Customising and deploying roadmapping in an organisational setting: The LEGO Group experience

Clive Kerr [1], Robert Phaal [2] and Kasper Thams [3]

[1] Centre for Technology Management, University of Cambridge, Cambridge, United Kingdom. civk2@cam.ac.uk
[2] Centre for Technology Management, University of Cambridge, Cambridge, United Kingdom. rp108@cam.ac.uk
[3] The LEGO Group, Rugmarken 1, 7190 Billund, Denmark. Kasper.Thams@LEGO.com

Abstract

When roadmapping is being introduced into an organisation, there are a number of 'reference' processes which can be consulted to help ease the barriers to implementation. However, it is critical to recognise that such reference processes offer a baseline design and careful consideration should be given to how they could be adopted for use within a specific organisational setting. Through a research engagement with the LEGO Group, this paper captures and reports on the process journey (including the problems faced by the users and lessons learned) in customising a reference process and the deployment of the adapted approach.

Keywords: Roadmapping; Technology management; Strategy; Innovation; LEGO

1. Introduction

Roadmaps are both a prominent and popular tool in strategic planning, innovation and technology management (Amer and Daim, 2010; Gerdsri et al., 2009; Geum et al., 2013; Gindy et al., 2006; Lee and Park, 2005; Phaal et al., 2003) – they provide a visual representational form for expressing and exploring the dynamic relationships between markets, products/services and technologies over an explicit time dimension. In regards to implementing roadmapping, process-driven workshops are increasingly being seen and adopted as a standard approach (Vatananan and Gerdsri, 2012). Underlying the workshop approach is a facilitated step-wise process, and there are a number of reference processes available. However, it must be recognised that when applying a reference process in an organisational setting, the reference provides a baseline for customisation (Phaal et al., 2004). To clarify: although workshops are becoming the standard approach in roadmapping, such approaches provide a 'reference' process not a 'standard' to be complied with and blindly implemented. So, initiating roadmapping in an organisation implies the development of customised processes (Phaal et al., 2004; Lee and Park, 2005; Gerdsri et al., 2009).

To demonstrate the customisation of a reference process, this paper reports on the experience of configuring and applying roadmapping into a part of the LEGO Group. The aim of this exemplar is to:

- Show the inherent flexibility of the roadmapping tool.
- Highlight the practical problems faced by a roadmapping user.
- Capture the lessons learned and share the adaptations made to the baseline process.
- Illustrate how a company can take ownership of the customisation and deployment through a 'start small, iterate fast' philosophy.

The work is based on an action research engagement and represented a collaborative effort between the LEGO Group and the University of Cambridge through the Strategic Technology and Innovation Management Consortium. The emphasis of the research was strongly application-based,

with the intent of gaining a better understanding of the managerial considerations of customising roadmapping and to provide improvements to the associated practices of implementation.

2. Literature review

2.1. Roadmapping as a planning tool

Management tools are "indispensable for business and competitive analysis" and their fundamental purpose is to "aid and guide managerial decision-making" (Wright et al., 2013). One such tool is roadmapping, which has a prominent history in the field of technology and innovation management. Motorola is credited with establishing the application of roadmaps for planning (Willyard and McClees, 1987) and the tool gained widespread attention and traction with companies as a result of the first industry roadmap, namely the Semiconductor Industry Association's Technology Roadmap (Schaller, 2004), being published. At the national, sector and organisational levels the application of roadmapping is now widely adopted as a principal tool in strategic planning (Phaal and Muller, 2009).

In the context of supporting organisational/corporate planning activities, roadmapping acts as a focal point (Phaal et al., 2006a) and promotes an enterprise perspective (Cosner et al., 2007). It provides a mechanism that links the executive level of decision-making to the operational level by integrating the technological issues with current and emerging market considerations so informing business strategy with the necessary portfolio perspectives (Petrick and Provance, 2005). As such, it is often highlighted that roadmapping's popularity is due to its ability to graphically convey relationships between markets, products/services, technologies and resources (Cosner et al., 2007; Geum et al., 2013). Obviously, these relationships can embody a market-pull dynamic (e.g. addressing customer needs) and a technology-push dynamic (e.g. exploiting an innovation). However, it should be noted that to generate/develop an effective roadmap requires simultaneous consideration of both the market-pull and technology-push dynamics of the specific situation (Amer and Daim, 2010).

Roadmapping also enables the different stakeholder groups to gain consensus on how to appropriately move forward/realise a vision given the particular circumstances of the situation being addressed. It is critical to recognise that a 'good' roadmap is essentially a manifestation of a generic underpinning framework, namely: Why-What-How-When-Where-Who. When deploying this flexible and powerful framework, roadmaps are fundamentally utilised to conduct the functions of 'align' and 'plan' (Kerr and Phaal, 2015). The 'planning' challenge inherent in roadmapping is to adequately portray a concise and integrated view of future courses of action (Amer and Daim, 2010). The resultant roadmap can then be used to communicate the strategic intent/vision, attract resources and funding, stimulate and mobilise action (Kerr et al., 2012a; Kostoff and Schaller, 2001). With the phased roll-out and implementation of roadmapping within an organisation, the on-going 'alignment' challenge is to synchronise and maintain commitment and co-ordination amongst the various stakeholders (Kappel, 2001; Whalen, 2007).

2.2. Practices in industrial organisations

In the literature, there are a limited number of industrial cases/examples that substantively portray roadmapping being deployed within organisational settings: Motorola (Willyard and McClees, 1987; Richey and Grinnell, 2004); BP (Barker and Smith, 1995); Philips (Groenveld, 1997; EIRMA, 1997); ABB (EIRMA, 1997); Hoogovens (EIRMA, 1997); LucasVarity (EIRMA, 1997); Lucent Technologies (Albright and Kappel, 2003); Rockwell Automation (McMillan, 2003); General Motors (Grossman, 2004); Royal Mail (Wells et al., 2004); Siemens (Farrokhzad et al., 2008; Lischka and Gemünden, 2008). The first issue to note with this list of available examples is that they are all rather dated – well over a decade since being reported. Secondly, and more

importantly, these specific instances merely provide a descriptive outline of the roadmapping approach. So although interesting, the potential for other companies to extract insights and lessons, which would inform their own design and implementation of roadmapping, is fairly minimal. For example there are no accounts of how the approaches were developed, how adaptations were made to allow a better fit with the organisation, and how any improvements were made based on feedback from actual implementation.

Additionally, there is a recognition in the literature that process-driven workshops are becoming a standard approach in deploying roadmapping (Vatananan and Gerdsri, 2012). Two of the better-known approaches are: T-Plan (Phaal et al., 2001) and S-Plan (Phaal et al., 2007). Both T-Plan and S-Plan are 'fast-start' methods; they adopt a rapid prototyping philosophy and embody the ethos of "iterating quickly as a learning process" (Phaal et al., 2012). As such these process-driven workshop approaches provide a defined reference process "that is used as a starting point from which the method is adapted as required" (Phaal et al., 2012). Phaal et al. (2003) stress that roadmapping is not a 'black box'. "Each application is likely to be different, depending on the specific needs of the organisation, the area of focus and the company context (prevailing systems, processes, available information and culture)" (Phaal et al., 2003). When applying a reference process in an organisational setting, the 'reference' is actually a baseline for customisation (Phaal et al., 2004). Phaal et al. (2006a) state that "it is unreasonable to expect that a particular tool will be suitable without customisation (it is important to adapt the tool to fit the situation, rather than compromise requirements to fit the available tool)". However, there is a lack of advice and guidance on how to suitably customise a roadmapping reference process. Given the history and literature base on roadmapping, this paper is the first known publication that provides a tangible and detailed account of how an actual organisation approached the issue of adopting and configuring a specific roadmapping reference process.

2.3. S-Plan 'reference' process

The S-Plan 'reference' process (Phaal et al., 2007) is an established and proven approach for initiating roadmapping. It has been applied in well over 200 research, development and application projects undertaken with industry, government and academic stakeholders (Phaal et al., 2012). The diversity of these applications spans numerous different sectors, company sizes and types, products, services, technologies, and against a variety of strategic contexts – thus demonstrating the flexibility and scalability of the approach (Phaal et al., 2012).

S-Plan's baseline process is configured for a one-day workshop (Phaal et al., 2007). It has been found that this normally provides a sufficient quality of input-versus-output against an acceptable level of commitment from key stakeholders, in order to gain their participation and ensure sufficient engagement in the process (Phaal et al., 2004) – typically, potential workshop participants will allow for a day from their busy schedules to trial the approach and gauge the outcomes that can be realised through applying the tool. The backbone of the S-Plan process consists of four key tasks (Phaal et al., 2007):

1. Generate a strategic landscape.
2. Identify opportunities.
3. Explore priority opportunities.
4. Agree next steps / a way forward.

Fig. 1 depicts the generic underlying structure to the S-Plan process sequence. The principal activities are the strategic 'landscape' (a structured brainstorm using the roadmapping framework) and the 'landmark' explorations (specific topic roadmapping on selected opportunities). Essentially, the one type of tool (i.e. roadmapping) is being deployed but at two different levels each with their own purpose. These two embodiments of roadmapping offer the minimum toolkit arrangement that can be deployed and also represents the core roadmapping modules at the heart of the S-Plan process (Kerr and Phaal, 2015; Phaal et al., 2012).

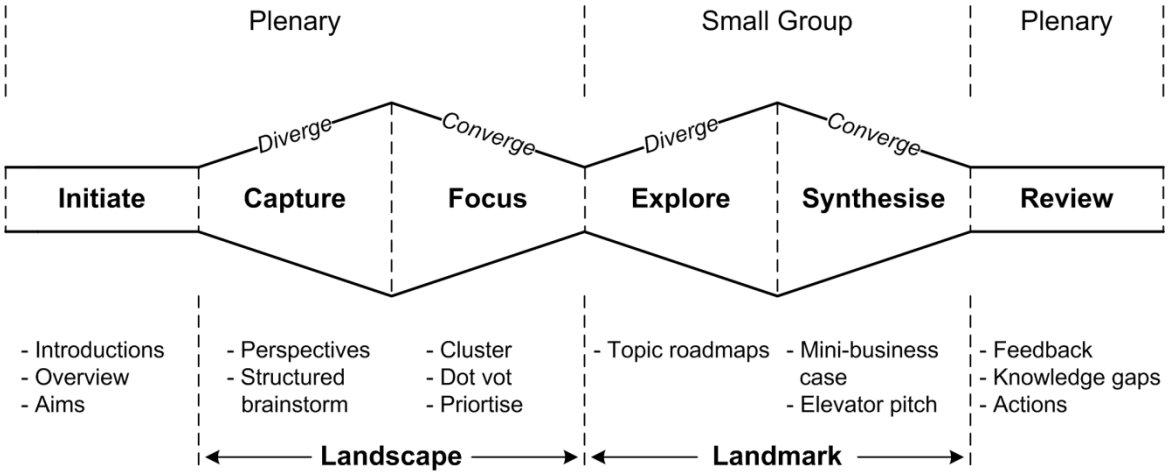

Fig. 1. Underlying structure of the S-Plan process (Adapted from Kerr et al., 2013).

As can be seen from Fig. 1, the strategic landscape activity is used to capture the inputs/perspectives from the various workshop participants and to then focus in on the key clusters of ideas/theme sets in order to enable the identification of the priority opportunities (typically through a dot voting exercise). The canvas of the landscape template is structured using the roadmapping framework developed by Phaal et al. (2004; 2008); typically it consists of three main layers:

- Market/business trends and drivers (representing the 'Why' aspects).
- Product/service opportunities (i.e. the 'What' aspects).
- Technology/resources (i.e. the 'How' aspects).

This landscaping is a plenary activity whereby all the workshop participants populate the wallchart progressively, for example from top-to-bottom in a layer-by-layer manner (Phaal et al., 2012), through a structured brainstorm (Kerr and Phaal, 2015; Phaal et al., 2007). It provides an effective means for participants to share their knowledge on the given domain/area/subject and for their inputs to be recognised (Kerr and Phaal, 2015). Therefore the landscaping activity greatly helps to initiate and support stakeholder interactions and its content forms a repository of rich and broad information that can be explored/analysed/refined (Kerr and Phaal, 2015). Using the landscape as a resource of 'content-against-context', the participants then identify and prioritise opportunities/strategic options through voting/scoring (Phaal et al., 2007). So, across the landscape, there will be a number of important 'landmarks' (i.e. interesting/priority opportunities for value creation and exploitation). These selected landmarks can then be unpacked and explored in greater depth/granularity – this process step is often called a 'deep dive' by many organisations (Kerr and Phaal, 2015). In the workshop, participants are organised into small multifunctional groups thus allowing multiple landmarks/topics to be investigated concurrently. The groups use a roadmapping template (often referred to as a 'topic' roadmap) with a common structure in order to gain a more consistent output against the parallel landmarks/topics being explored. Often the layout and design of these templates provide a supporting mechanism to explore the nature of each opportunity in more detail, articulate possible routes forward and to synthesise the main components of a mini-business case and/or 'elevator pitch'. A palette of potential elements/sections for such templates has been highlighted by Kerr and Phaal (2015), namely:

- Market trends and drivers.
- Business challenges.
- Vision / target end-state / objectives.
- Value proposition.
- Potential products / services.

- Current status / state-of-the-art.
- Deliverables / demonstrators / development paths.
- Internal capabilities and resource requirements.
- Enablers / barriers (including assumptions, constraints, knowledge gaps).
- Decision points, action steps and milestones.
- Summary narrative (including learning points and risks).

The outputs from this part of the S-Plan process can be considered as 'first-cut' roadmaps (Phaal et al., 2007). These are then presented for discussion and reviewed through a plenary session in order to establish a way forward and agree the next steps – so that the specific topics/landmarks start their implementation journey.

2.4. Potential issues/pitfalls

With the uptake and adoption of S-Plan as a reference process, it is often overlooked that its original intent was as a fast-start approach for the "rapid initiation of roadmapping" (Phaal et al., 2007). That is: it "provides an opportunity for the organisation to assess how best to take the approach forward, prior to committing significant resources and effort" (Phaal et al., 2007). Essentially, it is a means of getting initial buy-in to the roadmapping tool/method and, through the investment of a single workshop, allows an organisation to get a sense of what is possible in terms of outputs. Thus, gaining an acceptance of the process and using the initial content from the activities to gain traction across the stakeholders for further roll-out of the approach. As acknowledged by the developers of both T-Plan and S-Plan:

> "*The output of the fast-start approach is typically not a coherent technology roadmap, but is sufficient to enable participants to understand the value of the process*" (Phaal et al., 2003).

To clarify this position, consider Fig. 2. As stated in the previous section, although there is just one type of tool (i.e. roadmapping), it is being deployed at two different levels (landscape and landmark) – each with a specific purpose (structured brainstorm versus deep dive). These levels relate to hierarchical levels, or 'orders', and are defined according to the context to which S-Plan is being applied i.e. these 'orders' are dependent upon the unit of analysis of the organisational situation (Kerr and Phaal, 2015). For instance, the landscape (1st order roadmapping) might relate to a business unit and the associated landmarks (2nd order roadmapping) could then refer to the products being developed by that business unit (Kerr and Phaal, 2015). Alternatively, the landscape (1st order roadmapping) might be a technological domain and the landmarks (2nd order roadmapping) correspond to potential projects within that domain (Kerr and Phaal, 2015). It is important to recognise that the unit of analysis is tied to the landscape. So, while roadmapping is being used to generate a landscape, that landscape does not automatically equate to a roadmap. The topic roadmapping process generally does produce roadmaps, but further effort is required to create a 1st order roadmap (if desired) using 2nd order roadmaps as a resource through a process of integration and synthesis. It must be remembered that the landscape is actually a structured brainstorm, which is generated to get a sense of the context across the Why-What-How-When aspects, and the content captured from participants forms a knowledge source. During the S-Plan workshop, the landscape is interrogated to identify the priority opportunities (i.e. landmarks), which are then explored and developed to elaborate 'first-cut' topic roadmaps (Fig. 2). Although these first-cut topic roadmaps of the landmarks may need some further refinement, and perhaps additional information sought to fill in specific knowledge gaps, they are fairly coherent roadmaps. Whereas the landscape is just a landscape – it lacks any coherent narrative and doesn't articulate/reflect the richness of the strategic threads/plots across its canvas. It requires significant effort to distil the strategic narrative and synthesise the key messages from all the landscape data (i.e. contrasting and emphasising the 'signal' against all the background 'noise'). It also necessitates 'closing the loop'

back up from the individual landmarks (2nd order roadmapping) to the landscape (1st order roadmapping) as shown in Fig. 2. Additionally, the misconception associated with landscapes being perceived or portrayed as roadmaps is further compounded when a series of workshops are run with different groups of stakeholders but the separate landscapes are not assimilated into a singular consolidated view.

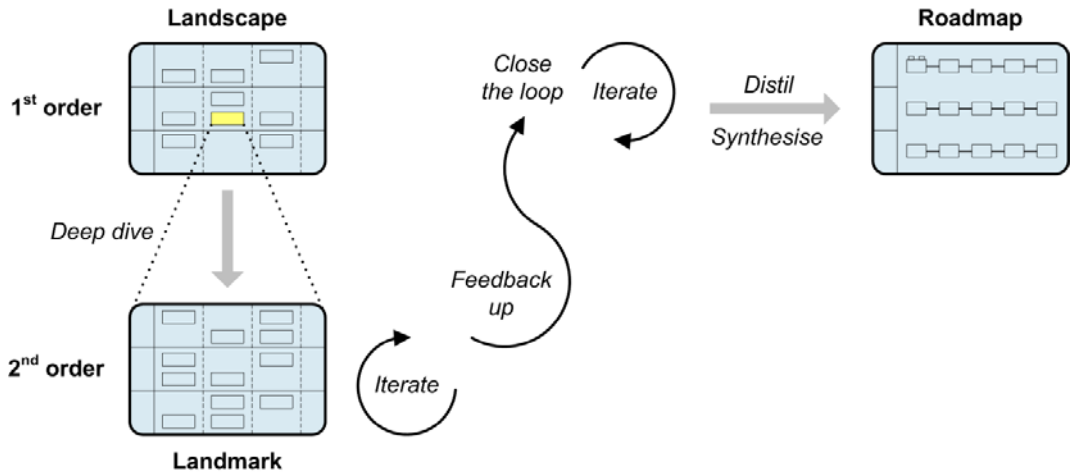

Fig. 2. Landscape and landmark versus roadmap.

Given that the S-Plan process is grounded in the workshop mode of engagement, the actual workshop itself is a high-profile event. However, one of the potential pitfalls associated with the prominent status of the event is that the conclusion of the workshop is seen as a 'fait accompli' – i.e. we have finished the roadmapping workshop and so we must have a completed roadmap. Of course this is rarely the case, especially given the previous discussion of landscapes being inappropriately considered to be roadmaps. Also, the workshop typically generates a wealth of data. When that data is documented and disseminated to the array of stakeholders, they do find it overwhelming (e.g. they can't see the 'wood for the trees'). The challenge of post-processing and analysing the data from roadmapping workshops is, in reality, a significant hurdle for most organisations. Often the information overload problem leads to organisations regressing to simple reporting as opposed to effective visual communication.

There are two primary constraints with the workshop method: (i) getting the appropriate mix of participants to be actively involved; and (ii) the time available for the workshop. Ensuring that the 'right' participants take part is a rather mundane, yet very important, issue of aligning dates in diaries. So it is the pressure on time that can have serious implications on the outcomes/outputs of the workshop if not thoughtfully and skilfully deployed. One very obvious pitfall is insufficient time being allocated to different parts of the process. For instance during the brainstorming of the trends and driver layer, the result is usually a limited understanding, if any, as to the significance and implications of the various PESTLE/STEEPLE factors on both the individual opportunities/landmarks and the organisation/landscape as a whole. Also, if the standard S-Plan process is run through in a very mechanistic fashion, then insufficient time could be allocated to addressing the 'visioning' component of the roadmapping framework resulting in a complete lack of a meaningfully articulated vision – this is one area that can ruin the credibility of the roadmapping method and subsequent roadmap. Furthermore, the captured data is often underutilised. Typically only a subset of the landmarks can be explored during the workshop, but rarely does an organisation revisit the remaining ideas/opportunities that were not initially investigated – some of these may still be valuable. There may also be a lack of recognition of alternative futures and multiple pathways/options to realising the set of opportunities proposed for taking forward.

3. Research approach

3.1. Action research

Roadmapping is an established management tool and as such requires a practice-based lens that examines and reflects upon its associated activities and processes (i.e. practices-in-use). Such a view is well positioned within the frame of engaged scholarship (Van de Ven, 2007) and the strategy-as-practice perspective (Jarzabkowski, 2004; Johnson et al., 2003; Whittington, 1996). According to Langley (2010), "if knowledge of practice is to a large extent embedded in practice" then it can be argued that "it is only through practice that knowledge of it may be acquired and transferred" and therefore necessitates an action research approach.

In action research, there is an underpinning belief that the best way of learning about an object/entity is through attempting to change it (Easterby-Smith et al., 2002). This approach "focuses on research in action, rather than research about action" (Coughlan and Coghlan, 2002). Action research projects are thus based on the combination of two central principles: (i) intent to take action; and (ii) a participatory/collaborative approach to the work (Eden and Huxham, 1996). This orientation has a good fit to the study of management tools. As stated by Phaal et al. (2006b), the development of 'practical' and 'well-founded' tools such as roadmapping requires "active collaboration with industry, working together on 'live' management problems and challenges". The aim is to "offer insights into users' intentions and the implications of using tools for specific interaction" and to reflect on how users "may employ the same tool not only in different ways but for different reasons" (Spee and Jarzabkowski, 2009). Action research can be considered as a 'live' case in real-time (Coughlan and Coghlan, 2002). It can also be seen as a variant of case research; however, the researcher is not an independent observer (Westbrook, 1995). It is not sufficient for the researcher to merely study the action of others, there must be deep involvement by the researcher in the intervention for making change (Eden and Huxham, 2002). Essentially, "the researcher becomes involved in and contributes to the practitioner's world" (Eden and Huxham, 1996). Reciprocally, and just as important, "the practitioner becomes involved in and contributes directly to the form of the research output" (Eden and Huxham, 1996).

The approach to customising roadmapping, as described in this paper, used an action research method through a practitioner-researcher model of industrial engagement. It involved immersion in the actual situation and co-operative design efforts between the University of Cambridge and the LEGO Group. The scope of the action research project was on the 'way things are done' (i.e. what-why-how) in regards to roadmapping process adaptations and then implementing the actual changes (e.g. through piloting/testing and on-going refinements). Under a 'look-think-act' framework of inquiry (Stringer, 2007), the methodology involved a series of iterative 'focus-develop-apply' steps (Westbrook, 1995). The objective of the project initiation stage was to 'look' at the specific situation within the LEGO Group in order to understand the context, clarify the purpose and then 'focus' in on the requirements and challenges being faced (see Section 3.2 for details). The 'intent for action' principle implies that the need for the work is in response to pressing issues and also is orientated towards solving a practical problem. In this case, the focus for the LEGO Group was on identifying and developing new capabilities and technologies for key operational processes across manufacturing. In parallel, roadmapping appeared as an attractive and potentially useful tool for supporting strategic planning activities across the LEGO Group (if the tool's functionality could be appropriately harnessed and embedded within the specific organisational environment). From a research perspective, this provided an opportunity to gain a better understanding of how to customise the deployment of roadmapping from a baseline 'reference' process.

In regards to the 'think-act' stages, there were two main 'action' and 'reflection' cycles within the project. Firstly, the standard form of the S-Plan reference process was applied in a pilot study in order for the LEGO Group to experience the process (in terms of what-why-how) and to gain a sense of the outcomes/value that can be generated. This trial was then reflected upon – see Section

4.1 for details. Secondly, through collaborative effort between the researchers and practitioners, a number of adaptations were developed during the tailoring of the reference process and new elements/features were introduced. Details of the design considerations when customising a roadmapping reference process are given in Section 4.2 and the set of process adaptations and associated implementations are detailed in Section 4.3. This second main cycle of action and reflection involved iterative micro-cycles of 'focus-develop-apply' as the customised process was rolled-out and further refined based on feedback/evaluation between each micro-cycle. The method of collaboration involved active engagement through design studio sessions, process walkthroughs, workshop debriefs and review meetings.

3.2. Collaborative engagement with the LEGO Group

The LEGO Group were interested in applying and leveraging the roadmapping tool to build a foundation for a more integrative and cross-functional approach to driving strategic innovation activities across the 'Operations' side of the organisation. The scope encompassed the development of new capabilities and technologies related to key operational processes across manufacturing and was framed by three fundamental questions:

- What is needed?
- What is possible?
- What are we able to do?

The capabilities identified through roadmapping should be as specific as possible, and there should be clear reasoning of the importance and relevance of each capability. Additionally, such capabilities should be closely bound to the strategic priorities and/or a clearly articulated market opportunity/driver. The main objectives of the roadmapping activities were to create alignment and establish co-ordination between and across functions on how to best reach their strategic ambitions; balancing the need to build on existing strong/unique capabilities (e.g. within moulding, decoration and packaging) versus developing new capabilities to fulfil strategic ambitions or create product newness (driven by consumer needs). Thus, the procedural challenges were how to use roadmapping to:

- Set and align the long-term direction across functions to guide future plans.
- Identify and decide on the capabilities needed to reach the ambitions at the right time.
- Spot unrevealed capability gaps and opportunities.
- Understand and reinforce linkages between capabilities being developed to heighten synergies (e.g. technology platforms with cross-portfolio application).

Whilst addressing these challenges, it was important to ensure that the approach taken appropriately fitted the organisational environment within the LEGO Group.

4. The LEGO Group's Experience

4.1. Trialling the S-Plan process

The LEGO Group initially piloted the S-Plan reference process designed for a 1½-day workshop; where the strategic landscape activity took place on the first day and then the landmark/topic explorations were conducted the following morning. This was facilitated by third party consultants, who were responsible for running the roadmapping process, which allowed the LEGO Group to fully immerse themselves in the activities without having to worry about looking after the mechanics of the process.

Following the trials, the LEGO Group reflected on their experiences with the S-Plan process and carefully examined how the specific steps/activities in the process could be applied within their own organisational environment. The underlying question driving their reflection was: if the LEGO

Group were to adopt the roadmapping method/tool and roll it out across the various internal groups, what would a 'fit for purpose' process look like? This question acknowledges that S-Plan is a fast-start approach and its reference process offers a backbone structure that should be customised to better fit with specific user needs. The LEGO Group's main concerns and lessons with S-Plan were:

- To maximise the value from roadmapping, it should not be deemed/portrayed as a single one-off workshop-styled event. A roadmapping workshop does not necessarily lead to the creation of a roadmap – so internal stakeholder expectations need to be managed in regards to outcomes. The workshop should be viewed as a means to rapidly capture perspectives/ideas, identify key themes/interests/clusters and then coalesce opinions on a general sense of a way forward.
- During the brainstorming, there is the danger of the workshop becoming too short-term focussed and biased toward current day views of problems/challenges, especially when there is not a clear end-state vision and sufficient direction setting.
- Given the pressure on time, there was a lack of discussion and reflection on the individual participant contributions on the landscape and how they could be 'best' combined. Also, the clustering of inputs/ideas across each of the landscape layers appeared rather ad-hoc.
- It was difficult to capture the 'so what' significance and implications from the different layers of the landscape.
- Although a number of priority opportunities/landmarks were explored, these were not fed back up to the landscape level. The process failed to address how the landscape could have been evolved, or at least be better informed, by these explorations of specific opportunities. This extra granular data and associated learning wasn't formally discussed/reviewed against the 'bigger picture'.
- It was a struggle to translate all of the workshop data into a cohesive set of initiatives/ integrated projects and then into tangible action plans.
- Much more effort needs to be applied in the background, after the workshop event, to fully develop a coherent roadmap that provides a robust expression of strategic intent and imparts a clear sequence/pathway of activities leading to the vision.

4.2. Design considerations when customising a 'reference' process

In regards to designing/adapting a roadmapping process, Phaal et al. (2004) indicate that there are two types or categories of process to consider. Firstly there is the micro-process which focuses on the detailed process for conducting specific activities (such as the landscaping) and in particular the agenda for the roadmapping workshop (Phaal et al., 2004). Then there is the macro-process which focuses on the overall staged process, composed of a set of semi-independent steps/tasks logically connected/sequenced, that enables the overall roadmap to be developed. For example, Phaal et al. (2004) have an initial recommendation of a three-stage process: "starting with planning, leading up to the one-day workshop, followed by a post-workshop meeting to review outcomes and agree on the way forward". This has been updated by the insertion of two additional stages into the macro-process:

- Between the planning stage and the actual workshop, there can be some 'pre-workshop work'. For example, capturing participant perspectives beforehand or conducting some market analysis which can feed into the workshop by being pre-populated onto the landscape.
- After the workshop but before the final review meeting, there can be some 'post-workshop work'. For example, additional activities or tasks to both analyse and synthesise the data captured/produced from the workshop event.

A generic pre-workshop / workshop / post-workshop arrangement is illustrated in Fig. 3. For pre-work, Kerr and Phaal (2015) stress that a key question for consideration is: "which tools are useful for pre-workshop preparations in order to maximise the utility from the actual workshops

themselves (which are often very time constrained)?" These supporting tools can facilitate the collection and pre-population of useful data. For example, using forecasting tools to develop the market trends/drivers layer by investigating requirements and needs (Vatananan and Gerdsri, 2012). Or, applying data mining tools "that predict, measure, and map capabilities like technologies, knowledge and skills" to help construct the bottom-layer of the roadmap (Vatananan and Gerdsri, 2012). In regards to post-work, Kerr and Phaal (2015) state that "workshops typically generate lots of data and one of the criticisms of a workshop-based approach is the lack of contemplation/reflection – so, which tools can best support this post-workshop 'sense-making' process?" One suggestion is to use interlinked grid-based tools to help extract 'insights' from workshop-generated data. For starters, they provide an effective means for spanning a landscape and formally plotting the relationships between its various layers (Phaal et al., 2001; 2003; 2012). Kerr and Phaal (2015) highlight that they can be more widely applied to identify:

- Key themes (e.g. hot topics and pertinent trends).
- Gaps (e.g. important absences of activity and inherent weaknesses).
- Synergies (e.g. cross-cutting themes and areas to be leveraged).
- Overlaps (e.g. duplication of effort).

Both the macro-level and micro-level process aspects have been considered when customising the S-Plan reference process for specific application to the LEGO Group context. Bearing in mind the experiences from piloting the baseline process, these process adaptations will now be outlined and discussed.

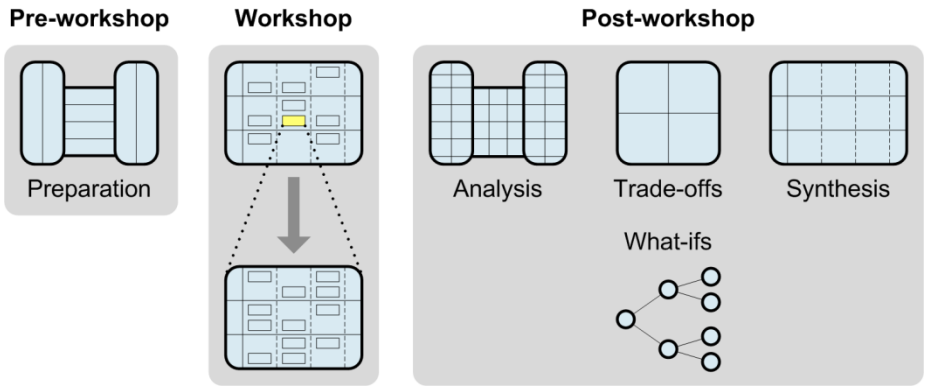

Fig. 3. Pre-workshop, workshop, post-workshop arrangement.

4.3. The LEGO Group's process adaptations

Roadmapping not only provides a mechanism for informing and influencing strategy; it actually provides a means of changing strategy by showing how and why the organisational course should be altered and what pathways are preferred. The act of roadmapping provides the freedom to reposition and even rethink strategic initiatives. So the roadmapping workshop is a high profile event. It is also high profile because it involves a significant level of social capital and goodwill from the stakeholders and participants. Additionally, workshop time is both pressured and precious – there exists the trade-off between the time necessary to capture data and conduct the activities appropriately versus allowing sufficient time for discussion and reflection on the potential outcomes (i.e. their significance and implications). The issue of expectation of outputs given the resource committed by stakeholders is always an underlying factor in how the process should be designed and conducted. Although the workshop may be a one-day event, if 20 people are spending a day – that's a significant investment. So the question becomes one of how to maximise the value from doing roadmapping workshops to ensure both direct benefits to participants and tangible recommendations/results for the organisation.

Based on the roadmapping framework (Phaal et al., 2004; 2008), the LEGO Group felt that the core focus for their future S-Plan styled workshops should be orientated much more on the middle 'What' layer which represented the 'opportunities / value creation / solution' space. It must be stressed that this approach acts as a common reference point – to then be adjusted to specific applications. By focusing on tangible opportunities, the overall approach was structured with the explicit aim of addressing key operational challenges rather than such challenges being emergent from the strategic landscape. This required a series of 'beacons' to be defined pre-workshop to guide the visioning (i.e. forward-looking perspectives specific enough to set direction, but not limit/constrain thinking to the current way of operating). To ensure that these were strategic imperatives for the 'Operations' domain, they were 'theme-based' so as to enable cross-capability mapping and cross-cutting initiatives to be formed. This includes various, and occasionally conflicting, ambitions such as the need to improve operational efficiency while increasing complexity in production driven by greater variety. Landscape architectures/templates would embody a number of these themes depending on the subject of the given roadmap (e.g. Moulding, Packaging, etc.). Then against these beacons, in the actual workshops, capabilities were sought and framed against: What is needed? What is possible? What are we able to do? It must be recognised that the beacons were used as a framing mechanism and, as such, workshop discussions were not necessarily limited to those pre-defined on the landscape.

To 'gain' time in workshops for discussion and reflection, extensive pre-workshop activities (interviews, one-to-one meetings, surveys, etc.) were used to capture data and then align inputs from the various stakeholders. This also alleviated the load/burden on participants to span an entire landscape in a single pass during a live workshop. The capturing of data before the workshops enables stakeholders to much more thoughtfully generate their perspectives (as opposed to the potentially rushed real-time inputs during the pressured environment of a workshop). Stakeholder inputs were sought pre-workshop on the following aspects (also see Fig. 4):

- Innovation pull (top layer of the landscape which includes mega-trends, consumer drivers, customer/channel drivers, internal ambitions) – identify drivers and scale ambitions. Example prompting questions included: What are the principal drivers to set direction for future innovation? Which are most important? What's missing from current thinking?
- Innovation push (bottom layer of the landscape which includes current evolving technologies, new step-change technologies, processes, knowledge and skills) – recognise key enabling resources and better exploit core technologies. Example prompting questions included: Which technologies can be leveraged for future innovation?
- Current/planned capabilities (short- to medium-term column of the landscape) – provide a clear understanding of what 'Operations' is capable of doing today and already working on (e.g. in the areas of Materials, Moulding, Decoration, Machines, Processing). Example prompting questions included: What are we able to achieve by developing our existing capabilities? What are our current gaps across the platforms?

The LEGO Group found that pre-work significantly increased the breadth and depth of inputs and allowed their internal facilitators the opportunity to filter and iterate the inputs/views – even uncovering issues below the surface. There were also secondary benefits: it familiarised stakeholders with the roadmap structure; sharpened their thinking on future challenges and reflection on current issues; clarified the key themes and focus areas; aligned sponsor expectations and buy-in; and, increased the readiness of workshop participants (mindset and priming). Essentially, participants were better ready to start the working sessions at the actual workshop events.

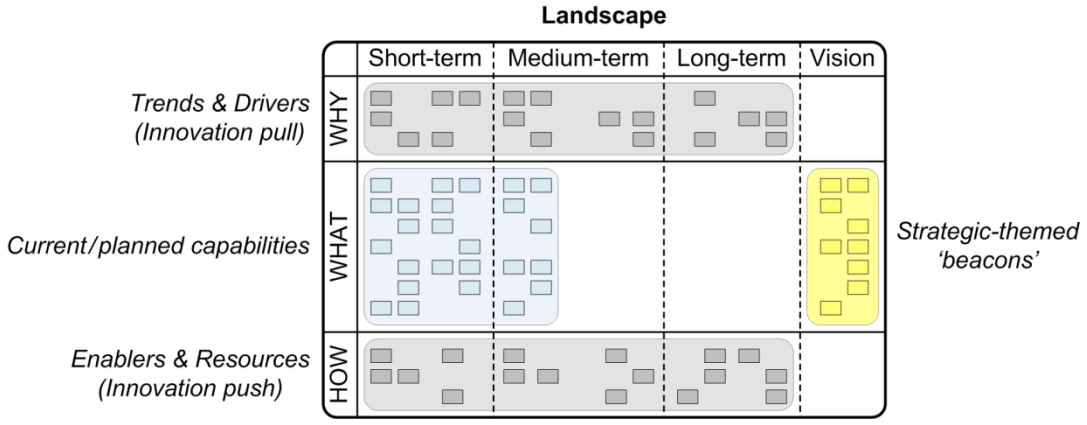

Fig. 4. Pre-population of data on the canvas of the landscape.

At the start of each workshop there is a review of the pre-populated data on the landscape in terms of the push (enablers) versus pull (drivers/ambitions) dynamics. The concept of 'dynamics' is crucial; the participants are not merely reviewing a list of enablers and drivers within their respective layers, they are also contrasting these factors against each other across the landscape and in regards to the strategic themes. And as such, this exercise provides a means for priming participants for the brainstorming activity.

One of the principal tasks for the workshop participants is to contribute 'innovation' ideas/opportunities for value creation. This is conducted through the regular brainstorming activities using sticky notes (Kerr et al., 2012a; 2012b). Value creation is defined as new capabilities and/or smart solutions that could represent future innovation initiatives for the Operations side of the organisation. It must be acknowledged that sometimes it's difficult to move beyond the obvious ideas/opportunities. To help address this issue and prompt/force thinking beyond the current planning horizon, the brainstorming is orientated to the middle- to long-term time dimensions (framed against meeting the strategic ambitions, satisfying the priority drivers, and exploiting the key enablers). Additionally, a period of reflection is built into the process to allow time for participants to review ideas and then identify 'blind spots / white spaces'.

Another principal task for the workshop participants is to unpack and explore ideas (or a combination of ideas) and produce a first-take on a pathway to realising value from the opportunity set against the ambition level for the related strategic themes. This activity is conducted in small groups, of typically 3-4 participants, who are asked to investigate their topic as framed by the following questions:

- What could it bring to us?
- What do we gain? What do we not get?
- How close does it come to the ambition?
- How might it play out?

For each topic, the pathways should have an explicit series of steps for their direction of travel and an initial sense of a storyline that reflects the nature of the push-pull dynamics. For instance, under the theme of 'enable agility/flexibility in production' there is a distinct narrative about the balance/fight between efficiency and differentiation of the machines and a sub-plot in regards to how best to leverage existing operational elements (such as platforms/equipment).

The LEGO Group acknowledges that the roadmapping workshop is often just the starting point for a much wider engagement with stakeholders. The workshop provides a natural 'centre-of-gravity' in which to continue the conversation with specific groups and also enable on-going dialogue across functional areas of the organisation – but it is a journey beyond the roadmapping events. Participants do need to have a sense of closure from the workshop itself and some tangible outcomes, but recognise that it's not a fait accompli in regards to creating the roadmap. A sense of

both individual and group closure can be gained by the participants, if at the end of the workshops some of the following are highlighted during the review/closing remarks:

- The 'low hanging fruit / quick wins' for immediate execution and to build momentum.
- The potential for leveraging on-going activities/platforms/learning.
- An initial understanding on how to move forward with the selective 'big ticket' opportunities.
- An alignment on the ambitions.
- An identification of the cross-cutting ideas that will likely represent future initiatives.

Post-workshop, the first step is to document the raw outputs. Workshop facilitators, participants and other stakeholders should not make the mistake of assuming that a combination of landscape and several landmarks equates to a roadmap being generated. A workshop can generate lots of data in an essentially semi-messy form, so it is necessary for the internal facilitators to initially post-process that data by further clustering/repositioning the ideas and also checking the contribution to the drivers, enablers and visionary beacons. In terms of analysis, some fundamentals are both extracted and identified including indirect benefits to other priority areas. This would include comparing the set of options (i.e. key individual ideas and key cross-cutting ideas) against the current 'Operations' strategy deployment and associated portfolio of programmes/projects before putting forward any recommendations/business case to decision-makers. At the landmark level, topic owners take responsibility to process their pathways in greater detail and to better understand the options inherent within specific pathways – taking into account the available degrees of freedom and organisational levers within their own particular spheres of influence. For example:

- What are the main activities and milestones for your department?
- What elements are 'critical' versus 'nice to have/do'?
- What are the 'pain points' (difficulties / disadvantages / risks) that you would face?
- What is the level of effort/resource required?
- What are your recommendations for an action plan?

Once the series of landmarks have been refined, they are brought together and fed back to the landscape level. Several iterative steps are then conducted to translate, synthesise and distil this information into a high-level summary roadmap (including an appropriate visualisation for the purposes of communication). During this phase, the domain champions take responsibility for:

- Reviewing and actioning key ideas/opportunities.
- Highlighting ambition gaps and weak themes.
- Establishing cross-cutting initiatives.
- Aligning capability pathway plans.

This section has outlined the set of adaptations that were made to the S-Plan process. To further draw out the lessons learned and to provide a concrete example of the type of feedback that was gained from in-company applications, Table 1 provides an illustrative walkthrough from the live case of deploying the customised roadmapping approach to the 'Moulding' domain. Against each step/task, organisational feedback on the process is given together with additional feedback to inform the on-going research agenda; where possible, specific quotes from those involved have been included.

Table 1
Example application of the customised roadmapping approach to the 'Moulding' domain.

Procedural step/task	Summary	Feedback on the process	Feedback to research
Pre-workshop stakeholder buy-in	One-to-one dialogue with stakeholders to adjust scope and uncover underlying topics of interest; in the case of moulding: "*we need strong focus on flexibility*"	Despite being clear on the overall purpose of the task for the roadmapping workshop, understanding stakeholder perceptions and opinions is important context	—
Pre-workshop 'beacon' development	Example of a beacon used to set direction: "*reduce changeover time by 30%*"	Such a beacon triggers thinking on process optimisation and technology options, but also "*uncovers potential 'below the surface' issues such as the mindset of our people*"	—
Pre-population of 'innovation pull' factors (e.g. trends and drivers)	Helps set a strong 'why' for the process – reminds people why this is important, e.g. "*the need to relate the increased volatility in the toy market with the changing retail landscape so making the theme of 'high flexibility' ever more important*"	"*A strength of the roadmapping process is to link the commercial and technical elements*"	It's a challenge to keep such linkages 'front of mind' and ensure relevance as multiple inputs are added, e.g. in regards to the flexibility theme: "*how much flexibility do we need – when do we have sufficient ideas to satisfy this need?*"
Pre-population of 'innovation push' factors (e.g. resources)	Workshops are thus undertaken from a strong base of previous research and with multiple initiatives already in place – "*which needs to be acknowledged and then reflected upon by participants in the workshop*"	"*A good reminder to mention the resources available, both technical and people competences*"	Often difficult to fully think-in to the process, "*occasionally people get too constrained if asked to meet a set of drivers along with leveraging resources at the same time*"
Pre-population of 'current/planned capabilities'	Workshops are thus undertaken from a strong base of previous research and with multiple initiatives already in place – "*which needs to be acknowledged and then reflected upon by participants in the workshop*"	"*Critical to link in with current base of activities*"	How to appropriately blend in with and relate to current on-going efforts: "*when do you stop current efforts to start new effort?*"
Participant review of pre-populated landscape	Contrast push-pull factors across the layers of the landscape, "*with so many stakeholders involved it's important they all buy-in to what is on the roadmapping canvas*"	Primes participants for 'value/opportunity' brainstorming	—
Participant brainstorming of ideas/opportunities across the landscape	All stakeholders to brainstorm and come up with new ideas – "*in reality, often the ideas are already known*"; it's more about surfacing the combination of ideas and then having a deeper dialogue on their prioritisation	Depending on the area and work done already, consider if the roadmapping workshop is aiming for 'new-new' ideas versus capturing existing ideas (but sharing and making them visible to all)	—

Prioritization of ideas/opportunities	Used a combination of dot-voting and qualitative assessment, "*in practice, make sure the owners/decision makers have a strong say*"	—	—
Topic roadmapping of selected ideas/ opportunities	Topic roadmapping of selected ideas; in the case of moulding, an example is: "*specific technical solutions of how we might lower the changeover time*"	Experience has shown that groups tend to develop roadmaps at different levels – "*some very high-level, others specific and much more granular*" – guidance is needed for consistency of output	—
Workshop closure and outcomes	Wrap up and ensure clear next steps; in the case of moulding: "*teams were appointed to continue work with five of the best ideas which would then be brought up for management consideration*"	Rather than the pure S-Plan focus on how to create a roadmap, "*in reality, what you want is a process to provide transparency and then follow-up evaluation to support decisions*"	"*The roadmap format works well for transparency but is difficult to take decisions on*", "*how to bring decision-makers a format with the correct content to make it easier for them to take decisions?*"
Post-workshop data analysis and documentation of outputs	Focus on finding patterns: "*where did the group agree and where did they not, what can be explained - what not*"	"*Creating a roadmap that is useful is difficult*", "*merely using the landscape created in the workshop does not reveal insights - just data*"	—
Roadmap development and on-going stakeholder alignment	Ensure to keep stakeholders engaged; in the case of moulding: "*the five teams worked with stakeholders towards creating the final proposal for decision-making*"	—	—

5. Discussion

Through this collaborative action research project, the experiences gained and lessons learned can be used to both inform the wider practice of roadmapping and to support the specific configuration of future implementations/approaches by other companies. Additionally, it highlights the importance and benefits from engagements at the interface between research and practice for progressing the application of management tools, such as roadmapping, and deepening the level of understanding of such applications based on 'live' case interactions with industry (resulting in tangible feedback and subsequent iterations for continued improvements).

It must be remarked that with the popularity of some prominent roadmapping reference processes, there is often the perception/misunderstanding that a roadmapping workshop directly produces a coherent roadmap. Additionally, it must be stressed and reinforced to roadmapping users/clients that certain reference processes, such as S-Plan, were originally intended as baselines and so should be customised to the circumstances of their potential deployment. Reference processes must not be deemed to be a 'standard' and then replicated as given – a dangerous assumption in the area of strategy (roadmapping), owing to the high levels of complexity, uncertainty and ambiguity in an often conflict-ridden high-stakes context. By all means take the reference process as a backbone structure, but the activities must be considered carefully as to whether they are 'fit for purpose' against the user's needs and be tailored to the specific organisational conditions. The S-Plan approach is intended as an initial step, as the 'fast-start' term

implies, with the first pilot application being typically positioned as a diagnostic. If a coherent roadmap is desired, and if there is the ambition to deploy the approach more widely in the organisation, then it is important to learn from the 'diagnostic' pilot and subsequent applications. Specifically, the S-Plan reference process focuses on the delivery of 2nd order topic roadmaps, and further synthesis and reflection is needed to translate the data and distil the content into a cohesive overarching narrative that underlies a solid coherent roadmap at the landscape (1st order) level.

The pertinent finding for highlighting to both the academic and practitioner communities is the critical importance of pre-work. In regards to the specific case of the LEGO Group, the pre-workshop elements have been received especially well by the organisation and have proven to be effective/powerful as a way to maximise the value of the time spent together during the roadmapping workshop (which often includes senior stakeholders and participants coming in from different regions). Even though the pre-workshop activities require substantial effort, the resulting benefits in the workshops are both clear and tangible, so demonstrating that the preparation is indeed very beneficial. More generally, it should be recognised that the pre-work has an important positive effect on the level of socialisation and priming leading to sponsor buy-in and participant readiness. Participants expect a 'working' session at the roadmapping workshop and the pre-work helps to set/manage expectations and to clarify what's in-vs-out of scope (i.e. what is up for discussion versus not up for discussion). It also enables participants to mentally prepare for the 'filtering' parts of the workshop (hence downselecting options they might particularly like). The pre-population of data onto the landscape is a useful mechanism to not only save time in the actual workshops but to also address the potential quality and relevance of inputs. One risk associated with the reference S-Plan process is that the landscape brainstorming is potentially compromised due to time pressures, so participant inputs can often be poorly articulated and/or expressed with an inappropriate level of granularity. The filtering of selective inputs before any workshop can address these issues. In addition to checking the quality, it also provides an early opportunity for internal facilitators to gauge the variety of inputs (e.g. the spread across themes and over the time horizons). This has indicated the possible introduction of a completely new process step, namely: a 're-framing' activity immediately before the main roadmapping workshop.

The task of the 're-framing' activity is to use the pre-work inputs as a guide for re-adjusting the emphasis on certain key issues/challenges given the participants who will be in attendance at a specific upcoming workshop. It also provides an opportunity to identify potential workshop process/task-related issues early on; for example, the declared objective may be to generate 'radical' ideas, but if all pre-inputs are of an 'incremental' nature, this will require extra attention in the workshop itself. As previously stated, workshop time is precious and given that the senior/expert stakeholders are being convened, such an event/forum for having strategic conversations should be positively exploited. The question is how to enhance meaningful interaction and engagement? A roadmapping workshop gives participants an opportunity and a shared responsibility to be proactive. So, the essence of structuring and conducting an effective workshop is orientated to maximising dialogue and reflection amongst the participants – it is not necessarily about writing lots of sticky notes and putting them up on a roadmapping chart. The first phase of an effective workshop is about listening, learning, appreciating and understanding different perspectives. This is then followed by a second phase of exploring, creating, shaping and aligning on options and pathways (i.e. 'what needs to happen' and 'ways to get there'). Therefore, the intent of the 're-framing' activity is to systematically consider the pre-work inputs in order to uncover thought-provoking issues (e.g. blind spots, levers, etc.) in the form of 'hooks' and 'trigger questions' that will be used to frame the roadmapping workshop, provide an angle to the potential conversations and then steer individual group engagement activities. This new 're-framing' process step is a topic for a future action research project.

6. Conclusions

Within the field of innovation and technology management, roadmapping has demonstrated itself to be a very powerful tool for helping organisations address their strategic challenges by supporting the development of appropriate responses and action plans. However, although roadmapping is both an established and proven tool, there still remains a distinct lack of rich organisational accounts of its adaptation when being configured for deployment. Two obvious gaps in academic knowledge are: (i) what customisations are needed to ensure a better fit with an organisation, and (ii) what improvements are being made based on feedback and experiences from actual implementations (including piloting/testing).

To evolve the implementation practices of roadmapping, it is necessary to study and extract the lessons learned from companies who have not just used the tool in an interventionist manner but are embedding it as a management competence. Specifically, within the roadmapping community of practice, there are a number of popular embodiments – for example, the S-Plan process. Yet, there is a lack of advice or suitable guidance on how to appropriately customise such reference processes to ensure they are 'fit for purpose' given the specific circumstances of the situation. To address this issue, a collaborative research project was undertaken between the University of Cambridge and the LEGO Group. The result is a tangible and detailed account of how the LEGO Group approached the adaptation and configuration of a roadmapping reference process. The research used a practice-based lens to examine and reflect upon the various activities and underpinning procedural steps/tasks.

This paper presented the LEGO Group's experience of trialling the S-Plan reference process and, based on the feedback from a pilot workshop and their initial sense of what the approach can deliver, the process was adapted to better suit the needs and outcomes expected from the stakeholders/sponsors/organisation. The customisation involved iterative learning through incremental modifications and field testing on live in-company cases (where the focus for the LEGO Group was on identifying and developing new capabilities and technologies for key operational processes across manufacturing). The consolidated set of process adaptations have been outlined along with the associated rationale for making the changes. From an academic stance, this provided the unique opportunity to gain a better understanding of how to customise the deployment of roadmapping from a baseline reference process. Through reporting this illustrative account of customising and deploying a roadmapping process in a real organisational setting, it is hoped that it will act as an exemplar for both practitioners and academics; showing the issues and potential insights/lessons, which would then support others to adapt and better develop their own procedural implementations of roadmapping.

References

Albright, R.E., Kappel, T.A., 2003. Roadmapping in the corporation. Research-Technology Management 46 (2), 31-40.

Amer, M., Daim, T.U., 2010. Application of technology roadmaps for renewable energy sector. Technological Forecasting and Social Change 77 (8), 1355-1370.

Barker, D., Smith, D.J.H., 1995. Technology foresight using roadmaps. Long Range Planning 28 (2), 21-28.

Cosner, R.R., Hynds, E.J., Fusfeld, A.R., Loweth. C.V., Scouten, C., Albright, R., 2007. Integrating roadmapping into technical planning. Research-Technology Management 50 (6), 31-48.

Coughlan, P., Coghlan, D., 2002. Action research for operations management. International Journal of Operations and Production Management 22 (2), 220-240.

Easterby-Smith, M., Thorpe, R., Lowe, A., 2002. Management research: An introduction. Sage Publications, London.

Eden, C., Huxham, C., 1996. Action research for management research. British Journal of Management 7 (1), 75-86.
Eden, C., Huxham, C., 2002. Action research. In: D. Partington (Ed.), Essential skills for management research. Sage Publications, London.
EIRMA – European Industrial Research Management Association, 1997. Technology roadmapping: Delivering business vision. Working Group Report Number: WG52, EIRMA, 46 Rue Lauriston, F-75016 Paris.
Farrokhzad, B., Kern, C., de Vries, M., 2008. Innovation business plan at Siemens: portfolio-based roadmapping to convert promising innovation projects into concrete successes. International Journal of Technology Intelligence and Planning 4 (2), 153-164.
Gerdsri, N., Vatananan, R.S., Dansamasatid, S., 2009. Dealing with the dynamics of technology roadmapping implementation: A case study. Technological Forecasting and Social Change 76 (1), 50-60.
Geum, Y., Kim, J., Son, C., Park, Y., 2013. Development of dual technology roadmap for open innovation: Structure and typology. Journal of Engineering and Technology Management 30 (3), 309-325.
Gindy, N.N.Z., Cerit, B., Hodgson, A., 2006. Technology roadmapping for the next generation manufacturing enterprise. Journal of Manufacturing Technology Management 17 (4), 404-416.
Groenveld, P., 1997. Roadmapping integrates business and technology. Research-Technology Management 40 (5), 48-55.
Grossman, D.S., 2004. Putting technology on the road. Research-Technology Management 47 (2), 41-46.
Jarzabkowski, P., 2004. Strategy as practice: Recursiveness, adaptation and practices-in-use. Organization Studies 25(4), 529-560.
Johnson, G., Melin, L., Whittington, R., 2003. Micro strategy and strategizing: Towards an activity-based view? Journal of Management Studies 40 (1), 3-22.
Kappel, T.A., 2001. Perspectives on roadmaps: How organizations talk about the future. Journal of Product Innovation Management 18 (1), 39-50.
Kerr, C., Phaal, R., Probert, D., 2012a. Cogitate, articulate, communicate: The psychosocial reality of technology roadmapping and roadmaps. R&D Management 42 (1), 1-13.
Kerr, C., Phaal, R., Probert, D., 2012b. Addressing the cognitive and social influence inhibitors during the ideation stages of technology roadmapping workshops. International Journal of Innovation and Technology Management 9 (6), 1-20.
Kerr, C., Farrukh, C., Phaal, R., Probert, D., 2013. Key principles for developing industrially relevant strategic technology management toolkits. Technological Forecasting and Social Change 80 (6), 1050-1070.
Kerr, C., Phaal, R., 2015. A scalable toolkit platform: Configurations for deployment in technology and innovation strategy workshops. R&D Management Conference, Pisa, Italy, June 23-26.
Kostoff, R.N., Schaller, R.R., 2001. Science and technology roadmaps. IEEE Transactions on Engineering Management 48 (2), 132-143.
Langley, A. 2010. The challenge of developing cumulative knowledge about strategy as practice. In: D. Golsorkhi, L. Rouleau, D. Seidl, E. Vaara (Eds.), Cambridge Handbook of Strategy as Practice. Cambridge University Press, Cambridge.
Lee, S., Park, Y., 2005. Customization of technology roadmaps according to roadmapping purposes: Overall process and detailed modules. Technological Forecasting and Social Change 72 (5), 567-583.
Lischka, J.M., Gemünden, H.G., 2008. Technology roadmapping in manufacturing: A case study at Siemens AG. International Journal of Technology Intelligence and Planning 4 (2), 201-214.
McMillan, A., 2003. Roadmapping - agent of change. Research-Technology Management 46 (2), 40-47.

Petrick, I.R., Provance, M., 2005. Roadmapping as a mitigator of uncertainty in strategic technology choice. International Journal of Technology Intelligence and Planning 1 (2), 171-184.
Phaal, R., Farrukh, C.J.P., Probert, D.R., 2001. T-Plan: The fast-start to technology roadmapping - Planning your route to success. Institute for Manufacturing, University of Cambridge, Cambridge.
Phaal, R., Farrukh, C., Mitchell, R., Probert, D., 2003. Starting-up roadmapping fast." Research-Technology Management 46 (2), 52-58.
Phaal, R., Farrukh, C., Probert, D., 2004. Customizing roadmapping. Research-Technology Management 47 (2), 26-37.
Phaal, R., Farrukh, C., Probert, D., 2006a. Technology management tools: Generalization, integration and configuration. International Journal of Innovation and Technology Management 3 (3), 312-339.
Phaal, R., Farrukh, C.J.P., Probert, D.R., 2006b. Technology management tools: Concept, development and application. Technovation 26 (3), 336-344.
Phaal, R., Farrukh, C.J.P., Probert, D.R., 2007. Strategic roadmapping: A workshop approach for identifying and exploring strategic issues and opportunities. Engineering Management Journal 19 (1), 3-12.
Phaal, R., Simonse, L., den Ouden, E., 2008. Next generation roadmapping for innovation planning. International Journal of Technology Intelligence and Planning 4 (2), 135-152.
Phaal, R., Muller, G., 2009. An architectural framework for roadmapping: Towards visual strategy. Technological Forecasting and Social Change 76 (1), 39-49.
Phaal, R., Kerr, C., Oughton, D., Probert, D., 2012. Towards a modular toolkit for strategic technology management. International Journal of Technology Intelligence and Planning 8 (2), 161-181.
Richey, J.M., Grinnell, M., 2004. Evolution of roadmapping at Motorola. Research-Technology Management 47 (2), 37-41.
Schaller, R.R., 2004. Technological innovation in the semiconductor industry: A case study of the international technology roadmap for semiconductors. PhD Thesis, George Mason University, Fairfax VA.
Spee, A.P., Jarzabkowski, P., 2009. Strategy tools as boundary objects. Strategic Organization 7 (2), 223-232.
Stringer, E.T., 2007. Action research. Sage Publications, Thousand Oaks, California.
Van de Ven, A.H., 2007. Engaged scholarship: A guide for organizational and social research. Oxford University Press, New York.
Vatananan, R.S., Gerdsri, N., 2012. The current state of technology roadmapping research and practice. International Journal of Innovation and Technology Management 9 (4), 1-20.
Wells, R., Phaal, R., Farrukh, C., Probert, D., 2004. Technology roadmapping for a service organization. Research-Technology Management 47 (2), 46-51.
Westbrook, R., 1995. Action research: A new paradigm for research in production and operations management. International Journal of Operations and Production Management, 15 (12), 6-20.
Whalen, P.J., 2007. Strategic and technology planning on a roadmapping foundation. Research-Technology Management 50 (3), pp. 40-51.
Whittington, R., 1996. Strategy as practice. Long Range Planning 29 (5), 731-735.
Willyard, C.H., McClees, C.W., 1987. Motorola's technology roadmap process. Research Management 30 (5), 13-19.
Wright, R.P., Paroutis, S.E., Blettner, D.P., 2013. How useful are the strategic tools we teach in business schools? Journal of Management Studies 50 (1), 92-125.