

Measuring Sustainability

Global Best-Practice Scan Toolkit

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ABSTRACT

The paper describes the development of a toolkit aimed at helping organisations to better understand their current capabilities and consequently plan future strategy in relation to issues of sustainability. The paper builds on foundations constructed from, firstly, the world's biggest study of creativity and innovation. This study has comprised the systematic analysis of close to three million successful innovations. The second foundation for the paper has been a collaborative programme of work funded by the EU to realise a sustainable innovation toolkit for SMEs and other organisations. This work has comprised inputs from leading sustainability institutions in Austria, Germany, Italy, Belgium, Slovenia and the UK. In addition to describing the 'Sustainability Scan' benchmarking tool, the paper also intersperses a number of real life case studies of innovations that serve to set the standard for defining sustainable 'success'.

Introduction – The Consumer Never Asked For The Bad Stuff

In 1946 a group of Soviet engineers and scientists began what was to become the biggest study of innovation ever conducted. The resulting output – The Theory of Inventive Problem Solving, or 'TRIZ' in Russian – now comprises the systematic analysis of close to three million successful innovations (Reference 1). Very few people have heard of TRIZ. Partly due to the closed society that existed in the Soviet Union before the fall of the Iron Curtain, but now increasingly because many of the companies using it see it as some kind of 'secret weapon'. This is a pity, and an especially significant one in the context of the creation of more sustainable products and services, since TRIZ has much to offer the subject.

One of the main findings of the research is that there is a general direction that all successful innovations will follow. In simple terms, this direction involves giving the customer – in the most general sense of the word – what they want; more of the 'good stuff' and less of the 'bad stuff'. Different customers will, of course define what is good and what is bad slightly differently, but there is also a considerable commonality. Cost is part of the 'bad stuff' for example. So is waiting time or an unwanted side-effect or a negative environmental consequence. It is possible to translate the good-stuff/bad-stuff story into a simple equation involving a term that TRIZ describes as 'ideality'. The 'ideality' of any system is thus defined as:

$$\text{Ideality} = \frac{\text{(sum of the good stuff)}}{\text{(sum of the bad stuff)}} = \frac{\text{Perceived (Benefits)}}{\text{Perceived (Cost + Harm)}}$$

If we can believe this idea of a direction of success, then it should suggest that over time any supplier will inevitably be forced to deliver 'more ideal' solutions if they wish to remain in business. Somewhere in this direction comes the thought that eventually this will inevitably mean providing solutions that contain less of the 'harm'. This is good news from a sustainability perspective. Unfortunately, however, for the vast majority of consumers (i.e. the ones that do not have sustainability firmly on their lifestyle agenda), the 'less harm' part of the story comes very much at the bottom of the priority list compared to more benefits or less cost. This is the bad news part of the sustainability story.

That consumers will place 'harm reduction' as a lower priority than higher benefits or lower cost should not be too much of a surprise. No consumer asked for the harm part of the equation in the first place; it simply came as an unpleasant, conscience-nagging side-effect. No wonder, then, that the large majority of consumers are unwilling to pay extra for a solution that contains less of the harm – 'give us more money and we will remove some of the stuff you never wanted anyway' is hardly the most enticing marketing strap-line.

The fact that the consumer never asked for the bad stuff is probably the single biggest problem facing the community of individuals and companies operating in the sustainability field. According to Reference 2, there are two possible solution directions to overcome this problem: 1) make sustainability 'cool' enough (the 'perceived benefit' part of the ideality equation) that consumers are happy to pay a premium for a more sustainable solution, or 2) find a way of offering consumers solutions that do not require them to make trade-offs and compromises between harm, cost or benefit. It is this second area where TRIZ has most to contribute (although see Reference 3). In order to see the method can deliver solutions that do not involve trade-off or compromise, we need to first explore and understand a little more about the dynamics governing the way in which systems evolve:

The Dynamics Of System Evolution

Studying several million successful innovations taken from all forms of human and natural system (Reference 3) evolution begins to reveal and unravel some of the dynamics governing the ways in which all systems evolve. It is almost impossible to do justice to this subject in the space available here. Reference 1 tries to do a better job in the still limited space of a few chapters. Two factors are nevertheless important. The first is that all systems evolve towards what TRIZ calls an 'Ideal Final Result' (IFR) end state. This (largely theoretical) end point, thinking about the above ideality equation, is where a system will be when it delivers all of the benefits required by the consumer (in all the different forms that the term implies), with none of the cost and none of the harm.

The second, more important, factor, then, is that the route by which systems will travel towards that IFR end-state is governed by an s-curve profile. S-curves are everywhere in TRIZ since all systems are governed by the dynamics of the phenomena that the curves describe. As indicated in Figure 1, every system, whether it is something as complex as 'planet Earth' or as simple as a nail, has 'an s-curve'. This s-curve says that whatever we wish to improve about a system – TRIZ uses 'ideality' as it encompasses the important aspects we might wish to measure – when we first think of a way of doing something, it is quite easy to make those improvements. This is the time when the s-curve profile is in the sharply-rising phase. Later on, however, the top of the curve begins to flatten out. This characteristic does not happen because of lack of effort to improve a system – often, ironically, we find ourselves putting in more and more effort to get less and less improvement in fact – but because something is stopping us from making the improvements. In TRIZ

terms, the flattened top of the s-curve exists due to the emergence of a contradiction; we would like to improve something, but something stops us from making that improvement.

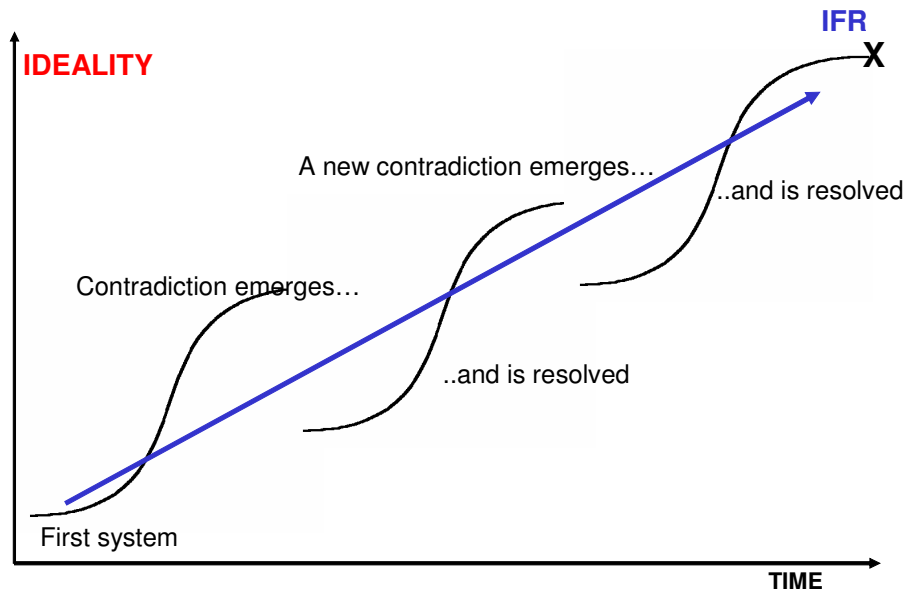


Figure 1: The Fundamental Dynamics Of System Evolution

Any attempt to improve any kind of system without understanding this dynamic is ultimately destined to fail. Once a system reaches the top of its s-curve, it will not improve any further. This is a fundamental given. The only way – according to the solutions studied within TRIZ at least – to improve a system when it has reached this top-of-s-curve position is to eliminate the contradiction and find a new system. The next part of Figure 1, therefore, indicates the next important aspect of the dynamics of evolution; systems will evolve towards the IFR end-state through a series of discontinuous jumps from one s-curve to another in a repeating pattern of emerging contradiction and resolution of that contradiction.

In studying several million successful jumps from one s-curve to another, TRIZ researchers paid particular attention to examining what the jumps from one system to another looked like. This is a radically different approach from the rest of the world’s emphasis on mathematical models and ‘optimisation’ strategies. There is no mathematics to describe the when and how a system will jump from one way of doing things to another. But – and it is a very big but – there are very definitely repeating patterns; jumps that happen in one area that also happen in a completely different one, and another, and another. TRIZ has so-far encoded 35 of these system jump patterns. We now need to look at what these patterns look like and see how they can enable the reliable measurement of ‘sustainability’. Before we get there, however, it is necessary to discuss an important complication that occurs during the evolution of systems. We have to pay particular attention to this complication here since it has significant implications on the ability of scientists and engineers to deliver more sustainable solutions.

A Complication – Systems Get More Complex Before They Can Be Simplified

As systems evolve, the TRIZ research has also shown, they will pass through a cycle of increasing and then decreasing complexity. Figure 2 illustrates the general principle. The underlying mechanisms of this characteristic are various and complex, but certainly include phenomena associated with technology availability, displacement of existing systems and cost-of-replacement issues (Reference 5, 6).

The characteristic is significant from the sustainability perspective particularly during the ‘increasing’ complexity phase. What this part of the curve is telling us is that there is a period during the evolution of any system when the complexity will inherently have to rise. When we see things getting more complex, we often tend to see and think of them as getting ‘less sustainable’. Even if this is the case, what the characteristic is trying to tell us is that whether we like it or not, the system has to become more complex before it can become simplified.



Figure 2: System Complexity Increases And Then Decreases

A simple example may serve to help understand the significance of this increasing-decreasing complexity characteristic. That example involves the solar panels fitted to the roof of a building. In recent times, environmental awareness has caused many home owners to consider adding some form of solar energy collector onto their roof. Such collectors will typically take the form of photo-voltaic cell arrays or heat exchangers – to either convert solar energy into either electrical energy or to heat a supply of water. In either case, the fact that a new function is being added to the roof means that the complexity of the ‘roof’ system is forced to rise. As shown in Figure 3, that increase in complexity emerges because the homeowner is forced to add something to what is already there.



Figure 3: Complexity Increases/Decreases Trend And Roofing Systems

Increasingly, however, there is a choice as forward thinking manufacturers begin to offer roofing materials that integrate the solar energy collecting and converting components into the tiles. Such integration represents a decrease in the overall complexity of the roof since the weather protection and solar collection functions become integrated into a single system – i.e. an integrated ‘solar-tile’ represents an example of a system on the downslope of the complexity-increases-then-decreases characteristic. This integrated solution is in most ways a ‘more ideal’ solution than the retro-fit option – it uses resources more effectively, is more efficient, is more aesthetically pleasing and eliminates the need for having to attach and pierce through the existing roof. If this is the case, then we might begin to wonder why every customer doesn’t automatically opt for this solution. The reason that they don’t is that a roof is expensive, and expected to last for many years. In such a situation, few if any consumers are prepared to scrap what may still have twenty or thirty more years of life left in it in order to reap the benefits of a ‘more ideal’ system. Hence, we have a not uncommon situation in which an apparently more sustainable solution forces the consumer into a number of less than ideal compromises. How we deal with those particular sorts of compromise is another part of the TRIZ toolkit and hence is beyond the scope of the discussion here, apart from to

say that those compromises can and will eventually be resolved. For our purposes here it is sufficient to note the existence of the characteristic and to be aware that sometimes when we are looking to deliver more sustainable solutions things may have to apparently ‘get worse’ before they get better again. Again according to the research, this characteristic is a fundamental dynamic of system evolution.

Trends of Evolution and Sustainability Scan Tool

So now we progress to the 35 trend patterns so far uncovered by the TRIZ research. Remember that each of these trends emerges by observing evolutionary discontinuities that repeat across different industries and disciplines. By way of introduction to these trends, Figure 4 illustrates a trend associated with the way that a system becomes progressively more dynamic. Each of the stages in the trend represents (roughly – it is an over-simplification, but hopefully a useful one) a new s-curve. We may observe this trend in relation to things like steering systems in cars, cutting equipment, image gathering systems, and any other system that involves some form of dynamisation of constituent parts. As with the way other trends are presented, the overwhelming direction of system evolution to increasing ideality is from left-to-right across the stages. Note in this trend how we can see systems getting first more complex – adding joints to an immobile system – and then less complex again – making the system first flexible and then discarding the mechanical construction altogether.

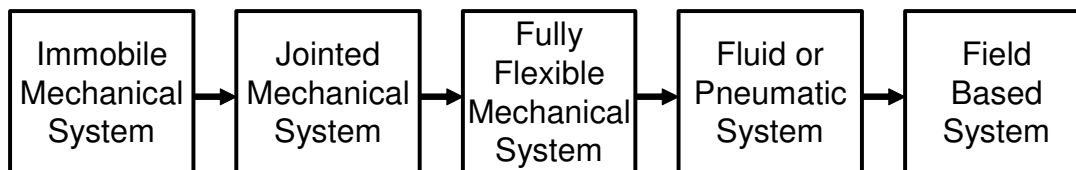


Figure 4: Increasing Dynamization Trend

The key to using this and all of the other trends from the sustainability measurement perspective is to understand whereabouts along the trend a current system under evaluation is. Roof-tiles, to go back to the previous example, are still at the first stage of this trend since they are generally speaking not designed to move. From an evolutionary perspective, therefore, these roof-tiles still have considerable untapped potential in terms of delivering a more ideal and more sustainable solution. Evolving to the third stage of this trend and making a flexible solar-panel roof tile, for example, would offer a more ideal system since it would allow the roof to shift its shape and orientation so that it captures the sun’s energy more efficiently throughout the day. The evolution ideas that emerge from using the trends in this way – seeing where we are and then using the unused stages to predict how our system might take advantage of the same types of jump – are probably their most valuable contribution to the engineer. Again space limitation here prevents further discussion on this subject (Reference 1 contains considerably more detail for those interested). Our attention continues to see how the trends can be used to measure the sustainability of a given solution.

This job can be made easier by looking at a second of the 35 trends. Figure 5 thus illustrates the trend known as ‘space segmentation’. This is another trend associated with the physical appearance of objects (other trends shift their focus to temporal and interface issues). It is a trend concerned with ‘doing more with less’, or making functional use of adding holes to systems.

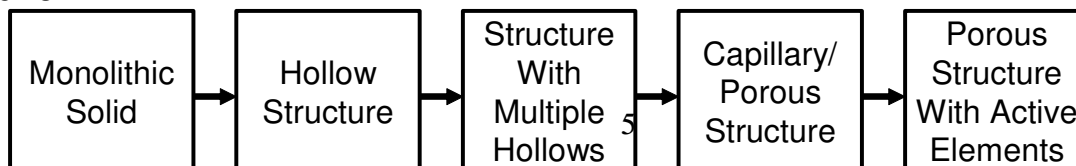


Figure 5: Space Segmentation Trend and Foam Metal Structures

This trend is very specifically focused on maximising the use of available resources, and as such is highly tuned to the idea of more sustainable systems. As we pass from left to right along this trend, we see systems evolving from solid lumps into hollow structures in which the holes get progressively smaller and (usually) more frequent. As an example of the sustainability advantages offered by evolution along this trend, and also as a demonstration of the trade-off and compromise eliminating benefits of making the jumps, we might think of mechanical structures and the engineers' perennial challenge to obtain the strongest possible structure with the lowest possible amount of material. The space segmentation trend will tell anyone still using a monolithic structure that there are four untapped stages of evolution that can all help to solve the strength/weight compromise. The latest auxetic foam materials, for example – systems that have evolved to the 4th stage of the trend – offer the ability to reduce the amount of material used by 80% without adversely impacting the strength. While again it is an over-simplification, it is useful to imagine the environmental impact that being able to reduce material consumption by 80% might make if everyone were to evolve to more ideal stages on the trend.

Since the measurement of sustainability is our focus here, let us now take these two trends and use them to take a system we wish to measure the level of 'sustainability' of. We might think of this as sustainability benchmarking. Or, in TRIZ terms, 'global benchmarking' –since that is what effectively we are doing. For the first time, TRIZ allows us to benchmark the evolution of systems against a truly global scale, one that bridges the gaps between different industry sectors and allows the good ideas of one sector to be systematically made available to those in other sectors. So, we take the system under consideration and compare it to the trends – asking 'how far along the trend has this system evolved?' – eventually doing it for all 35 (although we will find that not all will be relevant to a given system). Then if we plot each trend line as a spoke on a radar plot, we can produce a plot as illustrated in Figure 6. This plot is becoming known as an evolutionary potential radar plot. Since all of the trends are intimately connected to the evolution of more ideal systems, they are also an objective means of measuring the sustainability of the system under consideration. All of the space between the plot of where our system is and the outer perimeter of the plot represents the untapped opportunities to evolve the current system in the direction of more benefits, less cost *and* lower harm.

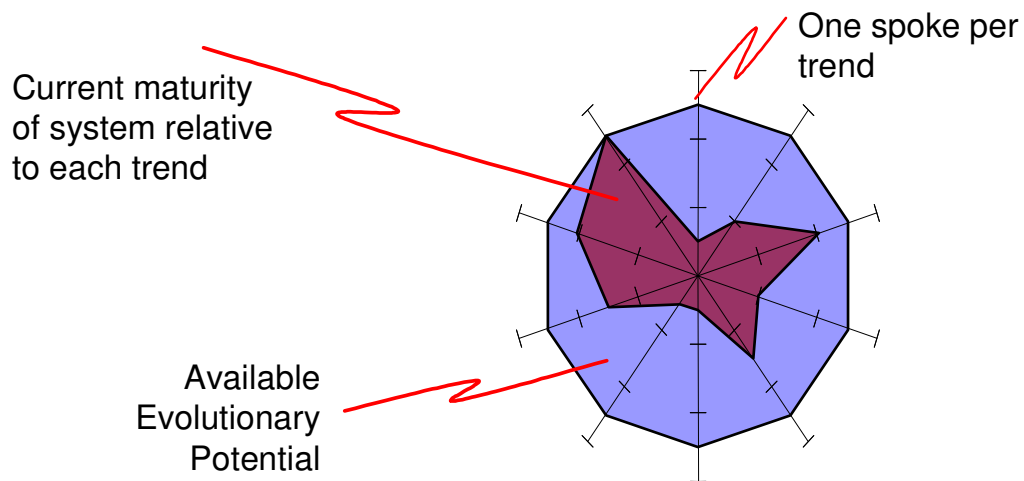


Figure 6: Typical Evolution Potential/Sustainability 'Global Benchmarking' Scan

Reference 7 describes the complete procedure for constructing and using the plots. One of the main emerging uses is as a benchmarking tool. Since the trends represent objective measures of systems of all varieties, they allow a consistent and quantifiable means of comparing one to another – Figure 7 – in order to, for example, judge which one may be more ideal and more sustainable than another.

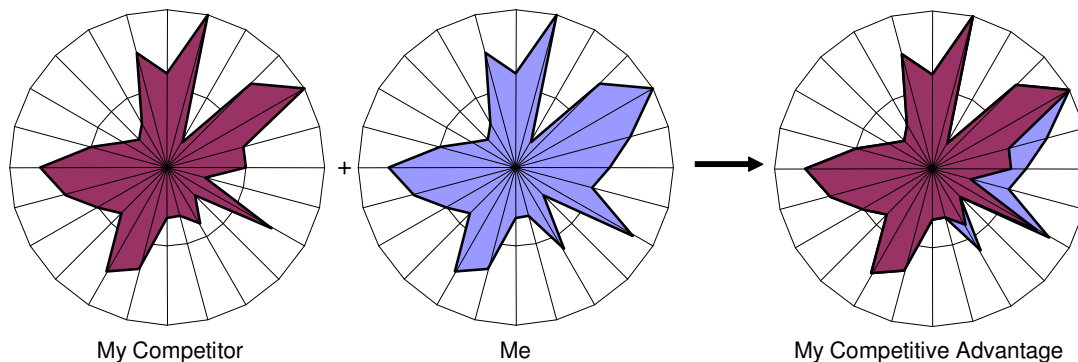


Figure 7: Comparing Sustainable Solutions

The CREAX research team actively monitors new design solutions and patents, constructing these evolution potential plots, and actively looking for new trends and trend stages. This is important since if one industry finds a new way of doing something, adding that solution to the TRIZ database will enable it to spread to other sectors more rapidly. Currently we construct around 4000 of these plots a month. In the last two years we have not found any new trends or trend stages, which should give some kind of confidence that the structure offered by the plots is generic in as global a sense as possible. Clearly also, it is evident that the research needs to continue in order to ensure that the claim and objective of having the best of the world’s knowledge in one manageable structure is one that can be justified.

Summary And Where Next?

There is a well-known farming saying that you don’t fatten a pig by weighing it. Measuring the ‘sustainability’ of a system does not make it any more sustainable. But. In another saying we hear that what gets measured gets done. One of the problems in and around the sustainability arena has been a lack of objective measurement systems. There are, of course, many ways of measuring ‘sustainability’ (various portfolio techniques, the eco-compass to name two commonly used techniques), but they are all subjective, relative and none of them offer any advice on how to turn a given solution into a more sustainable one.

TRIZ and the evolution potential radar plot method offer, for the first time, the ability to measure sustainability against an objective trans-disciplinary scale. Moreover, through the use of the discontinuous trend jump idea, the method not only permits measurement, but the opportunity to identify what evolution directions are going to lead to more sustainable design solutions. In TRIZ parlance, ‘someone, somewhere has already solved your problem’. The method thus allows users to systematically transfer successful sustainable ideas from one sector to another.

Sustainability is a necessary component in the long term survival of the human race. Innovation is the engine that will enable a sustainable future. Systematic innovation tools, and particularly those involved in achieving the elimination of trade-offs and compromises may be expected to play a significant role in ensuring people, planet and profit are able to not only co-exist, but also thrive in that sustainable future. Sustainability benchmarking tools will

enable organisations to identify where they stand and how they might become more effective.

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Darrell has spent most of his career to date, from the time he left school in 1980, until 1995, working for Rolls-Royce Aerospace. During his time at the company he worked in a variety of advanced engineering roles covering a range from computer programmer to propulsion systems engineer to aerodynamicist to strategy and programme manager in charge of the sustainability research underlying the company's shift from product-vendor to 'power-by-the-hour' service provider. He left the company in 1995 to undertake full-time research into systematic innovation and creativity methods at the University of Bath.

Darrell first started using systematic innovation methods in 1992, and has been teaching, developing products and solving technical and strategic business problems using them for a range of blue-chip companies since 1995. He is the author of over 100 patents, patent applications, and conference papers, and is author of the 'Hands-On Systematic Innovation' books. With colleagues in Europe and the US he is pioneering the business concept innovation application of TRIZ and other methods. He is now Technical Director of CREAX

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