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A FRAMEWORK FOR AGILITY IN TECHNOLOGY ROADMAPPING IN EA AND IT PORTFOLIO MANAGEMENT

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ABSTRACT

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While being an effective planning, forecasting and governing tool, technology roadmapping has fell behind on responding to the volatile environment organizations are in. Organizations need agility to be able to respond to rapid changes in today's world to keep with the competition. This means organizations need to make their planning and governance of IT agile. To respond to this need, this thesis suggests a framework as a solution for providing organizational agility in EA and IT portfolio related technology roadmapping. The framework was created based on previous literature on the subject, interviews of professionals in the field and eventually evaluation by professionals. The result is a framework that concludes of three parts: the technology roadmapping process in agile environments, a template for the roadmap-document and approaches that an organization may take on roadmapping. The solution is a general framework to help organizations create, maintain, update, and communicate their roadmapping plans and outcomes.

Keywords: Technology roadmap, TRM, enterprise architecture, IT portfolio management, design science, organizational agility

TIIVISTELMÄ

Kääriäinen, Jenni
Viitekehys ketterälle teknologia tiekartalle kokonaisarkkitehtuurissa ja IT portfolionhallinnassa
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Teknologia tiekartat ovat tehokkaita työkaluja suunnittelemiseen, ennustamiseen sekä hallinnoimiseen, mutta ovat jääneet jälkeen organisaatioiden nykyään muuttuvassa ympäristössä tapahtuvaan muutoksiin vastaamisessa. Pysyäkseen kilpailukykyisinä, organisaatiot tarvitsevat organisaation laajuista ketteryyttä voidakseen vastata nopeasti muutoksiin. Tämä tarkoittaa sitä, että organisaatioiden on tehtävä IT:n suunnittelemista ja hallinnointia tarpeeksi ketterästi. Vastatakseen tähän tarpeeseen, tämä tutkimus ehdottaa viitekehystä ratkaisuna organisaation ketteryyden saavuttamiseksi myös kokonaisarkkitehtuurin sekä IT portfolionhallinnan teknologia tiekartoissa. Viitekehys luotiin aiemman kirjallisuuden ja alustavien asiantuntijahaastatteluiden perusteella sekä muokattiin lopulliseen muotoonsa arviointihaastattelujen pohjalta. Tuloksena on viitekehys joka koostuu kolmesta pääosasta: teknologia tiekartan prosessista ketterässä ympäristössä, pohjasta tiekartta-dokumentille sekä näkökulmista joita organisaatio voi ottaa tiekartan prosessiinsa. Ratkaisu on geneerinen viitekehys, jonka tarkoituksena on auttaa organisaatioita luomaan, ylläpitämään, päivittämään sekä kommunikoimaan tiekartta prosessin suunnitelmia sekä tuloksia.

Asiasanat: Teknologia tiekartta, TRM, kokonaisarkkitehtuuri, IT portfolionhallinta, organisaation ketteryys, design science

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1 INTRODUCTION

Technology roadmapping (TRM) is a popular tool used in planning, forecasting and administration (Lee, S., & Park, 2005) of technologies to create a document that describes the future vision and how this vision will be achieved (Albright, 2003). It does not have a standardized composition but generally consists of layers like market/trends, product/service, technology, resources, and a timeframe (Albright, 2003). Roadmaps may be used by enterprise architects and IT portfolio managers in their common goal of planning the route from current situation to a vision of the future (Jugend, & da Silva, 2014; Jusuf, & Kurnia, 2017) and may help to align IT and business strategy (Phaal, Farrukh, & Probert, 2004a).

Some organisations use technology roadmaps on a singular issue and never adopt it wider in their processes, but many also adopt it as a strategic tool to help with planning (Phaal et al., 2004a). According to a study in the beginning of the century, around 10% of UK manufacturing companies used technology roadmapping (TRM) and 80% of them used it more than once (Phaal et al., 2004a). One significant difficulty in technology roadmapping is that organizations perceive it difficult to keep the roadmap on-going and up to date (Phaal et al., 2004a; Strauss, & Radnor, 2004; Pora, Gerdsri, Thawesaengskulthai, & Triukose, 2020).

Technology roadmapping has been researched for decades (Carvalho, Fleury, & Lopes, 2013) but because of its flexibility to be used in several different contexts, there is still a lot of research gaps in this area. Technology roadmap is described in most of the literature as a popular planning tool yet there is little evidence from localized surveys of practices that support this claim (Carvalho et al., 2013). It is evident that there are still many gaps in the area of technology roadmap research, including research on its use in specific purposes like enterprise architecture and IT portfolio management. Literature mentions technology roadmapping as an essential tool for both practices (Jugend, & da Silva, 2014; Jusuf, & Kurnia, 2017) but there is not much to be found about how these practices should use technology roadmapping in their specific context do roadmapping, especially in today's volatile environments. It has become clear that IT-enabled organizational agility is needed to be able to respond to the threats and

opportunities of the changing world around organizations (Tallon, Queiroz, Coltman, & Sharma, 2019).

Roadmapping has been a popular research subject among researchers for some time (Carvalho et al., 2013) but today some of the research about technology roadmapping may have become outdated because of the fast pace of changes in the practice of information technology. Agile ways of working like Scrum and SAFe have made it necessary to take a fresh look into this subject and see how organizations could use technology roadmapping in today's dynamic world of information systems. As old ways of working become more obsolete, there is still need for enterprise architecture, IT portfolio management and a tool for how these functions can plan and forecast the future.

1.1 Motivation

The research on roadmaps has its roots in the practical need of companies. From the beginning of technology roadmap research to today's research, the practical significance of technology roadmaps is strong. The research is motivated by the practitioners needing these tools to make better decisions, plan and forecast IT architecture and portfolio and this research can help to better understand and develop tools like roadmaps in today's context. And it is seen that roadmaps can truly give better tools for decision making to enterprise architecture in an organization (Van den Berg, Slot, van Steenbergen, Faasse, & van Vliet, 2019) while IT portfolio management puts the decision into practice (Cosner, Hynds, Fusfeld, Loweth, Scouten, & Albright, 2007).

According to structured reviews, prior research focuses mostly on the different roadmap types, roadmap structure, roadmap creation and implementation (de Alcantara, & Martens, 2019). The general structure of a technology roadmap recurs in different studies and the process of making and implementing a roadmap has been well studied in the past, but only a few studies focus on what happens after roadmap implementation. Phaal, Farrukh and Probert (2001) listed the key challenges in the TRM process: selling the benefits of the process to stakeholders, initiating, defining the scope, integrating the process into existing ones and maintaining the process. The maintenance is often mentioned to be challenging but there remains little research on the details of what makes maintaining a technology roadmap challenging and how practitioners could overcome the challenge. While all the main phases of roadmapping have their own challenges, this thesis focuses mostly on the challenges organizations face today in the roadmap integration, maintenance and update-phase, providing more iterative aspect into this phase.

Since most businesses need IT to compete in current markets and IT as a field has changed considerably even in the past few years, it is necessary to revise technology roadmapping as a tool. To be able to response to customer needs and market changes, the organization needs agility (Lee, O., Sambamurthy, Lim, & Wei, 2015). Lee et al (2015) found that to enhance organizational agility, IT needs

to be at the same time exploring new resources and opportunities and exploiting their current resources and opportunities. As situations may change quickly, roadmapping needs to be agile and the roadmap that is created needs to be kept up to date for it to provide maximum benefit in a dynamic environment.

1.2 Research questions

The research questions were formed to answer to problems in this field of research and to an existing need from experts in the field. Technology roadmap and the process of roadmapping needs to adapt to the challenges of today and agility in organizations. To fulfil this demand, this thesis creates a solution using design science methods. To be able to provide this solution, these research questions need to be asked:

1. What challenges do today's enterprise architects and IT portfolio managers have with technology roadmaps?
2. How can technology roadmapping in the context of enterprise architecture and IT portfolio management adapt to today's demand of organizational agility?

Both questions are part of what is needed to provide a solution for an existing problem: the answer to the first question should provide the needed information and motivation for the solution and the second question acts as a guide to developing and evaluating the solution. The first question needs to be asked and answered to be able to answer the second question. The first question is answered through literature review and some initial interviews to appropriate professionals to provide insight into the use of technology roadmapping today and investigate the motivation to create a solution to an existing problem. After analysing all the materials, the solution to the second question is provided. The solution is then to be demonstrated and evaluated by appropriate professionals in the field and final solution is given after improving the initial solution according to the evaluation given.

1.3 Structure of the thesis

First on this thesis design science as the research method is explained and the steps required in this thesis explained. The qualitative interviewing as a method is also explained since it is used to gain knowledge and evaluation of the solution from the professionals in the field.

The following sections go through the past literature on technology roadmapping. Focus is on the main literature on the roadmapping process and the document it creates as well as its role as a tool for enterprise architecture and IT portfolio management. Fifth section focuses on the existing solutions in past

literature for updating and maintaining a roadmap, which is considered to be one of the main challenges with roadmapping.

Sixth section summarized the findings from literature and from the initial interviews of professionals in the field. From the point of view of the design science, this section includes the problem identification and the objectives for the framework. The seventh section present the solution and justifications for it, containing three parts of the solution: the roadmapping process, the roadmap-document template and approaches to roadmapping. In a sub-section the main findings from the demonstration and evaluation interviews of the professionals regarding the solution are presented and according to this, the solution is modified to its final state. After this the main findings and analysis is explained in the discussions. In this sub-section some guidelines to managing this framework and roadmapping on a high level is given. Last section is conclusions that binds it all together, explaining the main findings in this thesis and suggestions for future research.

2 RESEARCH METHODS

Technology roadmapping as a tool should adjust to the needs that organizations have today. Compared to how IT has been managed in organizations before, today's world of agility does not seem to match completely with technology roadmapping. Agility is seen as a necessity even in the most slowly changing industries, some even claiming it should be sought no matter what the cost is (Tallon et al., 2019), and organizations need tools to help plan and foresee the future in a flexible and agile way. To answer to this need, we need to look more into the needs of professionals today and investigate how technology roadmapping as a tool is answering to these needs. When choosing the right research method for this, the research topic should be the main focus (Galletta, 2013). Because there is not enough knowledge of the issue in this context and there are yet only few findings about it, quantitative methods do not seem to be the best choice of action. The issue needs more qualitative research to bring actual value to professionals dealing with this problem.

Design science was chosen as the appropriate method to bring technology roadmapping in enterprise architecture and IT portfolio management up to date and bring agility into the tool. Design science is a method that has its roots in engineering and targets to create a solution to a real business problem (Hevner, March, Park, & Ram, 2004). In this thesis the aim is to create a framework that helps professionals in dynamic environments to maintain an agile technology roadmap for enterprise architecture and IT portfolio management. The environment is connected to the design science research through the business need, the problem that needs to be solved and through the relevance of the research (Hevner et al., 2004). The available knowledge base is applied to create an appropriate solution to the business need and then the solution will add to the knowledge of the subject.

As a part of the design science method, some interviews were concluded to sought out more knowledge on the problems of technology roadmapping and to demonstrate and evaluate the solution. These interviews were processed using familiar interviewing methods in qualitative research. More about this is discussed in the second sub-section of this section.

2.1 Literature collection and review

Literature on the subject was reviewed to provide necessary knowledge on the prior research and existing solutions. Literature for the review was collected using databases like IEEE, ScienceDirect, Scopus and Google scholar. In addition, some literature was found from the references of other papers and some were found from previously completed courses. Two most important sources of relevant literature are the Journal of Technological Forecasting and Social Change and the Portland International Conference on Management of Engineering and Technology (De Alcantara and Martens, 2019). Most popular journals for technology roadmapping are Technology forecasting and social change and research technology management (Carvalho et al., 2013). Majority of TRM studies have been done as a case studies and most of the studies were done in situations where TRM was used for a company, a product, a project or for an entire industry (Carvalho et al., 2013).

Search terms included “roadmap”, “technology roadmap”, “TRM”, “enterprise architecture”, “project portfolio management”, “portfolio” and combinations of these. The year and publication forum score were factors that would be considered when choosing the literature, although some publications were chosen even if they were old, simply because of their significance. Content wise the focus was on technology roadmapping research and finding research on TRM in EA and IT portfolio management. Abstracts were read before deciding whether to read forward or not.

To help keep track of the progress, literature was collected to an excel sheet owned and stored privately by the author. In this excel sheet for each research paper the information for the journal, publication forum review of the journal, title, authors, year, date found, search terms and the link or path on the computer/cloud is documented. The author kept track on which of the papers were read and made notes about the literature to find common factors and to draw conclusions. Similarities and important findings were highlighted on the notes.

2.2 Design science

Hevner et al. (2004) created guidelines to assist researchers that want to use design science as a research method and help them create the IT artifact. These guidelines can help to see all the different parts of a solution creation that need to be taken into consideration in the design creation. The guidelines are described in table 1 and mirrored to the actions that will be taken in this thesis to address this guideline.

TABLE 1 How design science guidelines are addressed in this thesis

Guideline	Description	In this thesis
1. Design as an artifact	Providing an artifact in the form of a model, a framework or an instantiation.	A framework is created in this thesis.
2. Problem relevance	Provide a solution to relevant and important business problem.	Problem relevance is expressed through literature review and interviewing professionals that use technology roadmapping in this context
3. Design evaluation	Evaluate the design for utility, quality and efficacy using rigid methods.	The design's quality, efficacy and usability is evaluated by professionals.
4. Research contributions	Contribute with a clear and verifiable design.	This thesis describes how a framework for a real business problem is created.
5. Research rigor	Rely on rigous methods to construct and evaluate the design.	Interviews are performed and analyzed using appropriate methods.
6. Design as a search process	Utilize available means while satisfying laws in environment.	Knowledge of context and means come from literature and interviews.
7. Communication of research	Present the research and solution.	The design and how it was created is communicated in this thesis paper.

Peffers et al. (2006) created the process for design science based on previous research that were using design science methods. The modified process used in this thesis is shown in figure 1. For problem identification one should define the real business problem that the solution is to be created for. The value of the solution needs to be justified. Atomizing the problem may help and in this thesis' case, it can be atomized to the technology roadmap document itself, the process of technology roadmapping, technology roadmapping in the context of enterprise architecture and IT portfolio management and maintaining the technology roadmap. The motivation and more precise definition of the problem is discussed in the next sections as the previous literature on the subject is reviewed and some initial interviews from professionals are analyzed to get are throughout understanding of the problem and the objectives. Once all the necessary information is

gathered and analyzed, the actual solutions may be designed and developed. In this thesis the solution is a framework for technology roadmapping for EA and IT portfolio management, that ensure organizational agility. To ensure that the created solution is answering to the actual business problem identified, the solution is then demonstrated to professionals and evaluated by them in interviews of professionals. Their evaluation will then guide in the possible improvements of the solutions. When the solution seems to be answering the problem and is improved according to the evaluation, the framework can be communicated. In this case, this communication is done through publishing this thesis.

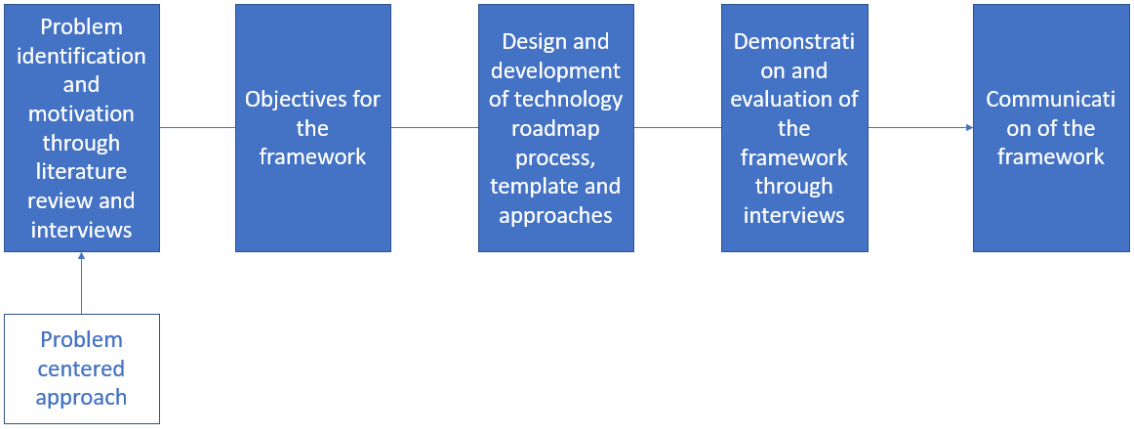

FIGURE 1 Design science research process (DSRP) in this thesis

2.3 Qualitative interviews

Qualitative interviews were chosen as the appropriate method to provide more information about the concrete problem with technology roadmapping among professionals. Purpose is to describe and to get more knowledge on the ecperiences of our interviewees, in this case EA and IT portfolio professionals (Schultze, & Avital, 2011). As knowledge of the applicability of technology roadmapping in today's volatile environment is scarce, the interviews add knowledge about the problems today's organizations have with technology roadmapping and gives ideas and feedback on what seems actually helpful and what does not. Also knowledge on what organizations need from TRM, how they are helpful and what is preferred. Since technology roadmapping relies largely on experts, and organizations usually need to customize TRM, it is justifiable to ask experts for an opinion on what problems needs attention and what aspects to concider in the solution.

To make most out of qualitative interviews, there should be a plan for how the data is analysed (Galletta, 2013). For the interviews in this thesis, this means reflecting after the interviews, organizing the data, transcripting the interviews, coding, finding patterns and themes within the codes and interpreting. Codes are ideas that are given a specific name and should be documented as well as include

information about their meaning, where the code came from and their relationships to other codes (Galletta, 2013). From these codes you will start to find the patterns that eventually lead to the interpretation and finally synthetization. It is also important to choose the right participants for your interview according to who may provide best answers to your research question and gaps in perspective or experience (Galletta, 2013).

To get a better understanding of the current situation in organizations that use technology roadmaps for enterprise architecture and IT portfolio management, four initial interviews were conducted. Semi-structured interview was chosen as a method to collect more information, since it gives enough structure to stay in topic but gives room for new discoveries (Galletta, 2013). In these interviews an IT architect, two enterprise architects and one IT portfolio manager from Finnish large or middle-sized companies were asked questions about their practice of technology roadmapping and what issues they find in roadmapping in general but also especially about issues with adjusting the roadmaps. These interviews acted as a guide to see if the research is headed to a direction that would give actual benefit to the practicioners in Finland. Two of the interviewees were from the financial sector, providing customers with digital services and two interviewees were from the energy sector, providing physical products alonf with digital services.

The initial interviews were conducted during January and February of 2021. Two of the interviews were recorded and transcripted, one interview was written using notes. The interviews were done as virtual meetings since at that time Covid-19 pandemic was ongoing and social distancing was recommended. The interviews lasted from 30 minutes to an hour and all interviewees gave permission to ask them to participate for the next step in the study.

After the interviews were transcripted, they were coded and analysed, as recommended by Galletta (2013). The codes were used to analyse the real problems with technology roadmapping, to provide frames for what the solution should look like and what could be useful in reality.

From the interviewees point of view the next step for them was to participate into demonstration and evaluation of the solution created in this design science research. The people interviewed in the initial interviews and some other professionals were asked to see a presentation of the framework created and then evaluate it. All of the participants in the initial interviews could not participate in the demonstration and evaluation of the solution. The evaluation interviews took 30-40 minutes. The participants that could participate in the demonstration and evaluation fo the solution were sent a brief leaflet of the solution and in their interview they were given a short introduction to the details of the solution. Then they were asked to answer these questions :

1. In your opinion, could your organization benefit from using this kind of solution?
2. In your opinion, could you imagine using this kind of solution for EA and/or IT portfolio management?

3. Would you change any of the steps in the iterative process for roadmapping?
4. Would you change anything on the technology roadmap document template?
5. Would you change anything about the approaches to the solution?
6. Other comments: what could be added, is something not relevant, adjustments to the solution?

3 TECHNOLOGY ROADMAP

History of technology roadmapping (TRM) goes all the way to the late 1970s and early 1980s, when automotive industry needed a planning tool (Phaal et al., 2004a). EIRMA (European Industrial Research Management Association) proposed a simple form of the technology roadmap, that has the basic structure of what roadmap commonly looks like. This consists of three layers: market, product and technology, a timeline, and relationships between these layers (Phaal et al., 2004a; Phaal, & Muller, 2007; Vatananan, & Gerdsri, 2012).

3.1 Definition of technology roadmap

Technology roadmap is a planning technique used to strategy and long-range planning of technology in the organization (Phaal et al., 2004a). There are various forms for technology roadmaps, and usually organizations will use a roadmap form that they deem to be the most useful for their purpose. Generally, a roadmap has a timeline and layers that describe technology, market, and product (Phaal, & Muller, 2007; Gerdsri, Assakul, & Vatananan, 2008). Roadmap can display the evolvement and dependencies between technology, market, and product (Phaal et al., 2004a).

Kappel (2001) found that the term roadmap had become a bit unclear because of the flexibility the tool has, the different definitions found in the literature can be found in table 1. The actual timeline length on the roadmap can depend a lot on the organization (Phaal, & Muller, 2007; Gerdsri et al., 2008). The timeline depends on what the organization considers to be a long time and what is the time it takes for the desired actions to become effective (Carvalho et al., 2013). The roadmap describes the plan how to reach the objectives, what is the schedule for reaching the objectives and it is also a tool for communicating the plan (Albright, 2003).

TABLE 2 Technology Roadmap definitions in literature

Technology roadmap definition	**Literature**
Business and technology strategy alignment	Phaal, Farrukh & Probert (2004); Lee & Park (2005); Strauss & Radnor (2004); Muller & Phaal (2009); Carlos, Amaral & Caetano (2018); Gerdsri, Puengrusme, & Vatananan, Tansurat (2019)
Plan to achieve future goals	Kappel (2001); Albright (2003); Lee, Park (2005)
Visual representation	Gerdsri, Puengrusme, Vatananan, & Tansurat (2019); Strauss & Radnor (2004); Carvalho, Fleury, & Lopes (2013)
Technology foresight	Hussain, Tapinos, & Knight (2017); Albright (2003); Kappel (2001), Kostoff & Schaller (2001)

While technology roadmaps may be customized for various use, a roadmap usually consists of parts that describe the "know-why", "know-what", "know-how", "to-do" and "know-when" (Albright, 2003; Phaal, & Muller, 2007). The "know-why" is the definition and scope of the roadmap, understanding the market and the competition. The "know-what" is the direction of the roadmap, defining architecture, the most important features, products and setting targets. In "know-how" we define the technologies to invest to on a long-term and link the technologies to the drivers like market drivers. The "to-do" defines the resources needed and identifies risks and the "know-when" is the timeline this all happens in (Phaal, & Muller, 2007; Albright, 2003). This general technology roadmap is seen in figure 1. In the figure "market pull" and "technology push" are also mentioned. The roadmapping may happen from the pull-perspective, meaning the key needs in the market pull these things to happen or from a push-perspective when key technologies push to identify the market need that could be filled with solutions of that technology (Albright, 2003; Phaal, & Muller, 2007; Kostoff, & Schaller, 2001).

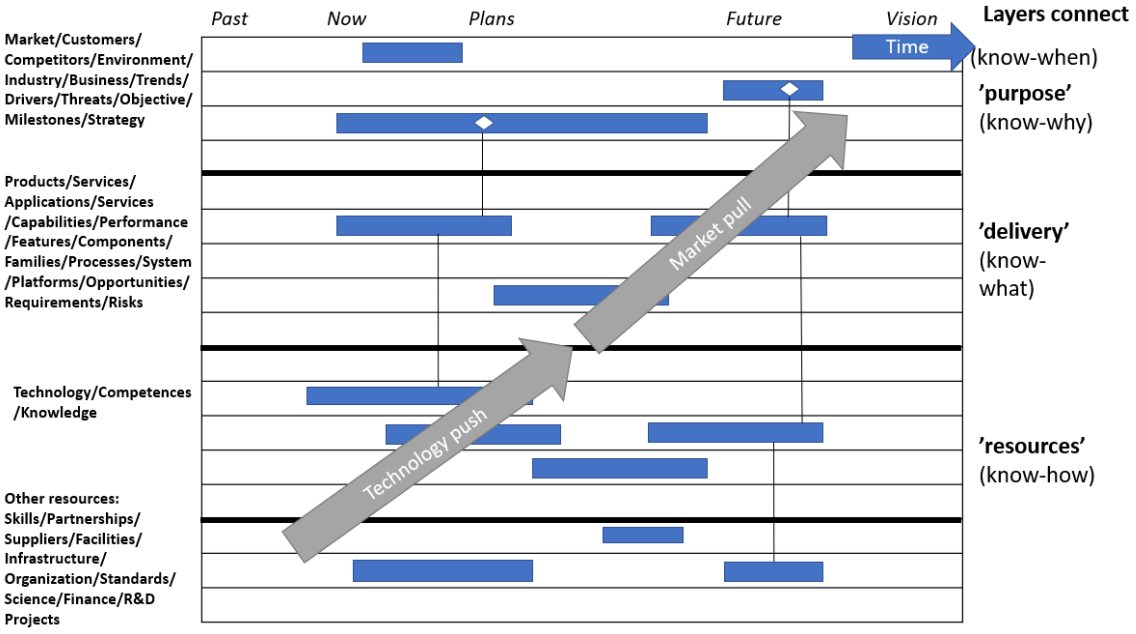

FIGURE 2 Technology roadmap that can be customized according to organization's needs (Albright, 2003).

Motivation is important in roadmapping and organizations may have different reasons to why roadmaps are taken into use (Kappel, 2001). It may be a strategic decision to get better advantage over competition or a reactive one, when there already is a threat of loss. According to Kappel (2001), the roadmap may be taken into use organization wide to make a cultural change or take the roadmap selectively into use for parts of the organization. When taking roadmapping into use organization wide, one may use methods like education, motivating with how others do it or even making it a policy in the organization. When taking roadmap into use selectively, methods include intervention, consulting, catalyst, and personnel transfer (Kappel, 2001).

3.2 Technology roadmap as a document

Technology roadmaps are the documents that are created in technology roadmapping. Technology roadmaps are flexible in the sense that they may take multiple forms, depending on what the organization needs. They may be different because of the purpose it is used for (Phaal et al., 2004a; Kappel, 2001) and the format they are represented with (Phaal et al., 2004a). Customizing the roadmap, to answer the organizations specific needs, is common (Lee, S., & Park, 2005). Time depends on the type of industry and what their planning horizon is (Phaal, & Muller, 2007; Vatananan, & Gerdsri, 2012; Carvalho et al., 2013) and the dimensions may differ in the roadmap document (Phaal, Farrukh, & Probert, 2004b). The technology roadmap should be planned in a way that shows the right

amount of granularity (Phaal, & Muller, 2007), meaning that the roadmap should be enough detailed to take all important factors into account but not so detailed that it becomes too complex to read.

An organization may have multiple smaller roadmaps (Carlos, Amaral, & Caetano, 2018) that are combined to the main roadmap (Phaal, & Muller, 2007). Cosner et al (2007) categorized roadmaps as market roadmaps, product roadmaps, technology roadmaps and enterprise roadmaps, but it as can be deduced, the enterprise roadmap is what contains all of these parts and in that sense is the roadmap with the layers for market, product and technology (Albright, 2003).

As Kappel (2001) mentioned, technology roadmap as a term is not the most clearly defined. In some literature it is mentioned to be one type of a roadmap among many others and in some literature technology roadmaps themselves have multiple types in them. Mostly these categorizations are done by the ultimate purpose the roadmap has: science-technology roadmaps (Kappel, 2001; Albright, 2003; Hussain, Tapinos, & Knight, 2017; Kostoff, & Schaller, 2001), product-technology roadmaps (Kappel, 2001; Albright, 2003; Hussain et al., 2017; Kostoff, & Schaller, 2001), industry roadmaps (Kappel, 2001; Albright, 2003; Hussain et al., 2017; Cheney, Pence, & Dilts, 2015; Kostoff, & Schaller, 2001), product roadmaps (Kappel, 2001; Phaal et al., 2004a; Kostoff, & Schaller, 2001; Cosner et al., 2007), product/portfolio management roadmaps (Hussain et al., 2017; Kostoff, & Schaller, 2001), project/issue roadmaps (Kostoff, & Schaller, 2001; Hussain et al., 2017), emerging technology roadmaps (Hussain et al., 2017), government roadmaps (Albright, 2003).

Phaal, Farrukh and Probert (2004a) discovered eight kinds of roadmaps, according to their intention of use: product planning, service/capability planning, strategy planning, long-range planning, knowledge asset planning, program planning, process planning and integration planning. Graphics examples of these different kinds of roadmaps are seen in figure 1 to give a better understanding of what these different kinds of roadmaps could look like, based on the sketches of Phaal, Farrukh and Probert (2004a).

Roadmaps may also be categorized according to the purpose and emphasis (Kappel, 2001). Purpose can be to gather knowledge on the industry (Cheney et al., 2015) or to coordinate locally, like inside an organization (Kappel, 2001) and emphasis can be on the trends or the positioning, like in market or in competition. With these variables you may choose to use a science/technology roadmap, an industry roadmap, a product roadmap or a product-technology roadmap (Kappel, 2001).

Bray and Garcia (1997) categorized technology roadmaps to product-technology roadmaps that focuses on product or service needs, emerging technology roadmaps that focuses on emerging technologies and competitive position, and issue-oriented roadmaps that look into a specific issue at hand.

Reason for needing a technology roadmap can come from the technologies available and emerging or from the markets and the needs. This is called the technology push and market pull (Albright, 2003; Kostoff, & Schaller, 2001; Phaal, & Muller, 2007). Roadmapping is usually started from either of these perspectives.

Technology roadmaps are mostly recognized as visual representations of the technology plan (Strauss, & Radnor, 2004; Gerdsri, Puengrusme, Vatananan, & Tansurat, 2019; Carvalho et al., 2013) but graphically there are also multiple types of roadmaps. These different types were identified to be multiple layers, bars, tables, graphs, pictorial representations, flow charts, single layer and text (Phaal et al., 2004a). These different types of roadmaps according to their graphical presentation are seen in figure 2 to give a better understanding of what these different kinds of roadmaps could look like, based on the sketches of Phaal, Farrukh and Probert (2004a).

Technology roadmaps usually have multiple layers that describe different aspects of the roadmap, like the market, the product and the technology. Albright (2003) mentioned that the technology roadmap essentially is composed of layers that answer to questions like "know-why", "know-what" and "know-how". These are also called the top-, bottom- and middle-layers (Vatananan, & Gerdsri, 2012). The components inside the layers may have dependencies between them (Phaal et al., 2004a).

When it comes to format, the need the technology roadmap is created for should be considered. Bars work when outputs can be simple and express layers of roadmap with sets of bars (Phaal et al., 2004a). Tables may be used when actions are gathered to some specific time period or can be quantified. A graph is a simple expression of the roadmap that can be used to quantified actions and even be expressed in layers. Pictorial roadmap is a way to communicate the roadmap in a simple way and a flow chart is a kind of pictorial roadmap that also shows the dependencies and flow of the components from one to another. Also presenting the roadmap as text is possible (Phaal et al., 2004a). The variety of different options of graphical representation of the roadmap shows the flexibility of the tool.

The timeline that a technology roadmap depends on the organization or industry in question (Lee, S., & Park, 2005). For a software company or high-technology industry a long-term plan may be two years while for an industrial organization like an oil company or for an industry like finance a long-term plan may be ten years. Phaal & Muller (2007) wanted to include in the technology roadmap not only the long-term timeframe, but as well the past, the short- and middle-term timeframes and the vision that is the organizations target. There is no one-fits-all timeline for all technology roadmaps and all these factors need to be chosen appropriate for the context.

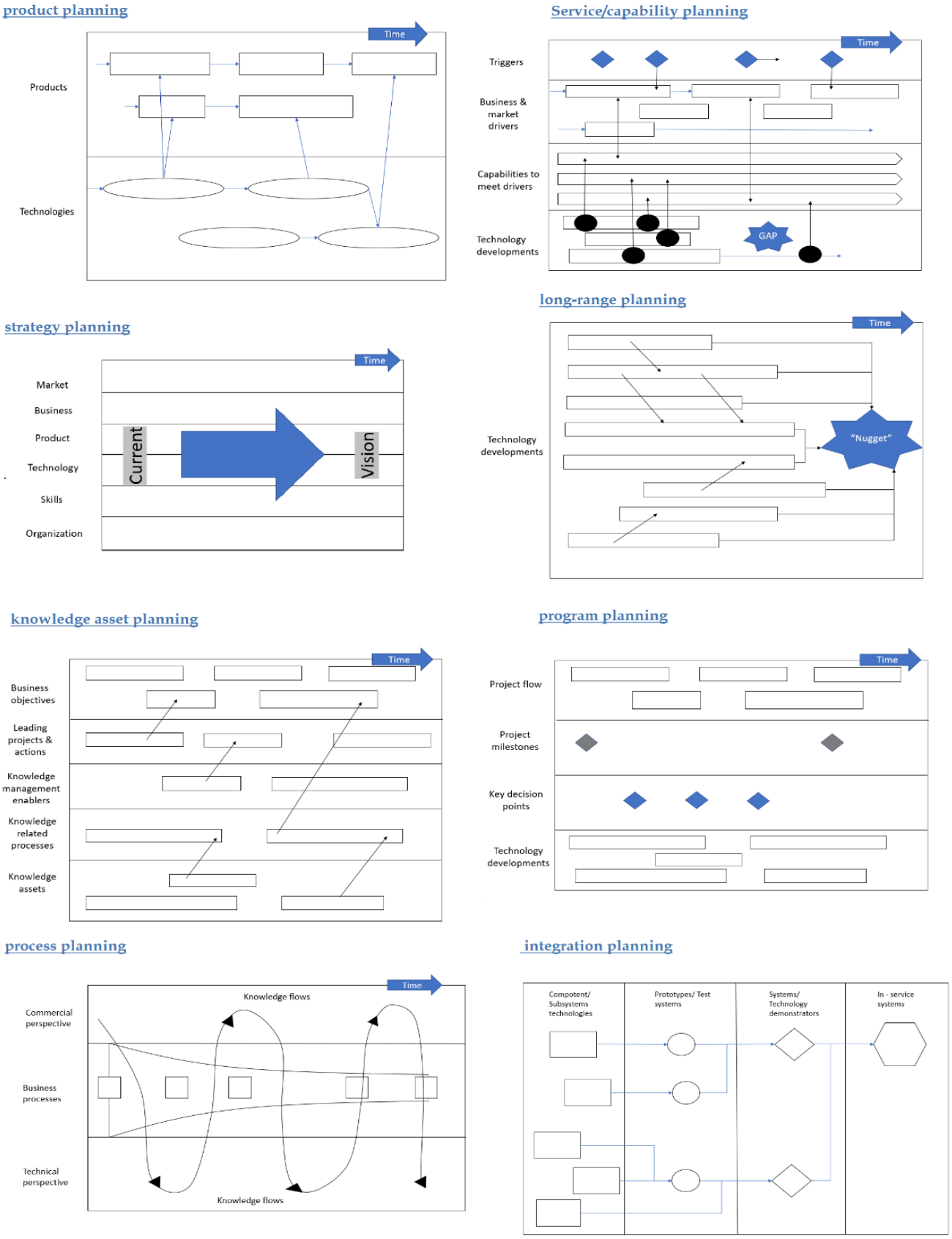

FIGURE 3 Eight types of technology roadmaps according to purpose by Phaal, Farrukh & Probert (2004).

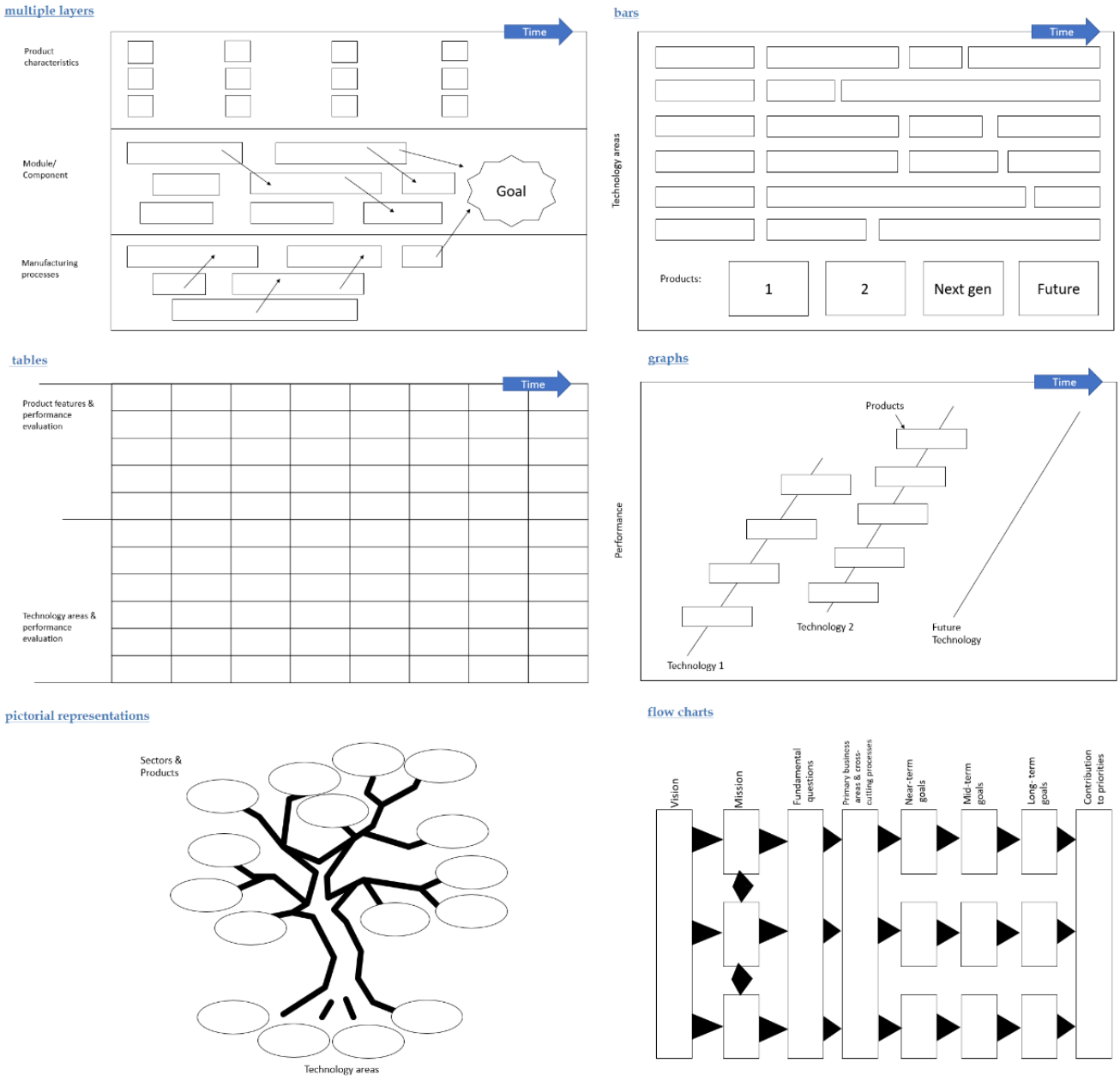

FIGURE 4 Different graphical representations of a technology roadmap by Phaal, Farrukh and Probert (2004)

3.3 Technology roadmap process

There are many research papers that address the process of creating a roadmap and the flexibility of roadmaps as a tool. This flexibility means that roadmaps are not standardized across organizations and industries but can be customized for

each purpose. Phaal's, Farrukh's and Probert's T-Plan is one of the most significant process plans to help organization take roadmapping into use as a planning tool in a simple and fast manner (Phaal et al., 2001). Phaal, Farrukh and Probert (2004b) continued their researched on roadmapping process, focusing on how their T-plan could be customized to fit any need organizations may have. Lee and Park (2005) created their own generic framework that can be used for customization. Like the technology roadmap itself, the roadmapping process phases may vary for all the different purposes roadmapping has in different organizations and there are multiple papers that have researched this issue. Most of past literature about TRM process seeks to provide steps or phases to follow for effective roadmapping in organizations.

The process of creating the roadmap gives value in itself (Kostoff, & Schaller, 2001; Cheney et al., 2015) and the process needs customization according to the needs each organization has for roadmapping. In literature, there is mention of different kinds of approaches to roadmapping: workshops (Phaal et al., 2001; Gerdsri et al., 2019; Phaal et al., 2004a; Vatananan, & Gerdsri, 2012), computer-based solutions (Lee, S., & Park, 2005; Kostoff, & Schaller, 2001; Vatananan, & Gerdsri, 2012; Petrick, & Echols, 2004), a hybrid of these two (Kostoff, & Schaller, 2001) and handing the responsibility to a dedicated team of experts (Kostoff, & Schaller, 2001; Cosner et al., 2007). Some researchers seem to prefer the workshop method (Phaal et al., 2001) while computer-based method has its advances in its objectivity (Kostoff, & Schaller, 2001) and team-based approach is deemed most appropriate for large, multi-division corporations (Cosner et al., 2007). It is also worth to mention that it can matter if the expertise is coming from in-house or some external need is necessary, bearing in mind where this external experience should be used best and where internal expertise is needed (Kostoff, & Schaller, 2001).

The choice for the steps in the chosen method are just as flexible as is the result of the process and the methods chosen. Some researchers have decided to focus more on what happens at the beginning of roadmapping, since defining the scope and the requirements for roadmapping is what most of the effort is based on (Kerr, & Phaal, 2019). Kajikawa, Kikuchi, Fukushima, and Koyama (2011) suggest that in the beginning of roadmapping, the risks of each technology should be identified and evaluated. From this risk evaluation can scenarios be created, and most appropriate scenario chosen to go forward with.

Bray and Garcia (1997) present their framework for technology roadmaps including three phases to be included in roadmapping: preliminary activities, TRM development and follow-up activities. These include planning for the roadmapping by setting the scope and providing leadership for roadmapping, developing the actual roadmap by identifying important factors and specifying drivers to eventually create the roadmap document and finally validating, implementing and updating the technology roadmap (Bray, & Garcia, 1997). Many researchers see that technology roadmapping generally consists of three main phases, like initiation, development and integration phases (Carvalho et al., 2013; Gerdsri et al., 2019). All the phases have their own challenges that have been

identified. In the initiation phase the challenges include the difficulty of starting-up the process of roadmapping, getting commitment from senior management, selecting the right people to be part of the process, customizing TRM process and selecting the architecture (Gerdsri et al., 2019). In the development phase Gerdsri et al. (2019) list difficulties to be facilitating the workshops, ensuring the quality of inputs and limitations in data about new technologies or key drivers. The challenges of the integration phase include integrating the TRM process into already existing processes in the organization, resistance to the TRM process altogether and the maintenance and updating of the roadmap (Gerdsri et al., 2019).

Even if the details in technology roadmapping phases that different researchers have developed may vary, it can be concluded that they consist of some planning phase before the actual document making is started, the phases where the document itself is made and action taken to maintain it after the document is ready. The issues practitioners face can be overcome if the challenges are recognized.

Technology roadmapping has some other issues and limitations that practitioners face when using it. Roadmapping is sometimes seen as a one-time exercise and will never be updated (Strauss, & Radnor, 2004). This is not the ideal use of a roadmap, but a bit paradoxically it is also hard to maintain (Strauss, & Radnor, 2004). It may be too easy to lose focus and pay too much attention to technology instead of focusing on customers and their needs in the future (Strauss, & Radnor, 2004). The lack of proper information may disturb the roadmap creation and if underlying, contextual factors are not brought up enough, they may be overlooked, and the resulting roadmap be inaccurate (Strauss, & Radnor, 2004).

The parts of the roadmap that are usually customized are time, layers, annotations, and the process (Phaal et al., 2004b). Graphically there are also multiple types of roadmaps. These different types were identified to be multiple layers, bars, tables, graphs, pictorial representations, flow charts, single layer and text (Phaal et al., 2004a). The timeframe on the roadmap can be customized to be as long as is needed, since the most appropriate timeframe to examine may differ between industries and organizations. The layers, that in the generic roadmap model are market, product, technology and additionally other resources, can also be customized to include any layers that are necessary (Phaal et al., 2004a).

Lee and Park (2005) suggested a framework for technology roadmap customization. Their framework consists of classification phase, standardization phase and modularization phase. In the classification the possible technology roadmap types were examined and purposes for roadmapping defined, which according to Lee and Park (2005) could be categorized to forecasting, planning and administration. After this the standardization phase eight kinds of roadmap types are found: four product types and four technology types. These are categorized also by being static (map) or dynamic (roadmap) and being internal examination of the company or external examination of the market. In the last phase of modularization the eight roadmaps are paired with the three purposes found to get a guideline for modularization, making everything else standard but the factors that are important: roadmap type and purpose for roadmapping (Lee, S.,

& Park, 2005). While the framework does in some way limit roadmapping with the standardization, it is a framework and should be treated as such. The process of identifying the purpose and types of roadmap to find types of roadmap for the context and then finding the right map for the purpose in the context can be used as a guide how to customize roadmaps if the framework does not work as such in that context.

Fast-start technology roadmapping was created in a study by Phaal, Farrukh and Probert (2001) to help organizations develop their first roadmaps in an organized way and see the important factors when creating a roadmap. Study developed a standard process (T-plan) to follow when making a roadmap. The process consists of workshops, which each address an important part of the roadmap, like market, product and technology, finally in the last workshop focusing on the actual roadmap creation (Phaal et al., 2004a). The study itself was made as an action research (Phaal et al., 2001) which is a very popular method is many roadmapping studies. This process intends to support the starting of the process, find key linkages between the business drivers and the technologies, identify possible market, product or technology gaps, develop competitive roadmap as well as support the technology strategy and communication. For the process to work, it needs the attention from the right participants, a proper schedule, information to be available, definition for what is going to be under analysis and the company objectives (Phaal et al., 2001). But naturally different organizations have different situations and have different needs, so the T-plan can be customized to include what is needed in the organization. This may mean that for example an organization wants to focus on how the competition influences their services and what technologies can be used to have better services to be able to compete against the competition. The general roadmap in the Fast-start process consists of the same parts that Albright (2003) mentioned: time or "know-when", the purpose or "know-why", the delivery or "know-what" and the resources or "know-how".

As important as it is to understand the technology roadmapping as a process, it is also important to understand what process the roadmapping is a part of. Relating to that, one of the important tasks in the last phases of roadmapping is integrating the roadmapping into existing processes. What bigger process roadmapping is a part of hugely depends on what are the purposes and benefits the organization pursues with technology roadmapping. These could be anything from using it for product, project or architecture planning, technology forecasting in industry or administrating IT development to having the targeted benefits be better IT-business alignment, better decision making or enhancing digitalization. Either way, these purposes and targeted benefits should be recognized as the technology roadmapping is taken as a smaller part of that bigger process to get the most value out of the tool. In the next section, technology roadmapping will be reviewed from the context of enterprise architecture and IT portfolio management, and in that context, what is technology roadmap's role in the bigger picture for the organization.

4 TECHNOLOGY ROADMAPS IN EA AND IT PORTFOLIO MANAGEMENT

Enterprise architecture (EA) is a framework that describes how an enterprise is constructed by describing primary components and their relationships (Rood, 1994). It also has been described as the view of current and future states of organization's data, processes, IT systems, relationships and the roadmap that describes how to go from the current state to the wanted future state (Jusuf, & Kurnia, 2017). The enterprise architecture components compose of external environment factors, enterprise strategy, enterprise culture, the people, organization structure, technologies, information, processes, tasks and enterprise products or services (Rood, 1994). It is a top-down, business strategy driven process (Buchanan, & Soley, 2002).

Once the future vision and to-be architecture is clear, IT governance, the process for deciding IT investments, needs to be thought about. In the most mature level of IT governance, IT development is not only about doing projects right but also doing the right projects (Symons, 2005). This is the main objective of IT portfolio management (Cooper, Edgett, & Kleinschmidt, 2002). Sometimes called project portfolio management (Project Management Institute, 2013) or product-portfolio management (Jugend, & da Silva, 2014), IT portfolio management is managing the IT portfolio of the organization, consisting of projects or programs, to deliver value (Project Management Institute, 2013). Whether it is project or product portfolio, depends on the organization and their business.

In the big picture, enterprise architects plan and forecast the future to achieve the desired to-be architecture and IT portfolio management makes sure that the desired vision is reached through keeping the portfolio in line with the vision and ensuring the portfolio provides value to the enterprise. Technology roadmap can help in planning, forecasting and decision making once the tool can evolve to meet up to the expectations of today's dynamic world.

4.1 Purpose and benefits of technology roadmapping to EA and IT portfolio management

Enterprise architecture traditionally focuses on the entirety of the organization's systems (Gøtze, 2013). Enterprise architecture's role is an essential part of understanding the enterprise's composition and one important aspect of enterprise architecture is to understand the current situation of the enterprise, especially systems of the organization and outline the future state of the enterprise (Shanks, Gloet, Someh, Frampton, & Tamm, 2018; Gøtze, 2013). Enterprise architecture methodologies essentially consist of four-step process: describing the current (as-is) state of the enterprise, describing the wanted future (to-be) state of the enterprise, researching the gap between the as-is and to-be state to figure out a plan how get there and finally introducing this plan (Kotusev, Singh, & Storey, 2015). To achieve all this, enterprise architects may use artifacts like roadmaps to represent the plan. These artifacts are documents that describe a part of the architecture and artifacts in EA include roadmaps, business strategy, business risks, flow chart diagrams, principles, policies and standards among many other possible artifacts (Kotusev et al., 2015).

As mentioned, one highly ranked strategic benefit is having a roadmap for enterprise architecture as a guidance to how the organization will get from their current state to where they want to be (Jusuf, & Kurnia, 2017). Roadmap helps with integration of organization's components. It is also mentioned as a highly ranked success factor for getting good product quality. Practitioners that were interviewed agreed that an organization should have a roadmap to succeed with their enterprise architecture (Jusuf, & Kurnia, 2017). While other tools can also help with these factors, a roadmap may help to communicate the as-is state, focus on strategic alignment and goals of enterprise architecture and make stakeholders understand the goal and benefits of it.

Jusuf and Kurnia (2017) found that important factors for enterprise architecture success include a good roadmap, good as-is quality, link to strategic goals, having a clear goal, quality of communication and stakeholders understanding enterprise architecture and its importance. In this same study, benefits from enterprise architecture were found to be operational benefits, managerial benefits, strategic benefits, IT infrastructure benefits and organizational benefits. These benefits in more detail consist of higher efficiency, better change management, support for portfolio management, better mapping, better prioritization, and decision making (Jusuf, & Kurnia, 2017). Based on this, we could say that enterprise architecture supports IT portfolio management and they drive each other forward to their common goal of strategy alignment (Jugend, & da Silva, 2014; Kotusev et al., 2015).

Part of enterprise architecture is the decision making on IT investments in the organization. According to Van den Berg, Slot, van Steenbergen, Faasse and van Vliet (2019), roadmaps can be used as a tool for the EA function to make

better IT decisions. What decisions are made for IT will affect how good the performance of IT will be and may have a big effect on the performance of the entire organization. Organizations that have a more mature EA and use tools such as the technology roadmap in their decision making, have succeeded better (Van den Berg et al., 2019). As IT portfolio management also has a big role in IT investment decisions, from this finding it is deduced that IT portfolio management benefits from a high-quality technology roadmap. Roadmapping aims to identify potential development, optimize decision making and produce strategic prioritization, all to the benefit of EA and IT portfolio management (Vishnevskiy, Karasev, & Meissner, 2015).

The model that portfolio management uses may be a gate-dominate model, a portfolio reviews dominate model or a mix of these both (Cooper et al., 2002). A gate-dominate model measures projects criterion, on which a decision is made to kill, forward or hold the project and it involves a real-time decision. A portfolio reviews dominate where meetings are hold regularly but not often on the complete portfolio to make decisions on which projects go forward. Many organizations may choose to use both approaches (Cooper et al., 2002).

The four main goals of IT portfolio management are to maximize the value of the portfolio, find the right balance of projects in the portfolio, keep a strategically aligned portfolio, and have the right number of projects for the given resources (Cooper et al., 2002). Jugend and da Silva (2014) also pointed out that portfolio management wants to realize the business strategy with the portfolio. To achieve these goals there are multiple tools, methods, and ways of working in portfolio management. Methods include financial monitoring, scoring, and ranking as well as maps, graphs and diagrams (Jugend, & da Silva, 2014). The methods are used to see the strategic, market, technological and risk factors that affect the portfolio and decision making. Since one of the main goals of portfolio management is to maximise the value of the portfolio, financial methods are used to see which decisions will create that value. It is an important factor in portfolio since private organizations are mostly there to make value to their owners and it is easy to validate portfolio decisions with financial benefits, but it also may affect negatively on the more innovating and disruptive projects (Jugend, & da Silva, 2014). Scoring and raking helps to prioritize the projects according to objectives. Analytic hierarchy process (AHP) and balanced scorecard (BSC) are used model for ranking. Maps, graphs, and diagram as a method include bubble charts, matrices and this thesis' main subject, roadmaps, visual representations of the decisions and their repercussions (Jugend, & da Silva, 2014). Roadmaps can be useful for portfolio management in different kind of portfolios in different lines of business.

Oliveira and Rozenfeld (2010) suggested a method where portfolio management acts tightly with technology roadmapping to create a portfolio of the right developments and a roadmap as a plan for implementing the development. Their method includes analyzing the layers that usually are included in a roadmap: market, product and technology. According to this analysis a proposal of appro-

priate set of projects is made. This set is then finally analyzed for financial, success and strategic analysis get a selection of projects into the portfolio (Oliveira, & Rozenfeld, 2010).

A roadmap used in enterprise architecture and IT portfolio management aims to do technology forecasting and represent plans made to achieve organization's goals (Kappel, 2001). Technology roadmapping can help IT portfolio management to see which products or technologies to develop or which projects or epics to include in the portfolio and how to schedule these developments (Jugend, & da Silva, 2014). It gives a visual tool to plan the resources, deadlines, functional responsibilities, and project approvals (Jugend, & da Silva, 2014). Because technology roadmap is a flexible tool, it can be used for different kinds of organizations with different kinds of IT management and different kind of products. One of its benefits is the customization possibilities, beings flexible enough to service many kinds of needs. Organizations typically reinvent their own roadmap process for their own specific demands (Lee, S., Kang, Park, & Park, 2008).

One of enterprise architectures main goals is to understand the current as-is architecture and the wanted future to-be state and see the timeline in between these states as well as what is needed to achieve the desired future state. A technology roadmap can be used as the tool for enterprise architects to plan the transition from current state to the desired future vision. IT portfolio managements mission is to have the right size of the right projects that bring the enterprise towards this future state that is aligned with the business strategy. In a sense, enterprise architects and IT portfolio managers have a common goal: to reach the strategic vision of the enterprise within a given timeline with the right IT development. To do this in an efficient and communicative way, they can use technology roadmaps as a tool to plan, decide and communicate when, what and how to do IT development (Lee, S. et al., 2008).

4.2 Technology roadmap type for EA and IT portfolio management

Since from the literature it can be deduced that the main objective of enterprise architecture for technology roadmapping is to see how the organization will get from the current state to the desired future state and for IT portfolio management how to schedule the developments to accomplish this vision, we can also deduce which kind of a technology roadmap could be most suitable in this context. In prior literature this has not been main focus, and this is why this report wants to research on the use of technology roadmapping in this context.

Enterprise architecture and IT portfolio management plan future locally (for the organization) and emphasis is on the future, meaning that the type for a technology roadmap in this context would be a product-technology roadmap (Kappel, 2001). The name product-technology roadmap may be misleading since the

product-layer is flexible and could be customized to be a layer for projects, epics or other developments to fulfil the objectives of IT portfolio management. The layers in Albright's (2003) general model for a roadmap, the know-why, know-how and know-when, are justified in the context of EA since most EA models and frameworks include similar levels. For example, the Zachman (1996) framework includes what, how, where, who, when and why. The four dimensions to enterprise architecture of business, information, applications and technology (Pulkkinen, 2006) support the traditional layers of a technology roadmap.

Lee et al. (2008) suggested a technology roadmapping process for project selection in portfolio management. Their solution includes main roadmapping steps, initiation, deployment, and implementation, and in addition to the usual steps in roadmapping, it takes into account the project planning and prioritization. In their case study, they found that the flexibility of technology roadmap is an advantage that should be preserved, that the roadmap needs periodical updates but that it did not deal with the critical project cost and profitability issues or the complex dependencies between projects.

A technology roadmap can be customized to the needs of the organization, meaning we may have a roadmap that has projects, programs, systems, resources as layers, dependencies between these layers and a timeline to describe when each development should be done to also achieve the to-be vision of the enterprise architecture. The format to choose depends a lot on the organization and the how they see fit to communicate the roadmap through the organization. It is important to decide which roadmap type according to purpose is appropriate in enterprise architecture and IT portfolio management and which layers fit their purpose the best. Enterprise architect's and IT portfolio managers objective is to realize business strategy and align technology strategy with business strategy (Jugend, & da Silva, 2014; Kotusev et al., 2015) while planning the transition from present to the future vision (Jusuf, & Kurnia, 2017). To plan the shift from current to the future state with business strategy realized, most appropriate technology roadmap type should be strategy planning-, long-range planning- or program planning- types (Phaal et al., 2004a).

4.3 Agility in EA and IT portfolio technology roadmaps

Today organizations face a lot of uncertainty from the changing markets, new competition, volatile prices, new regulations, and other factors that cause the business environment to be more dynamic than ever (Tallon et al., 2019). Agility is almost a necessity if the organization wants to beat the competition or even survive. Many organizations have taken the route to agility and made IT portfolio management and enterprise architecture to also take this step. But agility does not mean that organizations should lack in planning and not have a vision of the future. Many of the agile methods and frameworks include tools for planning and forecasting the future, also using roadmapping as one tool option.

Agility is about anticipating and responding to change and it can be found on many levels, from the organization level to team level (Tallon et al., 2019). According to Tallon et al. (2019), some researchers see that agility is achieved through scenario building and keeping IT developments on a relatively small size. For the organization to be able to anticipate and respond to unexpected changes, it needs organizational agility. This means agility in the organizational level, where the whole organization can be prepared and take action when there are new threats and opportunities like new customer needs (Lee, O. et al., 2015). IT ambidexterity can enhance organizations agility, especially in a highly dynamic environment (Lee, O. et al., 2015). According to Lee et al. (2015), IT ambidexterity requires IT exploration and IT exploitation, meaning the organization at the same time exploits the existing IT resources and opportunities and explores new resources and opportunities to benefit from.

In the Scaled Agile Framework (Scaled Agile, 2020) a roadmap is a tool to communicate the planned steps to take to get to the future vision. SAFe is a framework that guides organizations to take on lean and agile practices in their IT development. It consists of Agile Release Trains (ART) which are essentially teams of teams that develop solutions. This team should be aligned to a shared vision and be cross-functional to be able to deliver solutions from beginning to end. A program increment (PI) is a time interval similar to an agile increment when ART teams try to deliver value to the organization by development and testing. An epic is a description of a solution initiative that consists of smaller development items knowns as features.

A roadmap in SAFe framework is a planning tool to help see how solutions will be delivered over certain time frame (Scaled Agile, 2020). Looking at market rhythms and events is important in SAFe as in most agile frameworks it is important to keep dynamic to be able to respond to changing environments. But even in an uncertain environment you may do forecasting with appropriate tools to get better opportunities and competitive advantage. The roadmap in SAFe may be a short-term PI roadmap that describes recent commitments that the Agile Release Train (ART) will take on Program Increment (IP) and the few next PIs (Scaled Agile, 2020). Or the roadmap may be a long-term Solution roadmap that has a timeline of a few years and shows the steps needed to get to the future vision. The roadmap may also be a portfolio roadmap that describes multiple years of portfolio vision. This type of roadmap seems beneficial, since IT portfolio management has a positive impact on business unit agility (Tallon et al., 2019).

Since agile methods are used to give organizations better flexibility to respond to fast changes happening around them, it makes sense that roadmaps should not be rigid and static either. Carlos, Amaral and Caetano (2018) took advantage of agility to create a roadmapping framework that helps roadmaps be continuously updated. The agile roadmap management consists of three steps: planning the updating cycle, managing the updating cycle and analyzing the strategy of innovation. In this agile process, technology roadmap would be updated in iterative cycles (Carlos et al., 2018). Organizations also customize and

adapt the agile methodologies to fit to their needs and culture, so each organization have their own way of agility (Rasnacis, & Berzisa, 2017).

Technology roadmapping gives enterprise architecture and IT portfolio management solid tools to plan the road from the as-is current situation to the to-be vision of the future. While roadmapping is an old tool, it can be updated to be a valuable tool in today's agile world where change must happen fast.

5 MONITORING AND UPDATING TECHNOLOGY ROADMAPS IN EA AND IT PORTFOLIO MANAGEMENT

Many research articles mention that keeping the roadmap up to date is seen as a difficult task in organizations (Phaal et al., 2001; Gerdsri et al., 2019). While some authors only mention this as an issue, other authors have addressed the issue of keeping a roadmap alive in volatile environments. Solutions vary from creating an updating process with steps for deciding when to update and what to consider in updating (Holmes, & Ferrill, 2008), combining other methods like scenario planning with roadmapping to plan plausible futures (Strauss, & Radnor, 2004), using computer-based frameworks to help monitor change causing factors (Gerdsri et al., 2019) or change management models to help with implementing roadmapping into existing business processes (Gerdsri et al., 2008).

Organizations are expected to be reactive to technological change (Kappel, 2001) but it is not completely clear which approach organizations should take to keep their roadmap alive. Reactivity may not even be enough in volatile environment and may be necessary to pe proactive (Gerdsri et al., 2019). This section will look into literature addressing monitoring and updating technology roadmaps. While many of the papers focus on monitoring for internal or external change that causes a need for update (Gerdsri et al., 2019; Pora et al., 2020; Lischka, & Gemunden, 2008), others focus more on the structure and the steps in the updating process (Holmes, & Ferrill, 2008; Carlos et al., 2018) and others on tools that may be used to mitigate the risk of an out-of-date roadmap (Hussain et al., 2017; Strauss, & Radnor, 2004).

5.1 Updating processes

Perhaps the most straight-forward of all described methods for updating technology roadmap is by Holmes and Ferrill (2008). Reviewing the roadmap and the roadmapping process gives the update process better outcome and helps make

the decision whether to update the technology roadmap (Holmes, & Ferrill, 2008). There is a big difference between a simple review of the roadmap and a complete update of it. How frequently organizations review their roadmaps can also vary a lot, some review their roadmaps every few months but most review only once a year (Holmes, & Ferrill, 2008). The process of update and review of technology roadmap relies a lot on the internal and external drivers that the roadmap has. There may be internal changes like rapid changes in the technical developments inside the organization or external changes like new market opportunities (Gerdsri et al., 2019). They are the achievements what company wants to accomplish and drive them forward or factors that the company has no control over that may impact the company. In Holmes and Ferrill's (2008) plan for the update and review process, these drivers can be marked as happened, postponed or not-happened, according to its status. The product or the services in question in the roadmap have a status of delivered to market, delayed or cancelled (Holmes, & Ferrill, 2008).

First the organization should review their technology roadmapping capability by identifying any issues in the current plan, the status of products and services as well as status of internal and external drivers. After the organization has reviewed the roadmapping capability, the decision needs to be made if the roadmap needs updates and is still quite valid or if a completely new roadmap is needed (Holmes, & Ferrill, 2008). The process for a completely new roadmap is the process for roadmapping with the phases initiating, development and integrating, but the updating process is defined in Holmes's and Ferrill's (2008) model. In the updating process Holmes and Ferrill (2008) suggested that organizations should review old drivers, products or services and technologies for applicability, brainstorm new drivers, products or services and technologies, review product and technology themes and add these new discoveries to the roadmap chart. It needs to be noted that when brainstorming new products or services, there should be a connection to the driver and when brainstorming new technologies, there should a connection to the products or services. Also, the old information from the old roadmap needs to be transferred to the new roadmap, if it is still valid and reasons for roadmapping clear throughout. It also should be noted that this model was created for small- and middle-sized business environments, not for large business environments with multiple strategic business units.

TABLE 3 Updating process by Holmes and Ferrill (2008)

Drivers	**Products & Services**	**Technologies**
Review old drivers	Review old products & services	Review old technologies
Brainstorm new drivers	Brainstorm new products & services	Brainstorm new technologies
	Review themes	Review themes
Add to chart	Add to chart	Add to chart

Influenced by Holmes and Ferrill (2008), Carlos, Amaral and Caetano (2018) proposed a framework that uses the agile principles to create a process for updating the technology roadmap in an organization. Agile principles are defined to make management more simple, flexible and iterative to get better cost, time and quality performance and ability to change plan quickly and continuously (Carlos et al., 2018). Based on this, the updating of TRM should also be done iteratively in cycles.

Through an action research this agile principle was brought to the TRM updating process. In the framework of Carlos, Amaral and Caetano (2018) the steps include planning the updating cycle, managing the updating cycle and analyzing the strategy of innovation. Their proposed actions to update a roadmap can be seen in figure 4. The diamond shape in the figure describes the step where the decision must be made whether the roadmap is at sufficient level of validity or a completely new roadmap is needed.

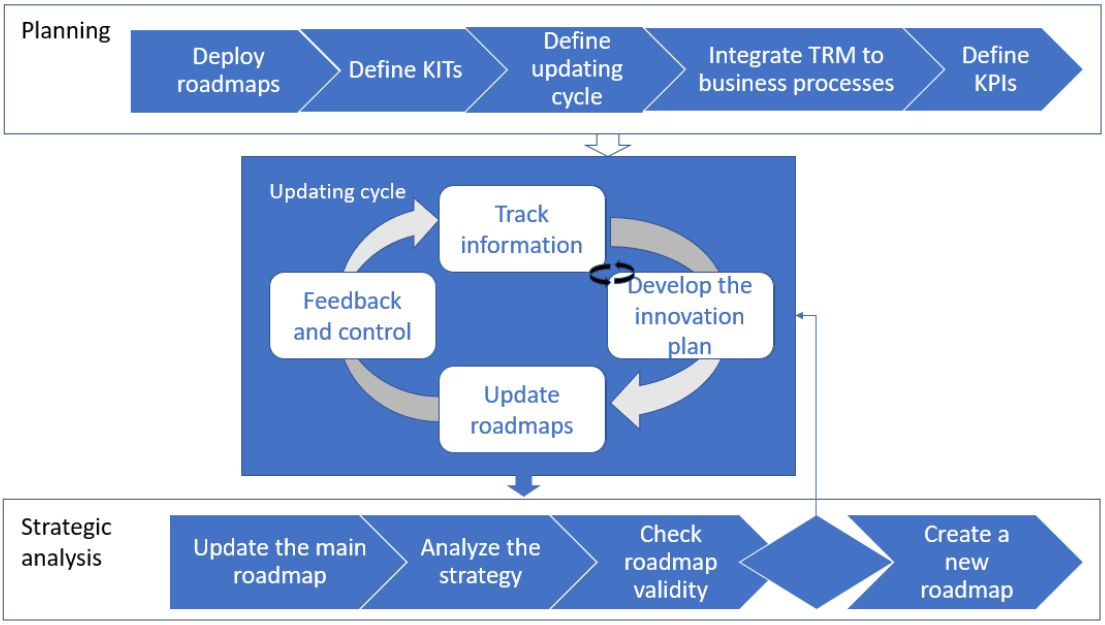

FIGURE 5 Roadmap updating by Carlos, Amaral and Caetano (2018).

The three main steps in the process plan the updating details, maintain the updating actions and analysing the situation (Carlos et al., 2018). The planning step focuses on determining all the necessary actions to the updating process in the organization, necessary information to monitor throughout the process (i.e., key intelligence topics and key performance indicators) and deploying the continuing roadmapping process. In the second step the actions in updating TRM are managed in an update cycle, consisting of monitoring and feedback. The last strategic analysis is to make two important decision: actions needed to address critical issues and validating the roadmap or creating a new one (Carlos et al., 2018).

This framework for updating process is not without its limitations and requirements for it to function properly. The organization should already have created their first technology roadmap when this process is taken into use (Carlos et

al., 2018). The process requires a team or a person in the organization that can give at least 20% of their time to maintaining this process but bearing in mind that going a lot above the 20% could be damaging to other processes in the organization. Carlos, Amaral and Caetano (2018) also emphasized that this framework needs to be adapted to the context of the organization's needs. This process in the framework does contain many steps to complete by the responsible team and as was mentioned by the researchers themselves, requires a lot of focus and effort. This may not be appealing to an organization that wishes to have a light process for the TRM update and the framework loses its lean approach in its various steps.

5.2 Monitoring the changes

While Carlos, Amaral and Caetano (2018) have included the monitoring of information into their framework, they did not give deeper analysis about the subject of monitoring. Lischka and Gemünden (2008) suggest that a steering committee should monitor if there are new findings and according to the findings, update business cases and do reprioritisation in the IT portfolio. Cosner et al. (2007) suggest reviewing the TRM periodically and have a specific roadmapping team be responsible for monitoring changes in the environment. Some other researchers have given their time to investigate the appropriate process for monitoring the changes that make it necessary to update the technology roadmap.

Gerdsri, Puengrusme, Vatananan and Tansurat (2019) created a framework that considers the change that happens outside of periodical review of an organization's roadmap. This framework describes a status for the roadmap that can be calculated using the internal or external factors that may cause a need for roadmap adjustment or even creating a new roadmap. Internal factors were described to be factors like technology not developed fast enough inside the organization for a product or even too fast for the market. External factors could be anything that affects the market opportunity and has the potential to change the timeline (Gerdsri et al., 2019).

The calculated status will then give indication whether the roadmap can be maintained, needs adjusting or needs a complete redo, depending on the gravity of the change factor (Gerdsri et al., 2019). After applying the roadmap, a specific team of TRM operations will monitor the internal and external factors, determine how impactful the changes are to make calculations for the status signal and inform the management team if there is a possible need for adjustment or revision (Gerdsri et al., 2019). The status signal may be green, yellow or red, depending on whether changes to the technology roadmap is not needed at all, some modifications to the roadmap are needed or if the whole roadmap needs to be created from the beginning. This is seen in figure 6, which describes the process in this solution.

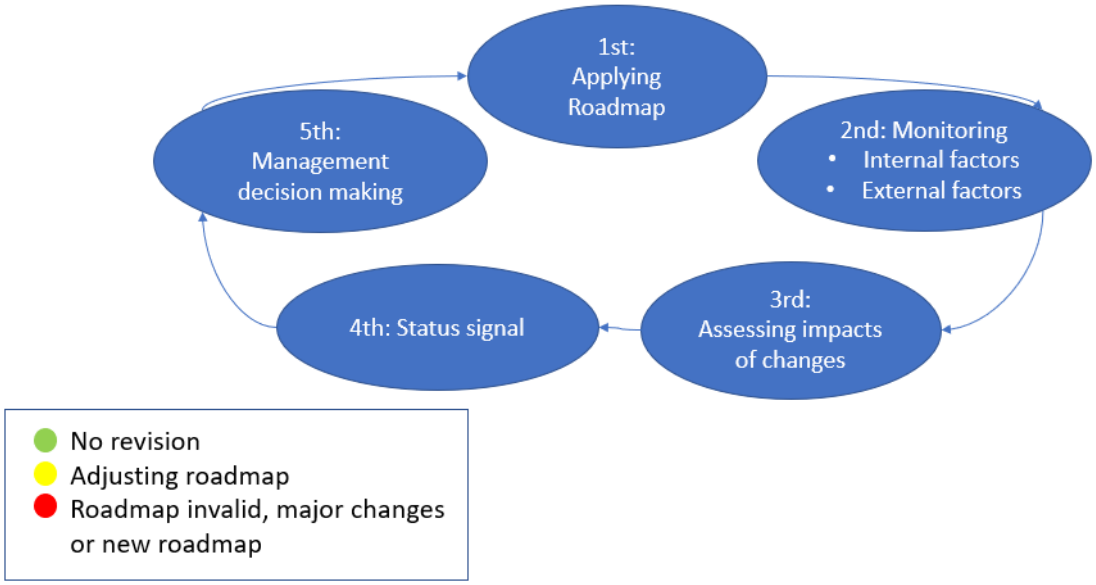

FIGURE 6 Updating TRM and monitoring changes in framework by Gerdsri et al (2019).

The problem with this framework is its complexity and reliance on the NASA TRL scales calculations and status signal calculations. The calculations include variables that the TRM operations team should determine but may be difficult to give an exact value to. Building this process into an organization needs quite some effort, skills and would need people with good skills with mathematics and technology development if the organization may not want to or even be able to use the TRL calculator that was introduced as a tool. The roadmap loses its benefit as a tool if it needs such complicated tools to be used. Compared to monitoring the changes manually, it should take time to set up the monitoring process but little less time to do the actual change monitoring. The actual decision about updating must be made by appropriate persons but the computer system can follow-up on the internal and external factors and their impact on the technology roadmap. Taking a manual monitoring process into use may be quicker but can take up more time in the long run.

5.3 Tools for updating or monitoring

Scenario-driven roadmapping is a method created by Hussain, Tapinor and Knight (2017) to take advantage of two foresight tools: scenario planning and roadmapping. According to them, technology roadmapping has some issues that could be solved using it with scenario planning, like roadmapping being linear and takes different forms. The model consists of scenario development phase and a TRM phase. In the scenario phase, the scene for scenario planning it set, uncertainties are identified, ranges of impact uncertainties have been specified, themes and scenarios are developed, scenario consistency checked, and final scenarios

presented. These scenarios are then the basis for TRM phase, where architecture framework is used and flex points identified. The flex points are indicators of important changes that may occur, they imply if a significant change is happening and connects the change with the scenario. This model creates only one roadmap for all scenarios and treats the scenarios as what may happen in the future.

There are multiple models and frameworks on change management that can be used in smaller or bigger changes. Mostly the change management models are used to lead the people to change that will happen in organizations (Galli, 2018) but some have also recognized that these models could help also in technology roadmap implementation (Gerdsri et al., 2008). Change management models have been used to address the struggle of implementing a roadmapping process into the existing processes in the organization (Gerdsri et al., 2008). The models researched for this purpose were Prosci's ADKAR model and Kotter's eight stages of change. If keeping a technology roadmap alive is seen as a problem, it could also be that integrating the technology roadmapping as a process into existing processes has not succeeded as well as hoped. This is exactly where change management model may come to use.

Prosci's ADKAR model consists of five elements that prepare for the change (Galli, 2018). The elements are awareness, desire, knowledge, ability, and reinforcement. First, we need awareness of why change needs to happen and what we risk by not changing, to motivate it to happen (Gerdsri et al., 2008). Change may be easier to implement if the possible loss without the change is there to be seen (Kappel, 2001). Next, we need desire to make the change happen with the motivation and applying positive or negative enforcement, giving people knowledge on how to behave with examples and guidelines. Finally, we give people the ability to use the new skills and behaviours by practicing and reinforce the change by taking it into the culture and reward wanted behaviour (Gerdsri et al., 2008). In the context of technology roadmapping, the process needs to be communicated to the organization, explain what is at risk if roadmap is not implemented, guiding each function what the roadmap means for them and rewarding success.

Kotter's eight steps change model is a famous model for organizational change (Galli, 2018). The steps are comparable with the issues organizations have when implementing change and gives steps to follow to avoid failure with change. The steps are:

- Establishing a sense of urgency: raising awareness of the reason for change and motivate for change,
- Guiding coalition: facilitate decision making,
- Creating a vision: give direction for change and a vision of what the future looks like, to help coordinate needed actions better,
- And communicating the vision: convince for commitment with the vision,

- Empower others to act on the vision: ensure ability to take act upon the vision throughout the organization,
- Short-term wins: get quick achievements to get credibility and proof for stakeholders,
- Improvements and more change: bigger changes after wins and more forward with the change, and
- Institutionalizing new approaches: integrate the changes into the organization culture and leaders to adopt this new behaviour.

Again, these steps can be used to implement the process of roadmapping and updating of the roadmap into organization. Motivating to take technology roadmap into use as soon as possible to realize the plan, deciding on a decision-making coalition to make the decisions on the technology roadmap, communicating what the vision of the roadmap looks like, guiding each function what the roadmap means for them, rewarding success and updating the technology roadmap to be better in each iteration. All of this should become part of existing processes to institutionalize roadmapping.

Both of ADKAR and Kotter's model have a lot in common and if not followed by the book, at least gives good advice to organizations implementing a roadmapping process. Identifying and expressing the motivation for the change, encouraging change in the people, reinforcing change behaviour, and anchoring the change in the organization culture are all actions that are seen in both models.

The roadmapping activities can generally be summarized to three phases: initiation, development and integration (Gerdsri et al., 2008). In the guideline provided by Gerdsri, Assakul and Vatananan (2008), using change management models as a tool, the ADKAR and Kotter change actions were integrated into these three roadmapping actions. While these change models can be especially used for the initial implementation of the roadmap, the change that is needed when organizations start to use the roadmap, but also for the change after roadmap is initiated.

Gerdsri, Assakul and Vatananan (2008) researched small and medium enterprises for use of ADKAR and Kotter's change management methods in roadmap updating. The updating in this case, however, is one that is planned and regular and not unexpected. It is not clear is these methods also work in an unexpected change situation and in large enterprises.

6 PROBLEM IDENTIFICATION AND OBJECTIVES

To describe the research problem and the objectives for the solution this design science research is trying to achieve, this section explains the findings in the initial interviews and in the literature review. After this the objectives analysed, and their justifications given in the last sub-section of this section. This acts as the basis for creating the solution.

6.1 Initial interviews

The initial interviews conducted to four enterprise architecture or IT portfolio management experts in Finland gave interesting insights into the challenges of technology roadmapping, as summarized in table 4. An IT architect working currently in financial sector highlighted the impact of technology product suppliers own roadmaps and how changes in their products or technologies that they offer and support may affect the technology roadmap of an enterprise. The enterprise architect in another financial sector company saw this more self-evident that it is a part of roadmapping that should be always considered. This also related to another important issue this interviewee pointed out: technical debt. If versions of these products are not regurarly updated and paid attention to in roadmaps, the eventual version update may become expensive. According to this interviewee, technology roadmaps mitigate the risk of huge unexpected changes, even though some unexpected changes may still occur.

The enterprise architect and the IT portfolio manager working currently in an oil industrial enterprise pointed out the expence and time it takes to recover from a sudden external or internal change. One significant example of sudden change was the coronavirus its effect to enterprises around the world, forcing these enterprises to update the technology roadmap and eventually their IT project portfolio. All three interviews confirmed the presumption that even in the most ridgid of industries, the organizations are in a dynamic environment and face changes regularly, even unexpectetly.

TABLE 4 Summary of initial interviews

Interview number	Organization industry	Interviewee role in organization	Findings
1	Finance (first)	IT architect	Service providers own roadmaps affect organization roadmaps. Version updates affect the roadmap as well. Categorizing systems according to their lifecycle phase. Architects have their own area of roadmap to be responsible for. Roadmap enhances predictability.
2	Industrial sector	IT portfolio manager EA architect	Portfolio implements roadmap, portfolio management ensures prioritization. EA supports decision making. Segments in organization. Scenarios are used. Changes like economic change from corona pandemic do occur and affect roadmapping. There is resource scarcity that is a challenge in itself.
3	Finance (second)	EA architect	Limited resources. Lots of dependencies between development items. Business and technical enablers. There are unexpected changes that trigger update in roadmap. Gardner and other existing tools for monitoring used. ADKAR could be a useful tool in roadmapping.

The experts from the oil industry enterprise also pointed out that enterprise architecture is the function that will plan how to get from their as-is state to desired to-be state, i.e. their technology roadmap and IT portfolio management is the function that implements this plan. The changes the technology roadmap undergo may have a huge impact on the IT portfolio proritization and result in project delays and even rejection. They also noted that technology roadmapping updating takes time even when resources are scarce. Also usually the biggest projects get the most attention and are more thought out than smaller projects which may result in disregarding their dependencies and factors that may cause change. Interestingly enough, in the second financial enterprise they have the opposite issue : mainly smaller developments have gotten forward and there is a need to see the bigger picture with long-term developments.

All of the experts told that their enterprise has updated or a procesff for updating their roadmap, although different process in all of them. In the first financial enterprise the IT architects all have their own area that they are

reponsible for and thus also responsible for updating the technology roadmap of their area. This happens approximately twice a year. In the other financial enterprise roadmap updating is done whenever that is seen necessary and seen more as an interative process, not that different from the process of creating the roadmap itself. In the industry enterprise the roadmap is updated once or twice a year by interviewing all necessary stakeholders and creating a roadmap based on the information. What is significant about their process is that they make a few scenarios that will be introduced to decision makers and then one of the scenarios is chosen to be the primal scenario. One relevant question could be if this scenario planning method could be used even more effectively to control the impact of changes to a technology roadmap? The interviewee in the second financial enterprise did not see that the updating process should be separate of the roadmapping process itself, but all of the roadmapping should be rather iterative. One of the main research questions is to seek agility to roadmapping in the dynamic environment that organizations are today, so it seems fairly important to incorporate iterativity into the solution designed in this thesis.

According to the interviews, change management is realized more once the project begins and actual change is beginning to be seen. But some applicability from ADKAR was seen as a possibility to technology roadmapping. ADKAR is a change management model that consists of establishing awareness, desire, knowledge, ability and rewards for change. ADKAR could be applied throughout the whole process for roadmap to become the change in the organization.

The second enterprise architect in the second financial enterprise highlighted the iterative quality of technology roadmapping and explained how in the enterprise many functions have their responsibility to monitor the current situation : monitoring the markets and its needs is responsibility of the business, monitoring product providers is responsibility of SIAM (Service integration and management : management of multiple suppliers) and monitoring technology is responsibility of IT. Technology is monitored using services of research firm Gartner and publication TechRadar. Most pressing issues in technology roadmapping seem to be how to communicate it to the organization, having limited resources and difficulty of the value it all creates and costs of it. There is always a risk of unexpected changes but with iteration this can be mitigated.

6.2 Problem description and justification

The problem that this thesis provides a solution for, is derived from the literature around technology roadmapping and demand for agility for organizations as well as the initial interviews of professionals in the field. Technology roadmapping (TRM) is a tool for planning, forecasting or administrating the future, even on a long-term timeframe (Lee, S., & Park, 2005). Definition for it is somewhat loose and the components of a roadmap are not standardized. Technology roadmap still generally uses layers and a timeframe to show how factors related

to technology develop over time (Phaal et al., 2004a). It may be an internal or external view that is needed, a top-down view from the market needs or a bottom-up from the technology development and almost always needs customization to fit to the context it is in. Generally the layers in the roadmap tell the « know-what », « know-when », « know-how » and « know-why » aspects. The roadmap may differ for example in the purpose of it or in the form of it (Albright, 2003).

To create and maintain a technology roadmap, a process needs to be defined and Phaal, Farrukh and Probert (2001) have created a plan to help organizations to create and implement their roadmapping process in a fast and efficient way, including planning, workshops and implementing phases in the process. In most simple way the process for technology roadmapping can compose of initiation, development and integration (Carvalho et al., 2013; Gerdsri et al., 2019). Customizing the roadmap is usually needed to take into concideration since they can be used for several different uses and roadmaps take different forms (Lee, S., & Park, 2005). A lot of the benefit to organizations from technology roadmaps come from the actual process, rather than the document itself (Cheney et al., 2015).

Enterprise architecture and IT portfolio management can benefit from technology roadmapping as a tool when planning and scheduling the IT developments to the desired future (Kappel, 2001) and when they want to make better IT decisions (Van den Berg et al., 2019). Enterprise management wants to see what is needed to get from the current as-is state to the to-be future state. IT portfolio management prioritizes current IT development and aligns projects with the strategy (Cooper et al., 2002). These functions have a common goal to forecast and plan the future of the organizations IT development and a roadmap is a good tool for it. Enterprise architecture could benefit most from a product-technology type of a roadmap (Kappel, 2001) and most appropriate technology roadmap type according to purpose could be strategy planning-, long-range planning- or program planning- types (Phaal et al., 2004a). The visual representation is more an issue of communication inside the organization, which should be set to be the most suited for that exact organization.

Literature on the technology roadmaps indicate that while the subject is old and it has been thoroughly researched, especially by some dedicated researchers like Phaal, Farrukh and Probert, there is still a lot to research and the fast-phase change in the IT industry gives it more to look at all the time. The definition of a technology roadmap is not strict but the general elements of it have been identified and the possible uses and forms of a roadmap. The process is as flexible as the format of the document itself but generally consists of three main phases. There are some issues to take into consideration when planning the roadmapping process to avoid these pitfalls.

There is a clear benefit from technology roadmapping to enterprise architecture and IT portfolio management. The flexibility of the roadmap gives it usability in multiple contexts but also makes it difficult to make any process, model or framework related to it reliable in every situation and organization. It also means that there is a lot to research about the subject. Technology roadmap

should be adjusted to fit the purpose and in this context a roadmap that helps to see the steps from the current state to the desirable future state is appropriate. A technology roadmap that focuses on local coordination and trends could be most useful.

The literature review and the interviews have shown a possible research gap in bringing the technology roadmapping to this day by adding agility into the tool. Organizations could utilize the tool even better once it fits into the dynamic environment most organizations are in. Since technology roadmap is a flexible tool and it also makes finding an exact definition for it difficult. But from literature it was possible to get a general structure for the technology roadmap and the main phases the process of roadmapping usually consist of. It can clearly be discovered from the literature that enterprise architecture and IT portfolio management benefits from using technology roadmapping in their objectives but how these functions should use technology roadmaps and how to customize it has not been studied that extensively. Customization is mostly researched to give a general answer to multiple possible purposes, providing a research gap for future research. In agile frameworks there are guides to using technology roadmaps in a way that does not compromise the agility and lean ways of working. This thesis will focus on keeping technology roadmapping up to date and with agility respond better to unexpected changes. It is clear from literature that while some action studies have been done on the subject, there is still a need to give practice better guidance on the matter and validate the usability of created solutions. There are suggestions for the process of updating a technology roadmap, suggestions to monitoring the internal and external factors that cause changes in the technology roadmap and suggestions for other tools with technology roadmapping to help mitigate the risk of unexpected changes or to help with updating, that can be utilized in creation of this solution.

In short, actions that affect if the technology roadmap is up to date: ensuring the technology roadmapping process is accepted into existing processes and kept going, mitigating the risk of unexpected changes, monitoring internal and external factors that cause changes to technology roadmap, making the decision to update and considering all necessary aspects of updating. It does not mean that all of these actions are necessary to do to have an up to date roadmap but depending on the organization and its environment, these actions can help.

Cosner et al. (2007), Lischka and Gemünden (2008), Gerdsri et al (2019) talk about technology roadmapping teams or steering committees that could be responsible for updating or monitoring the technology roadmap and the factors that may cause changes in them. When talking about a technology roadmap that is used in enterprise architecture, it is clear that experts in that area are also needed in these teams or steering committees to give their input. Cosner et al. (2007) also mentioned that if the steering committee would find new changes, it would mean reprioritisation to the IT portfolio. Enterprise architecture is part of creating and maintaining the roadmap since EA has the information on the as-is

and the to-be vision, IT portfolio management is the function that evaluates priority, schedule and implementation of the technology roadmap (Cosner et al., 2007).

While Holmes and Ferrill (2008) created an updating process that is great in its simplicity, it lacks in considering very volatile environments that may need more frequent checks to see if roadmap is still valid. But going through the whole review process constantly eats up a lot of resources so monitoring the changes to only do updating when necessary, makes sense. When analysing what kind of an update process and monitoring process is suitable for the organization, one should take into account all the requirements, limitations and characteristics of each model. This comparison of each model has not been done in literature so far and there is a research gap for researching what kind of a solution fits for each. In this thesis' case, in large, Finnish corporations.

Monitoring changes is more of a continuing process of updating the roadmap than having a roadmap review periodically. There is also a big difference in monitoring the changes and updating the technology roadmap. If changes are detected, it may not always mean update for the technology roadmap. There are not only multiple ways to update an existing roadmap but also many methods to monitoring the roadmap status and implementing roadmapping into existing processes. Any of these steps may cause problems to keeping the roadmap up to date and while there is literature on the subject, usually the research focuses on one of these issues. It is not a surprise if professionals and even researchers find it difficult to overcome the issue of keeping a technology roadmap alive.

Dynamic environments are not concidered well enough in the traditional technology roadmap structures and processes. Organizational agility is a necessity if the organization wants to stay in the competition. Maintenance of the technology roadmap is reported in the perious literature to be difficult and the roadmap becomes out of date quickly if there is no process for review and update in the organization. In a dynamic environoment, monitoring the changes around the roadmap is necessary to trigger the undating process for the roadmap. In the interviews professionals mentioned that creating and updating a technology roadmap takes time and the resource scarcity is one of tthe biggest problems in keeping the roadmap up to date. The professionals have encountered uncertainty and sudden changes that have triggered a need to update the technology roadmap, for example the coronavirus pandemic or changes in technologies vendors provide.

6.3 Objectives of solution

There were a lot of factor and problems that were mentioned in literature or in the interviews that should be considered. There are so many different uses for technology roadmaps, but this thesis will concentrate on the context of enterprise architecture and IT portfolio management. There is no use in making a model

that cannot be flexible, since that is one of the best characteristics of the technology roadmap. The solution created should be a general model, that can help organizations to customize the best solution for them in their current situation. It is clear that EA and IT portfolio management both benefit from a long-term plan, but it should also be done in an agile manner. Agility is one thing to consider in the solution and as one interviewee mentioned, roadmapping should be iterative to give best results. Problems in technology roadmapping maintenance seem to be mostly about implementing it as a part of existing processes, it being too time and resource consuming or too complex to maintain in a volatile environment.

The objectives for the research have been derived from these observations from the literature and the interviews. This solution will solve the need for agility in the technology roadmapping as a tool for enterprise architecture and IT portfolio management, especially in their target of planning and prioritizing It developments to achieve the desired future state. The objectives of this solutions are the following:

- usability as accepted by professionals: the solution should be evaluated to be useful by the professionals in enterprise architecture and IT portfolio management,
- structure should not be too complex, it should be lean: too complex structure for the solution will not serve the professionals,
- Focus on the context of EA & IT portfolio management: mostly from the point of view of decision making on current and future developments,
- be applicable in different environments: the solution should be a general model that can be customized for each organization and their needs,
- agile & iterative: the solution should serve the organizations need to be agile and the process for roadmapping should be iterative,
- use knowledge gathered from professionals and research: the literature review and the interviews should act as the knowledge base for the solution.

7 A FRAMEWORK FOR AGILE TECHNOLOGY ROADMAPPING FOR EA AND IT PORTFOLIO MANAGEMENT

In this section the solution is introduced along with the justifications for the structure of the solution. The problem to solve in this design science study was to update technology roadmapping, since as an old technology management tool it does not live up to the expectation of today's volatile world where organizations need agility to respond to changes fast. Technology roadmapping needs an update to be able to keep up with the changing world around organizations and to provide the maximum benefit to organizations. This thesis focuses on technology roadmapping used for the benefit of enterprise architecture and IT portfolio management, in their mission for better decision making and ensuring the right IT development is done at the right time. This solution also focuses mainly on helping organizations which do business in a dynamic environment although today not many organizations can say that they do business in a static environment.

Next the initial solution is introduced with justifications for chosen solution. After that the demonstration and evaluation of the solution that was done via interviewing EA and IT portfolio professionals is summarized. The solution was modified according to the comments from the professionals to answer to their needs and this final solution is introduced in the last sub- section.

7.1 Initial Framework for agility in technology roadmapping for EA and IT portfolio management

The solution in this thesis will consist of three parts: the suggestion for the general iterative roadmapping process, the general suggestion for the roadmap document and different approaches to take on roadmapping with this solution. As mentioned in the previous section, the objectives of this solutions are the following:

- usability as accepted by professionals: the solution should be evaluated to be useful by the professionals in enterprise architecture and IT portfolio management,
- structure should not be too complex, it should be lean: too complex structure for the solution will not serve the professionals,
- Focus on the context of EA & IT portfolio management: mostly from the point of view of decision making on current and future developments,
- be applicable in different environments: the solution should be a general model that can be customized for each organization and their needs,
- agile & iterative: the solution should serve the organizations need to be agile and the process for roadmapping should be iterative,
- use knowledge gathered from professionals and research: the literature review and the interviews should act as the knowledge base for the solution.

From the initial interviews some main themes were found to focus on: Vendors, version updates, clouds and moving to cloud, categories in roadmap, dynamic environment, resource scarcity, decision making, EA & Portfolio manager role, scenarios, policies, updating and review and change management. These were the most mentioned themes by the professionals and from that some of the objectives were derived. Mostly professionals battle with resource scarcity, the dependency to vendors roadmaps and the dynamic environment, where changes that affect to the roadmap occur every now and then. Because of resource scarcity and the fact that roadmapping occupies some of the most vital people in the organization, it should be done efficiently and wisely (Albright, & Kappel, 2003). Most of the professionals had their own processes for roadmapping and it usually depends on the organization's other existing processes as well, which verified the need for roadmapping flexibility. The organizations have categories for the technologies, developments that may affect in roadmapping as well as having multiple business units to give attention to in the roadmap.

Some other interesting highlights from the interview include the importance of communication and transparency, monitoring external changes through existing services and possibility to utilize the ADKAR change management model to technology roadmapping. The communication as a factor in the roadmap should is taken into consideration in the objectives to provide a clear and lean way of roadmapping and the same objective for the document itself. The document is the most important tool in the communication of the roadmap. ADKAR and the existing services for change monitoring possibilities are considered in the solution.

From literature the main highlights were: existing solutions created for technology roadmap updating like computer monitoring with roadmap status (Vatananan, & Gerdsri, 2011), review-based (Holmes, & Ferrill, 2008), scenarios as a tool in roadmapping (Hussain et al., 2017), business units, agility in roadmapping (Carlos et al., 2018). While these may not on their own provide the solution to the research problem, they can act as a base to build the solution on.

In addition to these, the purpose and benefits EA and IT portfolio management seeks from technology roadmapping should be a strong part of the solution. It was mentioned in the past literature that IT ambidexterity enhances organizational agility. This means that the organization should at the same time exploit and explore their IT resources and opportunities.

The solution for iterative technology roadmapping can be seen in figure 8. The solution for iterative technology roadmapping is based largely on Carlos et al. (2018) agile solution for updating. This solution is more simplified to meet the objectives of the solution and uses also change management methods and scenario building as additional tools. In the interviews, one interviewee mentioned that roadmap updating should not be a separate process from the roadmap creation itself. This is noted in the solution by including all the three phases initiating, development and follow-up in the solution although the initiation phase is not detailed in this thesis since it is left out of scope. In the roadmapping phase, the organization needs to exploit the resources they have and explore new opportunities that arise. In the follow-up phase these opportunities and threats are monitored and evaluated while existing capabilities are exploited. This ensures IT ambidexterity and enhances organizational agility.

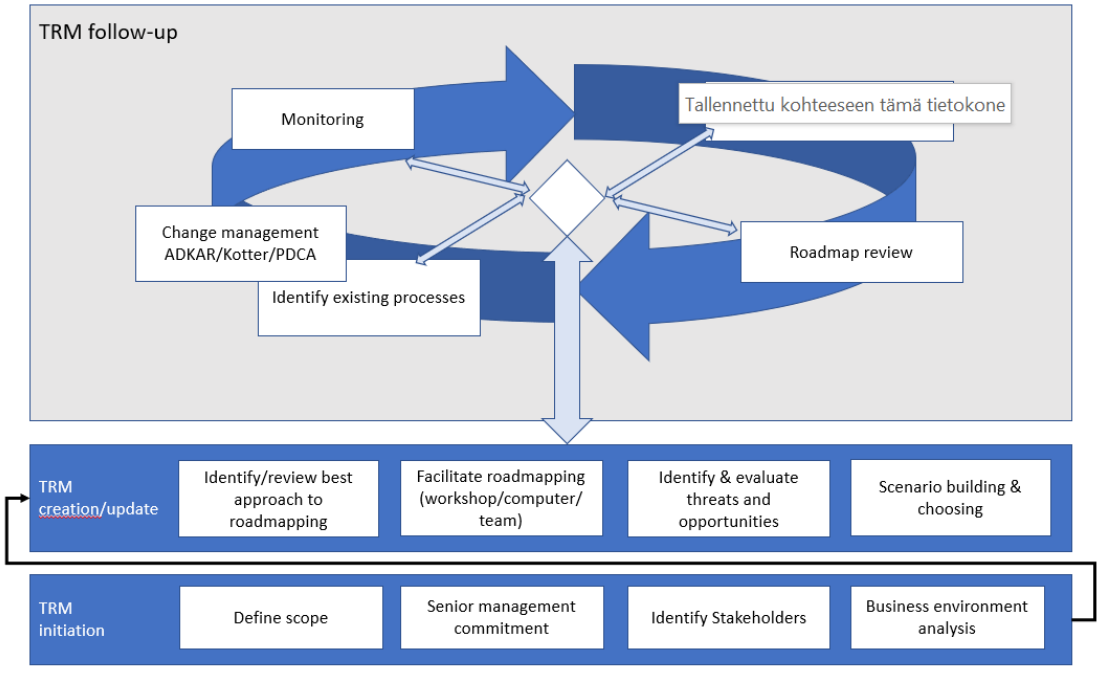

FIGURE 7 General model for iterative technology roadmapping

The steps on the first phase, initiation, are based on literature: defining the scope, senior management commitment and identifying stakeholders. success of roadmapping depends on stakeholders, specialists participating from different areas around the organization and customization (Oliveira, & Rozenfeld, 2010). Analysing the business environment of the organization affects the approach the organization takes to roadmapping. Scope definition: reason for roadmapping,

items addressed, focus, architecture, scale, objectives, outcomes, stakeholders (Kerr & Phaal, 2019). Stakeholders are important, especially in workshop and team approaches (Gerdsri, Puengrusme, Vatananan, & Tansurat, 2019; Kostoff & Schaller, 2001). With clear scope one can get senior management commitment which is vital for success (Kostoff & Schaller, 2001; Lischka, & Gemunden, 2008). Since roadmapping is a flexible tool, organizations may take many approaches to roadmap creation, like facilitating workshops, depending on a dedicated team, using data and computers to help make and maintain the roadmaps or basing decisions mostly on scenarios. After defining a scope and the approach, details for facilitating the roadmapping should be clear. The possible internal and external threats and opportunities need to be identified to be able to monitor them in the follow-up phase. Around the internal and external change factors, scenarios can be built. Factors are points where the scenario may change. Scenario describes a plausible future (Hussain, Tapinos, & Knight, 2017). You may create multiple roadmaps for each scenario, where the roadmap may change to a new scenario when at a change point there is a need for a new scenario.

In the follow-up phase the created roadmap should be implemented to existing processes and be realized across the organization. Just like adopting any new processes or tools or changing the approach to such, introducing or changing roadmapping and the actual roadmap document needs change management. When adopting EA, one may face resistance or confusion (Seppänen, Penttinen, & Pulkkinen, 2018), as one might when adopting a tool for EA. Here the change management models like ADKAR, PDCA or Kotter's model may help to ingrain the roadmap into each part of the organization. After that, the change factors internally and externally need to be monitored and react to changes with evaluation of their impact. Once the impact of the change is known, the roadmap can be reviewed, and a decision made whether the roadmap needs change.

The technology roadmap provides maximum value to organizations when it is flexible and can be customized for each need. The next part of the solution is a very general model on the actual roadmap document and which layers could be best suited for enterprise architecture and IT portfolio management roadmaps, according to the initial interviews and the literature on technology roadmap documents, especially by Albright (2003). While in Albright's general technology roadmap the layers include a lot of option for what they may include, this suggestion limited them to some of the most useful in enterprise architecture and IT portfolio management, thinking of their targets (figure 8). The roadmap created is a high-level roadmap from the perspective of EA and IT portfolio, each IT development may have their own roadmaps. This roadmap template should be taken only as a suggestion and an organization may want to include some other layers to their roadmap if so required.

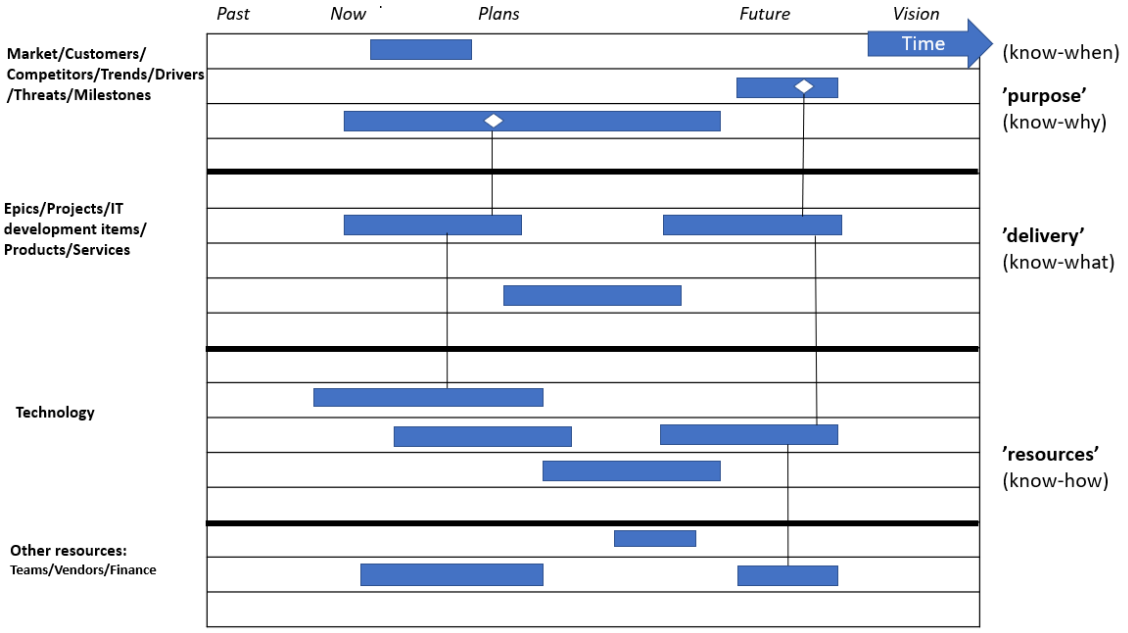

FIGURE 8 General technology roadmap document

The best approach to technology roadmapping seems to depend a lot on the business environment the organization is in. In figure 9 the list of the factors and possible technology roadmap approaches are found. This list can help organizations to identify the business environment type they are in. These approaches are suggestions on the best approach to roadmapping and which parts of it to highlight.

While computer-based solution provides good objectivity, it is too heavy to use in a semi-dynamic environment or in an organization that struggles with having the needed skills or resources to maintain such a process. The organization also needs a good source for information and a broad database of data for themselves. Team-based roadmapping is the best solution for organizations with many business units and a dynamic environment, with resources to spare to keep the roadmap alive. Iterative review fits an organization that is in a dynamic environment but has resource scarcity. In a similar situation but in a less dynamic environment, an organization could focus more on the scenario building in the beginning of roadmapping and change tactics according to scenarios if necessary. In an organization that has resource scarcity and high data maturity, but only semi-dynamic environment, the organization should see their best option from a computer-based solution or an iterative review.

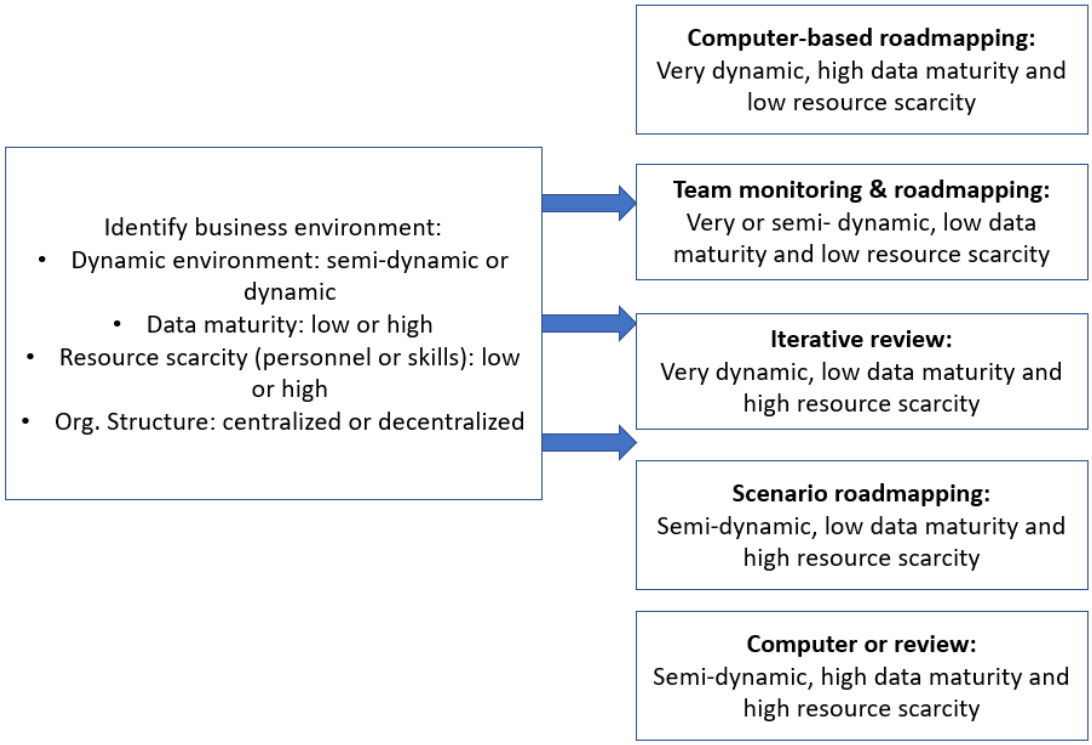

FIGURE 9 Identifying the business environment for TRM

The solution could be very similar in the general model for all these approaches, but the few factors could influence the details: who does monitoring, who does the updating, when it is done, how is the data about environment change factors gathered and analysed, what parts of the process are emphasized (for example scenario, change management and roadmap review). These are explained in table 5.

Monitoring can be done using such computer-based methods as explained by Gedrsri et al (Gerdsri et al., 2019) or using existing services or following up on internal and external factors. Changes in the factors are evaluated depending on the approach taken and according to that the roadmap status is reviewed. Change management model could be any familiar model, but especially ADKAR has been recognized in the initial interviews as a potentially useful model. ADKAR's steps, awareness, desire, knowledge, ability and reinforcement, can be used to ensure successful roadmap implementation. Communicate the roadmap to ensure awareness and knowledge, communicate the reasons to ensure desire to commit to the roadmap, give stakeholders the tools and skills to realize the roadmap and guard roadmap realization.

TABLE 5 Process steps for each approach to roadmapping

Roadmapping approach	Monitoring	Change evaluation	Roadmap review	Change management	Iteration timeframe
Computer-based	Using external and internal data gathered using computer to monitor changes, status of the roadmap and change status (Gerdsri et al., 2019).	Changes are evaluated according to their impact, for example using a mathematical model that was described by (2019).	If status is green, no needs are necessary. If status is yellow, the roadmap needs to be reviewed by the responsible person. If status is yellow, an update is needed.	Changes with impact should trigger change management efforts.	Can be a very short timeframe, iteration may not take a lot of time.
Team	Team monitors internal and external changes, following up on the changes in the team.	Team evaluates the change factors for their impact.	The team decides if TRM needs updating or informs the deciding stakeholders (e.g. senior management) of change status and their suggestion.	Team can use change management models to communicate the new roadmap across the organization and ensure commitment.	Not as often, depending on the organization from a week to a few months.
Iterative review	Monitor external factors using existing services like TechRadar or Gartner. Monitor internal factors from internal data sources in the organization.	Each external and internal factor should be evaluated by EA and IT portfolio managers.	Roadmap status is reviewed by EA and IT portfolio managers. Roadmap may not need any change, need some adjustments or a completely new roadmap.	EA and IT portfolio managers can use change management models to communicate the new roadmap across the organization and ensure commitment.	One iteration, for example one PI in SAFe.
Scenario-based	Monitor points of threats or opportunities in chosen scenario (or 'flex points' (Hussain et al., 2017))	If any changes in points of threats or opportunities, EA and IT portfolio management need to evaluate their impact on the roadmap.	Other planned scenarios may need to be taken as the main scenario on the roadmap if changes have big impact. If the changes are totally unexpected, new scenarios may need to be made.	Change management models can be used to communicate the scenarios in use across the organization and ensure commitment.	Depending on the organization, from a week to a few months.

7.2 Demonstration and evaluation

The initially created framework for agile technology roadmapping was presented to enterprise architecture and IT portfolio professionals that work in Finnish private and public organizations. Most of the participants in this phase were enterprise architects or IT architects in their organization, two out of seven were

IT portfolio managers. The demonstration & evaluation interviews are listed in table 6.

TABLE 6 Summary of demonstration & evaluation interviews

Interview number	Organization industry	Interviewee role in their organization	Main findings from this interview
1	Higher education	EA architect	Could use the solution. Usually, approaches are used as a mix. Process steps are not always in this order. Strategy and driver for roadmapping good to see.
2	IT services for education services	EA architect	A bit heavy to use but could see using the solution. Benefits important to be explained. Process iterative all the time, some of the process steps already done. Systems and applications-layer missing in the template. Mixture of approaches used in practice.
3	Higher education	EA architect	Already using solution similar to this, could use this to explain the process and benefits. Process steps good as is, could become hard to read if more detail added. Mixture of approaches used. Computer-based approach may be hard to implement.
4	Industrial sector	IT portfolio manager	Already using similar solution in some sense. Driver for roadmapping important to identify, may change. Guidelines requested. More examples of how the template and the approaches work. Timeline on the template could be adjusted.
5	Finance (second)	IT portfolio manager	Could imagine using this solution. Timeframe on the process and the template are essential. Guidance for appropriate tools to help with roadmapping requested.
6	Finance (first)	IT architect	Could use, helps with predictability and implementation of cloud services. Monitoring and review are important steps. Adding s systems and applications -layer to template could be useful. Mixture of approaches more likely to be used.
7	Higher education	EA architect	Could benefit from this solution. Identifying approach is part of defining scope. People and culture to be featured in the template. Computer-based solution requires very high maturity of data analysis.

Each enterprise architect or IT portfolio manager were sent a poster of the framework that was designed (appendix 1). In their interviews they were presented with the solution and were asked these questions that demonstrate and evaluate the solution:

1. In your opinion, could your organization benefit from using this kind of solution?
2. In your opinion, could you imagine using this kind of solution for EA and/or IT portfolio management?
3. Would you change any of the steps in the iterative process for roadmapping?
4. Would you change anything on the technology roadmap document template?
5. Would you change anything about the approaches to the solution?
6. Other comments: what could be added, is something not relevant, adjustments to the solution?

Each participant was asked to give comments about parts of the framework they agreed with and parts of the framework they would change. They were specifically asked to consider the solution from the perspective of their organization and give comments on different parts of the solution.

When the participants were asked to think about implementing this solution, the benefits from the solution to an organization was brough up. It should be very clear what benefits this approach gives compared to older approaches so that it could be sold to the senior management. Organizations will only start to use solutions that clearly bring value to them. It could be beneficial to explain in the solution more clearly the benefits this solution could give to organizations compared to the traditional roadmapping.

Every architect and IT portfolio manager said that they could imagine using the solution and that overall, the solution made sense. Some architects and IT portfolio managers mentioned that their organization had already started to use a similar solution but did not have such a detailed documentation of their processes and approaches. Some had not seen such a solution before and could imagine using it in their organization and thought the solution could be helpful for planning cloud service implementation and adding predictability. The participants from the public sector cited often the JHS 179 where the layers on that guideline are similar to the layers used in technology roadmapping: strategy (why we do), conceptual (what we do), logical (how we do), physical (what we use) and how to proceed. These layers all go together with the layers on Albrights (2003) roadmap model: Know-why, know-what, know-how and know-when.

It was mentioned that this solution seems to be adding complexity but decreasing complications of its governance. The solution includes many components that need to be understood as a whole, but it does not seem difficult to understand the solution. But at the same time, other professionals pointed out that complexity is increasing in organizations and that this solution would be a part of a complex entirety of organizations existing processes and tools. This

needs harmonization and guidelines on how to deal with the entirety of processes and tools, EA artefacts and IT portfolio decisions and this roadmapping solution. Roadmapping should not only include communication, but also agreement and compromise between parts of the organization: when to align and when not. Albright and Kappel (2003) mentioned that roadmapping should not only improve communication but also the ownership of plans, which requires agreement. Although even in this solution it is important to remember that there is no silver bullet for every organization and this solution should be flexible enough to be customized for each organization that wants to use it, as mentioned by other participants.

There were thoughts about the level of detail this roadmapping solution is offering and how to manage the entirety if this is the very high-level plan. When there can be multiple smaller roadmaps under this one, they need to be managed, harmonized and aligned to this higher-level roadmap. Who or what drives the roadmap at that current moment also needs to be considered carefully: is it technology (bottom-up) or perhaps customer needs (top-down) or even monetary decisions? This may change depending on the situation or phase of roadmapping and that should be addressed in the solution.

It was noted by one enterprise architect that there may be some duplicate work from the steps on the roadmapping process, since business environment evaluation as well as threat and opportunity identification are both usually done before roadmapping. The steps could rather be to ensure that these issues have been considered and the actual work can be done before roadmapping or in this phase if not already done. Another enterprise architect pointed out that some steps may be included in other steps; for example, the approaches the organization takes to roadmapping could be included in the definition of the scope. The importance of recognising the change factors and scenarios that relate to them was highlighted by some while others highlighted the importance of monitoring and roadmap review. All in all, the participants thought that the steps on the solution process are essential, only the wording and the order of the steps may need adjustment.

One participant mentioned that the phases are not always in the same order as on the solution and suggested putting the iterative cycle into a more linear model while having points of return for previous steps. Another architect saw this very differently: while they agreed that there are going to be times when the steps are done in a different order than on the solution, it could become too complicated to read if given too much detail. Frameworks are usually customized by each organization for their own needs and that is accepted by the professionals. Both participants that gave their opinions on the structure of the process model also mentioned the PDCA change management model and that they use this model in their organization. The cycle seems justified, but another suggestion was adding a point of confluence in the middle of the cycle like in Architecture Development Method (ADM) by the open group (The Open Group, 2001). This makes sense as it gives a chance to change the order of the steps but keeps the solution easy to read.

Few participants noted that the document template for the roadmap may lack an important layer from the point of view of enterprise architecture: a layer for systems and applications. The market-layer, the development or product-layer and technology-layer are all important to EA but between the development and technology there should be a layer for systems and applications. For example, in a customer relationship management system project, you need the actual system but may have dependencies and integrations to other systems and applications while the technologies needed could include something like web services and business intelligence. The systems and applications are not necessarily comprised of a single technology nor is it a product that the organization offers to its customers. It is a separate layer that is necessary for EA so that the bigger picture can be understood.

The drivers in this context are not that relevant on the top layer, more relevant to the top layer were thought to be market, trends, and milestones. The roadmap is driven by the strategy and the roadmap and principles implement the strategy; drivers are not relevant there. In digital transformation, people and culture are also important factors and should be considered in the plan. Some architects even questioned if the market layer should be a part of this kind of a technology roadmap but rather on a separate strategic roadmap. Then again, having strategy strongly aligned to the roadmapping activity with it driving the first layer on the roadmap could give an advantage in seeing how strategy is implemented through IT in the organization. If there are any significant changes in the market or otherwise in the environment, the strategy may change and that may affect the roadmap (Buchanan, & Soley, 2002).

The timeframe was thought to be confusing. It was not clear what the blue blocks on the roadmap document template should represent and what should they include. For this an informative example of the template in use could be of help. Although, it is still important to also analyse that a correct level is considered for each organization. One architect suggested that the timeline on the template could be more understandable with current state, current future, and future. Vision in the timeline was deemed confusing. The level of detail on the roadmap and its timeframe may well depend on the organization and its size. It was also pointed out that the technology layer needs to be considered early enough before projects, since it needs to be available for systems and projects to take advantage of it.

The approach taken in each organization depends on the business environment, as was mentioned in this solution. The business environment can affect the level of autonomy development teams are provided and which stakeholders to include in roadmapping and IT development. Almost every participant mentioned that in real life an organization would choose some sort of a mix of approaches, perhaps using each approach in different steps of the process or even using every approach throughout the roadmapping process.

Participants were using or interested in using scenarios in roadmapping. One professional pointed out that the scenarios can also get old very quickly and need to be kept up to date. It was not obvious to the participants what kind of a

team the team approach comprises of. It should be explained in the solution that this team could be a very high-level team comprised of experts in the organization that can make decisions about architecture and development, hence specific enterprise architects and IT portfolio managers assigned to the team. The approaches should have some connection to other processes and parts of the organization. It should be explained how the team connects to other teams in that approach, how the scenarios connect to decisions made across the organization, where the data in the computer-based approach comes from and how the iterative process connects to other processes. Examples of possible tools to help use this solution for prioritization and gathering change data was requested.

Most of the approaches were easy to understand and the participants thought that they could or already are using the approaches, nor did they mention that any approach would be missing. The computer-based approach as an approach was met with some questioning about its practicality but also it seemed some organizations use data and computer-based solutions along with other approaches. In practice the decisions are not usually left to be made by a computer, which is why one could consider using data and computer-based solutions as support to other approaches.

Next step in this thesis is to improve the solution according to the comments given by the participants in the demonstration and evaluation interviews. In the next sub-section a list of improvements is presented with the improved solution.

7.3 A Framework for Agility technology roadmapping in EA and IT portfolio management

After considering all the comments and suggestions that came from the evaluation interviews, these modifications were included to be done to the solution:

- Explaining the benefits compared to more traditional roadmapping,
- Giving more guidance on the level of detail and how to manage such a high-level plan,
- Addressing top-down versus bottom-up approaches and strategy as a driver,
- Adding a point of contact in the middle of the iterative process,
- Making the whole process iterative from initiation to follow-up,
- Adjust process step wording,
- Adjust the order of steps and decrease overlap,
- Adding a layer in the roadmap template for systems and applications between technology and projects/products,
- Adding people and culture into the template,
- Making the timeframe on the roadmap template clearer,
- Explaining better what computer-based and iterative approaches mean,

- Making the approaches more flexible for mixing and matching them, and
- Giving better examples and suggestions to how this solution could be used in practice.

The benefit compared to the traditional technology roadmapping is that this solution is iterative and encourages organizations to keep their roadmaps up to date. This solution gives guidelines for the organization of the important issues to address and presents different kinds of approaches to roadmapping. Every part of this solution is meant to be flexible and customized for each organization to serve their specific needs. The process and the approaches have been created with resource optimization as well as EA and IT portfolio management in mind.

There were differing opinions on the structure of the process model. Some professionals suggested that the steps on the process may not be a chain of event but rather one may need to jump back or forth in these steps. Then again there was a feeling that the model may become too hard to read and understand if it has too much of these points of confluence and reminded of models like PDCA that also are simplified as models for a reason. The model should be easy to understand but details can be added on it when the model is completely clear. Also, many felt that the iterative cycle would not begin until at the follow-up phase. Based on these evaluations the solution moulded into one cycle with a point of confluence in the middle (figure 10). The model still seems legible and flexible as was intended. The wording and order of the steps were changed along with scope being including the approach choice and evaluating the current driver for the roadmap at each iteration. The driver may change between technology and market.

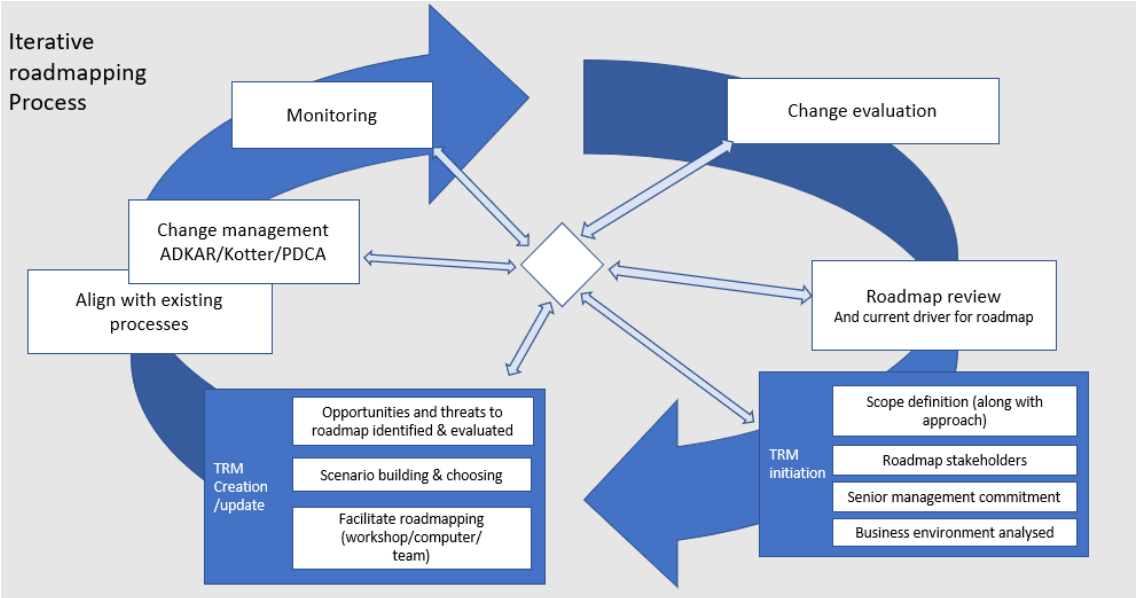

FIGURE 10 Iterative roadmapping process

In the evaluations it became clear that the roadmap-template lacked an important layer and that the timeframe on it was difficult to understand. The systems-layer and clearer, more logical timeframe was changed to the template. The harmonization of decisions and processes in the organization with the roadmapping process as well as harmonising this high-level enterprise architecture and IT portfolio management roadmap with lower-level roadmaps was brought up in the evaluation as a concern. The solution solves this since having a standard format should improve synergies on its own (Groenveld, 1997). The modified roadmap template is seen in figure 11.

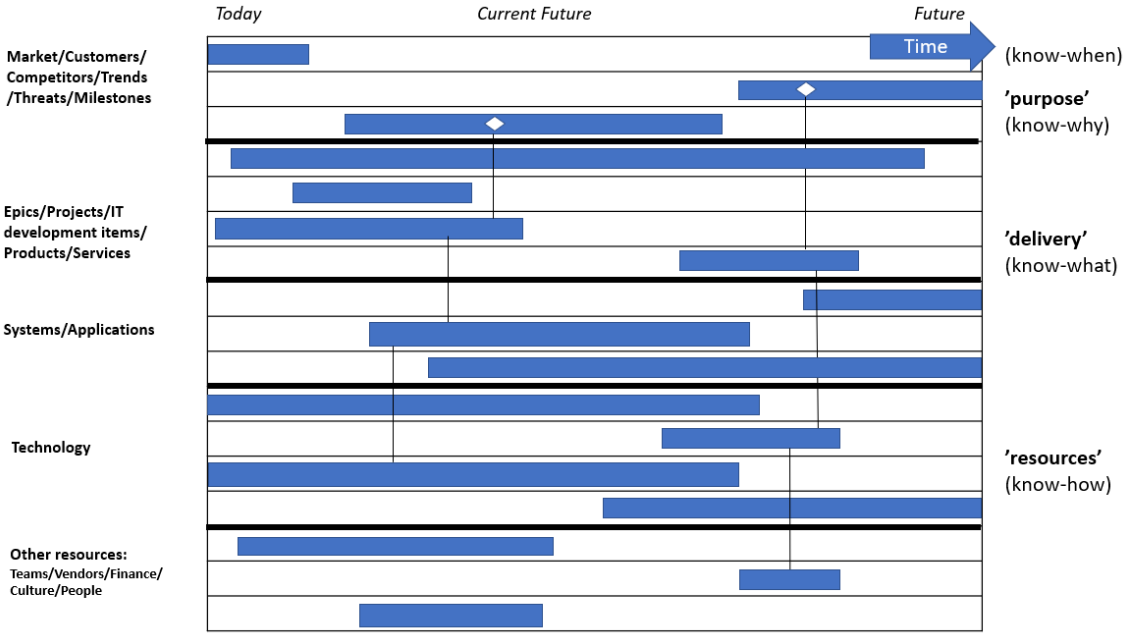

FIGURE 11 Technology roadmap template

To clarify the timeline and give a concrete vision of how to use the template, an example of how the roadmap-document template could be used in some organization that expects to develop a chatbot and transition from an old CRM system to a newer one is seen in figure 12.

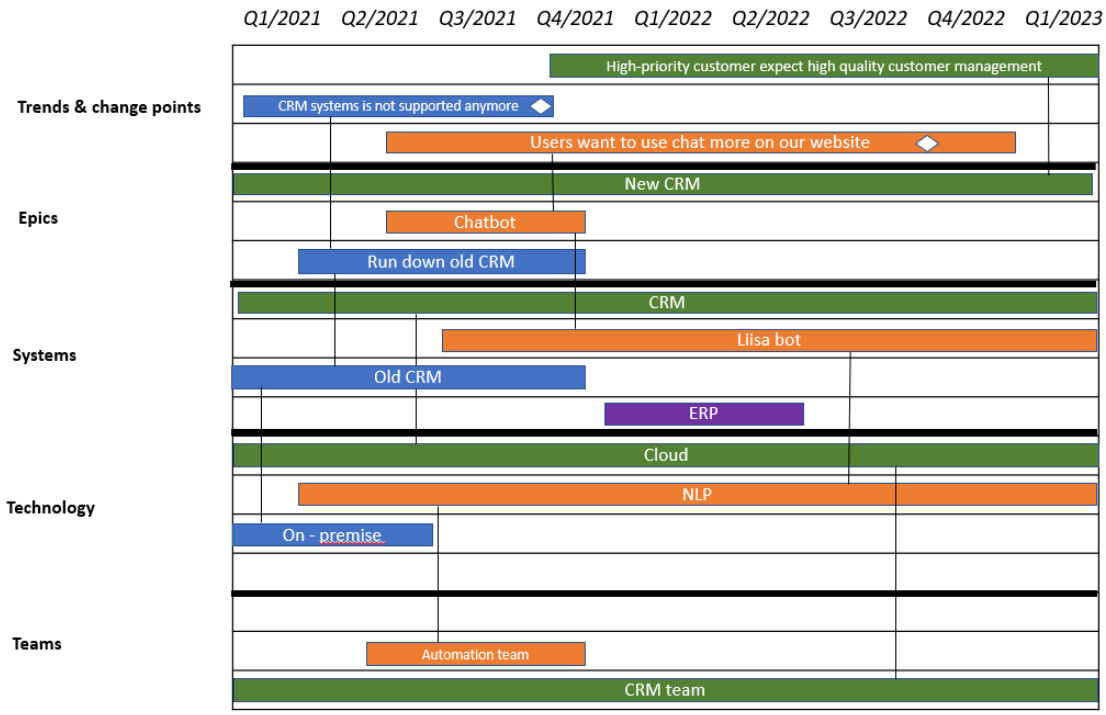

FIGURE 12 Example of technology roadmap made with the framework

It is true that in a bigger organization with a very large IT portfolio, using this template with all its details could become a mess that it hard to read and it would not bring much value as a communicative tool. This was one concern in evaluation interviews: how to keep such a large and complex architecture and IT portfolio in one, understandable piece? In larger organizations it would be more beneficial to cut down the number of layers or have a solution where you may filter to only see one layer, one program or other parts of the roadmap. Building the roadmap on a suitable tool that supports this kind of filtering and layering is advisable. This way the roadmap can have as much details as is beneficial but is still informative and easy to read. It should be noted that with too much detail it can become bothersome to keep a roadmap like this up to date with the process model suggested in this thesis. Therefore, in large organizations cutting down on detail and layers is crucial.

To clarify the approaches that were less understood by the professionals that evaluated the solution, table 7 explains some of them in more detail. Some clarifying explanations were added especially to computer-based and team based approaches.

TABLE 7 Clarified approaches to roadmapping

Road-mapping approach	Monitoring	Change evaluation	Roadmap review	Change management	Iteration timeframe
Computer-based	Using external and internal data gathered using computer to monitor changes, status of the roadmap and change status (Gerdsri et al., 2019). Internal data can be gathered from internal project management systems and external data from news and companies that provide data.	Changes are evaluated according to their impact, for example using a mathematical model that was described by (2019).	If status is green, no needs are necessary. If status is yellow, the roadmap needs to be reviewed by the responsible person. If status is yellow, an update is needed.	Changes with impact should trigger change management efforts and send information throughout organization.	Can be a very short timeframe, iteration may not take a lot of time.
Team	Team monitors internal and external changes, following up on the changes in the team. Team comprises of enterprise architects, IT portfolio managers and other necessary experts that have higher allocation to this work.	Team evaluates the change factors for their impact. Team should communicate with other teams, for example team inside different business functions.	The team decides if TRM needs updating or informs the deciding stakeholders (e.g. senior management) of change status and their suggestion.	Team can use change management models to communicate the new roadmap across the organization and ensure commitment.	Not as often, depending on the organization the team could meet up every week or once a month.
Iterative review	Monitor external factors using existing services like TechRadar or Gartner. Monitor internal factors from internal data sources in the organization.	Each external and internal factor should be evaluated by EA and IT portfolio managers.	Roadmap status is reviewed by EA and IT portfolio managers. Roadmap may not need any change, need some adjustments or a completely new roadmap.	EA and IT portfolio managers can use change management models to communicate the new roadmap across the organization and ensure commitment. The roadmapping process itself needs to be connected to existing processes with help from change management.	One iteration, for example one PI in SAFe. After one iteration, EA and IT portfolio managers report their observations to make a decision for roadmap.
Scenario-based	Monitor points of threats or opportunities in chosen scenario (or 'flex points' (Hussain et al., 2017))	If any changes in points of threats or opportunities, EA and IT portfolio management need to evaluate their impact on the roadmap.	Other planned scenarios may need to be taken as the main scenario on the roadmap if changes have big impact. If the changes are totally unexpected, new scenarios may need to be made.	Change management models can be used to communicate the scenarios in use across the organization and ensure commitment.	Depending on the organization, from a week to a few months. It should be noted that if the period is long, the scenarios tend to get old quick.

It became clear in the evaluation that one organization rarely only uses one approach to technology roadmapping. An organization gets most value out of technology roadmapping when using a mix of different approaches. An example of how an organization may use a mix of these approaches in their roadmapping is seen in table 8.

TABLE 8 Example of approaches

Monitoring	**Change evaluation**	**Roadmap review**	**Change management**	**Iteration timeframe**
The organization gathers data about their customers (computer-based) and enterprise architects use existing monitoring services to keep up with changes in the field (iterative).	When there are changes observed by the system that analyses the data or by the EA, the team will evaluate them in their weekly meeting.	Roadmap is reviewed in the teams weekly meeting (team) if there is impact from changes. If there is a smaller change, the scenario may change (scenario), otherwise the whole roadmap may change (iterative).	EA and IT portfolio managers use ADKAR to manage change in the roadmap. They communicate the new roadmap across the organization.	Data follows up on changes every day, Team has weekly meetings.

To manage such a huge high-level plan in any organization is a challenge, especially in a larger organization with multiple business functions. It was a wish from the professionals that evaluated the solution, to have some guidance to managing EA and IT portfolio level roadmapping in a harmonized way. This will be done in the next sub-section that discusses the findings in this thesis.

7.4 Discussions

After evaluation, the framework composes of the iterative roadmapping process, a template for the roadmap and approaches to roadmapping. Some small changes were suggested to the solution in the demonstration and evaluation interviews but mainly the participants thought that the solution seemed useful. Quality and Trustworthiness of the research depends on the generalizability of the result (Golafshani, 2003), here the result is the framework. The framework has been created using steps derived from the general design science research model and based on it demonstrated and evaluated. This was done by interviewing professionals in the field. The findings in these interviews indicated that all of the participants could use the solution and there were a lot of similarities in the comments given. This would suggest that the framework is generalizable and thus trustworthy.

There is no easy solution or all-inclusive guide for managing a huge high-level plan but to provide some guideline for practitioners based on literature and interviews with professionals:

- Senior management is crucial for success of roadmapping (Kostoff, & Schaller, 2001). Without the support of management, it is going to be difficult to keep the roadmap harmonized and up to date. If senior management commitment is hard to obtain, one may choose a bottom-up approach (Groenveld, 1997).
- Starting small may be a smart move (Groenveld, 1997). A larger organization should consider taking up smaller parts of the solution. The roadmap may not need to include every layer in the beginning, starting for example with a layer for projects may be enough. The organization can then build up from that.
- A roadmap is a great tool for communicating but creating one also requires communication. Most value is obtained in successful roadmapping (Cheney et al., 2015). Be certain that you include all necessary stakeholders to the process and create a consensus between stakeholders.
- There are tools that may be used for managing the data and roadmap of this size and even filter the roadmap. Microsoft has powerful tools like Excel and PowerBI that can process huge amounts of data and visualize them. Google also has similar tools. Organizations with high level skills could use R or Python. Gartner and TechRadar are used by many professionals to keep up with changes in the business. To follow up on internal changes, a system for project or portfolio management is necessary.

With the use of the framework and these guidelines, practitioners should be able to customize a roadmapping process, a roadmap and a mix of approaches suitable for their organization. All in all the design of the framework was successful and it appears to have created additional value to practice and literature.

8 CONCLUSIONS

The interviews and study of the past literature on the subject suggested that while technology roadmapping is still a popular tool also in enterprise architecture and IT portfolio management, it was also unfortunately outdated. The traditional model for roadmapping presented by Phaal, Probert, Albright, and other scholars that focused on this subject, does not respond well enough to the needs of organizations today. Organizations need to be agile to keep up with the competition and to stay up to date in the constantly changing world.

In the beginning of this thesis, literature was reviewed first. From literature it was discovered that technology roadmaps do not have an exact definition, but mostly consist of timeframe and layers like market, product, and technology. Main benefits come from the flexibility of the tool and from what is learned during roadmap creation itself. One of the main issues in technology roadmapping is maintenance of the roadmap and keeping it up to date. According to literature, technology roadmaps are created in workshops with experts, in a dedicated team, using data in a large database or some hybrid of these. There were some solutions created in case studies for the issue of maintenance, including using data to calculate change impact, using complex iterative processes and using review processes. Enterprise architecture and IT portfolio management benefit from the predictability technology roadmapping offers and helps with prioritization and decision making. EA plans the to-be architecture while IT portfolio implements this plan, technology roadmapping can help to make this plan and communicate it across the organization.

After analysis of current situation of technology roadmapping research, practice was studied by interviewing some professionals in the field. In the beginning of the research the plan was to make a survey to EA and IT portfolio management professionals about technology roadmap maintenance and updating. It became clear after literature review and initial interviews that more qualitative research is needed and most value could come from a design science study. The initial interviews revealed that organizations were using technology

roadmapping as a tool, but had a variety of issues like resource scarcity, unexpected changes from external and internal sources as well as fragmentation of development.

After this the solution was designed based on problem description and objectives derived from the findings in literature review and interviews. The solution was a framework that consisted of guidance to technology roadmapping enhancing organizational agility. The framework was demonstrated and evaluated in interviews with another set of professionals in EA and IT portfolio management. Finally, the framework was modified according to the comments from the interviews.

The framework created in this thesis consists of three parts: The roadmapping process, the template for the roadmap-document and the approaches to roadmapping. They were all kept general and flexible since that is one of the main benefits of this tool. Creating a successful roadmap requires scope and stakeholder definition (Kerr, & Phaal, 2019), senior management commitment (Kostoff, & Schaller, 2001; Cosner et al., 2007), opportunity and threat identification and scenario planning (Hussain et al., 2017). To keep the roadmap alive and being able to respond to changes, the organization should be able to monitor and evaluate changes (Cosner et al., 2007) and review the roadmap for adjustments (Holmes, & Ferrill, 2008). In addition to an appropriate timeframe, market-layer, product-layer and technology-layer (Albright, 2003), the document could benefit from a systems and applications-layer to help with EA. Approach to roadmapping could be any mix of different approaches that are based on solutions presented in literature about computer-based (Gerdsri et al., 2019), team-based (Cosner et al., 2007), scenario-based (Hussain et al., 2017) and iterative-based (Carlos et al., 2018) solutions.s

In the demonstration and evaluation interviews the professionals found the framework to be useful and all of the participants could imagine using the solution. While many of the professionals that were asked to evaluate the solution said that their organization already uses a solution like this one, they also said that it is beneficial that is has been explained here in detail and that they could use this to pitch a solution like this to senior management or other stakeholders. Many also took interest in parts of the solution that were not that familiar to them, at least in this context, like scenario planning, change management models like ADKAR and monitoring with existing services. It was even a little unexpected how many evaluation participants said that they already use a solution similar to this framework while nothing like it had been seen in literature, and how positive the feedback from the interviews was.

From past literature, it was clear that many researchers are into this subject and have given their take on this, even recent solutions could be found. But a solution like this was not found in the literature even when it seems that professionals have taken a route like this in their work. From the aspect of EA and IT portfolio management, the subject of technology roadmapping and especially a solution focused on this context could not be found. This framework provided a

simpler iterative process than can be found in past literature and mixing approaches instead of only focusing on one. It also seemed that many professionals make roadmaps that include projects or epics as a layer, but it was rarely seen in literature. It is safe to say that this thesis could provide input not only to practice but also to theory.

Deeper understanding of organizational agility and technology roadmapping as a tool could be obtained with further research. Future research can include adding detail to the initiation phase in this iterative process, studying this solution in practice and exploring current practices in organizations in detail. The latter would have interested some of the evaluation participants. Many organizations also mentioned that they already use a solution similar to this one, they just had not seen it presented by literature yet. Studying these organizations could help them to overcome any issues they have in roadmapping and even improve this solution.

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APPENDIX 1 POSTER FOR CREATED FRAMEWORK

JENNI KÄÄRIÄINEN | MASTER'S THESIS

TECHNOLOGY ROADMAPPING ADAPTED FOR ORGANIZATIONAL AGILITY

Suggested framework to the research question: How can technology roadmapping used in enterprise architecture and IT portfolio management adapt to today's demand of organizational agility?

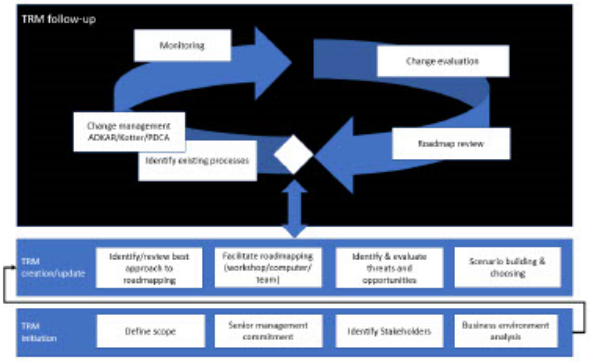
PURPOSE OF THE SOLUTION

Update technology roadmapping, since as an old technology management tool it does not live up to the expectation of today's volatile world where organizations need agility to respond to changes fast. This solution focuses on technology roadmapping used for the benefit of enterprise architecture and IT portfolio management, in their mission for better decision making and ensuring the right IT development is done at the right time.

THE SOLUTION

The solution consists of three parts: the suggestion for the general iterative roadmapping process, the general suggestion for the roadmap document and different approaches to take on roadmapping with this solution. The solution is based on literature and interviews of professionals in the field.

The iterative process for technology roadmapping includes all three main phases of roadmapping, although it focuses mostly on the follow-up phase. After roadmap creation, change management can be used to ensure success and changes on the roadmap are monitored and evaluated after each cycle. After change evaluation, the roadmap needs to be reviewed according to the change evaluation and decided if it needs an update.



The second part is the approaches the organization may take on this solution depending on the identified business environment they are in. The chosen approach affects the exact steps on the incremental roadmapping process: the iteration length, monitoring tools, change evaluation, review steps and the emphasis on a specific step.

Computer-based roadmapping:
Very dynamic, high data maturity and low resource scarcity

Team monitoring & roadmapping:
Very or semi- dynamic, low data maturity and low resource scarcity

Iterative review:
Very dynamic, low data maturity and high resource scarcity

Scenario roadmapping:
Semi-dynamic, low data maturity and high resource scarcity

Computer or review:
Semi-dynamic, high data maturity and high resource scarcity

The third part of the solution is a very general model on the actual roadmap document and which layers could be best suited for enterprise architecture and IT portfolio management roadmaps. This should be taken only as a suggestion and an organization may want to include some other layers to their roadmap if so required.