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# *Technology roadmapping: facilitating collaborative research strategy*

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## *Summary*

Roadmapping approaches are now widely used at company, sector and national levels to align research investments and other actions with goals and policy. This briefing provides an overview of the technique, focusing on how roadmapping can support industrial and research networks to build consensus about technology and other priorities required to move forward, illustrated with three case studies.

## *1. Introduction*

In this section the background and evolution of the roadmapping approach is discussed, the underlying concept is described, and its application summarised.

### *Background*

Technology roadmapping was originally developed by Motorola in the 1970s to support improved alignment between technology and product development[1] (see Fig. 1). Since then the approach has been adopted widely by many organisations in different sectors around the world, at company, sector and national levels. The underlying concept is very flexible, and roadmapping methods have been adapted to suit many different goals, supporting innovation, strategy and policy development and deployment[2].

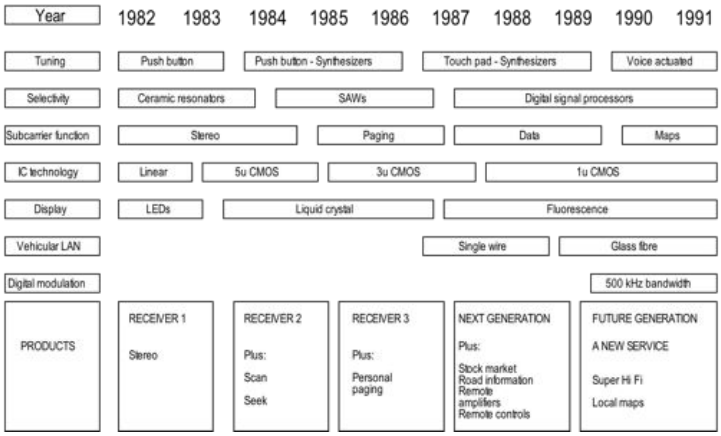


*Fig. 1 – First published Motorola technology roadmap, for car radios[1], linking technology investment to product evolution, looking forward 10 years*

[1] Willyard, C.H. and McClees, C.W. (1987), "Motorola's technology roadmap process", *Research Management,* Sept.-Oct., pp. 13-19.
[2] Phaal, R., Farrukh, C.J.P. and Probert, D.R. (2004), "Customizing roadmapping", *Research Technology Management,* 47 (2), pp. 26-37.

The most frequently cited benefit of the approach is *communication*. The process of roadmap development brings together the various key stakeholders and perspectives, building consensus. Once a roadmap has been developed it can be more widely disseminated, acting as reference point for ongoing dialogue and action.

## *Concept*

Bob Galvin, who was CEO of Motorola during the period when roadmapping was established, provides the following definition[3]: "A 'roadmap' is 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". This definition emphasises the importance that knowledge and expertise plays in the process, the forward-looking nature of the approach, and its flexibility.

Many different approaches to roadmapping have been developed, and roadmaps can take many forms, although generally the focus is a *graphical representation* that provides a high-strategic view of the topic of interest. The most flexible and powerful framework for the creation of roadmaps is illustrated schematically in Fig.2, comprising a multi-layered time-based chart, bringing together various perspectives into a single visual diagram. This type of roadmap enables both 'demand' and 'supply' views to be represented, balancing 'market pull' and 'technology push'.

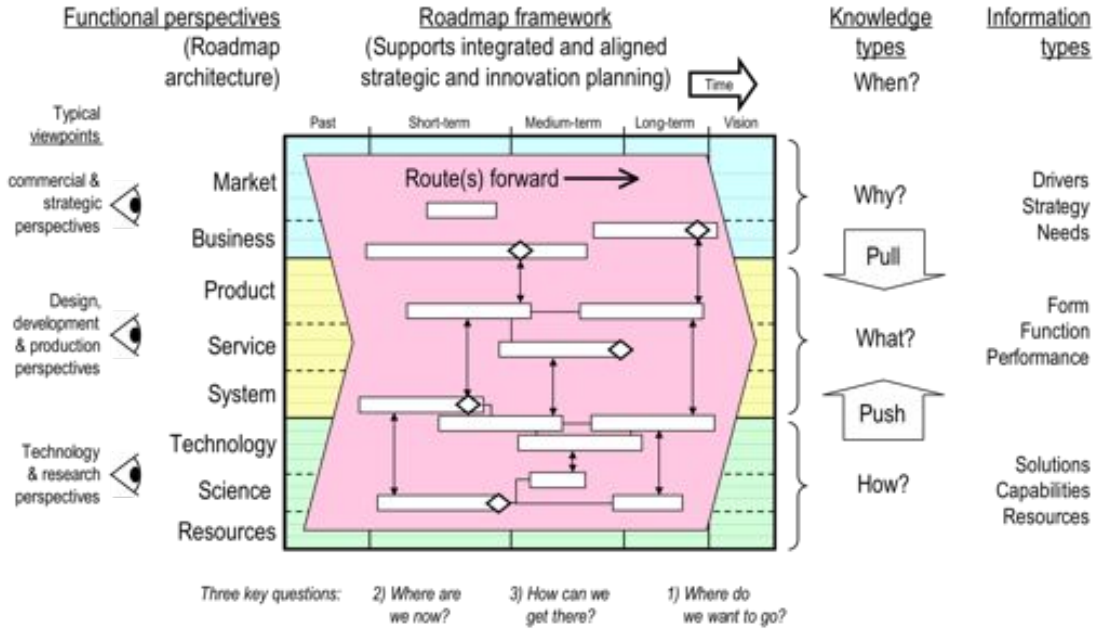


*Fig. 2 – Schematic multi-layered roadmap, aligning multiple perspectives*

This holistic roadmap framework links directly to fundamental questions that apply in any strategic context:

1. Where do we want to go? Where are we now? How can we get there?
2. Why do we need to act? What should we do? How should we do it? By when?

The generic form of roadmap illustrated in Fig. 2 highlights the flexibility of the approach, which can be readily adapted to suit a wide range of goals and contexts. In essence, roadmaps

[3] Galvin, R. (1998), 'Science roadmaps', *Science,* 280 (5365), pp. 803.

are simple, adaptable 'strategic lenses' through which the evolution of complex systems can be viewed, supporting dialogue and communication.

### *Application*

From its origins in the consumer electronics sector in the 1970s, roadmapping techniques spread initially to organisations in other technology-intensive sectors – aerospace and defence in particular. A key milestone in the evolution of the method was its adoption by the semiconductor industry, where in 1992 the first sector-level roadmap was published. This has been very influential, defining the collective vision of the industry and establishing a benchmark for technology development, accelerating innovation in the semiconductor sector[4]. Unlike company roadmaps, which are usually confidential, the International Technology Roadmap for Semiconductors is in the public domain[5], leading to a much wider awareness of the approach.

The application of roadmapping at the sector level was further promoted by the US Department of Energy, which funded a series of roadmaps in different industries[6]. The concept and term 'roadmap' was further popularised by the publication and promotion of the 'Roadmap for peace in the Middle East'[7], although this has led to a proliferation of so-called 'roadmaps' that do not build on the intellectual origins of the approach. A recent survey[8] of public-domain roadmaps has identified more than 900 examples from a wide range of sectors, including energy, transport, materials, aerospace, electronics, ICT, manufacturing, construction, healthcare, defence, and pure science.

## *2. Roadmapping in practice*

In this section the process of developing roadmaps is summarised, focusing on the role of workshops.

### *Approach*

It is often claimed that the *process* of developing roadmaps is as important as the roadmaps themselves, due to the associated communication and network-building benefits. The process needs to be customised to suit the context, along with the structure and format of the roadmap. Consideration should be given to how the first roadmap is developed and then also to how the roadmap can be maintained, to provide an ongoing reference point for communities of interest. Typically, for substantial sector level roadmaps it might take several months or more for a first good quality roadmap to be developed (suitable for publication).

While the particular approaches vary considerably, the use of workshops as a key ingredient is a common feature, owing to the communication and network-development benefits, building consensus about what the key issues of interest and concern are, and the actions that are needed to move forward. Figure 3 shows how the roadmap framework is used in a workshop, using the 'S-Plan' approach developed by the University of Cambridge Centre for Technology Management, providing a coherent structure ('common language') to guide discussion and capture views, in an active hands-on process[9]. Two activities are illustrated:

[4] Schaller, R.R. (2004), *Technological innovation in the semiconductor industry: a case study of the International Technology Roadmap for Semiconductors (ITRS),* PhD thesis, George Mason University.
[5] www.itrs.net
[6] www.eere.energy.gov
[7] United Nations (2001), A performance-based roadmap to a permanent two-State solution to the Israeli-Palestinian conflict.
[8] www.ifm.eng.cam.ac.uk/ctm/trm/documents/published_roadmaps.pdf
[9] Phaal, R., Farrukh, C.J.P. and Probert, D.R. (2007), 'Strategic roadmapping: a workshop-based approach for identifying and exploring innovation issues and opportunities', *Engineering Management Journal,* 19 (1), pp. 16-24.

1. A large roadmap wall chart (main photograph in Fig. 3) is used to share perspectives across the full scope of the topic of interest, to create a 'strategic landscape', providing context within which specific opportunities or issues of concern can be identified ('landmarks').
2. Small groups then explore the specific topics in more detail, using a common template, to develop 'first-cut' roadmaps for review and discussion, to agree priorities, way forward and actions (inset photograph in Fig. 3).

Further work is typically required before, between and after workshops to collect data, analyse results, develop roadmap representations and associated reports.

*Fig. 3 – Typical roadmapping workshop, showing how the roadmap framework provides a structured framework for guiding discussion and capturing views*

## *Success factors*

In 2003 the Dutch Ministry of Economic Affairs sponsored a study of the effectiveness of 'supra-company' (network level) roadmapping initiatives around the world[10], with the aim of assessing how roadmapping can support national (Dutch) innovation policy and systems. The study reviewed a total of 78 roadmapping initiatives, mainly in Europe, USA, Canada and Japan, from which the following 'good practices and lessons' were identified:

*Planning:*

- The roadmapping initiative should be clearly linked to *broader strategy initiatives* (for example, national innovation priorities).
- It is much easier to launch a roadmapping activity within an existing *'social infrastructure'* (for example, a industry association) – this is less of an issue for firm-level applications.
- In order to mobilise participants there must be a *sense of 'urgency'*.

[10] De Laat, B. and McKibbin, S. (2003), *The effectiveness of technology road mapping – building a strategic vision,* Dutch Ministry of Economic Affairs. [www.ez.nl]

- Creating *high-level commitment* from the start is critical, involving decision makers within companies (and government) throughout the process.
- *Visioning and goal setting* is important, as a focus for developing consensus within the community.
- Industry oriented roadmapping activities should be *owned by industry* from the outset to encourage take-up.
- A clear link to *decision-makers* is important if roadmapping is to have impact.

*Implementation:*
- *No single format* is suitable for all situations – the approach generally has to be customised.
- It is important that *momentum* is sustained, to keep participants interested and involved.
- Roadmapping is inherently exploratory in nature, and so the plan should be *flexible* to accommodate learning as the process advances.
- A spirit of *openness* is important, to encourage new participants and thinking throughout the process.
- The *financial aspects* need to be clear – generally the costs of such initiatives are shared between the administrating and participating organisations.

*Follow-up:*
- Roadmapping is typically an *iterative process,* benefiting from review after the first roadmap is produced.
- *Outcomes should be monitored,* including uptake and impact.

## *3. Case illustrations*

The use of roadmapping is illustrated in this section with reference to three summary cases, relating to corporate research strategy, the automotive sector and measurement science, all of which were based on the S-Plan workshop approach.

### *Corporate research strategy*

This case focuses on a global packaging company, with a central European corporate R&D facility and business units distributed around the world, organised in terms of geography and product lines. The company had grown through a series of acquisitions, with the corporate R&D Centre a legacy from one of the original companies. The central research laboratory provided troubleshooting and development support, funded directly by business units on a project basis. In addition, a 'tax' was levied on the business units to fund longer-term research, focusing on new materials, products and processes.

A key challenge for the company was a lack of alignment between business unit goals, which tend to focus on the short- and medium-term, with investment in longer term R&D in the research laboratory. There was a history of interesting technology developments that were not deployed in the business units, leading to a concern that corporate research budgets would be cut substantially, and the central research laboratory potentially closed.

The S-Plan process was used in a series of workshops, each focusing on particular business units, bringing together staff from both organisations, with the commercial perspective provide by the business unit and the technological perspective by the corporate R&D centre (see Fig. 4). The process was piloted first in one business unit, and then applied across other key business areas.

In each case, three key people worked together to plan and run the workshop, and ensure that the outputs were taken forward, both within the business unit and the research laboratory:

1) Senior manager within the central research laboratory, responsible for the interface with the business unit. This person tended to instigate the process, liaised with the business unit to ensure their commitment, made sure that appropriate technical experts participated in the workshop, and ensured that the outputs were implemented within the laboratory
2) General Manager of the business unit, who ultimately 'owned' the resulting roadmaps that were generated in each workshop, which focused on innovation opportunities and strategic options for the business unit. This person ensured that the business objectives were clearly understood, made sure that appropriate commercial, development and managerial staff participated in the workshop, and ensured that the outputs were implemented within the business.
3) Facilitator, an expert in roadmapping techniques, who helped to design and coordinate the process, and facilitated the workshops. This role was initially undertaken by an external consultant, but one of the aims was to ensure that the learning was transferred to the company. After the first three workshops staff in the research laboratory took on this role.

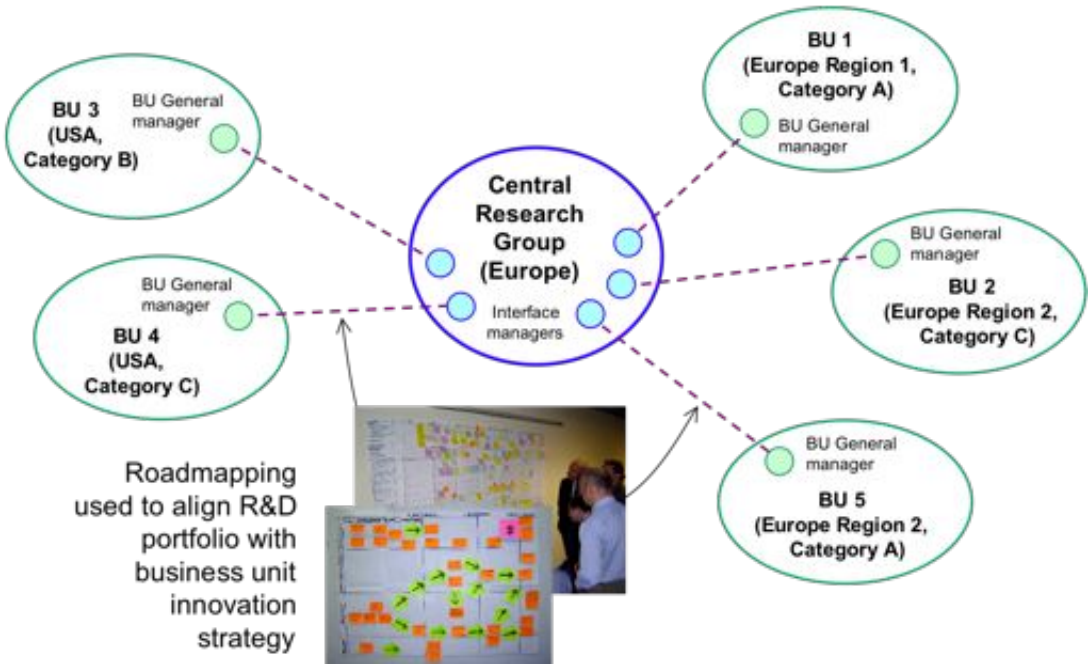


*Fig. 4 – Coordination of research strategy in global packaging company*

The main outputs from each workshop were a prioritised set of innovation opportunities and strategic options for the business units, and agreed plans to take these forward, combined with an understanding of the technologies needed to support these plans. This included short-, medium- and long-term technical priorities, aligned with the troubleshooting, development and research activities in the laboratory. The priorities established during the roadmapping process were compared to the existing R&D portfolio. Where existing programmes were identified that matched the business unit priorities these were strengthened, and were gaps were identified budgets were reallocated (projects where there was no link to business needs were stopped).

The overall benefits of the process were:

- Reinvigorated innovation strategy in the business units, with new opportunities identified and pursued.
- A realigned corporate research budget, linked to the future business needs of the company.

- A much stronger relationship between business units and research laboratory, and improved pull through of technology into the business.

## *Automotive – UK Foresight Vehicle*

The Foresight Vehicle programme[11] is hosted by the UK Society of Motor Manufacturers and Traders (SMMT). The initiative has been running for more than ten years, providing a national focus for technology development within the automotive sector in the UK. As of 2004, more than 100 individual projects have been generated, covering a wide range of manufacturing processes and product concepts.

A major roadmapping initiative was undertaken in 2002 (see Fig. 5), with the aims of identifying the technology areas that would benefit from support (aligned with EPSRC funding) and building the network of organisations involved. The process for developing the first version of the roadmap involved a total of 10 workshops over a period of 10 months, involving more than 160 participants from 60 organisations (including industry, academia and government).

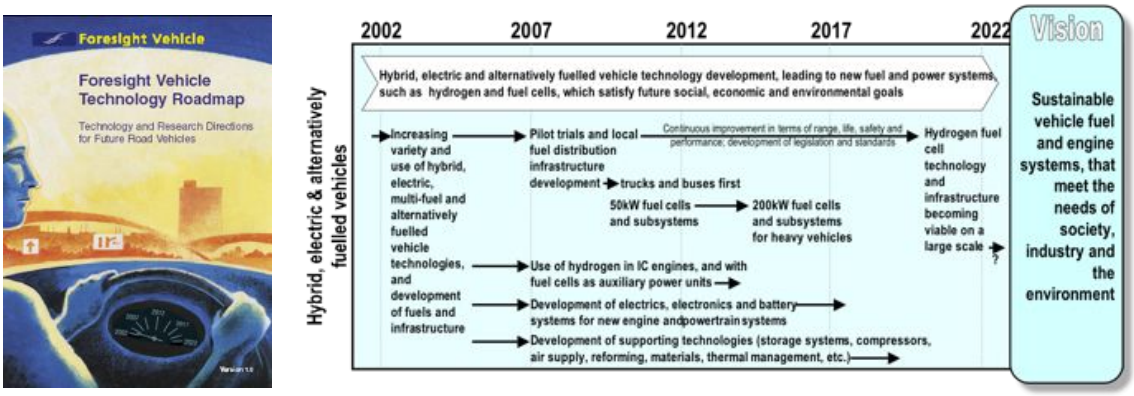


*Fig. 5 – Foresight Vehicle Technology Roadmap report (version 1), showing high-level roadmap for 'hybrid, electric and alternatively fuelled vehicles'*

The Foresight Vehicle Technology Roadmap has been widely disseminated, and has become a key reference point within the UK automotive sector, and internationally. The success of the first roadmap is demonstrated by the fact that the SMMT commissioned an update in 2004 (version 2), and is currently planning a third round.

## *Measurement science – UK MSET*

The Measurement and Standards for Emerging Technologies (MSET) series of roadmaps[12] were developed in 2006 (see Fig. 6), to identify measurement technology needs and research themes in a number of key UK sectors, reflecting the TSB Key Technologies and DTI Pillars. A series of one-day workshops were held, each relating to a different sector: Environmentally friendly transport, Secure environment, Sustainable consumption & production, Emerging energy technologies, Healthcare & bio-science, Intelligent connected world, Design, engineering & advanced manufacture, and the Built environment.

More than 100 non-NMS (National Measurement System) participants were directly involved in workshops, including industry (large and small companies), trade organisations,

[11] www.foresightvehicle.org.uk
[12] www.technology-roadmaps.co.uk

universities and the public sector (government departments and agencies, and research networks). Further consultation with the wider community enabled the outputs from the workshops to be tested and refined. The main graphical outputs, and the results have been published on the internet to encourage dissemination and comment.

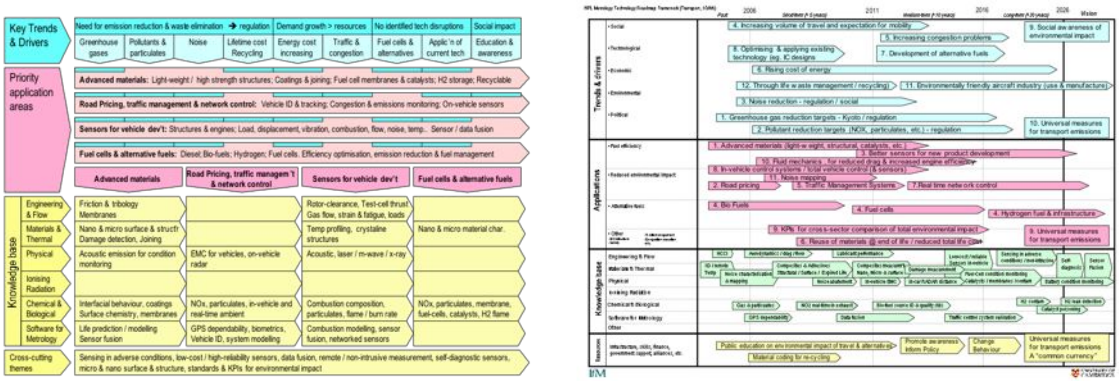


*Fig. 6 – Executive summary roadmaps for Environmentally friendly transport – a common structure throughout the eight sector roadmaps enabled crosscutting themes and synergies to be identified*

A ninth workshop focused on crosscutting themes and synergies, drawing on the results from the eight sector workshops. This was enabled by the use of consistent structures and workshop methods across all eight sectors. As well as common technological issues, a large degree of commonality in industry drivers was observed across the eight sectors.