Strategy Foresight

DETECTING WEAK SIGNALS, OUTLIERS AND FUZZY FUTURES

Bruce Garvey (Strategy Foresight Ltd)

"We didn't see it coming" is a term often used by decision makers, and when supported by the justification that "it" was a "Black Swan" event, is deployed to rationalize failure to act soon enough in response to earlier warning signals. Along with behavioural traits such as amnesia, denial, blind spots and hubris, the inability to spot such signals has also been put down to limited awareness and application of methods which can help identify "weak signals" and outliers. Operating not just as discrete, isolated phenomena, but in the form of symbiotic clustering – a variety of asymmetric signals of different strengths can merge to reveal a major change impactor. Such phenomena can be in the form of future (or more specifically "what if") scenarios and/or new technologies, which if not identified in time, can lead decision makers to fail to respond soon enough to disruptive outcomes. This paper offers an innovative approach with application of two but oft neglected methods which can help isolate signals having the potential to trigger future discontinuities, disruptive phenomena and events, and thus majorly improve "weak signal" identification – and support decision making under uncertainty."

1.INTRODUCTION

Recent situations in the UK and the wider world, such as Brexit, the Trump Presidency, recent UK terrorist events, impending trade wars and disruptive social movements (Gilets Jaunes and Extinction Rebellion), are evidence of forecast-driven decision making being challenged by complexity and uncertainty combined with limited foresight. Most organisations and their decision makers, and especially those engaged in crisis management, organisational resilience and strategy, are having to confront such issues by asking questions such as:

- How can I handle uncertainty and help mitigate strategic, operational and existential risks?
- How do I get to grips with both internal and external operating environments impacted by high levels of uncertainty and complexity?
- Do I need to structure a problem before thinking about solving it?
- How can I generate new yet viable solutions that will help improve performance?
- **Are there uncertainties I haven't thought about but should be aware of (weak signals)?**

If not strictly by definition, one can say that "weak signals" or outliers reside within the domain of the uncertain. Decision and policy makers are continually seeking alternative approaches to make better, more informed decisions and to mitigate risks of making bad decisions under various states of uncertainty (and complexity).

One of the earliest references to weak signals was by Igor Ansoff[1] (of "Corporate Strategy" fame) in 1975. He used the term to help organisations deal with discontinuities and strategic surprises. Weak signals reflect the early symptoms about a potential mutating trend and below radar information, which can reveal both organisational opportunities and threats.

Looking for weak signals can be seen as one of the foundations for strategic foresight. The challenge of course is how can such signals be identified amid all the noise generated by high levels of interconnectivity and complexity in a rapidly changing environment. This paper seeks to address this

[1] "Managing Strategic Surprise by Response to weak Signals" H.Igor Ansoff – California Management Review Winter 1975 Vol XVIII No. 2

conundrum and offer new methods and approaches to help analysts and decision makers.

2.WHAT ARE WEAK SIGNALS?

- **Weak signals reflect the early symptoms about a potential mutating trend and below radar information, which can reveal both organisational opportunities and threats.**
- **Identification can help organisations deal with discontinuities and strategic surprises.**

Maybe the best place to start is to ask what they are not. It has been argued [2] that they have to be isolated from the notion of "trends" since:
***"Trends** describe the expected future, the high probability, high impact developments we need to address. Focusing exclusively on the trends risks being blindsided by surprises. Trends are based on data. All data is in the past. It may be unreliable if the underlying system is changing in fundamental ways".*

Surprises come from places people are not looking. Many organisations are focussed too much on predicting the expected future, those high probability, high impact developments that could disrupt their operations. Conversely, those issues seen to have low or unknown probability and potentially high impact are often discounted or ignored with weak signals being lost in the general noise of issues to be addressed[3].

The dilemma for decision makers and analysts when challenged to identify where and how weak signals reside is thus:

> ***"Generally speaking, incorporating weak signals in strategic discussions is a known dilemma because on one side the vast variety of potential signals requires us to select which signals to process and which to ignore and on the other side the very concept of 'weak signals' disqualifies the selection rules we would usually apply, such as selecting signals that stand out or signals that have been helpful in the past."***

Voigt et al[4]

In addition, cultures exist within organisations that militate against addressing new challenges to current policy, acting as barriers to foresight. In effect analysts lack, (or have not identified) those tools and methods which might allow them to narrow down weak signals in terms of, not just inevitable surprises, but the differing shades of uncertainty and in particular genuine uncertainty. Weak signals are in many locations, often dormant; for example, a product, market, or service that doesn't yet exist—but could!

Whilst weak signals often have no history, and thus no basis on which to build a pattern, one also has to consider that there may be "Sleepers" – overlooked, forgotten, dormant potential indicators waiting for some "techno-analyst prince charming" to awaken them**.** Such signals will tend to be qualitative in nature as there is little hard data to enable signal strengthening. **This problem is**

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[2] "An Overview of the Horizons Foresight Method Using system based-scenarios and the "inner game" of foresight" Peter Padbury, Chief Futurist, Policy Horizons, Government of Canada 2019.

[3] "The strength of 'weak signals"**:** Martin Harrysson, Estelle Métayer, and Hugo Sarrazin.Pub. McKinsey Quarterly Feb.2014.

[4] "Identifying Weak Signals in Expert Discussions of Technology Enhanced Learning" Christian VOIGT, Elisabeth UNTERFRAUNER, Barbara KIESLINGER . *Centre for Social Innovation, Linke Wienzeile 246, 1150 Vienna, Austria* Pub. *eChallenges e-2011 Conference Proceedings Paul Cunningham and Miriam Cunningham (Eds) IIMC International Information Management Corporation, 2011. ISBN: 978-1-905824-27-4*

compounded by the non-linear way issues develop, with some changing slowly, much like the "slowly boiling frog" analogy, whilst others change fast and very radically.

Whilst information exists in the environment, individually of little consequence or impact, when clustered together with other weak phenomena, can reveal interesting information or signal strengthening options – what can be termed "symbiotic clustering".

A note of caution: There has been a recent tendency to think of weak signals as mainly manifesting themselves in the new technology/product area – partly due to the seemingly exponential rate of technological change and the urgency attached to identifying future development opportunities. However, weak signals should not be seen as just "eureka" moments which can only be identified by the analyst or indeed brainstorming sourced inspiration – and mistakenly being classified as "unknown/unknowns" (aka black swan events)! Weak signals are also present within the domain of the socio-economic and political – identification of which is key to developing on-going strategic awareness via scenarios, so that policy (commercial and political) can continually be challenged and re-assessed.

3.THE PREDICTION CHALLENGE – FORESIGHT OR FORECASTING?

Forecasting does try to predict the future. It takes data from the past and extrapolates it into the future using a variety of tools, from statistics to simulations. However, at a time when the underlying systems are changing in fundamental ways, users of forecasting should take care to confirm that the supporting assumptions are still accurate.

Foresight's function is to prepare strategies and shape policies that are robust enough across a number of plausible futures, particularly where the underlying systems are evolving (often asymmetrically). Thus, when surprises occur they can be highly disruptive to the incumbent system. In effect, it can be said Foresight is a form of "Strategic Options Analysis".

The premise here is that it is reasonable to expect that historical knowledge and data can help identify future threats and/or opportunities as they arise from familiar prior experience. However, when the threat or opportunity is discontinuous (or disruptive in modern parlance), then in the early stages, the nature, impact, and possible responses are unclear. Frequently it is not even clear whether the discontinuity (disruption)) will develop into a threat or an opportunity and fits neatly into quadrant 3 of the Uncertainty Profile matrix (presented below).

4.THE NATURE OF UNCERTAINTY

In 2012 consultants PWC identified[5] that: *"Today's fast changing world creates more uncertainty for organisations – and makes it harder for them to understand where new risks are going to come from".* In effect, they are struggling to identify weak signals.

"Uncertainty" is no longer a conceptual slogan but a reality we are living through. Do we need an alternative approach to help mitigate the impact of this new world – and do we really understand the difference between Uncertainty and Risk? The danger exists of looking too zealously for a trend linked to what is known today rather than a weak signal hidden away?

How to position Uncertainty in relation to Risk

There is confusion as to how we address uncertainty as opposed to risk – the latter term being regularly used to include uncertainty. This confusion is at the root of many of our preconceptions about what uncertainty is and what risk is. Uncertainty and Risk lie along a spectrum, which includes

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[5] "Black swans turn grey – The transformation of risk". PWC Risk Practices. January 2012.

of course, Certainty.
Uncertainty implies incomplete information where some or all of the relevant information to a problem is unavailable. Uncertainty can also be explained as being a situation where the current state of knowledge is such that:

* The order or nature of things is unknown.

* The consequences, extent or magnitude of circumstances, conditions, or events is unpredictable.

* Credible probabilities to possible outcomes cannot be assigned.

* A situation where neither the probability distribution of a variable nor its mode of occurrence is known.

As one moves, away from the Certain towards the Uncertain end of the spectrum, probable outcomes are reduced to being only possible outcomes and where information, especially in its quantitative form becomes increasingly unavailable and/or not relevant. Information relating to trends becomes increasingly intermittent and falls away. Thus, the challenge for management is to accept that not everything can be explained as a probabilistic measure which can be quantified (comfortable as that may be). In simple terms, "Risk" can be quantified (via probabilities), "Uncertainty" cannot, as it is not measurable. Other structural components creating difficulties for practitioners reside at the system level and include complexity and interconnectivity.

The positions of Uncertainty and Risk across the Risk Spectrum[6] (Uncertainty to Risk to Certainty), are not fixed; the boundaries overlap. Thus, Certainty is supported by hard data and quantitative analytics, Risk by Bayesian and other stochastic and quantitative methods, whilst Uncertainty manifests "fuzzy occlusions" supported by qualitative methods and models.

Simply put, the main difference between uncertainty and risk is that risk can be quantified – uncertainty cannot. But you can model it!

The Challenge of New Threats and Opportunities
The challenge of new threats, and indeed, opportunities, is aggravated by the behavioural reactions of organisations to these threats – it being a daunting prospect to accept that the old methods are no longer offering sufficient support to decision makers. A joint Cass Business School/Airmic study,[7] "Roads to Ruin – "A Study of Major Risk Events" highlights that the increasing interconnectivity of today's world weakens management's ability to identify weak signals or even develop the willingness to identify such signals and is all part of the behavioural barriers facing organisations.

Profiling Uncertainty and Risk
Outcomes or events, whether they reside at the uncertain or risk end of the spectrum, can be refined by determining their position in relation to axes based on predictability and visibility. Events can be Predictable or Unpredictable. By "predictable" is meant "to be made known beforehand" or simply, "capable of being foretold". The ability to identify how well an outcome can be predicted is dependent on how much control we have in making an event happen, what understanding we have, and/or what historical data (or experience) is available, and which in turn allows us to make varying levels of probability about an event's outcome.

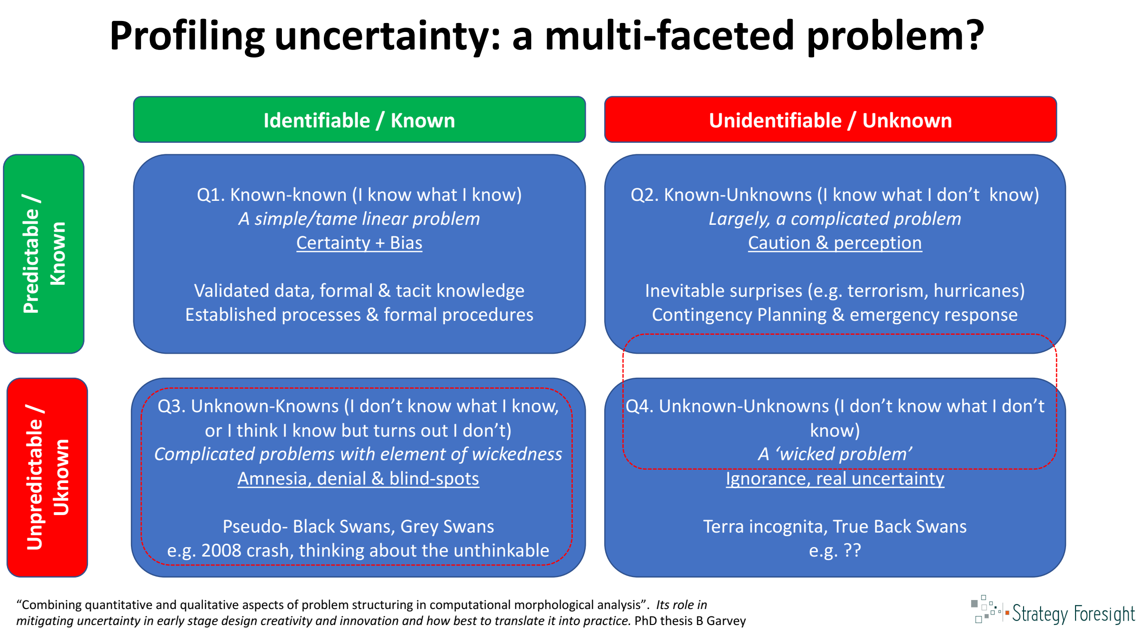
How different is event "Visibility" from "Predictability"? Can, "what type of event that may occur",

6 "Combining quantitative and qualitative aspects of problem structuring in computational morphological analysis*" Its role in mitigating uncertainty in early stage design creativity and innovation and how best to translate it into practice*. PhD thesis by B Garvey 2016. Imperial College London.

7 "Roads to Ruin – a Study of major Risk Events: Their origins, Impacts and Implications". Cass Business School/Airmic 2011.

be identified? Visibility implies being able to identify what **type** of event may impact us as opposed to the likelihood (predictability) of that event occurring. This requires identification in greater detail of the kind of events, which can have an impact. This brings into play the willingness to seek out potential **“weak signals”** which can manifest themselves as future surprises and/or unintended consequences (good or bad).

Of course, both elements are interrelated – some events are predictable **and** identifiable whilst at the other extreme there exist future events that are neither identifiable nor predictable. The relationship between event visibility and event predictability can be visualised in the following matrix:



As mentioned previously, the transition along the Risk Spectrum from Certainty to Uncertainty is fuzzy. Thus, the matrix quadrants (cells) are not discrete but rather contain occluded transitions – this in turn allows for moving from high levels to low levels of predictability or “knowingness” (hence the red line overlaps).

Those events which, any decision maker must take into account, can positioned as follows:

- *Quadrant 1: Predictable & Identifiable (Known knowns).*
- *Quadrant 2: Identifies predictable events not yet identifiable (Known Unknowns)*
- *Quadrant 4: Unpredictable & Not Identifiable (Unknown unknowns).*

  And
- *Quadrant 3: Unpredictable & Identifiable (Unknown knowns)*

Q3, Unknown Knowns can be interpreted as meaning “I don’t know what I know” and hence miss weak signals, and/or “I think I know but turns out that I don’t”. Either way weak signals can be manifest. Behavioural factors are to the fore in this quadrant with actors suffering from amnesia, denial, blind spots and hubris – sometimes all. Event indicators in this quadrant are also asymmetric which makes it difficult to ascertain the relative importance of both individual and clustered signals. This is a challenge to the inclination to weight the variables too early. The dictum that policy driven evidence should be challenged by evidence based policy is pertinent to this quadrant.

As a result, this is the most insidious, nay pernicious, of the quadrants, largely due to a number of behavioural factors as identified above - we think we know what or where the problem is or might occur, but can we handle the inherent complexities or do we even have the tools to address such complexity based uncertainty? Group-think and dogma based policy are the real enemies here and the issue is whether the stakeholders themselves are prepared to explore outcomes which may produce uncomfortable truths a theme expounded by Nik Gowing and Chris Langdon in 2016[8] . In other words, weak signal identification is as much challenged by individual and group willingness to accept such signals, as by the strength of the signal itself.

Quadrants 3 and 2 and to some extent even Quadrant 4, require an open-mindedness not always present in organisations. In addition to the maintenance of entrenched paradigms by various vested interests, decision makers are required to enter the "zone of uncomfortable debate", the ZOUD, which many organisations, policy makers, designers and practitioners, find difficult to confront. The disruptive and often cataclysmic nature of such events makes for uncomfortable reading – thinking about the unthinkable, which is why, when they occur, they are too readily deemed to belong to Quadrant 4: in the vast majority of cases they are not and just demonstrate a lack of foresight.

Weak signals, which by definition may have already become manifest in some way, should be allocated to the third quadrant of Unknown/Knowns (as per the major area bordered by a red line). Also by definition it can be argued that they cannot exist in the unknown/unknown quadrant because they are already manifest as a weak signal.

When Rumsfeld made his famous "intervention" this is the section he missed out. In many cases this quadrant is a flipped version of its Know/Unknown (Predictable/Not Identifiable) partner, except that the level of probability is far less certain. The level of certainty is reduced not only by how far in the future an event might occur but exacerbated by the numerous permutations influencing the outcome of an event in the intervening period. An example confronting analysts as to what will happen in the Middle East over the coming 12 months would suggest that we can identify the areas of concern – Iran/Saudi tensions, Yemen, Libya and Syria but the outcomes are highly unpredictable due to the variety of different stakeholders with interests in the region – each with their own agenda (the countries themselves, as well as USA, Russia, UK, France, China, Turkey, UN interests). Another example might be the potential of new business models based on new and emerging technologies, to disrupt.

In the end, management has to accept reality and realise that in order to avoid inevitable, often radical or even unpleasant, let alone unknown, surprises, and the "anomie" associated with such outcomes, it has to be more readily amenable to acknowledging that precision and the future are incompatible terms.

5.A WHAT TO DO? A NEW APPROACH TO IDENTIFYING WEAK SIGNALS

This paper's approach is to indicate how those concerns that manifest themselves in Quadrant 3 in the Uncertainty Profile matrix (Unknown/Knowns), can be mitigated by the deployment of two mutually supporting methodological methods – Morphological Analysis (MA) and Morphological Distance Analysis (MD). To avoid the "scary" titles we'll just use the shortened terms MA and MD respectively, albeit a more user-friendly term might be to call them "Strategic Options and Distance Analysis". MA is an oft neglected method used to support decision making under uncertainty, as it enables the structuring and analysis of complex problems. Under such conditions the analyst is challenged to seek out potential weak signals at the periphery of the decision makers vision.

[8] "Want to lead? Then tear up the rulebook"/"Groupthink is depriving the West of vision": Nik Gowing & Chris Langdon. The World Today June/July 2016/ Chatham House.

MA enables the structuring and analysis of complex problems which:

- Are inherently non-quantifiable
- Are stakeholder orientated with strong socio-political, cultural & technical positions
- Contain non-resolvable uncertainties
- Cannot be modelled easily or simulated
- Require a judgmental approach to be placed on a sound methodological basis.

The above criteria would indicate that many of the characteristics of weak signals can be addressed by methods such as MA.

In a morphological model, there is no pre-defined driver or independent variable and it is this ability to define any combination of conditions as an input or output that gives morphological models such flexibility. Thus, given a certain set of conditions, - what is inferred with respect to other conditions in the model allows researchers to explore viable alternatives in real time. In essence MA can be introduced to help shape and identify possible paths for analysts of all types (be they designers, forecasters, creatives, and policy framework initiators).

Using MA as a tool to draw out weak signals – a new approach.

Recently developed software and processes[9] can now overcome a traditional criticism of MA, in that it creates so many potential configurations or outcomes in the Problem Space as to be unmanageable. The combinatorial explosion of options created by MA can now be majorly reduced (typically over 95%), leaving the analyst to review a much smaller set of viable, internally consistent solutions.

A summary of the overall MA process is illustrated in three definite phases as below.

Phase 1 ***Generate the entire Problem Space*** *(Steps 1-6)*	• Identification of the main problem being addressed • Selecting an expert team representing the key stakeholders • Determining a focus question which encapsulates the problem • Facilitating the expert team to generate a problem space made up of the key parameters of the problem and then the states/ dimensions within each of the parameters • *The first steps here may require external facilitation and stakeholder management to finely structure the problem – before programming the software to generate the Problem Space which reflects the total number of possible configurations to be addressed.*
Phase 2 ***Perform Cross Consistency Assessment*** *(Steps 7-8)*	• This phase involves a form of cross impact or pair-wise analysis where the Problem Space is transposed[10] and each state within a parameter is assessed for consistency against every other state within the other parameters (i.e. can these two states logically co-exist). If they cannot, then every configuration where such an inconsistent pair exists is discarded.
Phase 3 ***Generate the Solution Space for decision support*** *(Steps 9-10)*	• Supporting software compiles those configurations only where all pairs within a configuration are consistent with each other. This process can eliminate over 95% of the original Problem Space to produce a set of viable internally consistent solutions. These solutions are presented as 'what-if' scenarios where any dimension in a parameter can be an input or an output.

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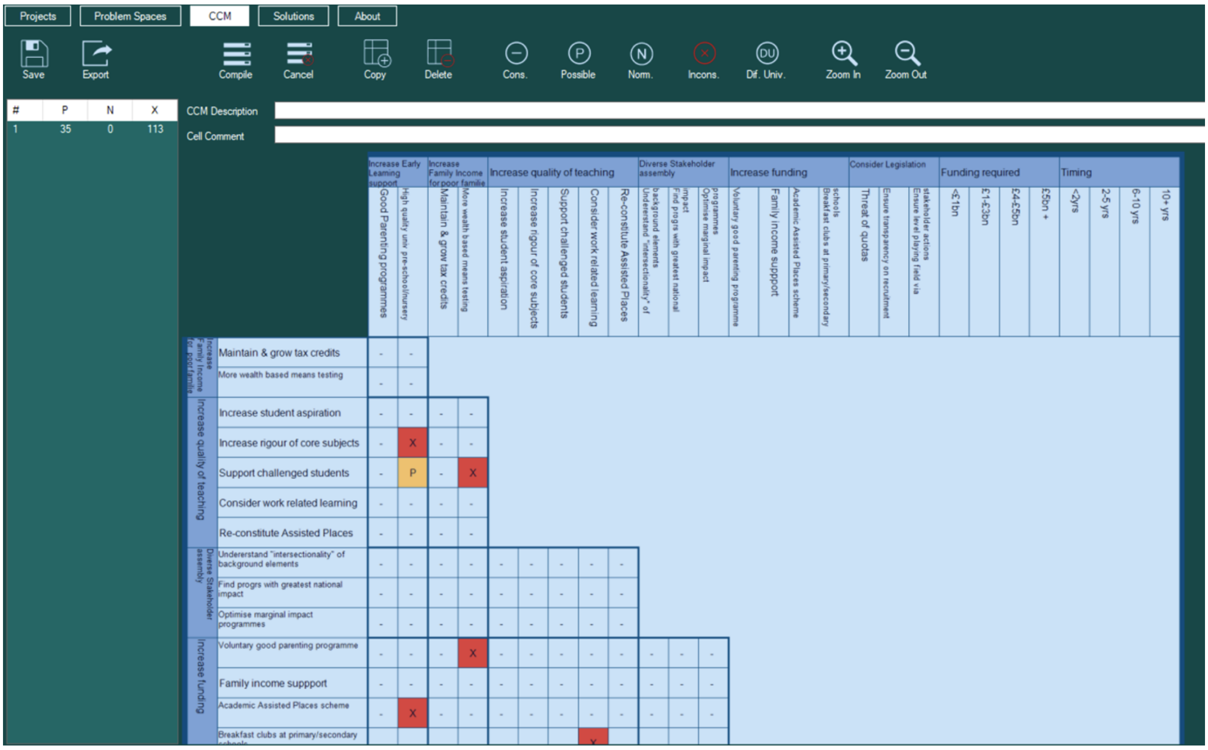
[9] "Combining quantitative and qualitative aspects of problem structuring in computational morphological analysis" *Its role in mitigating uncertainty in early stage design creativity and innovation and how best to translate it into practice*. PhD thesis by B Garvey 2016. Imperial College London.

[10] Transposition software converts the Problem Space into the Cross Consistency Matrix (cross impact and assessment). Once this latter matrix has been completed (or assessed) then the software goes into compile mode, discarding those configurations which contain any one or more pairs of inconsistent arguments as determined by the expert team. The remaining, fully consistent configurations are then presented as a Solution Space.

Large Problem Space configuration reduction: *Level 1 reduction – MA using CCA*
How can one analyse the large number configurations produced by the model? The most efficient way in which software can address this conundrum is by the process of pair-wise analysis entitled Cross Consistency Assessment (CCA) whereby a pair of conditions composed of one state within one variable is assessed for consistency with every other state in all the other variables.



This figure shows the paired cells in the Cross-Consistency matrix; those which are red with a cross are paired cells deemed inconsistent, whilst blank cells are deemed consistent.

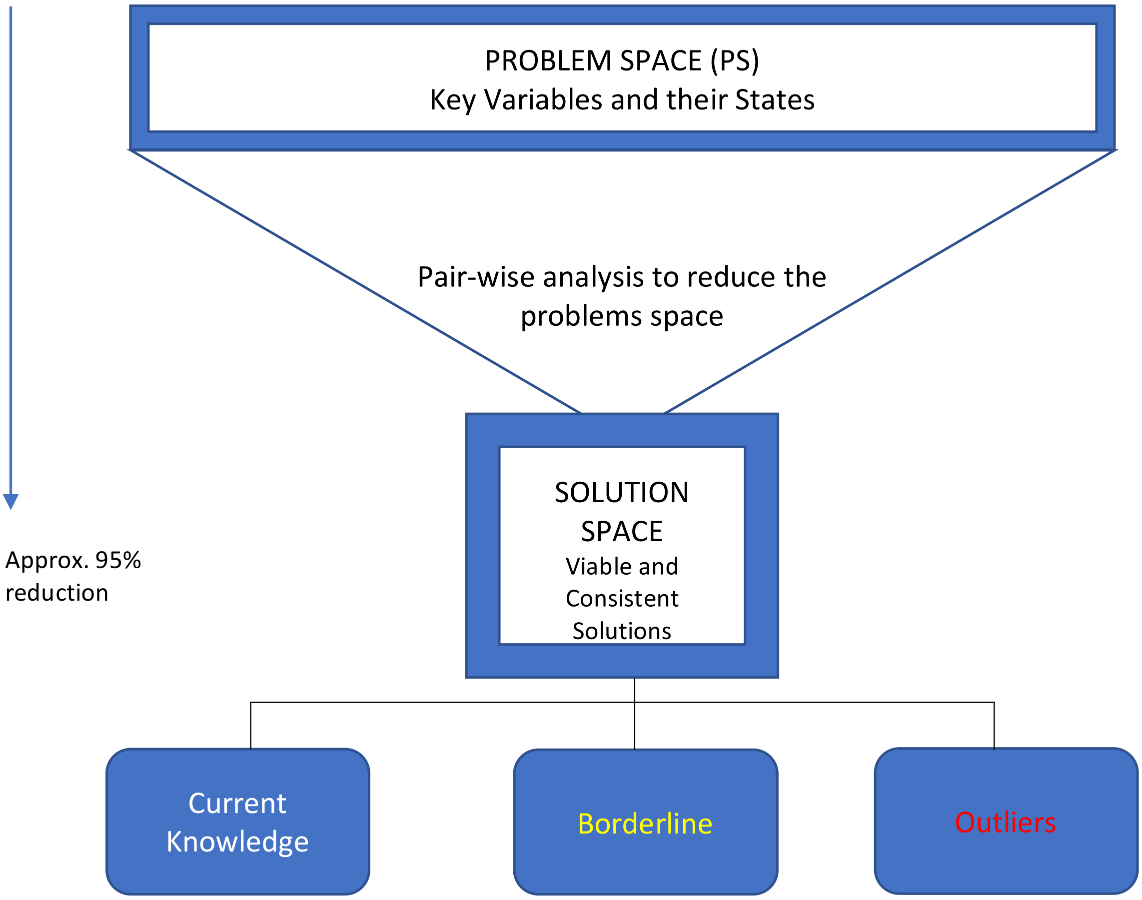
As identified earlier this phase 3 of the process allows the user to reduce the original large number of configurations in the problem space by up to and over 95%.

This much-reduced list of scenes can help the analyst identify interesting and viable outcomes. Refining the number of workable solutions provides improved screening of these outcomes (such as technology designers involved in ideation or scenario analysis).

Level 2 Reduction – Morphological Distance
When used as a follow on from the MA process once viable solutions have been generated, MD can be deployed to classify the remaining configurations[11] via a triage process.[12] The three zones are "Current Knowledge", "Borderline Options", and "Outliers"; the latter two criteria consisting of those configurations differing from Current Knowledge (CK), whilst still remaining viable solutions. Given the distance from identified viable solutions in the CK territory, Outlier solutions are likely to be truly creative and "off radar". **Such configurations can thus be assumed to be very similar in**

[11] "Using Morphological Distance to Refine Morphological Analysis Solutions" B Garvey (Imperial College London), P R N Childs (Imperial College London), G Varnarvides (Massachusetts Institute of Technology). Unpublished paper London 2013.
[12] "Technological Forecasting and Long-Range Planning" Ch.5 Morphological Analysis. Robert u. Ayres. Pub. McGraw-Hill 1969.

nature to a weak signal as they will be at the periphery of the analyst's vision. Allocated to the Outlier (O) zone, and being significantly different from CK options, they are more likely to offer designers or analysts the probability of a technological or alternative scenario breakthrough. Thus, the combined MA and MD process can be represented as follows:



Solutions further reduced according to distance from Current State

Issue of determining what is Current Knowledge
It is apparent that the determination of distance begs the question, "distance from what?" Within the viable solution sets, those configurations deemed to reflect Current Knowledge act as the base sets of configurations from which more distance sets, in the Borderline or Outlier zones can be determined. It is thus crucial that identifying the parameter profile of Current Knowledge solutions be made easily and as objectively as possible.

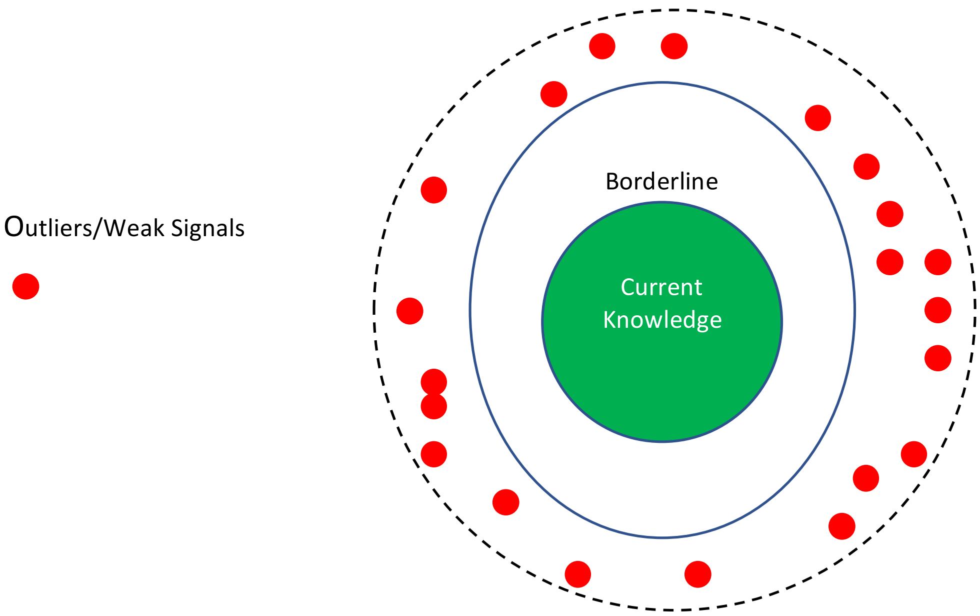
Examples in Creative Design and PESTLE Analysis
Case 1: The first example presented comes from architectural design and addressed the question: *"What possible configurations can the design of an apartment block take, which ensures cross-ventilation and sufficient daylight".*

The methodology helped to design new options for Apartment Typology. A 10-parameter problem space, composed of 155,520 configurations was initially reduced by deploying basic MA from which solutions were then reduced further using MD triage principles. The two-stage process generated a 99.9% reduction of the initial (155k configuration) problem space, to a mere 213 internally consistent options classified as being in the Outlier zone. Such was the remoteness from Current knowledge that these 213 options qualify as representing weak signal configurations.

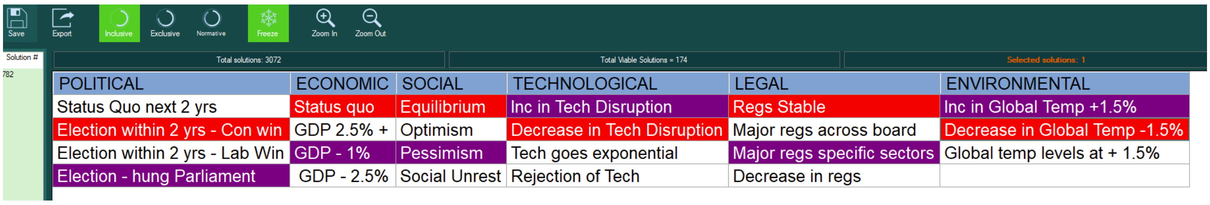
The final 213 solutions post MD were found to be distanced 4-5 parameters away from Current Knowledge solutions (from a 10-parameter configuration set). Finally, these Outlier solutions, were processed by a visual algorithmic editor and output as tri-dimensional CAD models which in turn could be easily evaluated and analysed by the architect/designer to reveal interesting, difficult to identify, design alternatives.

Case 2: A second example applied MA/MD to a PESTLE variable format, looking at what outlier options could be considered for the UK over the next two years or so, based on a selection of political scenarios. A small problem space was generated, totalling some 3072 different configurations. Following pair-wise analysis to reduce the original set of configurations, software compiled a reduced set of viable solutions, from 3072 to 174, or by 95%. These 174 viable solutions were then triaged according to distance principles.

An anchor configuration reflecting current knowledge was selected (scenario 2791). The set of Outlier/weak signals configurations was determined to contain 2 or less parameter/states which matched the configuration profile of the anchor set. Alternatively, at least 4 of the 6 sub-variables in the configuration were different from the anchor set. Analysis of the viable 174 scenarios identified that some 20 scenarios were distanced the maximum 6 parameter/states from the anchor configuration, representing 11.5% of the solution set. Another 42 scenarios, or 24%, were identified as being 5 parameter/states distanced from the anchor. These 20 outlier scenarios, being so far distanced from the anchor, could offer intriguing perspectives not readily identifiable had this exercise not been carried out and can be represented as in the graphic below.



In the following graphic one of the Outlier scenarios is shown (configuration with red cells), which is at the maximum distance from the anchor scenario (purple cells) – i.e. the selected scene has passed muster as a solution, but is very much an outlier in relation to current knowledge or policy – across all six of the variables.



POLITICAL	ECONOMIC	SOCIAL	TECHNOLOGICAL	LEGAL	ENVIRONMENTAL
Status Quo next 2 yrs	Status quo	Equilibrium	Inc in Tech Disruption	Regs Stable	Inc in Global Temp +1.5%
Election within 2 yrs - Con win	GDP 2.5% +	Optimism	Decrease in Tech Disruption	Major regs across board	Decrease in Global Temp -1.5%
Election within 2 yrs - Lab Win	GDP - 1%	Pessimism	Tech goes exponential	Major regs specific sectors	Global temp levels at + 1.5%
Election - hung Parliament	GDP - 2.5%	Social Unrest	Rejection of Tech	Decrease in regs	

CONCLUSIONS

The presence of high levels of uncertainty makes the task of identifying weak signals and outliers, that can mutate rapidly or conversely very slowly, problematical for analysts and decision makers. Corporate and individual behaviours can act as additional barriers to weak signal identification. We have shown how, by combining two problem structuring methods, viable and internally consistent outlier scenarios can be identified at the periphery of the analyst’s vision; scenarios which might have been overlooked or ignored using more traditional forecasting approaches. Such is the distance of these scenarios from current knowledge that they offer real insights into options that are difficult to identify in multi-variable and highly complex problem spaces.

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garvey@strategyforesight.org

www.strategyforesight.co.uk

The author: Bruce Garvey PhD
Bruce provides specialist support for organisations faced with high levels of uncertainty and complexity. His knowledge base allows him to address user problems and issues at a strategic level via a Systems Thinking (Holistic) approach. This is of particular value at the early stages of projects when addressing and identifying early stage “fuzzy-end” issues faced by both large and small (start-up) organisations. His methods are generic to all organisational types. In addition, he has developed proprietary decision support software to help structure complex problems which he offers as part of his overall service. This software and its accompanying process, helps decision makers to reduce, often large potential problems, to a much smaller set of viable options. Following on from a PhD research programme at Imperial College London he continually brings new research-based insights to his work. Bruce has published papers, presented at conferences and run workshop based courses on his specialist area and is a member of a number of working groups and networks in the Uncertainty domain. His current research interests include new approaches to identify “weak signals”, automated knowledge discovery and the impact of cognitive dissonance on decision making. Apart from the PhD he has a MBA from Cass Business School, London, a Post-Graduate Diploma in Economic Integration from Stockholm University, Sweden and a BSc (Hons) in Sociology from London University.