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Morphological Scenarios and Technology Roadmapping

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Abstract

With work still in progress, this paper reflects on the practical application and the benefits already delivered of a hybrid morphological scenario method that emerged from work by the Swinburne Foresight team for the Sustainable Built Environment National Research Centre in 2011 and 2012. The team has been undertaking research on the Centre's behalf to assist them set their funding priorities of applied technology research and innovation. The research had to build on prior well-received visionary work conducted with the Australian property and construction industry that captured the direction and challenges facing the industry. Visions for the future are important in that they provide a focus around priorities however visions must also be cast within realistic assessments of the plausible future conditions under which they will have to be achieved. To produce the realistic assessment the team designed a unique scenario approach that integrated morphological scenarios, developed from a morphological analysis, with a roadmap of emergent construction applications from a technology roadmap exercise. We report on the important interdependent practical challenges that through resolution contributed to our ability to deliver on the benefits that justified the approach adopted. These were the continued involvement of industry participants, the synthesis of the two methods, and matching the project deliverables to the client's needs. The team's commitment to developing team capabilities was also a contributing factor. The synthesised scenario method that emerged could have practical application in other contexts.

Keywords

Morphological Analysis, Scenarios, Technology Roadmap, Sustainable Built Environment

Introduction

The Swinburne Foresight team has been undertaking research on behalf of the Sustainable Built Environment National Research Centre (SBEnrc) in 2011 and 2012 to assist them in setting industry level research funding priorities. The team argued for and then demonstrated that morphological scenarios can be used with expert produced technology roadmaps to arrive at replicable, evidence based, defensible results with an audit trail such that the results can be transferred to the client's future decision making and scanning functions independent of the practitioner and for meeting the client's stipulated user participation and honouring of their industry wide 15 year vision. These are not unusual requirements for a client however delivering the results that were held to meet the requirements was unusually difficult. We believe this is the first time the morphological scenarios and technology roadmapping methods have been used in a foresight process for such requirements and therefore this project places the Australian building and construction industry at the forefront of the use of strategic foresight and places Australian futurists at the forefront of futures practice.

In this paper we reflect on four critical choices we made that allowed us to achieve the practical results that we had argued for and that therefore achieved the outcomes required by the client[1]. We propose that our team demonstrated a very clever *combination* of foresight methods to address the challenge of foresight for producing robust policy priorities with *participation* from industry in the research process while *enabling* the use of foresight knowhow in the industry; high quality effort require the right core *team capabilities*. We start the paper with a background to the project, followed by the reflection on the four critical choices and after that we conclude with reflection on the overall potential for this work in other areas, including our own practices.

[1] Another paper addressing the methodological contribution of this project is in progress.

Project background

The SBEnrc is an Australian research broker directly engaged with industry, government, academia and research organisations for the built environment industry with significant funding from Commonwealth, state and industry members around Australia and internationally. In the 2004 report *Construction 2020*, the Cooperative Research Centre for Construction Innovation (the predecessor of SBEnrc) captured the industry's aspirational visions to the year 2020 and the research that would be needed to realise that future for the industry. The research for *Construction 2020* made use of past foresight studies and the final document was very well received having engaged the views of several hundred people in the industry who participated in workshops and completed a questionnaire related to their individual visions for the industry.

In 2011 and 2012 the SBEnrc (from here on referred to as the client) called on the Swinburne Foresight team to use scenarios to come up with research and development (R&D) priorities for the industry for the next 20 years. The client required that the project would build on and honour the *Construction 2020* visions and would continue to engage the industry through a foresighting roadshow. The client also stipulated that technology roadmapping, a proven methodology for highlighting technology priorities, be used for developing the R&D priorities. The technology roadmap had to consider the complete range of possibilities for the industry.

A combination of methods

The Swinburne Foresight team’s first critical choice was to front-end the project with an expert-driven morphological scenario process and then to integrate the results from the technology roadmapping exercise and from this produce the R&D priorities. The client had not specified the technique or the type of scenarios to be used and so the team's decision in favour of morphological scenarios was based on the project requirements as already mentioned, the team's knowledge and experience, and the suitability of the method to the client and the team's requirements. In terms of the formation of a futures space within which to make decisions about R&D priorities it was the selection of the specific methods and the ordering of inputs and activities that had the greatest impact, as explained over the next three subsections on the morphological method.

Morphological analysis

Morphological analysis offers a rigorous process of describing a broad range of plausible future conditions of a social field, such as the Australian macro-social environment over the next 20 years that will constrain what the construction industry can do and to which the industry must adapt. In this way the client's normative future can be honoured as one of a broad range of plausible futures. A broad conceptual understanding of the morphological method is sufficient for this paper; for an overview towards obtaining a more detailed description of morphological analysis see Voros (2009). In broad terms morphology is about structure or form and “the morphological approach attempts to systematically examine the *entire range of possible combinations* of various attributes or dimensions of the object or area of interest” (emphasis added) (Voros 2009, p. 5). From morphological analysis a set of parameters is produced, called a morphological sector-factor array, that describes the plausible future conditions of the area of interest and from which morphological scenarios are constructed. The contents of the parameter set is determined by considering the area of interest as a whole or as a gestalt since the method "deals directly with *whole patterns* rather than component variables” (emphasis added) (Rhyne 1995, p. 659). Morphological analysis also differs from other scenario methods in that it is a way to "to consider the *entire field of possibilities* and construct scenarios” (emphasis added) (Godet 2010, p. 1462).

In 2011 it was already abundantly clear to the team that many types of scenario methods consider the integration of exploratory and normative scenarios as incompatible; yet this is what the team had argued for this project. Godet (2010) for example distinguishes between preactivity for scenario planning and proactivity for bringing about normative futures. For an update on scenarios see Bishop, Hines and Collins (2007), Börjeson et al. (2006), Bradfield et al. (2005), Chermack (2005), Godet (2000), van Notten et al. (2003), Varum and Melo (2010), and Vergragt and Quist (2011). Also, for the impressions of practitioners and theorists on using scenarios see the symposium in the *Journal of Futures Studies*, February 2009, vol. 13, no. 3. In that edition, a typical view regarding the incompatibility is presented by Graham Molitor, a practitioner who is firmly convinced that controlling for the future (by planning towards a normative vision) and the use of scenarios do not go together. In Molitor (2009) he explains that scenarios are not worth a great deal except sometimes when participants learn through a high quality scenario process. In contrast in Molitor (2008) he displays great reverence for the ability to take conscious control of the future and to establish a sense of direction that comes from technological foresight planning, a method that requires a visionary setting (a desired direction). In the 2009 article he is convinced that technological planning can spearhead tremendously greater economic value since economic eras are driven largely by waves of technological and scientific inventions. We take from this that for this project Molitor would advocate that it is sufficient to use the technology roadmapping results and the industry existing normative vision to determine the R&D priorities; it just would not be an easy task since he warns that selecting key priorities of national visionary projects "requires a great breadth of knowledge and the Wisdom of Solomon" (Molitor 2009, p. 103).

The team was also well aware of how exploratory and normative scenarios were being used together such as reported by Dortmans (2005) and Vergragt and Quist (2011). For Dortmans (2005) it is a case of finding a middle way (via path mapping) by transitioning between forecasting that determine migration paths for how to advance toward the future and backcasting that determine paths from the future vision toward the present. For Vergragt and Quist (2011) the difference between transitioning approaches and backcasting is that transitioning approaches are mainly about stimulating purposeful transitions towards desired futures particularly through technological development while backcasting does not necessarily need to rely on technological driving forces for transitioning.

Another important factor in the team's decision to use morphological scenarios came from felt resonance with a previous project that used morphological analysis to generate expert scenarios from which to do backcasting (see Navarro, Hayward and Voros (2008) for the Spanish approach). The attraction of the Spanish approach was that one of the exploratory scenarios was a normative industry scenario while the pathways backcast from the future and the use of expert opinion hinted at the idea of an expert generated technology roadmap. The Spanish approach described the inclusion of industry expertise on a brainstorming panel as industry participation in the process of developing rigorous and credible foresight information. The Spanish experience further supported the team's decision since morphological scenarios were used in a rigorous process with an audit trail; producing grounded and realistic results and tools with an audit trail help to engender trust with engineering, physical sciences and hands-on end-users thereby easing their introduction into the foresight work.

Morphological sector-factor array

The outcome of a morphological analysis is a parameter set or sector-factor array that represents the entire range of plausible variation in the social field or area of interest over the specified time frame. The array is used to construct plausible and internally consistent scenarios irrespective of any desired vision of for future. Rhyne (1981) describes the sector-factor array as a coherent description of the relevant parts of the field conditions (based on a whole-pattern appreciation of circumstances) where sectors are descriptors of the entire social field and the factors describe the range of conditions within each sector. Sectors and factors are usually qualitative descriptions however the things they represent depend on the field under consideration. There are guidelines and rules-of-thumb available for how to establish the sector-factor array based on practitioners' experience applying the method. Establishing the contents of the array is difficult and given our experience on this project we concur with Rhyne (1995) that:

> "Composition is an art, permeated with acts of judgment, and the output from an exercise of the FAR [morphological] method will always be limited by the appreciations and the creative abilities of the persons carrying it through.' (p. 658)

Rhyne (1995) and Coyle, Crawshay and Sutton (1994) advised practitioners to come up with no more than six or seven mutually exclusive or independent primary sectors from the total number of worthy sectors. We decided to follow this advice from very early on in the project. A benefit to us from following this guideline was that it encouraged discipline to describe the most relevant sectors from all the possible sectors that could be described. It also provided a way of assessing the right scope of each of the sectors so that the array fully clarified the strategic future space for the client. Another interesting point to make about a disciplined approach to describing a limited set of sectors is that, as Inayatullah (2009) said, there is a distinction between scenarios and alternative futures: identifying deep patterns and historical archetypes has parallels with finding the few patterns that best describe the system in question.

In relation to the morphological approach, another important choice we made, and the significance of it will be made clearer in the next section on participation (and that will be elaborated on in a paper on the contribution to methodology), is that we specifically excluded technology from the morphological analysis. This is in contrast to sentiments expressed by practitioners such as Molitor mentioned earlier, that technology is a primary spearhead of change.

A flow-on benefit from selecting and describing a limited number of well thought out sectors is that it helped us to simplify the identification and descriptions of the range of factors for each sector to between three and four for each sector. This is not a rule since the range of factors should be sufficient to describe the entire range of plausible conditions within the sector over the time frame of interest. With three to four factors per sector it meant we could later construct four scenarios that together covered the perceived conceptual spread of plausible evolution of the Australian macro-social conditions that might actually unfold. This further helped the workshop participants to engage with relevant, understandable and meaningfully challenging but not overly complex scenarios.

We are also contributing a new 'art' of the process that we found necessary to make the process work for us and the client. Ideally in morphological analysis one should involve the client during the analysis and scenario phases of the methodology, however in our process industry participants were involved after the morphological analysis. This meant that it was very important that the sector-factor array and the scenarios be recognisable and credible to the client. At the same time the morphological outputs had to also capture the realistically emerging factors and dynamics in the Australian macro-social environment that the client or industry might not have identified or be aware of. As might be expected, there are no available sources providing one with such outputs. To meet these diverging specifications we started our research by immersing ourselves in the industry mindsets through important industry literature to develop a deep appreciation of the industry and to understand the systemic nature of the industry. We then broaden our research with knowledge of other systems that interact with the industry and finally we used existing futures literature on the industry as a check for our sector-factor array.

Morphological scenarios

The morphological sector-factor array is used to construct scenarios by taking a factor from each sector and combining them to yield the scenarios. This delivers scenarios that are each an internally consistent description of the changing circumstances of a whole social field over the time frame in question. In contrast to other scenarios, morphological scenarios are not events-based descriptions. According to Rhyne (1981) "[a]s a set, those scenarios probe the perceived range of plausible variation within that field and during the time frame of the projection..." (p.331). The implication is that the industry's vision is part and parcel of these conditions (unless it is not a plausible scenario) as demonstrated by the normative scenario in the Spanish approach. Consequently morphological scenarios are more ‘industrial strength’ descriptions for establishing detailed policy settings compared to what might be achieved with a single normative (e.g., technological) visionary plan.

Participation

We've hinted earlier that the Swinburne Foresight team's design for client and industry participation in the scenario process was surprisingly different to what is expected from typical morphological and other scenario processes. The client required that the project continue the success and support generated by the *Construction 2020* report by engaging with the industry stakeholders in national roadshows; the client did not specify what was involved in engagement and participation. The Swinburne Foresight team’s second choice was to, rather than simply reporting the morphological and roadmapping results and getting support and feedback at roadshows, designing a scenario workshop process that brought industry thought leadership and expertise to the selection of R&D priorities required by the client. As explained next, it was the serendipitous decision to use a technology wall, and to use it in a particularly unusual way, during the scenario workshops that played a significant part in achieving the outcomes which justified this project. There were also unplanned outcomes obtained for participants from the scenario workshops.

Technology wall

The Swinburne Foresight team decided to exclude technology from the morphological analysis and consequently technology did not appear in the descriptors of the sector-factor array or in the morphological scenarios. This is an unusual decision given that technology is very often seen as a critical driving force within futures scenarios. Doing this allowed us to design a workshop process that reintroduced technology into the scenario workshops through the technology wall. The technology wall is a display of a broad range of emergent technologies relevant to the industry, including those that honour the industry vision and those that address the client's strategic focus. The smorgasboard of emergent technologies was produced independent of the Swinburne Foresight team by an expert led technology roadmapping exercise (by VTT Finland) incorporating the client's normative industry vision and with knowledge of the morphological scenarios but without constraining or directing the production of the plausible morphological scenarios for Australia. The technologies were described in terms of examples of potential future applications in language relevant to the industry. The technology experts selected technologies that could become commercially available over the timeframe of analysis including technologies that could become available if funding was directed to the necessary research. The Swinburne Foresight team's insight to exclude technology from the scenarios is very unusual yet it very fittingly contributed to the client's needs for R&D priorities.

In essence the scenario workshops brought together a set of scenarios that covered a plausible range of the entire range of future conditions most strongly impacting the industry (excluding technology conditions) with a set of technologies that could plausibly be available irrespective of the future conditions and available within the timeframe and then asked industry participants to immerse themselves in the scenarios, imagining themselves working and living successfully under those conditions. They were then asked to bring their industry experience to bear on the selection of appropriate and important technologies from the technology wall needed to meet the challenges and opportunities in their specific scenario world. This was exactly the question the client needed answered: which important technologies (not yet available) have to be available to the industry in the entire range of plausible futures as the industry strives to achieve its vision so that investment in R&D can be made now? One could say the process was designed to combine the future of desire (the normative industry vision) with the future of fate (the plausible future scenarios and technologies in the pipeline now).

In our view, the technology wall solution is a very clever way of resolving a generally accepted incompatibility between scenarios, normative visions, and planning as reported in the literature (mentioned earlier) and which has only partly been 'solved' by a 'transitioning' method. We have reversed the thinking of what is typically, in our experience, a view that technology is a push factor or a driving force and therefore that technology should be chosen in the present so as to (help) bring about a desired future. We demonstrated with our scenario workshops that people choose technologies according to the features that allow them to meet their needs and solve their problems brought about by the conditions of the time, adapting technologies as required. As practitioners we see the benefit of choosing to use this approach with the technology wall again in future projects.

Unexpected participant outcomes

The client required the engagement of industry stakeholders in national roadshows to report the scenario and technology results. However, because of the scenarios and technology wall process and because of the ease of replicating the workshop process with the materials made available, unexpected results have been obtained. As the first example very positive participant experiences have been reported following workshops. Secondly, workshop participants have reported their intentions to use the materials in their own work, for example one participant is planning to use the materials as a teaching aid for university undergraduates.

Enabling foresight

A third practical area relating to the Swinburne Foresight team ability to meet the project's stated aims concerns the range of choices about involving and communicating results to the client and the industry. These choices, we believe, facilitate the growth of foresight knowhow in the industry and because the project results will be publicly available the project is in effect contributing to the growth of foresight common property. We have already pointed to a number of decisions that assisted with this process such as using a methodology with an audit trail, developing outputs that are credible, relevant, and readily understood by the industry, involving industry in scenario workshops where they learned about the morphological scenario process and about their industry, and providing them with a sector-factor array from which many more scenarios can easily and non-trivially be constructed for use in strategic conversations. Another important choice we made for communicating results to assist the transitioning of decision making to the client's and the industry's own decision making and their own judgement processes was the use of a traffic light approach for selecting and presenting the R&D priorities.

Traffic light approach to R&D priorities

The traffic light method is highly recognisable framework used in complex decision making processes to make the assessment steps more concrete and the presentation of the outcomes clear and easy to understand. The framework is understood in almost all cultures and across all ages and is easy to implement. These characteristics make the framework particularly useful where the decision making needs to be transitioned to the client's own decision making processes and where the client need to develop their own judgements.

The participation by industry in the process of selecting R&D priorities was just one activity in producing the list of R&D priorities required by the client. On completion of the workshops, the selections by all the workshop groups (including technologies identified but not on the technology wall) were collated and a list of the critically needed industry technologies was constructed. The list was then subjected to further technology and innovation expert review for commentary on the timing and likelihood that the technologies would emerge over the specified time frame and for identification of additional technologies relevant to the industry and the scenarios but not specifically identified during the workshops.

The traffic light approach was used to assign the critical technologies on the list to 'green', 'amber' and 'red' categories according to a priority decision making process as follows. If a particular technology is likely to emerge from R&D over the timeframe of analysis, whether from the client industry or from another industry, then the technology was classed as 'green' meaning the technology need only be monitored for developments over time. If research is needed to adapt technology for use in the client industry or if partnering with another industry is needed to produce technology suited to the client industry, then the technology was classed as 'amber'. If a technology is unlikely to emerge from any industry due to insufficient current research effort then the technology is classified as 'red' indicating a very high priority for R&D effort is needed. The benefit of having used the traffic light approach to classify the critical technologies is that it enables the client to engage the industry in formulating its own judgements and criteria for allocating R&D priorities and to take ownership of the results. With all the materials the client can also incorporate the results into a foresight scanning framework.

Core team capabilities

And finally, the fourth area of practice that contributed to the Swinburne Foresight team's ability to meet the stated project aims is that of team capabilities. The morphological literature show general agreement on the difficulty of the method and the demands it places on the capabilities of the core morphology team. The process was no less demanding for us given that we had less time than the experts advise and we felt we had more than usual to do in that time with fewer resources. The literature tends to agree on the requirement for a heterogeneous mix of experts with unusual expertise who are not unduly influenced by the other team members and able to critically examine and defend beliefs. On how to manage the team and the processes the literature gives the impression of needing to employ a variety of decision making techniques to enforce team members' reaching agreement under the guidance of a strong and experienced facilitator. These are the ways in which the morphological methodology resolves the inevitable difficulties of getting individuals with their own unique personal capabilities to contribute fully what they know, like and can do to the interests of the project which may not completely overlap with their individual interests. Swinburne Foresight team went a step beyond using external enforcement techniques and strong facilitation to meet the challenge of supporting and maintaining high quality team effort.

Capability refers to what one knows, what one likes to do and what one can currently do. Much research has been conducted and many books have been written about how ambivalences existing in individuals become expressed in group life leading to contradiction, conflicts and tensions that impact group performance. Techniques that introduce external enforcements and strong facilitation are solutions to overcome difficulties but may serve to reinscribe invisibility of and make undiscussable and even more invisible the tensions and conflicts that they were meant to overcome. The Swinburne Foresight team made the decision to commit to the learning that can happen when there is a conscious holding (not resolving) of tension since together the team members are inescapably and unavoidably cooperating in the team purposes and they are doing so (often) unwittingly as their highest individual selves for their own purposes. Our commitment is based on, firstly, a recognition that purposes are unavoidably established when people come together and that the purposes in effect aim to the resolution of tensions and conflicts in whatever way necessary. The meeting of purposes and hence the resolving of tension therefore also spells the end of further learning. Secondly, our commitment is to a consciousness that distinctive and unique histories, capabilities and interests brought each individual to the team with an inexplicable knowing that who and what they each are is not significant or compelling. The benefit of the team's commitment was that we continually learnt how best to contribute what we knew, what we liked to do and what we could do as individuals to the purposes of the team.

Conclusion

The final outcomes of the SBEnrc foresight project are not in, however with this paper we wanted to report on the practical outcomes that have already been achieved. Specifically our reflections are on those practical and design choices that ensured that the stated project aims and client requirements were met and for which the morphological scenarios method was specifically argued for. The project had to arrive at replicable, evidence based, defensible results with an audit trail and a framework process the client could revisit and that could be transferred to the client's future strategic and scanning functions to become independent of the practitioner. Also, the project had to ensure user participation and had to honour the industry's 15 year vision. In this paper we presented on the critical choices we made in four areas of practice that meant these stated aims were achieved. In summary these four areas of critical choices are:

- our decision to use morphological analysis made it possible to design a scenario process that honoured the client's normative vision while producing R&D priorities for the present in a way that was previously not considered practically possible;
- we designed morphological scenarios workshops that used a technology wall to get industry participation and inputs into the research process and gave opportunity for participants to learn about foresight and the future of their industry;
- we used a traffic light approach to assist the transitioning of results and decision making from the prospective foresight phase of the work to the client and the industry and
- we developed team and team member capabilities work to overcome the contradictions, conflicts and tensions that, so usually in spite of all efforts, hold teams back from their highest team and individual performances.

The capabilities we have developed, the choices we have made regarding methods and techniques, and the discoveries we have made about the use of the technology wall as we reported in this paper are all aspects that we will be able to and will choose to use in future projects were applicable. They may also have application in other contexts for other practitioners and the technology wall stands out here as a new idea. The traffic light approach is a simple practical method with huge implications for communicating foresight results that can be adapted to other complex projects to help transition the ownership of the results and the decision making that need to follow to the client. The design of the combined morphological and technology roadmapping exercise involving a normative vision has significant promise for other scenario projects in areas where specific futures are desired to involve participants in new and surprising ways. We anticipate that the generalisation of the technology wall concept (for example by replacing technology with another factor of strategic interest to a client) could be used in sustainability foresight projects in other industries given the normative aspect of sustainability.

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