



Software-Supported Roadmapping in the Innovation Process

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Abstract

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Technology roadmaps enable decision-makers to forecast and plan the development trajectories of (future) technologies. As a visual communication medium, a roadmap shows the development of an entity over time and links the resources required to create that entity and the intended markets.

This information serves as important input in the decision about technologies to be used in the future or technological developments. Despite the obvious advantages of roadmapping, it is only used selectively in practice. The considerable cost and effort involved in creating and updating roadmaps puts a lot of companies off.

The obstacles in technology roadmapping can however be overcome in part using specialized software. This whitepaper presents the ITO-NICS Roadmapping-Engine which combines product and technology roadmapping in one integrated solution. Thanks to collaborative components, this software solution helps to overcome numerous challenges when roadmapping is used in practice.

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1 The Starting Situation: Challenges in Technology Roadmapping

Against the background of short product lifecycles, rapid technological developments in numerous fields, dynamic customer requirements and new business models as a result of the digitalization of value added, merely responding to changes in the business environment is not sufficient. To remain competitive in the long-term, companies must be proactive and develop the ability to implement the appropriate strategies, changes and adjustments at an early stage (Bullinger und Schäfer 1997 [Bullinger and Schäfer 1997]).



In this context roadmaps are an established instrument in the middle- to long-term strategic planning. Technology roadmaps enables decision makers to predict and plan development paths as well as chances and risks of observed technologies.

(Abele 2006)

As a visual communication medium, a roadmap shows the development of an entity over time – usually a product, business model or technology – and links the resources required to create the entity with the intended markets. This allows gaps in the resource planning to be detected, for example, or long-term investment decisions made for new technologies. The flexibility of the method means that the original field of

application, namely “Technology Management”, is being continuously extended (Möhrle und Isenmann 2008 [Möhrle and Isenmann 2008]).

Conventional technology roadmaps are used in technology management to control the development of new technologies.

Product roadmaps address the planning of new products and innovation roadmaps deal with the planning and implementation of innovative development projects (Durst und Durst 2016 [Durst and Durst 2016]).

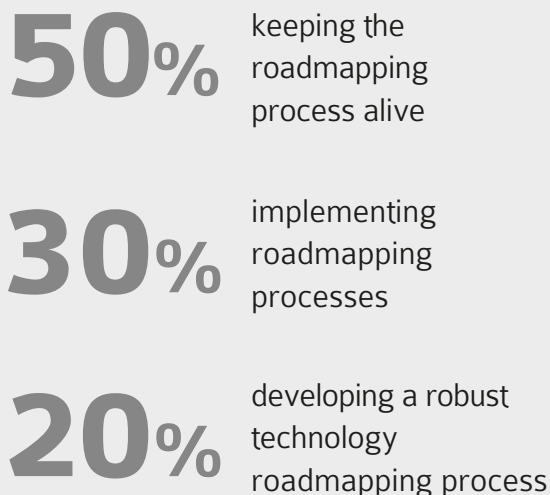
Integrated roadmaps examine several issues simultaneously such as product and technology planning for example. Depending on the focus, a roadmap encompasses different dimensions (also called levels or layers): products, technologies, markets, resources, drivers, projects, corporate goals or milestones.

Furthermore, the alignment of the roadmap determines the composition of the stakeholders, the range of the roadmap (company-wide versus intra-departmental) and the timeframe of the roadmap (project-related versus medium/long-term), for example.

The advantages of roadmapping are obvious:

Medium to long-term planning in strategically relevant company divisions is today more important than ever before.

However, there are numerous challenges which a company must overcome to use roadmapping efficiently and effectively. A study carried out by Phaal et al. (2001) surveyed more than 2000 manufacturing companies regarding the use of technology roadmapping. The surveyed companies specified the following as being the biggest challenges involved in implementing technology roadmapping:



Further obstacles to the implementation and use of roadmaps can be identified in literature and in practice:

- **Cost and effort involved in creating and updating the roadmap:** in addition to the outlay involved in creating roadmaps for the first time, difficulties in maintaining roadmaps are frequently cited as being a

a key obstacle in the way of their effective use (Phaal et al. 2001; Lee and Park 2005). In practice, roadmaps are usually created once in Microsoft Excel, PowerPoint or Visio. These documents are inflexible and cannot be updated dynamically or developed further (Lee and Park 2005). As a result, the roadmap remains an isolated tool which is detached from the current corporate planning and development and becomes obsolete quickly.

- **Reuse of individual roadmap components:** roadmap components which have already been elaborated such as markets, products or specific technological developments for example cannot be reused between different roadmaps. Each new roadmap must undergo the entire creation process on a current basis even if roadmaps are already being used in individual company divisions.
- **Adaptation options:** Lee and Park (2005) identified a lack of methods for adapting the roadmapping method to the specific requirements of a company as being the greatest obstacle.
- **Mapping a high degree of complexity:** roadmaps based on drawings can only map two dimensions and are over-burdened with a high degree of complexity. As soon as hundreds of technologies, resources and products have to be aggregated in one roadmap to be able to examine strategic decisions within the overall context, static modelling tools become unsuitable. It is precisely the dependencies that exist between individual technologies and resources to create new products, services and business models that are however relevant to be able to manage

and control a complex innovation portfolio in a structured manner.

- **Binding force:** to be able to use roadmaps as a strategic planning tool in innovation management, it is necessary to compare them continuously with reality, i.e. actual circumstances.

This is the only way that deviations from the plan and also their consequences in the plan portfolio can be identified.

In the case of static roadmaps, the outlay involved in carrying out a continuous comparison with actual circumstances is often only possible with considerable effort or not at all as the tools available are not suitable.



Isenmann (2008) sees the potential of software support as lying in particular in the organization of roadmapping projects as well as in the execution of the roadmapping core process.

Here software can support the decentralized cooperation of different actors who interact with each other without being bound to a specific time or place.

A central database, standardized formats and a uniform data structure help to speed up the work processes used in the creation of roadmaps. A variety of visualizations and analysis options further reduce the complexity of the data for the user.

In the following sections, a new collaborative and web-based software solution for integrated roadmapping which overcomes the above-mentioned obstacles in the implementation and active use of roadmaps is presented.

2 The Solution: The ITONICS Roadmapping-Engine

The ITONICS Roadmapping-Engine is a collaborative online software tool for integrated roadmapping. The software can be used as Software as a Service (SaaS) from the cloud or on-premise. In both cases the user interface is exclusively a web browser and does not require local installation.

Depending on the focus of the company, the software can be tailored to the specific roadmapping project. It is most frequently used in technology and product roadmapping and the following sections explain the Roadmapping-Engine in this context.

2.1 Entities in the Innovation Process

Markets

Here current and intended target markets are defined in greater detail and stored with planning data. When do specific new business fields, customer groups, competitor offers and social trends become relevant? How much turnover can be expected to be generated and when? How high is the estimated market appeal over the course of time? The new products, services and business models cannot be planned holistically until the time schedule and specific target figures from a market perspective are in place.

Products

All current and future products are entered, planned and controlled in product management. Products also encompass services and business models. The products are linked on an inter-dependent basis and to the related markets, technologies and resources. This layer collates all the products of a specific region, business unit or department and displays each of them with a specific implementation timetable.

Technologies

Here the timing for future technologies is established: when is it anticipated that a specific technology will be available for use in new products, services and business models? Which costs must be allowed for this? Are proprietary developments or external technologies involved? All data from technology management is collated here and serves to provide an integrated view in technology planning, implementation and control.

Resources

The resources which are significant for implementing the development projects are entered as the fourth layer in the technology and product roadmap. Here too you can create links to all other entities within the layer and across layers. Similar to the other entities of the roadmap, resources are described using a set of standard attributes, the links and the type-specific detailed information. Resources can be employee skills, development environments, research co-operations or public funding projects, for example.

2.2 Logic of the integrated product and technology roadmap

The product and technology roadmap integrates several views: the market and product view as well as the technology and resource view. The logic of the ITONICS Roadmapping-Engine follows the conviction that it is difficult to create a uniform view of markets, products, technologies and resources via one (heterogeneous) user group. Experts who are responsible for technology management focus on the core activity of technology development and the resources required for this whereas product management deals with the development, marketing and sale of products. That is why the logic of the Roadmapping-Engine works with context-defining groupings (bundles) for these two user groups. The groupings ensure that a context is already established to the other elements before an element is placed on the roadmap.

For this reason, **product bundles** always consist of at least one product which is assigned to at least one market and optionally to one technology. The product management team within a business unit is responsible for creating the product bundles. The process highlights the following issues:

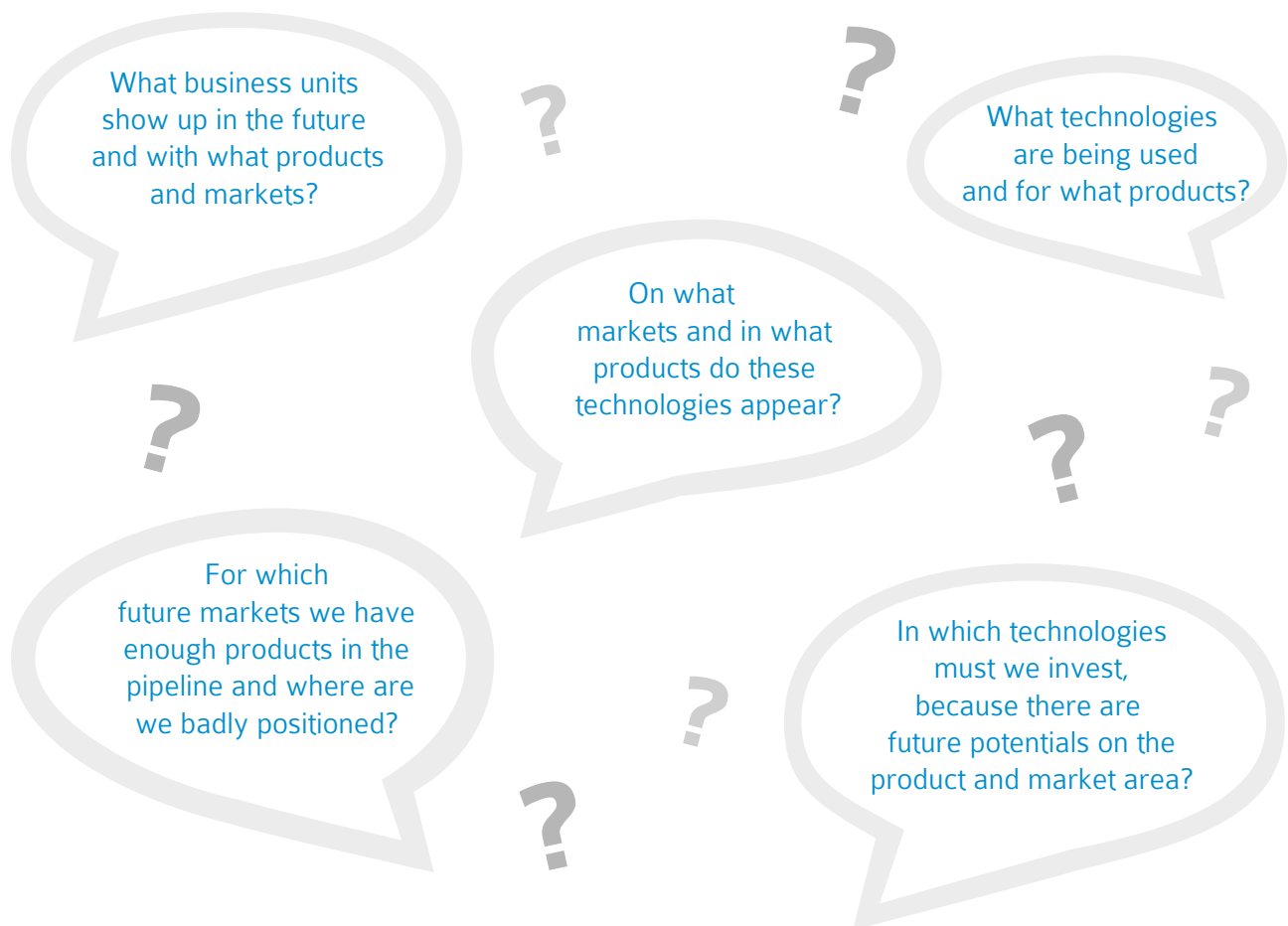
Which products should be placed on which markets and on which technology or technologies is the product based?

Technology bundles are created by experts from the technology management team and consist of at least one technology, one resource and one product. A technology bundle answers the question:

Which technology is used (today or in the future) in which product and which resources are required to create this technology?

This logic links all the markets for the products and technologies with the resources and vice versa without a Technology Manager having to deal with the sales markets and without a Product Manager having to familiarize himself with the technological resources of his product.

The access rights to the content of the roadmap are regulated using a rights and role concept and provide different views of this content. A Product Manager only sees the product bundles for which he or she is responsible. The situation is similar for the Technology Manager. Persons/departments responsible on a higher level, for example a manager of a business unit or the central prototype department can address the following questions using the aggregated view of the different roadmaps:



This change in perspective enables the roadmap to be created transparently and based on the relevant technologies and products. The relevant users who are responsible for providing the roadmap content can focus on their core activity and coordination work is greatly simplified. Thanks to the cascading rights and role concept, the company hierarchy can be mapped and sensitive data as well as strategic content can be released for dedicated user groups.

2.3 Architecture and Functions of the ITONICS Roadmapping-Engine

The basic architecture of the Roadmapping-Engine and all functionalities are geared to making working with the roadmapping method as efficient and effective as possible. Figure 1 shows the structure of the Roadmapping-Engine. The software tool uses numerous visualizations and is a web-based tool with a modern user interface and collaborative social media components (rating, commenting, liking, mes-

saging, etc.). As a result, content can be created, checked and assessed jointly irrespective of the end device, place and time. The distributed processing of the content reduces the time and effort involved in creating and maintaining the roadmaps. If a roadmap has been created, users can edit and update the content directly via the visualization function using a WYSIWYG editor.

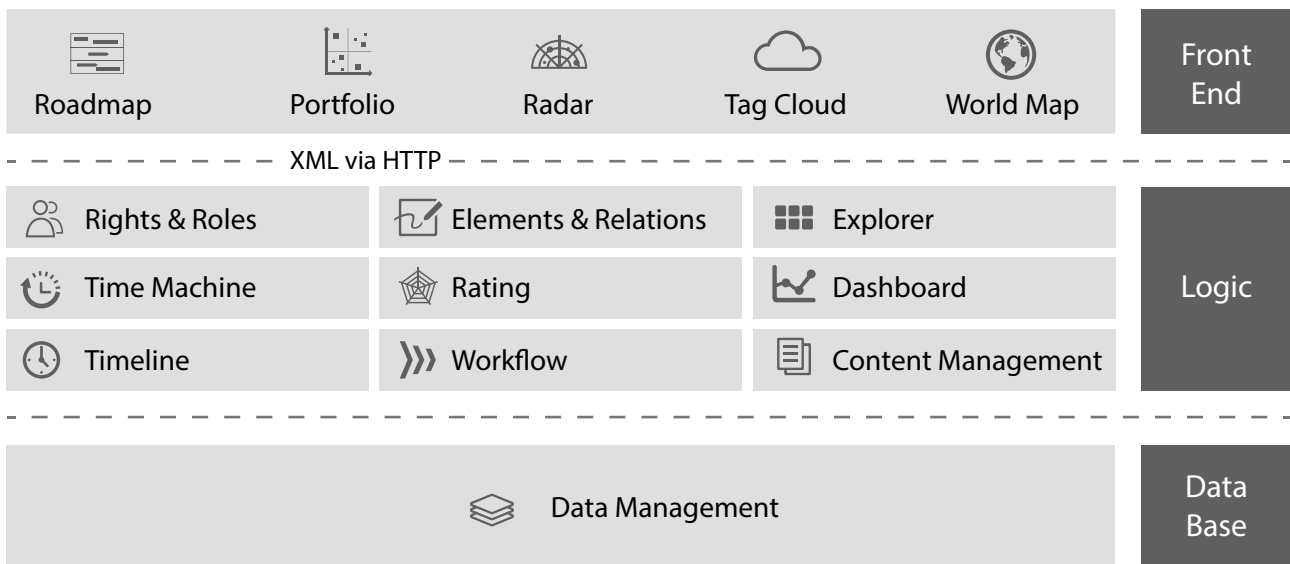


Figure 1: Architecture and Central functionalities of the Roadmapping-Engine

To be able to reuse individual components of the roadmap, all elements, relations and results are saved in the overarching roadmapping database. If a new roadmapping project is started, users can select and change any elements created previously such as technologies or markets, for example. The electronic availability of all roadmapping elements speeds up the process for creating new roadmaps and ensures consistency in the modelling. The Roadmapping-Engine is modular software which is tailored to the company-specific

roadmapping processes. The cascading rights and role concept also ensures that the software can adapt to organizational changes in real time. Thanks to the user management function, the company can change rights and roles at any time thereby controlling the visibility of the content.

The greatest obstacle to the use of roadmapping as a method in strategic and operational planning is the increasing complexity of the roadmaps themselves. To be able to make strategic decisions within the overall context, numerous technologies, resources and products must be aggregated in a roadmap. The Roadmapping-Engine implements this by way of different dynamic visualizations in which the user can display the information depending on the target group. The

visualizations are based on the standardized description of the individual roadmapping elements as well as their relations. Elements, for example, technologies are described using previously defined templates. In addition to the title, abstract and detailed textual description, links, references, documents etc. can be stored here. The element can then be indexed, categorized and linked to other elements (see Figure 2).

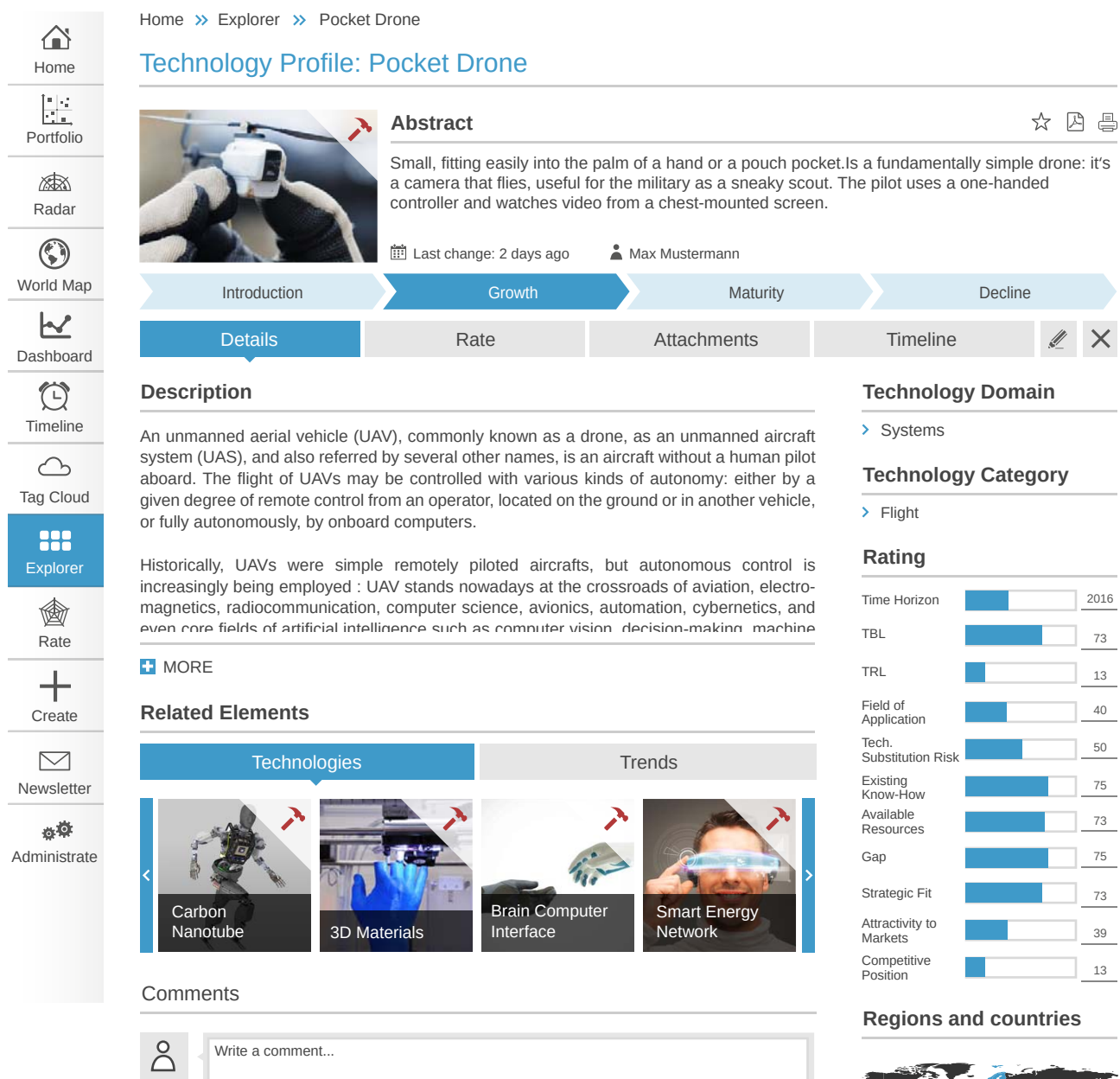


Figure 2: Detailed Presentation of the technology profile "Pocket Drone" and its relations

The product bundles and technology bundles described above are also created in accordance with this principle and ultimately it is the roadmap that dictates how they are linked. The description of the elements and how they are indexed, attributed and linked is the basis for reducing complexity across different functionalities and visualizations.

The Explorer function provides a multi-layered tool for searching and displaying all the information objects contained in the Roadmapping-Engine. In this view, you can browse the existing elements, filter them according to various criteria and then display and export them.

The best way, however, to reduce complexity is to ensure adequate visualization of the content.

For this purpose, the Roadmapping-Engine uses five visualization methods each of which has a different objective:

1. Roadmap

Thanks to filter and setting functions, different forms of presentation can be tailored in real time to the requirements of the user. More generally, the timeframe of the visible roadmap can be configured to include a start and end date (see figure 3). Furthermore, the entire roadmap can be filtered for example by department, division, region, plant and/or strategic focal point. You can also filter in accordance with strategic and tactical parameters such as for example “only show markets which are new for us”, “only show technologies with high disruption potential” etc. Here all elements linked to the filtered entities displayed are shown, including at different levels of the roadmap.

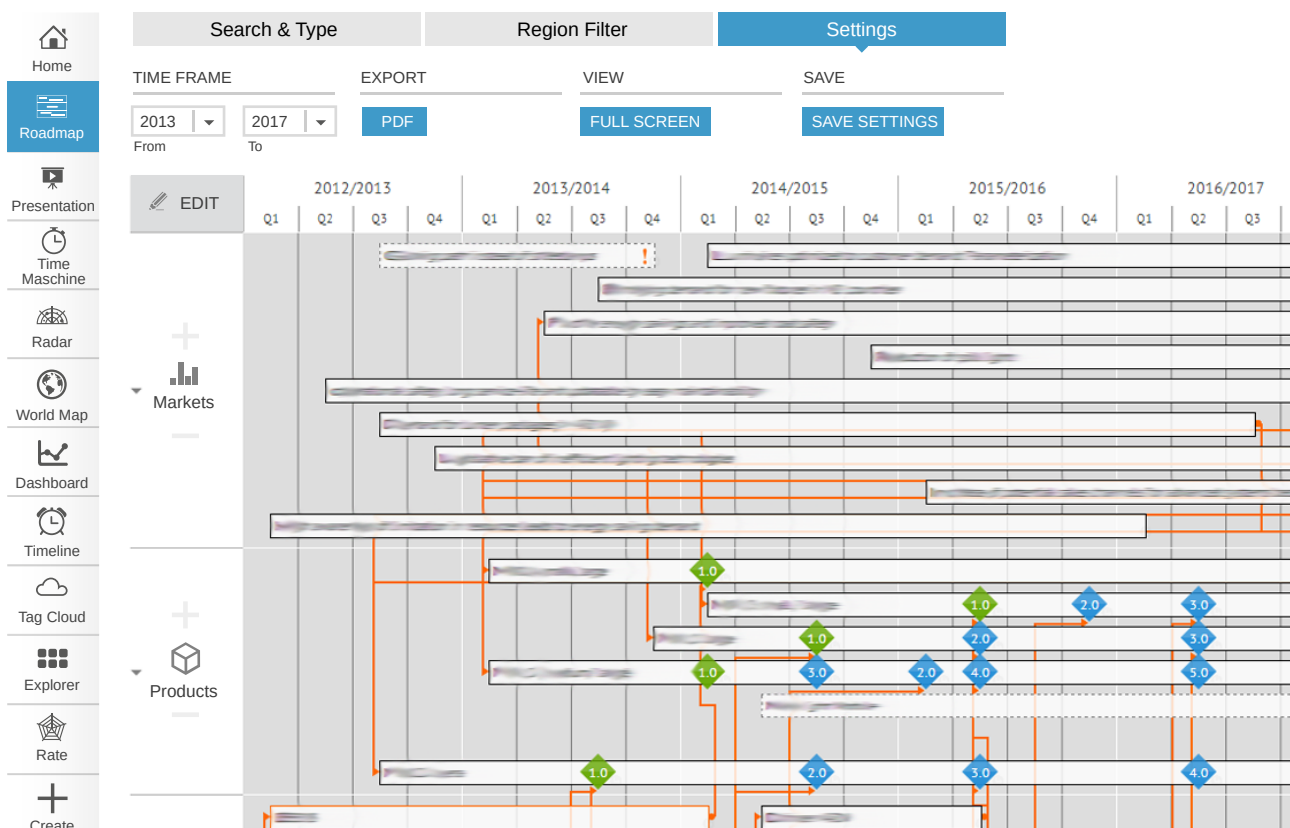


Figure 3: Details of the Interactive Roadmap Visualization

Using the specified filter options and an additional free text search, analyses of the roadmap for identifying critical paths, detecting possible over- or under-investments and assessing the innovation strategy are in principle targeted and quick to create. Companies are faced with methodological challenges particularly with regard to technological impact assessments. Because the technology is still at an early stage of development – frequently this tends to involve research rather than technology – and the associated uncertainty with regard to the form it will take in the future makes it more difficult to elaborate the consequences of its use systematically. To avoid sliding into pure speculation, an informed notion of the applications of a future technology must be elaborated. Here the Roadmapping-Engine serves as an integrated planning tool so you can steer investments in a targeted manner.

In addition to the standard view described above, numerous detailed views and additional information about interaction with the roadmap as well as its content are available to the user:

- **Focusing** the (filtered) roadmap on only one level, for example a market or technology
 - By clicking an element (for example a product) all elements which are not linked are hidden. In particular, **critical paths** and dependencies can be visualized in detail using this function.
 - Users can **simulate** changes in the roadmap before they save them.
- Here elements can be moved, deleted and/or added. During this process, the critical path is always visible and the changes in the overall roadmap and/or in sub-roadmaps can be simulated in real time. Thanks to a versioning function, you can restore older statuses of a roadmap at any time and/or compare them with a current status.
- Numerous **visual editing functions** enable you to edit and simulate data in the roadmaps quickly and intuitively. This means you can display additional information on an element in the roadmap simply by hovering over it with your mouse. You can move elements in Edit mode by means of drag-and-drop and plot dependencies of elements to each other simply using your mouse. Using a context menu which you activate by hovering your right mouse over an element, you can call up key editing functions directly in the roadmap (naming, start and end date, dependencies to other objects, categorization, keywords, etc.)
 - By increasing and reducing the font sizes, a roadmap can be handled using a wide variety of elements. Furthermore, the Roadmapping-Engine enables **scaling** to any display resolutions so that the roadmap can be used interactively for example both on tablet computers and on 4K displays in large conference rooms.

- Highlighting functions which allow you to change the style and color of text provide you with a quick overview even before filtering. This allows you for example to highlight technologies which must be bought in from an external supplier in italics. Giving an element a colored border in the market level can highlight the sales potential and the strength/thickness of the border of an element in the resource level can highlight the criticality of an element.

Users can create individual roadmaps and save them for later use. This also means different alternative roadmaps can be compared with each other to make a decision in favor of one variant or another transparent.

- Numerous export functions enable you to copy data and visualizations to conventional formats such as Microsoft Excel, Power-Point or PDF. They also, however, allow you to copy data to downstream PLM and project/program management systems.
- As a history management function, the Time Machine enables you to check the planning quality in the roadmapping process: you can call up all statuses of the roadmap from the past at any time and stored statuses from the past using a slide control with dates. This functionality makes changes in the roadmap transparent thereby enabling targeted discussions to be held about the planning quality in different levels – on the side of the markets, the products, the technologies and the resources.

2. Portfolio

To be able to make investment decisions as accurately as possible in complex environments, you will need more than roadmap

presentations which are usually not sufficient for the purpose. For this reason, the ITONICS Roadmapping-Engine provides further visualizations which increase decision-making quality and speed in comparison with conventional methods. Portfolios enable you to display up to five parameters at the same time: two axes, color, size and shape of the data points. You can display or hide the labeling of the data points. Since markets, products, technologies and resources are usually assessed with different parameters (for example Technology Readiness Level for technologies, market potential for markets and estimated market share for products), portfolio displays are only useful in one category in each case.

In a dynamic portfolio, on the other hand, you can very quickly identify the elements with the most potential thanks to filter and search functions. These can then be visualized in the roadmap in a filtered format so you can analyze their dependencies within the overall context.

3. Radar

The Radar is an alternative presentation method to the portfolio. Here again markets, products, technologies and resources can be mapped in their own independent radars which instead of two axes use the distance from the center point and the segments to arrange the elements on the radar area. With the color, size and shape functions for the data points, you also have five parameters available to you here which you can visualize simultaneously (see Figure 4).

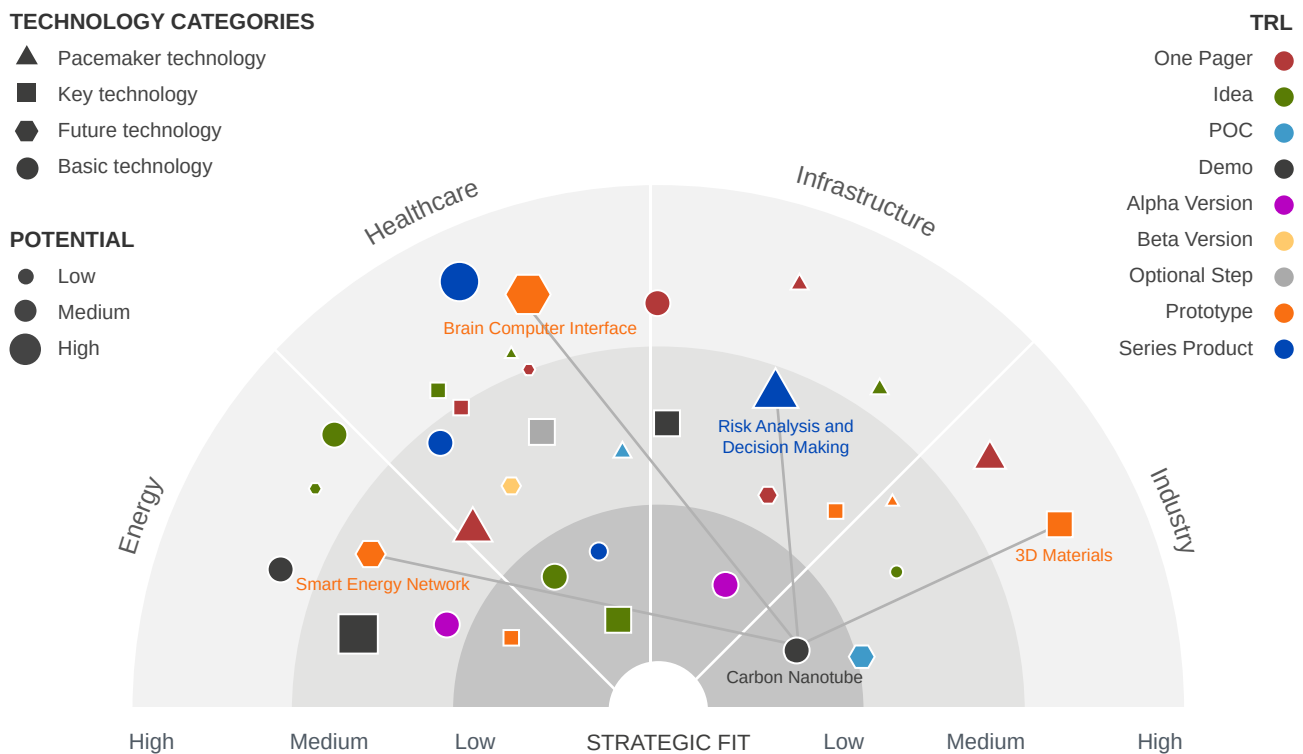


Figure 4: Technology Radar of the Roadmapping-Engine

The radar basically provides a different way of visualizing the portfolio. Using the distance from the center point as a time axis, however, facilitates a presentation which is conceptually closer to the roadmap and therefore very popular in particular in technology management.

4. Tag Cloud

The tag cloud provides an alternative overview of focal points in the future product and technology portfolio. It answers questions such as “How heavily are we relying on Technology X?” or “Have we considered trend Y in our portfolio?”. The larger a term is in the tag cloud, the more frequently it occurs in the portfolio. The algorithm behind this deletes filler words and in addition to the manually entered keywords also analyzes the texts in an element (description, abstract, title). A thesaurus function also recognizes synonyms.

5. World Map

In most companies, a region or country-specific view of future projects is often useful. By way of color coding, the “world map” enables products and markets to be highlighted visually (technologies and resources appear to be more global in nature and for this reason play a subordinate role in this visualization method). If you click a country/region, a list of the relevant elements is displayed. Like all other visualization methods, the world map has filter and browse options and can be scaled in any way. By selecting a country/region, specific roadmaps can be automatically created (which are displayed in the “Roadmap” view).

2.4 Practice: Experiences with the Roadmapping-Engine

A solid empirical basis was not available at the time of the publication of this document which is why we can only refer to “lone voices”. The vast majority of our customers report the following effects as a result of using the software which in all cases has replaced conventional methods such as Microsoft Excel, PowerPoint or VISIO:

- The initial outlay involved in implementing a software solution in roadmapping is considerable. The configuration and the attribution in particular have to be coordinated and decided with a large number of participants.
- The initial creation of the roadmaps in the individual company divisions requires discipline and ongoing supervision of the method and the software tool by specialists.
- Initial positive effects are already apparent as early as the roadmap creation stage: in comparison with conventional, more static methods the degree of detail and the quality of the roadmaps is considerably higher.
- Central planning units (such as for example corporate strategy, technology strategy and/or corporate development) have a considerably better understanding of all current and planned activities in the company thanks to the integrated view.
- Cohesion in planning is increasing: because utilization in particular of R&D resources can now be tracked, it quickly becomes clear which business unit is investing in which type of products and technologies. What is noteworthy here is the strong investment in further developments of existing products and markets and the often rather more cautious investment in new technologies, new products and/or hitherto unknown markets. This knowledge and the fact it can be tracked very precisely help enormously to link the corporate strategy with the R&D strategy and the strategies of the individual business areas.
- If the Roadmapping software is superseding all conventional tools, an ongoing update process is automatically activated. Thanks to its ease of use and the fact all changes can be tracked, users prefer the roadmapping software to conventional tools because not only can they make updates quickly, they can also carry out simulations and benefit from integrated planning.
- The ability to work with no restrictions on time or location is described as a key plus point: users can work with roadmaps anytime anywhere and if other users make changes the software automatically sends e-mail messages to all affected users (in other words users whose elements are affected either directly or indirectly by a change). The research team, for example, are contacted directly as a result if a technology is no longer in demand for a future product.

On the whole after the implementation phase, those surveyed reported extremely positive effects on the quality of the R&D planning.

3 Outlook: The Future of Software-Supported Technology Roadmapping

Roadmapping as a method is taking hold more and more. In addition to large companies, SMBs are now also increasingly using roadmapping to meet the challenges in strategic and tactical planning. This will also be linked in future to increased demand for software tools which can accommodate this method. Thanks to cutting-edge technical options, users can already effect highly complex visualizations from their browsers and thanks to SaaS, company-wide and cross-company cooperation is much easier to organize than a few years ago.

The ITONICS Roadmapping-Engine supports roadmapping in a very effective way in this collaborative, complex working environment. Thanks to the use of cutting-edge technology, the ITONICS Roadmapping Engine fulfils the requirements described by Isenmann (2008) in particular with regard to the organization, institutional anchoring and support of core processes in roadmapping and the use of roadmaps as a communication tool. With the Technology-Radar, upstream processes such as technology management, for example, are also connected just like downstream processes in PLM and in program/project management.



Markets



Products



Technologies



Resources



Literature

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