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Scenario-driven roadmapping for technology foresight

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ABSTRACT

This paper presents a novel method for using scenarios for technology foresight. Technology foresight is a well-established discipline, practised with popular foresight methods such as roadmapping and scenario planning. Applying each foresight method reveals limitations in practice, some of which can be addressed by combining methods. Following calls for combining foresight methods, and past attempts to integrate scenario planning and technology roadmapping, we propose a novel method for their combination. The resulting method — 'scenario-driven roadmapping' differs in: i) using scenario planning first to identify plausible images of the general environment and then using the scenarios for technology roadmapping; and ii) taking advantage of 'flex points' – critical developments which would signal transitions along particular pathways – to create a 'radar' to support effective monitoring of the environment over time. This new combined method takes advantage of the strengths of both methods, while addressing their limitations. A case study vignette centred on the work of a special interest group for Radio Frequency IDentification (RFID) technology adoption in the English National Health Service is presented to illustrate and reflect upon the use in practice of the 'scenario-driven roadmapping' method. Participants were able to develop a detailed technology roadmap with clear 'flex points' helping to connect present circumstances with pathways towards future scenarios. We report on how participants engaged with the scenario-driven method and outcomes achieved were recorded.

1. Introduction

The evolution of technology and the search of the 'next big thing' is a continuous quest for organisations. Mapping the future of a technology is nowadays an established practice (Boe-Lillegraven and Monterde, 2015) adopted by all kinds of organisations to anticipate better new trends and forces, and their impact on the advancement of a technology. Many types and methods for technology foresight have been developed in the last three decades (Mishra et al., 2002). Of them all, technology roadmapping stands out as the most popular, being widely used to support the development of future technologies (Lee et al., 2013). Despite its potential and value, technology roadmapping has a number of limitations (Lee et al., 2011). Thus, we observe efforts to combine technology roadmapping with other foresight methods in order to minimise the effects of these limitations (Saritas and Aylen, 2010).

Scenario planning is another very popular foresight method, often used in technology strategy development (Tran and Daim, 2008). Various studies have closely linked scenario planning and technology roadmapping (Drew, 2006; Lee et al., 2007; Phaal et al., 2004; Tran and Daim, 2008; Yoon et al., 2008), and others even suggested blending the two methods (Saritas and Aylen, 2010; Strauss and Radnor, 2004). Combining the two methods does however require very careful consideration, as they are distinct in logic, scope, and the level within the organisation at which they are utilised (Strauss and Radnor, 2004).

Technology roadmapping often assumes a straight line projection or single scenario, and can become less useful in the face of change that is volatile, systemic and sudden (Strauss and Radnor, 2004), especially over longer periods of time. Wright et al. (2013a), in a previous special issue on scenario planning in this journal, commended the potential outcomes of combining scenario planning with other methods. There are calls (Phaal and Muller, 2009) for using roadmapping processes to accommodate the uncertainties associated with future forecasts and aspirations, and where appropriate to communicate these in the roadmap itself.

This paper presents 'scenario-driven roadmapping', a novel foresight method combining scenario planning and technology roadmapping. Combining selected elements of scenario planning with selected elements of technology roadmapping is not new. Our method however is more comprehensive and differs in: i) using firstly scenario planning to identify plausible images of the general environment and then apply the method of technology roadmapping; and ii) taking advantage of 'flex points' – critical developments which would signal transitions along particular pathways – to create a 'radar' to support effective monitoring of the environment. This

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method takes advantage of the strengths of each method, while addressing limitations identified in the literature.

In the rest of the paper, we review technology roadmapping and scenario planning, emphasising the various frameworks which describe the activities that should take place when using the method in practical settings, and discussing their inherit weaknesses and limitations as foresight methods. We develop a new method which addresses these limitations, to improve the practice of technology foresight. Finally, a fully developed application is reported, which provides a basis for reflecting on the utilisation of the new method.

2. Literature review

2.1. Technology foresight

The field of technology foresight has its roots in the industrial era and developed from the need for long range planning for defence (Linstone, 2011). A popular definition of technology foresight is given by Martin (1995 p. 142) as:

> "*Technology foresight is the process involved in systematically attempting to look into the longer-term future of science, technology, the economy and society with the aim of identifying the areas of strategic research and emerging generic technologies likely to yield the greatest economic and social benefits*".

Broadly, there are a number shortcomings to technology foresight. Practitioners are urged to increase the quality of their work in order to present instances of "success stories" and further the impact of foresight activities (Costanzo, 2004; Cuhls, 2003; DenHond and Groenewegen, 1996; Rohrbeck and Gemünden, 2011; Salo and Cuhls, 2003). Researchers are called upon to contribute further to methodological and conceptual advances in order to provide a clearer understanding of what foresight activities can and cannot deliver (Rohrbeck and Gemünden, 2011; Salo and Cuhls, 2003).

There are several efforts to categorise, organise and arrange foresight methods (Georghiou, 2008; Magruk, 2011; Porter et al., 2004; Saritas and Aylen, 2010). Saritas and Aylen (2010) organised foresight methods into groups of: i) understanding; ii) synthesis and models; iii) analysis and selection; and iv) transformation and v) actions. Magruk (2011) developed a classification of technology foresight techniques with 10 types based on a cluster analysis: consultative, creative, prescriptive, multi-criteria, radar, simulation, diagnostic, analytical, survey and strategic. Georghiou (2008) presented a 'Foresight Diamond' where the four tips of the diamond, not intended to be independent, are defined as 'expertise, creativity, evidence and interaction'. Examples of 'expertise' methods include: roadmapping, expert panels and interviews presented as qualitative methods. Examples of 'creativity' methods include wildcards, simulation and gaming presented as semi-quantitative groups. 'Evidence' methods are also defined as semi-quantitative, including methods such as modelling, scanning, extrapolation and literature reviews. 'Interactive' methods are defined as fully quantitative including voting and polling. According to Georghiou (2008), roadmapping is in the 'expertise' area of the diamond, while scenario planning spans the area between 'expertise' and 'creativity'. Porter et al. (2004) presented technology foresight as encompassing a broad menu of methods, clustered in thirteen 'families', and often involving a blend of quantitative and qualitative methods in order to compensate for weaknesses in any one method. Placing scenario planning and technology roadmapping used in combination into perspective within the broader menu of technology foresight methods available, scenario planning belongs to Porter et al.'s (2004) 'scenarios' family and technology roadmapping belongs to both the 'descriptive' and 'matrices' families.

2.2. Scenario planning

Scenario planning is one of the most popular foresight methods (Ramírez et al., 2015; Schwartz, 2008) as it provides a future-focused method, which allows for the systematic use of insights from experts across a field, and helps explore the joint impact of various uncertainties (Van der Heijden et al., 2002). Scenario planning is not about predicting the future; it is about preparing an organisation for a number of plausible futures (Varum and Melo, 2010). Scenario planning provides an opportunity to envision plausible future states and thus helps to generate strategies to reduce risks, to take advantage of opportunities and avoid potential threats (Ramírez and Selin, 2014). Schoemaker (1995) identifies a range of conditions related to environmental uncertainty for using scenario planning. Van der Heijden (2005) extends the application of scenario planning beyond strategy development, to include anticipation, sensemaking and organisational learning. While scenario planning is widely used for strategy development in organisations (Huss and Horton, 1987), there are many instances of its application in other contexts such as national/regional, industries or even specific technologies (see Van Notten et al., 2003; and Franco et al., 2013 for reviews).

Ringland (2002) explains that the practical difference between scenario planning and 'traditional' planning methods is the time frame. Scenario planning is about taking a view of the long term future in order to help with the planning activities at different time horizons, whereas traditional planning is either too narrowly focused on the present or is based on 'single point' forecasts of the future (Burt et al., 2006). The core idea behind scenario planning is the anticipation of the future in multiple plausible images. As scenario planning has evolved (Bradfield et al., 2005) variation in its use has grown, and three schools of scenario planning thought have emerged (Wright et al., 2013a). In this study, we follow the intuitive logic school which promotes a process of qualitative inquiry to interpret the cause and effect of uncertainties in order to envision several alternative images of the future (Amer et al., 2012).

2.2.1. The process of scenario planning

Within the intuitive logic school of scenario planning, most scenario planning interventions are designed in accordance with early contributions to the field (Schoemaker and van der Heidjen, 1992; Schoemaker, 1995; Bradfield et al., 2005). The first stage concerns 'setting the scene'. Defining the purpose of the exercise, developing an understanding of the current situation, setting a time horizon, selecting the appropriate participants and defining the need for the scenario planning process are common aspects of the first stage (Schwartz, 1991), which normally takes place as a preparatory activity (Chermack et al., 2005).

The second stage covers identifying the key driving forces, either via interviews of key stakeholders or within a workshop setting. Tapinos (2012) showed that, although there is some variation in practice, the driving forces that shape the future should concern the general environment following PEST or one its derivatives (Burt et al., 2006). This stage can take place within a workshop setting with a wide ranging brainstorming session (O'Brien, 2004), though for larger interventions Van der Heijden (2005) proposes preparing a series of key questions to be used within interviews.

The third stage involves ranking driving forces by the level of uncertainty and impact. Van der Heijden et al. (2002) proposed the use of a two axis diagram to evaluate the relative importance and level of uncertainty for each factor in a qualitative, discussion-based approach. This diagram is used to cluster the driving forces identified in the previous stage in order to select the most important uncertainties. It has also been suggested (O'Brien, 2004) that the potential maximum and minimum values of each of the selected uncertainties should be considered.

The fourth stage encompasses selecting central themes and developing scenarios, using various techniques depending on the contextual setting of the exercise. The guiding principle is to develop plausible scenarios (Ramírez and Selin, 2014). It is evident that there is a lot of flexibility into how this stage is realised. Firstly, there is significant variation between different studies regarding how many scenarios should be identified; Amer et al.'s (2012) review found that the recommended number of scenarios to be developed varied from 2 to 8. Secondly, there are inductive and deductive methods to identify the scenarios' themes. The inductive approach is based on building the scenarios around uncertainties (see O'Brien (2004);