Technology Roadmapping: linking technology resources to business objectives

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1. Introduction

Many managers are aware of the strategic importance of technology in delivering value and competitive advantage to their companies. These issues are becoming more critical as the cost, complexity and rate of technology change increase, and competition and sources of technology globalise. The management of technology for business benefit requires effective processes and systems to be put in place to ensure that the technological resources within the organisation are aligned with its needs, now and in the future.

Following on from a brief introduction to the topic of technology management, this paper focuses on 'technology roadmapping', an approach that is being increasingly applied within industry to support the development, communication and implementation of technology and business strategy. Roadmapping is a very flexible approach, and the various aims that it can support are reviewed, together with the different formats that roadmaps take. Also important is the process that is required to develop a good roadmap, and the paper describes a method for rapid initiation of roadmapping in the business strategy[1], together with some of the characteristics of good roadmaps and the systems needed for supporting their application.

1.1 Technology and the management of technology

There are many published definitions of 'technology' (for example, Floyd 1997, Whipp 1991, Steele 1989). Examination of these definitions highlights a number of factors that characterise technology, which can be considered as a specific type of knowledge (although this knowledge may be embodied within a physical artefact, such as a machine, component, system or product). The key characteristic of technology that distinguishes it from more general knowledge types is that it is *applied*, focusing on the 'know-*how*' of the organisation. While technology is usually associated with science and engineering ('hard' technology), the processes which enable its effective application are also important - for example new product development and innovation processes, together with organisational structures and supporting knowledge networks ('soft' aspects of technology).

[1] *This paper has been produced as part of a three-year applied research project, supported by the UK Engineering and Physical Sciences Research Council (EPSRC)*

Treating technology as a type of knowledge is helpful, as knowledge management concepts can be useful for more effectively managing technology (for example, Stata, 1989, Nonaka, 1991, Leonard-Barton, 1995). For instance, technological knowledge generally comprises both explicit and tacit knowledge. Explicit technological knowledge is that which has been articulated (for example in a report, procedure or user guide), together with the physical manifestations of technology (equipment). Tacit technological knowledge is that which cannot be easily articulated, and which relies on training and experience (such as welding or design skills).

Similarly to 'technology', there are many definitions of 'technology management' in the literature (for example, Roussel *et al.,* 1991, Gaynor, 1996). For the purposes of this paper the following definition is adopted, proposed by the European Institute of Technology Management (EITM)[2]:

"Technology management addresses the effective identification, selection, acquisition, development, exploitation and protection of technologies (product, process and infrastructural) needed to maintain a market position and business performance in accordance with the company's objectives".

This definition highlights two important technology management themes:

- Establishing and maintaining the linkages between technological resources and company objectives is of vital importance and represents a continuing challenge for many firms. This requires effective communication and knowledge management, supported by appropriate tools and processes. Of particular importance is the dialogue and understanding that needs to be established between the commercial and technological functions in the business.
- Effective technology management requires a number of management processes and the EITM definition includes the five processes proposed by Gregory (1995): identification, selection, acquisition, exploitation and protection of technology. These processes are not always very visible in firms, and are typically distributed within other business processes, such as strategy, innovation and operations.

Technology management addresses the processes needed to maintain a stream of products and services to the market. It deals with all aspects of integrating technological issues into business decision making, and is directly relevant to a number of business processes, including strategy development, innovation and new product development, and operations management. Healthy technology management requires establishing appropriate knowledge flows between commercial and technological perspectives in the firm, to achieve a balance between market 'pull' and technology 'push'. The nature of these knowledge flows depends on both the internal and external context, including factors such as business aims, market dynamics, organisational culture, etc. These concepts are illustrated in Fig. 1.

1.2 Technology roadmaps

Technology roadmapping represents a powerful technique for supporting technology management and planning in the firm. Roadmapping has been widely adopted in industry (Willyard and

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[2] EITM is a collaboration between a number of European universities: see http://www-mmd.eng.cam.ac.uk/ctm/eitm/index.html

McClees, 1987, Barker and Smith, 1995, Bray and Garcia, 1997, EIRMA, 1997, Groenveld , 1997, Strauss *et al.,* 1998). More recently roadmaps have been used to support national and sector 'foresight' initiatives: for example, the Semiconductor Industry Association (SIA) Technology roadmap[3] (Kostoff and Schaller, 2001) and Aluminum Industry Technology Roadmap[4].

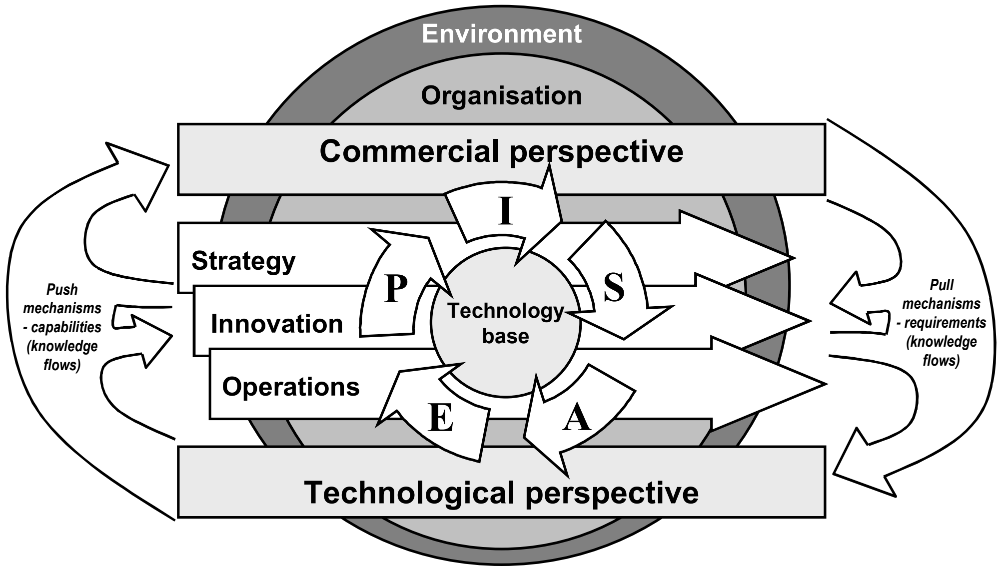


Fig. 1 - Technology management framework (Probert et al., 2000), showing technology management processes (identification, selection, acquisition, exploitation and protection), business processes (strategy, innovation and operations), highlighting the dialogue that is needed between the commercial and technological functions in the business to support effective technology management

Roadmaps can take various forms, but the most common approach is encapsulated in the generic form proposed by EIRMA (1997) - see Fig. 2. The generic roadmap is a time-based chart, comprising a number of layers that typically include both commercial and technological perspectives. The roadmap enables the evolution of markets, products and technologies to be explored, together with the linkages between the various perspectives.

A recent survey of 2,000 UK manufacturing firms (Phaal *et al.,* 2000) indicates that about 10% of companies (mostly large) have applied the technology roadmapping approach, with approximately 80% of those companies either using the technique more than once, or on an ongoing basis. However, application of the TRM approach presents considerable challenges to firms, as the roadmap itself, while fairly simple in structure and concept, represents the final distilled outputs from a strategy and planning process. Key challenges reported by survey respondents included keeping the roadmapping process 'alive' on an ongoing basis (50%), starting up the TRM process (30%), and developing a robust TRM process (20%) - see Fig. 3.

[3] *http://public.itrs.net/files/1999_SIA_Roadmap/Home.htm*
[4] *http://www.oit.doe.gov/aluminum/*

One of the reasons why companies struggle with the application of roadmapping is that there are many specific forms of roadmap, which often have to be tailored to the specific needs of the firm and its business context. In addition, there is little practical support available and companies typically re-invent the process, although there have been some efforts to share experience. For instance EIRMA (1997), Bray & Garcia (1997), Groenveld (1997) and Strauss *et al.,* (1998) summarise key technology roadmapping process steps. These authors indicate that the development of an effective roadmapping process within a business is reliant on significant vision and commitment for what is an iterative, and initially exploratory, process. However, these sources do not include detailed guidance on how to apply the approach.

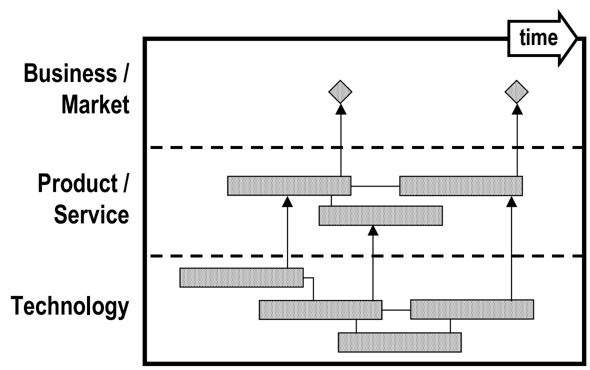


Fig. 2 - Schematic technology roadmap, showing how technology can be aligned to product and service developments, business strategy, and market opportunities.

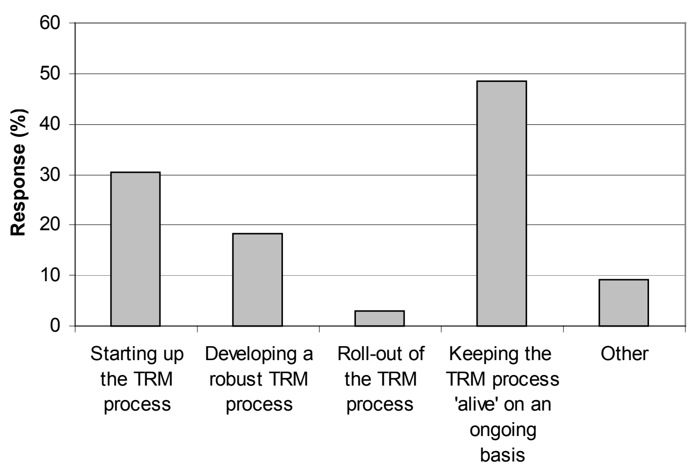


Fig. 3 - Key technology roadmapping challenges

Other factors that contribute to (and hinder) successful technology roadmapping are shown in Fig. 4, based on results from the survey described above. Factors that are particularly important for successful roadmapping (greater than 50% response) include a clearly articulated business need, the desire to develop effective business processes, having the right people involved and commitment from senior management. Factors that particularly hinder successful roadmapping include initiative overload, distraction from short-term tasks and required data, information and knowledge not being available.

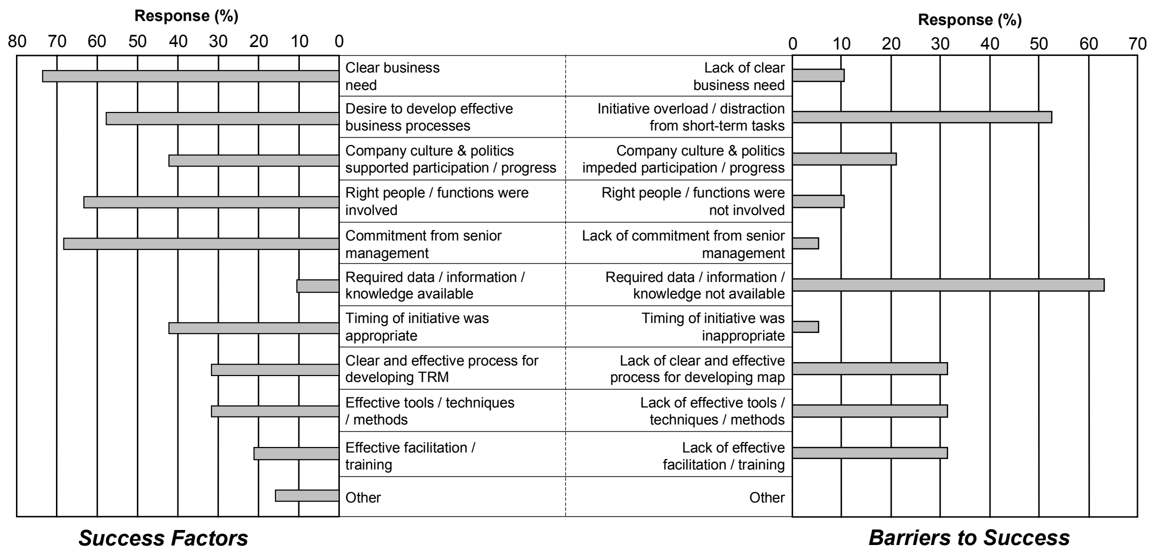


Fig. 4 - Roadmapping success factors and barriers to success

This paper presents an overview of the technology roadmapping technique, including the range of aims that the approach can support, and the various formats that roadmaps take. A process for the rapid initiation of roadmapping in the firm is presented (T-Plan), together with the general requirements for supporting the process in the firm.

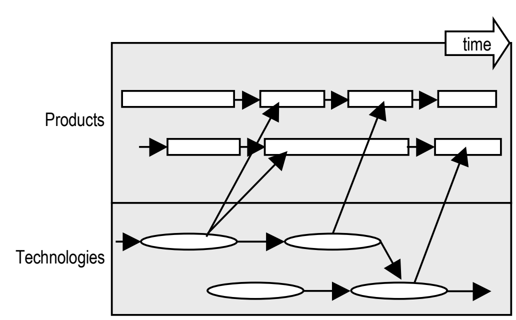
2. *Technology roadmapping – purpose*

The technology roadmapping approach is very flexible, and the terms 'product' or 'business' roadmapping may be more appropriate for many of its potential uses. Examination of a set of approximately 40 roadmaps has revealed a range of different aims, clustered into the following eight broad areas, based on observed structure and content (Phaal *et al.,* 2001a); see Fig. 5:

1. *Product planning*

Description: This is by far the most common type of technology roadmap, relating to the insertion of technology into manufactured products, often including more than one generation of product.

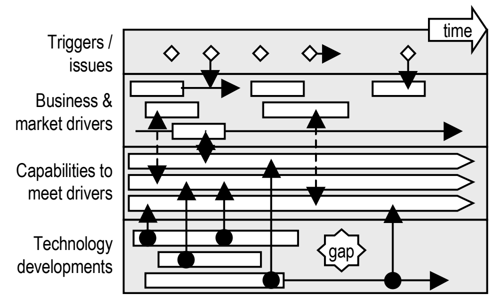
Example: A Philips roadmap, where the approach has been widely adopted (Groenveld, 1997). The example shows how roadmaps are used to link planned technology and product developments.



2. *Service / capability planning*

Description: Similar to Type 1 (product planning), but more suited to service-based enterprises, focusing on how technology supports organisational capabilities.

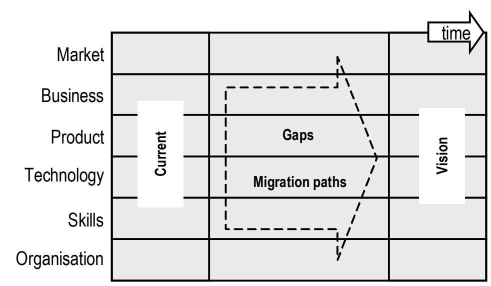
Example: A Post Office roadmap / T-Plan[5] application (Brown, 2001), used to investigate the impact of technology developments on the business. This roadmap focuses on organisational capabilities as the bridge between technology and the business, rather than products.



3. *Strategic planning*

Description: Includes a strategic dimension, in terms of supporting the evaluation of different opportunities or threats, typically at the business level.

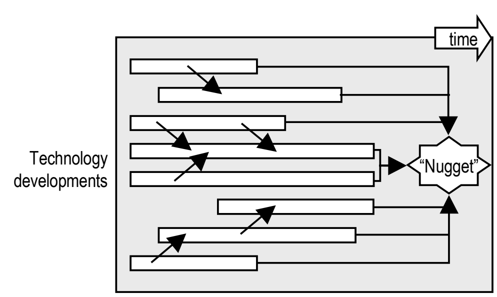
Example: A roadmap format developed using T-Plan to support strategic business planning. The roadmap focuses on the development of a vision of the future business, in terms of markets, business, products, technologies, skills, culture, etc. Gaps are identified, by comparing the future vision with the current position, and strategic options explored to bridge the gaps.



4. *Long-range planning*

Description: Extends the planning time horizon, and is often performed at the sector or national level ('foresight').

Example: A roadmap developed within the US Integrated Manufacturing Technology Roadmapping (IMTR) Initiative[6] (one of a series). This example focuses on information systems, showing how technology developments are likely to converge towards the 'information driven seamless enterprise' (a 'nugget').

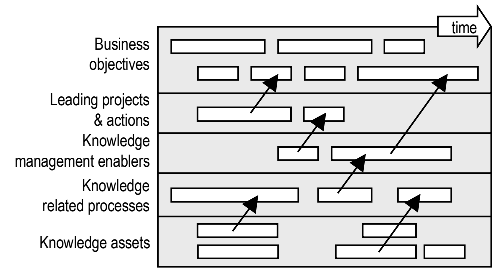


[5] *Several of the example roadmaps have been developed during applications of the T-Plan 'fast-start' roadmapping process*
[6] *IMTR (1999), Integrated manufacturing technology roadmapping (IMTR) project - information systems for the manufacturing enterprise, http://imti21.org/*

5. *Knowledge asset planning*

Description: Aligning knowledge assets and knowledge management initiatives with business objectives.

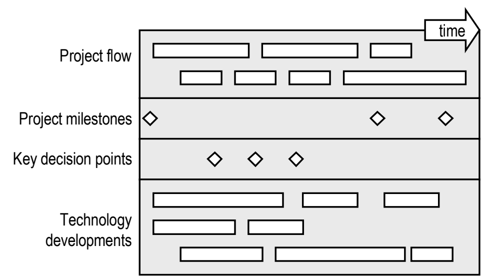
Example: This form of roadmap has been developed by the Artificial Intelligence Applications Unit at the University of Edinburgh (Macintosh *et al.,* 1998), enabling organisations to visualise their critical knowledge assets, and the linkages to the skills, technologies and competences required to meet future market demands.



6. *Programme planning*

Description: Implementation of strategy, and more directly relates to project planning (for example, R&D programmes).

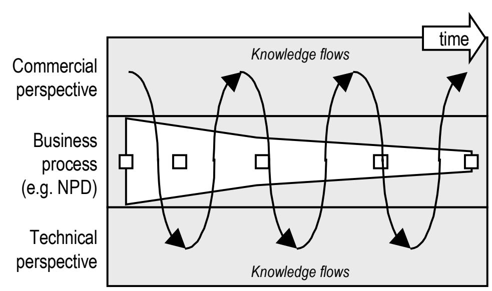
Example: A NASA roadmap (one of many) for the Origins programme[7], used to explore how the universe and life within it has developed. This particular roadmap focuses on the management of the development programme for the Next Generation Space Telescope (NGST), showing the relationships between technology development and programme phases and milestones.



7. *Process planning*

Description: Supports the management of knowledge, focusing on a particular process area (for example, new product development).

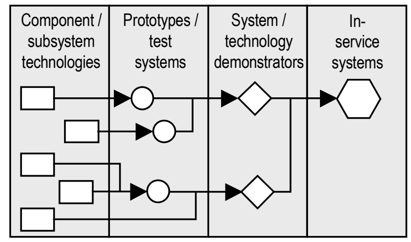
Example: A type of technology roadmap, developed using T-Plan to support product planning, focusing on the knowledge flows that are needed to facilitate effective new product development and introduction, incorporating both technical and commercial perspectives.



[7] *NASA (1997), Origins technology roadmap, http://origins.jpl.nasa.gov/library/techroadmap/roadmapidx.html*

8. Integration planning

Description: Integration and/or evolution of technology, in terms of how different technologies combine within products and systems, or to form new technologies (often without showing the time dimension explicitly).



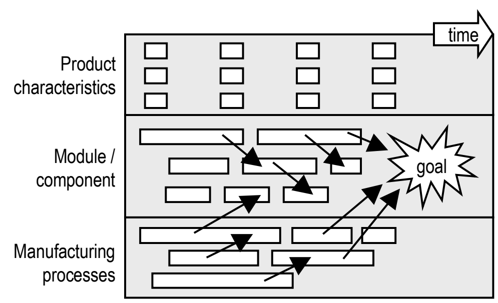
Example: A NASA roadmap[7] (Origins programme - see #6), relating to the management of the development programme for the NGST, focusing on 'technology flow', showing how technology feeds into test and demonstration systems, to support scientific missions.

3. *Technology roadmapping – format*

Another factor that contributes to the variety of roadmaps that have been observed is the graphic format that has been selected for communicating the roadmap, with the following eight graphic types identified, based on observed structure (Phaal *et al.,* 2001a):

a) Multiple layers

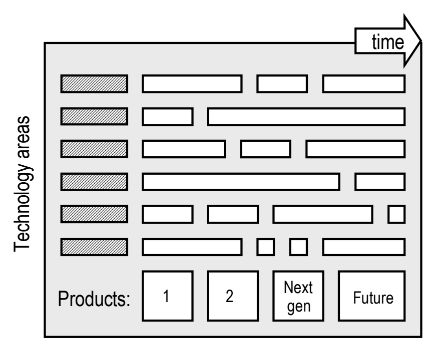
Description: The most common format of technology roadmap comprises a number of layers, such as technology, product and market. The roadmap allows the evolution within each layer to be explored, together with the inter-layer dependencies, facilitating the integration of technology into products, services and business systems.



Example: A Philips roadmap (Groenveld, 1997), showing how product and process technologies integrate to support the development of functionality in future products.

b) Bars

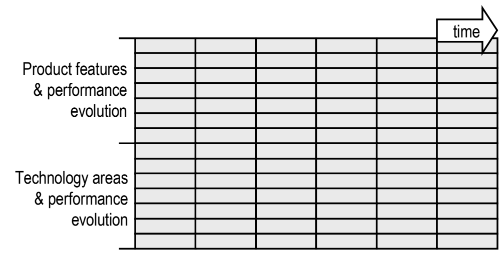
Description: Many roadmaps are expressed in the form of a set of 'bars', for each layer or sub-layer. This has the advantage of simplifying and unifying the required outputs, which facilitates communication, integration of roadmaps, and the development of software to support roadmapping.



Example: The 'classic' Motorola roadmap (Willyard and McClees, 1987), showing the evolution of car radio product features and technologies. Motorola has subsequently developed roadmapping to new levels, with roadmaps now forming part of corporate knowledge and business management systems, supported by software and integrated decision support systems (Bergelt, 2000).

c) *Tables*

Description: In some cases, entire roadmaps, or layers within the roadmap, are expressed as tables (i.e. time vs. performance). This type of approach is particularly suited to situations where performance can be readily quantified, or if activities are clustered in specific time periods.

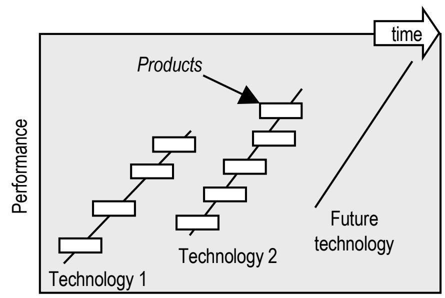


Example: A tabulated roadmap (EIRMA, 1997), including both product and technology performance dimensions.

d) *Graphs*

Description: Where product or technology performance can be quantified, a roadmap can be expressed as a simple graph or plot - typically one for each sub-layer. This type of graph is sometimes called an 'experience curve', and is closely related to technology 'S-curves'.

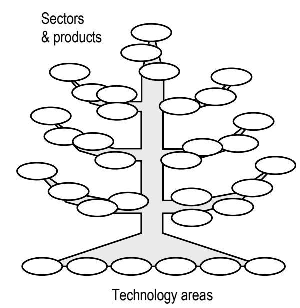
Example: A roadmap showing how a set products and technologies co-evolve (EIRMA, 1997).



e) *Pictorial representations*

Description: Some roadmaps use more creative pictorial representations to communicate technology integration and plans. Sometimes metaphors are used to support the objective (e.g. a 'tree').

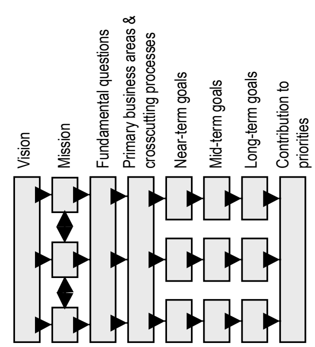
Example: A Sharp roadmap[8], relating to the development of products and product families, based on a set of liquid crystal display technologies.



f) *Flow charts*

Description: A particular type of pictorial representation is the flow chart, which is typically used to relate objectives, actions and outcomes.

Example: A NASA roadmap[9], showing how the organisation's vision can be related to its mission, fundamental scientific questions, primary business areas, near-, mid- and long-term goals, and contribution to US national priorities.



[8] *ITRI (1995), Electronic Manufacturing and Packaging in Japan, JTEC Panel Report, http://itri.loyola.edu/ep/*
[9] *NASA (1998), Technology plan - roadmap, http://technologyplan.nasa.gov/*

g) Single layer

Description: This form is a subset of type 'a', focusing on a single layer of the multiple layer roadmap. While less complex, the disadvantage of this type is that the linkages between the layers are not generally shown.

Example: The Motorola roadmap (Willyard and McClees, 1987), type 'b' above, is an example of a single layer roadmap, focusing on the technological evolution associated with a product and it's features.

h) Text

Description: Some roadmaps are entirely or mostly text-based, describing the same issues that are included in more conventional graphical roadmaps (which often have text-based reports associated with them).

Example: The Agfa 'white papers' support understanding of the technological and market trends that will influence the sector[10].

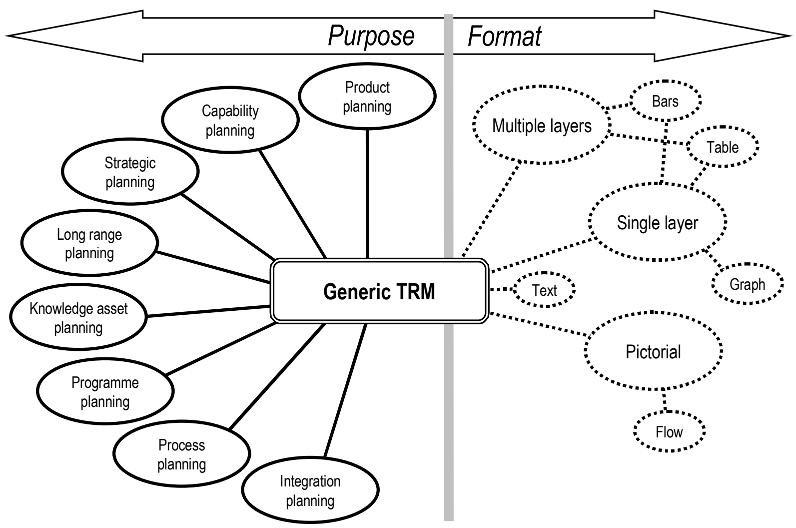


Fig. 5 - Characterisation of roadmaps: purpose and format

The range of roadmap types observed may be partially attributed to a lack of clear and accepted standards or protocols for their construction. However, it is considered that this also reflects the need to adapt the approach to suit the situation, in terms of business purpose, existing sources of information, available resources and desired use (the message being communicated). Roadmaps do not always fit neatly within the categories identified above and can contain elements of more than one type, in terms of both purpose and format, resulting in hybrid forms.

[10] *Agfa white papers (1999), http://www.agfa1to1.com/whitepapers.html*

4. *Technology roadmapping - process*

The T-Plan 'fast-start' approach has been developed as part of a three-year applied research programme, where more than 20 roadmaps were developed in collaboration with a variety of company types in several industry sectors (see Table 1). A management guide has been written to support the application of the T-Plan approach (Phaal *et al.,* 2001b), which aims to:

1. Support the start-up of company-specific TRM processes.
2. Establish key linkages between technology resources and business drivers.
3. Identify important gaps in market, product and technology intelligence.
4. Develop a 'first-cut' technology roadmap.
5. Support technology strategy and planning initiatives in the firm.
6. Support communication between technical and commercial functions.

The T-Plan process that has been developed to support the rapid initiation of roadmapping in the business comprises two main parts:

i. Standard approach, for supporting product planning (Phaal *et al.,* 2000).

ii. Customised approach, which includes guidance on the broader application of the method.

Table 1 - Applications of T-Plan fast-start TRM process

#	Company ID	Case type	Product / sector	Business aims	TRM type - purpose*	TRM type - format*
1	A	Exploratory	Industrial coding systems	Product planning for inkjet printing	1	a
2	A	Development	Industrial coding systems	Product planning for laser printing	1	a
3	B	Exploratory, development & test (10 applications)	Postal services	Integration of technology and research into business	2, 3, 4, 6, 8	a
4	C	Development	Security / access systems	Product family planning	1	a
5	D	Test (2 applications)	Software (labelling)	Exploration of product opportunity	1	a
6	E	Test & development	Surface coatings	New product development plan	1, 7	a
7	F	Test & development	Power transmission & distribution	Exploration of business opportunity for new technology	1, 3	a
8	G	Test & development (2 applications)	Railway infrastructure	Capital investment and technology insertion planning	3, 8	a
9	H	Test & development	Automotive sub-systems	Reliability services planning	2	a
10	I	Test & development (2 applications)	Medical packaging	Exploration of new business model	3	a
11	J	Test	Building controls	Exploration of new business model	3	a

* See Sections 2 and 3

4.1 Standard process (product planning)

The standard T-Plan process comprises four facilitated workshops – the first three focusing on the three key layers of the roadmap (market / business, product / service, and technology), with the final workshop bringing the layers together on a time-basis to construct the chart – see Fig. 6.

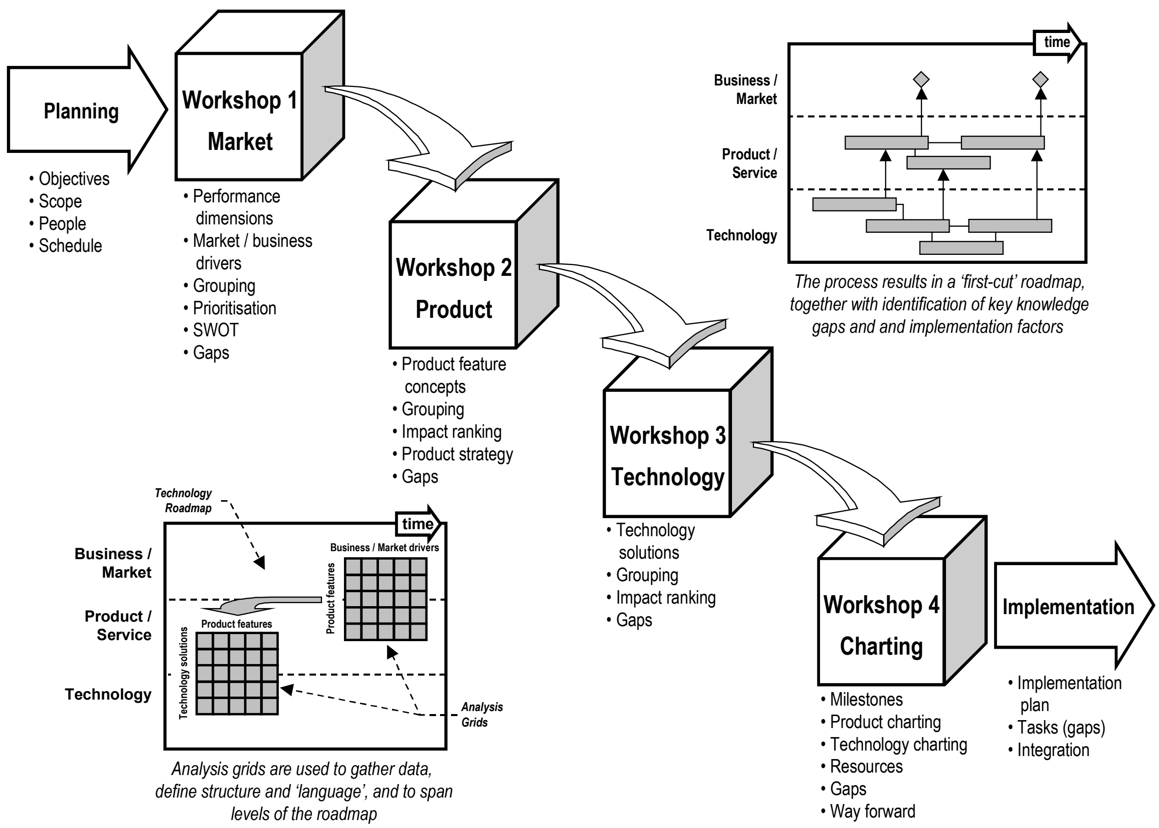


Fig. 6 - T-Plan: standard process steps, showing linked analysis grids

Also important are the parallel management activities, including planning and facilitation of workshops, process co-ordination, and follow-up actions. Simple linked analysis grids are used to identify and assess the relationships between the various layers and sub-layers in the roadmap.

4.2 Customising the process

As noted above, roadmapping can support a range of different business aims, including product planning, exploration of new opportunities, resource allocation and management and improved business strategy and planning. In addition, each organisation is different in terms of its particular business context, organisational culture, business processes, available resources, technology types, etc. For these reasons, if the full benefits of roadmapping are to be gained, then it should be expected that the approach will need to be customised to suit the particular application.

The multi-layer roadmap is the most common form, and the most flexible in application (see Sections 2 and 3), including the following dimensions:

- *Time:* this dimension can be adapted to suit the particular situation, in terms of time horizon (typically short in sectors such as e-commerce and software, and much longer for aerospace and railway infrastructure); scale (a logarithmic scale is typically used, with more space allocated to the short- vs. long-term); intervals (a continuous time scale can be used, or intervals such as six month, annual, or short-, medium- and long-term). Space on the roadmap can also be allocated for 'vision' and very long-range considerations, together with the current situation, with respect to competition or to define the gap between the current position and the 'vision'.
- *Layers:* the vertical axis of the roadmap is critical, as this needs to be designed to fit the particular organisation and problem being addressed. Often a considerable part of the initial roadmapping effort will be directed at defining the layers and sub-layers that will form the roadmap. The overall roadmap will typically follow the structure implied in Fig. 7, where the top layer relates to the organisational 'purpose' that is driving the roadmap ('know-why'). The bottom layer relates to the 'resources' (particularly technological knowledge) that will be deployed to address the demand from the top layers of the roadmap. The middle layer of the roadmap is crucial, providing a 'bridging' or 'delivery' mechanism between the purpose and resources ('know-what'). Frequently the middle layer focuses on product development, as this is the route through which technology is deployed to meet market and customer needs. However, for other applications services, capabilities, systems, risk or opportunities may be more appropriate for the middle layer, to understand how technology can be delivered to provide benefits to the organisation and its stakeholders.

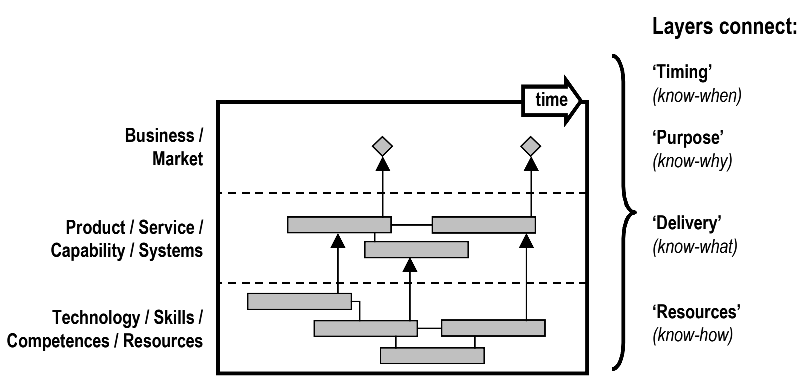


Fig. 7 - Generic technology roadmap (schematic)

- *Annotation:* in addition to the information contained within the layers, on a time-basis, other information can be stored on the roadmap, including:
  - *Linkages* between objects in layers and sub-layers (of various possible kinds)
  - *Supplementary information,* such as a key, statement of business strategy or market drivers, people involved in developing the roadmap and assumptions.
  - *Other graphic devices,* including objects, notes and colour coding, to indicate key decision points, gaps, critical paths, opportunities and threats.

- *Process:* the steps that will be required to complete the first roadmap, and take the process forward thereafter, will typically be different for each organisation (and often within the organisation too). The process that is most suitable depends on many factors, including the level of available resources (people, time, budget), nature of the issue being addressed (purpose and scope), available information (market and technology), other processes and management methods that are relevant (strategy, budgeting, new product development, project management and market research).

Planning is the most important consideration for customising the roadmap and roadmapping process, to clearly articulate the business and process objectives and to think through how the generic process of roadmapping might help to achieve the objectives, given the particular situation and context. Ownership of the roadmap is critical, firstly by a single designated person or group of people (committee or steering group), then by those that will participate in its creation, and ultimately on a wider basis within the organisation as a communication tool. If possible it is helpful to designate a person to manage the process and facilitate the workshops, ideally proficient in roadmapping. Aligning the capabilities of the roadmapping method with business goals and context at the planning stage is important if a good roadmap structure and process are to be developed.

5. Taking the process further

The development of an initial roadmap is the first, but very important, step on the way towards implementing roadmapping in a more complete and beneficial way, if that is deemed appropriate. The key benefit of the fast-start T-Plan approach, apart from the direct business benefits that arise from its application, is that the value of the method can be assessed quickly and economically. The learning that is gained by this initial application provides confidence about how to best take the process forward within the organisation.

While some companies choose to use the method for particular situations on a one-off basis, others have taken roadmapping forward to form a significant part of their strategy and planning processes. Roadmapping can become the focal, integrating device for carrying the business strategy and planning process forward, bringing together the market / commercial and technological knowledge in the business (Fig. 8). Key issues include deciding where the boundaries of the roadmapping process should lie, to what extent the method should be adopted, and how to integrate it with other systems and processes.

There are two key challenges to overcome if roadmapping is to be adopted widely within a company:

- *Keeping the roadmap alive:* the full value of roadmapping can be gained only if the information that it contains is current and kept up-to-date as events unfold. In practice, this means updating the roadmap on a periodic basis, at least once a year, or perhaps linked to budget or strategy cycles. The initial first-cut roadmap produced by the T-Plan process must be captured, stored, communicated, researched and updated, which requires careful consideration of the process and systems needed to facilitate this.

- *Roll-out:* once the first roadmap is developed in an organisation, it may be desired to facilitate the adoption of the method in other parts of the organisation. Essentially there are two approaches to rolling-out the method:
    - *Top-down,* where the requirement for roadmaps is prescribed by senior management – the particular format may or may not be specified.
    - *Bottom-up ('organic'),* where the benefits of using the method are communicated and support provided for application of the method where a potential fit with a business issue / problem is identified.

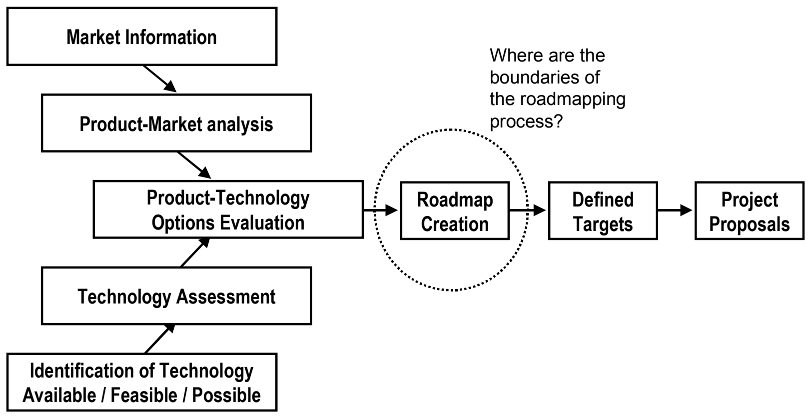


Fig. 8 – Roadmaps integrate commercial and technological knowledge (EIRMA, 1997).

In either case senior management support is important, in terms of enthusiasm for use of the method, but also in terms of ensuring that resources are made available (budget, time and facilitation), workshops scheduled and barriers removed.

A further issue to consider if the roadmapping method is to be used on an ongoing and more widespread basis is that of software for supporting the development, storage, dissemination and upkeep of roadmaps. Simple word processing and graphics packages are suitable for the initial development of a roadmap, but more sophisticated software would be beneficial if the process is to be taken forward. Software that is developed to support roadmapping should aim to provide the following types of functions:

- The multi-layer roadmap structure is recommended as the primary way of working with roadmapping data, owing to its simplicity and flexibility. Roadmapping objects (bars, linkages, annotations, etc.) can be defined in terms of their position in the layers, and on a time basis. The layered structure allows for a hierarchy of roadmaps to be developed, at any level of 'granularity' in the firm.
- Software should define a common architecture for building roadmaps in the firm, enabling data sharing and linkage, which requires specification of appropriate protocols and templates.
- The software should support management of the data that is associated with the roadmap, including data mining ('drill-down') and analysis, together with methods for managing the complexity of the data for the user (e.g. multiple perspectives on the data, critical paths,

linkages, etc.). Inclusion of additional management 'tools', such as the analysis grids used in the T-Plan method and portfolio project selection matrices is desirable.

- The software should be as customisable as possible, in terms of setting up the layered structure, definition of roadmapping objects, choice of graphical representation, and inclusion of annotations, notes and supplementary information.
- One of the strengths of the roadmapping approach is its support for *integration* of information, processes and methods in the firm, and the supporting software should reflect this, proving facilities for importing and exporting data, together with linkages to other business and management information systems. In its broadest sense, the roadmapping process and supporting software can form a central element of knowledge and information management systems in the firm.
- The software should cater for both 'novice' and advanced users. The software should be able to 'grow' with the company as its use of roadmapping expands and matures. The software should provide support for the development of individual roadmaps, as well as support for enterprise-wide roadmapping (scalability). The software should support multi-user, distributed participation in the development of roadmaps, which require input from various perspectives in the firm. Roadmap elements should be dynamically linked (within roadmaps and between roadmaps), so that the effects of changes to roadmaps can be readily determined.
- Software should fit in with the human process that is a key benefit of the technique; the development of good roadmaps typically requires multifunctional workshops. There is scope for creative approaches to the development of effective software-user interfaces, such as the use of electronic whiteboard and brainstorming technology. The role of software is to support the roadmapping process, and users should not expect that software alone will result in good roadmaps.

6. Summary and conclusions

Technology roadmaps clearly have great potential for supporting the development and implementation of business, product and technology strategy, providing companies have the information, process and tools to produce them. The following general characteristics of technology roadmaps have been identified:

- Many of the benefits of roadmapping are derived from the roadmapping *process*, rather than the roadmap itself. The process brings together people from different parts of the business, providing an opportunity for sharing information and perspectives. The main benefit of the first roadmap that is developed is likely to be the communication that is associated with the process, and a common framework for thinking about strategic planning in the business. Several iterations may be required before the full benefits of the approach are achieved, with the roadmap having the potential to drive the strategic planning process.
- The generic roadmapping approach has great potential for supporting business strategy and planning beyond its product and technology planning origins. It should be recognised that it is not a 'black box' methodology, that each application is a learning experience, and that a flexible approach, adapted to the particular circumstances being considered.

- Roadmaps should be expressed in a graphical form, which is the most effective means of supporting communication. However, the graphical representation is a highly synthesised and condensed form, and the roadmap should be supported by appropriate documentation.
- Roadmaps should be multi-layered, reflecting the integration of technology, product and commercial perspectives in the firm. The roadmapping process provides a very effective means for supporting communication across functional boundaries in the organisation. The structure that is adopted for defining the layers and sub-layers of the roadmap is important, and reflects fundamental aspects of the business and issues being considered. Typically these layers relate to key knowledge-related dimensions in the business, such as 'know-why', 'know-what', 'know-how', 'know-when', 'know-who', and 'know-where'.
- Roadmaps should explicitly show the time dimension, which is important for ensuring that technological, product, service, business and market developments are synchronised effectively. Roadmaps provide a means of charting a migration path between the current state of the business (for each layer), and the long-term vision, together with the linkages between the layers.
- Software has an important role to play in supporting the application of roadmapping in the enterprise. However, software alone cannot deliver good roadmaps, and needs to be integrated with the human aspects of roadmapping. A key benefit of roadmapping is the sharing of knowledge and the development of a common vision of where the company is going.

7. References

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