

Roadmapping and Roadmaps: Definition and Underpinning Concepts

Clive Kerr* and Robert Phaal

Centre for Technology Management, University of Cambridge, Cambridge, United Kingdom

Abstract—Roadmapping emerged from industry and has evolved over the decades, through improvements and refinements made by both practitioners and research groups, to become an established and extensively deployed method. Roadmaps are popular in helping to convey and communicate the essence of strategic plans, organizational initiatives, program pathways and future courses of action. But what actually constitutes a roadmap? What are the unique attributes that distinguish them from other journey-mapping approaches and forward-looking business documents? Drawing upon active involvement in industrial engagements, applied research, tool development, and supported by the literature, a roadmap has now been defined as: *a structured visual chronology of strategic intent*. Further, roadmapping has been defined as: *the application of a temporal-spatial structured strategic lens*. As a result of these more rigorous and robust expressions, this paper reports and reviews their underpinning concepts and dimensions, and puts them forward as the new standard definitions.

Index Terms—Roadmapping, technology management, strategy, innovation.

I. INTRODUCTION

Roadmapping and roadmaps provide a powerful and practical means of supporting organizations with their strategy, long-term planning, innovation and foresight activities. The method has a proven track record and its provenance is firmly rooted in industrial engineering, company practices and practitioner-led guidance [1]. Early applications can be traced back to NASA, Boeing, GE, Lockheed, USAF, Rockwell International and the U.S. Department of Energy [1]; whilst the formalized processes, which were influential in raising the awareness and encouraging uptake of the method, were due to seminal publications by Motorola [2], BP [3], Philips [4], EIRMA [5], Lucent Technologies [6] and the Semiconductor Industry Association [7], [8]. The method gained in prominence when it was demonstrated as an effective way of aligning investments in technology, alongside prospective performance levels and functionalities, to potential competitive/customer benefits and commercial expectations. Subsequently, it has been applied to components, products, services, systems, systems-of-systems and at the sector, regional, national and international levels [9]. And, adopted by numerous businesses and institutions across a wide range of domains to address a variety of challenges/initiatives and organizational contexts. Most commonly applied in manufacturing sectors, uptake in other fields has been much slower and, disappointingly, the method and its practices are seldom covered in general management courses or textbooks on strategy. This may be due to the method being commonly called *technology* roadmapping.

* Corresponding author at: Centre for Technology Management, Institute for Manufacturing, University of Cambridge, 17 Charles Babbage Road, Cambridge, CB3 0FS, UK.
E-mail addresses: civk2@cam.ac.uk (C. Kerr), rp108@eng.cam.ac.uk (R. Phaal).

As acknowledged by Phaal *et al.* [10], *technology* roadmapping is the dominant term, with *product* roadmapping being second-most common. Given the history, there is a long-standing association with technology-intensive organizations and, obviously, an evident technological focus, stimulated by the desire from technology departments/groups to better convey the value of technology within the business [10]. The *technology* prefix can be misleading, with potential users mistakenly inferring that the method is limited to solely technological considerations. It should be noted, a decade after their landmark 1997 publication, Philips Electronics provided a further reflection on their roadmapping experiences and stated that the *product-technology* roadmapping description had been replaced by *business* roadmapping, i.e. “the development of a medium-term (5–7 years) vision of how the business is likely to develop when markets and product characteristics as well as technology get equal emphasis” [11]. Other prefixes have also been used, such as *strategic* [10], [12]. Yet, there still remains either a misunderstanding or reluctance to fully appreciate and appropriately acknowledge the holistic approach and flexible nature of roadmapping/roadmaps. Business school academics and management theorists should, perhaps, look back with a more considerate and open view on practitioner-driven developments and contributions.

In the second ever issue of the *Journal of the Academy of Management* (dating from 1958), there was a warning to “not disregard ideas developed by the practitioner” and a call for frameworks to be “broad, expandable, and elastic and not restricted to a specific discipline” [13]. Roadmapping embodies and exemplifies such a position. As a method and management tool, which is underpinned by a generalizable framework, the approach is completely scalable to any unit of analysis and customizable to any strategic context [14], [15], [16]. Roadmaps have the ability to clearly and coherently portray and present the dynamic linkages (including highlighting discontinuities) between resources and capabilities, product/service solutions, organizational objectives and business drivers, market characteristics and the changing environment. The method enables and encourages “joined up thinking” [16], where all of the important perspectives can be represented together [17], so providing both a focal mechanism and integrative view [10], [14]. Greater recognition of roadmaps/roadmapping may be more forthcoming as their profile and potential is enhanced by being exemplified as having a core role in management toolkits and actively deployed as a platform [18], [19], [20]. That said, there still remains a fundamental and unresolved issue. There is no standard meaning or exact definition of *roadmap* and *roadmapping* [1], [12], [21]. Such an issue may very well engender the dismissive reception by management scholars, hence leading to the lack of inclusion and serious coverage of the method in business school research, courses and textbooks.

Within the technology/engineering management community, a number of authors have put forward a very basic definition of roadmapping, namely: the process of creating/developing a roadmap [22], [23], [24]. Although obvious, such a definition is limiting. In reality, there are companies who actively use roadmapping to good effect in process terms without producing roadmap artifacts. So, what are they actually getting from roadmapping? There is a lot of value in doing roadmapping beyond producing a roadmap, and a definition should reflect what is really behind the adoption and application of this mapping method. In regards to roadmaps, Beeton *et al.* [25] points out that “rather than defining the term, commentators tend to focus on the functional attributes of roadmaps, i.e. describing what a roadmap does, rather than what it is”. In the literature there is one prominent and highly citable definition. Bob Galvin, CEO of Motorola during the time when roadmapping was being formalized and embedded in the company, defined a roadmap as: “an extended look at the future of a chosen field of inquiry composed from the collective knowledge and imagination of the brightest drivers of change in that field” [26]. “Imagination” and “brightest” provide a strong positive vibe, and “an extended look at the future” is a wonderful turn of phrase. But, what do these words really mean? What actually is an extended look? In this paper we put forward

definitions for roadmap and roadmapping, together with a description of the underpinning concepts, substantiated by both practice and the literature.

II. ROADMAPPING AND ROADMAPS

Fundamentally, roadmapping and roadmaps support organizations with planning and alignment [19]. Planning is well understood, although alignment does need some explanation to clarify its full meaning. To align on a way forward a number of specific aspects must be given consideration. At the level of individual participants/groups/stakeholders there should be a reconciling of self-interests, opinions and perspectives [27]. In regards to the actual content and substance, there should be a common and agreed understanding of what can be delivered and/or demonstrated against the allotted timeframe and available resources [27]; and there should be a calibrating of what is being offered/proposed in comparison to future customer needs and expected contribution given the goals of the organization.

Roadmapping and roadmaps are conjoined; however, an immediate contrast can be made. It was readily acknowledged by Motorola that the greatest value was not necessarily in the finished roadmap, but rather in following the discipline of the roadmapping process [2]. Similarly, EIRMA [5] stated that the greatest value of a roadmap comes “from the business processes that have to be put in place to create it”, rather than the possession of a roadmap in itself. These are legitimate claims and a fair reflection for other organizations. However, it should not be construed as representing the full experience; nor does it give a complete account. As a counterpoint, consider the role and reach of a roadmap. Direct participation in the roadmapping process is typically limited to a relatively small group of representatives as compared to the wider audience and broader spectrum of stakeholders that are both influenced and impacted by a roadmap. Roadmaps are an important input for an array of individual decision-makers and decision-making activities [28]; especially for Senior Management in regard to the levels of funding/investments, competitive drivers, and positioning for market leadership. When an organization starts to lose focus and direction, they need to relook at their roadmap. Furthermore, synchronization is a key function that is enabled by roadmaps [29], with roadmaps providing the mechanism and allowing for synchronization [19].

Roadmapping and roadmaps are both *visual*. Their visual nature is one of the main reasons for their appeal [30], [31], [32]. In order to provide clear definitions, there does need to be a delineation between *-map* and *-mapping*. It is the visual aspect that provides the starting point for making the separation between the act of mapping and the map artifact. Visualization through the use of management tools has been considered by Kerr *et al.* [18], who identified two fundamental manifestations, namely: the visual form for the application of the method, and a visual form given to its output for the purposes of communication. Since roadmapping is a type of mapping, it is helpful to acknowledge cartographic practices. According to MacEachren and Kraak [33], visualizations in cartography are a means of: (i) visual thinking and knowledge construction, and (ii) communication (i.e. the transfer of information). Mapping is seen as a practical form of information processing, and the map as a compelling form of rhetorical communication [34]. In specific regard to roadmapping/roadmaps, Phaal and Muller [31], [32] use the terminology of knowledge elicitation and knowledge communication. In roadmapping, a visual workshop chart (or digital equivalent) is an elicitation and exploration tool, typically used to support collaboration, and to capture information as it emerges and as discussions evolve – the prime directive is get it put on the chart. The outputs then need to be synthesized and summarized into an appropriate visual representation for onward communication [35]. Fig. 1 shows the act of roadmapping and Fig. 2 displays an example of a roadmap artifact. With *-mapping* and *-map* being distinguished by the functionality of their visual embodiments, definitions for roadmap and roadmapping will now be provided and described in detail.



Fig. 1. The act of roadmapping.

III. WHAT IS A ROADMAP?

Kappel [29] noted that “all kinds of forward-looking documents are sometimes called roadmaps”. This is evident by the set of ‘roadmap’ documents collected by Phaal *et al.* [36]. In summary, it consists of 934 public-domain documents from a wide range of sectors including energy, transport, aerospace, defense, healthcare, electronics, ICT, manufacturing, construction, materials and science. As previously stated, roadmaps are *visual*. Of the 934 documents, only 398 contained visualizations [37]. It has been stressed by Gary DeGregorio, of Motorola Labs, that “documents are inefficient containers” whereas roadmaps provide a “compact method” of visually summarizing and communicating the information [38]. The condensed visual format of a roadmap is critical as it provides a combined singular view incorporating all the key perspectives [31], [32]. One-page views are recommended, as the key strategic issues can be focused on, set against the ‘big picture’ context [30]. Interestingly, a group manager at Digital Equipment Corporation highlighted that a roadmap provided a big picture that people did not previously get to see as part of regular planning [39]. As a means of communication, a roadmap visualization is effectively a boundary object used to convey information, connect with the necessary stakeholders, and mobilize action [40].

Roadmap visualizations can take a variety of forms, ranging from simple tables and graphs, Gantt chart-based schedules, multilayer block diagrams and bubble charts, through to more expressive figures such as Sankey diagrams, tree diagrams, flow-based pictorials and schematics, and even geographic maps and metaphor-based illustrations [35]. Additionally, a roadmap can have a composite arrangement, which combines a number of such visual forms, and presented as an integrated depiction [18], [38], [41]. Returning to the research corpus of 934 documents, of which 398 contained some sort of visualization; Kerr and Phaal [37] examined the examples and identified that only 267 of those constituted actual roadmaps. “Just because an image is called a roadmap doesn’t make it so” [37]. So, what were they missing? Many didn’t include a measure of time (either explicitly or implicitly). Time is the prime parameter of a roadmap [5] – “if there is no time, then it is not a roadmap” [1]. Some neglected to display a narrative or to articulate transitional pathways/routes across the current, intermediate and future states. Others failed to embody a sense of purpose. Several lacked structure in terms of encapsulating strategic content against context. Such filters, however useful, do not provide robust guidance on what constitutes a roadmap. Therefore, we now propose the following definition:

A roadmap is a structured visual chronology of strategic intent.

We will focus on each of these individual terms, in turn, and build up to the full definition.

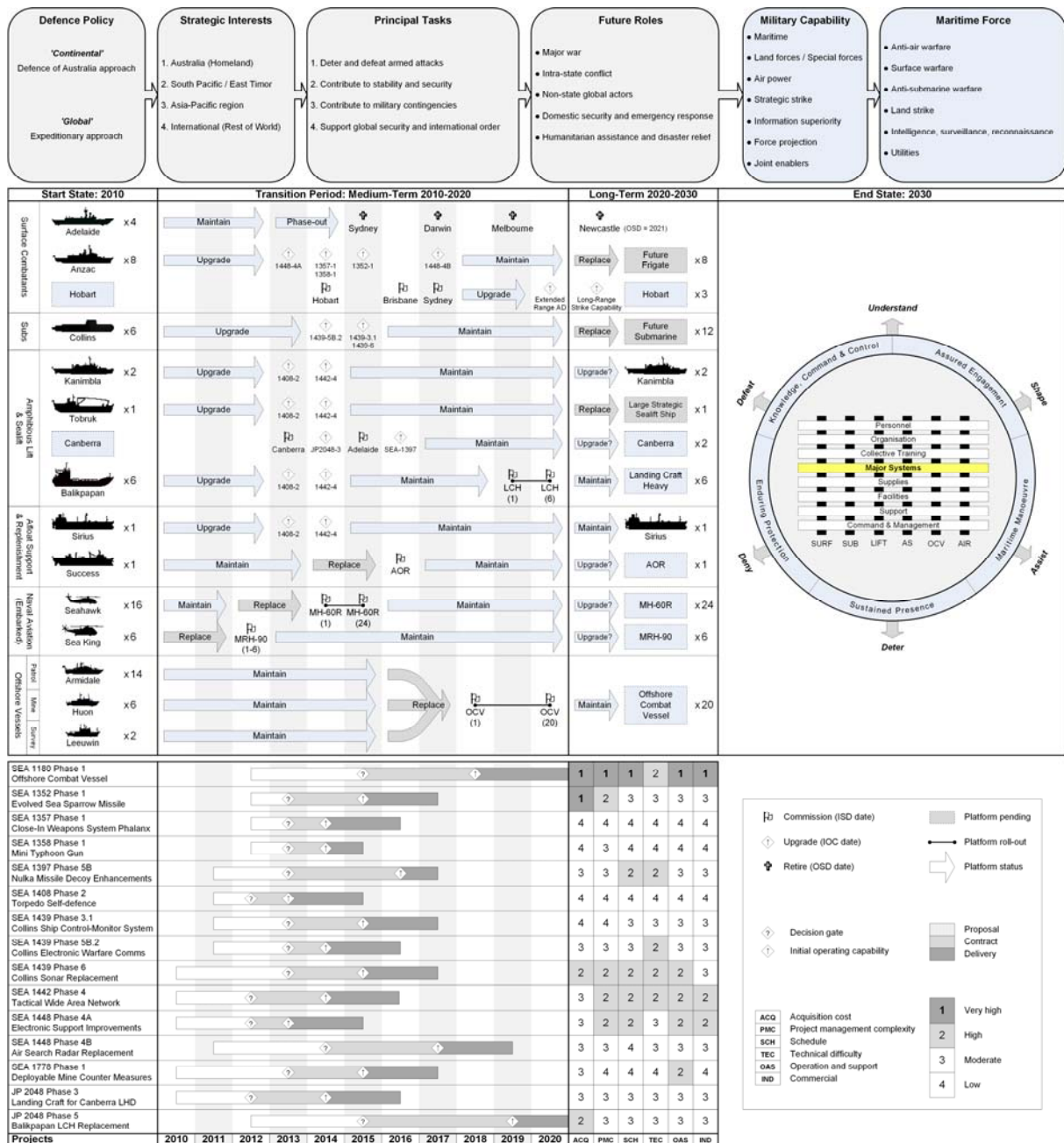


Fig. 2. The roadmap as artifact [41].

A. Structured Visual

A roadmap is a *structured visual*. Behind the presentational graphics and variety of visual forms, there is an underlying information architecture. This is a reflection of how an organization thinks about itself [10] and how its business is viewed physically and/or conceptually [12], [15]. When you look at an example, you are seeing a specific instance which has been configured for a particular task and customized for the given situation. Through an appropriate information architecture, a roadmap can be treated as a canvas that must be populated with content [12], [15], [42]. Crucially, the canvas is spatial and temporal in orientation. As a particular class of map, a roadmap has both spatial and temporal dimensions [22]. The manner in which the information is structured is key [23]. The term *structured* in the definition relates to the governing framework that allows for a generic structure to be applied across the temporal-spatial canvas (and made manifest through the

resulting architecture). Fig. 3 presents the governing framework. This version was produced by the authors and represents the most comprehensive and up-to-date depiction of the framework. Making the connection back to the discipline of cartography, “maps are rhetorically powerful graphic images that frame our understanding” [34]. To support and enable the functions of planning and alignment, a roadmap embodies a “dynamic systems framework” [10], [16]. The dynamic aspect relates to not only the unit of analysis under consideration (whether it be a technology, product, service, capability, etc.), but also encompasses the relevant internal business cycles (e.g. annual budgeting, quarterly planning, business development, etc.), as well as external factors (e.g. competitor activity, market conditions, demographic trends, etc.) [10], [43]. It is this dynamic framework that makes a roadmap distinctly unique [1], and why it is highly regarded as a practical, action-oriented tool [12], [15].

A roadmap is dynamic due to the inclusion of the time dimension [10]; and a measure of time should be explicitly shown [12], [15], [44]. Providing a sense of *when* is very important; yet, so few strategic management tools include time as a variable (for example, where is time in SWOT?). In the governing framework for a roadmap (Fig. 3), the framing of time is anchored by three fundamental questions: *Where do we want to go? Where are we now? How can we get there?* [10], [17]. These questions are the very essence of planning. “A plan is a conscious attempt, made in advance, to identify a desirable end, and to specify how this end is to be achieved” [45]. Further, Russell L. Ackoff, a pioneer in the field of operations research, systems thinking and management science [46], popularized the terms: ends planning and means planning [47], [48]. Translating these to the framework of a roadmap, *end* planning is *Where do we want to go?*, and *How can we get there?* is *means* planning [49]. The *Where are we now?* question acts to give a good compare-and-contrast, and it can (and should) be deployed as a diagnostic. For instance, one of the earliest case examples dates to the mid-1960s, where a position audit was a formalized activity in the strategic planning process of the International Minerals and Chemical Corporation, which was driven by the question of *Where do we stand?* in terms of resources, capabilities, etc. [50]. Correspondingly, they had the leading question of *What’s ahead?* in regards to competition, regulations, policies, incentives, etc. [50]. Such questions are time-oriented and, thus, can be positioned along the temporal dimension (see Fig. 3). The convention is to assign a measure of time (i.e. dates/periods/horizons) to the horizontal axis, moving from the current state into the future [12], [15]. As such, with movement across a roadmap, uncertainty grows – this may seem obvious (when stated), but it is often overlooked. The overall timeframe (i.e. length of the roadmap’s timeline) is context-dependent and, so, should be adapted to suit the particular situation [14]. It will depend on the rate of change to which the business/system is subjected, or industry clockspeed, and will also need to account for both the likely pace of technology advancements and structural change in the market [10], [31], [32]. The timeline can be segmented into a range of specific time frames. These, typically, will span the present, short-, medium- and long-terms, and end state vision [10]. The present, which covers the current position, can also include elements of the past, especially if it is deemed helpful to acknowledge or draw out the key events/decisions that led to the current situation [31], [32]. Where appropriate, path dependencies should be shown. Generally, the short-term is scaled to the *budget horizon* [31], [32]. The medium-term is where an organization has strategic options, and most likely the space to effect change. The long-term opens up to potential scenarios, and unconstrained possibilities. The final component of the timeline is then the end state vision, i.e. a clear, tangible and meaningful answer to the question of: *Where do we want to go?*

The terms *structured visual* in the roadmap definition were heavily influenced by the multilayered schematics published by Philips Electronics [4] and EIRMA [5]. These consisted

of a series of layers, or lanes, against a horizontal timeline. The Philips schematic mapped causal connections both within individual layers and across layers, so providing a means of showing potential interactions between markets, products and technologies [4]. With a comparable layout, the version published by EIRMA [5] had layers for external influences, deliverables (i.e. product/process characteristics and requirements), technologies, skills/science/know-how, and resources (e.g. intellectual, physical and financial assets). Building on the publications by Philips [4] and EIRMA [5], Phaal *et al.* [43] brought systems thinking to the multilayered structure by attributing the aspects of *know-why*, *know-what* and *know-how* to the layers and *know-when* to the horizontal time axis. With the questions of *Where do we want to go? Where are we now? How can we get there?* being positioned along the timeline, Phaal *et al.* [9] additionally articulated three questions for the spatial dimension, namely: *Why do we need to act? What should we do? How should we do it?* It is this set of core questions that provided the foundation for a generic framework (as illustrated in Fig. 3).

Going back to 1958, to the very first issue of the *Journal of the Academy of Management*, and to the paper entitled ‘*Management philosophy: The time dimensions of planning*’ [51], the concept of planning was broadly articulated as the “determination of *what* is to be done”. As part of that conceptual basis, the matter of *how*, *when* and *where* were included [51]. However, it was the work of Phaal *et al.* [12], [14], [15], [10], [17], [43], [52], [53] that coherently combined the various elements into a framework; elicited and expressed as a single structured visual arrangement of *why–what–how–when–who–where*. The central relationship in any roadmap is *know-what* against *know-when*. *Know-what* can be usefully thought of as *delivery* [52], [53]. Often, this directly corresponds to the development or evolution of products, service-based offerings, and other operations/expertise which result in revenue [10], [12], [15], [16]. Essentially, *know-what* relates to any tangible means that delivers benefits and, hence, generates value. *Know-how* is a collective label for resources, encompassing such elements as skills/competencies and physical/financial assets [12], [15], [52], [53]. Such resources need to be marshalled and managed as essential inputs for the development and deployment of the *know-what* delivery mechanisms [10], [16]. Technology could correspond to either *know-what* or *know-how* – it is dependent on the unit of analysis, i.e. technology would be *know-what* for a technology roadmap, but *know-how* in a product roadmap. *Know-why* relates to reasoning and rationale in regards to both internal and external trends, drivers and demands. Finally, *know-who* and *know-where* tend to be embedded in the content of the roadmap [10], [12], [15]. Phaal and Yoshida [54] later condensed the framework as a 3x3 grid according to the six questions of:

- *Why* do we need to act?
- *What* should we do?
- *How* can we achieve it?
- *When* do we need to respond?
- *Who* should be involved?
- *Where* should it happen?

There is an apparent simplicity to this approach. Although, the questions are not so simple to answer...

The structured *why–what–how–when–who–where* framework is akin to Rudyard Kipling’s “six honest serving-men” [55] from *The Elephant’s Child* (part of the *Just So Stories* collection):

*I keep six honest serving-men
(They taught me all I knew);
Their names are What and Why and When
And How and Where and Who.*

According to Colonel John Collins [56], U.S. Army and Director of Military Strategy Studies, strategists are either knowingly or unknowingly employing Kipling’s six honest serving men “in their quest to match meaningful *ends* with measured *means* while minimizing risks”. The Kipling Society have suggested that the source of inspiration was a 14th century epigram:

*If you wish to be wise I commend to you six servants,
Ask what, where, about what, why, how, when.*

Wilson’s *Arte of Rhetorique* from 1553 is another potential source, which gives:

*Who, what, and where, by what helpe, and by whose:
Why, how, and when, doe many things disclose.*

The roots of these framing questions have been traced back to ancient Rome, through Boethius, Augustine and Cicero. And, then back to the Greek rhetorician Hermagoras [57], who used the schema of *who, what, when, where, why, in what way, by what means*. However, further research has identified Aristotle (384–322 BC) as the ultimate source [58], with the questions of *who, what, by what means, for the sake of what (why), how, where, when* listed in Book 3 of his *Nicomachean Ethics*.

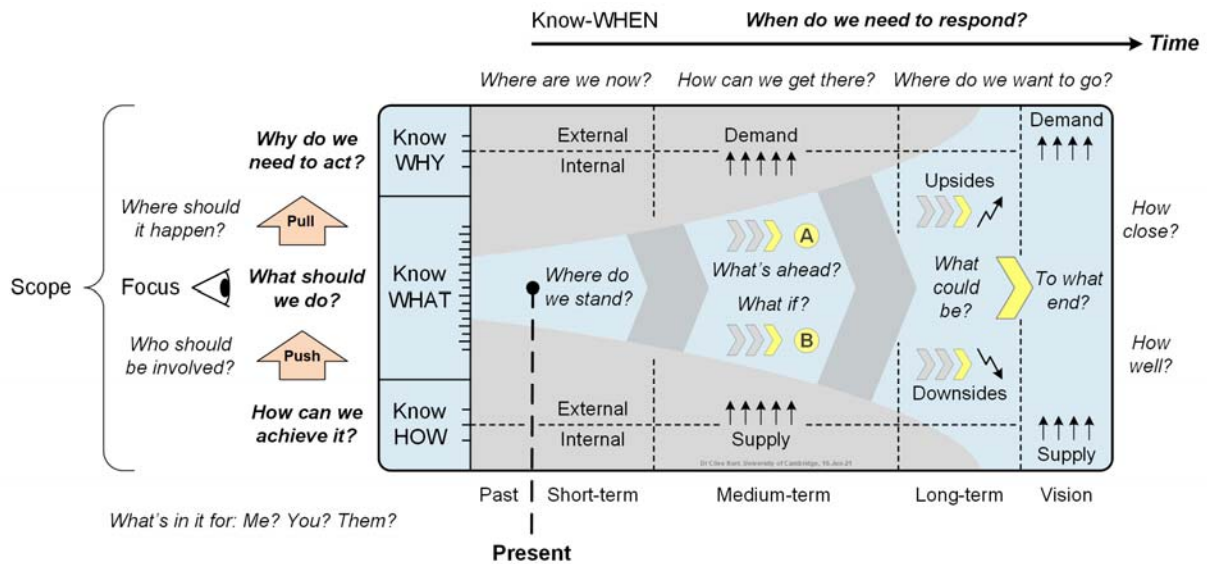


Fig. 3. Governing framework.

B. Structured Visual of Strategic Intent

Conceptualizing planning as the *practice of knowing* [59], *intent* is knowing *to what end*. So, *strategic intent* is “the vision or direction for the future” [60]. Therefore, a roadmap is a *structured visual of strategic intent*. In the management sphere, Hamel and Prahalad [61] gave currency to the terms ‘strategic intent’, conceived as ambitions that offer “the enticing spectacle of a new destination” [62]. Further, according to Hamel [62], strategic intent “is differentiated; it implies a competitively unique point of view about the future”. It is based on an understanding that competition for the future will be very different, i.e. *what could be* [63]. As such, it embraces competitive innovation (not competitive imitation) [63]. As stressed by Hamel and Prahalad [61], “while strategic intent is clear about *ends*, it is flexible as to *means*”.

The subject of *intent* has been extensively treated by the philosopher Michael E. Bratman, whose main research interests are the philosophy of action and practical rationality. His work gives a functionalist account of intention, in the context of plans and planning [64]. Intent is not merely some combination of desire and belief. In Bratman’s view, intentions are

commitments now to future action. As a fundamental building block of plans, they play a characteristic role in facilitating coordination and ongoing practical reasoning, bounded by limitations of information and resource constraints [64]. Coordination requires that we know what others intend, and so anticipates communication [65]. A roadmap is seen as “a means to communicate strategic intent and associated plans” [35]. As indicated by Phaal *et al.* [12], [15], strategic intentions are much more likely to be achieved if the various dimensions are laid out in the form of a structured roadmap. Bratman [64], [66] has asserted that plans must be *means–end* coherent. Further, Bratman [67] stated that to functionally support “organization and coordination of action” there needs to be a mechanism to “induce overlapping webs of cross-temporal connections and continuities”. Thus, a hierarchy of roadmaps is a practical and elegant solution, principally due to the design and deployment of the underpinning dynamic systems framework [10], [16], [31], [32].

C. Structured Visual Chronology of Strategic Intent

A *roadmap* is an attractive metaphor [1]. Although, admittedly, *road–map* can be rather awkward when the subject is aerospace or maritime-related. However, in general, it does helpfully signify its role in displaying a route or path from the current position to a future destination. The analogue to the route/pathway is a strategic narrative [35]. As a discrete artifact for the purposes of communication, a roadmap should be treated as a narrative graphic [37]. In addition to presenting the desired direction of travel, it must convey a sense of progress [35]. This story point of view is an expression of the logical connectivity between the *why–what–how–when–who–where* information. Each aspect, or layer, might represent a chapter or theme [31], [32]. These individual aspects must come together to result in an overall coherent composition. A narrative threads together the key informational elements, such as decision points, phase-gates, milestones, etc., to establish the main story arc (out into the future until the strategic intent can be realized). This can be conveniently reduced to, simply, a sequence of events [30]. Crucially, the narrative sequence must be made visible along the time dimension [35]. Thus, a roadmap is a *structured visual chronology of strategic intent*.

We decided to incorporate the term *chronology* into the definition, rather than *narrative* or *temporal narrative*. Temporal/time is already encapsulated in the term *structured*, i.e. a roadmap is a structured visual comprising a temporal-spatial canvas, and where a measure of time should be explicitly shown. A roadmap is indeed a narrative graphic; however the narrative aspect is often misinterpreted as being fixed/rigid, especially when a visual appears static. And, narrative is implied by the arrangement of events over time, i.e. a prospective chronology. In some fields, such as Organization Studies, a narrative is “a chronology of episodic linear events” [68]. More importantly, *chronology* allows for greater explanatory power as it embodies ordering of the narrative sequence together with the two further functions of orientation and options (see Fig. 4).

The major functional element to the term *chronology* deals directly with ordering. As stated by the sociologist Moore [69]: “if activities have no temporal order, they have no order at all”. According to Hegewisch [70], chronology has the practical purpose of furnishing a principle of order and promoting orderly arrangements. Chronology does have a connotation with history, but it is not solely for mapping the past. Chronology can equally be applied to “the divisions of the present or future, in which anything happens, or is going to happen” [70]. The strongest bond between historical chronology and a roadmap (as a chronology) is the use of a timeline. For centuries, the timeline representation has been deployed to depict a sequence of events [71]. In a roadmap, the time axis asserts forward movement into the future, through quantified chronological clock time, and based on a Newtonian conception of time. Time is “flowing like a line from past to present to future” [72]. It is objective, linear,

continuous, unitary and mechanical [72], [73], [74]. This allows for “clock time coordination” [75], which in turn involves synchronization [69]. And a roadmap is concerned with synchronization, rather than scheduling.

The next functional element of *chronology* relates to options. There is a tendency to believe that the depicted future pathway/route is going to occur as outlined. Perhaps, there is too much certainty inferred from the linear story being visually presented. Some stakeholders can become too wedded to their preferred way forward, so resulting in an unwillingness to alter course. A narrative can even be too convincing and persuasive – where the desired future is normalized to become the expected outcome. As highlighted by Beach [76], throughout organizations, “good narratives are believable narratives, even if they are flawed”. The future will not happen exactly the way it is laid out in a roadmap. Borrowing from the metaphor of a *road-map*, there may well be roadblocks and diversions, even some significant detours along the way. Thus, there is the *chronology* as a prospective sequence of events, and there is also the active component of *chronicling* an anticipatory future. Kappel [29] implied such a trait in roadmaps, i.e. articulating a course of action along with forecasts of likely happenings. There are options going forward. When attempting to deal with the time dimension across a sequence of events, there is a “genuine ontological difference” between future possibilities and present options [77], from conceivable to promising to within reach to attainable. A prospective chronology is more open to options thinking and alternatives. Building on this anticipatory perspective, the final functional element associated with *chronology* is orientation, in regard to the unfolding of time.

A roadmap depicts a flow from the present to the future. And, while there is a “picture of future happenings laid out before us”, the future has yet to take shape [78]. From a planning stance, “the present is not the passing moment but the slice of time required to create and install a plan” and “the relevant future begins when the plan is activated” [79]. And, so, the *chronograph* function comes to the fore. There is a flow to time, but it is not a steady flow [80]. The future comes at you; there is an unfolding of time. Whilst strategic planning is “dynamic by nature” [81], “the strategic essence of keeping the organization continuously relevant to the unfolding future time is unthinkingly ignored” [82]. A roadmap should be temporally orientated to change. When actually moving along through the timeline, it is important to critically review the roadmap against prevailing conditions, as the future comes rushing into the present. A roadmap will evolve as circumstances change [5]. There are options going forward, but those options have dynamism. Each window of opportunity is a moving window. Thus, timing matters. The ancient Greeks had two words for time: *chronos* and *kairos*. *Chronos* is quantitative clock time, whereas *kairos* is the particular qualitative opportune moment [74], [83], [84]. There is the *know-when* aspect as positioned against the roadmap’s time dimension, and as a lived experience of actively using a roadmap there is *knowing-when*, i.e. a sense that the time is right.

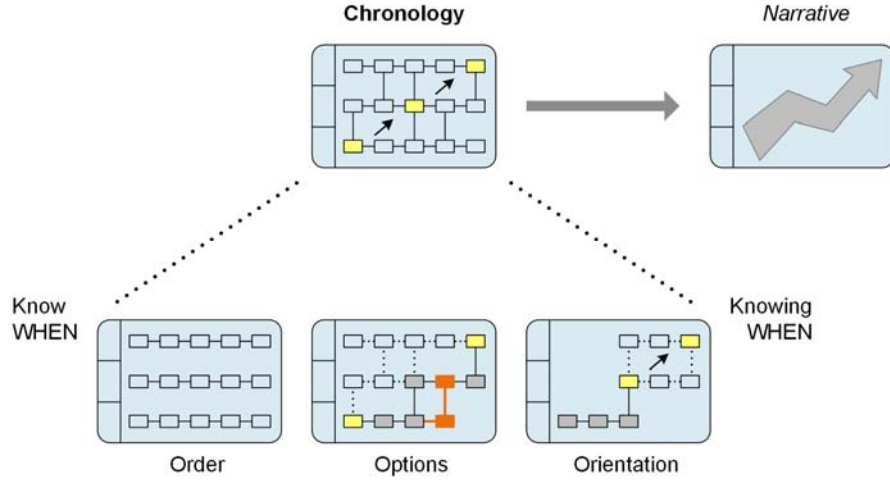


Fig. 4. Chronology as order, options, orientation.

IV. WHAT IS ROADMAPPING?

As can be seen from the explanation of a roadmap, the framework behind the structure is holistic and powerful. Roadmapping is a form of knowledge work that has a lot to offer in supporting the engagement and interaction between disciplines and communities [40]. In producing a definition, the challenge was to adequately reflect the essence of roadmapping, and capture its unique attributes, in contrast to other approaches and tools. In cartography, mapping is seen as a method of inquiry [34]. Further, Dodge *et al.* [34] points to the growing role of mapping “in the natural sciences, in disciplines such as astronomy and particle physics, and in the life sciences, as exemplified by the metaphorical and literal mapping of DNA by the Human Genome Project”. Correspondingly, in ‘*Making plans: Representation and intention*’, published in the *Planning Theory* journal, Hoch [65] states that planning combines “instrumental inquiry with deliberation”. In regard to the method of inquiry, roadmapping provides a general-purpose “*strategic lens*” [31], [32]. The act of mapping, to address problems and opportunities, clearly positions roadmapping as principally being a means of deploying the generic governing framework. Thus, we propose the following definition:

Roadmapping is the application of a temporal-spatial structured strategic lens.

This definition better reflects the reasoning behind the adoption of the method by organizations. It also avoids any limitations from the simplistic, and recursive, definition of roadmapping as the process of producing roadmaps. Roadmapping will often but not always lead to the production of a roadmap. The greatest value is in proactively applying the framework as a strategic lens.

V. DISCUSSION

The first term in the definition of a roadmap is *structured*. In Peter Drucker’s *Theory of the Business*, “the central challenge facing management” is “what to do” [85]. There are the classic questions of: What business are we in? What should our business be? What does the customer buy? What does the customer value? [86], [87]. However, Davoudi [59] highlights the “monopolizing tendencies” of the *know-what* aspect. A roadmap should have an appropriate blend of *why-what-how-when-who-where*. A solely *what* arrangement along a timeline, which is quite typical in software-based product roadmaps promoting the future roll-

out of features (i.e. product release schedules), is a relatively weak structural expression. Dobrucká [88] acknowledges that there is often the shortcoming or lack of making direct connections between *what* and *how* in practice. Further, NASA states that “we habitually confuse *what* with *how*” [89]. For example, Phaal and Muller [31], [32] stressed the need for a “separation of product from technology thinking”, as technology issues can “contaminate the product layer, limiting options by creating an assumption that a particular technology is the only solution”. In a roadmap, the *know-why* aspect is an important facet of the story [6], especially for Senior Management, as it attributes motive and reasoning [88]. It is even recommended that the framework is a “good test” of how mature and well articulated existing strategies might be, when placed within the structure of a roadmap [10], emphasizing the diagnostic function of roadmapping.

There are some elements that can be added to the governing framework. These are orientated to performance and review, once a roadmap is live and been lived for a period. The *know-how* aspect or *how* question, should be followed by: *how well?* [90]. The 4Ds framework from Holland and Lam [91] provides an additional component. Their framework consists of:

- Determining where we are.
- Defining where we want to be.
- Designing how we get there.
- Deciding whether we have got there.

The final D of these 4Ds provides a useful evaluative function that closes the loop; where the promises of delivery, realization of strategic intent, and quality of the implementations can be examined and lessons learned.

In regards to being *visual*, a roadmap does require thoughtful application of graphic design principles and good execution of its presentation [35]. It must be remembered that a roadmap is a critical artifact for onward communication within an organization and across various stakeholders. Yet, examples in the public domain are generally poor. Common problems include information overload, off-putting color schemes and distracting visual clutter [35]. The degree to which a roadmap is deemed aesthetically pleasing does have a significant bearing on the viewer’s perception [37]. However, “it is not about impressing an audience with a beautiful visualization, but rather informing them of the key information through facilitating their comprehension of the content and its context through the explanatory power of visual communication” [92]. The challenge is to convey a relatively large/complex amount of data in an intuitive format [92], whilst ensuring relevance for the intended audience [35], [92].

With respect to *chronology*, “many narratives involving timelines follow the linear chronological progression of time” [93]. Even though the medium is static, the narrative portrayal doesn’t have to appear visually frozen. A sense of dynamic change can be expressed. A practical way to impart a progressive story arc is to, simply, use a series of “stepping stones that lead from the current situation to the desired future state” [31], [32]. A leading diagonal representation that spans the roadmap canvas is a very prominent format. But, there is a danger of such forward progress being taken for granted and inferred as being a prescriptive journey. Examples of corporate roadmaps are overwhelmingly convergent. The destination might be set, but there should be some flex or alternatives in the route planning. The future as viewed in the present, does signify there needs to be optionality given the uncertainties ahead. There may well be a preferred or best route, but that doesn’t prevent showing a Plan-B. Actually, outlining some options would give more confidence to the audience, and demonstrate the depth of thinking behind the roadmap. As previously stated, the central relationship in any roadmap is *know-what* against *know-when*. But alongside the *what*, let’s not forget the wonderfully powerful question of: *what if?*

Given that “the future unfolds in non-extrapolatory, discontinuous ways”, Das [82] has called for strategy-making and management tools to be “future-salient”. The use of the term *chronology* includes the functional element of being temporally orientated. Against the timeline defined by clock time, there also needs to be an active awareness of when actually might be the right/opportune moment to act, respond or, perhaps, hold a wait-and-see stance. In the seminal book by Elliott Jaques entitled ‘*The Form of Time*’, a dual formulation of time was put forward which consisted of *chronos plus kairos* angled relative to each other [84]. Applying this to a roadmap, *chronos* would be the horizontal axis displaying clock time for the overarching strategic sequence, with the leading diagonal of *kairos* cutting across to take slices in time for both spotting and testing next steps. Managers can use *chronos* to regulate the deployment of resources and for the building of organizational capabilities [94]; whilst using *kairos* for keeping pace with events, exploring alternative paths, bringing attention to timely options, and dealing with the unexpected.

The final two terms in the roadmap definition are *strategic intent*. Knowing where you are going is essential. Hamel [62] emphasized that “strategic intent is as much about the creation of meaning as it is about the establishment of direction”. That end state, or vision, can be difficult to express in a tangible and meaningful manner. For some organizations, it is relatively easy, e.g. NASA merely has to show an image of the Moon or Mars and the destination is immediately relatable (and even compelling). But for most organizations, it can be a challenge to come up with a tangible and meaningful articulation. That said, an actual challenge could be used. For instance, when NASA were considering which technologies would be appropriate/available for future flight experiments and payloads, their roadmaps had the strategic intent of reaching a 1000-fold mission capability increase and a 10:1 lifecycle cost reduction [95]. Another approach would be to provide a ‘beacon’ to head towards [31], [32], [96]. This is a forward-looking perspective “specific enough to set direction, but not limit/constrain thinking to the current way of operating [96]. Organizations need to move beyond incremental thinking, and ask: *What could be?* [63]. As part of developing and communicating the story of the strategy, there will be lurking the question of: *What is in it for me/you/them?* [97]. The strategic intent needs to be seen as “inherently worthwhile” [62].

VI. SUMMARY

“Man does not possess a time-spanner to give a sense of the future” – that remark appeared in a PhD thesis, from 1969, entitled ‘*A systematic approach to corporate planning*’ [50]. Of the management tools that have been developed and deployed over the past 50 years, roadmapping/roadmaps comes the closest to claiming the mantle of *time-spanner*. But, somewhat embarrassingly, there has been a conspicuous lack of any rigorous definitions to what actually constitutes a roadmap and roadmapping. As artifacts for the purposes of communication, roadmaps embody future plans and pathways that are means-end coherent with causal connections across both the spatial and temporal dimensions. Thus, we have now defined a roadmap as *a structured visual chronology of strategic intent*. In regards to roadmapping, it is often perceived and treated as the process of creating/developing a roadmap. When done well, it can lead to the production of a solid and sound roadmap. But there is more functional utility and benefits to be gleaned from the act of roadmapping. There are companies who are not limiting themselves to only producing roadmaps. For instance, they’re using roadmapping at the corporate-level as a platform for management toolkits, as a catalyst for business development and organizational change, and as a routine means for addressing corporate challenges and exploring new opportunities. Thus, roadmapping has been defined as *the application of a temporal-spatial structured strategic lens*. This definition embodies the nature of the underpinning governing framework. By understanding the general

and holistic structure and concepts of roadmapping, we can help bridge the apparent schism between the academic/theoretical issues and real-world practice.

REFERENCES

- [1] Kerr, C. and Phaal, R. (2020) 'Technology roadmapping: Industrial roots, forgotten history and unknown origins', *Technological Forecasting and Social Change*, 155, 119967 (16pp).
- [2] Willyard, C.H. and McClees, C.W. (1987) 'Motorola's technology roadmap process', *Research Management*, 30(5), pp. 13–19.
- [3] Barker, D. and Smith, D.J.H. (1995) 'Technology foresight using roadmaps', *Long Range Planning*, 28(2), pp. 21–28.
- [4] Groenveld, P. (1997) 'Roadmapping integrates business and technology', *Research-Technology Management*, 40(5), pp. 48–55.
- [5] EIRMA – European Industrial Research Management Association (1997) *Technology roadmapping: Delivering business vision*. Working Group #52, EIRMA, Paris, France.
- [6] Albright, R.E. and Kappel, T.A. (2003) 'Roadmapping in the corporation', *Research-Technology Management*, 46(2), pp. 31–40.
- [7] Semiconductor Industry Association (1993) *Semiconductor technology workshop conclusions*. SIA, San Jose, CA, United States of America..
- [8] Semiconductor Industry Association (1993) *Semiconductor technology workshop working group reports*. SIA, San Jose, CA, United States of America..
- [9] Phaal, R., Farrukh, C. and Probert, D. (2010) *Roadmapping for strategy and innovation: Aligning technology and markets in a dynamic world*. Cambridge: Institute for Manufacturing, University of Cambridge.
- [10] Phaal, R., Farrukh, C.J.P. and Probert, D.R. (2005) 'Developing a technology roadmapping system', *Portland International Conference on Management of Engineering and Technology (PICMET)*, Portland, OR, United States of America, 31 July – 4 August. doi: 10.1109/PICMET.2005.1509680.
- [11] Groenveld, P. (2007) 'Roadmapping integrates business and technology', *Research-Technology Management*, 50(6), pp. 49–58.
- [12] Phaal, R., Farrukh, C.J.P., Mills, J.F. and Probert, D.R. (2003) 'Customizing the technology roadmapping approach', *Portland International Conference on Management of Engineering and Technology (PICMET)*, Portland, OR, United States of America, 20–24 July. doi: 10.1109/PICMET.2003.1222814.
- [13] Massie, J.L. (1958) 'Criteria for evaluating proposed frameworks of a general theory of management', *Journal of the Academy of Management*, 1(2), pp. 58–61.
- [14] Phaal, R., Farrukh, C.J.P. and Probert, D.R. (2004) 'Technology roadmapping: A planning framework for evolution and revolution', *Technological Forecasting and Social Change*, 71(1-2), pp. 5–26.
- [15] Phaal, R., Farrukh, C. and Probert, D. (2004) 'Customizing roadmapping', *Research-Technology Management*, 47(2), pp. 26–37.
- [16] Phaal, R., Farrukh, C. and Probert, D. (2006) 'Technology management tools: Generalization, integration and configuration', *International Journal of Innovation and Technology Management*, 3(3), pp. 312–339.
- [17] Phaal, R., Farrukh, C.J.P. and Probert D.R. (2007) 'Strategic roadmapping: A workshop approach for identifying and exploring strategic issues and opportunities', *Engineering Management Journal*, 19(1), pp. 3–12.

- [18] Kerr, C., Farrukh, C., Phaal, R. and Probert, D. (2013) 'Key principles for developing industrially relevant strategic technology management toolkits', *Technological Forecasting and Social Change*, 80(6), pp. 1050–1070.
- [19] Kerr, C. and Phaal, R. (2015) 'A scalable toolkit platform: Configurations for deployment in technology and innovation strategy workshops', *The R&D Management Conference*, Pisa, Italy, 23–26 June.
- [20] Kerr, C., Phaal, R. and Thams, K. (2017) 'Roadmapping as a platform for developing management toolkits: A collaborative design approach with the LEGO Group', *Portland International Conference on Management of Engineering and Technology (PICMET)*, Portland, OR, United States of America, 9–13 July. doi: 10.23919/PICMET.2017.8125436.
- [21] Lee, S. and Park, Y. (2005) 'Customization of technology roadmaps according to roadmapping purposes: Overall process and detailed modules', *Technology Forecasting and Social Change*, 72(5), pp. 567–583.
- [22] Kostoff, R.N. and Schaller, R.R. (2001) 'Science and technology roadmaps', *IEEE Transactions of Engineering Management*, 48(2), pp. 132–143.
- [23] Phaal, R. and Palmer, P.J. (2010) 'Technology management: Structuring the strategic dialogue', *Engineering Management Journal*, 22(1), pp. 64–74.
- [24] 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, United States of America.
- [25] Beeton, D.A., Phaal, R. and Probert, D.R. (2008) 'Exploratory roadmapping for foresight', *International Journal of Technology Intelligence and Planning*, 4(4), pp. 398–412.
- [26] Galvin, R. (1998) 'Science roadmaps', *Science*, 280(5365), p. 803. doi: 10.1126/science.280.5365.803a.
- [27] Kerr, C. and Phaal, R. (2019) 'Defining the scope of a roadmapping initiative: A checklist-based template for organizational stakeholders', *Portland International Conference on Management of Engineering and Technology (PICMET)*, Portland, OR, United States of America, 25–29 August. doi: 10.23919/PICMET.2019.8893851.
- [28] Kappel, T.A. (1998) *Technology roadmapping: An evaluation*. PhD thesis, Northwestern University, Evanston, IL, United States of America.
- [29] Kappel, T.A. (2001) 'Perspectives on roadmaps: How organizations talk about the future', *Journal of Product Innovation Management*, 18(1), pp. 39–50.
- [30] Phaal, R., Simonse, L. and den Ouden, E. (2008) 'Next generation roadmapping for innovation planning', *International Journal of Technology Intelligence and Planning*, 4(2), pp. 135–152.
- [31] Phaal, R. and Muller, G. (2007) 'Towards visual strategy: An architectural framework for roadmapping', *Portland International Conference on Management of Engineering and Technology (PICMET)*, Portland, OR, United States of America, 5–9 August. doi: 10.1109/PICMET.2007.4349483.
- [32] Phaal, R. and Muller, G. (2009) 'An architectural framework for roadmapping: Towards visual strategy', *Technological Forecasting and Social Change*, 76(1), pp. 39–49.
- [33] MacEachren, A.M. and Kraak, M.J. (1997) 'Exploratory cartographic visualization: Advancing the agenda', *Computers and Geosciences*, 23(4), pp. 335–343.
- [34] Dodge, M., Kitchin, R. and Perkins, C. (2011) 'Preface: Introducing the map reader', in Dodge, M., Kitchin, R. and Perkins, C. (eds.) *The map reader: Theories of mapping*

- practice and cartographic representation*. Chichester: John Wiley and Sons, pp. xix–xxiii.
- [35] Kerr, C. and Phaal, R. (2015) ‘Visualizing roadmaps: A design-driven approach’, *Research-Technology Management*, 58(4), pp. 45–54.
 - [36] Phaal, R., Farrukh, C.J.P. and Probert D.R. (2009) ‘Visualising strategy: A classification of graphical roadmap forms’, *International Journal of Technology Management*, 47(4), pp. 286–305.
 - [37] Kerr, C. and Phaal, R. (2017) ‘An exploration into the visual aspects of roadmaps: The views from a panel of experts’, *International Journal of Technology Intelligence and Planning*, 11(3), pp. 252–277.
 - [38] DeGregorio, G. (2000) ‘Technology management via a set of dynamically linked roadmaps’, *Proceedings of the IEEE Engineering Management Society Conference*, Albuquerque, NM, United States of America, 13–15 August. doi: 0.1109/EMS.2000.872498.
 - [39] Stedman, C. (1991) ‘DEC forms marketing umbrella unit’, *Electronic News*, 8 April, p. 11.
 - [40] Kerr, C., Phaal, R. and Probert, D. (2012) ‘Cogitate, articulate, communicate: The psychosocial reality of technology roadmapping and roadmaps’, *R&D Management*, 42(1), pp. 1–13.
 - [41] Kerr, C.I.V., Phaal, R. and Probert, D.R. (2014) ‘Depicting the future strategic plans of the Royal Australian Navy using a roadmapping framework as a visual composite canvas’, *Technology Analysis and Strategic Management*, 26(1), pp. 1–22.
 - [42] Kerr, C., Phaal, R. and Probert, D. (2012) ‘Depicting options and investment appraisal information in roadmaps’, *International Journal of Innovation and Technology Management*, 9(3), 1250022 (19pp).
 - [43] Phaal, R., Farrukh, C.J.P. and Probert D.R. (2000) ‘Fast-start technology roadmapping’, *9th International Conference on Management of Technology (IAMOT)*, Orlando, FL, United States of America, 21–25 February.
 - [44] Phaal, R., Farrukh, C.J.P. and Probert D.R. (2001) ‘Characterisation of technology roadmaps: Purpose and Format’, *Portland International Conference on Management of Engineering and Technology (PICMET)*, Portland, OR, United States of America, 29 July – 2 August. doi: 10.1109/PICMET.2001.952036.
 - [45] Murray, W. (1965) ‘Effective communication as a means of integrating an organization’, *Management International*, 5(2/3), pp. 185–200.
 - [46] Wikipedia (2021) *Russell L. Ackoff*. Available at: https://en.wikipedia.org/wiki/Russell_L._Ackoff (Accessed: 27 May 2021).
 - [47] Ackoff, R. (1970) ‘A concept of corporate planning’, *Long Range Planning*, 3(1), pp. 2–8.
 - [48] Ackoff, R.L. (1999) *Re-Creating the corporation: A design of organizations for the 21st century*. New York: Oxford University Press.
 - [49] Ma, T., Liu, S. and Nakamori, Y. (2006) ‘Roadmapping as a way of knowledge management for supporting scientific research in academia’, *Systems Research and Behavioral Science*, 23 (6), pp. 743–755.
 - [50] Johanson, R.C. (1969) *A systematic approach to corporate planning*. PhD thesis, North Texas State University, Denton, TX, United States of America.
 - [51] Dauten, P.M. (1958) ‘Management philosophy: The time dimensions of planning’, *Journal of the Academy of Management*, 1(1), pp. 23–33.

- [52] Phaal, R., Farrukh, C.J.P. and Probert D.R. (2001) *Technology management framework: Integrating management processes and tools*. STM Project Working Paper, Centre for Technology Management, Institute for Manufacturing, University of Cambridge, Cambridge, United Kingdom.
- [53] Phaal, R., Farrukh, C.J.P. and Probert, D.R. (2004) 'A framework for supporting the management of technological knowledge', *International Journal of Technology Management*, 27(1), pp. 1–15.
- [54] Phaal, R. and Yoshida, S. (2014) 'Architecting strategy: Visual form and function of roadmaps', *Portland International Conference on Management of Engineering and Technology (PICMET)*, Kanazawa, Japan, 27–31 July.
- [55] Kipling, R. (1902) *Just so stories*. London: Macmillan.
- [56] Collins, J.M. (2002) *Military strategy: Principles, practices and historical perspectives*. Washington, DC: Potomac Books.
- [57] Robertson, D.W. (1946) 'A note on the classical origin of circumstances in the medieval confessional', *Studies in Philology*, 43(1), pp. 6–14.
- [58] Sloan, M.C. (2010) 'Aristotle's Nicomachean Ethics as the original locus for the Septem Circumstantiae', *Classical Philology*, 105(3), pp. 236–251.
- [59] Davoudi, S. (2015) 'Planning as practice of knowing', *Planning Theory*, 14(3), pp. 316–331.
- [60] Long, R.L. (1993) 'Changing role of corporate planning', *Executive Excellence*, 10(6), p. 13.
- [61] Hamel, G. and Prahalad, C.K. (1989) 'Strategic intent', *Harvard Business Review*, 67(3), pp. 63–76.
- [62] Hamel, G. (1995) 'Attend to the 3Ds', *Executive Excellence*, 12(2), pp. 8–9.
- [63] Williamson, P.J. and Wilson, K. (2013) 'C.K. Prahalad', in Witzel, M. and Warner, M. (eds.) *The Oxford handbook of management theorists*. Oxford: Oxford University Press, pp. 546–567.
- [64] Bratman, M.E. (1987) *Intentions, plans and practical reason*. Cambridge, MA: Harvard University Press.
- [65] Hoch, C. (2007) 'Making plans: Representation and intention', *Planning Theory*, 6(1), pp. 16–35.
- [66] Bratman, M.E. (1981) 'Intention and means-end reasoning', *The Philosophical Review*, 90(2), pp. 252–265.
- [67] Bratman, M.E. (2007) *Structures of agency: Essays*. New York: Oxford University Press.
- [68] Cunliffe, A.L., Luhman, J.T. and Boje, D.M. (2004) 'Narrative temporality: Implications for organizational research', *Organization Studies*, 25(2), pp. 261–286.
- [69] Moore, W.E. (1963) *Man, time and society*. New York: John Wiley and Sons.
- [70] Hegewisch, D.H. (1837) *Introduction to historical chronology*. Translated by J. Marsh. Burlington: Chauncey Goodrich.
- [71] Rosenberg, D. and Grafton, A. (2010) *Cartographies of time: A history of the timeline*. New York: Princeton Architectural Press.
- [72] Slife, B.D. (1995) 'Newtonian time and psychological explanation', *Journal of Mind and Behavior*, 16(1), pp. 45–62.
- [73] Bluehorn, A.C. and Denhardt, R.B. (1988) 'Time and organizations', *Journal of Management*, 14(2), pp. 299–320.

- [74] Orlikowski, W.J. and Yates, J. (2002) 'It's about time: Temporal structuring in organizations', *Organization Science*, 13(6), pp. 684–700.
- [75] Wiebe, E. (2010) 'Temporal sensemaking: Managers use of time to frame organizational change', in Hernes, T. and Maitlis, S. (eds.) *Process, sensemaking and organizing*. Oxford: Oxford University Press, pp. 213–241.
- [76] Beach, L.R. (2018) 'Narrative thought and management', *Organizational Dynamics*, 47(2), pp. 63–69.
- [77] Brumbaugh, R.S. (1966) 'Applied metaphysics: Truth and passing time', *The Review of Metaphysics*, 19(4), pp. 647–666.
- [78] Rundle, B. (2009) *Time, space and metaphysics*. New York: Oxford University Press.
- [79] Alderson, W. (1959) 'Perspectives on the planning process', *Journal of the Academy of Management*, 2(3), pp. 181–196.
- [80] Koro-Ljungberg, M. and Hendricks, J. (2020) 'Narratives and nested-time', *Qualitative Inquiry*, 26(10), pp. 1196–1205.
- [81] Das, T.K. (1987) 'Strategic planning and individual temporal orientation', *Strategic Management Journal*, 8(2), pp. 203–209.
- [82] Das, T.K. (2019) 'Future orientation in strategy making', in Das, T.K. (ed.) *Time issues in strategy and organization*. Charlotte, NC: Information Age Publishing, pp. 1–25.
- [83] Andersen, T.J., Gatti, L. and Tompson, T. (2019) 'Time as context: Kairos and the spatio-temporal aspect of strategic leadership', in Das, T.K. (ed.) *Time issues in strategy and organization*. Charlotte, NC: Information Age Publishing, pp. 119–141.
- [84] Jaques, E. (1982) *The form of time*. London: Heinemann.
- [85] Drucker, P.F. (1994) 'The theory of the business', *Harvard Business Review*, 72(5), pp. 95–104.
- [86] Drucker, P.F. (1954) *The practice of management*. New York, Harper and Row.
- [87] Swaim, R.W. (2010) *The strategic Drucker: Growth strategies and marketing insights from the works of Peter Drucker*. Singapore: Jossey-Bass.
- [88] Dobrucká, L. (2016) 'Reframing planning theory in terms of five categories of questions', *Planning Theory*, 15(2), pp. 145–161.
- [89] McCarthy, J.F. (1980) *Matrix management for aerospace 2000*. Report: NASA-TM-81509, NASA, Lewis Research Center, Cleveland, OH, United States of America.
- [90] Burtonshaw-Gunn, S.A. (2008) *The essential management toolbox: Tools, models and notes for managers and consultants*. Chichester: John Wiley and Sons.
- [91] Holland, R. and Lam, B. (2014) *Managing strategic design*. London: Palgrave.
- [92] Kerr, C. and Ford, S. (2018) 'Fleet planning and technology upgrade projects: Supporting decision-making through visualisation', *International Journal of Project Organisation and Management*, 10(4), pp. 287–306.
- [93] Brehmer, M., Lee, B., Bach, B., Riche, N.H. and Munzner, T. (2017) 'Timelines revisited: A design space and considerations for expressive storytelling', *IEEE Transactions on Visualization and Computer Graphics*, 23(9), pp. 1251–1264.
- [94] Dougherty, D., Bertels, H., Chung, K., Dunne, D.D. and Kraemer, J. (2013) 'Whose time is it? Understanding clock-time pacing and event-time pacing in complex innovations', *Management and Organization Review*, 9(2), pp. 233–263.
- [95] National Aeronautics and Space Administration (1976) *Space electronics technology summary*. Report: NASA-TM-X-73044, NASA, Washington, DC, United States of America.

- [96] Kerr, C., Phaah, R. and Thams, K. (2019) 'Customising and deploying roadmapping in an organisational setting: The LEGO Group experience', *Journal of Engineering and Technology Management*, 52, pp. 48–60.
- [97] Jones, P. (2008) *Communicating strategy*. Aldershot: Gower Publishing.