Defining 'Breakthrough' Product Design Solutions

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Abstract
This paper seeks to define necessary definitions of what qualifies a design solution to be classed as a breakthrough. Three key areas are identified; one relating to functional connectivity and two to the concept of Evolution Potential - firstly to minimum threshold technology acceptability, and then secondly relating to potential relative to an incumbent design. The Evolution Potential process has been designed to enable objective assessment of incumbent and new technology solutions, relative to a globally generic discontinuous evolution benchmark. The paper contains a series of mini case study examples of breakthrough and non-breakthrough design solutions. A final section of the paper summarises breakthrough innovation tests that may be applied to future candidate design solutions and discusses issues relating to definition sufficiency.
Keywords: non-linear, discontinuity, disruptive, trend, conflict

Introduction

When is a new solution a 'breakthrough', and when is it not? An important question. One that, if the global statistics on innovation are to be believed, the world of inventors and innovating companies is not so good at answering. The average likelihood that a novel product or service idea will be successful on the market is somewhere in the order of 5%. Clearly, therefore, there is a question to be asked about our ability to judge what is and is not going to be successful. This paper examines three 'breakthrough' criteria, which, collectively, we hypothesize, conditions that need to be met during the definition of an innovative design solution. All three of these criteria are derived from and validated through an evolved form of the TRIZ methodology (Reference 1). The first relates to the functions and functionality delivered to a consumer by a design solution. The second relates to how evolved along the discontinuous evolution trends uncovered during the TRIZ research the design solution is relative to an already successful incumbent design solution. During the discussion of this second criterion, the Evolution Potential concept (Reference 2) is used to provide an objective global benchmarking capability. The hope in using the Evolution Potential framework is to demonstrate that the objectivity provided by the technique will allow us to determine some guidelines that we might be able to reproducibly use to gauge the likely success of our own novel designs. The third 'breakthrough' definition criterion, also relates to the TRIZ trends. The issue in formulating this third criterion, however, is not so much about benchmarking relative to incumbents, but to achieving a certain minimum acceptable level of maturity in the eyes of early adopter consumers. We begin the discussion with this third criterion:

Breakthrough Criterion 1) – Minimum Acceptable Technology Threshold

The discussion of this breakthrough definition criterion begins with a journey back in time to the early 1930s when Douglas had just designed the DC-3 aircraft and the world of commercial air travel was just about to take-off. The Douglas DC-3 (Figure 1) turned out to be the father of the modern-day commercial airline business. As such it represented a genuine breakthrough. Despite several previous attempts to make viable passenger carrying aircraft, the DC-3 was the first one to actually succeed.

Figure 1: Douglas DC-3

The benefit of hindsight now allows us to see that the main reason why the DC-3 succeeded where others failed is because it was the first design to integrate five technologies. All of the technologies were already in existence, but no-one had managed to bring them all together before. In this sense the DC-3 is very important from a 'breakthrough' definition perspective. This is especially so when we examine the DC-3 alongside one of its contemporaries, the Boeing 247.

The five technologies integrated into the DC-3 were the variable pitch propeller, monocoque cabin structure, retractable undercarriage, radial air-cooled engines and wing flaps. The Boeing 247, on the other hand, featured only four of the five. The designers at Boeing built the 247 without wing-flaps. The consequence of this decision was that the aircraft had a tendency to become unstable during landings. As a result of this, the designers were forced to down-size the engines. And as a consequence of this, the payload of the aircraft proved to be insufficient to make it commercially attractive for operators. This subtle and yet profound difference between the two aircraft offers us an important insight into the dynamics of innovation; that sometimes we need to combine multiple technical breakthroughs in order to create a commercial one. Looked at from the perspective of the Evolution Potential radar plot, we can see how commercial air transport only became viable when there had been a critical mass of jumps along the trends of evolution. Figure 2 shows a system level plot for the DC-3 highlighting the five jumps that were necessary to create the commercial breakthrough.

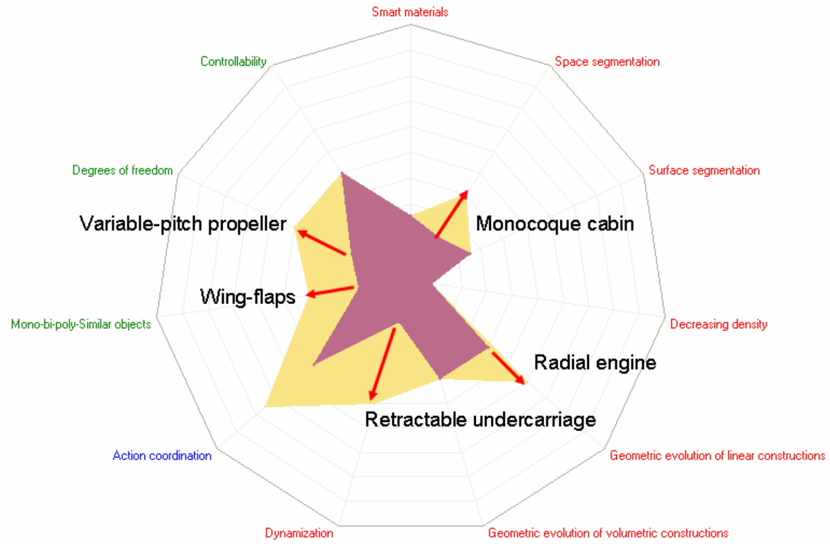

Figure 2: System Level Evolution Potential Plot For Douglas DC-3

So while it was perfectly possible to create a flight-worthy aircraft without any of the technologies integrated into the DC-3 (i.e. the dark shaded region in the radar plot), it took the jumps to the lighter shaded region before that flight-worthiness could be converted into commercial success.

The DC-3 provides an archetypal example of a system requiring to achieve a certain minimum technology threshold before the market determined that it delivered an adequate level of functionality. Unfortunately, as yet there appear to be no general rules to determine precisely how much evolution potential defines such a minimum threshold. In some consumer products for example, a far lower level of exploited potential has resulted in significant breakthrough commercial success (Reference 3). Nevertheless, the Evolution Potential trend framework provides a base from which it at least becomes possible to map the emergence of minimum technology threshold in a given industry sector. In the next section, our attention shifts to another use of Evolution Potential to help determine breakthrough. This time the focus is on benchmarking relative to an incumbent technology. By definition, therefore, our attention shifts to a time when a product has evolved beyond its minimum acceptable technology threshold.

Breakthrough Criterion 2) – Evolution Potential Benchmarking

In examining the concept of evolution potential benchmarking, we examine two case studies. The first case focuses on a recent 'failed' breakthrough, while the second switches to one that has just entered the market and hence we don't yet know whether it has been successful or not. The first case, then, focuses on the recently launched projection keyboard. The field-based keyboard illustrated on the right-side of Figure 3 has oft been used by people in and around the TRIZ community as an example of the 'Dynamization' trend. Indeed, as shown in the figure, the humble keyboard does make a very nice illustration of the trend in action

Figure 3: Keyboard Evolution To The 'Projection' Design

There is only one problem with this case study, however, and that is that the projection keyboard has not proved to be the commercial 'breakthrough' that its inventors (and several forecasters in and around the TRIZ community) predicted. This aside, we also need to understand the failure of the design a little better in the context of the Dynamization trend – which, after all, is there to tell us that 'good things happen when we advance from left to right along the trend'. So what is going on here?

Again, construction of the complete Evolution Potential radar plot for the keyboard should hopefully give us a clearer picture. Such a picture is illustrated in Figure 4. What this plot shows is a comparison between a conventional keyboard (left hand side of Figure 3) and the current form of the projection keyboard.

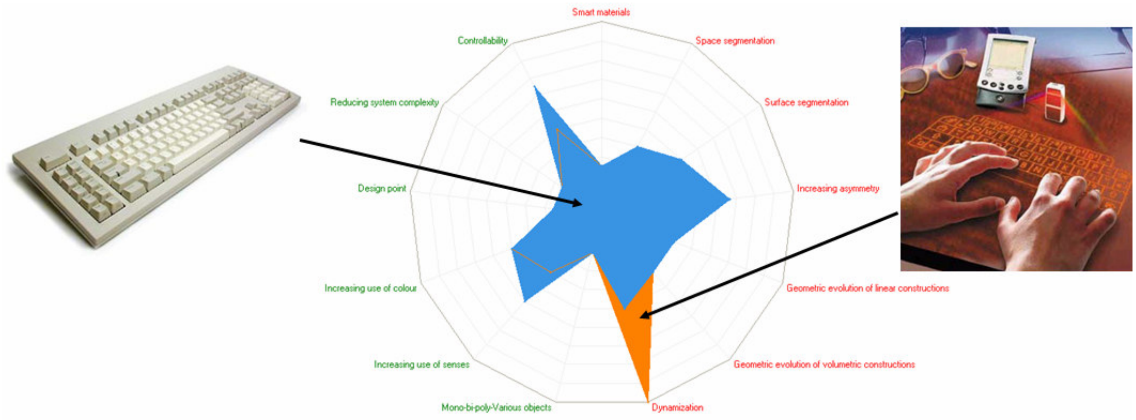

Figure 4: Evolution Potential Difference Between Conventional and Projection Keyboard

What figure 4 makes clear is that although the projection keyboard has made a very definite advance along the Dynamization trend, it has simultaneously made backwards jumps along two of the other trends. Namely, the projection keyboard does not have the same sense of touch ('use of senses' trend) and hence the same positive ('controllability' trend) feedback found in a conventional keyboard.

Whenever we see this kind of radar plot – where advances along one or more trends is countered by backwards jumps along other trends – then we have presented the consumer with a trade-off. While there is no hard and fast evidence to say that such a situation precludes the achievement of a breakthrough, the evidence tells us that we make the likelihood an awful lot lower than if no trade-off decision had been necessary.

One of the interesting aspects of the projection keyboard is that the initial perception of most people *seeing* it for the first time is that it is a great idea, bound to be a commercial success. Alas, that perception tends to disappear when one gets an opportunity to feel (or rather not feel) the keyboard in action. Hopefully this feel/feedback problem is one that is eminently solvable. Should this happen to the extent that the two backward trend jumps are reversed, the resulting radar plot would tend to suggest that the likelihood of commercial breakthrough is much more likely.

Let us now build from this case to an even more recent one. This time a product innovation that has not yet had sufficient time on the market to determine whether it will be a commercial breakthrough or not, the just-launched M3 Power razor. This new Gillette razor introduces pulsation into its razor products. In so doing, the razor makes a very definite advance along the Rhythm Co-ordination trend. Whether this technical breakthrough comes in response to the recent jump from three to four blades made by its competitors, or because of a desire to increase sales of the their complementary batteries, we shall probably never know. What we can see, however, when we construct a comparative Evolution Potential radar plot of the razor before and after the M3 Power is that yet again we see an advance along one trend countered by backward jumps along other trends. Figure 5 shows the plot.

In this case, the negative jumps have occurred along the Energy Conversion and Reducing Complexity trends. The addition of a battery to a previously passive device and – as shown in the inset close-up picture on the right hand side of the figure – the marked increase in complexity of the system together present the consumer with an interesting trade-off decision. As already stated, it remains to be seen whether the improvement in shaving performance delivered by the vibrating action will offset the inconvenience of having to purchase and replace batteries and increased likelihood of reliability/durability problems. From the evidence of other cases, like the earlier projection keyboard, it would appear that the M3 Power is not likely to become a significant commercial breakthrough. At least that is the prediction the radar plot allows us to be confident in making.

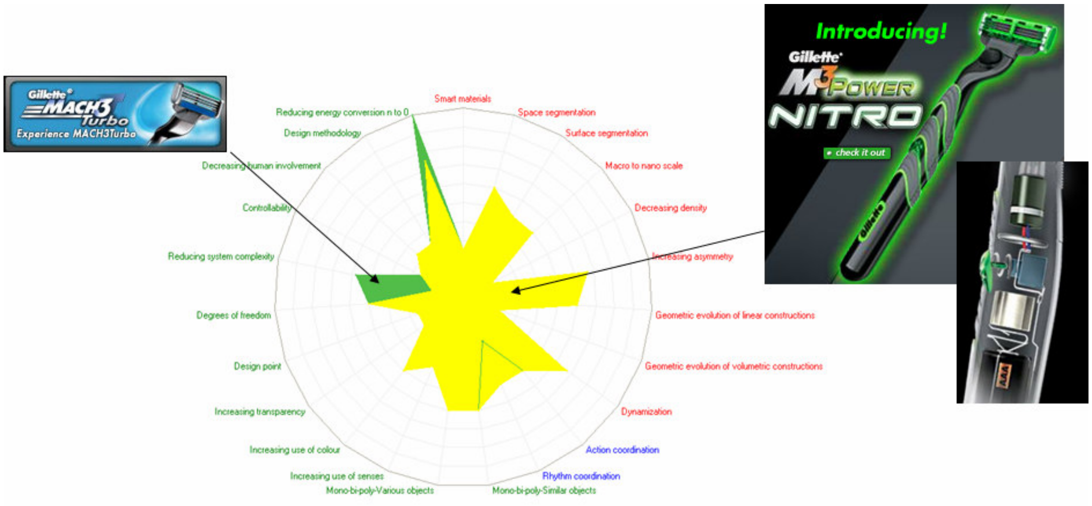

Figure 5: Evolution Potential Difference Between Gillette Mach3 and M3 Power Razors

Again like the projection keyboard, the chances of achieving commercial breakthrough are markedly increased when the consumer is not presented with a trade-off decision. The real M3 breakthrough is likely to happen when someone finds a way of delivering the improved performance created by the blade vibration without the need to add an external power source, or to add so many components to the design. Quite likely both are technically feasible with already existing technologies from other fields, but that is another story for another paper. For now, our focus needs to shift to the third breakthrough definition criterion:

Breakthrough Criterion 3) – Functional Connection

Think for a second about the Segway. At the time of its public launch at the end of 2001, inventor Dean Kamen was predicting that he would shortly be building 10,000 machines a week to meet demand for the product. One of Kamen's leading investors was predicting that the company would reach $1B faster than any other firm in history. So what went wrong? Why has the Segway, shown in various poses in Figure 6, become the butt of a thousand and one jokes and almost as many scenes in science fiction movies?

Figure 6: Segway – An Advertising Person's Nightmare?

Certainly the answer to this question has nothing to do with the focus of the previous two sections on defining 'breakthrough'. The focus of those sections was the Evolution Potential radar plot, and the idea that breakthrough solutions were almost invariably symbolized by a radar plot that was more developed than the equivalent plot for the system that came before it. To all intents and purposes, a radar plot for the Segway would indicate that it meets this breakthrough criterion. The Evolution Potential success criterion, therefore, although 'necessary' to help us define 'breakthrough' cannot be viewed as 'sufficient'. Clearly something else is there in the picture when we think about the Segway. And indeed the same applies when we think about other notable 'breakthroughs' that turn out not to be.

The key to our understanding of the next 'necessary' aspect in a true definition of breakthrough, then, forces us to think in more detail about the preceding radar plot definition. The key phrase here is 'more developed than what came before it', and the key connection we need to make relates to the TRIZ pillar 'function'.

One of the reasons we haven't drawn a comparative radar plot for the Segway versus its predecessors or equivalents is that it doesn't appear to have any. Sure, we could have drawn a plot for the Segway on top of a plot for a car? Or a scooter? Or a skateboard? Or, maybe something else? It is precisely this doubt where the key problem of the Segway lies as far as its potential customers are concerned; what to compare it to?

The general rule proposed here is that if a potential customer cannot link the function delivered by your 'breakthrough' idea to a function they need to get done, then your product is very unlikely to succeed. The most recent Clayton Christensen book (Reference 4) contains the quote, '*"When consumers buy a product, they are really hiring the product to get a job done for themselves. The jobs we are seeking to get done in life are remarkably stable. Companies are successful when they make it easier for their customers to get done something they historically cared about."* Christensen's reference to the word 'job' is a very definite equivalent to the TRIZ word 'function' – not only must customers be able to connect to something they want to do, but they must see that the newcomer does the job better.

Here's where things perhaps the logic starts to get a little difficult. What is the function of the Segway? According to the marketing it is a 'personal transporter'. So the function is transport? At least when we think about tangible functions, that would certainly appear to ring true. So why doesn't the Segway succeed in the market? It is more compact than a scooter, faster than walking, and easier to learn than a skateboard. Why didn't these advantages allow it to succeed?

The answer we think emerges only when we delve into the detail of what we mean by 'transport'. And by delving into the detail we mean examining some of the attributes of the transport function. We can help make this process more systematic by thinking about the 5Ws and H, and particularly the who, where, when, why and how questions. Thinking about 'where' for example might get us to realize that we are in the ground-transport business. Within this sector there are then road, rail, pavement (sidewalk) and 'off-road' categories. The Segway is intended to fit in the 'pavement' category – in that it doesn't go on rails, it isn't appropriate for roads or off-road situations. So far so good; Segway is in the pavement-transport business.

Next up is 'who'. Since we are in the pavement business and the system is designed to be self-balancing, and therefore easy to ride, we might answer this question as 'everyone that might use a pavement'. That assumption would certainly seem to fit with Kamen and his investors' perceptions anyway. Still no problem. Now we are in the pavement transport business and our customer is anyone currently traveling on foot.

Now what about the 'how' question. The most immediate connection here is that the Segway is a powered form of transport, as opposed to one that is human-powered. At this point we appear to have at least the start of a problem; powered transport is not supposed to go on pavements. The problem becomes worse when we think about another aspect of 'how', this time speed. The Segway is designed to travel at speeds up to 12mph. As soon as customers see this speed aspect of the Segway, we think that a number of distinct disconnects start to emerge: first because there is no precedent to say that powered devices should travel on payments, it becomes difficult for the customer to compare the Segway with something they know. Secondly, even though 12mph sounds like people will get from a to b more quickly, there is a second disconnect in that pavement traffic does not travel at 12mph. Actually it travels at 2 or 3 mph.

The disconnects become even worse when we take on board some of the 'when' aspects of the system. Is this an everyday product? Do I use it when the pavement is full of other people? When it is raining? What do I do when I want to go into a shop? Do I leave the Segway outside or bring it in with me? Again, it becomes very difficult for people to connect the Segway with a job that they want to get done.

Maybe the speed difference becomes less important when everyone is on a Segway, and maybe the convenience issue becomes resolved if shops are designed for people to enter on their Segways, but until those sorts of things happen, it is beginning to feel like the machine is not making it easier for users to 'get their jobs done'.

In the final analysis, the Segway, in the way that it was presented to the market, makes little or no functional connection to the needs of just about any of its target users. Hence it is almost inevitably bound to fail in today's world. And it will continue to fail until such times as Kamen can find a way of connecting the Segway to a functional requirement in which the myriad plus points of the system can actually be exploited by the user. Like as a form of transport along the decks of super-tankers. Or in warehouses.

The Segway, of course, isn't the only product to reach the market without recognizing the need to deliver a function better than its predecessors. Still in the field of transport, although this time shifted from pavement to road is the C5 electric car shown in Figure 7.

Figure 7: The Sinclair C5: Road Safety Anyone?

The functional disconnect with the C5 was primarily safety related. The fact that the C5 was open top and around half the height of a car meant that the attractions of green-power were almost always negated for all but the most dedicated of environmentalists. The functional disconnect here was primarily about 'where' and 'what'.

Not quite as famous as the Segway or C5, but nevertheless a product that found its way onto the market as a ‘breakthrough’ is the garlic cake (Figure 8). An evolution potential radar plot for the garlic cake is easy to plot on top of a radar plot for a normal cake. All else being equal, the addition of the garlic would look like an advance along the Mono-Bi-Poly trend and hence it could look like a ‘breakthrough’ confectionery concept. Alas, however, here too we will find a functional disconnect between what a consumer expects to see featured inside their cake and what the chef decided to include. The ‘what’ mis-match between sweet and savoury is profound enough to prevent all but the bravest to contemplate cutting themselves a slice.

Figure 8: Garlic Cake Anyone?

Note too the cake packaging concept – which serves to create yet another functional disconnect in the mind of the consumer. Cake. In a jar? Are you sure?

Only Connect – Final Thoughts

The general message from the garlic cake and Segway alike, is that if you are presenting something new to the market, the consumer needs to have some kind of functional datum to which they will connect and therefore compare your offering with their prevailing expectation.

If they can’t make that connection, or if the connection they make shows that your product does the job less well than the incumbent product then, tempting as it might be to try launching your garlic cake onto the world, history says that your chances of success are somewhere between slim and non-existent. In other words, you do not have a ‘breakthrough’.

The likelihood that any product or service will be seen by the market as a ‘breakthrough’ depends on many factors. Our aim in this paper has been to demonstrate the role that the TRIZ trends and the Evolution Potential concept have to play in the overall picture. Based on our experiences in drawing many thousands of these plots, it is quite clear to us that the chances of achieving ‘breakthrough’ are highly dependent on making positive advances along at least one trend (and very often – as in the DC-3 example – several), without making negative jumps along other trends.

In this paper we have identified three ‘breakthrough’ definition criteria. It is our view that not only can they be used as a retrospective test, but that their main use is as a forward-looking, pro-active design analysis and synthesis toolkit. It is not yet clear whether the three tests represent a necessary and sufficient ‘breakthrough’ litmus test. Probably not. Apparent breakthroughs can often emerge from consumer fads. These, however, tend to be temporary in nature. It is far from clear that they can be systematically pre-determined, although Reference 5 describes a tool to help in the process. Reference 5 also concerns itself with the ‘sufficiency’ breakthrough test, suggesting that innovation timing has something to contribute to the story. The research continues to resolve the remaining uncertainties. In the meantime, the three tests presented here are believed to offer at least a start, from which the design community might objectively build a breakthrough design benchmarking capability of an integrity which has not previously been possible.

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