Matrix 2022: Re-imagining the Contradiction Matrix

Chapter · September 2021

DOI: 10.1007/978-3-030-86614-3_16

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Matrix 2022: Re-Imagining The Contradiction Matrix

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Abstract. The search for contradictions and the strategies used to resolve them has in many ways now been automated. To the extent that it is possible in some situations to create a Matrix offering problem solvers a 'live' list of ranked Inventive Principles used by others to challenge a given pair of conflicting parameters. There are, however, a number of problems with this automated approach. The two main ones relate to the difficulties of assessing the quality and likely breakthrough impact of historical solutions extracted from whatever knowledge repository is being used to build the Matrix. The paper describes a programme of research to resolve these problems. The methodology adopted utilises a 'first-principle' based methodology in which conflict pairs are distilled down to 'root contradictions' with solution strategies that challenge existing 'text-book' Laws and design 'best practice' heuristics.
Having built a Matrix, when it then comes to users deploying the Principles it suggests, the next problems revolve around the variable effectiveness of the Inventive Principles in enabling the generation of high quality, breakthrough solutions. Some, too, are more abstract than others, which leads to them being easier or more difficult for users to apply effectively. These differences are especially apparent when dealing with the higher level of contradiction present in trilemma situations. The research has sought to resolve these problems by presenting the Matrix output information in novel ways that vary according to user experience, extent of breakthrough solution potential, and requirement to manage or to transcend trilemma problems.

Keywords: Inventive Principles, AI, breakthrough, impact, trilemma, iron-triangle, Nature

1 Introduction

The world of innovation continues to be largely dysfunctional despite the fact that the COVID-19 pandemic has triggered a society-wide shift to a new S-curve and thus opened up myriad new innovation opportunities. One of the main reasons for the dysfunction appears to be ongoing confusion surrounding the definition of the word 'innovation' (Systematic Innovation E-Zine (SIEZ), 2020). To some authors, the word means 'novel ideas', to a majority it means 'implemented novel ideas', but for only a small percentage does the definition include the all-important measure of success. Following the advice of an author that has defined innovation as 'novel ideas', as is found in, for example, Open Innovation (Chesbrough, 2019), and the result – if fortune permits – will at best result in the generation of more novel ideas. One should not, however, expect to be any more successful with those ideas than the millions of other similarly fooled problem solvers. Only when innovation is defined with 'success' as a part of the assessment criteria does it become possible to separate the signal from the noise.

This separation is vital to understanding the 'DNA' of innovation. It is the thing that, now it has been done, reveals the central role of contradictions and in particular the need to find solutions that transcend the usual trade-off and compromise solutions most designers, engineers and scientists have been taught to accept. 98% of all innovation attempts still end in failure. Examination of the 2% that succeeded reveals that a shade over 86% of the successes are attributable to a contradiction-transcending solution (Mann, 2018):

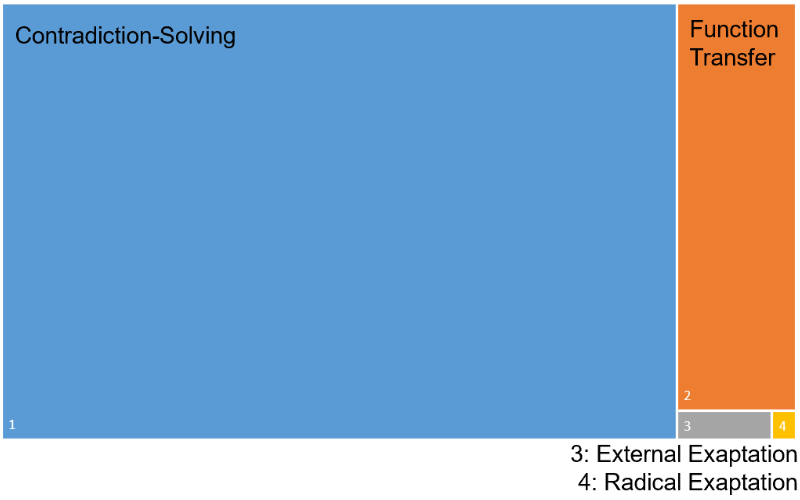

Fig. 1. Solution Strategies Of The 2% Successful Innovation Attempts

This finding serves as the basis for the ongoing effort to reveal and reverse-engineer any and all conflicts and contradictions. And, now, the culmination of the latest phase of that research in the form of Matrix 2022, the fourth generation contradiction solving tool for technical problem situations. Much has been written about the first three generations, especially the first, one of the most visible outputs from the original Altshuller-lead TRIZ research. The 39x39 version of this 'Matrix for Resolving Technical Contradictions' was first published in 1971, and, thanks to a lack of copyright protection, has now been freely distributed to all corners of the Internet and beyond. By 1975, Altshuller had declared that there should be no further development of the Matrix, and consequently it remained untouched until the late 1990s when CREAX took up the challenge to update the tool. This work culminated in the 2003 version (Mann, et al

2003). In an attempt to try and unite the TRIZ community, the book accompanying the 2003 version of the Matrix included the names of Boris Zlotin and Alla Zusman. The primary research underpinning the new tool, however, had been done through a combination of the CREAX patent research team, and work at the University of Bath (Mann, Dewulf, 2003). The most visible effect of this work saw the number of parameters in the matrix increase from 39 to 48. This increase reflecting the broadening demands on problem solvers to work with parameters – Noise, Emissions, Safety, Aesthetics – that reflected a world more in tune with the environment and the importance of 'design'. Less visible, but more important was the sequencing of the Inventive Principle recommendations for each improving/worsening pair of Matrix parameters. All of the 'holes' in the original Matrix were filled in, and, because the world was less 'mechanical' than had been the case in the 1960s when the original patent research was conducted, also made a marked shift into the worlds of electronics and IT.

Sadly, the 2003 Matrix failed to achieve the desired coming together of the TRIZ community. To the extent that MATRIZ still resolutely insists on teaching only the original Matrix during its Certification activities. The fact that multiple comparison papers have overwhelmingly confirmed the increased effectiveness of the 2003 Matrix perhaps speaks volumes about the ongoing doldrums surrounding TRIZ. From an outsider's perspective it beggars belief that a TRIZ provider would rather continue promoting a redundant tool rather than one that has a proven track record of relevance to 21st Century problems (Mann, 2008).

In any event, the success of the 2003 version of the Matrix (including translation into Japanese, German, Chinese, Danish, Dutch, Spanish) justified continuation of the research programme to continue tracking and reverse engineering patents and other inventive solutions involving contradictions. In 2006, a declaration was made that the Matrix would be re-issued at the point when the accuracy of the 2003 edition had dropped below 95%. Where 'accuracy' was taken to mean that, as the research team analysed newly published patents and applications, the Principles evidenced in the inventive steps of inventors matched those found in the relevant conflict-pair in the Matrix. As it turned out, it was 2010 that this threshold was crossed, and thus Matrix 2010 was published. By this time, a significant proportion of the research had been automated. Meaning that software tools had been developed to identify conflicts and contradictions and, more significantly, to identify which solutions were more impactful than others (SIEZ, 2010). These two innovations increased the rate of adding new data-points to the Matrix exponentially.

Matrix 2010 added two more parameters to the matrix, both reflecting the increasing importance of dealing with 'intangibles' (i.e. user emotions) during the problem solving process. The other big addition to the 2010 tool was the research to reverse-engineer contradiction solving in the natural world, and a first attempt to not just collate the most-frequently used Inventive Principles used to transcend a given pair of conflicting parameters, but also to try and map the impact of those Principles. The idea of 'impact' reflecting the fact that some Inventive Principles spark larger breakthroughs than others.

Again, at the time of publication, the 95% accuracy threshold was declared as the trigger for publication of the next edition. Starting around 2012, the research team began to notice the acceleration of a downward trend in the Level of Invention found in patents and other repositories of problem-solving knowledge. This downward trend has meant that, as of the end of 2020, Matrix 2010 was still accurate on over 97% of new cases. It almost began to feel like it was time to halt the research.

The debate wasn't helped by the emergence of software tools purporting to be able to generate 'live' versions of the Contradiction Matrix. Or at least 'live' versions of a given row and column in the Matrix. Indeed, this was something that the Systematic Innovation (SI) research team had already been contemplating for some time. Perhaps the best of the attempts to reach the open market was that found in the patentinspiration software (Dewulf, 2018). This software allows users to collate a cluster of patents, select a number of attributes of interest (speed, strength, power, etc) and have the software then search through the patents and find those in which two or more of the chosen attributes were a focus of the inventive solution. This capability, like equivalent others, turns out to be useful from a 'gisting' perspective, but suffers from a significant and, one might go so far as to say, fatal flaw. It turns out to be very easy to find solutions that contain the right words, but very difficult indeed to work out whether the solution is any good or not. And thus arises the issue of impact. If there was to be a value in continuing with Contradiction Matrix research, it would have to do better than merely pointing users towards the 'most frequently used' Inventive Principles. It should also provide meaningful advice on which Principles delivered the most impactful – i.e. biggest breakthrough, biggest step-change, most-likely-to-deliver-successful-step-change solutions.

2 Measuring 'Impact'?

2.1 Inventive Principle 'Success'?

Before delving more deeply into this 'impact' question, it is helpful to take half a step backwards and examine how the SI research team software tools have made progressive strides in this direction. The sequence of Inventive Principle recommendations in each box of Matrix 2010 don't just represent 'the most frequently used' Principles for each improving and worsening parameter combination, they represent, 'the most frequently used to deliver successful solutions'.

Now, clearly, the moment 'success' is brought into the research search strategy, life becomes an order of magnitude more complicated than a pure frequency-of-use count. Just because a prospective innovator has solved a contradiction does not mean they are going to end up in the lucky 2% of eventually successful attempts. They may, for example, have solved the wrong contradiction as far as customers are concerned. Or, far more likely, given the absence of Innovation Capability in most organisations (SIEZ, 2021), is that an innovation attempt will fail during the execution phases of a project. The '99% perspiration' phases described by Thomas Edison. It is impossible (so far!) for these 'wrong problem' and 'wrong execution' aspects to be built into a contradiction-impact ranking algorithm.

What has been possible, however, thanks to the algorithms developed for the ApolloSigma software (SIEZ, 2010), is to identify those technical solutions that at least offer the potential for delivering success. ApolloSigma was designed to analyse patents and patent applications and classify them as either 'Duds', 'Blindsiders, 'Rembrandts' or 'Stars'. The way the software has been calibrated, in keeping with the globally recognised statistic that 97% of patents will never pay back the fees paid by inventors, is that if all of the patents in the world were analysed by the software, 3% of them would end up in the 'Stars' quadrant. This being the quadrant where – per Figure 2 – the expected near term value of the patent is high, and the expected long term future value is also high. This latter measure is calculated based on how well an inventor has made their patent invulnerable to design around using jumps along one or more of the TRIZ Trends of Evolution (for example, if a patent Claim describes a geometric feature that is 'flat' or 'straight', the Geometric Evolution Trend suggests that the use of curvature will be somehow beneficial. Such a switch, too, offers the potential for an easy 'design around' of the original patent).

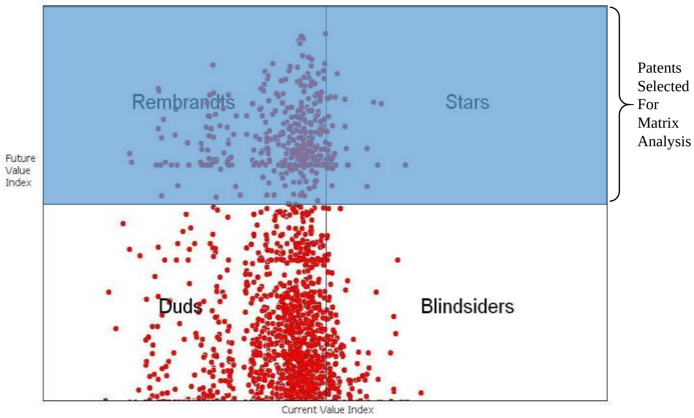

Fig. 2. ApolloSigma Patent 'Impact' Analysis

In simple terms, it is possible to think of the Principle recommendations made by Matrix 2010 as a frequency analysis of the 'Rembrandts' and 'Stars' quadrants of the ApolloSigma analysis results. In slightly more complicated terms, there is still a proportion of the Matrix research that still needs to be done manually. One such area involves patents that have been drafted badly by patent lawyers (and thus score badly in

ApolloSigma), but nevertheless still contain a core idea that offers significant breakthrough potential. At the time of writing, the SI research team is still manually analysing around 3% of the total number of patents that will find their way into the Matrix.

So much, then, for the Matrix 2010-level state of the art in terms of measuring the breakthrough impact of a contradiction-solving solution. What are the other factors that might enable a new kind of impact-related Contradiction Matrix to be configured?

The first factor is one that was recognised a long time ago (Mann, 2002): the correlation between the Level of Invention of a given solution and the number of Inventive Principles for which there is evidence within those solutions. A Level 1 solution, if it contains any evidence at all of having solved a contradiction (‘managed’ is a more appropriate word than ‘solved’ usually), it is very likely to correspond to a single inventive jump. Which in turn equates to a single Inventive Principle (all the time here it is important to remember that in almost no cases will a patent under analysis have been generated by a person who actively used TRIZ, rather, patents are being analysed from the perspective of whether or not they offer an ‘illustration’ of an Inventive Principle related breakthrough strategy). A Level 2 invention may well offer evidence of two Inventive Principle jumps. A Level 3, three and so on.

Discovering a patent that contains evidence of multiple Inventive Principle step-change strategies being used thus correlates strongly to ‘high impact’. But this then leads to a deeper question: does one of the Inventive Principles contribute more to the resultant high Level invention than the others? Or is it the (synergistic) combination of Principles that delivers the overall leap?

This is the sort of question that is implicitly discussed in many of the Patent Of The Month articles in the Systematic Innovation E-Zine. Repeat these kinds of analysis a few tens of thousands of times, and a realisation begins to emerge: some Inventive Principles are indeed much more impactful than others. The level of impact, annoyingly, often depends on the specific context of a problem, but, fortunately, by assessing the likely impact of a given Principle for each box in the Matrix a large part of the context problem is resolved. This being the case, it becomes possible to conceptualise a new Contradiction Matrix in which each box in the Matrix, rather than being a ranked list of Principles can be expanded into a frequency-impact graph as shown in Figure 3.

The use of ‘relative’ frequencies and impacts in the Figure is a way to non-dimensionalise the findings. Relative in this context means that, in the Strength-versus Weight conflict pair illustrated in the Figure, Principle 28, Mechanics Substitution, is the Principle that has been observed to be the most impactful. It, therefore, is positioned at the very top of the graph, and the y-axis positions of each of the other Principles are then presented in terms of their impact relative to Principle 28. The same idea also applies to the relative frequency axis, where Principle 40, Composite Materials, is currently the most frequently used Principle to challenge the strength-versus-weight conflict.

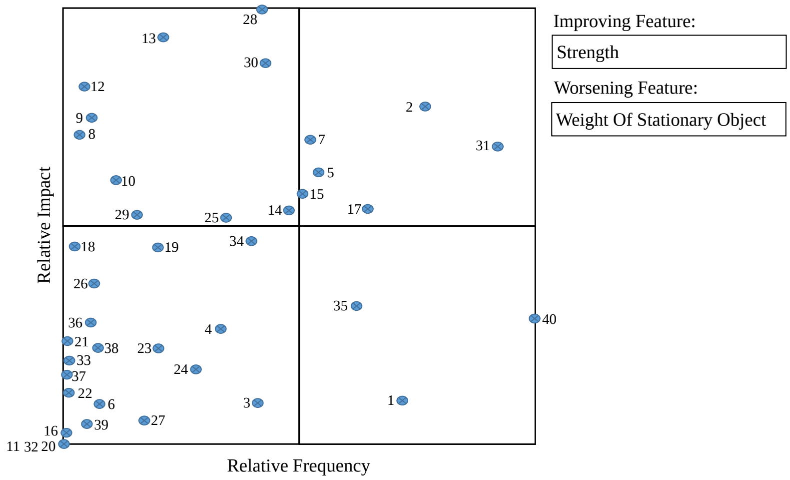

Fig. 3. Typical Matrix 2022 Inventive Principle Frequency-Impact Graph

The first big problem that emerges from the ability to create these graphs becomes one of presentation. Matrix 2010 contained 2450 boxes. Filling each box with the 'top four' Principles makes it possible to print out a readable Matrix sheet slightly bigger than A3-size. Drawing the same number of frequency-impact graphs, on the other hand, demands two orders of magnitude more space. Which, ultimately means that, while there will still no doubt be a Matrix 2022 foldout sheet (it will contain the four Principle closest to the high-frequency, high-impact top-right corner of the graph), the user will only be able to obtain the full richness of the data by means other than the printed page. Matrix 2022, in other words, will be an app. An app, more specifically, that will allow the user to open up the relevant frequency-impact graph for each box. Or, in keeping with the Matrix+ software feature that allows a user to interrogate and rank the Principles from multiple boxes at the same time, the M2022 app will construct a composite frequency-impact graph for multiple boxes in the Matrix at a time. Which, by process of extrapolation, means that it must also be possible to create an overall composite Inventive Principle frequency-impact graph for all technical contradiction problems.

2.2 Principle Combinations

This new presentation format also makes it much more possible to highlight important Principle-combinations to users. For a high-Level solution containing evidence of multiple Inventive Principles, in addition to being able in many cases to identify the most impactful of those Principles, it is also instructive to be able to identify combinations of Principles that are used commonly. Figure 4 illustrates the method by which we anticipate illustrating the most common of these Principle combinations:

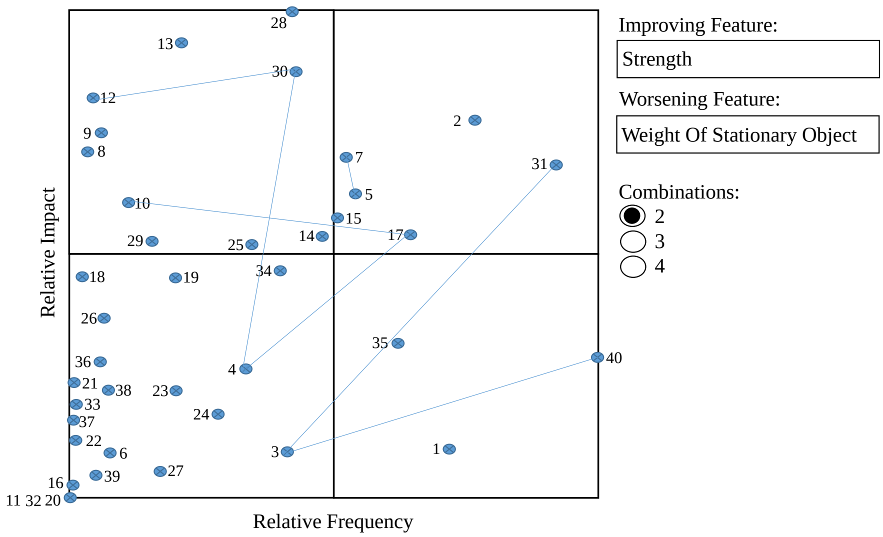

Fig. 4. Typical Frequency-Impact Graph Showing Common Principle-Combinations

So much for the 'easy' way to begin making sense of Inventive Principle 'impact'. The difficult way involves a more profound shift in thinking. One that takes us away from two-parameter, 'dilemma' form contradictions into a real world in which 'everything is connected to everything else'. A world that is fundamentally complex. Which means a world full of so-called 'iron triangles' or 'trilemma' situations…

3 Trilemmas And Beyond

Let's begin this section with the idea that solving dilemmas is easy. Take, as an exemplar, the classic mechanical engineering conflict between the Strength of a structure and its Weight. The current 2010 version of the Contradiction Matrix informs users that the list of strategies used to successfully challenge this strength/weight conflict are, in descending order of frequency, Principles 40, 31, 17 and 1. Each of these strategies will swiftly allow problem solvers to generate ideas that offer step-change improvements in strength/weight ratio. Each of them, too, will also generate a multitude of 'yes, but' adverse side-effects:

Composite Structures – in crude terms, shifting from a metal to composite structure will improve strength/weight but will also increase material cost by tens of percentage points, and overall manufacturing cost, in the current state of the art, by around an order of magnitude. A more sophisticated interpretation of 'composite' might take problem solvers to some form of additive-manufacture-enabled 'meta-material' in which different materials are able to be judiciously placed in different parts of a structure or micro-structure. The net result again being a higher strength/weight ratio, but an even greater manufacture cost penalty using today's technology.

Porous Materials – foam-metals, for example, offer the potential for >80% increase in strength/weight relative to a traditional solid material, but, yet again, the manufacture cost will be an order of magnitude higher and, perhaps more challenging, the foam makes it much more difficult to reliably join one foamed component to another.

Another Dimension – the addition of things like stiffening struts, bulges and other geometric manipulations are to be found in almost all car body panels these days. Sophisticated shapes permit the creation of extraordinarily strong structures from very thin metal gauges, but again, all these structures come with a range of down-sides – more expensive to manufacture again, more difficult to repair, more difficult to paint and protect obscured features from corrosion, etc.

Segmentation – reducing strength requirements through segmentation of the weight into (for example, crudely again) multiple different structures is the sort of macro-level solution that is much more about 'managing' the contradiction rather than actually 'transcending' it. In the strength/weight case, all this strategy really does is makes one big problem into several smaller ones. Which in turn negatively impacts things like manufacturability, labour cost, repairability, etc. Principle 1 in general, is rarely a high impact breakthrough generating Principle.

Important to note here are, first, the idea that any and all of these 'yes, but' consequences of shifting in the direction suggested by any one of the recommended Principles are, in TRIZ terms, 'merely' the next contradictions and thus may receive attention in a second (or more) iteration of the contradiction-solving procedure. Second, and perhaps more important is the idea that the solution directions generated from one Inventive Principle are likely to come attached to different 'yes, buts' than the solution directions generated by other Principles. We will return to this second point in the next Section of the paper.

Meanwhile, what this generic strength/weight example should suggest is that solving dilemmas is easy. It is easy because the trade-off in effect gets passed to a third parameter. A phenomenon it is possible to generalise to include any and all other situations. Perhaps the most classic of which is the 'iron triangle' of Project Management, where the aphorism, 'Cost, Specification, Budget – which two do you want?' has long been understood (and used) by experienced Project Managers. It is extremely easy, they will say, to deliver a project on time and on budget, but which fails to meet the specification. Or one that meets the specification and budget, but is late. Or one that meets the specification and is on time, but is overspent. The way to solve this 'trilemma' problem is to introduce a fourth parameter – usually 'Risk' – that is able to be compromised in order for the other three parameters to be delivered (SIEZ, 2021a).

In general, by extrapolating to ever great numbers of parameters, it is possible to hypothesise that **it is possible to transcend the contradictions between any N parameters by shifting the trade-off to an (N+1)th parameter**.

From a design perspective, the implications of this apparently benign-sounding statement are close to profound:

In any design specification there will typically be a number of ‘red-line’ parameter boundaries, constraints that must be met. The weight of an artifact must be low enough for one person to lift it, for example. The power output must be greater than X. No products shall fail before the warranty period. Etc. There will then be other parameters which will be classed as ‘highly desirable’ – the manufacture cost needs to be less than $Y, for example, or emissions should be lower than competitor products. And then, finally, are all the other parameters that neither the designer nor the customer particularly cares about.

These three parameter categories – must, desirable, don’t-care – then begin to form the necessary input to a step-change more capable Contradiction Matrix. A Matrix that permits a user to rank the relative priority of all the relevant and present parameters and generates an Inventive Principle frequency-impact graph based on that priority ranking. One that ranks the Inventive Principles in terms of their known capability to transcend contradictions between pairs of the ‘must’ and ‘desirable’ parameters, and allow the inevitable left-over, (N+1)th and other ‘don’t care’ parameters to become worse. And, moreover, taking on board the parallel idea of frequently used combinations of Principles, to present to the user a series of the most likely combinations for the specific ranked list of design parameters. This, in essence, is what Matrix 2022 has been designed to achieve.

4 Matrix 2022

Previous generations of the Contradiction Matrix for technical problems have essentially focused on what we now understand to be ‘Complicated’ problem situations (SIEZ, 2020a). That is, situations where there is the potential for a ‘right’ answer, and as such, from a TRIZ-based procedural perspective, the potential, too, for the essentially linear process found in the original ‘prism’ – define the specific problem, abstract to the generic problem, look-up the generic solutions in the Contradiction Matrix, translate those generic solutions into the specific solution. Such technical problems do still exist, and the new architecture of Matrix 2022 certainly does not preclude working in this linear fashion. Modern day problems, however, particularly ones in which there is a desire to consider a multitude of conflicting parameters rather than just two, are highly likely to cross the boundary between ‘Complicated’ and ‘Complex’. Once this boundary has been crossed, the traditional linear problem-solving approach is no longer appropriate. If only because, in a Complex environment, there is no such thing as the ‘right’ answer any more. In such circumstances, the best way for problem solvers to proceed involves processes that are essentially iterative in form and are divergent-convergent in structure. The iteration part of this story simply means a preparedness and stamina on the part of the problem-solver to persist through multiple problem-solution iterations, with, ideally, an opportunity to test the latest solution iterations with representative customers before embarking on the next iteration. The divergent-convergent part means recognising that, when it comes to using the Inventive Principles to spark novel ideas and solution directions, there is no longer such a thing as using one Principle to generate one solution idea and expecting that to be the answer. Divergence in a complex systems context means using as many Principles as possible to generate as many solution 'clues' and 'directions' as possible (the 'divergent' part of the solution generation process) before seeking to combine those clues into a potentially viable or cluster of viable 'answers' (the 'convergent' part). Matrix 2022 has also been configured with this divergence-convergence sequence in mind. The tool, through the context-specific Principle frequency-impact graphs offers problem solvers access to what is in effect a ranked list of all 40 of the Principles for that situation. Or, more typically, as illustrated in Figure 5, presenting a situation-specific set of Principle combinations.

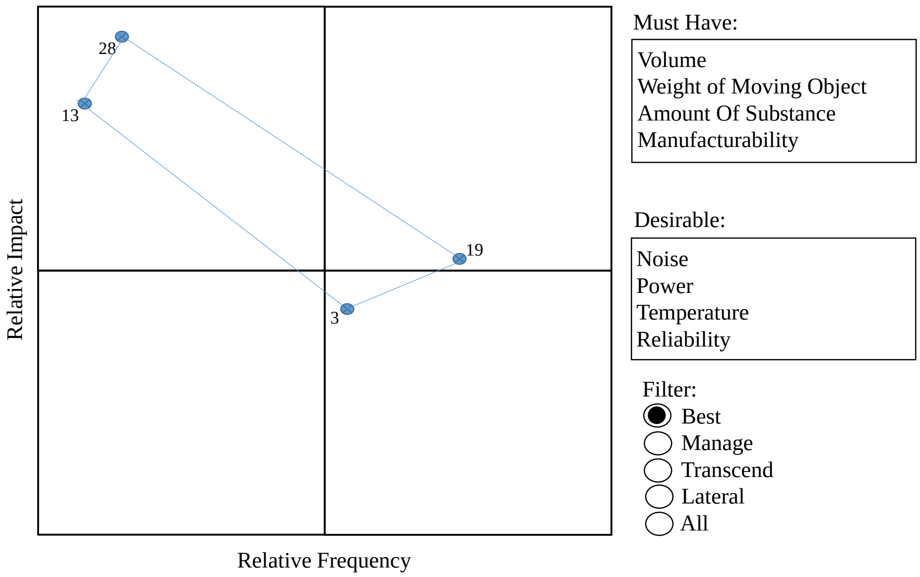

Fig. 5. Example Of Matrix 2022 App User Interface Showing Parameter Prioritisation

It will, too, thanks to the latest tools for establishing where the Complicated/Complex boundary lies for a given situation (SIEZ, 2021b) also inform users whether it is more appropriate to use the Matrix in either its linear 'complicated' form, or its divergent-convergent 'complex' form.

5 Conclusions and Future Work

Matrix2022 is intended to offer users a step-change advance in capability relative to previous versions of the tool. The largest contributors to this step-change are believed to be, first, the measurement and use of Inventive Principle 'impact' in delivering meaningful, high quality solutions. And, second, the use of algorithms that enable problem solvers to deal with trilemma and higher level problem situations in which multiple different design parameters cannot be compromised. These two jumps necessitate deployment of a new user-interface for the tool. One that looks set to be app-based.

When the latest, 3.0, version of the Contradiction Matrix for business situations (Mann, 2018a) was published, it included the map of future generations reproduced in Figure 6. By substituting 'Matrix 2022' for 'BM3.0', the same evolution trajectory is likely to occur with the technical version of the Matrix. That, in effect, means that the Ideal Matrix is no Matrix at all. Matrix 2022, then, looks set to be the last of the technical-only Matrix tools. The concept of 'contradictions identifying themselves' is already a capability found within the PanSensic suite of software tools (SIEZ, 2015). Meaning that the only real challenges involve, firstly, the appropriate integration of technical, business and IT Matrix tools into a coherent whole, and, secondly, to build a Principles recommendation algorithm that takes due account of the relative importance of business and technical parameter requirements and priorities. A job that, like most things in the TRIZ world, stems from the empirical analysis of enormous quantities of data. Data that, this time around, in effect becomes the training data for a TRIZ-based, First-Principle-configured machine-learning algorithms. Which sounds like some kind of TRIZ-originated, contradiction-transcending singularity is near.

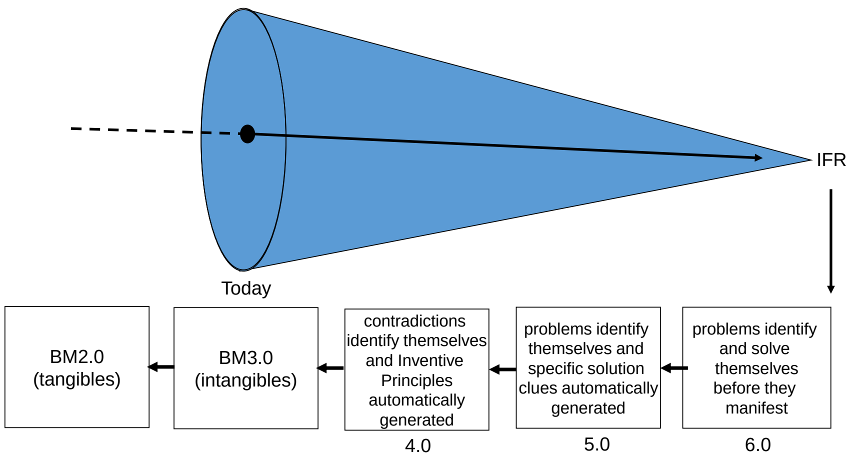

Fig. 6. Mapping Future Contradiction Matrix Generations

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