Fraunhofer INNOVATION

Sven Schimpf | Robert Phaal | Olivier L. de Weck | Thomas Abele

Roadmapping Field Study Update 2023

How are roadmaps applied in the real world?

In Cooperation with:

IfM MANAGEMENT TECHNOLOGY POLICY

Massachusetts Institute of Technology

TIM CONSULTING
Technologie- und Innovationsmanagement

Introduction

Roadmapping is an established planning tool in a wide variety of organizations. However, there are high variances in the quality and scope of the use of roadmaps. Many organizations could benefit much more than they do from integrated planning using roadmaps across functions and hierarchies, especially in volatile times. To find out where we stand in practice, the update of the roadmapping field study was undertaken in 2022, building on our earlier study in 2015.

Roadmapping in a nutshell:

Following the metaphor of a navigational road map, management roadmaps chart structured time-based pathways to reach strategic goals, supporting integrated strategic planning and communication across organizational units.

Roadmapping: a planning tool in transition

Since its emergence in US technology-intensive sectors more than five decades ago, roadmapping has had increasing and evolving application in corporate use. Motorola was one of the pioneers in the documented use of roadmapping in the 1970-80s, particularly in the strategic planning and coordination of technological products. European companies, such as Philips, continued to develop roadmapping in the 1990s, taking account of a wider range of functional perspectives. Two of the most influential approaches are those of the European Industrial Research Management Association (EIRMA) and the S- & T-Plan workshop approaches from the University of Cambridge, both adopting a basic model that emphasizes market, product, and technology perspectives for integrated strategic planning. Building on this basic model, roadmapping can be expanded and adapted methodically and thematically to fit virtually any strategic context, as evidenced by the many applications in companies, sectors and scientific fields over the years.

How and for what do organizations use roadmaps and what can we learn from them?

As an evolving practice-driven method, it is important to track how and for what purpose roadmapping is used in practice. Based on this question, we undertook a roadmapping field study in 2015. The key findings then were that roadmaps are mainly used for a time horizon of up to 5 years (...and rarely beyond); that mostly products, technologies and projects were mapped (...and services rather rarely); and that customers and market analyses were the most frequently used sources of information (...few of the participants used external roadmaps as a source of information). Only about a quarter of the participating organizations used roadmapping for production planning at that time, despite the ongoing discussions around the Internet of Things and Industry 4.0. Maturity models for technologies were used by only 10 % of the participants and, although there were numerous IT solutions already existing, an overwhelming proportion of organizations created their own roadmap schemes using standard office software.

For some time, we have had our eye on an update of the 2015 study - now that time has finally come. As a collaboration between the Fraunhofer Group for Innovation Research, IfM Cambridge, MIT and TIM Consulting, we have updated the questions to account for current developments, specify details and address an international audience.

Overall, the questions asked in the survey are intended not only to be a scientific survey tool but also to be a test bench for roadmapping activities: Where is the potential for further development of roadmaps in your organization?

Sven Schimpf
Robert Phaal
Olivier de Weck
Thomas Abele

Table of Contents

1 Why, What and How: Roadmapping

Roadmapping practice has continued to expand and grow in recent years. Our understanding of roadmapping in the context of this study focuses on strategic roadmapping, with the aim of supporting strategic planning processes in organizations, establishing the interface to operational planning, and creating transparency across different organizational levels and business units. Simply put, it is a process for structuring and visualizing complex (innovation) system change.

1.1 Reference work and history of roadmapping

To provide an overview of roadmapping is challenging for various reasons. The term 'roadmapping' is often used in different ways, with the method rarely covered in mainstream management and business school research and education. Furthermore, the transition to related topics such as project and portfolio management is often seamless.

The origins of roadmapping are obscure, as described by Clive Kerr and Robert Phaal in their 2020 article '*Technology roadmapping: Industrial roots, forgotten history and unknown origins*'. The first known examples of technology roadmaps were observed in US high-tech sectors in the 1960s, such as aerospace, defense, semiconductors, and energy systems. Companies in the electronics sector were influential in the adoption and development of roadmapping in the 1970-90s, such as Motorola, Lucent Technologies and Philips. The first sector level technology roadmap was created in the 1990s, the International Technology Roadmap for Semiconductors ITRS, driving forward innovation in the sector to this day (Kerr and Phaal 2020).

For science and technology roadmaps, the original focus of roadmapping, a basic definition of roadmaps and description of a taxonomy for possible objectives and the successful construction of roadmaps was provided more than 20 years ago (Kostoff and Schaller 2001), with early guidance on a process for technology roadmapping published by the Sandia National Laboratories in the USA (Garcia and Bray 1997). A general overview, especially on the approach to technology roadmapping from a company and network perspective, is provided by Phaal et al. (2004) in their article '*Technology Roadmapping - A planning framework for evolution and revolution*'.

Academic interest in roadmapping emerged in the 1990s (Park et al. 2020), with more than 1,100 academic articles published to date, covering a wide range of topics, such as practical approaches, novel applications, analytical methods, digitalization, underpinning concepts and theory, and literature reviews.[1]

For technology roadmapping, the recent book by Olivier L. de Weck is recommended: '*Technology Roadmapping and Development: A Quantitative Approach to the Management of Technology*'. It provides a complete and coherent account, not only for roadmapping, but for the management of technology-intensive innovation, including numerous examples and helpful methods (de Weck 2022).

Also, worth mentioning here, are the publishers' compilations '*Technologie-Roadmapping. Zukunftsstrategien für Technologieunternehmen*' (Möhrle and Isenmann 2017) and '*Roadmapping Future: Technologies, Products and Services' (Daim 2021)*, both bringing together valuable contributions from academia and industry.

1.2 Structure of roadmaps

A basic idea of roadmapping is to classify and align different organizational and planning areas in terms of time, to make their interfaces visible and to present integrated strategic plans in a structured visual form, reducing information asymmetries and improving communication. The three planning perspectives of market, product and technology are often included in roadmaps, although the roadmap structure and

[1] Bibliography with numerous contributions collected by the IfM Cambridge is available under the following link: https://www.ifm.eng.cam.ac.uk/uploads/Research/CTM/Roadmapping/Roadmapping_Bibliography_Phaal.pdf

process of roadmapping can be extended and adapted to virtually any organization-specific contexts and requirements.

While roadmaps can take many visual forms, the underpinning knowledge architecture reflects six fundamental and universal questions (Phaal and Muller 2009):

1. **Why do we need to act?**
   For example, environmental or market drivers, policy, or strategy.
2. **What should we do?**
   For example, products, services, or other value-adding tangible systems.
3. **How should we do it?**
   For example, technology, capabilities, resources, or other enablers.
4. **Who will be involved with and responsible for the initiative?**
   For example, with reference to the RACI matrix, categorized as those responsible, accountable, consulted, or informed.
5. **Where will the activity occur?**
   For example, partners, suppliers, existing or new business units.
6. **When should we do it?**
   For example, considering potential changes and developments of markets or technologies.

Roadmapping provides the capability to track activities considering interdependencies throughout planning and execution.

1.3 Process of roadmapping

Roadmapping can best be understood as a service to other core management and business processes, such as strategy, technology, or innovation management, through the application of the structural principles embodied in roadmapping. As an integrating framework, roadmapping brings all relevant strategic information together into one structured visual chart. In early iterations roadmapping serves a diagnostic function, as the coherence and completeness of strategic thinking and planning become clear (or not). The various pieces of the strategic 'jigsaw' need to be assembled into a coherent whole, with the roadmap representing the picture on the jigsaw puzzle box. As strategic plans become mature, so do the corresponding roadmaps, which should typically align with decision points in client processes, such as portfolio reviews in strategic planning processes or gates in new product development.

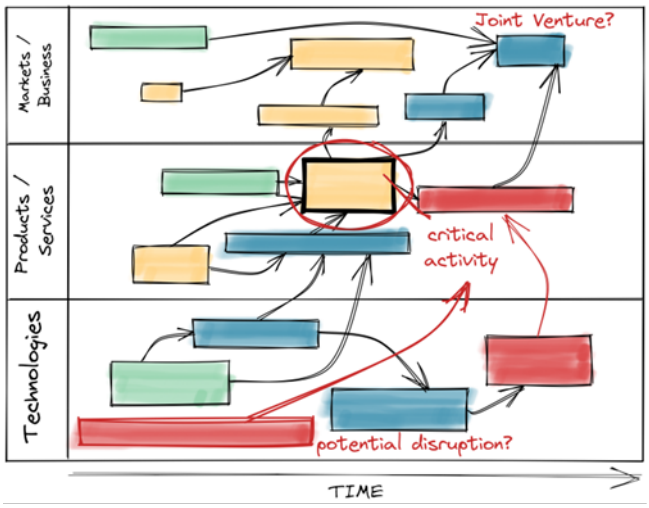
Roadmapping is '*neutral*' to process, in the sense that any strategic planning process logic can apply, with the client process steps associated with the sequence in which data, information, or knowledge populates the roadmap 'canvas'. For example, a market-pull logic will start in the market layer of the roadmap, flowing on to product, and then technology layers, while a technology-push process logic will flow in the other direction. A range of management tools and frameworks may be necessary to address the strategic issues in such processes. Roadmaps serve a key function as '*integration hubs*' in a broader system of methods and tools.

Three fundamental questions are closely associated with the time dimension that must be answered for all relevant system perspectives:

a) **Where do we want to go?**
   Vision and goals for the system - the end state. When uncertainty is high, this might be represented not only through one state, but through multiple, possible, imaginable, or desirable scenarios.
b) **Where are we today?**
   Current system state, allowing to define the strategic gap or challenge being faced related to the vision and goals.
c) **How can we get there?**
   Plausible pathways providing a bridge between the current and future system states.

Roadmaps are not static plans, but rather serve a strategic navigational function. They help building consensus and confidence about the way forward and current plans. Thus, roadmaps should be updated on a regular basis, depending on the rate of change, aligned with the process that the roadmap serves.

Figure 1:
Basic, schematic structure of a roadmap combining key strategic perspectives as layers: technologies, products / services, and markets / business areas.



As already mentioned, the format of roadmaps can lead to confusion with project, program, or portfolio planning. The scope of application of strategic roadmaps is much broader, integrating different levels of project plans, programs, or portfolios. Also, the

time horizon covered is generally longer, to ensure the coherence of projects and activities with future value creation.

The primary (foreground) function of roadmapping is to synthesize market, product, and technology information as a planning step (see Figure 1). However, roadmap architecture can support coherence throughout the process and associated toolset, as a secondary (background) function, and thus the boundaries of roadmapping require careful consideration.

1.4 Associated information sources, methods, and tools

The selection of information sources highly influences the scope, quality, and maturity of information of a roadmap. Closely related is the field of information mining (for example Li et al. 2023; Li et al. 2022) and the application of supporting tools. Another important field of associated methods and tools is the evaluation of the layers represented in the roadmap such as markets, products, and technologies (see for example Alzahrani et al. 2022). Among evaluation methods, maturity levels such as the technology readiness level (see for example Petrescu et al. 2021) take a special role for the timely allocation of objects in roadmaps. Another area of associated methods and tools is the integration of roadmaps with subsequent or overlapping planning instruments for projects, portfolios, or programs (see for example Gupta et al. 2022).

1.5 Current and future challenges

Society and industry are facing transformative change and disruption in the 21st century that require more systematic, inclusive, and holistic approaches to strategic planning, which roadmapping is ideally suited to support. For example, sustainability is now widely recognized as a key strategic priority for many governments and organizations, as it is a necessary requirement to enable mankind to continue to live in a viable environment in the future. Digitalization and the resulting possibilities of using machine learning and artificial intelligence will continue to shape our society in the years to come, similar to the Kontratieff cycles of the past. Due to events of recent years such as the Covid-19 pandemic, regional conflicts, natural disasters, and changes in global cooperation, the economy, politics, science, and society are all facing new challenges and uncertainties.

Roadmapping offers the possibility to include these topics either as cross-cutting topics, events, or separate levels, and to consider them transparently in a flexible planning process interlinking anticipated and actual developments. So far, this potential seems to have been used only to a small extent, as indicated by the challenges mentioned in the first execution of this study in 2015 or by related studies as for example from 2017 on the integration of sustainability aspects in innovation management where roadmapping was used only by 25 % of the participants (Lang-Koetz and Schimpf 2019).

1.6 Roadmapping in the real world

Very few detailed firm-level roadmaps are in the public domain and few detailed accounts of organizational processes of roadmapping have been published in journals, owing to obvious concerns about confidentiality, which is a barrier to dissemination and adoption of the method and one of the motivations for this survey.

An early impulse for this roadmapping field study was provided by a survey of UK manufacturing companies more than 20 years ago, with manufacturing firms reporting the use of roadmapping at that time, highlighting challenges associated with initiating and sustaining roadmapping in companies (Farrukh et al. 2001). Due to the frequent mention of roadmapping in the context of technology planning, the results of the study on early technology identification in multinational companies are also worth mentioning here (Bürgel et al. 2008).

The main source of detailed firm-level examples of roadmapping is the industry-oriented journal Research-Technology Management RTM, published by the US Industrial Research Institute IRI. The RTM journal published detailed early accounts of roadmapping experience from firms such as Boeing, BP, General Motors, Ingersoll Rand, John Deere, Lucent Technologies, Motorola, Philips, Rockwell Automation, and the Royal Mail. Also of note is the report of Working Group 52 of the European Industrial Research and Management Association (EIRMA 1997), which compared practices from ABB, Hoogovens, LucasVarity and Philips.

More recent noteworthy examples of organization-level roadmapping initiatives include the following:

- Lischka and Gemunden (2008) and Farrokhzad et al.(2008) have described how technology and portfolio-based roadmapping was implemented at Siemens, providing assurance that specific technologies will be available at the right time.
- Kerr et al. (2019) describe how the LEGO Group implemented roadmapping for its production systems, starting with a cross-functional pilot workshop.
- Pearson et al. (2020) elaborate on how the fusion start-up Tokamak Energy deployed roadmapping in an agile manner to support its internal technical strategy, with a simplified communication roadmap developed for investors.

- Iyigun Meydanli and Polat (2022) describe the implementation of technology roadmapping within Arçelik, the Turkish-based durable consumer goods manufacturer, to support research and development across the business.
- Garza Ramos et al. (2022) attempt to adapt the technology roadmapping framework to a start-up company in drug discovery and research.

In contrast to firm level applications, policy and sector level roadmaps are widely available in the public domain[2], as such roadmaps are intended to provide a coordinating role in innovation systems and are typically sponsored by government agencies or industry associations. Organizations participate in such initiatives to ensure their voice is heard, as the resulting roadmaps are influential in setting strategic directions and funding programs. Public-domain roadmaps of this kind are also useful sources of market and technological intelligence for firm-level strategy and roadmapping activities, whereas our 2015 study showed that they are only seldom used as information sources.

Reviews of public domain roadmaps and approaches (de Laat and McKibbin 2003; Chakraborty et al. 2022) have identified a number of success factors that are also applicable to firm-level applications. These include the need to have clear links to strategy and decision making, high-level commitment and ownership, participation of key stakeholders, an iterative approach, monitoring of outcomes, and the need to customize the roadmap structure and process to fit context and purpose. In addition, a study with Korean companies in 2009 examined the relationship between technology roadmaps and various success factors such as process support, software deployment, and organizational support (Lee et al. 2011). The flexibility of roadmapping has long been a recognized benefit of the approach, with principles and guidance for customization provided by Phaal et al. (2004) and Lee and Park (2005). Roadmapping originally emerged in large technology-intensive organizations but is equally applicable in smaller and non-technology intensive organizations, suitably adapted. For such contexts it is important to reduce complexity and improve efficiency (to reduce resources and effort), and a lighter touch, agile approach is beneficial, which is also suitable as a starting point for larger-scale initiatives. To this end, the T-Plan and S-Plan 'fast-start' workshop methods were developed by Phaal et al. (2003) and Phaal et al. (2007) for product-technology and more general strategic roadmapping applications. Agile concepts can also benefit foresight applications of roadmapping at the sector and policy level (O'Sullivan et al. 2021).

The use of roadmaps specifically in small and medium-sized enterprises SMEs was investigated in 2009 with the aim of developing a roadmapping method customized for this target group (Laube 2009, 118f). The T-Plan approach was adapted and widely applied by SimTech in Singapore to support SME manufacturing firms, in terms of their strategy and technology acquisition (Holmes and Ferrill 2005).

Recently there has been a trend towards blending qualitative and quantitative analysis, drawing on the power of analysis and simulation - termed 'model-based' roadmapping (Alcantara and Martens 2019). Also of note is the quantitative approach of de Weck (2022), especially the advanced technology roadmap architecture ATRA and associated educational programs that emphasize learning through the development of technology roadmaps, leading to a growing repository of technology roadmaps that are publicly available.[3]

[2] Overview of available roadmaps from the Institute for Manufacturing IfM, University of Cambridge available here: https://www.ifm.eng.cam.ac.uk/uploads/Research/CTM/Roadmapping/public_domain_roadmaps.pdf

[3] Overview of technology roadmaps from Massachusetts Institute of Technology MIT available here: https://roadmaps.mit.edu/index.php/Main_Page

2 The Roadmapping Field Study

2.1 Aim and structure of the roadmapping field study

The aim of this study is to analyze the status-quo of roadmapping practice. For this purpose, the study is divided into four areas, in accordance with the earlier 2015 survey (Schimpf and Abele 2017, p. 335):

- **Application areas and content**
  For what purpose are roadmaps used in organizations, what content is mapped, which maturity stages are covered, and what time horizon is considered?
- **Organizational integration**
  Which business units are involved with which roles, which activities are defined in formalized processes, and at what frequency are the roadmaps updated?
- **Information sources, methods, and tools**
  Which sources of information are used to create and update roadmaps, which methods are applied in the context of roadmaps, and which software tools are used?
- **Challenges and best practices**
  What are the main challenges of roadmapping, which methods, structures and processes do participating organizations consider as recommendable, and what should be avoided when introducing or consolidating roadmaps?

In addition to these areas, organizational and respondent-specific data such as the position of the participants, as well as the size, sector and turnover of the organization were queried.

2.2 First implementation of the study in 2015

The roadmapping field study was conducted for the first time in the period from July to September 2015, based on a discussion among the authors about what organizations understand by roadmaps and roadmapping, and on how roadmaps are used in day-to-day business. The basic structure of the study was developed based on this discussion. Table 1 shows the overview of media in which the results of the study conducted in 2015 were published.

Table 1: Publications related to the results of the roadmapping field study 2015

Medium	Language	Reference
Brochure*	DE/EN	(Abele and Schimpf 2016b, 2016a)
Infographic*	DE/EN	(Schimpf and Abele 2016b, 2016a)
Conference proceedings*	DE/EN	(Schimpf 2016, 2017)
Book contribution	DE	(Schimpf and Abele 2017)
Article	EN	(Schimpf and Abele 2019)

* Download link available in the bibliography

Building on the roadmapping field study 2015, further topics were addressed, such as an overview of roadmapping software available on the market (Abele et al. 2017, 2018) and a study on how companies deal with potentially disruptive technologies (Schimpf 2020).

2.3 Adjustments in the update

The first and most important point in the further development of the study is cooperation with international partners to involve the most relevant experts globally and to reach international participants.

Two themes emerged in the discussion that were further developed. Firstly, questions were added to better understand the use of complementary methods (such as portfolio management or maturity models). Secondly, the topic of IT support and automated data analysis was added.

The study was conducted as an online survey. By anonymizing the results, no direct comparison of the participating organizations is possible. Participants of the 2015 roadmapping field study who had agreed to provide further information were invited to contribute to the update.

The opportunity to participate in the online survey was disseminated via the networks of the participating organizations, such as websites, blogs, social media and newsletters and was available from December

2021 to April 2022. Of the total of 465 respondents, 190 contributions could be used for the evaluation due to adequate data quality (compared to 81 in the 2015 study).

The presentation of the results mainly focuses on quantitative evaluation, with insights drawn from the correlation analysis, and comparisons with results from the 2015 study.

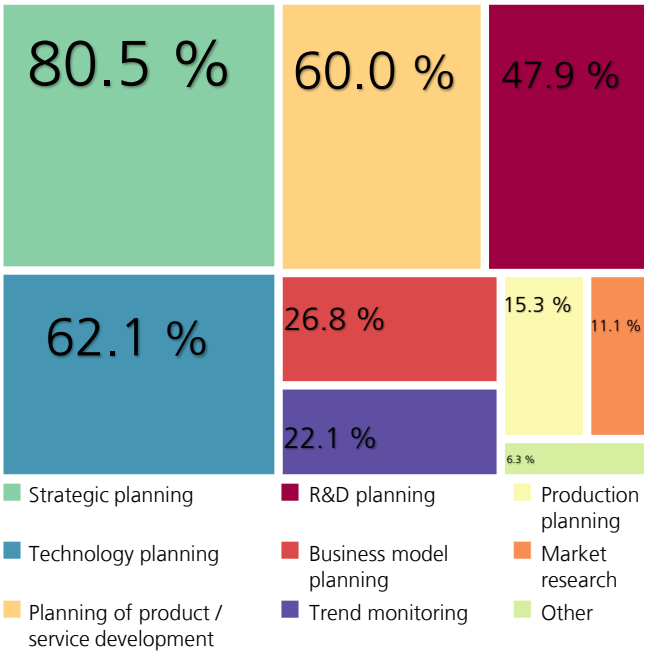
3 Areas of Application and Contents of Roadmaps

The first block of questions focuses on understanding the roadmapping purpose and areas of application, together with content and associated objects in roadmaps.

3.1 Areas of roadmap application

As a basis for all further questions, it is important to understand the purpose for which roadmaps are used in organizations. Depending on the purpose, the design and organizational integration of roadmaps can and should be adapted. In the 2015 field study, the main areas of application where strategic and technology planning, followed by R&D planning and the planning of product or service development. These areas were broadly confirmed again in the update. The distribution of the areas of application is shown in Figure 2.

Figure 2:
'For what purpose(s) are roadmaps used in your organization?' (n=190, multiple answers possible)



Feedback from the participants indicates that production planning plays a role in only a few organizations, which is similar to the findings from the 2015. It can be observed that business model planning has gained in importance compared to the results of the 2015 study. Insights into how organizations map business models on the roadmap - whether through separate levels or in combination with products, services, or solutions - would be interesting in this regard.

As the level of know-how on the roadmapping method increases, so does the respective share of strategic planning, technology planning and business model planning, which is shown through a positive correlation. It is also interesting to note a negative correlation of organizational size by number of employees with the use of roadmaps for strategic planning. The number of organizations that indicate strategic planning as an area of use of roadmaps decreases with size, from a proportion of 100 % of small organizations to 69.8 % of organizations with over 2000 employees.

3.2 Content of roadmaps

In terms of content, as with the areas of application, there is little deviation from the results of the previous study. The focus of the participating organizations is on products, strategic options or objectives, and technologies (see Table 2).

Table 2: *'What is the content of roadmaps in your organization?'* (n=189, multiple answers possible)

Content	Percentage
Products	62.4 %
Strategic options / objectives	59.8 %
Technologies	57.1 %
Projects	53.4 %
Features / functions	43.4 %
Processes	27.5 %
Business models	25.9 %
Components	25.4 %
Markets	23.3 %
Trends	22.2 %
Figures of merit	10.6 %
Technical models	10.1 %
Financial models	7.9 %
Other	5.3 %

Similar to the area of application, business models have gained in importance as a content compared to the 2015 study. It is also noticeable that competences were only stated by two organizations under the item '*Other*'.

It can be observed that participants with higher levels of knowledge on roadmapping increasingly mention products, technologies, and business models as content of their roadmaps. A correlation also exists between content and sectors. Products are the focus of attention in manufacturing (C) - in contrast, significantly less in public administration, social security, education (O, P, Q, U).

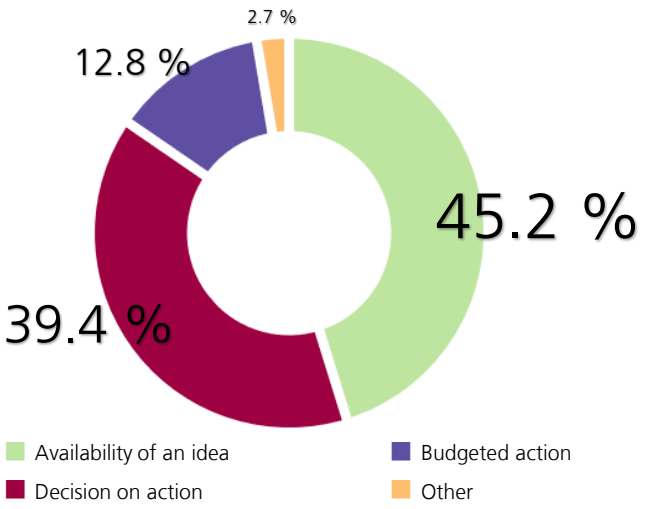
3.3 Adding and removing objects

One of the challenges of roadmaps is to keep them continuously updated and maintained across different organizational levels and areas. An important part of doing so is the specification of criteria for adding and removing objects.

Adding objects to the roadmap

Among the options proposed for creating items on the roadmap were (1) availability of an idea, for example in the form of a product, technology, or project idea, (2) decision on action, for example for engaging in a project, for product or technology development, or (3) budgeted action for development projects.

Figure 3:
'*What is the level of maturity necessary for an object to be positioned on a roadmap in your organization?*' (n=188)



As shown in Figure 3, the most frequently mentioned criteria among the participants of the study were that of an existing idea, followed by decision on action and then, with a considerably lower number of mentions by budgeted action. For the option '*other*', for example, reaching pre-study level or identifying technological value for the market were mentioned as criteria to include objects on the roadmap.

The assignment of the criteria for creating objects on a roadmap corresponds in its order and with only minor deviations of less than 10 % in each case to the results of the 2015 study with the highest deviation for the option of budgeted action which was chosen by a lower share of participants in the current study.

Removing objects from the roadmap

The question on criteria for removing items from the roadmap was designed differently than the question on adding object. First, the question was if criteria for removal are defined. If answered positively, three fields were provided to name the most important criteria.

The question was answered positively including the naming of criteria by 86 of the 190 participants. For the evaluation, the criteria for removing objects from the roadmap were thematically clustered and categorized. As shown in Table 2, strategic and financial criteria are the ones most frequently used, followed by the maturity level. For the category '*termination of project or topic*', no additional criteria were given by the participants.

Table 3: '*Do any criteria exist in your organization for the removal of objects from the roadmap? If yes, which ones?*' (n=190, thereof n=86 with positive feedback. Multiple answers possible when specifying criteria)

Criteria for removal defined	**Percentage (n=190)**
Yes	45.3 %
no	54.7 %
Category (Multiple answers possible)	**Percentage (n=86)**
Strategy	44.2 %
Finance	37.2 %
Maturity level	32.6 %
Termination of project / topic	25.6 %
Technical feasibility	9.3 %
Market	4.7 %
Human resources	4.7 %
Surroundings	4.7 %
Other resources	2.3 %

The proportion of participants providing criteria for removing objects is slightly higher compared to the 2015 study. The lack of resources named by participants 2015 as a criteria for removal was further detailed by participants in the categories '*finance*', '*human resources*', and '*other resources*'.

4 Organizational Integration of Roadmaps

In the area of organizational involvement, the focus is on roles and responsibilities of roadmaps, on the level of knowledge about roadmapping, and the framework of organizational involvement, such as the time horizon, the update intervals and the processes associated with roadmaps.

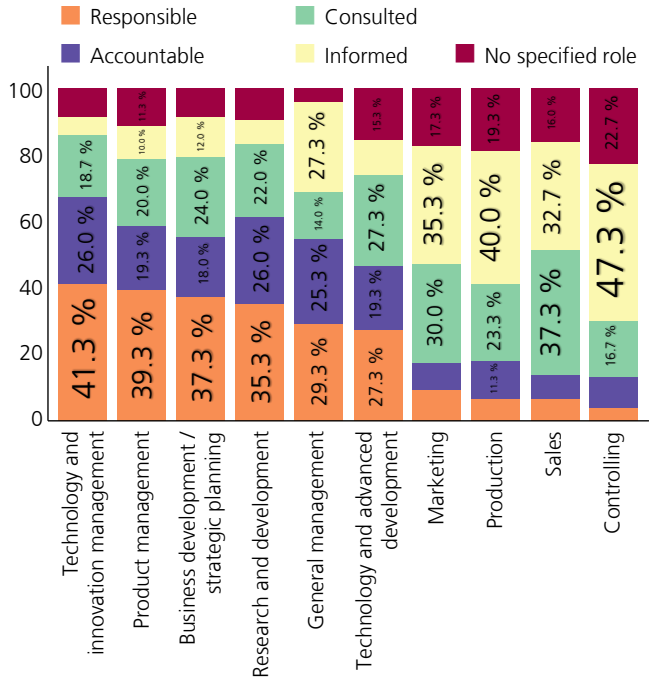
4.1 Roles and responsibilities

The categorization of the responsibility assignment matrix, also known as the RACI matrix, was used to query roles and responsibilities. This detailing of the roadmap responsibility question asked in the 2015 study divides the stakeholders involved in an activity into responsible, accountable, consulted and informed according to their type of involvement, as described in more detail in Table 4 (PMI 2013). The results to the question on the allocation of roles and responsibilities are shown in Figure 4.

Table 4: Categories of the responsible assignment - RACI matrix in the context of roadmapping

Category	Description
Responsible	Responsible for the development, maintenance, and updating of roadmaps
Accountable	Accountable for the content of roadmaps
Consulted	Consulted for the development, maintenance, and update of roadmaps
Informed	Informed about the development, maintenance, and update of roadmaps

Figure 4:
'*What roles do exist for roadmapping in your organization?*'
(n=150, multiple answers possible)

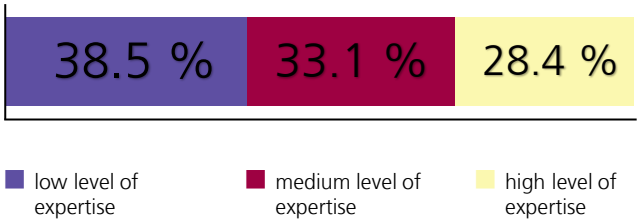


The current study confirms the results of 2015. Technology and innovation management is the functional area most frequently responsible for roadmapping. Compared to 2015, general management is less frequently mentioned as responsible. Controlling and production are the functional areas most frequently informed. Considering production an area that is more and more frequently driving innovation the rather passive classification of responsibilities seems interesting. Sales on the other hand has a more active role, shown by its first position in the mentioning as '*consulted*'.

4.2 Level of expertise in roadmapping

In our original assumption for the study, we had assumed that roadmapping would enjoy increasing popularity. The consistency of popularity with the level of expertise on roadmapping in the participating organizations enables an assessment of the potential for use beyond individual technologies or projects as an integrative tool for different business and organizational areas.

Figure 5:
'How would you describe the level of expertise in roadmapping in your organization?' (n=148)



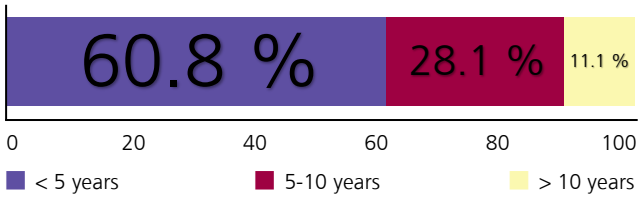
The level of expertise was surveyed in relation to the temporal dimension. Less than two years of sporadic experience with roadmapping was regarded as a low level of expertise, two to five years of occasional experience as a medium level of expertise. Those organizations with more than five years of experience in roadmapping embedded within organizational systems and processes were deemed to have a high level of expertise. Correlations associated with the level of expertise are of particular interest and are given separate attention in this study as a cross-cutting issue. These have been examined for all characteristics and framework conditions queried and can be found in the respective description, in case correlations were identified.

Since 2015, the distribution of the level of expertise among the participants has changed only slightly. The distribution is shown in Figure 5, with a predominant proportion assessing the level of expertise of their own organization as low or medium.

4.3 Time horizon and updating frequency of roadmaps

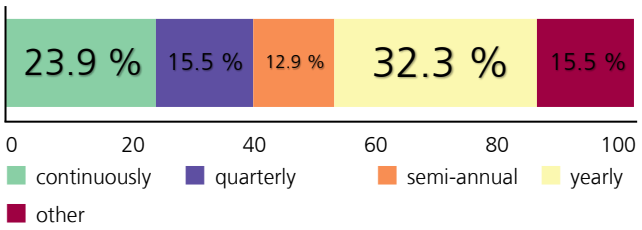
The classification of roadmapping as a planning tool raises the question of which time horizon is depicted in the roadmaps of participating organizations. Basically, operationally oriented roadmaps that map details, tend to cover short time horizons. Strategic roadmaps, on the other hand, support longer-term planning. The update intervals of roadmaps are similar. For the use of roadmaps in individual organizations, in addition to the classification between operational or strategic use, the development intervals and the volatility of the industry or technologies used are important influencing factors for time horizon and updating intervals.

Figure 6:
'Which time horizon is covered by roadmaps in your organization?' (n=153)



As shown by the distribution in Figure 6, only a few of the participating organizations work with roadmaps that include a time horizon of more than ten years. For almost two thirds of the participants, the time horizon is less than five years. The significant correlation of the time horizon covered with the size of the organization is also interesting, with larger organizations tending to have shorter time horizons than smaller ones. The proportion of organizations using roadmaps for time horizons beyond ten years has increased significantly from 2.5 % to 11.1 % since 2015. Of course, it must be considered that the composition and number of participants differ between the two studies.

Figure 7:
'How often are roadmaps updated in your organization?' (n=155)



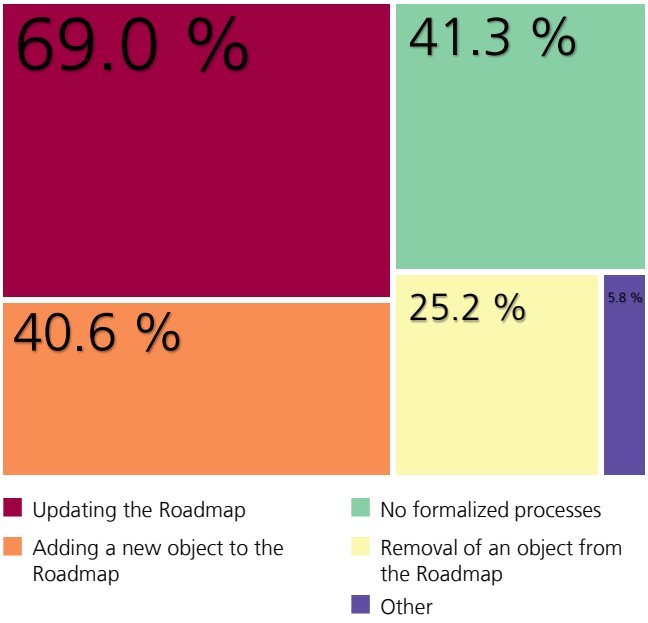
As shown in Figure 7 and analogous to the results of the 2015 study, annual updating of roadmaps is the most frequent choice. Continuous updating was mentioned slightly less frequently and biannual updating significantly less frequently than in 2015. The comments for this question highlighted the irregular and content-dependent update as well as an update at longer intervals of between two and five years.

4.4 Processes of roadmapping

In roadmapping a distinction can be made between the process for setting up and organizationally implementing roadmapping and the processes required to use it. In the survey we focus on organizations that use roadmapping and therefore on the processes that are applied during this use. For the question we asked for the specifications of processes for some of the most important activities for the use of roadmapping. These include adding new objects to the roadmap, updating existing objects and removing objects from the roadmap.

As shown in Figure 8, most of the participating organizations have defined processes in the context of roadmapping. The most common process seems to be the updating of the roadmap, whereas the removal of objects from the roadmap is only defined as a process in a quarter of the participating organizations.

Figure 8:
'For which of the following activities do you have defined processes available?' (n=155, multiple answers possible)



Comparison with the results published in 2015 is only possible with a few adjustments. In the roadmapping field study 2015, 54 out of a total of 81 participants had stated that they had processes defined. Percentages were calculated based on positive answers. Adjusted to the total number and including the participants in whose organizations no processes are defined, the percentage of organizations in which processes are defined in the context of roadmapping has remained the same. In the update of the study, however, the share of organizations that have defined processes for updating their roadmaps is almost 15 % higher than in 2015.

It is interesting to note that significantly more organizations have specified criteria for removing objects from the roadmap (see Table 3) than defined processes for removing objects. It seems that criteria work well without processes defined.

Looking at correlations, it can be observed that with an increasing level of knowledge, the proportion of organizations that have defined processes also increases. Looking at the kind of processes, it shows that the proportion of organizations that have defined processes for adding and removing items from the roadmap as well as for updating increases with the number of employees.

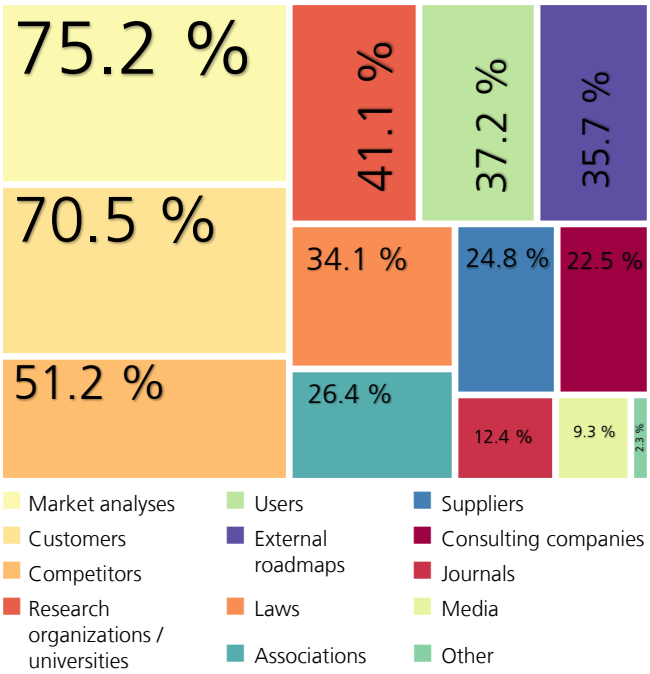
5 Information Sources, Methods, and Tools to support Roadmapping

The use of information sources and of complementary methods and tools has an essential influence on the quality of roadmaps. In this area of the survey, we addressed the following questions: What are the main sources of information used in the context of Roadmapping? What methods are used and to what extent is roadmapping software and automated data analysis used?

5.1 Information sources

The sources of information used influence what kind of information is included in the roadmap and could thus provide clues to its content, its quality, and the associated objectives. For example, scientific publications usually have a lower degree of maturity for implementation than patents or information from the competitive environment. The usage of peer reviewed or validated information sources can indicate a higher level of quality. In addition to the type of information source, the thematic origins of the information can indicate whether an organization is planning more incremental improvements solely in its own field of activity, or whether looking beyond the industry also suggests larger innovation steps. Figure 9 shows the distribution of external sources of information mentioned among participants.

Figure 9:
'What are the five most important external information sources used for updating roadmaps in your organization?'
(n=130, multiple answers possible)



Among the sources of information mentioned, the market plays a dominant role. The most frequently mentioned information sources, similar to the results in 2015, are market analyses, customers, and competitors. In this context, it is noticeable that the market-oriented organizational areas, such as marketing and sales, take on a rather passive role in roadmapping, classified as being '*informed*' in the RACI matrix (see Figure 4). On fourth position, also like in 2015, research organizations and universities are mentioned as an information source for roadmapping.

There are correlations between sector affiliation and sources of information such as trade journals or consulting companies. Trade journals are used frequently in public administration, social services, and education (O, P, Q, U) as well as transportation and storage (H) and rather rarely in manufacturing (C). Consultancy firms are used as a source of information very frequently in electricity, gas, steam, and air conditioning

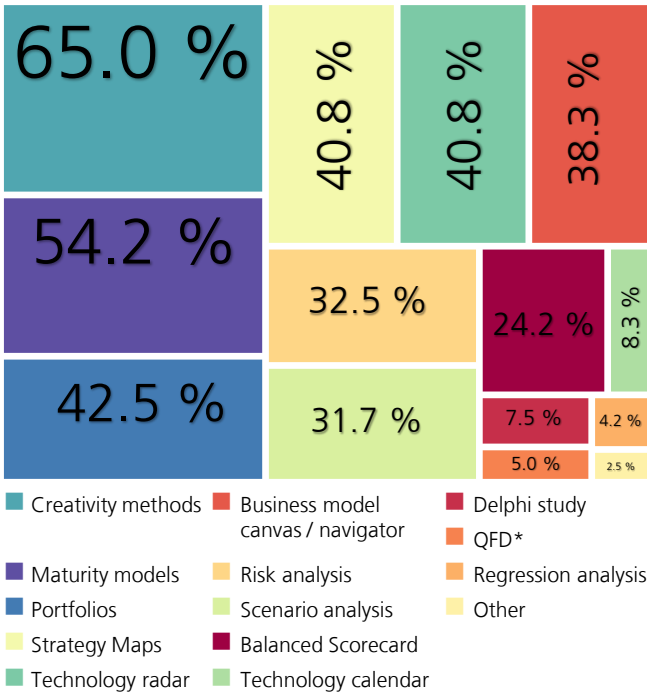
supply (D) and much less frequently in information and communication (J) or services (K, M, N, S, R).

5.2 Methods

In 2015 we have asked about the use of methods on a generic level. We detailed the question in the update to find out what specific creativity methods, portfolios and maturity models are used.

In the 2015 study, portfolios and creativity methods were mentioned by almost half of the participants (43.3 % and 41.7 %, respectively), while maturity models were only mentioned as a method used by 10.0 % of the participants. The proportion of participants using portfolios is similar in the current study, while the proportion using creativity methods and maturity models is significantly higher than in 2015 (see Figure 10).

Figure 10:
'Are creativity methods / portfolios / maturity models used in your organization in the context of roadmaps? Which methods are used in your organization to feed or complement roadmaps?' (n=120, multiple answers possible)



Additionally, information on the interaction between supporting methods and roadmapping was detailed in the update. Below is an overview and short description of the methods mentioned most frequently:

- **Creativity methods:**
  Supporting the collection and development of ideas for inclusion in the roadmap.
- **Maturity models:**
  Evaluation of objects based on the maturity level with a view to the distance of application.
- **Portfolios:**
  Classification and evaluation of options based on two valuation axes, combined with other factors if necessary.
- **Strategy maps:**
  Alignment between strategy and roadmaps, allocation of R&D resources.
- **Technology radar:**
  Transition from scouting and monitoring of technology developments and trends into development, input for the roadmap.
- **Business model canvas or navigator:**
  Detailing and evaluating objects on the roadmap, especially through value proposition.
- **Risk analysis:**
  Assessment of options and objects of the roadmap for internal and external stakeholders.
- **Scenario analysis:**
  Long-term planning, comparison of different options and future scenarios.
- **Technology calendar:**
  Input on new technology options, and expert search.

In respondence to the option 'Other', the importance of contacts at trade fairs and workshops was highlighted, along with user involvement in surveys and focus groups.

There is a negative correlation between the size of participating organizations and the use of creativity methods, which means that creativity methods are used in a higher proportion in small organizations. It can also be observed that the use of some methodological approaches increases proportionally with the level of know-how on roadmapping. This is the case for creativity methods, maturity models, strategy maps, the technology radar, technology calendars and quality function deployment (QFD).

In addition to the use of creativity methods, portfolios and maturity models, participants were also asked to specify the exact methods. The answers to these questions are briefly presented and explained below.

Types of creativity methods

Creativity methods are the methodological approach used most often to complement roadmapping, both in 2015 and in the current update. They are especially meant to support the early phases of the innovation and planning process. At least one creativity method was named by 65.0 % of participants. Among the total number of creativity methods that are used in combination with roadmapping, brainstorming is mentioned most frequently, followed by design thinking and scenario analysis. The consideration of the scenario analysis as a creativity method emerging from participants responses indicates a discrepancy

between literature and practice. In literature, this method is rather classified as a foresight method.

Portfolio models and assessment dimensions

In the context of this study, portfolios are understood as the classification and evaluation of objects in a mostly two-dimensional view (i.e. '2x2 matrices' or 'bubble charts'), in which the size of the objects is sometimes used as a third dimension for visualization. In contrast to the question on the use of creativity methods, common examples for portfolios from innovation and technology management referring for example to Markowitz, Pfeiffer as well as the risk-reward technology portfolio matrix developed by Arthur D. Little were mentioned in this question.

Among the participating organizations, 42.5 % answered the question '*Are portfolios used in the context of roadmaps in your organization?*' with the indication of at least one portfolio. The results were classified to include explicitly named portfolios as well as their categories and assessment dimensions in the analysis.

Among the most frequently named portfolio models are the investment portfolio approach of Harry M. Markowitz (Markowitz 1999, 1952), technology portfolio management according to Werner Pfeiffer (Pfeiffer et al. 1982) as well as the product-market portfolio matrices of GE McKinsey (Wind 1975) and the Boston Consulting Group (Henderson 1970). Although current portfolio approaches relating to business models, platforms, and intellectual property are also mentioned occasionally, the more traditional models still seem to be applied most frequently. The category of portfolios is also understood by many participants to include cost-benefit analysis, which is usually not attributed to this category in literature.

Table 5: List of most frequently mentioned assessment dimensions used in portfolios among participants using portfolios in the context of roadmapping (n=51, multiple answers possible)

Dimension	Percentage
Return	15.7 %
Risk	15.7 %
Technology attractiveness	13.7 %
Effort	11.8 %
Strength of resources	11.8 %
Competitive strength	11.8 %
Market attractiveness	9.8 %
Strategic fit	7.8 %
Benefit	5.9 %

The most frequently mentioned assessment dimensions used in portfolios are shown in Table 5. It is surprising that the dimension of technology maturity, which is often considered a basic element for roadmaps, seems to be used only very sporadically in portfolios. However, this may also be because maturity models are a separate category of the questions in this survey (see below).

Maturity models

Maturity models represent an important class of assessment for temporal classification and planning, applicable across levels or areas. Within the question '*Are maturity models used in your organization in the context of roadmaps? If yes, name the most frequently used maturity models*', technology readiness levels TRL (Olechowski et al. 2020) the capability maturity model CMM (Paulk et al. 1993) and the digital maturity model DMM (Gervasi et al. 2021) were mentioned as examples. More than half (54.2 %) of participants indicated that they use at least one maturity model in the context of roadmaps (n=120).

By far the most frequently used maturity model is the TRL framework for managing technological development (69.2 % of the participants), followed by CMM for managing capability development (13.8 %), DMM for development of digital systems (12.3 %), with 6.2 % of respondents reporting the use of customized, organization-specific maturity models. In contrast to the high importance of market-oriented information sources among the participants, market readiness levels (MRLs) are only occasionally mentioned.

Compared to the 2015 roadmapping field study, the proportion of participants using maturity models (10.0 % at that time, 54.2 % of participants in the current study) is significantly higher in the update -

which may be due to a higher level of awareness of the models now, as well as the more detailed questioning.

5.3 Tools

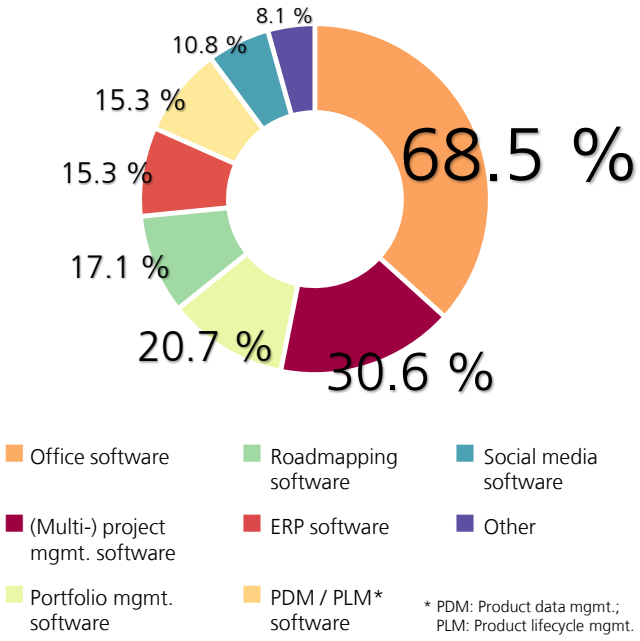
Tools include software solutions that support the process of roadmapping, as opposed to methodological support. This also includes tools for automated data analysis and processing, which are used as to gather input for the roadmap or for the evaluation of its content.

The low proportion of participants in our roadmapping field study 2015 (14.7%, n=68) who were using dedicated roadmapping software at the time prompted us to compile an overview of available roadmapping software (Abele et al. 2017). The advantage of dedicated software solutions for roadmapping is manyfold, including the decentralized maintenance and a data-based structure that allows the use of roadmaps at different levels of detail. In addition, role concepts and visualization options also play an important role, especially as motivation for maintenance and further development as well as for communication (Schimpf and Lang-Koetz 2019).

Roadmapping software

For the question '*Which information technologies are applied in your organization for the consolidation, update, and visualization of roadmaps?*', we have deliberately kept the space for answers quite broad and included as options, for example, social media solutions, enterprise resource planning ERP software, project management software and office software. Office software is used most frequently (68.5 %), followed by project management software (30.6 %) and portfolio management software (20.7 %) (see Figure 11).

Figure 11:
'*Which information technologies are applied in your organization for the consolidation, update, and visualization of roadmaps?*' (n=111, multiple answers possible)



Since we did not ask for further specification of the detailed usage, only the categories most frequently mentioned will be discussed here. The category of office software was dominated by presentation and spreadsheet software. The category of (multi-) project management software includes both generic project and task management solutions as well as those specifically intended for the management of agile projects. Portfolio management software includes both specialized software solutions and those offered in the context of customer relationship management CRM or enterprise resource planning ERP solutions. The list of roadmapping software used is shown in Table 6.

Table 6: List of roadmapping software specified in the category '*Roadmapping software*' responding to the question '*If yes, which?*' (out of 19 participants using roadmapping software, the solution was specified by 16 of the participants)

Roadmapping software or supplier	Frequency
ITONICS	4
Sopheon	2
Atlassian	2
In-house development	2
Sharpcloud	2
Condeco	1
JOIN	1
AHA	1
Mindjet	1

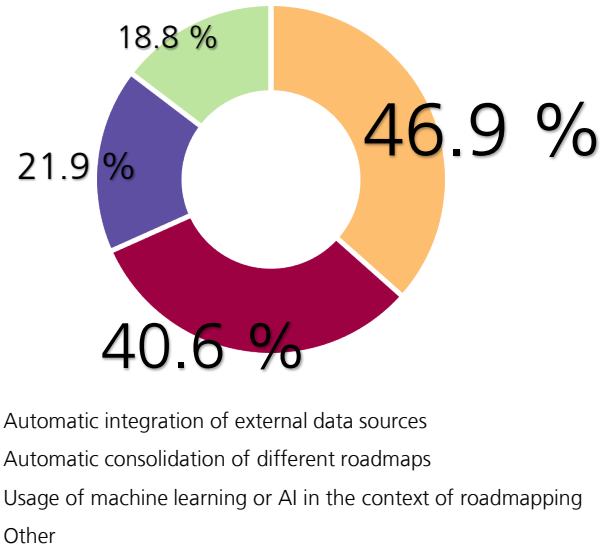
In comparison to the results of 2015, it is particularly noticeable that product data management PDM, product lifecycle management PLM, and portfolio management software are mentioned significantly more often. At the same time, the number of participants who use office solutions for roadmapping has declined somewhat.

Automatic data analysis

Topics such as data analysis, machine learning and artificial intelligence AI are already an integral part of our everyday lives, and the trend towards higher performance and more widespread use is clearly emerging. In the innovation process and thus, for example, in the strategic and operational planning of products, processes, technologies and competences, an increasing importance of this topic can therefore be assumed, just as in many other areas. (Fraunhofer Group for Innovation Research 2018; Fraunhofer Group for Innovation Research 2021). During the finalization of this study, this topic area gained additional awareness through the developments in the area of generative artificial intelligence.

The question of whether automatic data analysis tools are used in the context of roadmapping was answered positively by slightly more than a quarter of the participants (28.6 %). The details of the answers to this question are shown in Figure 12.

Figure 12:
Breakdown of positive responses to the question '*Does your organization apply automatic data analysis tools for generating, updating, or consolidating roadmaps?*' (n=32 who answered positively to the question on use out of a total of n=112, multiple answers possible)



Among the option '*Other*', the use of automatic data analysis, market research and the automatic adjustment of schedules were mentioned.

6 Best Practices and Pitfalls in Roadmapping

Recommendations from participants that have already gained experience with roadmapping are among the most valuable insights of this study. This area is divided into methods, structures or processes that have proven to be recommendable, the biggest future challenges in the use of roadmaps, and pitfalls for the implementation, consolidation, updating and visualization of roadmaps – all from the perspectives of the participants.

The answers to these open questions were clustered in a text analysis, categorized according to the focal points, and ordered by nominal frequency. The results of this analysis are presented below.

6.1 Recommendations for successful methods, structures, and processes

Among the methods, structures and processes mentioned as recommendations, a high variance of different topics was raised. They include the following, in order of descending nominal frequency, answering the question '*Are there methods, structures, or processes used in your organization that you would recommend to other organizations in the context of roadmapping? If yes, which ones and why?*':

- **Team and stakeholder**
  The most frequently mentioned cluster revolved around the roadmapping team, partly with the recommendation to form a cross-functional team or a bottom-up approach as well as the recommendation of a clear top management mandate, moderated workshops, and training on roadmapping procedures for the teams involved. In addition to the team and its competences, the involvement of stakeholders was repeatedly emphasized as a success factor. Recommendations included alternating responsibilities for updates and maintaining a degree of freedom for departments.
- **Strategy and trend management**
  The existence and regular update of a strategy was frequently emphasized by the participants. This includes technology strategy as well as market and product strategy, complemented by pragmatic recommendations such as regular strategy meetings and methodological approaches. Methods recommended included bottleneck-focused strategies, blue ocean strategy tools or open strategy. In addition to strategy, continuous trend and technology scouting was also named as a recommendation.
- **Process, in- and output of roadmaps**
  Both self-developed approaches and methods from the Institute for Manufacturing IfM Cambridge were recommended particularly frequently for roadmapping itself. The involvement of users or consumers, patents, supplier roadmaps and the competition were mentioned as inputs. Downstream in roadmapping, the link to projects and multi-project management was recommended, as was a clear distinction between roadmapping and project management.
- **Methodological approaches in roadmapping**
  Among the methodological approaches recommended in the context of roadmapping were, for example, business model development, the use of a stage-gate process and agile methods such as SCRUM or agile technology and innovation management.

The recommendations in comparison to the results of 2015 were aligned in terms of the most frequently mentioned issue, which concerned the consistency of the roadmap across different planning levels. Likewise, the mix of top-down and bottom-up approaches can be found in current recommendations on team, competences, and stakeholders. The unified approach, the third cluster of recommendations in 2015, overlapping in the current update in the recommendation on the methodological approach as well as in the one on strategy and trend management. Of course, the current recommendations are shaped by the transformation of innovation systems that organizations are increasingly confronted with today. Recommendations were formulated by 53 of the participants in the update.

6.2 Future challenges in roadmapping

In addition to the recommendations, participants were then asked about the challenges related to roadmapping, they expect to face in the future. To the question '*Where do you see the biggest future challenges in the application of roadmaps in your organization?*', which was answered by 82 of the participants, the most frequently mentioned topics in descending order of nominal frequency were the following:

- **Commitment of management and stakeholders**
  The most frequently mentioned challenge was the commitment of the stakeholders in the participants' organizations. This includes top management as well as all the departments involved. Additional challenges mentioned were acceptance of the approach of roadmapping, discipline in its application and the binding nature of roadmaps in the organization.
- **Future content**
  The content challenges of roadmaps, although frequently mentioned, contained little commonality. Recurrently, the challenge of software to support roadmaps was mentioned, as well as the systematic development of roadmaps. Thematically, topics such as sustainability, security, regulatory aspects, and competence management were mentioned as challenges.
- **Technology and market perspective**
  In the technology and market perspective, the perception of turbulent environments regarding both technology and market developments were mentioned as challenges. This includes the integration of user requirements as well as technology impact assessments and, in a broader sense, technology and innovation management in these turbulent environments.
- **Holistic thinking and integration**
  The challenge of a holistic and integrated application of roadmapping is closely associated with the level of organizational and senior management commitment. For example, the mapping of the entire organization and the value chain as well as the synchronization of the planning of different business areas or departments were mentioned as a future challenge to create planning transparency in the organization or beyond and to being able to plan increasingly complex systems.

The three most important challenges mentioned in the 2015 roadmapping field study were holistic understanding in a first place, followed by the development of structured processes and the availability of resources for roadmapping. The aspects of considering technology and market perspectives as well as the naming of future contents as challenges, which were both frequently mentioned in the update, are signs that reflect an increasing volatility and uncertainty in innovation systems.

6.3 What to avoid...

The objective of the third question was to identify the main pitfalls related to roadmapping. To the question 'Based *on your experience, what is important to avoid when implementing, consolidating, updating, and visualizing roadmaps?*', the following aspects were highlighted by 75 of the participants (to be avoided):

- **...too much detail and complexity**
  By far the most frequently mentioned point by the participants on what to avoid was an exaggerated level of detail and complexity, and the associated lack of focus of roadmaps. Also mentioned as to be avoided was the attempt to depict all future projects or the use of beautiful but excessively complex visualizations.
- **...undefined processes and responsibilities**
  Under this point, lack of structures, lack of governance and the slowing down of roadmaps through centralized processes and the application of unsuitable performance metrics were mentioned to be avoided.
- **...lack of stakeholder involvement**
  Among the lack of involvement of stakeholders, the involvement of relevant organizational areas, including technical and R&D departments, was mentioned most often. Early communication of roadmaps that have not yet been completely agreed upon, was also mentioned as something to be avoided.

Compared to 2015, most important pitfalls were relatively similar. Among the answers, too much detail and complexity were mentioned most often and the pitfalls in the overall approach and the processes of roadmapping on a second place by number of mentions.

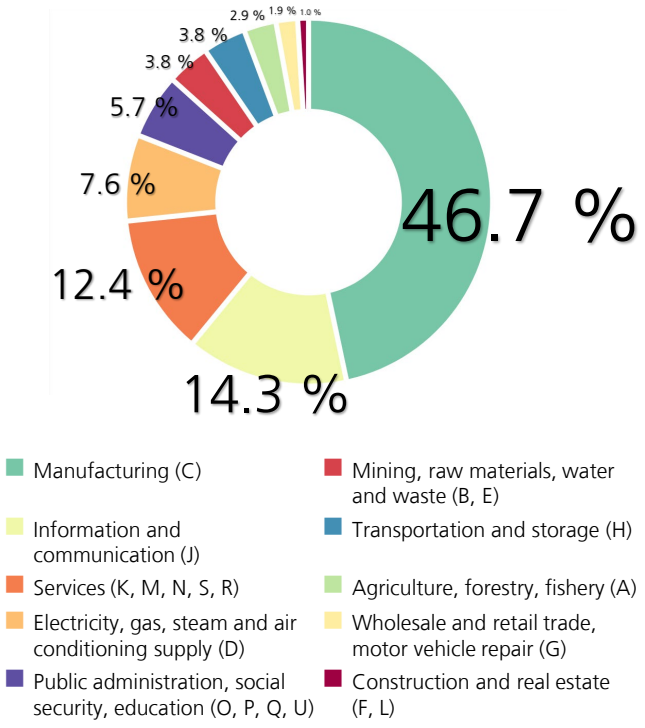
7 Participants of the Study

With a total of 432 accesses, participation in the survey for the current update was considerably higher than in the 2015 roadmapping field study, which is certainly also due to the international coverage. For the analysis, based on the completeness of answers provided, 190 of the data sets were considered. In some of these, not all questions were answered, which is made transparent in the individual evaluations by the size of the respective sample.

7.1 Sector affiliation

Almost half of the participating organizations that provided information on sector affiliation come from the manufacturing sector. The further breakdown of participants (according to NACE rev 2) can be found in Figure 13.

Figure 13:
Sector affiliation of the participating organizations according to the question '*In which sector does your organization operate? (According to NACE rev. 2)*' (n=105)

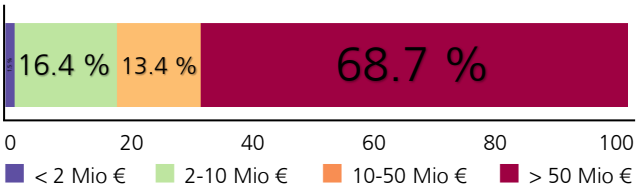


The sector affiliation of the participating organizations compared to the 2015 roadmapping field study is not entirely trivial, due to the change in categorization of sectors between the 2015 study and the update. However, the then predominant share of participants from plant and mechanical engineering, equipment manufacturers and the automotive industry is reflected in the share of manufacturing. The share of participants from services has grown to a double-digit percentage in the update compared to 2015.

7.2 Size of organizations

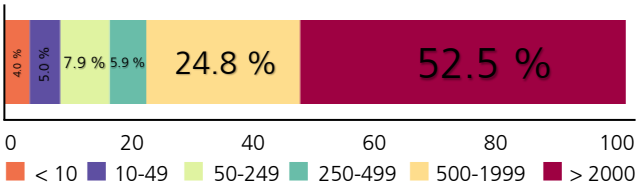
The participants in the survey are mostly larger organizations with an annual turnover of more than 50 million euros and more than 2000 employees and only a small proportion of micro-enterprises with an annual turnover of less than 2 million euros (see Figure 14). Due to the focus of the study on organizations that use roadmaps and in view of the added value of roadmaps especially in dealing with complex systems in innovation, technology, and strategy development, this seems hardly surprising.

Figure 14:
Annual turnover of the participating organizations according to the question '*What was the annual turnover of your organization 2020?*', each converted into euros using the exchange rate of the 31th December 2020 (n=67)



In accordance with the EU Directive on enterprise size classification (2003361/EC), only a small proportion of the participating organizations (16.9 %) can be classified as SMEs with fewer than 250 employees. Analogous to the organizational size according to turnover, a majority of participants represent organizations with more than 2000 employees (see Figure 15).

Figure 15:
Number of employees of the participating organizations according to the question '*How many people were employed by your organization in 2020?*' (n=101)

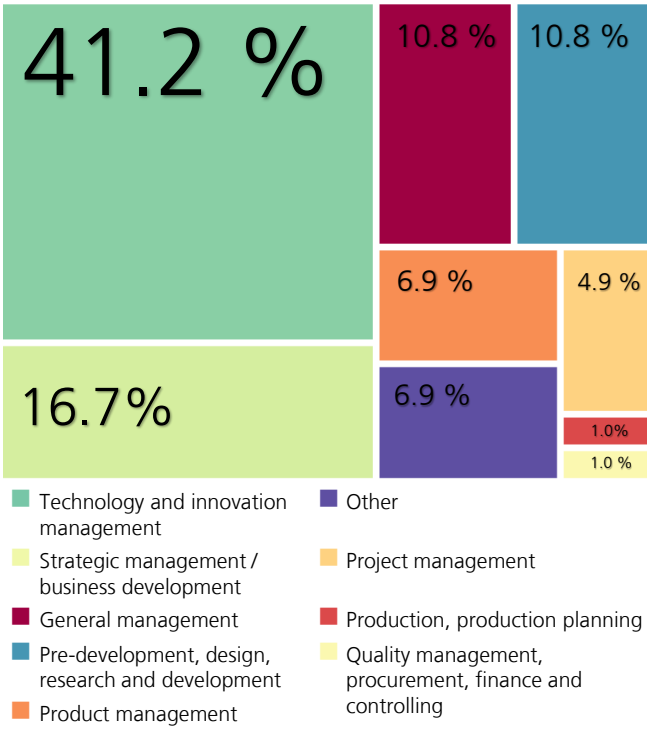


Compared to the 2015 field study, the share of large organizations in terms of the number of employees and annual turnover is almost 15 % higher in the current update.

7.3 Functions of the participants

The largest proportion of participants work in technology and innovation management, followed by strategic and business development (see Figure 16).

Figure 16:
Functions of the participants according to the question '*In which function do you work in the organization?*' (n=102)



The distribution of participants represented is more concentrated in technology and innovation management than it was in 2015, with, at that time only about a quarter coming from this functional area. The proportion of participants from representing strategy and business development has also increased significantly.

7.4 Survey sample

Due to its size, distribution and methodological approach, the sample of the survey does not claim to be representative, neither of a group of organizations nor of a specific sector. Like the 2015 roadmapping field study, it is intended to provide a spotlight on current practices to identify approaches for action and improvement for the use of roadmaps and roadmapping as a whole. Likewise, the insight into the current state in the field allows the extraction of scientific challenges and research needs.

Thanks to the cooperation between international scientific institutions, contact persons from a wide range of nations participated in the survey. In terms of the total number of accesses, the use of the German and English surveys was similar, with over two hundred accesses each. Regarding the currency of the annual turnover, the majority were given in euros, followed by dollars and British pounds.

8 Résumé

In organizations that are struggling with new challenges such as increasing complexity, higher volatility, technological convergence and growing uncertainty of global value chains, the use of roadmaps is becoming increasingly important. Not only can interfaces be made transparent today, but future planning options can also be addressed, evaluated, and projected into the future, interlinking different departments or business units or external partners.

A lot has happened since the 2015 roadmapping field study. Governments came to power that the public had only partially (or not at all) expected, unforeseen changes in the composition of alliances of states have occurred, a global pandemic has kept the world in suspense, armed conflicts with international linkages are on the rise, and sustainability has become a priority looking at a looming threat of climate change and global warming. In the context of these developments and events, combined with a general rise of complexity in most innovation systems, effective and efficient strategic planning has become more important, but not necessarily easier.

The roadmapping method has not stood still in its development either. In particular, the technological possibilities for software support, visualization and automatic data analysis have constantly evolved. In addition, there is increasing support for the integration of different methodological approaches for the identification, evaluation, and planning of objects on a roadmap, with increasing consideration of the possible impact of targeted developments in corresponding innovation ecosystems.

The high number of participants in this rather specialized study confirms a constant and steadily growing interest in this topic. As was to be expected, the increased interest in the topic of business model development is shown in the results of this study. As in 2015, on the other hand, the low presence of production planning in the roadmaps seems surprising and probably only partially does justice to the role of production today. Another interesting point is the inconsistency between information sources used and functional areas involved. Look at the results of the update, market-oriented information sources are at the top of the priority list, whereas market-oriented organizational units are to a major part involved in a passive role. Similar to the results of the 2015 roadmapping field study, office software is still the solution chosen by a large majority of participants. The question is whether this is the best available solution or whether better solutions should be considered – or developed.

However, it is not only the open questions on recommendations, future challenges and pitfalls that have shown that roadmapping is an interdisciplinary approach that can be used in a highly flexible way. Successful roadmapping requires a high level of commitment from all actors involved. In this sense, and with reference to all those who have contributed to the development of our road and world maps:
'*Be a Roadmap Maker!*'

We would like to express our sincere gratitude to the participants of the study! Without their commitment, such an analysis would not be feasible. We would also like to thank all the other supporters who helped to get the roadmapping field study *off the ground in a second edition.*

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The Authors

Prof. Sven Schimpf is Managing Director of the Fraunhofer Group for Innovation Research and Professor of Innovation and Interdisciplinarity Research as well as director of the Institute for Human Engineering & Empathic Designs HEED at Pforzheim University. In addition to the connections between interdisciplinarity, innovation and technology planning and the management of potentially disruptive innovations, he supports companies in the development and integration of roadmaps and their combination with innovation methods of strategic and operational planning.

Dr Robert Phaal has been a member of the Centre for Technology Management at the Institute for Manufacturing IfM, University of Cambridge since 1997. He is a mechanical engineer with a PhD in computational mechanics and has industrial experience in technical consultancy, contract research and software development. His research focuses on the field of strategic technology and innovation management (STIM). He is particularly interested in the emergent dynamics of technology-based industries and the development of practical management tools and toolkits.

Prof. Olivier L. de Weck is Professor of Astronautics and Engineering Systems in the Apollo Programme at the Massachusetts Institute of Technology in Boston. He conducts research in the field of engineering systems. His focus is on the interdependence of new technologies with the design of complex systems such as aircraft, spacecraft, products, services, and industrial ecosystems and how these evolve over time.

Prof. Thomas Abele is managing director of TIM CONSULTING, which he founded in 2009 and which specializes in projects, training, and audits in the field of technology and innovation management. In parallel he is Professor FOM International University where he coordinates the Competence Center for Technology & Innovation Management KCT.

CRediT authorship contribution statement

Sven Schimpf: conceptualization, methodology, formal analysis, writing – original draft, visualization, supervision.
Robert Phaal: conceptualization, writing – original draft.
Olivier L. de Weck: conceptualization, writing - review & editing.
Thomas Abele: conceptualization, methodology, writing - review & editing.

Contact / Imprint

Contact

Fraunhofer Group for Innovation Research
Nobelstraße 12, 70565 Stuttgart, Germany
http://www.innovation.fraunhofer.de

Prof. Sven Schimpf
sven.schimpf@innovation.fraunhofer.de

Dr. Robert Phaal
rp108@cam.ac.uk

Prof. Olivier L. de Weck
deweck@mit.edu

Prof. Thomas Abele
thomas.abele@tim-consulting.de

friendly
Review

Prof. Tugrul U. Daim, Portland State University
Prof. Ralf Isenmann, Wilhelm Büchner University
Prof. Peter Ohlhausen, Fraunhofer Institute for Industrial Engineering IAO and Reutlingen University

Proofreading

Azra Dania, Fraunhofer Group for Innovation Research; Sabrina Weitz, TIM Consulting

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