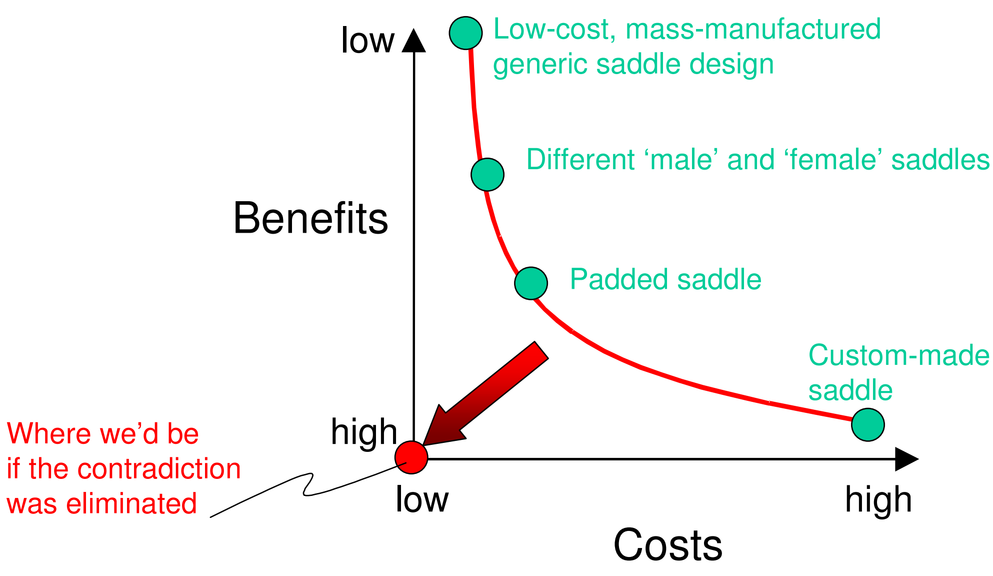

Figure 5: Classic Bicycle Saddle Cost versus Customization Benefit Contradiction

The bottom left hand corner of the picture denotes the point we would be at if the cost versus benefit contradiction did not exist. We might think of this point as our Ideal Final Result.

The ideality tool, in fact, turns out to be a good start point for designing a better saddle (Reference 11 has previously described a solution derived by solving a technical contradiction within the normal design paradigm). From an ideality perspective, an ideal saddle would 'adapt itself' to the shape of any user without complicating the design relative to current designs. In other words, rather than blasting the customer with too many choices, give them exactly the saddle they want by letting them know that it will work out for itself how best to adapt to their individual shape.

There are a number of TRIZ tools capable of getting us to an inherently customized comfortable bicycle seat solution. The quickest route in this case takes the 'self-adapting' concept from the ideality definition above and uses it as a prompt to examine a knowledge base to see if anyone has solved a similar problem elsewhere (TRIZ research suggests that it is 99% likely they have). Using this route and the US patent database, quickly identifies the idea of rheopexic gels as a means of providing adaptable **and** stable shapes – Figure 6.

United States Patent [19] **Pomeranz et al.**

[11] **Patent Number: 4,471,538**

[45] **Date of Patent: Sep. 18, 1984**

[54] **SHOCK ABSORBING DEVICES USING RHEOPEXIC FLUID**

[76] Inventors: **Mark L. Pomeranz**, 9760 Viceroy Dr. East, Jacksonville, Fla. 32217; **R. Saul Levinson**, 26 Carriage La., West Milford, N.J. 07480

[21] Appl. No.: **388,549**

[22] Filed: **Jun. 15, 1982**

[51] Int. Cl.³ **A43B 13/18; A41D 19/00;** F16F 5/00; B68C 1/00; B62J 1/00

[52] **U.S. Cl.** **36/28;** 36/43; 188/322.5; 2/159; 54/41; 297/214

[58] **Field of Search** .... 36/28, 29, 35 A, 35 B, 36/71, 43; 128/594; 560/151; 188/322.5; 2/19, 159

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Primary Examiner—Werner H. Schroeder
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Attorney, Agent, or Firm—Frishauf, Holtz, Goodman & Woodward

[57] **ABSTRACT**

Shock absorbing devices utilize rheopexic fluid contained in a deformable sealed chamber which is subjected to external shock forces. Upon application of the shock forces to the deformable sealed chamber, the rheopexic fluid filled therein is exerted with shear stress which causes the rheopexic fluid to increase its consistency and shock absorbent characteristics as a function of increasing shear stresses applied thereto. Additionally, when used in an application wherein the device is placed against a body part of a user, the rheopexic material "molds" itself to the body portion of the user. When left at rest, the rheopexic material returns to its initial fluid, low-consistency state.

17 Claims, 12 Drawing Figures

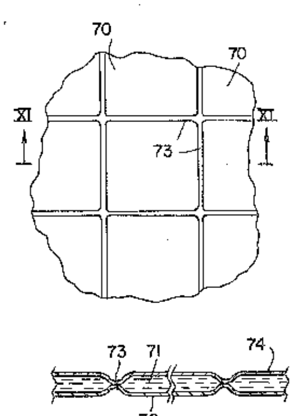

Figure 6: US4471538: Shock absorbing devices using rheopexic fluid

A rheopexic gel turns out to have highly desirable stress-thickening properties as described in the patent abstract:

“Shock absorbing devices utilize rheopexic fluid contained in a deformable sealed chamber which is subjected to external shock forces. Upon application of the shock forces to the deformable sealed chamber, the rheopexic fluid filled therein is exerted with shear stress which causes the rheopexic fluid to increase its consistency and shock absorbent characteristics as a function of increasing shear stresses applied thereto. Additionally, when used in an application wherein the device is placed against a body part of a user, the rheopexic material "molds" itself to the body portion of the user. When left at rest, the rheopexic material returns to its initial fluid, low-consistency state.”

The invention (now expired, albeit cited by a significant 87 other patents since) offers a potential solution to the problem that does not complicate the design of a saddle relative to the conventional gel-padded saddles already on the market; and consequently offers increased benefit (adapatability, comfort) at a fundamental cost no greater than current designs.

2) Shoes

The largest number of patent citations for the Figure 6 rheopexic gel is for applications as shoe insoles. Such devices again offer the potential for ready adaptability not just to individual shoe wearers, but also to the changes that take place in an individual’s foot size and shape at different times of day (evidence records that feet can alter shape by as much as one shoe-size during the course of a typical day). It may be argued that a rheopexic gel insert has complicated the system called ‘shoe’ relative to current designs, and as such, the benefit of a mass-customized shoe versus cost contradiction has not been completely eliminated in this case. The TRIZ evolution trend known as ‘Trimming’, however, suggests that ideality can be increased in this case by merging insole and shoe, and incorporating an appropriate gel into the manufacture of the shoe.

It is likely that the reasons we don’t all walk around in self-adapting shoes are due to a) a failure on the part of shoemakers to make a connection between shoe sole design and the integration of a rheopexic gel, and more likely, b) the probable emergence of other problems when a gel insole is introduced into the shoe design. To take a likely scenario in this second case, it may be that any membrane required to encapsulate the gel would have a negative impact on the breathability of the shoe. If this is the case, then in TRIZ terms, we have found another contradiction, and thus a route into finding ways by which others have successfully overcome similar problems.

3) Lighting

The concept of ‘mass-customized’ lighting systems for homes or hotels is already fairly well established through the emergence of systems like that illustrated in Figure 7.

Any system that follows the TRIZ-predicted evolution trends away from mechanical systems to ‘field’-based systems and towards increased controllability, is consistent with an ability to offer customers a highly configurable, adaptable system. The Figure 7 lighting system, for example, is programmable from a PC and allows home-owners to design and pre-set a wide variety of different lighting settings within a room.

This type of system is able to take ready advantage of existing resources in many homes (ring main to act as communication medium between different switches, dimmer switches, intruder sensors, etc) to give – like most ‘field’/software implementable systems – ways of breaking the benefit versus cost contradiction to enable ready mass-customization (albeit with probable ‘video –programming’ syndrome – 95% of owners understand 5% of the controls on their video player – issues still to be resolved.) Reference 12 discusses this subject further in relation to e-business situations.

Figure 7: ‘Mass Customized’ Programmable Light Switching

Taking this lighting concept a stage further would be a system that allowed the user to modulate not just the level and mix of lighting in a room, but also to modulate the colour of those lights. At the present time, the cost versus benefit mass customization contradiction has not been eliminated for such a concept. Any individual user is able to customize the colour of lighting in a room only by physically changing light-bulbs or by having multiple bulb holders or by incorporating multiple light filters – each of which necessarily involves cost trade-offs.

Again, TRIZ can help to identify means of breaking the cost-benefit contradictions as they currently stand. From an ideality perspective, the light bulb would change colour ‘itself’. A search for solutions relevant to this problem would not reveal a viable design at this time. The technology trends uncovered by TRIZ researchers in conjunction with some of the latest design attempts, however, reveals significant evolutionary potential (13) left in the design of lighting systems, and further points towards possible means by which the contradiction breaking, colour changing light-bulb might well be a possibility.

4) Home Customizable Foods

Initial research (14) suggests that the food industries are ripe for mass customization in several sectors. During the 20th century, the food industry necessarily focused on economic mass production of ‘safe’, ready-made foods. This trend was largely driven by a combination of three main factors; rapidly increasing population, increasing legal responsibility for delivering products which did not cause harm to the consumer, and decreasing desire on the part of the consumer to spend time preparing meals. In the eyes of many consumers, this increase in overall ideality has been achieved by focus on cost and harm rather than ‘benefit’, and in many senses the emerging trend towards mass customisation is a consumer-lead drive to redress the balance between the top and bottom elements of the previously seen ideality equation. Mass customization, in many senses, is about increasing the ‘benefit’ to each individual customer. The initial stages of this phenomenon may be seen in in-store coffee blenders that allow customers to blend different beans to suit individual taste, but an increasing number of products are using the same TRIZ inventive principle 1 ‘Segmentation’ to achieve equally attractive customized products. Figure 7 illustrates one such concept for a product to suit households in which different people have different tastes or liking for spicy food.

Figure 7: Segmented Ready-meal Product Concept

Discussion

History tells us that the successful producers of today’s solutions are highly unlikely to create the next generations solutions (15, 16). The reasons for this phenomenon are both multitudinous and complex, but probably should include elements such as the failure of organizations to recognize the definitions of success (or ‘benefit’) registered by customers, and the paradoxical situation in which products are most vulnerable to be superceded at around the time when they are making most profit for the incumbent organization. TRIZ is beginning to change this situation for a number of leading edge companies; it provides powerful insight into the evolution of both technical systems and markets, and it is the only piece of research anywhere which not only recognizes the importance of eliminating contradictions, but also provides systematic solution triggers for actually doing so.

In many senses, ‘mass customization’ may be seen to be about solving contradictions. TRIZ research has uncovered the fact that the most successful inventions are the ones in which the inventor has not accepted the trade-offs and conflicts most of us take for granted. Furthermore, the research has identified that these contradiction-breaking inventors have used only a small number of inventive strategies in overcoming contradictions. TRIZ thus provides us with potentially very powerful new ways of looking at mass-customization issues:

The ‘ideality’ concept leads us to solutions which ‘do things for themselves’. Adaptive systems – like the viscosity changing rheopexic gel solution discussed earlier, or shape-memory alloys, thermo/photo-chromic materials etc – offer much from the perspective of ready incorporation into solutions that inherently ‘customize themselves’ to the changing desires of individual customers. In most cases they do so in a way that fundamentally breaks the traditional cost versus adaptability benefit contradiction that hampers many mass-customization initiatives. They are thus strategically very important in a design context.

Another pillar of TRIZ, Functionality, similarly offers important messages for mass customization and protection of companies from disruptive technologies. The ‘solutions change, functions stay the same’ message is vitally important. The fact that each individual customer has subtly different functional requirements (and priorities) is even more so.

Benefits versus costs. It is usually the customer who demands 'benefits' (although not necessarily if they have to pay for them – if cost is equal, they will almost always go for the solution offering greater net benefit), and suppliers who work to reduce cost (it's the only element of the ideality equation they have any really understanding/control of). The overall message is that it is increasingly likely that benefits 'win' over 'cost' – if you don't give them to the customer, it is increasingly likely someone else will.

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