Universität Stuttgart

Development of Outcome-Driven Product Roadmaps

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Zusammenfassung

Kontext: Unternehmen sehen sich zunehmend mit einer hohen Marktdynamik, sich schnell entwickelnden Technologien und sich ständig wechselnden Nutzererwartungen konfrontiert. Dies hat Auswirkungen auf das Vorgehen der Produktplanung eines Unternehmens. Für die Planung der Evolution von Produkten, Features oder Services ist das Produkt-Roadmapping ein weit verbreiteter Ansatz. Der in deutschen Unternehmen meist verwendete Ansatz ist eine Vorausplanung von Produkten, Funktionen oder Services, welcher der Annahme unterliegt, dass die Zukunft in hohem Maße vorhersehbar ist (so genannte "Feature-driven roadmaps"). Jedoch ist es in einer Welt mit hoher Dynamik und Ungewissheit nahezu unmöglich, langfristig vorherzusagen, welche Produkte, Features oder Services die Bedürfnisse der Kunden erfüllen werden. Daher scheitern "Feature-driven product roadmaps" in der Regel in dynamischen und unsicheren Marktumfeldern. Dies führt dazu, dass oft Produkte, Features oder Services entwickelt werden, die überhaupt nicht oder nur selten genutzt werden. Folglich haben Unternehmen Schwierigkeiten, Produkt-Roadmaps zu erstellen, die für den Einsatz in einem dynamischen und unsicheren Marktumfeld geeignet sind und die im Einklang mit agilen Softwareentwicklungsprozessen eingesetzt werden können. Zudem ist die Durchführung von sogenannten Produkt-Discovery-Aktivitäten ein Schlüssel für ein erfolgreiches Produkt-Roadmapping in einem dynamischen und unsi-

cheren Marktumfeld. Jedoch sind viele Product Owner oder Produktmanager ratlos, wie viele Ressourcen sie für die Durchführung von "Produkt-Discovery-Aktivitäten" aufwenden sollen und tun sich schwer, diese mit ihren agilen Softwareentwicklungsprozessen zu verzahnen.

Ziel: Ziel dieser Dissertation ist es, Werkzeuge, Prozesse und Techniken bereitzustellen, die es Produktmanagern, Product Ownern oder ähnlichen Rollen ermöglichen, ihre Produkt-Roadmapping-Praktiken an ein dynamisches und unsicheres Marktumfeld anzupassen, um verlässliche Produkt-Roadmaps zu erstellen.

Methoden: Als ersten Schritt haben wir eine systematische Literaturanalyse durchgeführt, um den aktuellen Stand der Forschung zu identifizieren sowie Forschungslücken aufzudecken. Darüber hinaus haben wir Experteninterviews, eine Webumfrage sowie eine graue Literaturanalyse durchgeführt mit dem Ziel, den Stand der Praxis sowie relevante Herausforderungen für Praktiker in Bezug auf Produkt-Roadmapping zu ermitteln. Basierend auf diesen Erkenntnissen haben wir in Zusammenarbeit mit Praktikern sechs Artefakte in Form von Werkzeugen, Prozessen und Techniken entwickelt und deren Verständlichkeit, Anwendbarkeit und Nützlichkeit durch zwei Experteninterviewstudien sowie einer multiplen Fallstudie nachgewiesen.

Beiträge: Erstens geben wir einen Überblick über den aktuellen Stand der Forschung über das Gebiet des Produkt-Roadmapping. Zudem haben wir ein Produkt-Roadmap-Bewertungstool namens DEEP entwickelt und validiert. Mit Hilfe dieses Tools können Unternehmen ihren derzeitigen Stand der aktuell eingesetzten Produkt-Roadmapping-Praktikern visualisieren. Auf Grundlage der Bewertungen des DEEP Modells haben wir einen Produkt-Roadmap-Transformationsansatz entwickelt. Dieser Ansatz ermöglicht es Unternehmen geeignete Maßnahmen zu identifizieren mit dem Ziel, ihre Produkt-Roadmapping-Praktiken an ein dynamisches und unsicheres Marktumfeld anzupassen. Wie bereits erwähnt, ist es für die meisten Unternehmen eine Herausforderung zu identifizieren, wie viel Ressourcen sie für Produkt-Discovery-Aktivitäten investieren sollen und wie sie diese Aktivitäten in ihre agilen Prozesse integrieren können. Um dieses Problem entgegenzuwirken, haben wir einerseits den sogenannten "Product Discovery Effort Worthiness

Index" entwickelt, der es Unternehmen ermöglicht herauszufinden, wie viel Aufwand in die Durchführung von Produkt-Discovery-Aktivitäten investiert werden soll. Anderseits entwickelten wir einen Ansatz, mit welchem Unternehmen ihre Produkt-Discovery-Aktivitäten mit ihrer agilen Softwareentwicklung verzahnen können, um frühzeitig Produktrisiken zu erkennen. Darüber hinaus geben wir Handlungsempfehlungen in Form von neun "Good Practices" und einem vorgeschlagenen Produkt-Roadmap-Format.

Fazit: Unsere Beiträge bieten Leitlinien, damit Unternehmen ihre traditionellen Produkt-Roadmapping-Praktiken an ein dynamisches und unsicheres Marktumfeld anpassen können. Hiermit soll die Wahrscheinlichkeit des Produkterfolgs erhöht und die Verschwendung von Ressourcen reduziert werden. Daher zielen unsere Artefakte darauf ab, dass Ressourcen für die Entwicklung von kundenorientierten Produkten eingesetzt werden. Aus wissenschaftlicher Sicht liefert diese Dissertation neue Erkenntnisse auf dem Gebiet des Produkt-Roadmappings. Daher können Forscher unsere Arbeit als Grundlage nutzen, um weiteres Wissen über Produkt-Roadmapping in einem dynamischen und unsicheren Marktumfeld zu erweitern und zu vertiefen. Ein Beispiel für weitere Forschung ist die Frage, ob die in dieser Dissertation entwickelten Artefakte in anderen Kulturkreisen (z. B. Asien) angewandt werden können bzw. welche Aspekte für eine erfolgreiche Anwendung abgeändert werden müssten.

Abstract

Context: Organizations are increasingly challenged by high market dynamics, rapidly evolving technologies, and shifting user expectations. This situation has implications for the product planning of a company. For the planning of the evolution of the products, features, or services, product roadmapping is a widely used approach. The most common product roadmapping approach within German companies is upfront planning that includes products, features, or services based on the assumption that the future is highly predictable (so-called feature-driven product roadmaps). However, in a world of high dynamics and uncertainties, it is almost impossible to have a long-term prediction of which products, services, or features will satisfy the needs of the customers. As a result, such so-called feature-driven product roadmaps typically fail in dynamic and uncertain market environments. This lead to the circumstance that often products, features, or services are developed that are not or only seldom used. Therefore, companies are struggling with their ability to provide product roadmaps that fit into dynamic and uncertain market environments, and that can be used together with lean and agile software development practices. In addition, the conduction of product discovery is crucial for the success of product roadmapping in a dynamic and uncertain market environment. However, many product owners or product managers don´t know how much resources they spend for conducting

product discovery and struggle to implement it into their agile processes and iterations.

Objective: To address the problem mentioned above, the aim of this thesis is to design tools, processes and methods that enable product managers, product owners, or similar roles to transform their product roadmapping practices to a dynamic and uncertain market environment in order to create reliable product roadmaps.

Methods: First, we conducted a systematic literature review in order to identify the state of the art and uncover research gaps. In addition, we use expert interviews, a web survey, and a grey literature review to identify the state of practice and relevant problems related to product roadmapping for practitioners. Based on these findings, we developed, in collaboration with practitioners, six artifacts in the form of tools, processes, and methods and demonstrated their comprehensibility, applicability, and usefulness through expert interview studies and a multiple case study.

Contribution: First of all, we provide an overview of the state of the art and practice regarding product roadmapping. Besides this, we developed and validated a product roadmap assessment tool called DEEP that enables practitioners to assess the capabilities of their current applied product roadmapping practices. Based on the results of the assessment of the DEEP model, we developed a product roadmap transformation approach. This approach enables companies to identify suitable measures to transform their currently applied product roadmapping practices to a dynamic and uncertain market environment. As mentioned above, most companies struggle to identify how much effort they should spend on product discovery and how to integrate product discovery activities into their agile processes and iterations. In order to counter these problems, we developed, on the one hand, the so-called Discovery Effort Worthiness Index, which offers a tool for companies to identify how much effort they should spend on methods to discover and validate features. On the other hand, we developed an approach that companies enable to integrate their product discovery activities with product development and delivery to systematically identify product risks at an early stage. In addition, we provide recommendations for actions in the form of nine good practices and a proposed product roadmap format.

Conclusion: Our contributions provide guidelines to transform traditional product roadmap approaches to a dynamic and uncertain market environment. This aims to increasing the probability of product success and might leads in a reduction of waste. Therefore, our approach aims to ensure that resources are used for the development of customer-oriented products and thus increases the sustainability of a company. From the scientific point of view, this thesis provides novel results in the field of product roadmapping. Therefore, researchers can use our work to expand and deepen further knowledge related to product roadmapping in a dynamic and uncertain market environment. An example of further research is whether the artifacts in this thesis can be applied in other cultural settings (e.g., Asia).

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Stefan Trieflinger in February, 2024

Chapter 1

Introduction

1.1 Motivation

Nowadays, the market environment for developing digital products and services is characterized by high market dynamics, rapidly evolving technologies, and constantly shifting user expectations [GM10]. In addition, disruptive approaches threaten established market participants and attempt to drive them out of the market [LMRC17; TMW+22]. This situation is often described as BANI world [Gra20; Sri21; Tem21], which is an acronym for the characteristics **B**rittle, **A**nxiety, **N**on-Linearity, and **I**ncomprehensible. Brittle represents the strong fragility and instability of a system (e.g., a business model) due to today´s high dynamics and the associated uncertainties. A brittle system often seems strong and is often maximized for efficiency, but it can break spontaneously. A good example is the cultivation of monocultures, which is very efficient and successful but brittle since a simple change in climate or plant disease can instantly break it. Anxiety indicates the fear of making decisions in such an environment. This usually leads to passivity, as managers and leaders feel helpless and conclude that they can't make wrong decisions if they don't make decisions. However, such behavior usually leads to stagnation while the world keeps evolving. Therefore, such a company will not adapt to the varying requirements of a dynamic market environment, resulting in a significant disadvantage. Non-linear means that cause and effect are seemingly incoherent or disproportionate. Reasons for this could be that other factors (e.g., fast-changing customer behavior) distort the cause and effect or that a delay occurs between visible cause and visible effect. This is similar to the complexity stated in the better-known term VUCA [Gra20; Sri21; Tem21] (**V**olatility, **U**ncertainty, **C**omplexity, **A**mbiguity), but instead describes the consequences of the complexity, which is that people cannot understand the correlation between cause and effect anymore. This can also be found in the last part of BANI, which is incomprehensible. Incomprehensibility refers to the difficulty of interpreting phenomena such as the underlying reasons why the customers do not use a feature or why something worked, and something else did not, even if obviously it should be the other way round. Often such situations are subject to an information overload, i.e., a large amount of data makes it almost impossible to analyze and understand such phenomena [Gra20; Sri21; Tem21].

These factors bring a high level of dynamism to the market, which is becoming increasingly uncertain and makes it difficult for companies operating in the software-intensive business to plan their future product portfolio. Product roadmaps are the most commonly used approach in practice for planning and visualizing future product planning. [LMRC17; Per18; PFP01b]. In general, the fundamental purpose of roadmaps is to explore, visualize and communicate the dynamic linkages between markets, products, and technologies over time [KKT+15]. In the context of software-intensive business, a product roadmap should guide the team in achieving the corporate vision and enable them to recognize and act on events that require a change of strategic direction [Alb02]. Consequently, product roadmaps are strategic communication tools that map out the vision and direction of a company and the work that is required to get there [LMRC17]. Moreover, product roadmaps aim to create alignment and a shared understanding of the future direction to gather support and to be able to coordinate the effort among all stakeholders [MTL18]. Several authors point out that creating customer value is critical to the success of product roadmapping in the software-intensive business [KKT+11; LMRC17; Per18; SSAS11]. However, Komssi et al. [KKT+11] and Kim, Beckman, and Agogino [KBA18] mentioned that companies seem to focus on the functional and performance needs of their products and have tended to develop more features in their products instead of identifying which features provide the most value to the customers and the business. This is in line with recent studies that revealed that many software-intensive companies focus on developing a variety of features (defined mainly by opinions from experts or management) rather than on solving customer problems. This mindset leads such companies to use a traditional product roadmap format consisting of a fixed-time-based chart including detailed planned products, features, or services over a time horizon of usually one year [MTL18; MTL19d; TMPL22a].

However, due to increasing market dynamics combined with the adoption of lean and agile practices, it is almost impossible for companies to predict which products, features, or services will satisfy the customers' needs, especially in the long-time horizon [MS09; SSAS11]. Therefore, upfront planning, as is the case with feature-driven product roadmaps, works well in stable and predictable markets where no frequent changes occur and where a static and temporally precise prediction is possible [LMRC17; MTB+20; MTL19d]. As a result, two major problems have been uncovered with using feature-driven product roadmaps in a dynamic and uncertain market environment. First, feature-driven roadmaps aim to answer the question of which point in time the software development should begin and when a product, feature, or service is ready for market launch. Consequently, feature-driven roadmaps only contain outputs such as products or features and don't consider the outcomes to be delivered to the customers and the business. This situation often leads to developing products, services, or features that customers do not want or cannot use. The reason is that the product, feature, or service does not provide sufficient value to the customers. The second major problem is that the features with all their details are planned upfront in the product roadmap over a long time horizon. Due to the high dynamics, market conditions, and priorities constantly change, leading to frequent ad hoc adjustments to the product roadmap. These frequent adjustments cause employees, stakeholders, and external partners to lose trust in the product roadmap and doubt the company's reliability [Cag08; LMRC17].

These issues are supported by our studies that aim to identify the current state and problems of product roadmaps [MTL18; MTL19d; TMKL20; TMPL22b]. Therefore, the question arises of how software-intensive companies can transform their product roadmap by moving from feature-driven product roadmaps to a flexible approach focusing on delivering value to the customer and the business. Overall, it can be said that neither the scientific literature nor the industry provides profound approaches on how companies can identify their current state of product roadmapping nor which methods or techniques are crucial for successful product roadmapping in a turbulent market environment [MTL18; MTL19b; MTL19d]. The overarching aim of this thesis is to overcome this problem.

1.2 Goals

Based on the situation described in the motivation, we have formulated the following overall aim for this thesis adapting the template proposed by Wieringa [WW14].

Support product managers, product owners, or similar roles
by designing tools, methods, and techniques
that enable them to transform their product roadmapping practices
to create and maintain reliable product roadmaps
for developing digital products in dynamic and uncertain market environments.

To ensure the achievement of this overall aim, we formulated the following subgoals contributing to fulfilling the overall goal.

Subgoal 1: Provide a tool with which software-intensive companies are able to assess their current product roadmapping practices: The first step toward achieving our overall goal is to enable companies to systematically assess their product roadmapping practices currently in use. This steps intends to make the current status of product roadmapping visible as well as to identify improvement potentials. These insights should justify the need to transform the product roadmap to management and stakeholders to gain commitment and sufficient resources.

Subgoal 2: Develop an approach that guides companies through the transformation process of the product roadmap: Based on the assessment mentioned in subgoal 1, the question arises of what a company needs to transform its current applied product roadmapping practices. Therefore, the second subgoal is to develop an approach that guides companies through the product roadmap transformation. This product roadmap transformation approach should enable companies to systematically identify those parts of their product roadmapping practices that offer the highest potential for improvements. Based on this, recommendations should be made as to which methods should be performed to achieve this improvement.

Subgoal 3: Create a supportive tool for product owners and agile teams to decide how much effort is needed and which methods are suitable to conduct product discovery: Conducting product discovery activities (the ability to identify and validate outputs before implementation) is highly relevant for product roadmapping to discover what products or features should be developed in the future to satisfy the needs of the customers. In our studies, we have revealed that many companies and their product owners are aware of methods of conducting product discovery activities but need support to identify how much resources they should spend for its execution. The reason for this is, on the one hand, that resources are limited, and therefore not all features can be discovered with product discovery activities. On the other hand, it can quickly happen that the effort spent on product discovery activities exceeds the actual value delivered by the respective product. Therefore, this subgoal includes the development of a tool to determine how much product discovery effort should be invested to apply user research to validate a product idea.

Subgoal 4: Provide an approach that supports the integration of product discovery with the product development and delivery of a company: Another finding from our studies was that companies conducting product discovery activities lack an approach to integrating them into their product development and delivery. Therefore, this subgoal aims to close this gap by providing such an approach. The purpose of integrating product discovery and product delivery and development is to ensure that product discovery insights are taken into account in product development and delivery.

It should be noted that this thesis aims to support practitioners in assessing their current product roadmapping practices and transform them to the conditions of a dynamic and uncertain market environment. Therefore, the first two subgoals are the focus of this thesis. The needs for the third and fourth subgoals were uncovered through studies conducted to develop and validate artifacts to achieve the first and second subgoals. For this reason, the artifacts designed to achieve subgoals three to five support the artifacts developed to accomplish the first and second subgoals.

1.3 Research Questions

We have defined four research questions based on our subgoals, which are presented below. To define these research questions, the scientific literature on product roadmapping was analyzed, and research gaps were identified. In addition, we identified the state of practice regarding product roadmapping and its associated challenges by conducting three expert interview studies, a web survey, and a grey literature review. To answer these research questions (RQs), we have developed artifacts (tools, processes and methods) in collaboration with practitioners. These artifacts were validated by interviewing practitioners who applied the artifacts without explanation and instructions and by conducting a multiple case study. We defined our research questions as follows:

- **RQ1:** How can companies evaluate their currently applied product roadmapping practices?
- **RQ2:** How can companies transform their product roadmapping practices into more flexible approaches focusing on delivering value to the customer and the business?
- **RQ3:** How can product owners or agile teams decide how much effort is needed and which methods are appropriate to apply product discovery to a particular idea for a roadmap item?
- **RQ4:** How can practitioners integrate product discovery activities with product development and delivery to ensure that the findings of product discovery are considered in product development?

1.4 Research Scope

The research scope of this dissertation can be described along three dimensions.

Software-intensive business: The research presented in this thesis focuses on software-intensive business. Approaches from other disciplines, such as mechanical engineering, are not considered. This is because other fields have various characteristics and are therefore not directly applicable to product roadmapping in software-intensive businesses. For example, the market in mechanical engineering is to be considered stable, i.e., the market is less dynamic, and the technological change and customer behavior change slowly [VTR92; WG15]. This means that predictions can usually be made reliably over a long-time horizon (e.g., for five years). In contrast, software-intensive business is characterized by high market dynamics, rapidly evolving technologies, and fast-changing customer behavior. Therefore, predictions in software-intensive businesses over more than three months are almost impossible. As a result, the requirements for creating and maintaining product roadmaps in stable and dynamic markets must be considered different. This thesis relates to dynamic markets typically found in the software-intensive business.

Product Roadmapping: This research aims to support product managers and product owners in transforming their current product roadmapping practices to operate successfully in a dynamic and uncertain market environment. Other types of roadmapping, such as technology roadmapping or industry roadmapping, are explicitly excluded. Moreover, this thesis focuses on software product roadmapping, and consequently, related fields of action such as requirements engineering, release planning, or technology forecasting are out of scope.

Company-wide: The research focuses on product roadmapping in the context of the future direction of a product or product portfolio within a company. Product roadmapping exceeding company borders, for example, in software ecosystems, is explicitly excluded. The reason for this is that product roadmapping within ecosystems involves more variables (e.g., the behavior of other actors in the ecosystem) that cannot be reliably isolated compared to product roadmapping within a company. Therefore, the approaches in this thesis have limited applicability to software ecosystems.

1.5 Research Approach

The thesis at hand pursues the objective of supporting practitioners in creating and maintaining product roadmaps in a dynamic and uncertain market environment. Therefore, this thesis aims to solve a real-world problem related to product roadmapping. In order to achieve our objective, we chose the design science paradigm as a framework for our research. Alan Hevnern [Ala10], in his book "Design Research in Information Systems" defines design science as

> *a research paradigm in which a designer answers questions relevant to human problems via the creation of innovative artifacts, thereby contributing new knowledge to the body of scientific evidence. The designed artifacts are both useful and fundamental in understanding that problem.*
>
> — *ALAN HEVNERN [ALA10]*

Furthermore, Alan Hevnern [Ala10] points out that the discipline of Information Systems has produced knowledge through two complementary but distinct paradigms: design science and behavioral science. In contrast to design science, the behavioral science paradigm has its roots in natural science research and aims to develop and justify theories [Ala10; HCHC10]. It begins with developing a hypothesis, followed by data collection to prove or disprove it [Ala10]. On the other hand, design science has its roots in engineering and artificial science and aims to produce and evaluate an IT artifact to solve identified organizational problems. The term IT artifact is defined as constructs (vocabulary and symbols), models (abstractions and representations), methods (algorithms and practices), and instantiations (implemented and prototype systems). Moreover, Alan Hevnern [Ala10] points out that a critical step in conducting design science is evaluating the IT artifact being developed in terms of its utility for the identified problem. As mentioned in the motivation, the identified problem of this thesis is that software-intensive companies are struggling to create and handle reliable product roadmaps in a dynamic and uncertain market environment. Following the DS paradigm, companies should be provided with an IT artifact to build capabilities to develop and handle product roadmaps in dynamic and uncertain market environments. In order to conduct design science systematically and effectively, this thesis follows the seven guidelines proposed by Alan Hevnern [Ala10] The following shows these seven guidelines and our measures to fulfill each guideline.

A **Guideline:** Design as an Artifact
Description: Design science research must produce a viable artifact in the form of a construct, a model, a method, or an instantiation.
Measure: This thesis produces six artifacts in the form of models (tools) as well as processes and methods for the effective execution of these models.

B **Guideline:** Problem Relevance
Description: Design science research aims to develop technology-based solutions to important and relevant business problems.
Measure: In order to show the practical relevance of the problem, we conducted three expert interview studies, one web survey, and a review of the grey literature. In addition, we conducted a systematic literature review to identify the current state of the art regarding product roadmapping and to identify research gaps.

C **Guideline:** Design Evaluation
Description: The utility, quality, and efficacy of an artifact must be rigorously demonstrated via well-executed evaluation methods.
Measure: Overall, we evaluate the two primary artifacts of this thesis to solve our identified problems in two evaluation phases. First, we provide both artifacts to practitioners requesting to apply them in their respective company contexts without any explanations and instructions. This was done to ensure that practitioners applied both artifacts unbiasedly. Afterwards, expert interviews were conducted to gain feedback on the comprehensibility, applicability, and usefulness of the models. This led to identifying improvement potentials, which we incorporated into the models. In the second evaluation phase, we conducted a multiple case study with various companies. These case study were undertaken since applying both artifacts in practice deals with real environments and situations with many variables (such as management influence or limited resources and time). Such variables were not or only partially covered by the interview studies in the first evaluation phase. In addition, we uncovered additional practitioner

issues while evaluating our primary artifacts. This led to the development of four additional artifacts that support the use of the primary artifacts.

D **Guideline:** Research Contribution
Description: Design science research must provide clear and verifiable contributions in the areas of the design artifact, design foundations, and/or design methodologies.
Measure: In the context of this thesis, 23 papers were published. These publications show that the six artifacts developed in this thesis provide novel insights and contribute to solving previously unsolved problems. Therefore, the six artifacts are considered innovative and provide value to the practice and scientific community. Furthermore, these publications have demonstrated that the research methods used to develop these artifacts are reproducible and well-suited to generate further design knowledge on the topic of product roadmapping in a dynamic and uncertain market environment.

E **Guideline:** Research Rigor
Description: Design science research relies upon the application of rigorous methods in the construction and evaluation of the design artifact.
Measure: According to Hevner et al. [HCHC10], rigor can be fulfilled by effectively applying knowledge incorporating the existing theoretical foundations and the correct application of the research methodologies. To meet these requirements, the first step was to conduct a systematic literature review to determine the state of the art on product roadmapping and identify research gaps. The existing knowledge and approaches identified through this systematic literature review serve as the basis for developing all artifacts in this thesis. This ensures the requirement of effective application of knowledge incorporating existing theoretical foundations. Second, the existing knowledge related to product roadmapping in a dynamic and uncertain market environment was expanded by collecting primary data. The correct application

of the research methods in the process of collecting these primary data was confirmed by the positive reviews of the publications of the results of this dissertation. In addition, Hevner et al. [HCHC10] mentioned that constructs, methods, and instantiations must be exercised in a suitable environment, and appropriate subject groups must be obtained. To fulfill this requirement, we have only selected companies that develop digital products or services and deliver them to customers (in the B2C, as well as the B2B market). The participants of our studies were employees from different departments involved in product roadmapping of their respective companies. This includes, for instance, product managers, product owners, innovation managers, members of the management board, and employees of the department's marketing or sales. Consequently, the selection of participants was based on their experience regarding product roadmapping and their respective roles within their companies. To assess whether the candidate is suitable to participate in our studies, we conducted preliminary discussions with each candidate before the interview. For each study, we recruited new study participants to exclude confirmation bias and gain new insights.

F **Guideline:** Design as a search process
Description: The search for an artifact requires utilizing available means to achieve desired ends while satisfying laws in the problem environment.
Measure: Primary data was collected through expert interview studies and one web survey to identify the state of practice, challenges, and success factors regarding product roadmapping in a dynamic and uncertain market environment. These insights were used to develop the artifacts in this thesis. In addition, we incorporated the experience of experts in the field of product roadmapping into the development process of our artifacts that were not involved in the previously mentioned studies.

G **Guideline:** Communication of research
Description: Design science research must be presented to technology-

oriented as well as management-oriented audiences.
Measure: The results of this dissertation were published in 23 papers and presented and discussed at scientific and practical conferences in software engineering. The feedback from the communities was incorporated into the design process of the artifacts.

For the conduction of design science research, several approaches exist, such as the approach from Hevner et al. [HCHC10], Johannesson and Perjons [JP14], Peffers et al. [PTRC07], and Wieringa [Wie09]. We decided to apply the design science research framework according to Peffers et al. [PTRC07]. The reason for this was that Peffers et al. [PTRC07] developed a detailed process, including individual phases, that provided us with excellent guidelines for conducting our research. Another reason for choosing the approach proposed by Peffers et al. [PTRC07] was that this approach is designed to be iterative. This allows us to develop the first version of our artifacts, gather feedback from researchers and practitioners, refine the model based on this feedback, and evaluate the current version in further studies. The design science frameworks, according to Peffers et al. [PTRC07] is shown in Fig. 1.1 and consist of the phases: 1) problem identification and motivation, 2) define objectives of a solution, 3) design and development of the artifact, 4) demonstration, 5) evaluation and 6) communication.

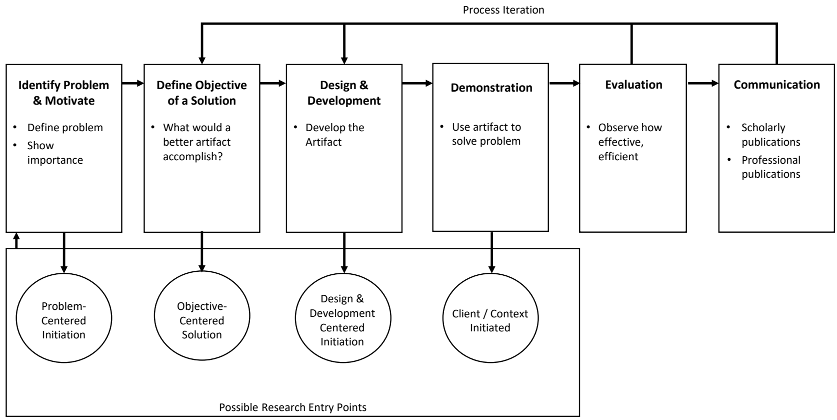

Figure 1.1: Design science framework according to Peffers et al. [PTRC07]

The artifacts developed in this thesis aim to support practitioners in transforming their product roadmapping practices to a dynamic and uncertain market environment. Hence the practical value of our results should guide the validation process. Nevertheless, concrete criteria for the validation must be defined. Considering the scientific literature, several authors propose criteria to validate qualitative studies. For example, Whittemore, Chase, and Mandle [WCM01] propose using the criteria 1) plausibility, 2) relevance, 3) credibility, and 4) importance of the topic, while Eisenhart, Howe, et al. [EH+92] suggest applying the criteria 1) completeness, 2) appropriateness, 3) comprehensiveness, 4) credibility, and 5) significance. Based on these suggestions, we have decided to use the following criteria: 1) comprehensibility (i.e., practitioners understand the purpose and terms of the model), 2) applicability (can the model be used in the respective company context of the practitioners), and 3) usefulness (do the artifacts provide value to practitioners). These criteria are intended to ensure that the results of the work can be transferred into practice. In addition, this dissertation should fulfill the following scientific goals: 1) novel in research, 2) scientific-methodical 3) empirically founded. Figure 1.2 shows my defined goals in relation to the artifacts developed and validated in this thesis.

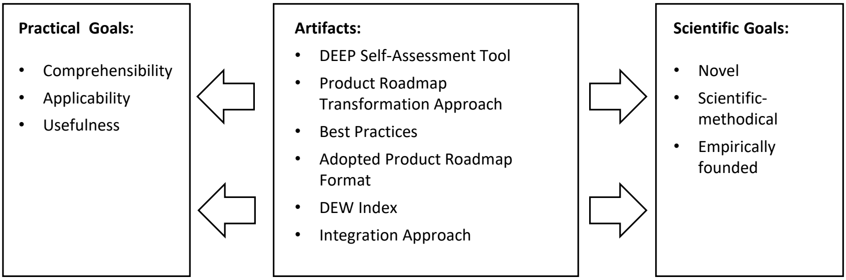

Figure 1.2: Practical and scientific goals of this thesis

1.6 List of Publications

This thesis resulted in a total of 23 publications, which were presented and discussed at international scientific and practical conferences. The following list includes the most relevant publications for this thesis.

1. J. Münch, S. Trieflinger, D. Lang. 'Product roadmap–from Vision to Reality: a Systematic Literature Review'. In: 2019 IEEE International Conference on Engineering, Technology and Innovation (ICE/ITMC). IEEE. 2019, pp. 1–8 [MTL19b]
2. J. Münch, S. Trieflinger, D. Lang. 'What's Hot in Product Roadmapping? Key Practices and Success Factors'. In: Product-Focused Software Process Improvement: 20th International Conference, PROFES 2019, Barcelona, Spain, November 27–29, 2019, Proceedings 20. Springer. 2019, pp. 401–416 [MTL19d]
3. S. Trieflinger, J. Münch, V. Knoop, D. Lang. 'Facing the Challenges with Product Roadmaps in Uncertain Markets: Experience from Industry'. In: 2020 IEEE International Conference on Engineering, Technology, and Innovation (ICE/ITMC). IEEE. 2020, pp. 1–8 [TMKL20]

4. J. Münch, S. Trieflinger, D. Lang. 'DEEP: The Product Roadmap Maturity Model: A Method for Assessing the Product Roadmapping Capabilities of Organizations'. In: Proceedings of the 2nd ACM SIGSOFT International Workshop on Software-Intensive Business: Start-ups, Platforms, and Ecosystems. 2019, pp. 19–24 [MTL19a]
5. J. Münch, S. Trieflinger, D. Lang. 'The Product Roadmap Maturity Model DEEP: Validation of a Method for Assessing the Product Roadmap Capabilities of Organizations'. In: Software Business: 10th International Conference, ICSOB 2019, Jyväskylä, Finland, November 18 20, 2019, Proceedings 10. Springer. 2019, pp. 97–113 [MTL19c]
6. S. Trieflinger, J. Münch, S. Wagner, D. Lang, B. Roling. 'A Transformation Model for Excelling in Product Roadmapping in Dynamic and Uncertain Market Environments'. In: Product-Focused Software Process Improvement: 22nd International Conference, PROFES 2021, Turin, Italy, November 26, 2021, Proceedings 22. Springer. 2021, pp. 136–151 [TMW+21]
7. S. Trieflinger, J. Münch, L. Weiss, B. Roling, D. Lang. 'Transformation Towards a Product-Led Company: Case Studies from Industry'. In: 2022 IEEE/ACM International Workshop on Software Intensive Business (IWSiB). IEEE. 2022, pp. 9–16 [TMW+22]
8. S. Trieflinger, D. Lang, S. Spies, J. Münch. 'The Discovery Effort Worthiness Index: how much product discovery should you do and how can this be integrated into delivery?' In: Information and Software Technology 157 (2023), p. 107-167 [TLSM23]
9. S. Trieflinger, J. Münch, D. Petrik, D. Lang. 'Why Traditional Product Roadmaps Fail in Dynamic Markets: Global Insights'. In: Product-Focused Software Process Improvement: 23rd International Conference, PROFES 2022, Jyväskylä, Finland, November 21–23, 2022, Proceedings. Springer. 2022, pp. 382–389 [TMPL22a]
10. S. Trieflinger, D. Lang, J. Münch. 'Counter the Uncertainties in a Dynamic World: An Approach to Creating Outcome Driven Product

Roadmaps'. In: Product-Focused Software Process Improvement: 23rd International Conference, PROFES 2022, Jyväskylä, Finland, November 21–23, 2022, Proceedings. Springer. 2022, pp. 319–333 [TLM22]

For publications 1., 2., 4., and 5. I am not the first author, but I was primarily responsible for the following tasks: 1) conceptualization, research design, preparation and conduction of the research project, writing.

1.7 Structure of this Thesis

The remainder of this thesis is structured as follows. Chapter 2 presents the theoretical background and concepts which are necessary for the understanding of the following chapters. Chapter 3 includes related work closely associated with the results of this dissertation. Chapter 4 presents our systematic literature review and contains related studies to this thesis that emphasize the research gap. Chapter 5 includes our expert interview studies, web survey, and grey literature review to reveal the state of practice. Chapter 6 presents the problems addressed in this thesis and derives requirements for the artifacts to be developed. Chapter 7 presents the first part of our solution approach, which consists of our product roadmapping assessment tool called DEEP. Chapter 8 includes the first evaluation phase of the DEEP model, in which feedback was collected from practitioners to demonstrate the comprehensibility, applicability, and usefulness of the model and to identify improvement potentials to customize the DEEP model. Chapter 9 extends the DEEP model by developing a holistic product roadmap transformation approach. Like the DEEP model, this transformation approach is validated in the first phase by conducting an expert interview study described in Chapter 10. Chapter 11 describes a multiple case study in which the DEEP Model and the product roadmap transformation approach were applied in a real business context. This case study represents the second evaluation phase of the artifacts developed in this thesis. In Chapter 12 we suggest the so-called Discovery Effort Worthiness (DEW) Index which enables companies to decide how many resources to invest in product discovery (i.e, the ability of a company to identify and validate customer-oriented roadmap items). In addition, this chapter includes our proposed approach for integrating product discovery into the product development and delivery processes of a company. This integration approach aims to systematcally analyze product risks to increase the chance of product success. Chapter 13 provides recommendations for actions to guide practitioniers in developing and maintaining product roadmaps in a dynamic and uncertain market environment. Finally, Chapter 14 summarizes our contributions, discusses the implication of our study and gives an outlook of further research topics.

Chapter 2

Theoretical Background

2.1 Software Product Management

In recent years, agile software development methods have attracted the attention of practitioners and researchers worldwide [AWSR03; DGSO10]. Examples of such methods are Extreme Programming (XP), Feature Driven Development (DFF), or Scrum [Fel18]. The expected effects of such methods are that the product development process becomes more responsive to a changing environment, individuals and interactions are considered more important than tools and processes, and customer collaboration is valued more than contract negotiation [VJBJ11]. Several studies have proven that using agile methods in the software development process can be successful [Alt15; CC08; LMD+04]. This attracts the attention of other domains (project management, sales, marketing, etc.) to introduce agile methods. One such domain is software product management [VJBJ11]. According to Ebert and Brinkkemper [EB14], software product management is a key success factor for developing software-intensive products as it spans the entire life-cycle and thus ensures both technical and business perspectives. This covers a broad spectrum, from gathering product ideas to deciding which products should be developed and delivered to customers [BWSB10].

In order to provide a comprehensive overview of all essential areas of software product management, Bekkers et al. [BWSB10] developed the Software Product Management Competence Model, as shown in Figure 2.1. The model consists of four primary business functions representing the core of software product management. These primary functions are 1) portfolio management, 2) product planning, 3) release planning, and 4) requirements management. Each business function contains several focus areas, i.e., the key activities performed in each business function. The business function portfolio management means gathering strategic information and decision-making across the entire product portfolio. This business function consists of the focus areas I) market analysis (collecting information regarding the market to make decisions about the content of the product portfolio), II) product lifecycle management (collecting information and making decisions about the product lifecycles and major product changes across the product portfolio) and III) partnering and contracting (establishing partnerships, pricing, and distribution aspects). The business function product planning focuses on gathering information for the creation of a roadmap for a product or product line and contains the focus areas: I) roadmap intelligence (collecting decision-supporting information required for the creation of the product roadmap), II) product roadmapping (developing the product roadmap), and III) core assets roadmapping (planning of the creation of core assets, i.e., components that are shared by multiple products). The business function release planning covers the software product management capabilities needed to successfully create and launch a release. Release planning contains the focus areas I) requirements prioritization (prioritizes the identified requirements), II) release definition (selects the requirements that will be implemented in the next release), III) release definition validation (validates the release definition by internal parties), IV) scope change management (handles different kinds of scope changes during the development of a release), V) Build validation (validates the built release before it is launched) and VI) launch preparation (prepares the internal and external stakeholders for the launch of the new release). Finally, the business function requirements management focus on the continuous management of requirements outside of releases and includes the focus areas I) requirements gathering (collecting of requirements from internal and external stakeholder), II) requirements identification (determining actual product requirements and connecting similar requirements) and III) requirements organizing (structuring the requirements throughout their entire lifecycle and describing dependencies between various product requirements).

The arrows in the model between the stakeholders and the business functions indicate the interaction between the stakeholders and the corresponding function. In addition, interactions between adjacent business functions are indicated by the arrows between these business functions. Finally, the arrows between the various focus areas show the information flow between these areas [BWSB10].

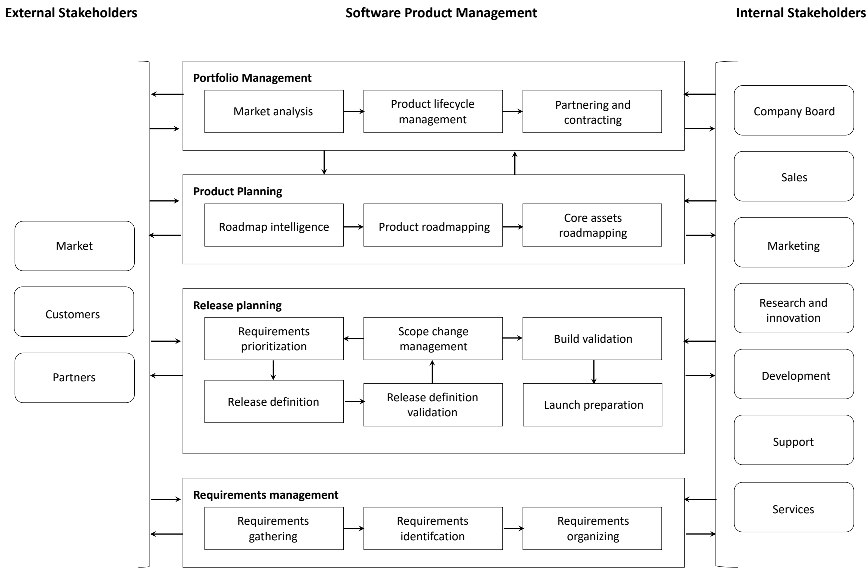

Figure 2.1: Software product competence model according to Bekkers et al. [BWSB10]

Vlaanderen, Van de Weerd, and Brinkkemper [VVB13]point out that due to the complexity of software products with a large variety of stakeholders, long lists of requirements, and a rapidly changing environment, the software product management process is complex and has a huge impact on product success. In more detail, Lehtola et al. [LKVK09] point out that to achieve product success, the ability to discover and implement the most valuable requirements (i.e., those requirements that deliver the most value to the customer and the business) of the products, features or services is essential. This means that those requirements that deliver the most value to the customers and the business should be included in one or more sequences of releases [SGF+10; VLR02]. This is shown within the business functions “release planning” and “requirements management” in the model, according to Bekkers et al. [BWSB10]. The input for the development of such requirements is usually provided by the product roadmap. However, if the roadmap does not consider the factor of customer value, it is not very likely that the requirements of the products, features, or services will deliver value to the customer and the business. Therefore, product roadmapping is essential to creating the most promising requirements and achieving product success [BWSB10; SGF+10]. The concept of roadmapping is described in more detail in the following.

2.2 Roadmapping

In general, roadmapping is a flexible technique used to support strategic and long-range planning. The basic purpose of roadmapping is to explore and communicate the dynamic linkage between markets, products, and technologies over time [Kap01; LKVK09]. Following this purpose, Groenveld [Gro97] describes roadmapping as a process that contributes to the integration of business and technology by displaying the interaction between products and technologies over time, taking into account both short- and long-term product and technology aspects. Probert and Radnor [PR03] describe roadmapping as a process that aims to develop a common view within a group of stakeholders about how they will achieve a desired objective. Similarly, Galvin [Gal98], former chairman of Motorola, stated that roadmapping aims to generate an augmented future of a chosen field of interest composed of collective knowledge and imagination of the brightest driver of the field. The approach of roadmapping gained widespread attention after its application by Motorola in the late 1970s and early 1980s [PR03] and was subsequently adopted by several companies [PFP04]. For example, several prominent organizations such as Rockwell automation [McM03], Philips [Gro97], and Lucent [AK03] introduced their own roadmapping approaches. Therefore, roadmapping is widely adopted in practice [HO17; HT12; PFP01b].

In software engineering, companies use roadmapping to bridge the gap between business planning and product development [LKVK09; PFP04]. In addition, roadmapping analyzes the organization's business environment for potentially disruptive approaches [SVS18] and provides practitioners with a vehicle for the holistic consideration of problems, opportunities, and new ideas [LKK05; SVS18]. This made roadmapping a popular and famous approach used nowadays in areas such as strategic planning or innovation and technology management [CFL13; MIP13; PSD08]. This popularity is mainly due to the communication and networking benefits arising from the roadmapping process in terms of building shared understanding across internal and external organizational boundaries. Therefore, roadmapping focuses on sharing perspectives and interactions between people that foster communication, new understanding, insights, creativity, and learning [PFP05]. This includes supporting people at all levels to achieve milestones and becoming committed to their role in the overall process [GAV10; Gro97]. Consequently, roadmapping is both a learning experience and a communication tool for roadmap participants [KS01]. Typically, the roadmapping process is iterative, subjected to periodic reviews and adjustments based on human interactions such as face-to-face meetings or workshops [PFP05].

Groenveld [Gro97] points out that the roadmapping process will differ from one company to the other. The reason for this is that companies serve different markets and have different cultures [Gro97]. However, Phaal, Farrukh, and Probert [PFP04] point out that the most appropriate roadmapping process depends on many factors, such as the level of available resources (e.g., people, time, budget), the nature of the issue being addressed (purpose and scope), available information (market and technology) as well as other processes and relevant management methods (strategy, new product development or market research). Regarding which participants should participate in the roadmapping process, Albright [Alb02] mention that roadmapping best performed as a cross-functional team activity led by an experienced facilitator. Moreover, the author points out that the roadmapping process should align the various team members and ensure that the team feels accountable for its plan while the facilitator steers the team toward a realistic plan [Alb02]. In a similar way, Phaal et al. [PFMP03] suggest that a multifunctional team should typically be responsible for the roadmapping process's conduction. This team should represent commercial and technical perspectives and range in size from 5 to 35 participants [PFMP03].

2.3 Roadmaps

Roadmaps emerge as an output of the previously mentioned roadmapping processes [LKK05]. In everyday life, the term roadmap describes a layout of paths or routes that exists (or could exist) in some particular geographical space. Therefore, travelers use roadmaps to decide between alternative routes to reach a physical destination. Thus, a roadmap originally serves as a traveler's tool that provides essential understanding, proximity, direction, and some degree of certainty regarding the planning of a journey [KS01]. In practice, roadmaps are a leading managerial approach to support the development of strategies and plans concerning product and technology innovations [OF15]. Moreover, roadmaps ensure that gaps in the plan are identified and can be closed in the future [Alb02]. In order to achieve this, roadmaps communicate visions, attract resources, stimulate investigations, and monitor progress [LLL06].

Considering the scientific literature, there are several definitions for the term roadmap. Kappel [Kap01] defines roadmaps as forecasts of what is possible or likely to happen and plans that articulate a course of action. Similarly, DeGregorio [DeG00] points out that a roadmap provides a simple yet powerful visualization of a forecast that can be applied in several key areas such as technology, capability, parameter, features, product, platform, system, environment, threat, and business opportunity. According to Phaal and Muller [PM09] roadmaps are an aggregation of relevant information into an integrated view of the evolution of a complex system. Rinne [Rin04] describes roadmaps as a map of unfolding evolutions of technologies and the products that implement them. Finally, Albright [Alb03]defines roadmaps as living documents that describe a future environment and objectives to be achieved within that environment. Moreover, Albright [Alb03] points out that it is advisable to review and update a roadmap over time; otherwise, it is not useful.

Roadmaps can take various forms, but they all seek to answer the three questions: 1) where are we going? 2) where are we now, and 3) how can we get there? [PFP05]. The most common approach is the generic roadmap proposed by EIRMA [PFP01b] as shown in Figure 2.2. This generic roadmap is a time-based chart comprising several layers that typically include both commercial and technological perspectives. The roadmap enables the evolution of markets, products, and technologies to be explored, together with the linkages between the various perspectives [PFP01a]. As Figure 2.2 shows, the generic roadmap proposed by EIRMA consists of three layers 1) business/-market, 2) product/services, and 3) technology. The market layer represents the market and business drivers [PFP01a]. This means the purpose of the company aspires together with the factors that influence that purpose. This means the purpose of the company aspires together with the factors that influence that purpose [PFP05]. The product layers outline the way how this purpose is to be achieved [Guo10]. This includes products and services that are linked directly to revenue generation. Finally, the technology layer of the roadmap is concerned with the resources (including technology) that must be marshaled and integrated to develop the products or services in the product layer [PFP05]. According to Wells et al. [WPFP04], roadmaps may be technology-driven (technology push) or needs-driven (market pull), but the most powerful are those that merge the two perspectives. The reason for this is that successful products and services must satisfy a customer and market need and be possible to develop through the deployment of technology [YPP08]. In a technology push approach, possible products and features are explored that could be enabled by available technology based on estimations and perceptions of what solutions could fulfill a customer need. In contrast, in a market pull approach, a clear market or customer need must be identified that has the potential to meet the stated requirements. Subsequently, technological solutions are sought that can enable the desired product functionality and performance. Regarding the relevance of these two approaches, Yoon, Phaal, and Probert [YPP08] point out that in recent decades there has been a shift from the technology push to the market pull approach. The reason for this is that due to past costly product failures, companies tend more to apply strategic marketing and drive product development based on a clear understanding of the problems and needs of the customers. However, the authors mentioned that a technology-push approach may still be suitable for emerging technologies or where new applications for existing technologies are sought [YPP08].

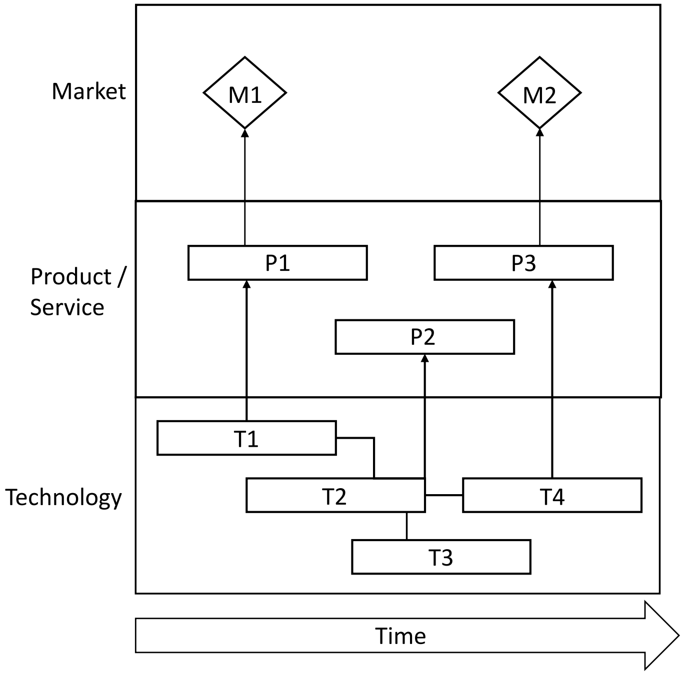

Figure 2.2: Generic roadmap proposed by EIRMA [Ass+97]

As mentioned above, roadmaps can and have been applied to many different subjects [PM09]. Consequently, various authors have dealt with classifying roadmaps into different categories. First of all, Kostoff and Schaller [KS01] classify roadmaps into the three fundamental roadmapping approaches 1) expert-based, 2) computer-based, and 3) hybrid. The main focus of the expert-based approach is to use the knowledge and experience of the participating stakeholder to subjectively identify the structural relationship within the network and specify the quantitative and qualitative attributes of the links and nodes of the roadmap. The computer-based approach focuses on large textual databases describing science, technology, engineering, and end products that are subjected to computer analysis. The purpose of this approach is to identify research, technology, engineering, and product areas, their relative importance, and identify and quantify their relationships to other areas. In contrast to the expert-based approach, the computer-based approach involves more objectivity. This means that the computer-based approach is not subject to the experts' preconceived limitations, constraints, bias, and personal and organizational agendas. However, the authors point out that the computer-based approach does not include interaction with experts, which is essential for the roadmapping process. Therefore, the authors recommend applying a hybrid approach that includes aspects of both the expert and the computer-based approach. In more detail, a company should identify, extract and apply each approach's features that are best suited to their context to achieve optimal results [KS01].

Phaal, Farrukh, and Probert [PFP01b] examined a set of 40 roadmaps based on their purpose and categorized them into the following categories: 1) product planning, 2) capability planning, 3) strategic planning, 4) long-range planning, 5) knowledge asset planning, 6) program planning, 7) process planning) and 8) integration planning. In addition, the authors identify general characteristics of roadmaps and proposed guidelines for the development of roadmaps. The guidelines are as follows: 1) roadmaps should be developed in graphical forms, as this most effectively supports the communication between the different stakeholders, 2) roadmaps should be multi-layered and reflect the integration of technology, product, and business perspectives across the company, 3) roadmaps should explicitly show the time dimension, as it is crucial to ensure that technological, product, service, business, and market developments are effectively synchronized, 4) the structure chosen for defining the layers and sub-layers of the roadmap should reflect fundamental aspects of the business and issues being addressed and 5) the roadmapping approach should be flexible and adaptable to a specific situation [PFP01b].

Finally, Kappel [Kap01] presents a taxonomy of roadmapping as shown in Figure 2.3. The X-axis distinguishes between roadmapping to gain insights at the industry level or to coordinate at the company level. The Y-axis distinguishes the roadmap according to its content focus, either on specific trends or positioning within an industry. Applying this taxonomy, Kappel [Kap01] differs between the roadmap formats 1) science or technology roadmaps, 2) industry roadmaps, 3) product-technology roadmaps, and 4) product roadmaps. Assuming the primary purpose of the roadmap is to better understand the future by identifying specific trends and making accurate forecasts, the result is a science or technology roadmap (upper left domain). When a prediction of technology performance, adoption, cost, etc., is combined in a document with its industrial context, this leads to an industry roadmap (lower left domain). In the case that specific product plans are combined with marketplace and technology trends, this results in product-technology roadmaps (upper right domain). Finally, product roadmaps (lower right domain) are created when a direction and schedule for product development and evolution are formulated to communicate with customers and internal stakeholders [Kap01]. In this context, it should be noted that the scope of this thesis is developing and handling product roadmaps in a dynamic and uncertain market environment. Therefore, product roadmaps are explained in detail in the following section.

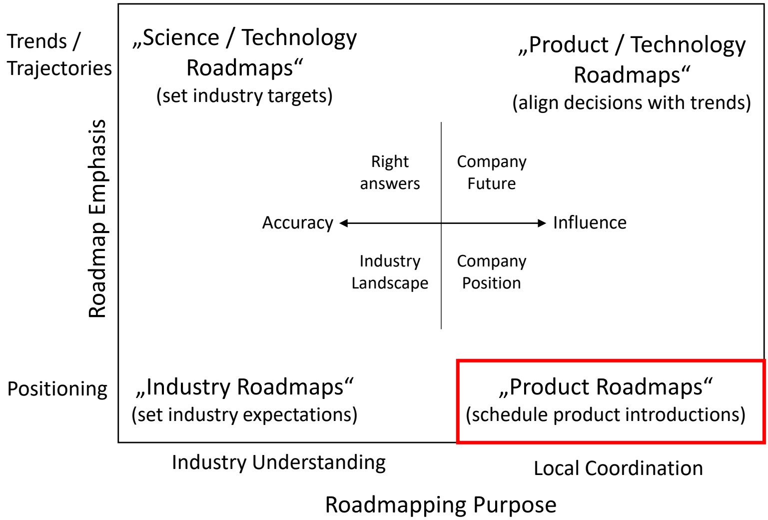

Figure 2.3: Roadmapping taxonomy according to Kappel [Kap01]

Product Roadmaps are strategic visualization tools to translate corporate strategy into executable plans and could be considered as forecasts or planning of the evolution of a product or product portfolio [AK03; JPW+17]. Consequently, product roadmaps are typically based on the requirements of a company's strategic plan and define the steps required over time to achieve the desired objectives [SR04]. Therefore, product roadmaps are essential tools for product managers, as they facilitate product strategy decisions and drive choices about which products should be developed in the future. In addition, product roadmaps are intended to ensure that the required resources are available for the development of future products and that these planned products fit into the corporate strategy [KSB+20]. Besides this, the product roadmap serves as input for the product backlog and supports the prioritization of the backlog [HH07]. Suomalainen et al. [SSAS11] point out that product roadmaps aim to improve two main purposes in the context of software engineering: First, how to serve important markets with the right products at the right time, and second, how to improve the processes required for the development of new products [SSAS11]. In order to reach these objectives, a critical activity is to identify the content on the product roadmap [Cag08; LMRC17; MTH20]. In this context, Patnaik and Becker [PB99] point out that the needs of the people endure longer than solutions, thus companies should focus on satisfying those needs rather than developing a particular product. Therefore, identifying and understanding the customers' needs provides a cornerstone for creating and updating product roadmaps [KSB+20; SSAS11].

Regarding the roles involving creating and updating a product roadmap, usually, senior management creates the product roadmap and is responsible for handling and updating the product roadmap [MTL19d; TW97]. In contrast, the findings of Lehtola, Kauppinen, and Kujala [LKK05] revealed that often the owner of the product is responsible for the product roadmap, which is created with a scope of 2 – 3 years. Moreover, the authors point out that stakeholders other than product management and product development require information about the future development steps of a product to planning their activity [LKK05]. Therefore, Groenveld [Gro97] and Albright [Alb02] suggest establishing a cross-functional roadmapping team consisting of product management, marketing, sales engineering, and services. In addition, Groenveld [Gro97] recommends that this team determine a leader who becomes the owner after the product is created. Similarly, Albright [Alb02] suggests that a facilitator should steer the team to achieve the set objectives. This is in line with the view of McCarthy [McC03], who proposed that the roadmapping team must be interdisciplinary. The reason for this is to ensure that all relevant information and opinions to achieve product success are included in the roadmap. As further examples of participants in the roadmapping process, the author mentioned the R&D department, members from business development, representatives from finance, and other core staff members from product-relevant functions. In addition, a product roadmap can provide information for stakeholders outside a company [APK+16; HH07]. For example, in the B2B business, a product roadmap provides the customers with access to short-term commitments, enabling them to initiate appropriate planning processes [APK+16]. More generally, companies often involve customers in the product roadmapping process to include their opinions on the future to increase their loyalty to the company [HH07].

Chapter 3

Related Work

As the first step of our research, we analyzed the existing literature. Therefore, this chapter presents related work and explains how it differs from this thesis. The next chapter (Chapter 4) focuses on conducting a systematic literature review that reflects the state of the research.

Hirose et al. [HPF+20] developed a maturity model designed to guide the organization-wide roadmapping implementation process. The model comprises six maturity levels described as follows: The first level is called "initial" and addresses companies that have started exploring the possibility of applying roadmapping. Therefore, such companies do not have a clear strategy for how roadmapping could be used and which participants should involve in the roadmapping process. Within level 2 (defined), the management has decided to apply roadmapping and is willing to allocate resources for this project. In addition, a roadmapping team has been established, and the company is prepared to introduce roadmapping and its roll-out. In level 3 (rolled out), the team understood what aspects are necessary to apply roadmapping, including the required tools for developing roadmaps. In addition, roadmapping workshops are conducted throughout the company, and a plan for the roll-out approved by management is in place. Subsequently, in level 4 (developed), pilot roadmaps have been developed and used restricted to certain units or departments. Level 5 (standardized) includes that roadmapping activities have been fully integrated, and roadmapping has become a common language across the company. Moreover, a specific unit is determined, which is responsible for the conduction of the roadmapping process. Finally, a company has reached level 6 (sustained) when the organization has decided to take an active approach to sustain roadmapping implementation, and risks and uncertainties are taken into account. The maturity model of Hirose et al. [HPF+20] determines the maturity of companies by providing a goal and description on the basis of which a company can determine its maturity level. Consequently, this approach includes no systematic assessment of the current state of product roadmapping. This aspect is considered by the maturity model developed in this thesis. Furthermore, Hirose et al. [HPF+20] provide key indicators to reach the next maturity level, while the transformation approach in this thesis provides concrete methods based on a systematic assessment for reaching a higher maturity level.

Lombardo et al. [LMRC17] developed a so-called “Roadmap Health Assessment Checklist”. The checklist includes 15 questions. The questions address various topics around product roadmapping, including 1) focus on value, 2) embrace learning, 3) rally the organization about priorities, 3) get customers excited, and 4) avoid overpromising. The health check can be seen as a quick assessment that covers the main issues of product roadmapping. In contrast to the maturity model in this thesis, the checklist by Lombardo et al. [LMRC17] does not explicitly show various stages for each dimension and does not consider specific organizational aspects such as responsibility and ownership of the roadmap. In addition, the authors do not recommend any measures to improve the roadmapping practices, which is part of this thesis.

Kim, Beckman, and Agogino [KBA18] introduced the concept of design roadmapping that aims to create an understanding of customer and user needs and the development of a clear and shared vision of customer experience to be created. The process starts with establishing a cross-functional team responsible for creating the design roadmap. This is followed by collecting comprehensive data on users, user experiences, and trends. For this purpose, the authors recommend conducting selective in-depth interviews, surveys, and behavioral observations to identify unexplored needs and opportunity spaces for innovation. Based on the collected data, the next step is identifying so-called design principles such as common needs, user groups, or pain points. These design principles serve as the basis for prioritizing technologies applied to the needs and pain points of the identified user groups. Finally, the creation of the design roadmap is executed by combining the insight from user research and technology analysis to create a plan that focuses on the development of customer-centric solutions through the application of appropriate technologies. A template for a design roadmap is shown in Figure 3.1. The approach developed by Kim, Beckman, and Agogino [KBA18] focuses on creating a new product roadmap, while the approach in this thesis addresses the transformation of an already existing roadmap (since most companies have a roadmap in place). Nevertheless, creating a new roadmap is also possible with the approach in this thesis. To achieve this objective, the approach developed in this thesis proposes methods to create artifacts that are essential for operating in a dynamic and uncertain market environment (e.g., outcomes). This is similar to the approach by Kim, Beckman, and Agogino [KBA18], which also identifies the content of the roadmap based on customer needs. However, Kim, Beckman, and Agogino [KBA18] do not address procedures to develop further artifacts such as solution ideas or validated learnings. This aspect is covered by the approach in this thesis.

Al-Ali and Phaal [AP19] proposed the digital transformation roadmap by combining roadmapping with design sprints. The authors argue that applying design sprints can help companies understand and evaluate the digital trends and drivers forcing the organization to change. The digital transformation roadmap consists of the future digital experience as its vision and aligns various organizational capabilities around it. Besides that, the authors point out that designing and conducting business experiments will help systematically reduce the uncertainty in developing digital products.

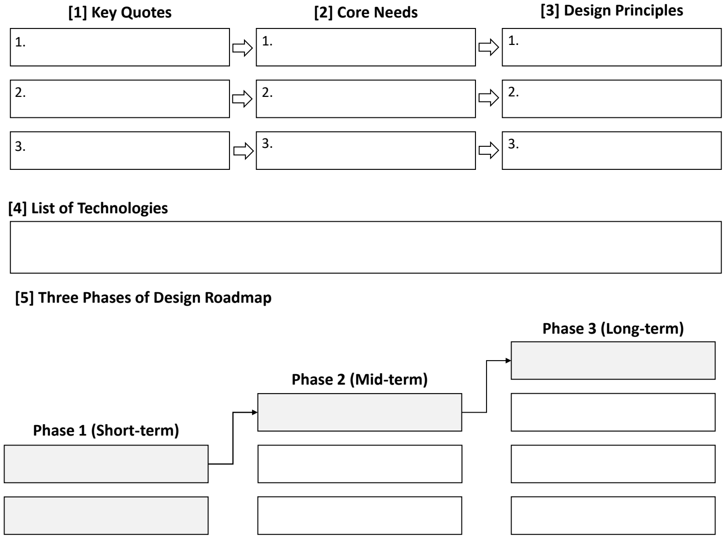

Figure 3.1: Design roadmapping template according to [KBA18; KCBA16]

Al-Ali and Phaal [AP19] suggests recommendations on how to integrate design sprints into roadmapping. The potential of design thinking is also used in parts of this thesis to identify items on the roadmap. The difference to the paper by Al-Ali and Phaal [AP19] is that this thesis focuses on the transformation of roadmaps, including the development of a detailed approach that integrates product discovery (such as Design Thinking) and roadmaps. The last mentioned can be considered as an extension of the paper of Al-Ali and Phaal [AP19].

In order to support practitioners with the scoping of roadmapping, Kerr and Phaal [KP19] developed a checklist-based template. Overall, the template consists of six sections to steer the discussions on expectations and priorities with the key organizational stakeholders. The first section focuses on answering the question of why roadmapping is needed in a company. This section aims to discuss the business need (e.g., for a product) and achieve a common context. The second section deals with the issue of which aspects should be addressed by the roadmapping process. This includes answering the following questions: 1) what is the unit of analysis? 2) what is the potential scope? 3) what are the main sub-layers and timeframes? 4) what is the scale of organizational ambitions? 5) what are the intent and organizational expectations, and 5) what does the organization want to realize? The third section aims to clarify which people should be involved in the roadmapping process. In this context, it is recommended to assign responsibilities depending on the role and knowledge of the different actors. The fourth section addresses where roadmapping can incorporate related resources. Examples of resources are other tools, sources, internal processes, or external collaboration. In this context, the authors recommend that the inclusion of other tools should be considered complementary to the core modules of roadmapping methods. The fifth section addresses the issue of when roadmapping will be deployed. This includes aspects such as determining when to prepare for a roadmapping workshop or when to develop the roadmapping architecture. Finally, the sixth section is optional and deals with the question of whether roadmappping can be supported. This section aims to identify organizational enablers for continuous improvement, capability building, deployment guidelines, and community of practice. The template developed by Kerr and Phaal [KP19] seeks to elicit the requirements for an upcoming roadmap development by reaching an agreement among all stakeholders. The application of this template can be seen as preparation for an upcoming roadmap transformation. However, Kerr and Phaal [KP19] do not address aspects to assess the current roadmap or aspects of transforming a roadmap.

Kittlaus [Kit] developed the ISPMA Software Product Management Framework to provide a holistic overview of the activities of software product management. The purpose of the model is to support practitioners in establishing and improving the discipline of software product management in companies. The framework consists of columns highlighting functional areas of software companies, such as strategic management, product planning, or the development of software-intensive products. Different activities are assigned to each functional area, and the authors provide recommendations for performing each activity throughout the book. Product roadmapping is assigned to the functional area of product planning in the framework. In this context, the author proposes the roadmapping process, as shown in Figure 3.2. The first step of the roadmapping process is to identify options for developing a product vision and strategy. Each option is a building block representing an essential aspect of the product to be developed for product success. This means that each option aims to create value by satisfying the needs and problems of the customers. The second step is to create a roadmap that shows when and how each option will be realized or whether an option will be adjusted or discarded. The author recommends conducting this step in a workshop where decision-makers from product management, marketing, development, and other product stakeholders participate. The roadmap created provides input for requirements engineering, release planning, or performance and risk management. The roadmap process proposed by Kittlaus [Kit] includes high-level recommendations but lacks detailed guidance for practitioners on what aspects are essential to developing a roadmap for the software-intensive business. This gap is closed by the presented approach in this thesis.

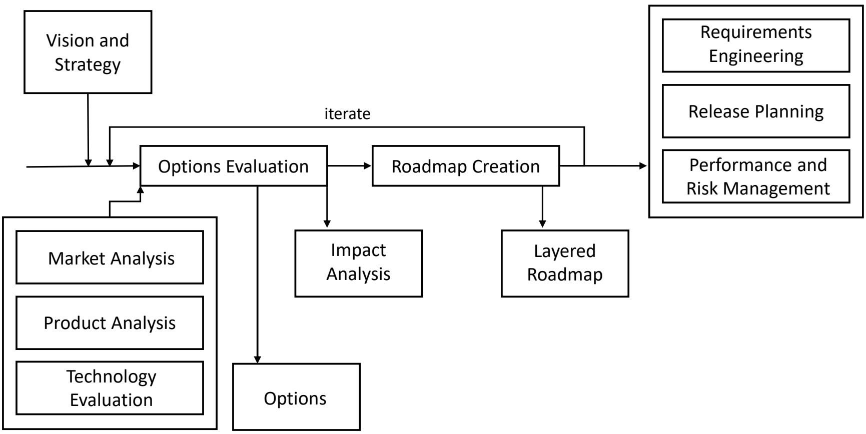

Figure 3.2: Roadmapping process according to Kittlaus [Kit]

The analysis of related work shows that the topic of product roadmapping occurs in the scientific literature. Little research is available on topics such as product roadmap maturity models [HPF+20; LMRC17], approaches for introducing roadmaps [KBA18], combining roadmaps with design sprints [AP19], and roadmap alignment [KP19]. In addition, a product management framework was developed were roadmapping is a part of it [Kit]. However, related works does not adress or only abstractly the transformation of product roadmaps and product roadmapping practices to a dynamic and uncertain market environment. Consequently, there is a gap on detailed approaches, guidelines and best practices that practitioners can apply to perfom such a transformation.

Chapter 4

State of Research

As mentioned in the previous chapter, we conducted a systematic review of the existing scientific literature. Conducting a systematic literature review was necessary since an initial search revealed that the topic of product roadmapping is not well established in the scientific literature. Therefore, the aim of this systematic literature review was to gain further insights by determining the current state of the art on the topic of product roadmapping. These insights should serve to identify research gaps, justify the positioning of future research, and highlight future research avenues. This systematic literature review is part of the phase “identify problems and motivitate” in the design science process (see Figure 1.1). To achieve our objective, we formulated the following research questions:

- **RQ1:** How many papers have been reported in the scientific literature that addresses (product) roadmapping?
- **RQ2:** What approaches have been reported in the scientific literature that addresses (product) roadmapping?

The chapter extends the following publication.

- J. Münch, S. Trieflinger, and D. Lang. 'Product roadmap–from vision to reality: a systematic literature review'. In: *2019 IEEE International Conference on Engineering, Technology and Innovation (ICE/ITMC)*. IEEE. 2019, pp. 1–8

4.1 Research Design

We conduct our study based on the guidelines provided by Keele et al. [Kee+07] for the execution of systematic literature reviews. In the guideline, Keele et al. [Kee+07] reorganize the traditional procedure that is commonly used in medicine for application in the software engineering domain. In order to define the scope of our systematic literature review, we used the categories of 1) population, 2) intervention, 3) outcome, and 4) context, as defined by Keele et al. [Kee+07]. Each category is described in the following.

Population: We analyzed the published scientific literature on product roadmapping from 2000 until 2018. The reason for choosing this time period was that the agile manifesto that emerged in the early 2000s opened up for developing products and services for new ways of developing products and services. Therefore, we expect the main contributions to this topic in the chosen timeframe.

Intervention: We include studies that address procedures and methods of product roadmapping.

Context: We focus on the academic literature and exclude grey literature such as blog posts, videos, slide decks, or reports.

Search strategy: The procedure involved in performing a systematic review is intended to be well-defined to ensure that such a study is objective and repeatable [BSN+09]. To obtain sufficient results to answer our research question, we first defined a list of search terms based on reviewing previous studies on product roadmapping. In addition, we have presented this list to two experts with more than seven years of experience in the field of product roadmapping to review this list and complement it with practical knowledge. Subsequently, we used this list of search terms in an initial search and involved them iteratively. This means that search terms are not used and deleted from the search term list in the case that a search term did not identify relevant papers for our study. In contrast, additional search terms were added based on the insights gained from the initial search. The search terms (ST) include terms for product roadmapping in conjunction with terms for possible outcomes or impacts of product roadmapping. After evaluating different viable options, we defined the following search terms:

- **ST1:** Product AND Roadmapping
- **ST2:** Innovation AND Roadmapping
- **ST3:** Outcome OR Oriented AND Roadmap
- **ST4:** Value OR Driven AND Roadmap
- **ST5:** Feature OR Driven AND Roadmap
- **ST6:** Goal OR Oriented AND Roadmap
- **ST7:** Requirements AND Engineering AND Roadmap
- **ST8:** Theme AND Based AND Product AND Roadmap
- **ST9:** Theme AND Based AND Requirements AND Engineering
- **ST10:** Service AND Oriented AND Roadmapping
- **ST11:** UX AND Roadmap
- **ST12:** User Experience AND Roadmap
- **ST13:** Service AND Design AND Product Roadmap
- **ST14:** Release AND Management AND Product AND Roadmap
- **ST15:** Service AND Engineering AND Product AND Roadmap
- **ST16:** Product AND Release AND Planning

The complete string used in our search was:

ST1 OR ST2 OR ST3 OR ST4 OR ST5 OR ST6 OR ST7 OR ST8 OR ST9 OR ST10 OR ST11 OR ST12 OR ST13 OR ST14 OR ST15 OR ST16

Inclusion and exclusion criteria: In order to filter out the irrelevant papers, we defined the inclusion and exclusion criteria as shown below.

The inclusion criteria are:

- Journals or conference papers in which the topic of product roadmapping is represented.
- Papers that have been published after the year 2000.

The exclusion criteria are:

- Publications whose full text was not available.
- Studies that adopt a complete set of methods from another reference.
- Publications presenting the results of the same study (usually presented by the same authors) in various journals. In such a case, we included one publication in the result set
- We excluded grey literature since it is not peer-reviewed.

Data resources and study selection process: In order to collect data, we use the three data sources “IEEE Xplore", “ACM Digital Library”, and “Springer Link", as they are widely used for software engineering and related topics. The data selection process started with the use of the search string mentioned above on each of the selected databases. The search was conducted on February 2019. We analyzed the articles that were published from January 2000 until December 2019. When appropriate, we applied filters to obtain only relevant results from the research area of computer science. This leads, for example, to the exclusion of research fields such as sociology science, agricultural science, or biology. Due to the high amount of hits in some databases, we defined a stopping condition to get a manageable set of papers. This means that we considered the first 150 articles in each database. Only in the case of continued knowledge gain after 150 papers we analyzed another 50 articles from this database. After scanning titles, removing duplicates, and reading abstracts and full texts, we obtained 23 relevant papers. In addition, we conducted forward snowballing (i.e., search in papers that cited the paper) and backward snowballing (i.e., search in the paper's reference list), leading to 10 additional hits. In order to structure the existing body of literature, two researchers performed a qualitative content analysis and classified the relevant papers into various categories. Therefore, each researcher highlighted the key findings and statements separately. Subsequently, the assignment of the articles to the different categories was done in consultation with all researchers. Our applied search process consisted of five phases and is shown in Figure 4.1.

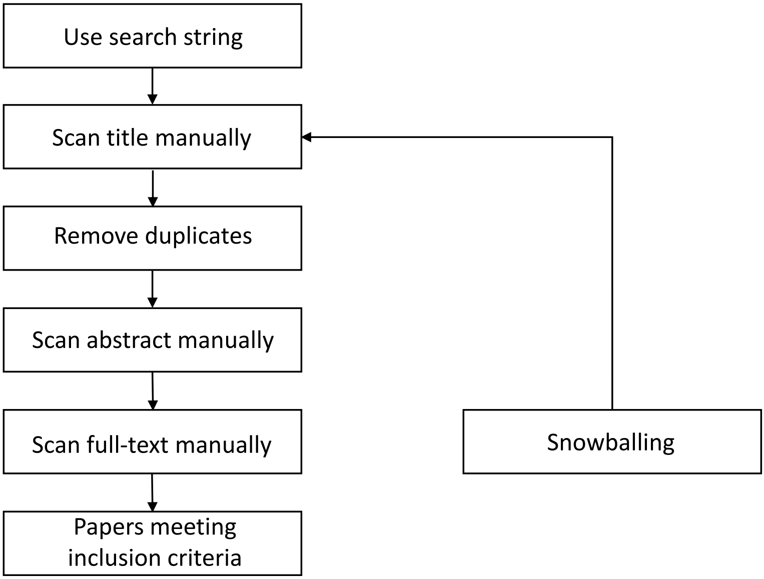

Figure 4.1: Study selection process

As mentioned above, we conducted our systematic literature review in February 2019. However, it can be assumed that the scientific literature regarding product roadmapping has expanded from 2019 to 2022. In addition, during our research process, we could identify further promising databases that we did not include in our review in 2019. Therefore, we decided to extend our systematic literature review from 2019 and additionally introduced the databases "Web of Science", "Science Direct", and "AiSel" to search for relevant articles. In addition, we adjusted our search term by including terms that we identified as relevant during our research process but had not included in the first review. In contrast, we have deleted terms that we did not consider relevant to our search. Below, the deleted terms are shown in red, the added terms are marked green, and black indicates that the terms have not changed. The process for data selection remained unchanged, and the search period was expanded to December 31, 2021. This means we choose the time period from January 1, 2000, to December 31, 2021. The start date remained unchanged since, by changing the search string, it would be conceivable that we would identify relevant articles in the first time period (January 1, 2000, to December 31, 2021) that we did not find with the first search term.

- **ST1:** Product AND Roadmapping Roadmap
- **ST2:** Innovation AND Roadmapping Roadmap
- **ST3:** Outcome OR Oriented AND Roadmap
- **ST4:** Value OR Driven AND Roadmap
- **ST5:** Feature OR Driven AND Roadmap
- **ST6:** Goal OR Oriented AND Roadmap
- **ST7:** Requirements AND Engineering AND Roadmap
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- **ST11:** UX AND Roadmap
- **ST12:** User Experience AND Roadmap
- **ST13:** Service AND Design AND Product Roadmap
- **ST14:** Release AND Management AND Product AND Roadmap
- **ST15:** Service AND Engineering AND Product AND Roadmap

- **ST16:** Customer AND Value AND Roadmap

As can be seen above, we have additionally added the search string "Customer AND Value AND Roadmap". The reason for this was that we identified these terms as relevant for our review based on the experience we gained during our research process regarding product roadmapping. This leads to the following adjusted search terms (AST).

- **AST1:** Product AND Roadmap
- **AST2:**Innovation AND Roadmap
- **AST3:** Outcome AND Roadmap
- **AST4:** Goal AND Roadmap
- **AST5:** Requirements AND Engineering AND Roadmap
- **AST6:** Theme AND Roadmap
- **AST7:** Service And Roadmap
- **AST8:** UX AND Roadmap
- **AST9:** Release AND Roadmap
- **AST10:** Customer AND Value AND Roadmap

The complete search string for the updated review was

AST1 OR AST2 OR AST3 OR AST4 OR AST5 OR AST6 OR AST7 OR AST8 OR AST9 OR AST10

4.2 Results

First, it should be noted that the results presented below consolidate the findings from our first and extended systematic literature review. By applying the selection process described above, we obtained a final set of 53 relevant papers (including the papers in Chapter 3). Regarding our first research question (RQ1), Figure 4.2 shows the number of papers in each database along our selection process.

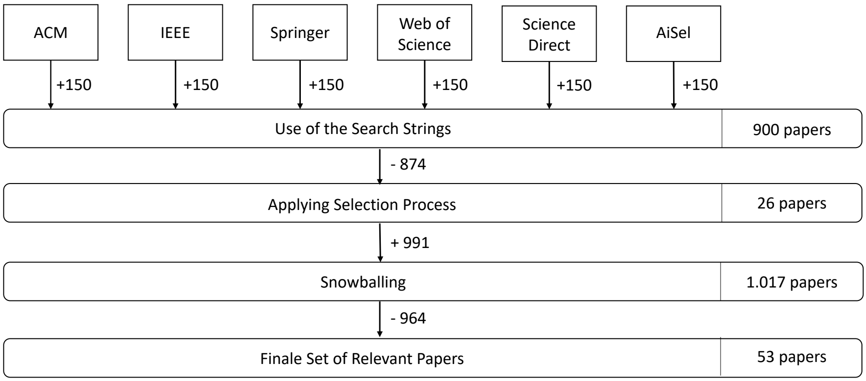

Figure 4.2: Number of papers along our selection process

Another interesting question is whether the topic of roadmapping got increasing or decreasing attention from researchers over time. The results (see Figure 4.3) show that overall, there is a constant interest in product roadmapping. In more detail, the number of publications shows a slow start in 2002 (1 publication), followed by a low stream of publications from 2003 to 2008. The number of publications increased in 2009 (5 papers) but declined again in 2010 (1 paper). A first peak was in 2011 with 7 papers. Then the publications dropped to zero in 2012, followed by a low stream in 2013 and 2014. In 2015 there was a second peak with seven papers. After that, the publications decreased to two papers in 2016 and one paper in 2017. An increase was observed in 2018 (4 papers), followed by a further decrease in 2019 (2 papers). A third peak was in 2020 with 6 papers. After 2020 there was another descent in the numbers. However, it should be noted that most relevant papers focus on roadmapping from a broader perspective, and only a few articles are closely related to product roadmaps. Although there is a constant stream of articles, there are gaps. This might indicate that there is no large research community that focuses specifically on the topic.

In order to answer the second research question (RQ2), we analyzed the relevant papers and assigned each paper to a category. This leads to the

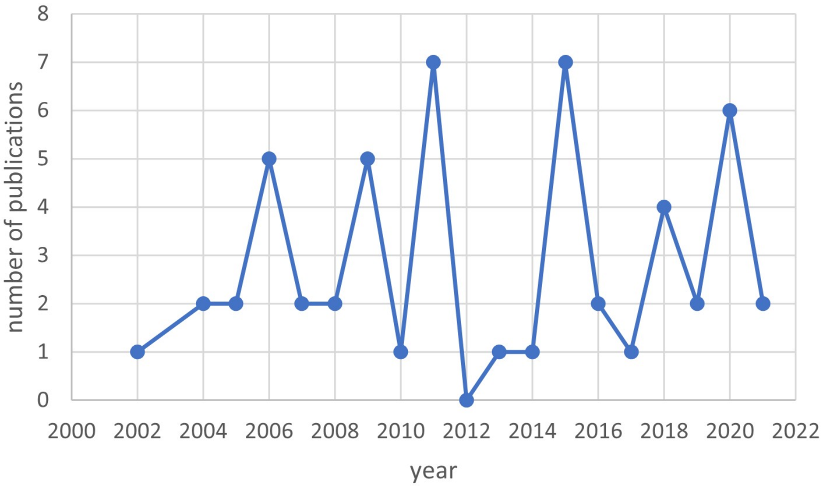

Figure 4.3: Number of relevant papers from 2000 to 2022

identification of eight categories in the context of product roadmapping. The results show that 25.93 percent of the analyzed papers deal with the roadmapping process. This means that the authors typically identified and described various steps to create and update roadmaps. 18.52 percent of the articles present a roadmapping framework (i.e., a basic conceptual structure for a set of processes, artifacts, or resources). An example is a paper that presents a framework for assessing roadmapping performance. 12.96 percent of the analyzed papers address the combination with other approaches, such as scenario planning or the business model canvas. 14.81 percent of the papers focus on describing specific types of roadmaps (e.g., strategic roadmap, product roadmap, technology roadmap). This includes describing the relationships and interactions between these different types of roadmap types. 11.11 percent report practical experiences and lessons learned regarding product roadmapping, while 9.26 percent discuss problems and challenges related to product roadmapping. Finally, 3.70 percent present a model or an approach to visualize roadmaps, and the same percentage discuss a maturity model regarding product roadmapping. Figure 4.4 gives an overview of the distribution of the analyzed papers concerning the categories we identified. It should be noted that the total number in Figure 4.4 is 54. This is because the paper by Cosner et al. [CHF+07] was assigned to the category roadmapping processes and roadmap types.

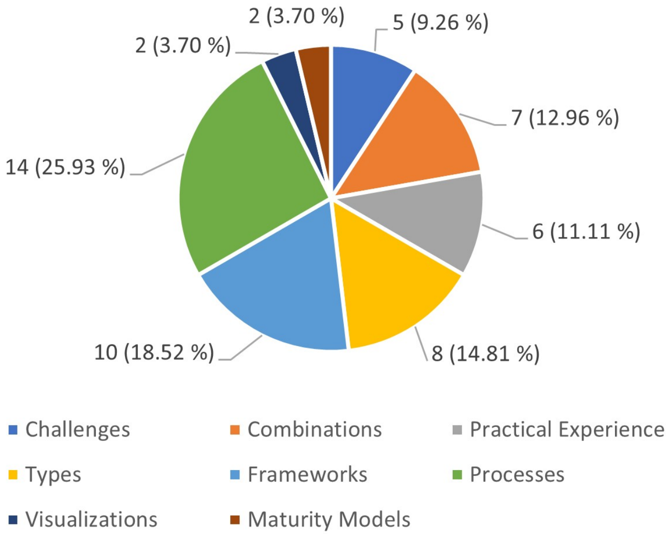

Figure 4.4: Distribution of relevant papers by subject

In order to gain more detailed insights into RQ2, we analyzed each paper and elaborated on the main contribution of each paper. The main content of each paper is described below according to our identified categories (except those that are described in Chapter 3).

4.2.1 Process for Creating and Updating Roadmaps

Lee et al. [LJLS21] proposed a roadmapping process that consists of three stages. The first stage (ideation) focuses on developing ideas of innovation opportunities that result from the short-term market and business needs or long-term changes in the technological and business environment. Subsequently, the second stages (selection) focus on evaluating the proposed ideas of possible innovation opportunities in the first stage. This stage also includes grouping ideas into several topics, which are subsequently prioritized. Finally, the third phase (planning) involves creating detailed plans to realize the topics selected in the second phase. In this context, investigating and evaluating technologies from various perspectives is critical. Due to its flexibility, the authors point out that the proposed process is predominantly suitable for roadmapping in a turbulent market.

Moreover, de Souza et al. [SSF+20] proposed an agile process for product roadmapping, especially for start-ups. This process begins with a planning phase that includes developing a vision, branding, and positioning and determining the target audience for the products to be developed. Moreover, a roadmap architecture should be defined, and an appropriate time horizon determined. Regarding the latter, the authors recommend a time horizon of six to twelve months. Subsequently, the development phase identifies the new products and services to be included in the roadmap. To discuss this issue, the authors suggest conducting a small meeting approach rather than formal workshops. The intention of this recommendation is that smaller workshops foster the engagement of entrepreneurial teams by better dealing with the time availability of team members. This meeting should be held in informal places such as restaurants and pubs and include the activities 1) roadmap charting, 2) analysis of gaps and 3) alignment. Regarding the creation of the roadmap, the authors recommend to left blank spaces because filling the entire map with details would add little value since operational issues are more likely to change over time. Finally, the implementation phase includes the establishment of new processes and structures to develop the agile roadmap as well as the assignment of responsibilities and resources.

Vähäniitty, Lassenius, and Rautiainen [VLR02] present a process based on product roadmapping that supports small companies in their product planning. The process consists of the phases 1) define the strategic mission and vision and outline the product vision, 2) scan the environment, 3) revise and distill the product vision as product roadmaps, 4) estimate the product life cycle and evaluate the mix of planned development efforts. The steps in the process should be performed periodically to align the roadmap to new information and changing market situations. Smaller updates should be done to ensure that roadmaps always contain current information.

Cosner et al. [CHF+07] identified three processes for creating roadmaps: First, the enterprise team constructed a central process, which is responsible for the roadmapping process. The business unit content owners should provide the information required to conduct this process. Second, a workshop approach, i.e., the roadmaps, is constructed in collaborative sessions with the business unit content owner. Third, in a distributed approach, the individual business units and functional content owners construct the roadmap to enable subsequent integration based on guidelines provided by the enterprise team.

Fenwick, Daim, and Gerdsri [FDG09] present a process for technology roadmapping that integrates marketing and decision-making methods. In this context, value drivers are determined to reflect the customer's current needs and future expected needs. The process of creating a value-driven technology roadmap contains the phases 1) assessment (evaluate the company´s internal capabilities as well as the external industry environment), 2) market analysis (understand the value proposition for customers), 3) services availability (create an offer of desirable products and services and necessary technologies) and 4) the development of a roadmap to link technology to future market opportunities.

Schaller, Vatananan-Thesenvitz, and Stefania [SVS18] introduced the concept of business model innovation (BMI) roadmapping. The process of BMI roadmapping involves five critical steps: 1) evaluate the environment and future trends, 2) analyze the current business model, 3) identify the business model domains that will be the focus of the roadmap, 4) define design elements that need to be performed on business model domains and 5) revise changed business model with the current situation and the market fit. The implementation steps of the approach consist of four stages: 1) initiation: get the firm ready before beginning the implementation, 2) development: develop a desired roadmap by involving the right individuals in the process and by gathering the correct information to conduct a step-by-step analysis, 3) integration: integrate the approach into ongoing business planning activities, and 4) evaluation: assessment of the integrated BMI roadmap and, if necessary, apply corrective actions.

Beeton, Phaal, and Probert [BPP13] outline how a standardized exploratory roadmapping process can be applied to capture and structure supply chain insights and develop future views of the competitive issues facing a diverse industrial area. The process of developing the exploratory roadmap consists of three steps: 1) planning, 2) insight collection, and 3) insight processing. Planning includes establishing a steering committee, articulating the need for the roadmap, setting system boundaries, designing the roadmap architecture, recruiting experts, and miscellaneous preparatory work. Insight collection consists of the steps choose a workshop format, characterize the strategic landscape, conduct a voting process to identify issues from the content of the strategic landscape, and rank the identified issues. The collation, the transcription, and the development of a visual representation are components of the phase insight processing. The process produces a roadmap that provides useful information, structure, and context for strategic planning and innovation processes in a complex multi-stakeholder industry.

Fleury et al. [FHSP06] analyzed to adjust the alignment between the strategic objectives and the software development process at software companies. The authors propose a methodology that includes the categorization of software companies into the groups 1) customer-oriented, 2) service-oriented, and 3) product-oriented according to their core capabilities. The authors create these groups based on the dimensions "level of customization" and "number of customers per project". On this basis, the customization of the technology roadmapping technique takes place. Thereby, projects such as the individual development of a single software system for one customer are distinguished with respect to roadmapping from a product that aims to serve many customers' needs.

Suomalainen et al. [SSAS11] surveyed 52 participants from 34 companies to identify the state of practice of product roadmapping. Overall, the results of the study showed that organizations consider the product roadmap mainly as a tool for strategic decision-making, as it aims to display the future directions of the product portfolio of the company. Moreover, the authors indicate that product roadmapping is a continuous process since the roadmapping team holds regular meetings (e.g., biweekly, quarterly, or biannually) to create, update and review the roadmap. Regarding the roadmapping process, the study revealed that feature management is a critical aspect of product roadmapping. Therefore the authors suggest that a roadmapping process should contain the following phases: 1) capturing features, 2) analyzing features, 3) prioritizing features, 4) roadmap validation and agreement, and 5) change management of the roadmap. In this context, the most problematic areas are prioritizing features, managing changes and maintaining the roadmap, sharing information, communicating, and making a roadmap agreement. Finally, the authors suggest that several stakeholders should participate in the roadmapping process, with the study identifying product management, marketing, customers, engineering, and partner respective as the most important ones.

Arman and Kharrat [AK16] proposed a process that consists of the following main steps. 1) identifying goals, objectives, strategies, and entities, 2) conducting an as-is analysis, 3) performing a to-be state analysis, 4) executing a transition analysis, 5) drawing the roadmap, and 6) monitoring and evaluation. The authors point out that one of the essential aspects of this approach is using strategic themes to move from the as-is state to the to-be state. The reason for this is that these themes act as the main building blocks for shaping the desired future. This supports the roadmap team to ensure that all gaps and shortages between the current state (as-is) and the desired state (to-be) are covered. This helps the team make decisions that serve as input for the subsequent step, "drawing the roadmap".

Freitas et al. [FOB+20] developed a roadmapping approach that can be used to develop multilevel and integrated strategic innovation planning. The development of such a roadmap consists of the following steps: The first step addresses the roadmapping theme and its discovery by small groups of internal experts. In more detail, this includes the definition and agreement on the roadmapping theme, the thematic discovery by brainstorming and interviews, the data analysis, and the identification of critical topics. The second step aims to clarify the roadmapping theme and processes to a larger group of participants to create a company-wide roadmap architecture. The third step is collecting data and organizing and consolidating information through the created roadmap architecture. Within this step, various organizational functions and hierarchies should be involved to support the development of the roadmap and validate it. Finally, the last step focuses on visualizing the roadmap and its communication across the company.

Gerdsri, Vatananan, and Dansamasatid [GVD09] proposed the three stages, 1) initiation, 2) development, and 3) integration, as phases of the roadmapping process. The initiation stage prepares an organization to start implementing a roadmapping process. The development stage focuses on creating a roadmap by engaging the right people, gathering the necessary information, and conducting a step-by-step analysis. Finally, the integration stage pursues the goal of integrating the roadmapping process into ongoing business planning activities in a way that a roadmap can be constantly reviewed and updated promptly. The authors point out that this three stages model helps the key players to understand the unique requirements and the level of involvement in each stage. This is important since the role and responsibilities of each player vary throughout the process.

Ho and O'Sullivan [HO17] propose a process of managing roadmapping practices to develop effective strategies for standardization in support of innovation. The process starts with the phase "initiation and planning," in which, firstly, existing information is gathered or updated. Subsequently, the focus and scope of the roadmap are determined, and decisions are made about required processes and their participants. This information develops a vision and goals, followed by defining a fundamental concept. Then the input and analysis phase takes place, which includes the sub-steps 1) design of a basic system architecture, 2) the identification of current standards and activities, 3) the analysis of (inter)national environments and issues (tech and non-technical), 4) the conduction of a gap analysis as well as the 4) refinement of the system architecture defined in the first sub-step. Finally, the phase synthesis and output includes the establishment of priorities and action plans and implementing and publishing of the roadmap. The authors point out that as roadmapping is an ongoing learning process, it is crucial to review and revise the roadmapping process continuously.

4.2.2 Roadmapping Types

As mentioned in Chapter 2.3, EIRMA [Ass+97] proposed a generic roadmap consisting of a time-based chart comprising a number of layers that typically include commercial and technological views. This generic roadmap (see Figure 4.5) is intended to explore the evolution of markets, products, and technologies, together with the linkages between the various views.

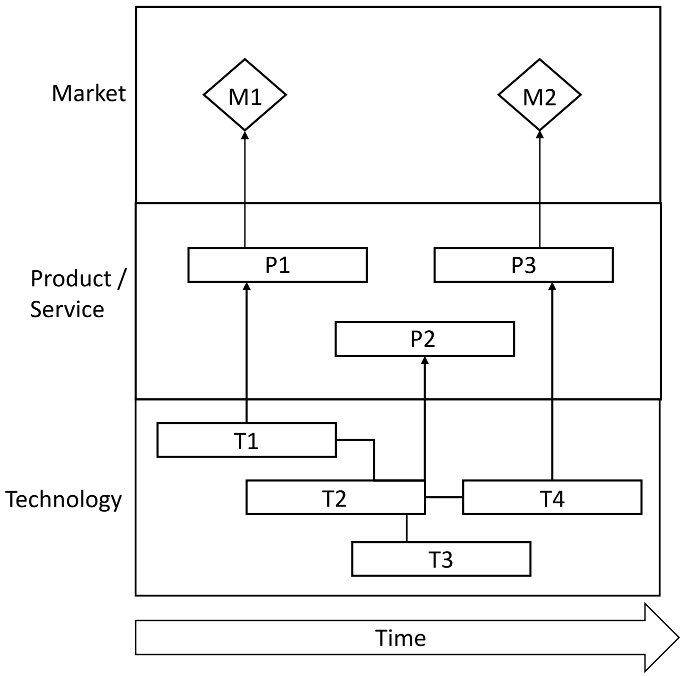

Figure 4.5: Generic roadmap proposed by EIRMA

Geum and Park [GP10] extended the generic roadmap approach of EIRMA [Ass+97]. The intention of adapting the approach of EIRMA [Ass+97] was that companies develop more products and services in a system rather than a single product. Therefore, Geum and Park [GP10] developed the so-called Product-Service System Roadmap (PSS roadmap). Overall, the PSS roadmap consists of four layers, with the technology layer (fourth layer) and product layer (third layer) adopted from the approach by EIRMA [Ass+97]. The difference to the approach, according to EIRMA [Ass+97], is that services are not included in the product layer but are assigned in their own layer. This distinction aims to provide a detailed view of the integrated offering of products and services combined in a system to deliver required user functionality in a way that reduces the impact on the environment. Consequently, the product and service layers are equally important in delivering value to the customer. The structure of the PSS roadmap is shown in Figure 4.6. Similarly, Kameoka et al. [KNFK06] proposed a comprehensive strategic roadmapping approach that consists of the layers 1) research and development programs, 2) technology, 3) product, 4) service, and 5) market belong a time axis. The authors argue for the addition of a separate service layer by pointing out that in the rise of services, it is important to pay attention to the convergence of science, technology, and services.

Phaal, Farrukh, and Probert [PFP05] generalize a roadmap format consisting of three broad layers. The top layer of the roadmap includes the organization's purpose and factors that influence that purpose, such as trends and drivers. The middle layer of the roadmap includes the mechanisms through which the purpose is achieved. This layer consists of products, services, and operations. The bottom layer of the roadmap includes the resources that must be deployed and integrated to develop the delivery mechanisms. In addition, the article describes a concept of 'linking grids' to link goals and strategies on different levels of the organization. Thereby, an alignment of an organization concerning goals and roadmaps can be addressed.

Phaal and Muller [PM09] present a slightly different generalization of roadmap layers. The top layer relates to the trends and drivers that govern

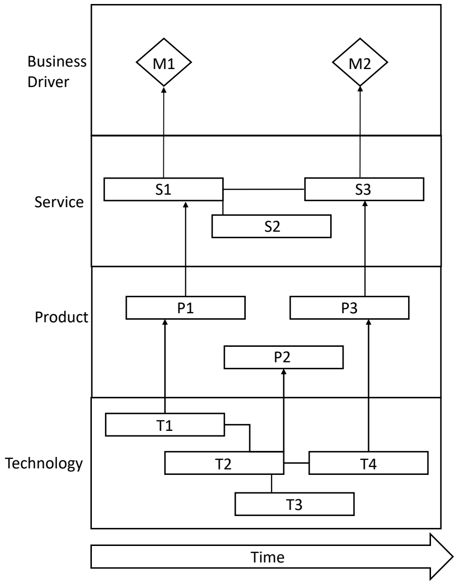

Figure 4.6: PSS roadmap proposed by Geum and Park [GP10]

the overall goals or purposes associated with the roadmapping activity. The layer includes external markets, industry trends, and drivers. Furthermore, it contains internal business trends, drivers, milestones, objectives, and constraints. The middle layer relates to the tangible system that needs to be developed to respond to the trends and drivers in the top layer. This layer includes products, service infrastructure, or other mechanisms for integrating technology capabilities, knowledge, and resources. The bottom layer contains the resources that need to be marshaled to develop products, services, and systems, including knowledge-based resources such as technology, skills, and competencies and other resources such as finance, partnerships, and facilities. The article also presents a generalized process for roadmapping that includes phases such as ideation, divergence, convergence, and synthesis. These phases could be seen as a reflection of modern product development practices that require a smooth integration of discovery and delivery activities. At least this process highlights the iterative process of roadmap creation and maintenance. The approach presented by Phaal and Muller [PM09]) strongly emphasizes technology-based solutions and their integration into the next higher-level roadmap layer (i.e., connection with the product/service system).

Cho and Lee [CL11] examine 761 roadmaps in service sectors to gain insights into their application and purposes. The study showed that the majority of roadmaps were developed for the purpose of administration, followed by planning and forecasting. Another interesting finding was that the mapping periods spanned medium to long time periods, and most relied on expert opinions for their development. Overall, the study revealed that the properties of roadmaps in the service sector are similar to those of roadmaps in manufacturing areas. Furthermore, based on the set of roadmaps examined, the authors derived the following roadmap types: 1) Product-focused technology roadmap (developed in industries where product offering is critical in providing services), 2) service-focused technology roadmap (designed for pure services), 3) product-service integration roadmap (developed for environments where integrated planning of products and services is essential), 4) technology-driven service roadmap (starts from technology planning to find new services opportunities based on technology development) and 5) product-service technology roadmap (contain all elements of product, service, and technologies).

The enterprise roadmap, according to Cosner et al. [CHF+07], includes the following layer information: 1) strategic roadmap, 2) market roadmap, 3) product roadmap, and 4) technology roadmap. The strategic roadmap addresses the long-range objectives of the management. The market roadmap includes known and anticipated customer needs, competitive strategies, the regulatory environment, complementary product evolution, substitute products, and disruptive innovations. According to Cosner et al. [CHF+07], product roadmaps show the performance and evolution of products, features, and services. Technology roadmaps include expected research and development products, their availability dates, the driving factors for research and development, and related information. The enterprise roadmap integrates the described different roadmap types across the enterprise. Although the paper has a precise understanding of the term "product roadmap", it emphasizes some critical issues with respect to the creation of a product roadmap and its relation to the outcomes of a roadmap. Linking roadmaps to outcomes such as business and customer value is seen as highly relevant by the authors. This can be seen, for instance, in the statement: "*If a roadmap does not reflect true customer needs, then using it is worse than having never created it*"." Although this can be considered a very important statement, the paper does not elaborate in detail on how to integrate outcomes into roadmaps.

In another paper, Phaal, Farrukh, and Probert [PFP04] discovered through an analysis of 40 roadmaps 16 different types of roadmaps, which they divided into two clusters. The first cluster has been identified in terms of intended purpose: 1) product planning, 2) service/capability planning, 3) strategic planning, 4) long-range planning, 5) knowledge asset planning, 6) program planning, 7) process planning, and 8) integration planning. The second cluster relates to graphical formats: 1) multiple layers, 2) bars, 3) tables, 4) graphs, 5) pictorial representations, 6) flow charts, 7) single layers, and 8) text. Roadmaps can have characteristics of more than one type and be assigned to both categories. In such a case, the roadmap adopts a hybrid form.

Kim et al. [KSB+20] examined the differences between design roadmaps and technology roadmaps within companies by conducting two case studies. The study showed that these two roadmap types are similar in their visual representation and timelines but differ in their elements. In more detail, technology roadmaps contained more internal elements, such as products and technologies, while design roadmaps contained more external elements, such as meaning-based user values and customer segments. Moreover, the case study revealed that the anchor of customer requirements to create value in strategic planning was critical for both companies in the case studies when transforming their roadmapping processes toward more enduring strategic outcomes.

4.2.3 Challenges with Roadmapping

Kim, Yao, Agogino, et al. [KYA+15] conducted an interview study with product managers, technology managers, and designers from San Francisco and identified challenges from roadmapping in the industry. First, the study revealed that roadmaps are ineffective in predicting the future. According to one participant in this study, the reason for this is that markets have become even more dynamic. Therefore, it is difficult to make reliable statements over a long time. Another identified challenge is the lack of feedback loop from research on end-users. This means, on one the hand, that customer feedback is not effectively incorporated into the roadmapping process and, on the other hand, that there are no effective methodologies to extract insights from customers. Finally, the studies identified an overdependence on feature-driven roadmapping processes as a challenge. In this context, the authors point out that nearly every roadmapping process the participants described was technology-driven. Regarding this insight, the authors stated that such an approach has been effective in the past, but nowadays, an approach is needed that focuses more on generating radical innovation to shifting customer preferences. Moreover, the authors point out that if a company adds features based on technological progress, the product may deviate from the most significant customer needs.

Komssi et al. [KKT+11] identified the following problems based on a study with two Finnish software product companies: 1) Linking business strategy to solution planning involved the trouble of seeing the big picture of the offering, 2) an overly feature-driven mindset culminated in roadmapping that prioritized low-level software features, 3) the practitioners had difficulty articulating the content and value of services, which hindered service marketing, and 4) only a few employees had good knowledge of their customer's activities, and that knowledge was fragmented on the different areas of their customers' activities. According to the authors, the companies sought to solve these problems by bringing a holistic view to analyzing customers' processes and roadmapping and sharing fragmented customer knowledge between cross-functional team members in collaborative workshops. A major finding was that the companies had to link strategy and release planning and improve their roadmapping practices.

Pora et al. [PTGT18] obtain challenges of technology roadmapping based on the three categories 1) people, 2) process, and 3) data. The challenges of the category "people" are the commitment of the top management and the selection of the right key players. The category "process" includes the challenges: initialization of the roadmapping process, choosing and customizing the appropriate roadmapping approach, the facilitation of workshops to generate and share the knowledge required in the roadmapping process, the alignment of the key performance indicators, and the organization of the roadmapping process. In addition, the defined current rules and working procedures do not support a rapidly changing business environment. Finally, the category "data" contains the challenges of predicting future events due to limited data availability for technologies or market forces, frequent updates to reflect changes, and the irrelevance of disruptive changes to roadmapping.

Ho and O'Sullivan [HO20] conducted a case study and identified product roadmapping challenges and practical steps to counter those challenges. The authors grouped the challenges they identified into the categories 1) knowledge transformation, 2) knowledge translation, and 3) knowledge transfer. The category knowledge transformation includes the challenges of large numbers of participants from diverse backgrounds or organizations, different goals, objectives, or motivations represented by multiple participants, and the strategic orientations that prevent open communications and the willingness to share information. The category knowledge translation consists of the challenges of using different terminologies and jargon by different participants with various backgrounds, as well as the understanding and perspective of the industry by different stakeholders. Finally, the category knowledge transfer contains the specific focus and interests of individual participants in roadmapping, the large amount of information collected from multiple sources, and a varying structure of roadmaps resulting from different issues and the rapid development of technologies. For each category, the case study revealed the following practical steps to overcome these challenges. Category knowledge transformation: 1) define an overall vision and objectives and 2) engage professional facilitators and experts in management teams. Category knowledge translation: 1) define a common terminology and system architecture, 2) develop linking taxonomy and typology as appropriate, and 3) conduct a cross-check to identify inter-relationships and linkages. Finally, the category knowledge transfer includes the steps of 1) developing a high-level roadmap as a reference point and 2) using a consistent roadmap structure. Besides this, the step to keep living documents through continuous revision and updates help to counteract the challenges in each of the categories mentioned above.

Maglyas, Nikula, and Smolander [MNS11] interviewed six Russian companies to analyze how software product management is implemented in practice. The findings showed that the companies were unfamiliar with software product management but were interested in the topic. Especially introducing and managing software products in a competitive market provides big challenges for many software companies. The authors point out that organizations have to change their mindset from implementing many features to identifying and satisfying the needs of their customers.

4.2.4 Visualization of Roadmaps

Kerr and Phaal [KP15] introduce a design-driven approach and visual representation of roadmaps for more transparent communication among stakeholders. The approach consists of four process steps: 1) defining the frame of the roadmap, 2) establishing the structure of the layout for the roadmap, 3) depicting the relationships that connect various elements of the roadmap, and 4) articulating a direction for the strategic narrative captured by the roadmap.

Vähäniitty et al. [VLRP09] present a model to visualize product roadmaps developed in cooperation with three small software companies. The model consists of five layers, with the top four representing the development of various parts of the entire product (platforms, product components, releases, and services) as activity (presented as horizontal bars in the model), while the bottom layer shows the estimate of human resources required a given point in time. The different activities are connected with arrows to indicate their dependencies. The model expresses the releases and development schedules for the product, the composition of each release, changes to the underlying technologies, services that need to be considered by product development, and planned resource usage.

4.2.5 Roadmapping Frameworks

Vähäniitty and Rautiainen [VR08] present a conceptual framework of the possible links between agile software development and long-term business, product, and release planning. The framework contains business unit, product, and service levels, development portfolio, and project and iteration management. With the help of the framework, people can identify needed roles, responsibilities, and decision structures. Roadmapping is part of the product and service level within the framework. In this context, the contents of the roadmap are balanced and synthesized to develop products or services for the immediate future. This includes matching available resources for product development and ensuring that the products or services align with the company's business goals.

Dissel et al. [DPFP06] introduce the value roadmap approach (VRM) based on technology roadmapping. The VRM provides a framework for supporting technology evaluation and valuation (to explore, communicate, calculate, maximize, and manage value). The approach is supported by workshops and can be used at the early stages of a technology development project to explore the value proposition and to improve the design of the technology development project. The VRM includes the layers "market and business trends and drivers" (the drivers that focus on external market trends), "value streams" (the sources of future revenue and savings), "enablers and barriers" (the technical challenges and risks, together with complementary assets and actions needed to exploit the potential value of the technology or capability) and the "technology capabilities" (the underlying technologies that are the result of the technology investment decision). A key feature of the VRM is the time axis, which links the short-, medium- and long-term perspectives for all of the layers. The VRM process is typically conducted as a workshop or set of workshops with technical and business participants involved. It contains the following stages: 1) define a strategic framework, vision, and scenario (the overall assumptions, boundaries, and constraints that the VRM has to consider concerning the technology investment decision to be made), 2) map technology development and investment milestones, 3) define value streams, 4) map market and business trends and drivers, 5) map barriers and enablers, 6) review project plan and VRM, 7) present visualization, and 8) maintain VRM as a process.

Gerdsri et al. [GPVT19] developed a framework that companies enable to assess the current state of their roadmap. The purpose of this approach is to support management in deciding when to review and update a roadmap. Therefore, a company needs to track changes in its critical drivers to produce a status signal that indicates the current status of the roadmap. This signal shows whether the roadmap needs to be revised or can be maintained in its current state.

Gerdsri and Manotungvorapun [GM21] suggest a framework for developing a strategic relationship-building strategy for effective university-industry collaborations (UIC). The framework consists of four phases that require cooperation from the executives and the UIC committee, who directly engage with academic partners. Phase one includes identifying requirements and the preferred characteristics of potential academic partners from the executives of a company. In phase two, the UIC committee uses the identified requirements and characteristics to develop an assessment tool that includes measurement items and a scoring rubric. A measurement item represents a question or statement associated with the identified characteristics of academic partners. To develop a scoring rubric, the authors recommend describing five stages that reflect the maturity of each measurement item. This results in a matrix with the measurement items on the Y-axis and the scoring on the X-axis and enables each measurement item to be scored from very weak to very strong. In phase three, this assessment for evaluating academic partners is executed by the executives of a company and the UIC committee. Finally, in phase four, the UIC committee analyses the assessment results, provides feedback, and transforms these results into a strategic roadmap. This means that the obtained results are prioritized and visualized in the form of a roadmap to outline the strategic path of future partnerships.

Cheng et al. [CCFT14] developed a hybrid roadmapping framework for technology forecasting and assessment which guides companies in strategic innovation and technology planning. The framework is composed of four main steps: First, the development of a preliminary roadmap takes place, which includes the following sub-steps: 1) introduction of roadmapping, 2) understanding the business strategy, 3) define the company needs, 4) define aim and scope, and 5) develop roadmap framework. Second, this preliminary roadmap created in the first primary step will be expanded by conducting the subsequent sub-steps: 1) identify market and business drivers, 2) identify other elements being concerned such as products, services, applications, technologies, resources and 3) establishing the linkages among all the elements being concerned. Third, the roadmap will be validated by 1) evaluating the credibility of the first version of the roadmap and 2) generating the results to validate this roadmap. Finally, the finalization of the roadmap takes place. This includes the sub-steps of 1) developing awareness of technological threats and opportunities, 2) developing plans for acquiring or developing technologies, and 3) assigning resources to accomplish the plans for acquisition and development. Moreover, the authors point out that the finalized roadmap must be updated regularly through the iteration of the proposed process.

Geum et al. [GLKP11] suggest a framework for product roadmapping to create a product-service integrated roadmap. This framework's target audience are managers planning to start product-service integration. The first phase includes determining the context and scope of the roadmap, defining the role of technology, and the roadmap format. The second phase focuses on deciding how roadmapping will be performed, i.e., the definition of the roadmapping process and the methods to use within this process. Finally, the third phase is implementing the roadmapping process by executing the methods defined in the second step.

Based on a literature review Vishnevskiy, Karasev, and Meissner [VKM16] propose a framework that focuses on strategic planning by firms and public authorities. The framework consists of the following five main phases: 1) Pre-roadmapping: explore the need to implement innovative technologies, products, and services (for instance, surveys on the opinions and preferences of experts), 2) desk research: analyze all available knowledge and derive risks, 3) expert procedures: conduct expert interviews with representatives of business, academia, or public sectors to collect tacit knowledge, 4) creative analysis: analyze the data collected in the previous phase to gain insights on main potentials and limitations concerning future projects and 5) interactive discussion: perform workshops that aim to discuss possible scenarios based on all previous stages and materials with the focus on market opportunities for innovative products. These steps create a preliminary version of the roadmap, which should be discussed with a broad range of stakeholders, such as leading experts, representatives of government agencies, and citizens.

Phaal, Simonse, and Den Ouden [PSD08] propose the so-called innovation process framework that consists of four stages. First, the stage "explore" aims to create as many relevant ideas as possible. Subsequently, the stage "create" identifies which ideas promise the most value to quickly filter out less exciting ideas and focus on the most potentially worthwhile ones. Then, in the stage "shape", the preparation of a clear business case takes place, which is used to decide whether to proceed. This includes exploring opportunities in relation to the business constraints and estimating resources required for the realization of the plan. Finally, the stage "implement" contains detailed planning and validation of the business case and the design of the market, financial, competence, and research and development plans. The authors point out that the structure of a roadmap provides a common language throughout the entire framework. In contrast, the content of the roadmap and the roadmapping process can vary widely between the stages "explore" and "implement".

4.2.6 Practical Experience and Lessons Learned

Suomalainen [Suo15] identified the current state of practice regarding continuous planning by conducting a multiple case study with three companies. First, the author identified that strategic, financial, business, and product planning was performed in all case companies. Regarding the planning of the product portfolio, the study shows that none of the case companies used the practice of continuous planning. Instead, the product roadmap was reviewed and updated monthly in one case company and annually in two case companies. For all case companies, management approval is required before the planning can be published. In addition, the planning horizon in all companies was three years plus the current year. Therefore, the authors point out that the planning practices of the three case companies can be considered more traditionally. Continuity in planning activities was only recognized when companies were forced to respond to certain activities, such as changes in the turbulent market environment. Moreover, internal changes such as adopting agile and lean development practices force all the case companies to shorten their product planning review cycles to months and shorten team-level planning to weeks or days.

Wilby [Wil09] reports on his practical experience regarding the adaption of the roadmap during the agile transformation of Borland Software Corporation. Wilby describes the following requirements of the roadmap: 1) the roadmap should be a living document designed to answer key strategic questions, 2) the roadmap should be reviewed and updated quarterly, 3) the roadmap should include a written distribution plan to keep all employees and stakeholders up to date, 4) the roadmap should provide the flexibility to maximize the advantages of agile development. To meet these requirements, Borland Software reviewed and changed the roadmap in a two-day workshop with key members of the department's product management, engineering, marketing, sales, and support. After introducing the "agile roadmap", the greatest perceived benefit was overcoming communication barriers between the different teams. Furthermore, the author firmly believes that introducing the "agile roadmaps" has positively affected the development and delivery of a better product-market fit.

Lehtola, Kauppinen, and Kujala [LKK05] describe lessons learned from a Finnish software product company that has developed and evaluated its roadmapping process in its organization. The authors point out that roadmapping may provide help in explicating the needed link between the business view and requirements engineering. The authors emphasize that the information documented in the roadmaps should be at an appropriate level of abstraction.

Furthermore, de Oliveira et al. [OFPG20] analyzed three roadmapping projects and identified the following learning points: 1) the conduction of individual interviews can be more efficient than workshops with large groups for gathering information regarding the development and updating of a roadmap, 2) some experts prefer to meet via online conference calls due to agenda issues, lack of initial interest, or unclear facts concerning the project, 3) splitting the roadmapping process into shorter and focused workshops can reduce uncertainties and ensure flexibility to cope with unexpected issues, 4) the project team receives insights while conducting and evaluating expert interviews that prepare them to facilitate workshops and ensure that the most critical issues are addressed, 5) the project team should apply an interview protocol and use strategic management tools in order to define the information that should be considered during the interviews, 6) the roadmap architecture is an ideal standard framework for conducting interviews and supports organizing and consolidating data into a preliminary roadmap.

Schimpf and Abele [SA19] have published a comprehensive study on roadmapping. The authors conducted an internet survey with practitioners from German companies, including a correlation analysis aiming to validate or reject several hypotheses. Regarding the content of the roadmaps, the study shows that most roadmaps cover products and technologies, but the contents of the roadmaps vary considerably. Besides this, the authors mention the following top three pitfalls regarding roadmapping: 1) mismatch between the level of detail or complexity of the roadmap and the level of detail required for the purpose of roadmapping, 2) lack of appropriate processes and methods, and 3) inappropriate use of software solutions.

In collaboration with practitioners, Uchihira [Uch07]) proposed the following principles for utilizing a roadmap: 1) consider the target markets and target audience when developing roadmaps, 2) change the roadmap in response to the changing situation in the market and technology, and 3) use an XML-based standardization of roadmap syntax and taxonomy roadmap exchange. However, the authors point out that this applies more to society's roadmaps than company roadmaps. Besides this, the authors recommend that the Plan-Do-See cycle should be applied to sustain a roadmap. The phase "Plan" means the roadmap owner constructs or updates the roadmap. In the phase "Do", the stakeholders conduct research and development activities using the created roadmap and inform the roadmap owners of the progress and results of the activities. Finally, in the phase "See", the roadmap owners list the roadmap items to be changed according to the information received from the "Do" phase.

4.2.7 Combination of Roadmapping with other Tools and Methods

Strauss and Radnor [SR04] combine scenario planning and roadmapping. This approach is designed to be used in unstable environments. The key goals of the approach include encouraging new and deeper dialogue among stakeholders within the organization and recognizing underlying issues and potentially limiting perspectives. The authors mention that how a company uses this approach would vary according to current practice, including the extent to which roadmaps already exist or are in the pipeline.

Tang, de Boer, and van Vliet [TBV11] consider the roadmapping process from a knowledge-sharing perspective in situations involving many stakeholders. The authors identify the effectiveness of exchanging timely knowledge of requirements, design, and impact analysis as a major problem. Moreover, the authors mention that much of this knowledge has been created but is not shared effectively. Consequently, the authors propose complementing the roadmapping process with a semantic wiki system. This approach includes an appropriate ontology to index roadmapping concepts in roadmap documents. As a result, the knowledge consumer can search the knowledge base directly or receive notifications when contents become available.

Güemes-Castorena and Toro [GT15] integrate the business model canvas and technology roadmapping in one single process, complementing each tool's strength and supplementing the weak points. A promising advantage of this integration might be that the technology roadmap gives future perspectives on the evolution or transformation of the business model. This enables the creation of a business model for both the current situation and the medium and long term. This intends to give companies hints about which elements of the business could change and contribute to mitigating business risks.

Passey, Goh, and Kil [PGK06] pointed out that companies are struggling to determine the scope and context of the product roadmap and provide flexibility for additional innovations, especially in the near future. To counter these problems, the authors propose to combine concept visioning and scenario building with roadmapping. The integration of these concepts enables to identify the context of the roadmap in a rapidly changing market environment and justifies resources for future product development. Besides this, the authors mentioned that for the success of product roadmapping, a facilitator role should be established to align the different parties to common goals and to achieve roadmap consensus.

Jantunen and Smolander [JS06] conducted theme-based interviews to gain insights and an understanding of the roles and their challenges regarding the roadmapping process. The authors defined the roles of contributor, controller, and distributer as distinctive for the roadmapping process. The contributor´s job is to bring valuable information into the roadmapping process, the controller ensures that roadmapping is done systematically, and the distributor takes the information in a roadmapping context and passes it to those roles who will need to act upon it. In the case of the contributor, the main challenge is to determine what type of information is of the greatest value in a roadmapping context. To this end, the authors concluded that future-oriented tacit knowledge of the market would be most valuable for the company. The challenge of controllers is to introduce systematic practices to the roadmapping context and provide transparency of the decisions made. One underlying cause for experienced problems appeared to be the inability to understand the values behind the expressed needs. In this context, the authors point out that the main cause for this challenge is the inability of a company to understand the value behind the expressed needs. Finally, the distributor faces the key challenge of understanding which roles depend most on roadmapping knowledge. The answer to this question helps the company decide who should take the distributor's role.

Ozaki, de Vasconcellos, and Bengtsson [OVB15] conducted a multiple case study to identify Brazilian companies' current state of product roadmapping. The study revealed that each company applies its roadmapping process, depending on its size and strategy. Nevertheless, the authors highlight some common steps within the companies involved in this study, which are: 1) planning, 2) analysis, 3) effort estimation, 4) prioritization,and 5) formalization and development. Moreover, the studied companies do not establish roadmaps for the long term, i.e., they do not plan future versions beyond the immediate next version. All three companies perceived that the speed with which they evolve their product planning is a critical competitive advantage. Thus, the authors conclude that the participating companies practice an agile way of developing the roadmap. Besides this, Ozaki, de Vasconcellos, and Bengtsson [OVB15] list the main aspects for the implementation of an agile roadmapping process as follows: 1) Institutionalized cycle (roadmapping is not considered as one short project, but is carried out continuously), 2) continuous technological monitoring, 3) roadmap focus on the short term, 4) strong interaction between the business and development areas. Table 4.1 presents the selected studies based on their categories. It should be noted that this table contain both, the Chapter 3 as well as the Chapter 4.

Table 4.1: Identified papers according to their categories

Author	Roadmapping Process	Roadmapping Types	Roadmapping Challenges	Roadmap Visualization	Roadmapping Frameworks	Practical Experience and Lessons Learned	Combination of Roadmapping with other Tools	Maturity Models
Al-Ali and Phaal [AP19]							X	
Arman and Kharrat [AK16]	X							
Beeton, Phaal, and Probert [BPP13]	X							
Cheng et al. [CCFT14]					X			
Cho and Lee [CL11]		X						
Cosner et al. [CHF+07]	X	X						
de Oliveira et al. [OFPG20]						X		
de Souza et al. [SSF+20]	X							
Dissel et al. [DPFP06]					X			
Fenwick, Daim, and Gerdsri [FDG09]	X							
Fleury et al. [FHSP06]	X							
Freitas et al. [FOB+20]	X							
Gerdsri et al. [GM21]					X			
Gerdsri et al. [GPVT19]					X			
Gerdsri and Vatananan [GVD09]	X							
Geum and Park [GP10]		X						
Geum et al. [GLKP11]					X			
Güemes-Castorena and Toro [GT15]							X	

Author	Roadmapping Process	Roadmapping Types	Roadmapping Challenges	Roadmap Visualization	Roadmapping Frameworks	Practical Experience and Lessons Learned	Combination of Roadmapping with other Tools	Maturity Models
Hirose et al. [HPF+20]								X
Ho and O'Sullivan [HO20]			X					
Ho and O'Sullivan [HO17]	X							
Jantunen and Smolander [JS06]							X	
Kameoka et al. [KNFK06]		X						
Kerr and Phaal [KP15]				X				
Kerr and Phaal [KP19]					X			
Kim et al. [KYA+15]			X					
Kim et al. [KBA18]	X							
Kim et al. [KSB+20]		X						
Kittlaus [Kit]					X			
Komssi et al. [KKT+11]			X					
Lee et al. [LJLS21]	X							
Lehtola et al. [LKK05]						X		
Lombardo et al. [LMRC17]								X
Maglyas et al. [MNS11]			X					
Ozaki et al. [OVB15]							X	
Passey, Goh, and Kil [PGK06]							X	
Phaal and Muller [PM09]		X						
Phaal, Farrukh, and Probert [PFP04]		X						

Author	Roadmapping Process	Roadmapping Types	Roadmapping Challenges	Roadmap Visualization	Roadmapping Frameworks	Practical Experience and Lessons Learned	Combination of Roadmapping with other Tools	Maturity Models
Phaal, Farrukh, and Probert [PFP05]		X						
Phaal et al. [PSD08]					X			
Pora et al. [PTGT18]			X					
Schaller et al. [SVS18]	X							
Schimpf and Abele [SA19]						X		
Strauss and Radnor [SR04]							X	
Suomalainen [Suo15]						X		
Suomalainen et al. [SSAS11]	X							
Tang et al. [TBV11]							X	
Uchihira [Uch07]						X		
Vishnevskiy et al. [VKM16]					X			
Vähäniitty and Rautiainen [VR08]					X			
Vähäniittyet et al. [VLR02]	X							
Vähäniittyet et al. [VLRP09]				X				
Wilby [Wil09]						X		

4.3 Threats to Validity

The first threat to validity is the database used in this review. In some cases, we received high numbers of hits per search term. We defined a stopping condition of 150 papers to make the search manageable. Therefore, the paper that passed our selection process depends on the algorithms implemented in the databases, which return the papers according to their relevance. Since we did not influence the quality of these algorithms, it cannot be excluded that relevant papers were not considered. We applied our stopping condition to mitigate this threat only when no new knowledge was obtained. Second, the search string represents another threat. This means that it is conceivable that authors have used keywords that our search string does not include. To counter this threat, we created a list of keywords with three practitioners and one researcher and iteratively adjusted this list in an initial search. In addition, we included snowballing in our search process to increase the number of relevant papers. Third, we narrowed the search by starting in 2000. This restriction may affect the completeness of our review as papers published before 2000 were not included in our review. However, our initial search revealed that only a few papers regarding product roadmapping were published before 2000 and that none of these papers deal with product roadmapping in a dynamic and uncertain market environment.

4.4 Discussion

This systematic literature review identified 53 papers that have a close relation to the issue of product roadmapping. Overall, the analysis of the identified papers showed that product roadmapping is anchored in the scientific literature but discussed only on an abstract level. For example, papers dealing with product roadmapping processes provide only rough guidance than detailed insights into what a roadmapping process looks like and what methods should be performed at each step of that process. Furthermore, the analysis showed that the approaches identified in this literature review mainly focus on a traditional understanding of roadmapping with many upfront design decisions and detailed estimations over a long-time horizon. They mainly stem from the traditional product management domain with predictable planning (such as production planning) or focus on complementary or secondary elements of product roadmaps (such as technology roadmaps or platform considerations). Few authors (e.g., Suomalainen et al. [SSAS11] or Komssi et al. [KKT+11]) point out that such an approach is unsuitable for developing digital products or services as the high market dynamic with the associated uncertainties makes reliable predictions almost impossible over a long-time horizon. Therefore, product roadmaps for a dynamic market environment must be understood as flexible changing artifacts that can be adapted over time based on learning. They can be seen as prototypes of strategies that embrace learning and evolution and aim to align development activities and organizations around clear goals (or outcomes) and priorities. The alignment of roadmaps with the strategic goals of a company is only partly covered in the scientific literature. For example, the proposed approach by Vähäniitty, Lassenius, and Rautiainen [VLR02] contains the integration of the vision and strategic goals in the roadmapping process. Also, Fleury et al. [FHSP06] deal with aligning strategic objectives and software development. Although the alignment problem is partially covered, the identified papers do not provide sufficient detail on defining outcomes (or objectives, key results, themes, and subthemes) and integrating them into roadmaps. Furthermore, several studies (e.g., Komssi et al. [KKT+11], Kim, Yao, Agogino, et al. [KYA+15], or Maglyas, Nikula, and Smolander [MNS11]) have point out the challenge of integrating the views and opinions of customers or users into the roadmapping process. This challenge is partially and only superficially addressed in the identified papers. Examples are the value roadmap approach presented by Dissel et al. [DPFP06] or the value-driven technology process according to Fenwick, Daim, and Gerdsri [FDG09]. However, none of the identified papers addressed the relationship of product discovery activities with the roadmapping process. The conduction of product discovery can be seen as an essential activity as it helps to ensure that products or services are developed that contribute to the solution of current customer problems and thus mitigate product risks. If customers are not included in the roadmapping process, the risk is that products, features, or services are developed that the customers do not want or need. Consequently, conducting product discovery activities and their integration in the roadmapping and software development and delivery process presents a relevant research gap.

4.5 Conclusion

We conducted a systematic literature review and identified how many papers address product roadmapping. Altogether, 53 scientific papers could be identified that we clustered in the following categories 1) roadmap types, 2) processes for creating and updating roadmaps, 3) problems and challenges with roadmapping, 4) approaches to visualize roadmaps, 5) generic frameworks, 6) practical experience, 7) the combination of roadmaps with other tools and 8) roadmapping maturity models. In addition, significant research gaps could be identified, and interesting avenues for future research are ahead. The results show that most papers in the scientific literature discuss product roadmapping on a quite abstract level and do not give insights into the demands of digitalization. This is consistent with the outline of related work (see Chapter 3), indicating little research on product roadmapping in the scientific literature. In particular, there is insufficient knowledge available in the scientific literature on how to address challenges with traditional product roadmapping approaches and how to create and maintain product roadmaps under highly dynamic conditions. This means the development of digital products or services is typically done in highly dynamic environments with many uncertainties. Similarly, the chapter of related work shows that there are no approaches emerging in the scientific literature to transform traditional product roadmap approaches to a dynamic and uncertain market environment. Therefore, the requirements of developing product roadmaps in a dynamic and uncertain market environment must be investigated to provide insights on how to develop flexible roadmaps that focus on delivering value to the customers and the business. This also includes the transformation of traditional roadmapping approaches towards a product-led organization with an outcome-oriented roadmapping, i.e., roadmapping that considers the value that should be delivered to the customer and the business. Considering these results, it can be said that the development of artifacts for the field of product roadmapping is highly relevant for research. However, at this stage, we cannot make any empirical statement about whether the topic of product roadmapping is a relevant problem for practitioners. In order to answer this question, further research is necessary. Therefore, the next chapter focuses on identifying the state of the practice.

Chapter 5
State of Practice

Complementing the state of the art, it is also essential to gain a deep understanding of the current procedure of product roadmapping in practice and the problems practitioners face. This is important to ensure that this thesis develops artifacts that solve relevant practitioner problems. Therefore, the following chapter describes the studies we have conducted to identify the state of practice as well as the associated challenges and success factors. The empirical investigation of existing challenges and success factors in the application of product roadmapping leads to gaining a better understanding of what kind of artifact with what contents should be developed for a potential solution approach. Overall, we conducted three expert interview studies, one web survey, and an analysis of the grey literature. This chapter is part of the phase "identify problems and motivate" in the design science process (see Figure 1.1). Overall, this chapter extends the following publications:

- J. Münch, S. Trieflinger, and D. Lang. 'Why feature-based roadmaps fail in rapidly changing markets: a qualitative survey'. In: *Software-intensive business: start-ups, ecosystems and platforms: proceedings of the International Workshop on Software-intensive Business: Start-ups,* *Ecosystems and Platforms (SiBW 2018): Espoo, Finland, December 3, 2018.-(CEUR workshop proceedings; 2305)*. RWTH Aachen. 2018, pp. 202–218

- J. Münch, S. Trieflinger, and D. Lang. 'What's hot in product roadmapping? Key practices and success factors'. In: *Product-Focused Software Process Improvement: 20th International Conference, PROFES 2019, Barcelona, Spain, November 27–29, 2019, Proceedings 20*. Springer. 2019, pp. 401–416
- S. Trieflinger et al. 'Facing the challenges with product roadmaps in uncertain markets: experience from industry'. In: *2020 IEEE International Conference on Engineering, Technology and Innovation (ICE/ITMC)*. IEEE. 2020, pp. 1–8
- Y. Voigt, S. Trieflinger, and J. Münch. 'Product roadmaps in the new mobility domain: state of the practice and industrial experiences'. In: *2021 IEEE International Conference on Engineering, Technology and Innovation (ICE/ITMC)*. IEEE. 2021, pp. 1–9
- S. Trieflinger et al. 'Why Traditional Product Roadmaps Fail in Dynamic Markets: Global Insights'. In: *Product-Focused Software Process Improvement: 23rd International Conference, PROFES 2022, Jyväskylä, Finland, November 21–23, 2022, Proceedings*. Springer. 2022, pp. 382–389

Considering these studies mentioned above in more detail, the first expert interview study [MTL18] served in particular to evaluate our developed interview guide, but also to gain initial insights into how product roadmapping is applied in practice. This study involved 4 participants from one case company. To gain more comprehensive insights, we conducted another expert interview study [MTL19d] with 15 participants from 13 German companies. This study aims to gain first insights into which approaches, procedures, and methods software-intensive companies apply to create and update roadmaps and which challenges and success factors are associated with this. To deepen this knowledge, especially about existing challenges, we extended our interview guide to include more purposeful questions about current challenges and additionally interviewed 18 experts from 13 different companies [TMKL20]. To increase the external validity of our findings, we conducted a final expert interview study [VTM21] with 8 participants from 7 companies operating in the New Mobility Industry. New Mobility is a young market that encompasses the development of digital and novel business models for the fields of Connected Cars, Shared Mobility, and Electrification. This topic entails exceptionally high market dynamics with associated uncertainties. Therefore, this study primarily provides us with insights that confirm our previous findings. To extend the insights gained from the expert interviews, we conducted a web survey with 66 participants. This survey aims to gather further insights into existing approaches, procedures, and methods in practice. In addition, we included questions about what measures participating companies have taken to transform their product roadmapping practice to a dynamic and uncertain market environment and what challenges they face in implementing these measures. In addition to the expert interviews and web survey, we conducted an analysis of the grey literature [TMPL22a]. The intention of this measure was to expand our previous research, especially in an international context. This means that our previous findings are obtained from German companies. Thus, there is no evidence as to whether they are valid outside Germany. This applies in particular to our identified challenges, as these serve as the basis for the development of the artifacts presented in this thesis. Our entire procedure to determine the state of practice is shown in Figure 5.1. In this context, it should be noted that the initial expert interview study is excluded since it serves primarily for the evaluation of the interview guide used in the subsequent expert interviews.

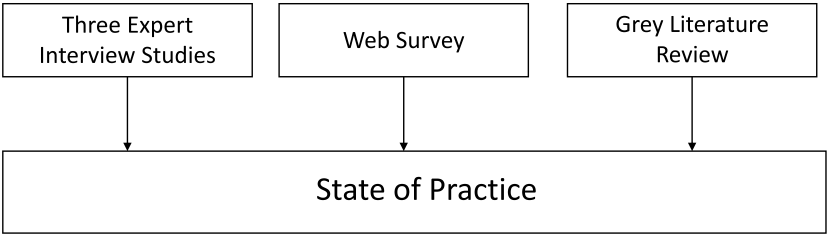

Figure 5.1: Procedure for identifying the current state of practice

5.1 Expert Interview Studies

The analysis of the current state of research has revealed that only a few studies address the current procedure of the practice regarding product roadmapping. In more detail, none of the identified papers provide detailed insights into how German companies apply product roadmapping and what problems they face. Therefore, we conducted three expert interview studies [MTL19d; TMKL20; VTM21] to gain qualitative insights into this issue. In addition, the studies aim to identify what factors are essential for a successful product roadmapping from a practical perspective. To achieve our objectives, we define the following research questions:

- **RQ1:** What approaches, procedures, and methods for creating and operating a product roadmap are currently applied in German companies developing software-intensive products in dynamic and uncertain market environments?
- **RQ2:** What challenges are associated with product roadmapping in the case companies?
- **RQ3:** What are the success factors of product roadmapping in the case companies?

5.1.1 Research Design

In order to achieve our objective, a qualitative study design was chosen as the studies aim at identifying new insights. In more detail, the experience, opinions, and views of experts, which interact in the context of product roadmapping, needed to be obtained. Moreover, Fink [Fin03] identified the following opportunities where a qualitative survey method is preferable to a quantitative method: 1) the study focuses on investigating the knowledge and opinions of experts in a particular field, 2) the study intends to collect information through interviews with own words rather than with using predefined choices, 3) there is not enough prior information of the study subject to enable either the use of standardized measures of the construction or a formal questionnaire, 4) the sample size is limited due to access or resource constraints. All aspects are relevant to our research, therefore, we decided to conduct a qualitative study before a quantitative study. Moreover, semi-structured expert interviews allow interviewees to share their own opinion using free speech, but at the same time, provide a similar structure for all interviews, making results comparable and patterns visible [BB15]. We developed an interview guide to focus and structure the interviews and ensure thematic comparability. In line with our research questions, this interview guide focuses on identifying the product roadmapping practice currently in use and the associated challenges and success factors. The interview guides were sent to the interviewees in advance for preparation purposes. An evaluation of the interview guide was conducted with four experts with different roles around product roadmapping (e.g., product managers, product owners, etc.) at the Robert Bosch Smart Home GmbH [MTL18].

Overall, we were able to recruit 41 experts from 33 various companies. All companies participating in our study develop and deliver software-intensive products, thus operating in a dynamic and uncertain market environment. We selected the interviewees based on their experience regarding product roadmapping. The search for suitable participants and the subsequent establishment of contact was conducted via the social business platforms Xing and LinkedIn to find appropriate business contacts. We conducted preliminary discussions with each potential participant to ensure that the selected interviewees were suitable for our research.

Table 5.1 gives an overview of the participants who voluntarily participated in this research. The column “Experience” refers to the years in which the expert was involved in roadmapping activities. 33 interviews took place from February to November 2019, and 8 interviews were conducted from July to August 2020. 10 interviews were conducted face-to-face in the office of the case company, while 31 interviews were conducted online or via phone. The audio of the conversations was recorded for accurate data analysis. We analyzed the data by creating transcriptions word by word, highlighting main responses, and interpreting and extracting keywords and key quotes. As mentioned above, Table 5.1 shows the interviewees in terms of identifying the state of practice regarding product roadmapping.

Table 5.1: Participating interviewees (current state of practice) (size classification: small <50, large >250)

Interviewee	Position	Experience	Company Size
Interviewee 1	Product Manager	4 years	Small
Interviewee 2	Product Manger	9 years	Medium
Interviewee 3	Innovation Manager	3 years	Large
Interviewee 4	Product Manager	10 years	Large
Interviewee 5	Product Manager	2 years	Medium
Interviewee 6	Product Manager	7,5 years	Medium
Interviewee 7	Product Manager	7 years	Medium
Interviewee 8	Head of Product Mgmt.	6 years	Large
Interviewee 9	Head of Product Mgmt.	8 years	Medium
Interviewee 10	Head of Product Mgmt.	17 years	Medium
Interviewee 11	Head of Product Mgmt.	7 years	Medium
Interviewee 12	Head of Product Mgmt.	5 years	Small
Interviewee 13	Head of Product Mgmt.	11 years	Medium
Interviewee 14	Head of Product Mgmt.	6 years	Medium
Interviewee 15	Head of Product Mgmt.	8 years	Medium
Interviewee 16	Chief Product Owner	20 years	Small
Interviewee 17	Head of Product Mgmt.	5,5 years	Medium
Interviewee 18	Head of Product Mgmt.	20 years	Large
Interviewee 19	IT Portfolio Manager	2,5 years	Small
Interviewee 20	Head of Product Mgmt.	7 years	Medium
Interviewee 21	Product Manager	5 years	Medium
Interviewee 22	Head of Product Mgmt.	12 years	Small
Interviewee 23	Chief Product Owner	15 years	Medium
Interviewee 24	Product Manager	7 years	Medium
Interviewee 25	Product Manager	4 years	Medium
Interviewee 26	Product Manager	0,5 years	Large
Interviewee 27	Platform Integration Manager	15 years	Small
Interviewee 28	Head of Product Mgmt.	3 years	Large
Interviewee 29	Product Manager	3 years	Large
Interviewee 30	Product Manager	2 years	Small
Interviewee 31	Head of Product Mgmt.	12 years	Large
Interviewee 32	Product Manager	4 years	Large

Interviewee	Position	Experience	Company Size
Interviewee 33	Freelancer	8 years	Large
Interviewee 34	Head of Product Mgmt.	11 years	Large
Interviewee 35	Manager B2B Systems	18 years	Medium
Interviewee 36	Product Manager	5 years	Large
Interviewee 37	Director Product Development	12 years	Large
Interviewee 38	Head of Product Mgmt.	6 years	Large
Interviewee 39	Product Manager	8 years	Small
Interviewee 40	Customer Experience Manager	1 year	Large
Interviewee 41	Product Manager	3 years	Medium

5.1.2 Results

5.1.2.1 Current state of product roadmapping

To answer RQ1, we analyzed the information from the transcripts and figured out that despite many common practices, companies have a quite individual approach to product roadmapping. Within the coding process, we have created nine clusters based on similar statements of the interviewees. In the following results regarding the current applied product roadmapping practices of the participating companies are described along these clusters. It should be noted that the findings presented below are from the paper "What´s hot in product roadmapping - Key practices and success factors" [MTL19d]. Therefore, only 13 companies are mentioned in 5.1.2.1. The presented challenges (see 5.1.2.2) and success factors (see 5.1.2.3) stem from all 33 companies.

Roadmap Items: First of all, we analyzed which items (i.e., which kind of information artifacts) have been found on the product roadmaps. Typical examples of roadmap items are outputs (i.e., products, features, deliverables), goals/outcomes, topics (i.e., generic subject), or themes (i.e., high-level user or system needs). The study shows that seven out of 13 companies use products or features without goals. The roadmap of two companies includes goals such as “increase the number of paid users of our digital service” or “increase the value of in-app purchases by 15 percent". Two companies' roadmaps contain topics such as “development of a solution in the area of smart home". Two companies use themes such as "feeling safe at home" or "check your home, wherever you are" as roadmap items. Only a few companies actively use goals or outcomes in the roadmap. For instance, one head of product management stated that their *"roadmap includes goals because the management or the customer considers a feature as a commitment. However, the roadmap is a living document that can frequently change at any time."* (Head of Product Management) Another product manager mentioned that outcomes are more suitable as a basis for creating product roadmaps: *"When we talk about goals or visions, we don´t want to mix them up with solutions. That means that we [...] aim at delivering value for the business and the customers. Therefore, we emphasize outcomes over outputs on our roadmap."* (Product Manager)

Adequacy of item detailing based on the timeline: The adequacy of the item detailing answers the question of how detailed the items are planned with respect to short-, mid-, and long-term timeframes. This dimension is essential because, in dynamic environments with high uncertainty, it often does not make sense to have a fine-grained planning of all the details in the long-term timeframe. The analysis of the interviews shows that companies whose roadmap contains only features or products without goals or outcomes typically use detailed planning over a long-time horizon. This means that all features and all respective tasks for developing those features are planned and worked out in detail for the short-, mid-, and long-term. Companies that use goals as part of their roadmap have different levels of planning detail for different timeframes. This means that the planning of items is more detailed the closer they are in time. One participant said: *"I would never plan the roadmap in detail for one year. In this case, the high level of market dynamic would lead to much effort to adjust the roadmap. My planning is only for short-term items in detail, the mid- and long-term consist only of topics or ideas. In general, only as detailed as necessary."* (Head of Product Management) This indicates that roadmaps are likely to fail when their level of detailing is not adequate. Another participant mentioned that *"due to the dynamic and uncertain market environment, detailed planned roadmaps over a long time-horizon make no sense as the predicted planning will not be* *achieved. Therefore, our roadmap contains detailed planning for the short-term, the mid-term includes so-called candidate features, which are under evaluation, and the long-term roadmap involves only ideas or high-level topics."* (Product Manager)

Reliability: Reliability can be seen as the trustworthiness of a roadmap and its ability to provide direction for an organization and its teams. This very much depends on the amount and frequency of changes and the way how changes are done. Five companies reported that their roadmaps are subject to frequent ad hoc adjustments. Within two companies, the adjustments of the product roadmap are done in regular review cycles: *"The roadmap is usually changed after our quarterly planning meetings, in which we analyze the current market situation."* (Product Manager) Six companies change their roadmap through systematic change management, and adjustments are done reactively: *"A typical situation for an adjustment is that we must react to a market launch of an innovative product of a competitor. In such a case, the product owner proposes how the change should be conducted and coordinates this change with the management."* (Product Manager) The analysis shows that frequent ad hoc changes of the roadmap occur in such companies where products are planned in detail over a long-time horizon. This problem decreases the acceptance of a roadmap, and it is likely that *"each product owner has, in addition to the official roadmap, a separate backlog. This is sorted by priority, relevance, return on invest, outcome, and so on."* (Product Manager) The analysis shows that roadmaps containing goals, topics, or outcomes are more likely to be subject to systematic adjustments and less subject to ad hoc changes. These systematic adjustments increase the reliability of roadmaps, which can be seen as a prerequisite for their successful usage.

Confidence: Confidence describes the ability of a feature in the roadmap with regard to the fulfillment of the expected goals/outcomes at an acceptable cost. In consequence, confidence should significantly affect the probability that a feature is decided to be implemented. One participant mentioned that *"product management has the task to ensure that every product contributes to our goals and vision."* (Product Manager) Another participant said: *"Before we include a product in the roadmap, we have a strategic meeting* *which includes the validation of the contribution a product delivers to achieve our goals."* (Product Manager). 12 out of 13 companies consider the impacts of roadmap items on goals. This is done mainly based on assumptions and estimates and rarely on empirical facts. One participant mentioned that they try to evaluate the cost and impact of features through expert interviews. He mentioned that *"regarding features where* [they] *are not sure about the costs and value creation for customers,* [they] *conduct interviews with experts."* (Product Manager) One company uses advanced product discovery methods to validate the impacts of products or features upfront. This increases the confidence that the product or feature will have the expected effect after implementation and delivery.

Product Discovery: The dimension of product discovery describes the ability of a company to identify and validate items on the roadmap before implementation. In six companies, no product discovery is conducted at all. Four companies assess features based on expert knowledge without further validation. A participant said: *"I think product discovery is not relevant for a service platform. In our processes, the product manager determines which product will be put onto the roadmap".* (Head of Product Management) Another interviewee mentioned: *"We don´t talk with the customer, but the product managers estimate whether the product will be successful in the market. Very often, I hear: 'The product is innovative; I think the customer will buy it."* (Head of Product Management) Two companies decide about product roadmap items based on customer requests. One interviewee explained: *"We have the service or sales team, which the customers can contact in the case of questions, problems, and wishes. I interview these people in regular time intervals to identify the wishes of our customers."* (Head of Product Management) Seven companies are conducting some kind of discovery activities by involving the customer more actively. One participant, for instance, mentioned: *"We organize workshops in which we invite a selection of users to participate. The purpose of such workshops is to identify what pain points the customers have, how they are solving their problems today, and what kind of solution we must provide that leads to a change of customer behavior."* (Head of Product Management) Another participant explained: *"We invite* *potential customers to visit us and test our prototypes for new product ideas. While testing, we observe the customers and conduct an interview with each person after the observation. The result of the observation and the feedback is used to improve our prototypes."* (Product Manager)

Prioritization: This dimension addresses how roadmap items are prioritized and which factors are considered. Nine companies prioritize the roadmap items mainly based on expert opinions. One company conducts the prioritization of the roadmap items based on the capability to deliver: *"I prioritize the features mainly according to "quick wins", as they can be quickly implemented and deliver value to our business quickly. Furthermore, I discuss the prioritization with the engineering and adjust it if necessary."* (Head of Product Management) Three companies conduct the prioritization based on a process focused on delivering value to the customer and the business. One approach is *"[. . .] to answer the question of which items deliver the most value to the company? Therefore, a team consisting of me, the product manager, the product owner, and the head of engineering conducts the evaluation process. We chose these different participants as they considered the items from different views. In more detail, the product manager is responsible for all products and evaluates that all products contribute to achieving our goals, the product owner manages the requirements to build each product, and the head of engineering is responsible for the technical implementation of the products. Within the evaluation, we score each item with points from one to four according to the following criteria: 'development effort', 'costs', 'value for the customer', 'feasibility', 'market relevance', and 'strategic alignment'. After the evaluation, the total score of each item is calculated and compared with the other items. The higher the total number of points, the higher is the value of the item in the context of the company's vision and thus also the prioritization within the roadmap."* (Product Manager) Another participant reported their approach: "*We developed a metric using the following criteria: customer and market value and positioning in relation to our competition and profitability. On the basis of these criteria, we calculate the value of each item, and this determines the prioritization."* (Product Manager) Estimation procedures are often applied. In the words of one participant: *"To conduct the prioritization, we estimate* *the following criteria: What is the business value of the outcome? How high is the effort, and which uncertainty factors exist? We put these three criteria into relation and prioritize the items accordingly."* (Head of Product Management) The analysis of the interviews showed that prioritization procedures foster the creation of customer value and an optimized resource allocation. However, prioritization is usually based on subjective estimations or expert opinions, not empirical facts.

Extent of alignment: This dimension specifies the width and depth of alignment of the roadmap, i.e., how good the stakeholder coverage is, how deep they are involved, and how well they understand their respective roles. When talking about alignment, most of the analyzed companies understand the benefits of stakeholder alignment and refer to the number of roadmaps they are using. Nine companies are using several roadmaps covering different views, e.g., engineering or sales. One participant reported: *"Each department that delivers services to the customer has its own product roadmap, and there is another roadmap for the management that contains all products."* (Product Manager) Four companies are using only one roadmap that is used as an orientation for all departments and teams, and one of them has *"a central roadmap that everybody knows". Based on this roadmap, every department is aligning its tasks and measures."* (Head of Product Management)

Ownership and responsibility: Ownership refers to the question, who owns the roadmap and is accountable, i.e., signs off and approves the roadmap? Responsibility means who is responsible for the definition of the roadmap and conducting the product roadmapping process? This dimension can influence the success of the whole roadmapping process. One interviewee mentioned: *„After the development of the roadmap [...] usually the head of product management presents the roadmap to the management and based on the opinion of the management adjustments take place. After the management has approved the roadmap, it will be communicated across the company and to customers or stakeholders."* (Product Manager) Overall, each company participating in the study applies the approach that the management approves the roadmap and releases the budget for further activities regarding the roadmap items. Product management also creates, maintains, and manages the product roadmap in each company.

5.1.2.2 Challenges regarding product roadmapping

As mentioned, the challenges and success factors presented below are from three expert interview studies [MTL19d; TMKL20; VTM21]. This includes 41 experts from 33 various companies.

The uncertain and dynamic market environment poses different challenges: *"Currently, we have to deal with many uncertainties and permanent changes of requirements."* (Product Manager) Furthermore, internal processes and stakeholders lead to unforeseen changes in the roadmap: *"Due to the rapid changes of the market, it happens that a department has the feeling that it is no longer valuable for the company. Therefore, it wants to show that it is still important. And suddenly, a new product pops up with the demand to introduce it into the market. Usually, this leads to a shifting of capacity and the circumstances that other planned and approved products are not delivered on time.*" (Head of Product Management) Rapid market changes require the ability to face and manage uncertainties. However, many companies lack a process that is able to cope with uncertainty: *"Our current process is designed for the entry and change of requirements once or twice a year, and this is not often enough."* (Product Manager)

The roadmap of seven companies covers a long-time horizon. Thus *"[...] one challenge is to provide a reliable roadmap over a long time period [although] there are a lot of uncertain variables [...]. As a result, we have to update our roadmap frequently."* (Product Manager) This decreases the reliability of the roadmap, and employees consider the roadmap not as a trusted planning tool. Moreover, replanning consumes much capacity of the participating employees, which could be used more efficiently. In a nutshell: *"As soon as a roadmap is planned in detail and long-term, it becomes difficult. For example, you learn a lot about the customer and their needs during development. This means shifting the requirements and deadlines, which leads to a constant adjustment of the roadmap."* (Product Manager)

The behaviors of management, marketing, and sales also provide several challenges. *"One challenge is the members of the management of the various business areas who know exactly which feature the customer needs."* (Head of Product Management) Typically, the management defines concrete features based on its own opinion without validation. Moreover, management is often only willing to provide a budget for products and features that they have proposed. This often leads to the development of products and features that are not or rarely used. In addition, management and sales often see the roadmap as an obligation that all products or features are available at the specified release dates, e.g., for a market launch. *"The management or the sales department thinks that the data in the roadmap is always correct and never changing. However, the roadmap is a living document that frequently changes during a month. The problem is when they communicate specific dates to the customer. This leads to long discussions and disappointments [. . .].*" (Head of Product Management) Moreover, predicting the expected market launches of a product is also considered a challenge. *"The management or the stakeholders expect exact information to which point a product is ready for market launch. However, predictions over a long time period are very difficult to make, and in most cases, this information is wrong [. . .].*" (Product Manager) This leads to circumstances where the roadmap contains incorrect but binding information. Typical consequences are missing deadlines, budget overruns, poor quality, or decreasing team motivation, leading to disappointed customers and stakeholders. The pressure to still fulfill the roadmap promises keeps the team from doing the right things. Adding to that, another interviewee mentioned: *"Often management has a precise idea of how a roadmap must look like. I have observed that product managers know that the current product roadmapping process doesn´t work, but they are afraid to try out new methods."* (Product Manager) This triggers frustration and leads to a culture in which employees try to avoid mistakes. However, the interviews have shown that this case also occurs vice versa. *"Our culture is very experimental, and we always try to introduce new methods. This is often difficult for employees. Because they are habitual to use a standard procedure."* (Product Manager)

The interviews also revealed conflicts between business and engineering.

One participant mentioned, for instance, that *"engineering has no understanding for the achievement of short-term business goals such as a quick and small product launch to enter quickly into a market. The reason is that they would like to deliver a completely functional product. On the other hand, the sales department has no understanding of technological limitations. They have their requirements and expect that the engineering department integrates these requirements without any delay. This leads again and again to conflicts."* (Head of Product Management) However, for sales and marketing, the reliability of the roadmap is an essential topic in planning activities such as campaigns. *"If sales or marketing people look into the roadmap, the data it contains must be reliable, especially the information to which point in time a product, feature or service will be available."* (Product Manager)

Another challenge is identifying and applying a method for prioritizing the items in the roadmap. *"We have developed a metric with different factors to determine the prioritization for each product. Sometimes I get results and think: That can't be correct. In my opinion, the other product is more important to reach our goals. Thus, the use of mathematical methods concerning roadmapping is very limited."* (Head of Product Management) Besides that, obtaining the information for the prioritization process is also challenging. *"To prioritize the requirements, I am missing important information such as: By how much would the product increase our margin or which time is estimated to finish the product development? Such input is often missing, and this makes it very difficult to prioritize all the requirements."* (Product Manager)

Several challenges occur in the case of systems (such as an IoT system consisting of several hardware components, sensors, and an app). *"A challenge is to identify the dependencies of the products (which components are required at which point of time) in an early phase and to document them in the roadmap. Furthermore, the different components are delivered by different teams. For this reason, it is difficult to obtain the current state of the implementation from each team to react to delays in an early stage."* (Product Manager) This might, for instance, increase the risk of a delayed market launch. A related challenge is to align the development of different products that belong together: *"Our organization is focused on the development of individual products, not systems.*

This means each department has its own roadmap. To deliver all required products at the same time, the challenge is to merge the different information in one central roadmap." (Product Manager) Another challenge is to motivate all relevant stakeholders to be an active part of the development of the product roadmap. It is challenging to integrate the relevant stakeholder and employees in a way that they are aligned with the roadmap and collaborate.

The key challenges of our study are listed in the following:

- Technologies and markets change rapidly.
- Feature-driven-roadmaps need to be changed frequently.
- Frequent changes consume much capacity, and employees lose trust in the roadmap.
- The internal processes are not suitable for handling frequent changes of the roadmap.
- The need for differentiation with respect to short-, mid-, and long-term timeframes is made.
- The roadmap contains unrealistic and incorrect information.
- Marketing and sales ask for accurate long-term predictions for release dates to plan their activities (such as campaigns and industry events).
- Output-focused salary and incentive systems.
- The roadmap owner prescribes roadmap features and overrules product management.
- Relevant information for prioritizing the roadmap is missing.
- Product discovery requires capacity.
- It is difficult to motivate stakeholders to actively participate in the roadmapping process.
- Management assesses its employees by how well they implement a feature-based roadmap regarding time and scope.
- The employees do not trust in the roadmap, i.e., the roadmap is not reliable.

5.1.2.3 Sucess factors of product roadmapping

Several participants mentioned that it is crucial to customize new roadmapping practices to their specific context (including higher-level processes, development environment, organizational structures, and roles). Using off-the-shelf approaches without tailoring them to the company context is not an appropriate way to successfully establish roadmapping practices. One participant mentioned that *"[...] there is no standard process for roadmapping. It is important to test, evaluate and adapt the product roadmapping process [..]."* (Head of Product Management) Several participants also highlighted that the process of adapting a new roadmapping approach is an incremental process that might take a longer time period and cannot be done in one go.

Another critical success factor that several participants mentioned is that a roadmap should look different for different timeframes. Different timeframes in the roadmap should have different planning levels (e.g., more detailed planning for the short term) and different types of items (e.g., planning of themes instead of features for the long term). A participant said that *"in a dynamic and uncertain market environment, creating a detailed roadmap for one year makes no sense. In my opinion, the suitable period of time for a roadmap depends on the market in which a company operates. The quality of the information provided is very important to determine the different roadmap items."* (Product Manager) These aspects significantly affect the necessity for frequent changes of the roadmap and thereby influence the reliability of the roadmap. Only if the time horizon, the level of detail, and the item type are adequate for the timeframe the need for changes is low, and they can be managed systematically. This allows managers and employees to feel comfortable working with the roadmap, and they can rely on it as an instrument providing orientation and guidance.

Another major success factor mentioned is that clear strategic objectives should be specified and communicated. A participant mentioned that *"each product to be developed should contribute to achieving our goals and vision. If this is not the case, ambiguities and misunderstandings always lead to frequent roadmap adjustments."* (Product Manager) In this context, it is essential to define a clear and understandable vision and communicate it across the company. Furthermore, the business and customer objectives should be derived from this vision. The contribution of roadmap items to these objectives should be clearly expressed and evaluated. It should be clear which value each feature on the roadmap delivers to contribute to achieving the company's goals. A clear vision and goals contributing to that vision also help prioritize items on the roadmap.

Several participants mentioned that it is important for the success of a roadmap that roadmap items are validated with respect to their underlying assumptions (such as "is there a customer need for that feature?", "is the problem to be solved important?", "are there enough customers that have this problem?", "is it feasible to implement the feature?", "does the feature have the expected outcome?") before implementation. This should be done on a continuous basis. A participant mentioned the following: *"In the past, we saw again and again that we developed a product that had little demand from the market. Therefore, we need a process that identifies the problems and needs of the customer. It is not enough to talk with the key account manager about customers. Moreover, periodical checks should be conducted to review that the roadmap still corresponds to current market conditions."* (Head of Product Management) A thorough validation of roadmap items before implementation requires the integration of discovery activities in the product development process.

Involving all relevant stakeholders was also considered as a key success factor for the roadmapping process. One interviewee mentioned that *"[...] a clear process to determine the items for the roadmap is necessary. This means a cross-functional collaboration of the different stakeholders and departments (e.g., management and discovery). It does not make sense that one person is responsible for filling the roadmap based on his opinion. Moreover, meetings are not suitable for discussing the topic of product roadmap because usually, the time is too short. Rather the roadmap should be discussed in the context of two or three full-day sessions."* (Product Manager) A participant mentioned that the success of alignment can be recognized by the case that *"a stakeholder looks at the roadmap and understands it immediately."* (Product Manager)

Different representations of the roadmap are an essential factor for meeting the requirements of the various stakeholder and for keeping the roadmap understandable. A participant mentioned: *"The management does not have the time to read all the detailed information that is important for product management. For this reason, we create a management summary in which only the most important information is included."* (Head of Product Management) Also, several interviewees mentioned the quality of the communication and alignment as a success factor: *"For the roadmapping process to work, it is essential that there is good communication among all stakeholders. For example, to manage the product roadmap, a product manager requires all information and must know all dependencies of the products."* (Product Manager)

The right mindset of the organization is another key factor for success. A participant mentioned that *"freedom and responsibility are very important for roadmapping and product development processes. This means that employees should not be put under pressure but receive the freedom to unfold."* (Product Manager) Top-level management should be involved early in the product roadmapping process and give product management the necessary freedom to create and manage the product roadmap. Furthermore, the decisions regarding the roadmap (e.g., prioritization of a new item) should not be taken emotionally. One participant said: *"Usually, the idea finder is very enthusiastic about the implementation of his idea. However, it might be that the management or other colleagues believe that the proposed product does not fit into the overall strategic direction. This leads to many discussions on an emotional level."* (Product Manager)

Last but not least, several interviewees mentioned the culture and values lived in a company as success factors. Necessary for the success of a roadmap is a *"management that doesn't expect a one-year roadmap and then measures the employees how well this roadmap has been executed by the initial plan, but a management that has understood that there is a dynamic and uncertain market, in which long-term planning is almost impossible. Moreover, values such as openness, respect, or honesty are important for the roadmapping process, leading to a good working atmosphere and more collaboration among different stakeholders."*(Product Manager).

The key sucess factors of our study are listed below:

- An open culture of the company and an open mindset of the management.
- Management does not expect a detailed planned roadmap over a long time horizon.
- Transparent and honest communication of all participants involved.
- The level of planning detail and the item types in the roadmap vary with different timeframes.
- Changes to the roadmap are clearly justified.
- The roadmap is aligned with the company vision and the product vision.
- The product vision and strategic objectives are clearly stated and communicated.
- The contribution of roadmap items to higher-level goals (up to the vision) is determined.
- The contribution of roadmap features with respect to their outcomes is validated before implementation (especially for the short-term timeframe).
- Product discovery methods are integrated into the roadmapping process.
- A clear process for prioritization and decision-making is established based on high-quality information input.
- All relevant stakeholders are involved in the creation and evolution of the roadmap.
- Different consistent representations of the roadmap for various stakeholders exist.
- The organizational culture values openness, respect, and honesty.

5.1.3 Threats to Validity

Different frameworks exist for assessing the validity and trustworthiness of qualitative studies. We use the framework proposed by Yin [Yin09] as the basis for the discussion of the validity of our study. Internal validity is not discussed since causal relationships were not examined in the present study. **Construct validity:** As a means for establishing construct validity, the goal and the purpose of the interviews were explained to the interviewees before the interviews. In addition, the way of data collection through semi-structured interviews allowed for asking clarifying questions and avoiding misunderstandings. **External validity:** The external validity is restricted due to the limited number of participants and because the results are derived from German companies that operate in an uncertain and dynamic market environment (e.g., smart home). Thus, the results are not directly transferable to other industry sectors. However, an analytic generalization to a similar context is possible. **Reliability:** The reliability was supported by providing a publicly available interview guide. The analysis has been conducted in a systematic and repeatable way. Therefore, a replication of the study and a reduction of researcher bias is supported.

5.1.4 Discussion

The expert interviews show that the participating companies have a lot of common practices but a quite individual approach to product roadmapping. Those companies that have already implemented fairly mature product roadmapping practices are especially strong with respect to the dimensions "roadmap items", "adequacy of item detailing based on the timeline," and "roadmap reliability". This means that they do not treat different timeframes equally with respect to the detailing level and the type of items in the roadmap. For example, detailed planning of products and features for the short-term, hypothesis of possible solutions that are in the validation phase in the medium-term, and the long-term horizon includes only ideas or high-level themes (i.e., customer or system needs). However, the most common approach (7 out of 13 companies) of the participating companies is a fixed time-based chart consisting of products and features over a long-time horizon (so-called feature-driven roadmaps). The study shows that such an approach leads to frequent ad hoc adjustments that typically lead to a decrease in reliability. Moreover, feature-driven product roadmaps are only a scheduled list of products or features that include early commitments to concrete solutions. However, such promises are difficult to fulfill in a dynamic market environment. As a consequence, stakeholders or employees lose trust in the product roadmap. Reliability and trust can be seen as indispensable for the acceptance and successful usage of a roadmap. To increase reliability, it should be discussed what customer and business outcomes should be achieved, which serves as a basis for determining possible solutions.

Moreover, the interviews show that many participating companies see product discovery activities as necessary to identify and validate features. However, 6 out of 13 companies do not conduct product discovery activities but determine which items will be placed on the roadmap through expert opinions or individual customer requests. This indicates that such companies lack knowledge of how to conduct product discovery activities. In contrast, 7 out of 13 companies conduct discovery activities to identify current customer problems and determine which products should be developed to solve those problems. However, the interviews revealed that such companies lack a deep understanding of how to systematically build a product discovery process and which methods within that process are most effective.

Furthermore, the results show that the prioritization process of many companies is also based on the opinions and views of experts. Similar to the conduction of product discovery activities, there is also a lack of understanding of which prioritization methods are appropriate and most effective for use in a dynamic market environment. In contrast, the interviews showed that those companies that use the right prioritization process foster the creation of customer value and optimize resource allocation. Considering alignment, most companies use several roadmaps (i.e., each department has its own roadmap) that are not connected with each other. This poses the risk that different departments pursue different goals, so there is no company-wide alignment on common objectives. To support alignment, establishing a cross-functional team (e.g., consisting of members of management, product management, and technical staff), which is responsible for creating a central product roadmap, has proven to be a suitable measure. This central product roadmap should serve as input to derive specific but consistent representation for internal departments and external stakeholders. However, in all participating companies, the management decides on the roadmap, i.e., management determines how the roadmap is structured, as well as reviews and approves the content of the product roadmap. Complementary product management is responsible for creating and updating the product roadmap. In this context, the interviews show that product managers have a good understanding of product roadmapping in a dynamic and uncertain market environment. However, product managers must first convince management to management, i.e., provide valid and comprehensible reasons to be allowed to make changes to the existing product roadmapping process.

5.1.5 Conclusion

In this study, we conducted 41 semi-structured expert interviews to identify the current state of practice regarding product roadmapping as well as their associated challenges and success factors. Overall, we note that many participants already have a good understanding of success factors and, in some cases, the conduction of concrete measures for product roadmapping in dynamic market environments. However, they are currently struggling with overcoming key challenges. On the one hand, management makes the final decision about the product roadmap, such as what structure and format to use by creating the roadmap and which items to be included. In such cases, reluctance to adopt new approaches and insistence on traditional methods prevents a successful transformation of the product roadmap. Therefore, convincing the management to undertake a roadmap transformation is a major challenge. On the other hand, the most promising areas for improvement are stating the outcomes a company is trying to achieve and making them part of the roadmap, sharing or co-developing the roadmap with stakeholders, and establishing discovery activities.

5.2 Web Survey

To extend the insights gained from the expert interviews on the current state of practice regarding product roadmapping, we conducted a web survey in addition to the expert interviews. In order to achieve our objective, we defined the following research questions.

- **RQ1:** What approaches, procedures, and methods for creating and updating a product roadmap are currently applied in German companies?
- **RQ2:** What measures have the participating companies taken to adapt their product roadmapping practices to a dynamic and uncertain market environment?
- **RQ3:** What challenges do the participating companies face within this adaptation process?

5.2.1 Research Design

To design the survey, we adapted the guidelines according to Linaker et al. [LSHM15], which consists of the following steps: 1) defining the objective and research questions, 2) identifying the target audience and the sampling frame, 3) designing the sampling plan, 4) designing the survey instrument, 5) validating the survey instrument, 6) collecting and analyzing the survey data, and 7) discussion. Moreover, Miles and Huberman [MH94] suggest linking qualitative and quantitative questions to provide richer detail and a deeper understanding of the research. Consequently, multiple-choice questions and open-ended free-form text entry fields were integrated into the survey. Overall, our questionnaire consisted of 18 questions and was divided into three parts. The first section served as an introduction and contained demographic questions, including "which position do you hold in your company?", "how many years of experience do you have concerning product roadmapping?” and “in which industry sector do you work?”. The second part of the survey contains questions about the current product roadmapping practices. Therefore, we formulated questions around the nine clusters we had identified in the expert interview studies mentioned in 5.1.2.1. This includes, for example, questions about the items used on the roadmap, whether and in what form product discovery activities are conducted, or who is responsible for the product roadmap. To facilitate the input of the users, we formulated five answer options for each question based on the insights of the expert interviews. This allows participants to select an answer option that reflects their current product roadmapping practices. If no answer option is applied, the user could enter the applied practice by manual input. Finally, the third part consisted of a free text entry field to identify what measures the company has taken to adapt its product roadmapping practice to a dynamic and uncertain market environment. This also includes what challenges the participating companies had to overcome in implementing the corresponding measures.

Survey instrument validation: To pretest our survey for its validity, usefulness, and readability, we conducted a pilot phase with five selected partners from the industry and within our academic organization. Specifically, this includes one chief product owner, one product manager, and three researchers from the area of software-intensive business. The pilot phase focuses on verifying that the questionnaire is worded correctly, ensuring that questions are not misunderstood, identifying missing, unnecessary, or irrelevant questions, and assuring that the questionnaire is of appropriate length.

Collection and analysis of the survey data: To obtain a high response rate, we distributed our survey via several social business platforms (e.g., LinkedIn) and social media channels (Twitter, Facebook, Instagram). More specifically, we sent an invitation to complete the survey to 14 Meetup groups focusing on product management. In addition, we contacted selected potential participants directly. Therefore, we used several search keywords such as “product manager” or “product roadmapping”. This led to a sample size of 66 participants from different industry sectors. According to a study conducted by Mentor [Men21], 69.500 product managers are employed in the DACH region. Of these, 16.300 product managers are engaged in developing and maintaining IT products or services. Therefore, the total sample of our target group can be considered as 16.300. In order to be able to make a statement about the quality of our sample for the web survey, we used the formula according to Yamane [Yam73]. The authors suggest calculating a suitable sample size (n) as follows:

$$n = \frac{N}{1 + Ne^2}$$

N is the population size, and e is the level of precision [Yam73]. As mentioned above, the size of our population is 16.300, and we chose 0.05 for the level of precision. These numbers inserted into the formula of Yamane results in

$$390 = \frac{16.300}{1 + 16.300 * 0.05^2}$$

As the calculation shows a sample size of more than 390, we could claim strong generalizability. This means that our survey covers 16.92 percent of the population size. However, it should be noted that this number applies to the entire DACH region. Our survey aims to attract product managers from Germany. Therefore, it can be assumed that the coverage is to be regarded as higher. Nevertheless, the results of this web survey can only be generalized weakly or moderately. For this reason, in addition to the web survey, we conducted expert interviews and analyzed the grey literature. This allows us to compare the results of these three various methods.

The survey was published from December 2019 to February 2020. Regarding the data analysis, we exported the answers in Excel sheets, used descriptive statistics, and summarized the results in tables and charts. To answer RQ2, and RQ3, we used free form text entry fields that were analyzed through thematic data analysis to provide summary statistics and make patterns visible.

5.2.2 Results

Overall, 66 participants from 20 industry sectors participated in our survey. In the following sections, we first describe the demographic data of the participating companies and present the collected data obtained from the questions used to identify current product roadmapping practices. Afterward, we describe the measures identified that the participating companies have taken to transform their product roadmapping practices to the requirements of a dynamic and uncertain market environment, as well as the challenges that the companies faced during this transformation process.

5.2.2.1 Demographic data

Figure 5.2 gives an overview of the roles of all participants in this survey. It shows that 22 out of 66 participants act as product managers. Other well-presented roles are members of the management (9 participants), product owners (8 participants), and heads of the department of product management (8 participants).

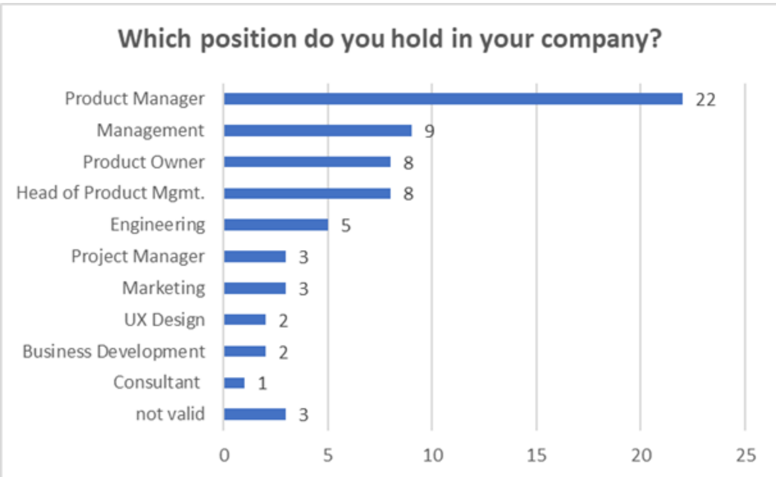

Figure 5.2: Role of the participants in the web survey

Figure 5.3 shows the experience of the participants regarding product roadmapping, which are distributed as follows: “Five to ten years” (17 participants), “three to five years” (15 participants), “one to three years” (14 participants), “less than one year” and “more than ten years” (10 participants each).

Figure 5.3: Experience of the participants regarding product roadmapping

Figure 5.4 illustrates the distribution of the industry sectors of the participating companies. The main branches of the companies are the “Software Industry” (12 participants), “E-Commerce” (7 participants), the “Construction Industry” (7 participants), “Automotive” (6 participants), as well as the industry sectors “IT” and “Electrical Engineering” with 5 participants each. In contrast, the industries “Automation Technology” (3 participants), “Mechanical Engineering” (3 participants), “Banking” (3 participants), and “Smart Home” (2 participants) are less represented. 9 participants stem from other industry sectors such as textiles, event management, education, and trade show construction. Moreover, the industry sector of 4 participants was not valid since they did not provide correct inputs. (e.g., “dffd” or “swfr”).

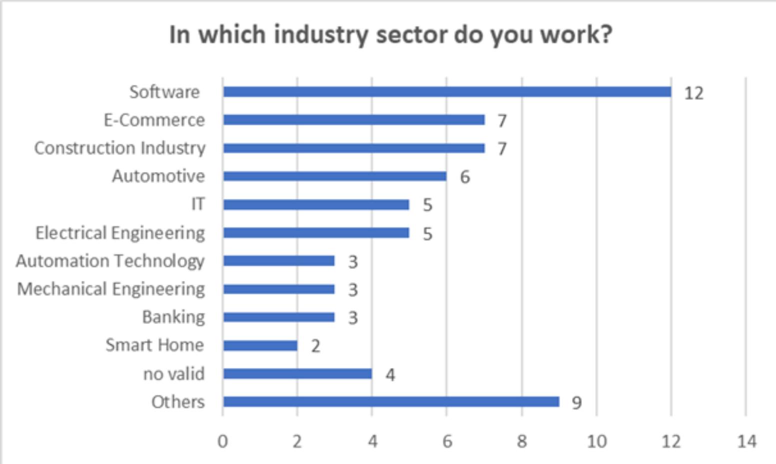

Figure 5.4: Industry sectors of the participants

5.2.2.2 Current state of product roadmapping

Roadmap Items: First of all, we gathered data about roadmap items, i.e., which kind of information artifacts, companies are using on their product roadmaps (see Figure 5.5). The study shows that 27 out of 66 companies use products and/or features without goals. In more detail, the roadmaps of 6 companies consist mainly of products, and the roadmaps of 21 companies include mainly products and features. In addition to products and features, 11 companies primarily use business goals such as “increase the value of in-app purchases by 15 percent”. Based on these business goals products and features are derived. Such a procedure can be seen as a first step in the right direction. However, these roadmaps only consider the company’s goals and not the value the product should deliver to the customer. In contrast, the roadmaps of 14 companies include mainly customer and business goals, products, features, and for the long-term timeframe topics such as “the development of a solution in the field of smart home”. Topics indicate a field where a new product development should occur, but similar to business goals, and topics do not consider the exact customer value. In addition, the roadmap also needs to be aligned with the product vision. These missing aspects are covered by the roadmaps of 14 companies, which contain the product vision that serves as input for formulating customers and business goals.

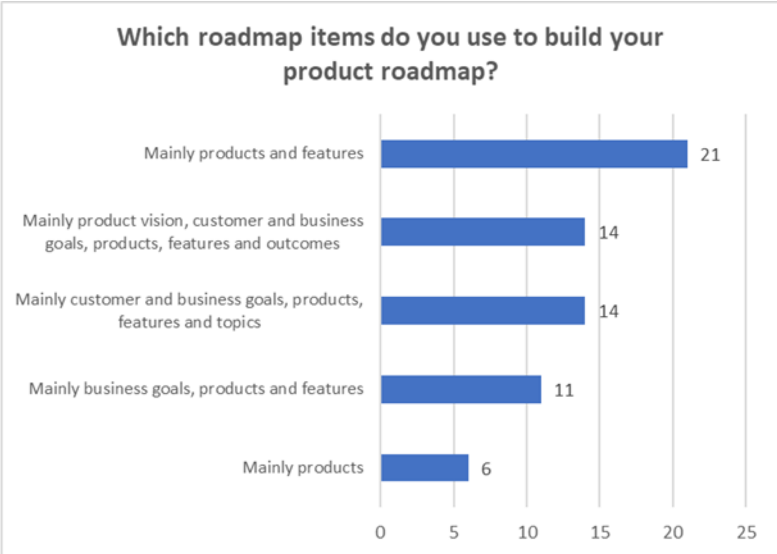

Figure 5.5: Results of the dimension roadmap items

Adequacy of item detailing based on the timeline: Next, we gathered data about how detailed the roadmap items are planned with respect to short-, mid-, and long-term timeframes (see Figure 5.6). This dimension is important because, in dynamic and uncertain market environments, it is essential to react quickly to new requirements arising from the markets (such as disruptive approaches), rapidly changing customer behavior or rapid technological developments. The study shows that 7 companies planned the next steps ad hoc. This means that the roadmap only considers the short-term, and there is no mid to long-term view. The roadmap of 7 companies includes a detailed planning over a long-time horizon. This means that all tasks are planned and worked out in detail for the short, mid-, and long term. However, due to the high uncertainties in a dynamic and uncertain market environment, such long-term fine-grained planning is not suitable. The roadmap of 11 companies include some correlation between time and level of detail, but the detailing of the items is not done systematically and does not reflect the necessity for detailing. An example is that events (e.g., fairs) in the future are more detailed than higher prioritized work packages planned closer in time. More systematically, the roadmap of 16 companies contains a clear correlation between time and level of detail. This means the closer the time, the more details. Finally, the detailing of the roadmap items by 25 companies depends on the timeline. This means that short-term items are detailed, prioritized, estimated, and validated. Mid-term items are under validation, and the long-term view only contains themes (i.e., high-level customer or system needs).

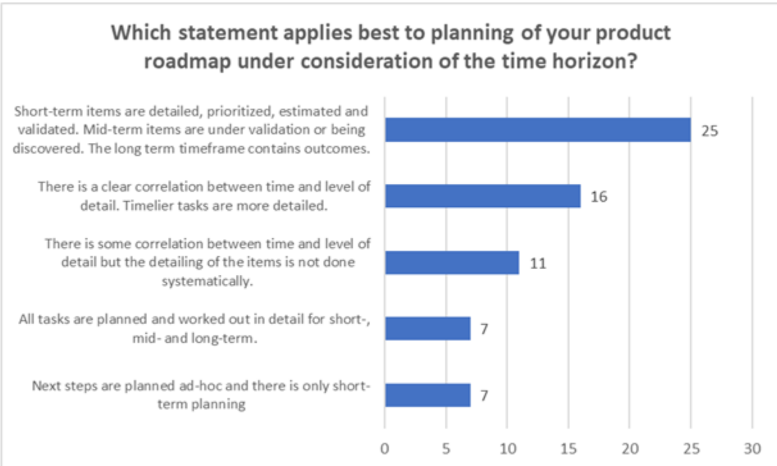

Figure 5.6: Results of the dimension adequacy of item detailing based on the timeline

Reliability: This question aims to gather insights about how often and in what way adjustments are made (see Figure 5.7). The roadmap of 6 companies is subjected to permanent ad hoc adjustments. This leads to the situation that the roadmap offers little stabilization and orientation; therefore, there is little trust in the roadmap. Within 16 companies, the roadmap is subjected to frequent ad hoc adjustments and provides low orientation. 21 companies adjust their roadmap mainly in regular review cycles (e.g., in a quarterly planning meeting). However, this approach usually brings confusion and relatively high effort. The reason is that the adaption cycles are usually very high, leading to large and complex work packages. 20 companies conduct adjustments of their roadmap mainly reactively on demand. This means that the process of roadmap adjustments is controlled and allows, for example, to react to disruptive market change, but it is not actively shaped. In contrast, adjustments to the roadmap are mainly made proactively by three companies. This means that the roadmap is structured in a way that adjustments are only necessary for strategic changes.

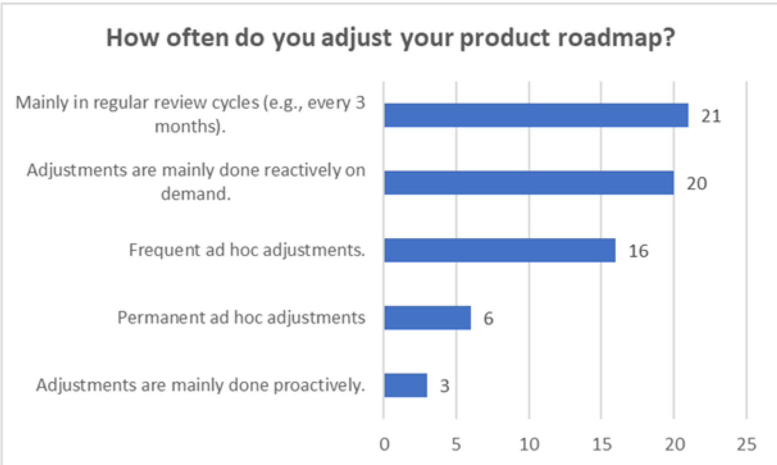

Figure 5.7: Results of the dimension adjustments to the product roadmap

Confidence: This question aims to gain insights into how the influence of the roadmap items on the achievement of business and customer goals is measured (see Figure 5.8). The study shows that 60 out of 66 companies consider the impacts of the roadmap items on their goals. In more detail, 20 companies estimate the confidence based on the knowledge of experts. This means that usually, one role, such as the product manager estimates the impacts of the product on the goals of the company and, thus, the probability that a product or feature is decided to be implemented. 8 companies determine the impacts based on data from the past by extrapolating it into the future. A typical example is the identification of confidence based on statistics. 17 companies partially validate the impacts, for example, through interviews for products whose development involves a lot of effort and high costs. Finally, 15 companies have established a systematic process to validate the impacts of the products or features upfront. This procedure increases the confidence that the product or feature will have the expected effect after implementation and delivery.

Figure 5.8: Results of the dimension measure of the influence of the roadmap items on customer or business goals

Product discovery: The questions aim to identify how product discovery activities are conducted in the companies (see Figure 5.9). Product discovery describes the ability of a company to identify and validate items on the roadmap before implementation. In total, 39 out of 66 companies do not conduct product discovery activities. In detail, in 4 companies, a manager is typically defining the roadmap items. Similarly, 18 companies decide which products or features are included on the roadmap based on the knowledge of experts without further validation. 17 companies decide about product roadmap items based on customer requests. An example, therefore, is implementing a feature that several customers request. Moreover, 18 companies are conducting discovery activities by involving the customer more actively (e.g., through customer interviews or customer focus groups), but there is no coordination with the activities of the product delivery. The latter means that there is no clearly defined interface between product discovery and product delivery. Finally, 9 companies conduct product discovery activities, which are closely integrated with product delivery activities. The advantage of such an approach is that the parallel execution of product discovery and delivery enables the product team to adapt the solution to the customers' needs more quickly. This leads to faster development and release cycles and reduces waste.

Figure 5.9: Results of the dimension conduction of product discovery activities

Prioritization of roadmap items: This question aims to determine how companies prioritize their items on the product roadmap (see Figure 5.10). Prioritization refers to the factors that an organization considers for making decisions. 1 company uses the first-in-first-out method to prioritize the roadmap items. This means that the items are listed and developed in chronological order. 23 companies prioritize the roadmap items based on the opinions and views of experts. These can be based, for example, on sales requests and analyst recommendations or the development of new features based on an analysis of the competition. Moreover, 8 companies conduct the prioritization of the roadmap items based on the capability to deliver (e.g., low-hanging fruits). 8 companies perform the prioritization process based on short-term benefits (e.g., shareholder value). Finally, 26 companies conduct the prioritization with an established process focusing on delivering value to the customer and the business. An example, therefore, is conducting a regular assessment of the roadmap items with a cross-functional team. Criteria for the assessment of the roadmap items can be, for instance, the feasibility (assessed by the engineering team), the desirability (assessed by the marketing, sales, or UX teams), and the viability (assessed by the product management team).

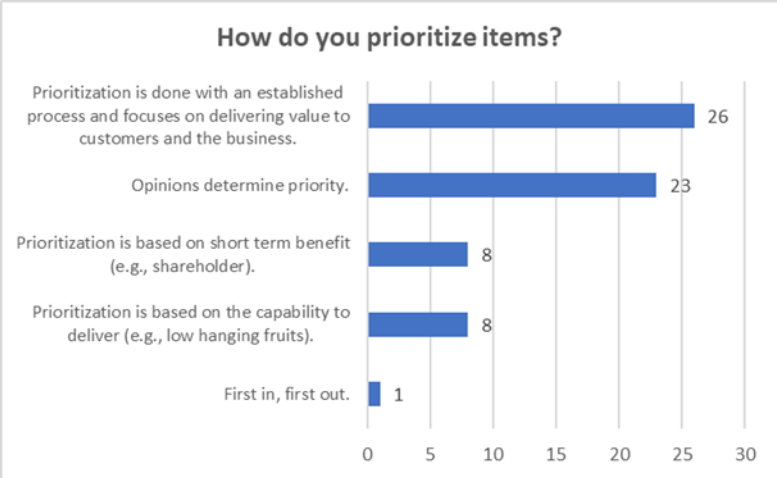

Figure 5.10: Results of the dimension prioritization of the roadmap items

Extent of alignment: We gathered data about the alignment of stakeholders (see Figure 5.11). The extent of alignment specifies how good the stakeholder's coverage is, how deep they are involved, and how well they understand their respective roles. The product roadmap will not fulfill its purpose without the alignment and buy-in of the key stakeholders. In 9 companies, no one or only one stakeholder, such as the high-level management, has a product roadmap that is not communicated to others. 14 companies have several loosely connected product roadmaps for internal stakeholders, while 8 use loosely connected product roadmaps for internal and external stakeholders. Moreover, 15 companies develop a central roadmap for internal and external stakeholders. Finally, 20 companies create one central product roadmap based on cross-functional collaboration. This enables all departments involved in the product development process to introduce their views and contribute to the development process of the roadmap.

Figure 5.11: Results of the dimension extent of alignment around the product roadmap

Responsibility for the product roadmap: This question strives to gain insights about who is responsible for the product roadmap (see Figure 5.12). Responsibility addresses the questions "who can decide about placing items on the product roadmap?" and "who is responsible for the development and conduction of the product roadmapping process?". 2 companies are using tools to decide if and which items should be placed on the product roadmap. In 10 companies, the product management department creates and maintains the product roadmap. Within 13 companies, the management decides which items are placed on the roadmap, while in 13 companies, specific roles such as the portfolio manager make this decision. Finally, in 28 companies, product management maintains the product roadmap in collaboration with key stakeholders.

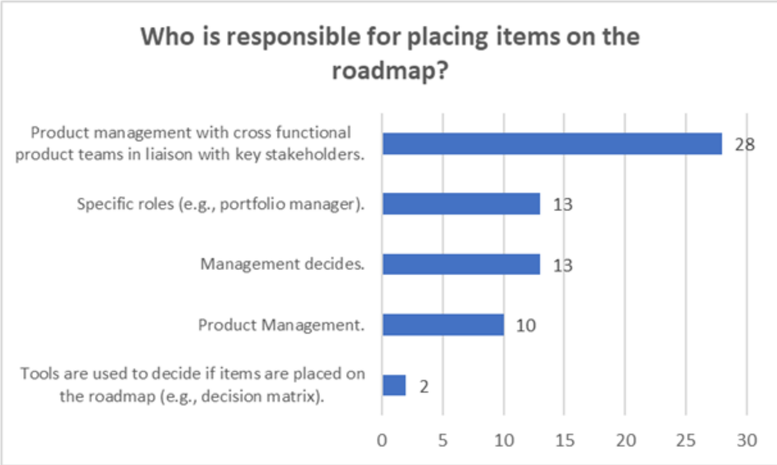

Figure 5.12: Results of the topic who is responsible for the product roadmap

Ownership of the product roadmap: This question aims to identify who owns the roadmap and is accountable for it (i.e., who signs off and approves the roadmap), (see Figure 5.13). The web survey showed that 4 companies have not defined an owner for the roadmap. In 25 companies, the management decides which items are included on the product roadmap. In 12 companies, the ownership is shared between multiple roles, for instance, between the product manager and the product owner. Within 5 companies, the department's strategy or portfolio planning owns the roadmap, while in 20 companies, the roadmap is approved by the department product management together with cross-functional product teams.

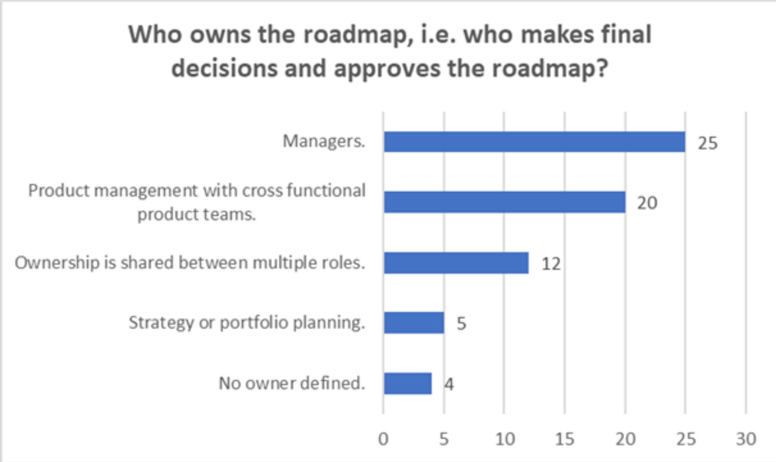

Figure 5.13: Results of the topic who owns the product roadmap

5.2.2.3 Measures to adapt the product roadmap to a dynamic and uncertain market environment

To answer RQ2, our questionnaire included a part about the measures that companies have taken to adapt their product roadmapping practice to a dynamic and uncertain market environment (see below). The numbers in brackets indicate the number of mentions of the measures. As the data shows, the most frequently mentioned measures were 1) the integration of customer insights in the roadmapping process (8 mentions), 2) the definition of clear responsibilities (8 mentions), and 3) the establishment of cross-functional teams (7 mentions).

- Integrate customer insights in the roadmapping process. (8)
- Definition of clear responsibilities. (8)
- Establishment of cross-functional teams. (7)
- Introduction of a product roadmapping tool. (5)

- Regular reviews and updating of the roadmap together with stakeholders. (4)
- Creation of new roles (e.g., business owner, portfolio manager). (4)
- Introduction of product discovery and prototyping. (4)
- Continuous prioritization process. (4)
- More systematic breakdown of the corporate vision towards a roadmap. (3)

To answer RQ3, we asked the participants what challenges they are facing within the transformation process of the product roadmap to a dynamic and uncertain market environment. The most mentioned challenges regarding the transformation process of the product roadmap were 1) breaking up traditional corporate structures and mindsets, 2) convincing the management, and 3) introducing of an effective prioritization process (see below)

- Breaking up traditional corporate structure and mindset. (8)
- Unwillingness of management to change the current roadmapping practice. (6)
- Introduction of an effective prioritization process. (5)
- Aligning stakeholders around the roadmap. (4)
- Introduction of cross-functional collaboration.(4)
- Conflicts with stakeholders, as not all expectations can be fulfilled. (3)
- Definition and commitment of common goals between the departments. (3)
- Conflicts between the departments regarding the ownership of the roadmap. (2)
- Motivate colleagues to give input. (2)
- Integrate customer views into the roadmap. (2)

- Integration of the sales and marketing team into the agile product team. (2)
- Keep an overview of all ideas. (1)
- Identify metrics for outcomes. (1)
- Common understanding between the persons involved. (1)

5.2.3 Threats to Validity

We used the framework according to Yin [Yin09] to assess the validity and trustworthiness of our study. **Construct validity:** Construct validity refers to the correct measures for the examined concept. To mitigate this threat, we conducted an iterative validation phase with external test persons from our institute and industry to check the questionnaire's feasibility, usefulness, and readability. **Internal validity:** The internal validity might be threatened by the questionnaire as such. This means we cannot know whether the participants have understood the question correctly or answered it truthfully. To increase the internal validity, we developed the questions based on previously conducted studies [MTL18; MTL19d; TMKL20]. **External validity:** The participants of this study are German companies that are developing software-intensive products, and therefore the results are transferable to companies that operate in such environments. It should be noted that cultural differences to countries outside the German-speaking area cannot be excluded. The reported results are based on the personal opinions and experiences of the participants. Respondents may have given answers that do not fully reflect the reality of their companies. This threat to validity is mitigated by the fact that the participants had no obvious incentive to report false facts. **Reliability:** Reliability focuses on the stability and consistency of the results of the study. The reliability was supported by the analysis, and calculations of this study were performed systematically and repeatable. In addition, the researchers analyzed the data neutrally and in an unbiased manner. Therefore, the traceability of the study and a reduction of researcher bias is supported.

5.2.4 Discussion

Like the previously conducted expert interview studies, the web survey has shown that often (27 out of 66) roadmaps are output-oriented, i.e., they contain products and features and do not consider the delivery of customer value. The roadmap of 25 out of 66 companies includes customer and business goals, topics, and features. Such an approach focuses on achieving objectives from which features are derived. This leads to a shift in the discussion from debating about features to agreeing on goals. This helps to make strategic product decisions and can thus be seen as a first step in the right direction. However, this goal-oriented approach does not consider the value that should be delivered to the customers and the business. This missing value aspect, including the provision of a product vision, is covered by the roadmap of 14 out of 66 companies. Therefore, regarding the items used in the product roadmap, it can be said that the results of our previously conducted expert interview study were confirmed, and consequently, suggestions for improvement concern the formulation of a product vision, the identification of outcomes, including them into the roadmap and deriving features from these outcomes.

Moreover, the survey showed that only a few companies (15 out of 66) use a systematic approach to evaluate the impact of the roadmap items on the achievement of customer or business goals. This was also in line with our expert interview study, where only one out of 13 companies used such an approach. This indicates that these companies are struggling to find an appropriate method to evaluate the roadmap items' influence on business or customer goals. Another possible reason is that the opinion and influence of the expert are too powerful. This means that other participants do not or only slightly question the expert opinions since they fear negative consequences (e.g., disadvantages regarding their career in the company). This situation makes it difficult to establish a process to evaluate the impact of the roadmap items on the objectives of the customers and company.

Furthermore, the survey revealed that 35 out of 66 companies identify the roadmap items based on expert knowledge or customer requests. This indicates that conducting product discovery activities is not widely used. Similar to the evaluation of what impact the roadmap items have mentioned in the previous paragraph, this could be due to companies not knowing what methods are available to conduct product discovery activities or expert opinions prevailing over conducting product discovery. This could also explain why outcomes are less integrated into the roadmap. Moreover, the results showed that when companies conduct product discovery activities, these activities are not or only loosely integrated with product delivery activities. This confirms the findings of the expert interviews that product discovery is still largely decoupled and done by individuals but not systematically integrated into the company's processes.

Regarding the prioritization of the roadmap items, the survey showed that many participating companies (26 out of 66) established a process focusing on delivering value to the customer and the business. Nevertheless, in 23 of 66 companies, the opinions of experts determine the priority of the roadmap items. This applies to 9 out of 13 companies participating in the expert interview study. Therefore, it can be said that suitable processes are used for prioritizing the roadmap items, but the experts' opinions also strongly influence the prioritization process.

Moreover, the study shows that 35 out of 66 companies are very mature regarding the alignment of the product roadmap. This means that input regarding the future product portfolio (e.g., customer experiences from the sales department) is collected from various departments, and a central roadmap is created based on these inputs. This serves as a starting point for the different departments to create their department-specific plans so that all activities within product development contribute to achieving the company's overall goals. In contrast, at 9 companies, only management has access to the roadmap, and 22 companies use several loosely connected product roadmaps. Likewise, 9 out of 13 companies that participated in the expert interview study also use several loosely connected product roadmaps. Therefore, it can be said that systematic approaches to achieving alignment around the product roadmap are not yet applied on a large scale.

Furthermore, our survey identifies that 41 out of 66 companies delegate the responsibility to product management or similar roles to discuss and coordinate the content of the roadmap together with other departments and key stakeholders. This might indicate that companies have realized that giving product management responsibility for the roadmap is meaningful. The reason for this is that usually product management has the task of shaping the future of a product or product portfolio as well as coordinating the various interests of all stakeholders involved. Therefore, it is more likely that product management will strive to keep up with the latest methods and trends in product management than management. However, in 13 of 66 companies, the management keeps the accountability of the roadmap. Our expert interview study shows that in all 13 case companies, the management has accountability for the roadmap. This indicates that management is willing to hand over responsibility to the operational level, but it is also common for management to want to keep the accountability of the roadmap. However, it is expected that transferring ownership to product management gives it the ability to implement its decisions more quickly. This allows them, for example, to introduce new product management methods to react more rapidly to changing conditions.

The study also shows that the participating companies have taken comprehensive measures to adapt their roadmap to the dynamic and uncertain market environments. In this context, the frequently mentioned measures were 1) to integrate customer insights in the roadmapping process, 2) the definition of clear responsibilities, and 3) the establishment of cross-functional teams. However, the transformation process of the roadmap to the requirements of a dynamic and uncertain market environment poses different challenges for the participating companies. In this context, the most mentioned challenges were 1) breaking up traditional corporate structures and mindsets, 2) the unwillingness of the management to change the current applied product roadmap process, and 3) establishing an effective prioritization process.

5.2.5 Conclusion

Overall, the web survey has shown that the practices of companies are very heterogenous, i.e., they have various kinds of strengths and weaknesses regarding various aspects of product roadmapping. This is also in line with our impressions gained from the expert interviews. Based on the comparison of the two empirical study results, it can be concluded that the participating companies show different areas for improvement depending on their current product roadmapping practices. Promising areas identified in the web survey included formulating a product vision, introducing outcomes into the roadmap, establishing product discovery activities, and integrating them with product development and delivery. These findings are also consistent with our findings from the expert interview. In addition, the web survey showed that, on the one hand, management delegates the responsibility for the roadmap to product management and gives them the freedom to implement new methods, but on the other hand, the final decision of the roadmap still lies with management. The latter finding is reinforced by the fact that the most commonly mentioned challenge within the transformation process was the unwillingness of management to change the current product roadmapping practice. The expert interviews also support this statement. Therefore, it can be concluded that a major challenge in transforming product roadmapping practice is to convince management to test and introduce new methods. The fact that companies have already taken measures to transform their product roadmap to a dynamic and uncertain market environment shows that the participating companies have realized that new approaches for product roadmapping are necessary. However, within this transformation process, companies face not only challenges related to the roadmapping process (e.g., integrating customer insights in the roadmapping process) but also many challenges of an organizational nature (e.g., breaking up traditional structures and changing the mindset of other departments). To overcome these challenges, it is recommended that areas for improvement not be selected arbitrarily but rather that those areas that deliver the most promising progress be systematically identified, depending on the current status of the companies' product roadmap. On this basis, successful pilot projects can help to convince management and critical stakeholder.

5.3 Grey Literature Review

In addition to the previously presented expert interviews (see Chapter 5.1) and web survey (see Chapter 5.2), we conducted a grey literature review (GLR). The reason for this is that companies and experts around the world often communicate their experiences more easily and quickly through grey literature such as white papers, blogs, or business books. Therefore, this grey literature review aims to expand the external validity of our previous research, especially in an international context. This means that the results from the expert interviews and web survey are compared with the insights of the grey literature review and expanded and/or adjusted as necessary. To achieve our objective, we conduct a comprehensive grey literature review on product roadmapping in a dynamic and uncertain market environment. Therefore, we searched for relevant articles using a broad search string. After applying our inclusion and exclusion criteria, we categorized the relevant articles according to their subject areas. This led to the formation of the following five categories: 1) product roadmapping processes, 2) product roadmap alignment, 3) product roadmap formats, 4) product roadmap prioritization techniques, and 5) challenges regarding product roadmapping. Each of these categories leads to a separate publication with its own research questions. It should be noted that this chapter contains only the results of the category "challenges regarding product roadmapping". The reason for this is that understanding the underlying reasons for developing the solution approach presented in this thesis is essential to present the complete challenges we identified regarding product roadmapping. Nevertheless, the other categories have helped us to gain a basic understanding of various aspects that are important for the success of product roadmapping in a dynamic and uncertain market environment. Examples include methods currently used for prioritizing roadmap items or formats and items proposed for operating in a dynamic and uncertain market environment. Details about the category's product roadmapping processes [TMS+21], product roadmap alignment [ESR20], product roadmap formats [MTB+20], and product roadmap prioritization techniques [TMB+21] can be found in the given sources. In order to identify relevant findings regarding the current challenges practitioners face in product roadmapping, we defined the following research questions

- **RQ:** What challenges about product roadmapping are reported in the grey literature?

5.3.1 Research Design

Since the study aims to gain new insight, it was designed to be exploratory. To conduct the study in a systematic and repeatable manner, it follows the guidelines according to Garousi, Felderer, and Mäntylä [GFM19], which considers the three main phases: 1) planning the review, 2) conducting the review, and 3) reporting the review. Table 5.2 shows each of our performed activities along these phases

Table 5.2: Design of the grey literature review

Planning the review	Identification of the need for a GLR. Definition and refinement of the search strings. Determination of the inclusion and exclusion criteria.
Conducting the review	Usage of the search string. Performance of the study selection process. Conduction of a quality assessment. Data extraction.
Reporting the review	Write down the findings as documentation.

5.3.1.1 Planning the review

Identification of the need for a GLR: First, we assessed whether a GLR is an appropriate method for our study. For this purpose, the Garousi checklist [GFM19] (see below) was used. Garousi, Felderer, and Mäntylä [GFM19] suggest that if one or more questions can be answered positively, the conduct of a GLR is recommended, otherwise, a systematic literature review (SLR) should be performed. The first and second question has already been answered by our systematic literature review, as presented in Chapter 4. This review showed that most scientific articles describe product roadmapping abstractly and do not address the requirements of an increasingly digital and dynamic environment. Therefore, there is little knowledge available about overcoming the challenges of traditional product roadmapping approaches and creating and maintaining product roadmaps in dynamic and uncertain market environments. To answer the third, sixth, and seventh questions in the checklist, it was necessary to collect options and views from practitioners. This was done through our expert interview study (see Chapter 5.1) and web survey (see Chapter 5.2) that indicate that there is a high level of interest in insights about the topic of "product roadmapping in a dynamic and uncertain market environment". To obtain more information about this issue, the conduction of a grey literature review is an appropriate approach. From the scientific point of view, the findings of the grey literature review represent a transfer of novel knowledge to the scientific community. These insights can be used to apply abductive reasoning and extend the existing scientific literature. Furthermore, our previously conducted expert interview study and web survey focus on the conduction of product roadmapping and the associated challenges in German companies. The conduction of a grey literature review helps to reveal experiences, approaches, and challenges published by authors worldwide. Therefore, a review of the grey literature helps to compare our previous findings with those outside Germany and to extend them if necessary. The questions of the checklist according to Garousi, Felderer, and Mäntylä [GFM19] are listed in the following. The green mark means that we have answered yes to the question, while the red mark means that we have answered no to the question.

1. Is the subject “complex” and not solvable by considering only the formal literature?
2. Is there a lack of volume or quality of evidence, or a lack of consensus of outcome measurement in the formal literature?
3. Is the contextual information relevant to the subject under study?
4. Is it the goal to validate or corroborate scientific outcomes with practical experiences?
5. Is it the goal to challenge assumptions or falsify results from practice using academic research or vice versa?
6. Would a synthesis of insights and evidence from the industrial and academic community be useful to one or even both communities?
7. Is there a large volume of practitioner sources indicating high practitioner interest in a topic?

Identification of our search string: The search terms were developed in a brainstorming session with two researchers and two practitioners. In this session, we developed a list of terms to obtain tailored results to reach our objectives. Subsequently, we tested the individual terms by evaluating the quality of the returned results on the first two Google pages. On this basis, we deleted search terms (e.g., agile roadmap) that do not provide sufficient results, i.e., the returned results did not serve to answer our research questions (e.g., an article dealing with another topic than product roadmapping) and were therefore out of scope. In contrast, we added search terms often used in the headings of returned articles that were not included in our list. Afterward, we connected the various search terms with Boolean operators. After evaluating different options, we have defined the following search terms:

- **GST1:** Innovation
- **GST2:** Product*

- **GST3:** Product Management
- **GST4:** Agile
- **GST5:** Outcome*driven
- **GST6:** Outcome*oriented
- **GST7:** Goal*oriented
- **GST8:** Theme*
- **GST9:** Roadmap*

The complete string used for this study was

(GST1 OR GST2 OR GST3 OR GST4 OR GST5 OR
GST6 OR GST7 OR GST8) AND GST9

Definition of the inclusion/ exclusion criteria: To filter relevant from irrelevant articles, we defined the inclusion and exclusion criteria as shown below

Inclusion:

- The article discusses the application of product roadmapping in practice.
- The article is published in English or German.
- The URL is working and freely available.

Exclusion

- The source is non-text-based.
- The article contains duplicated content of a previously examined article.

5.3.1.2 Conducting the review

The data retrieval process was performed using the predefined search string and applying it to the Google search engine (google.com). To avoid biased results based on past activities, the search was conducted in the incognito mode of the browser. Further, a VPN service was used to anonymize the location from which the search was conducted. Moreover, the relevance ranking was applied, which ranks the results according to the Google PageRank algorithm. The Google option to include similar results was activated to increase the number of available URLs. The search was conducted on January 17th, 2020, and yielded 556 hits. In addition to the search process, we conducted snowballing (i.e., considering further articles recommended in an article). This led to 66 further articles. Thus, we subjected a total of 426 articles to our selection process, which resulted in identifying 193 relevant articles which address the main topic of product roadmapping in a dynamic and uncertain market environment. On this basis, we have categorized the 193 articles according to the following subject areas 1) product roadmap formats [MTB+20], 2) product roadmapping processes [TMS+21], 3) product roadmap prioritization techniques [TMB+21], 4) alignment of various stakeholders around the product roadmap [ESR20], and 5) challenges and pitfalls regarding product roadmapping [TMPL22b]. The procedure of our selection process is shown in Figure 5.14.

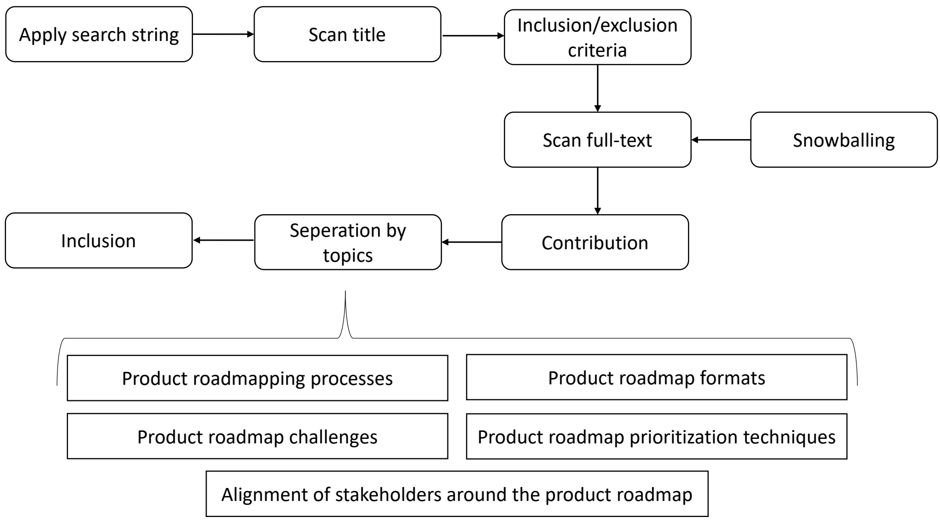

Figure 5.14: Study selection process of the GLR

To analyze the relevant articles, we conducted a qualitative content analysis to identify and structure our results. In more detail, we first extracted the topics of each category. Examples include the challenges of product roadmapping or different roadmap formats and their corresponding roadmap items. Subsequently, we extracted key statements for each topic to understand the approach and the underlying reasons. Two researchers highlighted the key findings and statements separately. In case these reviews yielded different results, the article selection process was conducted by a third researcher. To include an external perspective, we discussed the results with three practitioners who have many years of experience with product roadmapping. This did not result in any changes in the results.

Quality assessment and data extraction: Since grey literature is not peer-reviewed like scientific papers, we subjected the relevant articles to a quality assessment. For this purpose, we assessed the number of 193 relevant articles according to the quality assessment procedure proposed by Garousi, Felderer, and Mäntylä [GFM19]. This means that each relevant article was assessed based on the following criteria: 1) the author´s authority, 2) the description of the objective and methodology, and 3) the novelty and impact. Each assessment criteria contained specific questions (e.g., is an individual author associated with a reputable organization, is the conclusion supported by the data, or is the article supported by authoritative contemporary references), that were answered by assigning points. In more detail, the entire assessment includes 16 questions that are rated based on a three-point Likert scale as follows: 1 point was assigned if the article fully met the assessment question, 0.5 points were awarded if the article partially met the assessment question, and 0 points were given if the article did not meet the assessment question. After all questions were answered, the points were summed up, and a total score was calculated. The maximum score that can be achieved is 16 points, while an article is considered trustworthy if it reaches a total score of 8 points. To answer the questions regarding the author´s authority, we conducted additional inquiries via Google. In addition, the assessment includes the question of how many backlinks an article contains to assess the impact of the article. Therefore, we use the tool Backlink checker (see `https://ahrefs.com/de/backlink-checker`). Afterward, the results were presented to one practitioner at Robert Bosch GmbH, who has eight years of experience in product roadmapping. This review did not lead to the exclusion of an identified article. In the next step, data extraction was conducted by performing a content analysis for each article and extracting the information needed to answer our research questions. This data extraction serves as input for the reporting, i.e., we documented the findings of each included article.

5.3.2 Results

First of all, Figure 5.15 provides an overview of the mentioned challenge frequencies in the articles identified in our review. It should be noted that usually, several challenges are discussed in one article. The most commonly identified product roadmapping challenges were 1) a feature-driven mindset,

2) including too many details in the product roadmap, and 3) using individual opinions to decide which items are placed on the product roadmap.

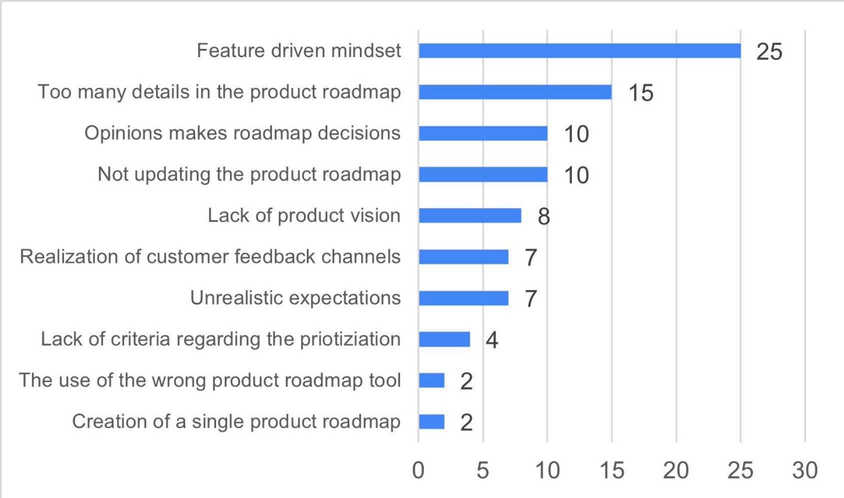

Figure 5.15: Frequency of challenges mentioned in the identified articles

Moreover, we determined the origin of the authors of the relevant articles. For this purpose, we extract the author's respective place of work by researching social media networks such as LinkedIn or Twitter. This was done to identify to what extent the results obtained can be generalized. This means how far our results are valid outside Germany. As a stopper, we defined that the author has been employed in the specified country for at least one year. This was done to ensure that the authors reported their perception based on the impressions gained from the country concerned. It should be noted that there are cases where one author has written several articles in our result set. All authors fulfilled this prerequisite. As Figure 5.16 shows, the set of authors is heterogeneous and includes North America, Europe, South Africa, Australia, and China. The most frequently common countries are 1) the United States of America, 2) the United Kingdom, as well as 3) Canada and Germany. The origin of two authors could not be identified. The reason for this was that the publication of the article was made under a pseudonym, which meant that the corresponding author´s country of work could not be determined.

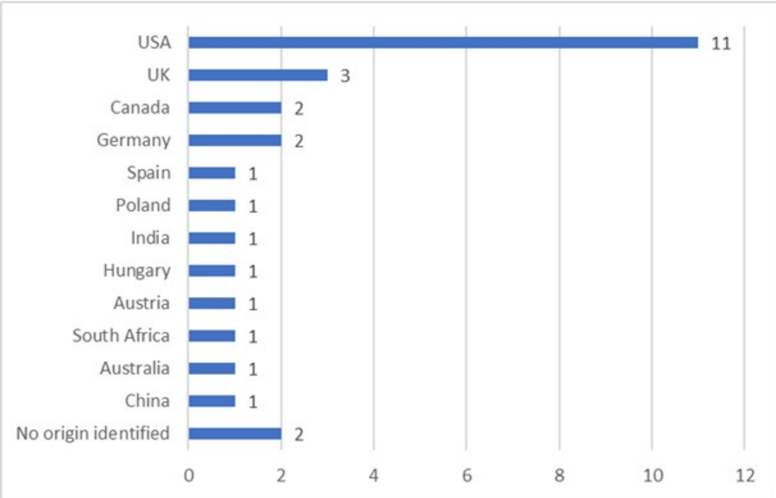

Figure 5.16: Frequency of the respective place of work of the authors of the identified articles

As mentioned above, our aim was not only to identify challenges related to product roadmapping but also to gain an understanding of why practitioners face these challenges and the implications associated with them. Therefore, the underlying reasons for the challenges mentioned in Figure 5.15 and their consequences are described below.

Feature-driven mindset: First of all, several authors reported that product roadmaps often consist of features, including exact delivery dates, on a timeline over a long-time horizon (usually one year) [Sah18]. Such a roadmap format is called a feature-driven product roadmap. The first problem with feature-driven roadmaps is that all the details are planned upfront. However, such detailed feature planning upfront does not work in a dynamic and uncertain market environment [Per20]. The reason for this is that features estimated beyond the next release tend to change as new risks or dependencies are uncovered [Dat19]. Therefore, feature-driven product roadmaps are often subjected to frequent adjustments [Mar23]. These adjustments are associated with a high effort, as all features that have been worked out in detail must be rescheduled with the associated responsibilities [Cag08]. The second problem with feature-driven product roadmaps is that when customers or stakeholders see a feature to be delivered on a specific date in the product roadmap, they will interpret this as a commitment, and expectations are raised [Gil23]. However, the uncertainty that comes with developing products in a dynamic market environment makes it very likely that features will not be delivered as planned and communicated. This applies particularly to features planned in the mid and long-term in the product roadmap [Got17]. This leads to customers or stakeholders perceiving the non-delivery as a broken promise and being disappointed and dissatisfied. Third, feature-driven roadmaps consider features, but they do not include the value to be delivered by the feature to the customers and the business. This can lead to the problem that the features planned on the product roadmap do not contribute to the solution of customer problems and are therefore not bought or used by customers [Cag08].

Too many details in the product roadmap: Another problem is including too many details in the product roadmap. This means very detailed descriptions of user stories, requirements, or resources [McC19]. However, including too many details blur recognition of the strategy to achieve a company's product vision. This causes the product roadmap to be challenging to understand by all stakeholders leading to misunderstanding and a decrease in the execution of the product strategy [LMRC17]. In addition, if the underlying reason for conducting the planned product development in the roadmap is buried under details, it will be difficult to generate enthusiasm and excitement among the employees [Got17].

Individual opinions decide which items will be included in the product roadmap: In many companies, management or experts (e.g., product managers, product owners, etc.) decide which items to place on the product roadmap [Rex18]. The problem with this approach is that only individual opinions determine the content of the product roadmap, but the perspective of the customers are not included [Pra16]. This approach can lead to the development of products based on false assumptions and use cases [Too21]. In the worst case, this can lead that the team members feeling unappreciated and losing their commitment to the company ProductPlan [Prob]

Not reviewing and updating the roadmap: Furthermore, several authors point out that the product roadmap creation is seen as a one-time activity rather than a continuous process [Kab21]. This means that companies often create and work on their product roadmap at the beginning of the year and use them subsequently as a fixed document with no further changes [Dhi22]. However, the problem is that priorities, resources, budget, and external factors such as competitors or major customers can change at any time, affecting the content of the product roadmap [Pro23]. Therefore, it is crucial to continuously review and update the product roadmap at a short time interval (e.g., every week or as a cadence of stakeholder meetings takes place [Dhi22]. Otherwise, the company forgoes the opportunity to incorporate findings into the product development process after creating the product roadmap [Kab21].

Lack of an enterprise-wide known product vision: Wick [Wic16] points out that many companies do not have a product vision or companies have a product vision but never use it [Wic16]. The danger of not having or communicating a product vision is that the teams involved in product development are unclear about the overall goal of developing the planned products in the product roadmap. First, this situation makes it difficult for the teams to identify and prioritize measures contributing to product success [Won]. Consequently, the teams will not be able to identify which measures contribute most to achieving the product vision and struggle to prioritize the various measures [Dat19].

Identification and implementation of product discovery activities: Another problem is that companies often struggle to identify and implement product discovery activities [LMRC17]. Umbach [Umb17] reports that one reason is that product managers often stay in their offices and do not leave the building to talk to (potential) customers. Datta [Dat19] added that another reason is that product teams do not have enough time and resources to devote to identifying product discovery activities in the race to meet deadlines. The risk of not involving the views and opinions of the customers in the product roadmapping process is that the product roadmap development will be based on assumptions without validation [Bow21]. This affects that many products are included in the product roadmap and developed that do not create the intended change in customer behavior (e.g., the start of using a certain product instead of another product from a competitor). Consequently, these products will not succeed on the market [Dat19].

Deciding how much resources to invest in product discovery: Several authors point out that product managers typically have a broad range of inputs for developing new ideas [Dal09; Haa15; Sch23; Sut23]. For example, by leading customer conversations, tips from the sales teams, or ideas from various departments of the company. As a result, product management receives a variety of ideas that need to be discovered. However, existing capacities are often insufficient to systematically validate all ideas [Haa15]. In addition, it is conceivable that the effort required to conduct product discovery activities exceeds the value delivered by the idea [Pic21]. For these reasons, product managers are faced with the challenge of deciding how much effort to put into each idea [Cag08; LMRC17].

Separating your product discovery team from the product development and delivery team: A further pitfall is to separate the product management from the product development and delivery team [Sch21]. This pitfall brings several risks: The main risk is that if the product discovery team consists of different people or if there are several weeks or months between these two phases, there is the danger that the insights gained during product discovery will not be taken into account during delivery [Cag08; Jan23]. Besides this, there is the pitfall that an idea validated by discovery may not be feasible. Without regular communication and coordination between product discovery and delivery, much time is wasted on an idea that cannot be implemented [Tei19]. Finally, in case of discovery and delivery are not connected can lead to the circumstances that the delivery team does not fully understand the motivations and thinking behind the problem and the corresponding idea (e.g., documentation is misunderstood). Consequently, the features that will be implemented will not or only partially solve the identified problem [Fel00; Jan23].

The use of the wrong product roadmap tool: Kabisch [Kab21] points out that many product roadmap tools include the mapping of features on a timeline. As described above, such a product roadmap format is called feature-driven. If a company uses such a tool, it will adapt its product roadmapping to the proposed format of the tool. As a result, the company will be operating in a dynamic and uncertain market environment with an inappropriate product roadmap format with all its disadvantages [Kab21]. In addition, Dhiman [Dhi22] also points out that many companies are using Excel or PowerPoint, which are unsuitable for creating and handling a product roadmap. The main reason is that these tools are too static, making it difficult and exhausting to create or update the product roadmap [Dhi22].

Unrealistic expectations: Another pitfall is to make unrealistic and arbitrary expectations on the roadmap [Cag08; Dhi22; LMRC17; Naj]. Setting unrealistic expectations can originate from various sources, for example, from management to the operational level but also from product management to software development. Such behavior will generally damage the relationship between the expectation setter and the recipient [Pro23]. A typical example of setting unrealistic expectations is the specification of non-realistic release dates [Naj].

Lack of criteria for the conduction of the product roadmap prioritization process: Another problem is that product managers often prioritize their roadmap items based on individual opinions. This includes views of the management or various product team members as well as customer requests [Umb17]. However, this includes the pitfall that often subjective opinions are influenced by personal bias and often present only a single point of view. Therefore, there is a low probability that these opinions reflect the most critical current customer problems and are inappropriate for application in the prioritization process of the product roadmap [Cag08; LMRC17].

Creation of a single product roadmap for all stakeholders: Dhiman [Dhi22] points out that a common mistake in the creation of the product roadmap is to create a single product roadmap. The problem with this approach is that a product roadmap is an artifact that needs to be refereed by many stakeholders such as the CEO, CPO, marketing, sales engineering as well as customers. This means that the information that is focused on and emphasized should be tailored to the stakeholder to whom the product roadmap is presented [Proa]. Therefore, creating a single roadmap will not be sufficient for informing and collecting feedback from these stakeholders [Dhi22].

5.3.3 Threats to Validity

We use the framework based on Wohlin and Runeson [WR00] as the basis for the discussion of the validity of our study. **Construct validity:** First, the construct validity is threatened by the Google search engine regarding the accessibility of search results. After applying the search string, Google returned 78.300.000 articles, but we only had access to 426 articles that we used as input for our selection process. We cannot know whether these 426 articles represented the total search result of 78.300.000 articles. Moreover, the search string itself poses a threat to the construct validity. There may be articles dealing with product roadmapping but use terms not covered by our search string. Therefore, we may have missed some relevant articles. **Internal validity:** Internal validity concerns the validity of the methods used to examine and analyze the data. To mitigate this thread, the quality assessment was conducted by two reviewers independently to limit confirmation bias and interpretation bias. In the case that the individual reviews led to different results, the process was repeated by a third reviewer to make a final decision. **External Validity:** The external validity considers to what extent it is possible to generalize the findings. The results and conclusion relate to product roadmapping in a dynamic market environment with high uncertainties (e.g., the software-intensive business). Therefore, the results are not directly transferable to other industry sectors. **Conclusion validity:** The conclusion validity concerns the degree to which the conclusions of a study are based on the available data. To counter this risk, we have presented and discussed our findings with practitioners of software-intensive businesses. In this context, no major ambiguities or inconsistencies were found [WR00].

5.3.4 Discussion

In this study, we conducted a comprehensive grey literature review to extend our previous understanding of how practitioners conduct product roadmapping in a dynamic and uncertain market environment. In this context, we identified 170 articles that focused on the main topic of product roadmapping and decided to categorize the variety of articles according to the following subject areas: 1) product roadmapping processes, 2) product roadmap formats, 3) product roadmap prioritization techniques and 4) alignment of various stakeholders around the product roadmap. Each of these subject areas provides us with valuable insights into novel methods for conducting product roadmapping in a dynamic market environment with the associated uncertainties. This means insights into the issues of what structure and items a roadmap can have, what phases a roadmapping process can consist of, what methods can be used to prioritize the content of the roadmap as well as to achieve alignment around the product roadmap. Since the source of our results was the experiences of practitioners, we consider these findings as successfully proven in practice and thus provide a fundamental basis to develop possible solutions to the problems we have identified.

Moreover, we identified challenges companies face in developing and maintaining product roadmaps in a dynamic and uncertain market environment. The analysis of the articles showed that the challenges identified by the GLR are primarily in line with the findings from the expert interviews (see Chapter 5.1) and web survey (see Chapter 5.2). This means that, overall, the challenges related to product roadmapping are to be considered very heterogeneous, i.e., they concern various subject-specific and organizational aspects. As a key challenge, the GLR revealed a feature-driven mindset, i.e., discussion about detailed outputs guides the roadmapping process but ignores outcomes to be delivered to the customers and the business. Such a feature-driven mindset leads to the creation of feature-driven roadmaps. This is also in line with our findings in our previous results.

In addition, a major challenge identified by the GLR and the previous studies is that roadmap items are often defined based on the opinions of management or experts. This indicates that such companies do not conduct product discovery activities. However, the expert interviews and the web survey showed that the results are split regarding the execution of product discovery activities. In detail, 45 companies do not perform product discovery activities, while at 34 companies, product discovery activities are an integral part of the product development processes. This means that 57 percent of the participating companies have realized that conducting product discovery activities is essential to develop product roadmaps in a dynamic and uncertain market environment. In this context, the GLR uncovered two new findings: On the one hand, those companies performing product discovery activities struggle to identify how many resources to invest in discovery and validating features. The main reason for this is that resources for conducting product discovery are often severely limited; thus, not all features can be systematically discovered and validated. This leads to the issue that many companies, especially their product owners, do not know how much resources they should spend to conduct methods for discovering, evaluating, and validating certain outputs. In addition, there is the risk of trying to produce a complete body of evidence, e.g., repeatedly confirming findings that have already been discovered to make convincing arguments to critics. This can easily lead that the effort spent on product discovery activities exceeding the value delivered to customers, resulting in wasted time and resources. In this context, our GLR identified that companies face the challenge of finding approaches to integrate their product discovery activities with product development and delivery. Our survey also indicated this, as only 9 out of 66 companies apply such an approach. Without the integration with product discovery and product development and delivery, there is the risk that the knowledge gained from the product discovery activities is not or is only partly considered in the software development and delivery process. Therefore, it is likely that the product to be developed does not fully meet the customers' needs. In summary, it can be said that developing approaches to address these two problems will help companies to transform their product roadmapping practices to a dynamic and uncertain market environment.

5.3.5 Conclusion

The GLR showed, as already the expert interviews and the web survey, that companies are confronted with different challenges regarding product roadmapping. Since the GLR included perspectives and knowledge from practitioners in the United States of America, the United Kingdom, and Europe, it can be said that the challenges identified in this thesis apply not only to the German-speaking region but also to an international context. The analysis of the relevant articles in this GLR that focus on current road mapping methods underscores that product managers often have a good understanding of conducting product roadmapping in a dynamic and uncertain market environment. However, many product managers struggle to demonstrate the management evidence of the need for a product roadmap transformation. This confirms our findings from our previous studies that product managers need a tool to visualize and evaluate their current product roadmapping practice that serves as a basis for identifying improvement potentials. In addition, the expert interviews and web survey showed that some companies in Germany are struggling to identify and establish suitable methods for transforming their product roadmap. Examples, therefore, are methods for the definition of outcomes, the establishment of product discovery activities, or methods that foster the creation of alignment around the product roadmap. On the other hand, the expert interviews and web survey showed that companies with mature product roadmapping practices need support to evolve their product roadmapping practices further. Examples include providing a method to figure out how much resources to invest in product discovery activities or approaches to integrate product discovery with product development and delivery. In addition to these findings, our GLR has shown that the application of product roadmapping in German companies is less advanced compared to international companies. Therefore, the results from our grey literature review provide an excellent basis for developing approaches to support German companies in transforming their product roadmapping practices.

Chapter 6

Alignment of Problems, Requirements and Goals

6.1 Problems

Based on the state of practice and research, four problems were identified that are addressed by the approach presented in this dissertation.

Problem 1: Companies have no reliable method and tooling to determine their current status of product roadmapping. Usually, several product managers have a good awareness of how to perform product roadmapping in a turbulent market environment. However, they lack a tool to systematically visualize the current applied product roadmapping practices and identify weaknesses. This includes the problem that product managers are facing the challenge of determining a suitable starting point for the product roadmap transformation process. In addition, product managers struggle to convince management and other stakeholders to allocate resources and budget to transform current product roadmapping practices to operate successfully in a turbulent market environment.

Problem 2: Companies lack competencies and approaches for transforming their product roadmapping practices. In order to transform the product roadmapping practice to the demands of a turbulent market environment, it is not sufficient to know the current state of product roadmapping. It is also necessary to identify which improvement areas should be tackled first to transform the current product roadmapping practices. In addition, methods must be determined that lead to an improvement of the selected improvement area. In many cases, such decisions are not made systematically and empirically but are determined subjectively by experts. Consequently, in practice, this leads to companies selecting an improvement area of product roadmapping in which the company has already reached a high level of maturity or selecting measures that are not suitable for improving a selected improvement area. Both cases result in little to no progress in transforming product roadmapping practices to a turbulent market environment and lead to a waste of resources such as time or budget.

- **Subproblem 2.1: Companies (especially product managers or product owners) do not know how much resources they should spend on product discovery.** One critical capability for product roadmapping in a turbulent market environment is to identify and validate those contents on the product roadmap that delivers the most value to the customer and the business. To meet this capability, conducting product discovery is essential. However, on the one hand, resources are limited, and therefore, not all features can be explored by product discovery activities. On the other hand, it can happen that the effort spent on user research activities exceeds the value delivered by the respective feature. This leads to the issue that many companies and their product owners do not know how much resources they should spend to conduct product discovery.

- **Subproblem 2.2: Companies struggle to integrate product discovery processes in their software development and delivery.** In addition to subproblem 2.1, companies are facing the challenge of integrating product discovery activities with their product development and delivery. Not considering such integration can lead to the circumstances that the results of product discovery are not taken into account within the product development and delivery. Consequently, there is the risk that products or features are developed that do not meet the customers' needs.

6.2 Requirements on the Solution Approach

Based on our problems identified, a list of requirements for the solution approach in this dissertation was derived.

- **Requirement 1:** The approach should provide an easy-to-use systematic assessment of the current state of product roadmapping.
- **Requirement 2:** The approach should support practitioners in uncovering the most promising areas of improvement in terms of product roadmapping as well as prioritize them.
- **Requirement 3:** The approach should provide practitioners with guidelines on what steps are required for a product roadmap transformation.
- **Requirement 4:** The approach should serve as a decision support tool for practitioners to identify suitable methods for transforming the product roadmap and evaluate their success.
- **Requirement 5:** The approach should support practitioners in identifying how much resources should be spent to identify and validate possible solutions.
- **Requirement 6:** The approach should support practitioners in integrating their often loosely coupled product discovery activities with product development and delivery.

6.3 Mapping Problems to Requirements

	R1: Easy-to-use systematic self assessment	R2: Uncover the most promising areas of improvement	R3: Guidelines on what steps are required for a transformation	R4: Decision support to identify suitable transformation measures	R5: Support to idenify how much resources should be invest in product discovery	R6: Integration support for product discovery into product development and delivery
P1: No reliable method to identify the current state of product roadmapping	X					
P2: Lack of competencies for transforming their product roadmapping practices		X	X	X	X	X
SP2.1: Lack of methods to identify how many resources should spend on product discovery					X	
SP2.2: Struggle to integrate product discovery in the software development process						X

Figure 6.1: Mapping problems to requirements

6.4 Mapping Requirements to Goals

The requirements relate to objectives G1 to G4 as follows:

	G1: Provide a tool with which software-intensive companies are able to assess their current product roadmapping practices	G2: Develop an approach that guides companies through the transformation process of the product roadmap	G3: Create a supportive tool for practitioners to decide how much effort is needed and which methods are suitable for conducting product discovery	G4: Provide an approach that supports the integration of product discovery with the product development and delivery of a company
R1: Easy-to-use systematic self assessment	X			
R2: Uncover the most promising areas of improvement		X		
R3: Guidelines on what aspects are required for a product roadmap transformation		X		
R4: Decision support to identify suitable measures for the product roadmap transformation		X		
R5: Support practitioniers systematically conduct product discovery			X	
R6: Integration of user research activities into the product delivery				X

Figure 6.2: Mapping requirements to goals

6.5 Summary

This subsection presents an overview of the problems of the state of practice. As mentioned, based on the current state of practice, the following two major problems could be identified: 1) Companies have no reliable method and tooling to determine their current status of product roadmapping, and 2) companies lack competencies and approaches for transforming their product roadmapping practices to a dynamic and uncertain market environment. One reason for the first problem is that often management has the accountability of the roadmap, and product management struggles to demonstrate to management the need for a product roadmap transformation. As a consequence of the problems, many companies still use traditional product roadmapping approaches (feature-driven product roadmaps) that do not work in a dynamic and uncertain market environment. Nevertheless, some companies have realized the need for new approaches and procedures to product roadmapping and are in the process of transforming various areas of their product roadmaps. However, our research indicates that the measures to transform the product roadmap tend to be selected arbitrarily, so there is no systematic analysis of which areas should be chosen to achieve the most progress. Therefore, systematically identifying which areas should be tackled for improvement will support companies in transforming their product roadmapping practices. This includes recommendations on what actions should be performed to achieve this improvement. Furthermore, our study to identify the state of practice has shown that product discovery is a crucial activity for the success of product roadmapping in a dynamic and uncertain market environment. With regard to the conduction of product discovery, we could identify two problems: On the one hand, companies are struggling to identify how much resources they should spend on conducting product discovery and, on the other hand, which approaches can be used to integrate discovery activities with product development and delivery. Since both of these problems contribute to a successful product roadmap transformation, they were formulated as subproblems of the problems of the company's lack of competencies and approaches for transforming their product roadmapping practice. Based on the problems mentioned above, concrete requirements were derived, and on this basis, goals for this thesis were formulated. Achieving these goals should adequately support software-intensive companies in transforming their product roadmapping practices and answers the research questions mentioned in Chapter 1 and, consequently, the practitioners' problems stated in Chapter 5.

Chapter 7

Development of the DEEP Product Roadmap Assessment Tool

This chapter presents the first step of our solution approach, which consists of developing a product roadmap assessment tool. This was done in the phase "design and development of the artifact" within the design science research framework (see Figure 1.1). After developing our artifact, we verified its functionality based on the experience and corresponding business context of practitioners in an expert workshop. Therefore, this chapter covers also the phase "demonstration of the artifact" of the design science process (see Figure 1.1). The product roadmap assessment tool aims to provide product management with a tool to assess and visualize the current state of product roadmapping. The visualization of the current state of product roadmapping can be used to demonstrate management current weaknesses systematically and thus convince management of the need for a product roadmap transformation. Furthermore, the assessment results serve as a basis for analyzing which areas of the current product roadmap process promise the most benefit for improvement. To achieve our objective, we have defined the following research questions:

- **RQ1:** What are the relevant dimensions of product roadmaps in dynamic and uncertain market environments?
- **RQ2:** How can maturity be characterized along these dimensions?
- **RQ3:** How can the overall roadmapping maturity be determined and described?

The chapter extends the following publication.

- J. Münch, S. Trieflinger, and D. Lang. 'DEEP: the product roadmap maturity model: a method for assessing the product roadmapping capabilities of organizations'. In: *Proceedings of the 2nd ACM SIGSOFT International Workshop on Software-Intensive Business: Start-ups, Platforms, and Ecosystems*. 2019, pp. 19–24

7.1 Research Design

To develop and visualize the product roadmap assessment tool, we decided to conduct expert workshops. The results from the systematic literature analysis (see Chapter 3 and 4) and our insights from the studies to identify the current state of practice (see Chapter 5) serves as inputs for the workshops. The expert workshops aim to identify aspects of product roadmapping in which companies differ. We named these aspects "dimensions" and defined five stages for each dimension.

The expert workshops were attended by two researchers and one expert from a large automotive industry company with six years of experience in the field of product roadmapping. We selected the practitioner based on his extensive experience with product roadmapping and his position as a product management executive. The expert workshop was held on 17 May 2019 and lasted 6 hours. Within the workshop, we used the findings from the expert interviews, discussed the relevant dimensions for the product roadmap assessment tool, and identified different maturity stages for each dimension. This led to the identification of nine dimensions, each assigned to five stages. Afterward, these stages were annotated with scores that reflect their maturity. The idea of such scoring is that practices are comparable with respect to their maturity. An example of this is that having an expert decide which items are included in the roadmap resulted in a lower score than using product discovery to identify items on the roadmap.

In order to initially demonstrate the applicability of the model, we used five transcripts of the expert interviews mentioned in Chapter 5.1. These transcripts were arbitrarily screened out for an initial demonstration and therefore were not used in the development of the model. Based on the descriptions of the interviewees regarding their current product roadmapping practices, we applied the model and determined the maturity level of each company. Thus, weaknesses of the model, such as inconsistencies in weighting or unclear definitions of elements of the model, have been uncovered and could be discussed and fixed.

7.2 Results

7.2.1 Dimensions of the DEEP Product Roadmap Assessment Tool

With regard to RQ1, our research resulted in the identification of nine relevant dimensions (D1-D9). These dimensions were named and sorted by priority as follows:

Dimension 1: Items to be found on the roadmap. A suitable roadmap for digital products contains items of different granularity (from products to outcomes to the vision). The product roadmap should not only describe what will be built but also why it should be built. This requires that roadmap items are connected to outcome-oriented goals, i.e., customer- or business-oriented goals. The product roadmap items should contribute to delivering value to customers and the business. The roadmap also needs to be aligned with the product vision.

Dimension 2: Adequacy of item detailing based on the timeline. Items should be more detailed the closer they are in time. For example, the roadmap should not contain detailed long-term planning. The reason is that features typically need to be discovered and validated before they are planned in detail. Defining detailed features in long-term planning usually leads to unnecessary upfront efforts and might lead to promises that engineering cannot deliver on. Figure 7.1 shows a detailed planning over a long-time horizon on the right side, while on the left side, the level of detail decreases as time progresses. Due to the high market dynamics that change the market conditions, it is likely that the mid- and long-term planning on the right side will no longer contribute to the achievement of the customer and business goals at the time of their delivery (waste).

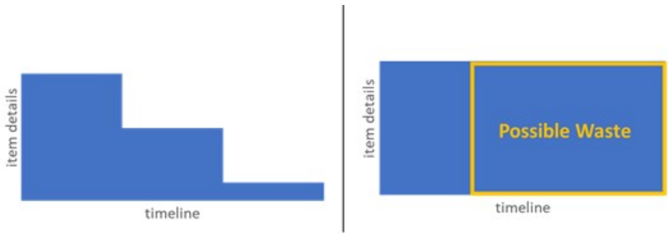

Figure 7.1: Adequacy of item detailing based on the timeline

Dimension 3: Reliability. Reliability can be seen as the trustworthiness of a roadmap and its ability to give orientation to an organization and its teams. This mainly depends on the roadmap's stability and how adjustments are made. A roadmap should be stable in a way that changes are only done in a systematic and justified manner. There should be a reason for changing the roadmap and a regular cadence for revisiting and refreshing the roadmap. Ad hoc and not sufficiently justified changes should be avoided. This helps to better understand what should be delivered in the next cycle and avoid those uncertain features being seen as a promise to deliver.

Dimension 4: Confidence. Confidence describes the trust in a roadmap item regarding its ability to fulfill the respective goal/s with the appropriate cost. It also illustrates the tentative nature of roadmap items in mid-term planning. The short-term planning should consider only roadmap items with high confidence about their contribution to the respective goals. The mid-term planning should indicate the degree of confidence in potential roadmap items with respect to contributing to goals.

Dimension 5: Product Discovery. This dimension describes the ability of a company to identify and validate items on the roadmap before implementation. The seamless integration of discovery activities in the product development process helps avoid building features that nobody wants or needs. Using product discovery techniques (such as customer interviews or observations) before deciding about features to implement can be seen as an indicator of high maturity in product roadmapping in dynamic technological and market environments.

Dimension 6: Placing features on the product roadmap. This dimension defines who can decide about placing items onto the product roadmap. A clear responsibility is necessary to pursue the product strategy and simultaneously coordinate stakeholder needs. Product management or cross-functional product teams should be established in a way that they can take over the responsibility of placing items on the roadmap.

Dimension 7: Prioritization of roadmap items. This dimension describes how roadmap items are prioritized and which factors are taken into consideration. The prioritization should aim at finding the most efficient and effective way to deliver value to the customer and the business. Having a clear prioritization process helps to integrate all stakeholder needs early and to align these around the priorities. With insufficient prioritization, the most important items might not be done first, and chances to do them later might be endangered.

Dimension 8: Ownership This dimension answers the question of who owns the roadmap (if someone at all). The owner of the roadmap should not be separated from those who create the roadmap. Having no ownership might lead to conflicts and inconsistencies.

Dimension 9: Level and subject of alignment. This dimension specifies the depth and width of alignment of the roadmap, i.e., how many stakeholders are covered with the roadmap and how well the alignment is. The product roadmap will not fulfill its purpose without the alignment and buy-in of the key stakeholders. All stakeholders must have individualized but consistent representations of a common roadmap that reflects their information needs. A process for achieving alignment and buy-in needs to be in place (i.e., through regular cross-functional meetings and workshops).

7.2.2 Stages of the DEEP model

As mentioned above, we assigned each of the nine dimensions to five stages representing commonly applied product roadmapping practices. As discussed in 5, the analysis of the state of practice revealed that the status quo of product roadmapping is very heterogeneous. We, therefore, decided to use five stages (S1-S5) for each dimension. Using a five-stage model for each dimension enables organizations to recognize their status quo but keeps the complexity on an efficient level. The stages are defined as follows by having an increase in maturity from S1 to S5:

Dimension 1 (D1): Items to be found on the roadmap:

- **D1.S1:** The product roadmap contains only products.
- **D1.S2:** The product roadmap contains only features.
- **D1.S3:** The product roadmap contains customer-oriented goals.
- **D1.S4:** The product roadmap contains topics (e.g., connected mobility or smart home and customer / business-oriented goals.
- **D1.S5:** The product roadmap contains a product vision, themes (high-level customer and system needs), customer / business-oriented goals and features for the short-term.

Dimension 2 (D2): Adequacy of item detailing based on timeline:

- **D2.S1:** Next steps are planned ad hoc, and there is no mid- to long-term view. Only short-term planning.

- **D2.S2:** All tasks are planned and worked out in detail for short-, mid-, and long-term views.
- **D2.S3:** The detailing is not done systematically and does not reflect the necessity for detailing, i.e., events in the future are more detailed than higher prioritized work packages that are planned closer in time.
- **D2.S4:** There is a clear correlation between timeline and detailing. The closer in time, the more details.
- **D2.S5:** The detailing depends on the timeline. Short-term items are detailed, prioritized, estimated, and evaluated. Mid-term items are under evaluation, and the long-term view contains themes only.

Dimension 3 (D3): Reliability:

- **D3.S1:** The roadmap is subject to permanent ad hoc adjustments, and therefore there is little trust in it.
- **D3.S2:** The roadmap is subject to frequent ad hoc adjustments and provides low orientation.
- **D3.S3:** The roadmap is adjusted in regular review cycles, but adjustments create confusion and relatively high effort.
- **D3.S4:** The roadmap is subject to systematic change management, and adjustments are done reactively. The process of roadmap adjustments is controlled and allows to react to, for example, disruptive market changes, but it is not actively shaped.
- **D3.S5:** The roadmap is subject to systematic change management, and adjustments are done proactively. The roadmap is built in a way that adjustments are only necessary for strategic changes.

Dimension 4 (D4): Confidence:

- **D4.S1:** It is not considered which effect the roadmap item has.
- **D4.S2:** The effect of roadmap items is considered but only estimated.

- **D4.S3:** The effect of roadmap items is considered and determined based on the past and extrapolated for the future (e.g., statistics).
- **D4.S4:** The effect of roadmap items is considered and partly evaluated.
- **D4.S5:** The effect of roadmap items is considered and systematically determined and evaluated.

Dimension 5 (D5): Discovery:

- **D5.S1:** There is no discovery, but the manager defines the roadmap items.
- **D5.S2:** There is no discovery. Roadmap items are identified based on expert knowledge.
- **D5.S3:** There is no discovery, but customer requests are considered when defining roadmap items.
- **D5.S4:** Professional discovery is used to define roadmap items, but the abilities for delivery are not considered.
- **D5.S5:** Professional discovery is used to define roadmap items and is closely integrated with delivery.

Dimension 6 (D6): Placing items on the product roadmap

- **D6.S1:** In order to decide if an item is added to the roadmap, simplified tools are used (e.g., a decision matrix).
- **D6.S2:** The top management is deciding about the contents.
- **D6.S3:** The middle management is deciding about the contents.
- **D6.S4:** The decision is delegated to special roles (e.g., portfolio manager, domain owner, etc.).
- **D6.S5:** Autonomous and cross-functional product teams decide about putting items onto the roadmap to reach goals.

Dimension 7 (D7): Prioritization of roadmap items:

- **D7.S1:** First in, first out – the items are listed in chronological order.
- **D7.S2:** Opinions determine priority. These can, for example, be based on sales requests and analyst recommendations or so-called "me-too features" from the competition.
- **D7.S3:** Prioritization is based on the capability to deliver (e.g., low-hanging fruits).
- **D7.S4:** Priority is based on short-term benefit (e.g., shareholder value).
- **D7.S5:** Priority is based on vision and sustainable value proposition.

Dimension 8 (D8): Ownership

- **D8.S1:** The product roadmap has no owner.
- **D8.S2:** The manager owns the product roadmap.
- **D8.S3:** The ownership of the product roadmap is shared between multiple roles.
- **D8.S4:** The department strategy or portfolio planning owns the product roadmap.
- **D8.S5:** The product management or product teams own the product roadmap.

Dimension 9 (D9): Extent of alignment

- **D9.S1:** There is only one roadmap that covers the interests of the top management.
- **D9.S2:** There are one or several roadmaps that cover the interests of the internal stakeholders.
- **D9.S3:** There are separate roadmaps to cover internal and external stakeholder interests.

- **D9.S4:** There is one central product roadmap (for each product) that meets the needs of the business, employees, and potential investors.
- **D9.S5:** There is one central product roadmap (for each product) that focuses on the needs of the business, employees, potential investors, and the customer at the same time. This roadmap can be extended by different views for specific stakeholders, but they must be consistent regarding the contents.

Inserting the dimensions as rows and the stages as columns leads to a matrix, as shown in Figure 7.2. As the Figure also shows, there is an increase in maturity from left to right. Consequently, the more right the stage is located, the more purposeful the corresponding product roadmapping practice is for successful product roadmapping in a dynamic and uncertain market environment. Moreover, during our research, we observed that the identified dimensions and their corresponding stages differ in their impact regarding a successful product roadmapping. For example, being mature in D1 and D2 was found to be more relevant than achieving excellence in D7 – D9 only. Furthermore, the stages also contribute differently to reaching maturity. Moving from S1 to S2 can, for example, contribute less to the overall maturity than moving from S4 to S5 since the gap (capabilities and processes that need to be built to reach the next stage) between S4 and S5 could be bigger. To include these observations in our maturity model and provide a valuable assessment tool, we decided to integrate a scoring model. This considers that those dimensions that have a high impact on the success of product roadmapping (D1, D2) are annotated with a higher score than those with a low impact (D7 – D9). Moreover, using a 100- point scoring model simplifies and increases usability. In addition, a 100-point scoring model leaves enough possibilities to represent the differences in importance between the dimensions and stages. The first version of our product roadmap assessment tool is shown in Figure 7.2.

Dimension	Stage of Maturity				
Items to be found in the product roadmap	Products (1 point)	Features (3 points)	Customer- and business-oriented goals (8 points)	Topics (e.g., connected mobility or smart home and customer / business-oriented goals (15 points)	Product vision, themes (i.e, high-level customer/ system needs), customer / business-oriented goals, and short-term features (20 points)
Adequacy of item detailing based on the timeline	Next steps are planned ad hoc and there is no mid- to long-term planning. Only short-term planning exists (1 point)	All tasks are planned and worked out in detail for short,- mid- and long-term (3 points)	The detailing of the items is not done systematically and does not reflect the necessity for detailing (10 points)	There is a clear correlation between time and the level of detail. The timelier items are more detailed (12 points)	The detailing depends on the timeframe. Short-term items are detailed, prioritized, estimated and validated. Mid-term items are under validation or being discovered. The long-term timeframe contains themes only (20 points)
Reliability	The product roadmap is subject to permanent ad-hoc adjustments. (1 point)	The product roadmap is subject to frequent ad-hoc adjustments. (3 points)	Adjustments of the product roadmap are done in regular review cycles. (8 points)	The product roadmap is subject to systematic change management and adjustments are done mainly reactively. (12 points)	The product roadmap is subject to systematic change management and adjustments are done mainly proactively. (16 points)
Confidence	The effects/impacts of product roadmap items are not considered. (1 point)	The effects/impact of product roadmap items is considered but only estimated. (4 points)	The effects/impacts of product roadmap items are considered and determined based on the past (e.g., statistics) (7 points)	The effects/impacts of product roadmap items are considered and partly validated. (10 points)	The effects/impacts of product roadmap items are considered and systematically validated. (14 points)
Discovery	No discovery activities. Typically, a manager is defining the roadmap items. (1 point)	No discovery activities. Product roadmap items are identified based on expert knowledge. (2 points)	No discovery activities. Product roadmap items are identified based on customer requests. (4 points)	Professional discovery activities but no or only lose integration with delivery activities (8 points)	Close integration of discovery and delivery activities (10 points)
Placing features on the product roadmap	Tools are used to decide if items are placed on the roadmap (e.g., decision matrix) (1 point)	Higher-level management (2 points)	Middle management (2 points)	Specific roles (e.g., portfolio manager) (3 points)	Product management or cross-functional product team in liaison with key stakeholders (6 points)
Prioritization of product roadmap items	First in first out (1 point)	Opinions determine priority (2 points)	Prioritization is based on the capability to deliver (e. g. low hanging fruits) (3 points)	Prioritization is based on short-term benefit (e.g., shareholder value) (3 points)	Prioritization is done with an established process and focuses on delivering value to customers and the business. (6 points)
Extent of Alignment	No alignment. No one or only one stakeholder such as high-level management has a product roadmap that is not communicated to others. (1 point)	Several loosely connected product roadmaps for internal stakeholders exist. (1 point)	Several loosely connected product roadmaps for internal and external stakeholders (such as customers or investors) exist (2 points)	One central product roadmap exists for different internal and external stakeholders. (3 points)	One central product roadmap exists that allows to derive different representations for different stakeholders. A process for achieving alignment and buy-in is in place. (3 points)
Ownership	No owner defined (1 point)	Managers (2 points)	Ownership is shared between multiple roles (3 points)	Strategy or portfolio planning (4 points)	Product management or product team (5 points)

Figure 7.2: First version of the DEEP Product Roadmap Assessment Tool

7.2.3 Levels of the DEEP model

A company can perform an assessment by selecting the applicable stages for each dimension and summing up the corresponding score. Then a total score is calculated that reflects the overall maturity of the roadmapping practices. The total score calculated by summing up the nine dimensions of the DEEP model is mapped to five maturity levels (see Table 7.1). The minimum score that can be reached is nine points, the maximum is 100. Since dimensions D1 and D2 are considered the most relevant ones, we decided to set the upper barrier for a level when D3-D9 are already on Sx, but D1 and D2 remain on S(x-1). For example, for level one, that means D1S1 + D2S1 + D3S2 + D4S2 + D5S2 + D6S2 + D7S2 + D8S2 + D9S2. The lower barrier for the next level is defined to be one point above the upper barrier from the level below.

Table 7.1: Levels of the DEEP Model

Score	**Overall Maturity Level**
9 - 18 points	Level 1
19 - 35 points	Level 2
36 - 61 points	Level 3
62 - 87 points	Level 4
88 - 100 points	Level 5

Figure 7.3 shows the meaning of a higher level after summing up the points of the selected nine dimensions: The higher the level, the more orientation and confidence the roadmap provides and takes into account the delivery of value to the customer and the business. We chose these two aspects because we believe they are critical to the success of product roadmapping in a dynamic and uncertain market environment.

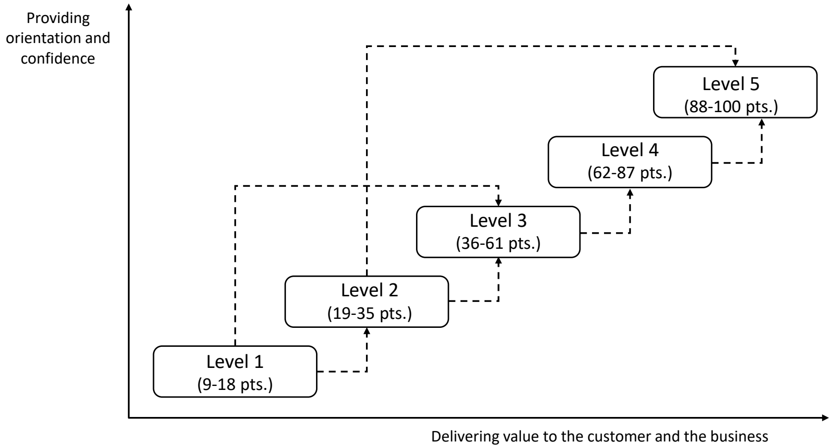

Figure 7.3: Meaning of the DEEP Levels

7.3 Threats to Validity

In order to discuss the validity and trustworthiness of our study, we applied the framework provided by Yin [Yin09]. This framework consists of four aspects 1) construct validity, 2) internal validity, 3) external validity, and 4) reliability. Each aspect is discussed below. **Construct validity:** Regarding construct validity, there is the threat that the expert involved in the development of the DEEP model misunderstood the goal and purpose of the research. To address this, the objective and purpose were discussed with the expert before the research question was defined. This includes discussing technical terms to ensure that all three persons involved in developing the DEEP model are using the same terms with the same meanings. **Internal validity:** Internal validity includes the threat that the use of knowledge to develop the DEEP model is incorrect or valid only in a particular context. Therefore, we have selected an expert with several years of experience in the field of product roadmapping and operating in the software-intensive business. In addition, different views and opinions of the participants were discussed during the model development, and the results were finally documented after all participants had agreed. **External validity:** The basis for developing the DEEP model was the previously conducted expert interviews and the participants' specific knowledge in the expert workshops. All of these experts operate in German companies or universities focusing on software-intensive business. Therefore, the impact of cultural differences cannot be excluded. **Reliability:** One risk to reliability is the bias of the expert who participated in the workshop due to familiarity with the processes only from his own company. In order to counteract this threat, the knowledge of two researcher was additionally involved in the model development. In addition, the DEEP model is also based on the views and opinions of several practitioners from various companies that participate in the previously conducted interview study. Moreover, there is the threat that the insight provided by the expert may not fully reflect his experience or the reality of their business. This is mitigated by the fact that participants had no incentive or motivation to report false facts. In addition, the findings from the identification of the state of practice (see Chapter 5) served as the basis for the model development.

7.4 Conclusion

In this study, we presented the first version of our product roadmap assessment tool that represents the first part of the solution approach in this thesis. The model is especially suited for companies that operate in the software-intensive business. The DEEP model was developed with the goal of providing practitioners with a tool to assess their organization's product roadmap capabilities. The model consists of nine dimensions, each comprising five stages. Each dimension describes a relevant aspect of product roadmapping, such as roadmap detailing, reliability, or confidence. Each dimension includes five stages representing common product roadmapping practices for the corresponding dimension. In addition, each stage was assigned with scores that reflect their maturity. A company can conduct an assessment by selecting the applicable stage for each dimension that most closely reflects their currently applied product roadmapping practices. After summing up the scores for the nine selected dimensions, a company receives its overall maturity level for product roadmapping. An initial demonstration of the comprehensibility, applicability, and usefulness of the assessment model was conducted by applying the DEEP model to documented statements made by practitioners in the previously conducted expert interview study. Further research included the validation of the model by practitioners to refine it based on their perceptions.

Chapter 8

Expert Interview Study to Validate the DEEP Product Roadmap Assessment Tool

As the first step to verify the comprehensibility, applicability, and usefulness of the DEEP model, we conducted expert interviews with practitioners of the software-intensive business. This takes place in the phase "evaluation of the artifact" in the design science research process (see Figure 1.1). The aim of this study is to identify how practitioners perceive the DEEP model and to obtain feedback to refine the model. In order to achieve this objective, we have defined the following research questions:

- **RQ1:** Can practitioners easily and efficiently use the model for assessing the product roadmap maturity of their organization or organizational unit?
  - **RQ1.1**: Do practitioners understand the questions, dimensions and stages of the DEEP model?

  - **RQ1.2**: Can practitioners easily map the dimensions and stages to their organizational context to conduct the self-assessment?
- **R2:** Can practitioners easily and efficiently use the model for assessing the product roadmap maturity of their organization or organizational unit?

The chapter extends the following publication.

- J. Münch, S. Trieflinger, and D. Lang. 'The product roadmap maturity model DEEP: validation of a method for assessing the product roadmap capabilities of organizations'. In: *Software Business: 10th International Conference, ICSOB 2019, Jyväskylä, Finland, November 18–20, 2019, Proceedings 10*. Springer. 2019, pp. 97–113

8.1 Research Design

In order to validate and evolve the model, we provided the developed DEEP V1.0 product roadmap assessment tool to practitioners without any explanations or instructions. This was done to ensure that the participants applied the DEEP model unbiasedly and to get feedback regarding the comprehensibility, applicability, and usefulness of the model. For a better understanding, we have formulated a question for each dimension (e.g., what items do you use on your product roadmap?). In the next step, we conducted interviews with each practitioner to identify improvement potentials (e.g., ambiguities) of the DEEP model. All interviews were conducted by phone and by the same researcher. The average length of the interviews was 47 minutes, ranging between 31 and 81 minutes. All interviews were conducted in the German language. To focus and structure the interviews and to ensure thematic comparability, we developed an interview guide that consisted of the following questions: 1) What do you think are the strengths and weaknesses of the model? 2) Which phrases did you find difficult to understand during the application? 3) Does the calculated score reflect the status of your current product roadmapping process?

We recruited 14 experts who operate in a dynamic and uncertain market environment with high uncertainties. The selection of those participants was based on their experience in product roadmapping and their role in the organization (team lead, etc.). The search for suitable participants and the subsequent establishment of contact took place via a social business platform. Table 8.1 gives an overview of the participants in this study. The column "Experience" refers to the years in which the interviewee was involved in product roadmapping activities. Each interview was recorded. We analyzed the audio files by extracting the main responses, key statements, and quotes and revised the model based on the statements of the participants. We discussed these adjustments with a practitioner at Robert Bosch GmbH with many years of experience in the field of product roadmapping to obtain an additional expert opinion.

Table 8.1: Participating interviewees (first validation of the DEEP model) (size classification: small <50, large >250)

Interviewee	**Position**	**Experience**	**Company Size**
Interviewee 1	Product Manager	15 years	Large
Interviewee 2	Product Manager	7 years	Small
Interviewee 3	Head of Product Mgmt.	11 years	Large
Interviewee 4	Head of Product Mgmt.	6 years	Large
Interviewee 5	Head of Product Mgmt.	8 years	Medium
Interviewee 6	Product Manager	14 years	Medium
Interviewee 7	Product Manager	4 years	Large
Interviewee 8	Product Manager	18 years	Large
Interviewee 9	Product Manager	9,5 years	Small
Interviewee 10	Head of Product Mgmt.	9 years	Large
Interviewee 11	Head of Product Mgmt.	12 years	Medium
Interviewee 12	Software Engineer	5 years	Medium
Interviewee 13	Board member (CEO)	16 years	Small
Interviewee 14	Product Manager	9 years	Medium

8.2 Results

This section outlines the feedback that was gathered during the interviews. First, we present general feedback. Afterward, we structured the feedback according to those model dimensions that generated feedback we considered valuable for modifications in the model. In addition, we describe how we adjusted the model based on the feedback.

Overall, the current version of our model was described as comprehensible, applicable, and useful. For example, one participant stated: *"It is obvious that the model is designed to increase the customer value when developing products. From my perspective, the model provides useful insights to improve the current product roadmapping practice."* (Product Manager) Another participant mentioned: *"I think the model supports the identification of weaknesses regarding the current product roadmapping process and gives good insights to improve it."* (Head of Product Management) Another participant reported: *"What I find particularly pleasant about this model is the possibility to review the current roadmapping practice and learn which other possibilities exist to create and handle a product roadmap. I think the model helps identify relevant factors to improve the product roadmapping practice."* (Head of Product Management) The evaluation showed that all participants understood that they had to select the stage representing their current practices best for each dimension. In addition, the participants had no ambiguities regarding our developed scoring system. In detail, each participant understood that each dimension is assigned to a certain score so that the total score is calculated by summing up the points of each selected stage (which determines the maturity level). Nevertheless, to further increase the usability, we slightly improved the design of our model. In detail, we added a question for each dimension so that the different stages serve to answer these questions. This provides clearer instruction to the users, that has to answer the question by selecting one stage for each dimension. Besides the general feedback, the interviews provided comments and recommendations for improving specific dimensions. These comments and recommendations and the adjustments we made to the model will be discussed in the following.

Shift of the dimensions "prioritization of product roadmap items" and "extent of alignment": Seven participants noted that the dimensions "prioritization of product roadmap items" and "extent of alignment" have a higher impact on the success of product roadmapping than the dimension "responsible for placing items on the roadmap". Therefore, the dimension "responsible for placing items on the roadmap" was placed after the dimensions "prioritization of product roadmap items and "extend of alignment".

Dimension: Items to be found on the product roadmap: During the interviews, five participants mentioned difficulties matching the roadmap items they use in their current practice with a corresponding stage in the model. The reason is that their companies use several roadmap items, such as features, goals, topics, or themes. Since our model (in version 1.0) asked only for one type of item per stage (e.g., only products in the first stage), it was complicated for the participants to identify the stage that best matched their current roadmapping practices. Consequently, they did not know which stages to choose. However, after the participants considered the second dimension, "adequacy of item detailing based on the timeline," the answer got clearer. Therefore, we changed the sequence of the first two dimensions. In addition, we modified the phrasing of the different stages to emphasize those items that can mainly be found in a roadmap of a certain stage. Figure 8.1 shows the revised dimension "roadmap items".

Dimension	Stage of maturity				
Roadmap Items: Which items are on your product roadmap?	Mainly products (1 point)	Mainly products, features (3 points)	Mainly customer-oriented goals (10 points)	Mainly customer and business goals, products, features and for the long-term timeframe topics (e.g., smart home) (12 points)	Product vision, themes (i.e., high-level customer and system needs), customer/ business- oriented goals and short term features (20 points)

Figure 8.1: Revised dimension roadmap items

Dimension: Product discovery: Regarding this dimension, the expert interviews showed that the comprehensibility and evaluation of the different stages provided several challenges. First, the participants did not fully see the difference between the second and the third stage. For example, one participant asked: *"Does the stage 'no discovery activities. Product roadmap items are identified based on customer requests' only refer to the identification of requirements based on customer requests or does it also include expert knowledge?"* (Head of Product Management) To make it clear that each stage is considered separately from each other, we introduced the word "mainly" in the second stage (i.e., "product roadmaps items are mainly defined based on expert knowledge."). This ensures that only those organizations select the second stage that mainly uses the knowledge of experts to define their product roadmap items. Similarly, in the third stage, we introduced the word "mainly" (i.e., "product roadmap items are mainly defined based on customer requests"). We chose the word "mainly" because it provides more flexibility. As a result, our model covers situations where the organization concerned identifies not only its roadmap items through customer requests but also uses the knowledge of experts.

Another challenge for the participants posed the term "professional" regarding the wording of the fourth stage, "Professional discovery activities but no or only lose integration with delivery activities." It was not completely clear to the participants which requirements had to be fulfilled to characterize their discovery activities as "professional discovery activities." To counter the confusion regarding the word "professional" within the third stage, we replaced "professional discovery activities, but no or only lose integration with delivery activities" with "several discovery activities are conducted (e.g., user research), but they are not or only loosely integrated with delivery activities." This ensures that each user obtains a better understanding of what is required for the fourth stage. Figure 8.2 shows the revised dimension "product discovery".

Dimension	Stage of maturity				
Discovery : How do you conduct product discovery?	No discovery activities. Typically, a manager defines the roadmap items. (1 point)	Product roadmap items are mainly defined based on expert knowledge. (2 points)	Product roadmap items are mainly defined based on customer requests (4 points)	Several discovery activities are conducted (e.g., user research), but they are not or only loosely integrated with delivery activities. (8 points)	Close integration of discovery and delivery activities (10 points)

Figure 8.2: Revised dimension product discovery

Dimension: Responsible for placing features on the product roadmap: Within this dimension, several participants saw the potential to improve the description of the stage with the highest maturity level. For example, one participant mentioned: *"In the current model, the highest level of responsibility for placing items on the product roadmap is called: 'Product management or cross-functional product team in liaison with key stakeholders'. In my opinion, product management working in a cross-functional way with other teams and management is the highest form of maturity."* (Head of Product Management) Another participant mentioned: *"I think, in an agile company, usually different collaborating teams are responsible for placing items on the product roadmap."* (Product Manager) Besides that, two participants stated that according to their experience, middle management plays a minor role compared to high-level management. In this context, one participant said: *"My experience is that decisions regarding the product roadmap are discussed less by the middle management and more often by the high-level management."* (Product Manager) According to this feedback, we summarized the two separate stages, "high-level management" and "middle management," into one stage. The practitioners saw product management in cross-functional collaboration with other teams as the highest maturity level. To integrate this insight into the model, we phrased the fifth stage in version 2.0 as follows: "Product management with cross-functional product teams in liaison with key stakeholders" (i.e., we changed "or" to "with"). In addition, the expert interviews revealed that most practitioners considered an organization more mature if the product management is responsible for placing items on a product roadmap instead of management. For this reason, we defined the fourth stage in a way that product management is responsible for placing items on the roadmap. Figure 8.3 shows the revised dimension "responsibility".

Dimension	Stage of maturity				
Responsibility: Who is responsible for placing items on the product roadmap?	Tools are used to decide if items are placed on the roadmap (e.g., decision matrix). (1 point)	Management (2 points)	Specific roles (e.g., portfolio manager) (3 points)	Product Management (4 points)	Product Management with cross-functional product teams in liaison with key stakeholders. (5 points)

Figure 8.3: Revised dimension responsibility

8.3 Threats to Validity

To discuss the threats to validity, we used the framework according to Yin [Yin09]. Internal validity is not discussed since causal relationships were not examined in the study at hand. **Construct validity:** One threat to the construct validity is the monotonous study sample. The selection of participants with diverse background from various companies mitigates this threat. **External validity:** The external validity is limited since this study involves experts from German companies developing software-intensive products and thus facing the challenge of a dynamic and uncertain market environment. Therefore, cultural differences to other countries cannot be excluded. **Reliability:** The reported results are based on the personal perceptions of each participant. Therefore, it cannot be excluded that the participants reported facts that do not reflect the truth. This threat is mitigated by participants' lack of motivation or interest in distorting the truth. In addition, it is conceivable that misunderstandings arose during the interviews since contact with the participants was brief. To counter this threat, email clarifications were requested from the interviewees when in doubt.

8.4 Conclusion

In this study, we conducted the first validation of the DEEP model and evolved the model based on feedback from the participants. Overall, the structure and content of the model were well received by practitioners. The practitioners participating in the evaluation did not identify major incompleteness or inaccuracies of the model. The results from applying the assessment model (i.e., the maturity levels) were widely in agreement with the own perceptions of the study participants. Therefore, it can be concluded that the model is comprehensible, applicable, and useful. Nevertheless, the interviews showed occasional ambiguities in the arrangement of some dimensions and wordings used in some stages. Therefore, the validation led to the rearrangement of some dimensions of the model, and the wording of some stages has been revised.

PRODUCT ROADMAP MATURITY ASSESSMENT

DEEP Version 2.0

ROADMAP DETAILING How adequate is your roadmap detailed with respect to the timeline?	1: Next steps are planned ad-hoc and there is only short-term planning.	3: All tasks are planned and worked out in detail for short-, mid- and long-term.	8: There is some correlation between time and level of detail, but the detailing of the items is not done systematically.	15: There is a clear correlation between time and level of detail. Timelier tasks are more detailed.	20: Short-term items are detailed, prioritized, estimated and validated. Mid-term items are under validation or being discovered. The long-term timeframe contains themes.
ROADMAP ITEMS Which items are on your product roadmap?	1: Mainly products	3: Mainly products, features	10: Mainly business goals, products, features	12: Mainly customer and business goals, products, features and for the long-term timeframe topics (e. g., smart home)	20: Mainly product vision, customer and business goals, products, features and for the long-term timeframe themes (i.e., high-level customer needs)
RELIABILITY How often do you adjust your product roadmap?	1: Permanent ad-hoc adjustments	3: Frequent ad-hoc adjustments	8: Mainly in regular review cycles (e.g., every 3 months)	12: Adjustments are mainly done reactively on demand.	16: Adjustments are mainly done proactively.
CONFIDENCE How confident are you that the roadmap items have the expected impacts on goals?	1: The impacts are not considered.	4: The impacts are mainly estimated by experts.	7: The impacts are mainly determined based on data from the past (e.g., statistics).	10: The impacts are partly validated.	12: The impacts are systematically validated.
DISCOVERY How do you conduct product discovery?	1: No discovery activities. Typically, a manager is defining the roadmap items.	2: Product roadmap items are mainly defined based on expert knowledge.	4: Product roadmap items are mainly defined based on customer requests.	8: Several discovery activities are conducted (e.g., user research) but they are not or only loosely integrated with delivery activities.	10: Close integration of discovery and delivery activities.
PRIORITIZATION How do you prioritize items?	1: First in, first out	2: Opinions determine priority	3: Prioritization is based on the capability to deliver (e.g., low hanging fruits).	3: Prioritization is based on short-term benefit (e.g., shareholder value).	6: Prioritization is done with an established process and focuses on delivering value to customers and the business.
EXTENT OF ALIGNMENT How do you align stakeholders?	1: No one or only one stakeholder such as high-level management has a product roadmap that is not communicated to others.	1: Several loosely connected product roadmaps for internal stakeholders exist.	2: Several loosely connected product roadmaps for internal and external stakeholders exist.	3: One central product roadmap exists for different internal and external stakeholders.	6: One central product roadmap exists that allows to derive different representations for different stakeholders. A process for achieving alignment is in place.
RESPONSIBILITY Who is responsible for placing items on the roadmap?	1: Tools are used to decide if items are placed on the roadmap (e. g., decision matrix).	2: Management	3: Specific roles (e.g., portfolio manager)	4: Product management	5: Product management with cross-functional product teams in liaison with key stakeholders.
OWNERSHIP Who owns the product roadmap and is accountable?	1: No owner defined	2: Managers	3: Ownership is shared between multiple roles.	4: Strategy or portfolio planning	5: Product management with cross-functional product teams.

MATURITY
Please sum up the number of points for the fields you selected.

Total points:	Maturity level:	1	2	3	4	5
	Score:	9 – 18 pts	19 – 36 pts	37 – 62 pts	63 – 87 pts	88– 100 pts
	Recommendation:	Complete reset of roadmapping practices		Incremental improvement of roadmapping practices		

Figure 8.4: DEEP model V2.0

Chapter 9

Development of the Product Roadmap Transformation Approach

The developed and validated DEEP model enables companies to self-assess their current product roadmapping practices. As a result of applying the DEEP model, the user receives the overall product roadmap maturity level of their currently applied product roadmapping practice and a score for each dimension. However, the DEEP model does not provide guidance on systematically analyzing which dimension should be tackled for transformation and what concrete methods should be conducted to improve the corresponding dimension. Consequently, improving one or several dimensions will lead to a higher level in the DEEP model. Therefore, we decided to return to the phase "design and development of the artifact" of the design science process (see Figure 1.1) and developed another artifact in addition to the DEEP model. As with the development of the DEEP model, we conducted the phase "demonstration of the artifact" (see Figure 1.1) by verifying the functionality of the developed artifact through the business context and experience of various practitioners. In more detail, this chapter introduces a product roadmap transformation approach that we built based on the DEEP model. The product roadmap transformation approach aims to replace the often traditional product roadmapping practices found in the weakly rated dimension in the DEEP model with practices that are suitable for creating and operating a product roadmap in a dynamic and uncertain market environment. To achieve our objective, we formulated the following research questions.

- **RQ:** How can companies transform their product roadmapping practice to a dynamic and uncertain market environment using the DEEP product roadmap self-assessment tool?

The chapter extends the following publication

- S. Trieflinger et al. 'A transformation model for excelling in product roadmapping in dynamic and uncertain market environments'. In: *Product-Focused Software Process Improvement: 22nd International Conference, PROFES 2021, Turin, Italy, November 26, 2021, Proceedings 22*. Springer. 2021, pp. 136–151

9.1 Research Design

We developed the product roadmap transformation approach by conducting expert workshops with three practitioners and two researchers. We selected the practitioners based on their practical experience with product roadmapping and their roles in the respective companies. The latter means that these participants are involved in the product roadmapping process in their company. In addition, each practitioner was also involved in developing the DEEP model. To integrate different perspectives into the model development, we selected a heterogeneous set of practitioners to participate in the expert workshops. This means that the practitioners differ in their industry sectors within the software-intensive business and company sizes. Table 9.1 gives an overview of the practitioners that participated in these workshops. We held three workshops on March 5, 2021 (1,5 hours), March 17, 2021 (1 hour), and March 30, 2021 (1,5 hours). Care was taken to ensure that there was sufficient time between the conduction of the various workshops to allow all participants to reflect on the results of the individual workshops. The same practitioners participated in all workshops. Due to the COVID-19 pandemic, the workshops were conducted online, and the tool Mural was used for documentation. To include the holistic product roadmap transformation approach, the conduction of the DEEP assessment was chosen as the start of our discussion. Then open discussions with the practitioners on what steps should be taken to reach a higher level with respect to the DEEP model were held.

Table 9.1: Practitioners that participated in the expert workshops (size classification: small < 50, large > 250)

Participant	**Position**	**Experience**	**Company Size**
Participant 1	IT Coordinator	7 years	Large
Participant 2	Head of Product Mgmt.	8 years	Small
Participant 3	Product Owner	2 years	Medium

9.2 Results

In the following, the product roadmap transformation approach that emerged from the expert workshops is outlined. The aim of the product roadmap transformation approach is to provide guidance and direction on what methods a company should take to transform its currently applied product roadmapping practice to a dynamic and uncertain market environment. The product roadmap transformation approach is an extension of the DEEP model and consists of the following three parts: 1) a process that proposes steps to transform the currently applied product roadmapping practices to a dynamic and uncertain market environment, 2) recommendations on how to proceed to select a dimension in the DEEP model to be improved and 3) two mapping tables that provide the user of the transformation approach with methods that lead to an improvement of the previously selected dimension. The product roadmap transformation approach is shown in Figure 9.1, and each of its phases is described in the following.

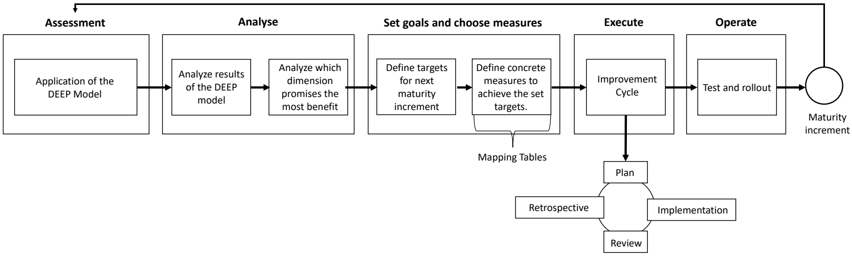

Figure 9.1: Product roadmap transformation approach

Analyze: Based on the results of the DEEP model, the first step of the product roadmap transformation approach is to analyze which dimension of the DEEP model promises the most benefit when improved. It should be noted that the lowest-rated dimension does not necessarily have to be the highest priority for improvement. The reason for this is that this decision also depends on the respective company context (e.g., market, industry), the company's goals, and the position of the person who plans and implements the methods (e.g., product owner, member of the management team, head of product management).

Set goals and choose measure: The phase "set goals and choose measure" includes the definition of a clear improvement objective and corresponding measures contributing to achieving the objective. An example of an objective could be to improve the dimension "extent of alignment" from level two to level four by establishing a process that fosters alignment. Conceivable measures in this context could be 1) the development of a common product vision by conducting workshops with various stakeholders, 2) the review of this product vision by conducting customer interviews, and 3) the consolidation of the content of all existing and loosely coupled product roadmaps based on the previously created product vision. To define suitable measures for the set objective, the product roadmap transformation approach provides appropriate guidelines. With the help of two mapping tables (see detailed description below), measures can be identified that contribute to improving the respective dimension. The transformation approach relies on empirical evidence as much as possible. Care should be taken to define appropriate key results for each measure to be delivered at the end of the iteration. This helps to analyze to what extent the defined objective has been achieved.

Execute: This phase aims to implement the improvement actions identified in the previous phase and analyze their impact on the roadmapping process. To implement the identified measures, we suggest using an iterative process including the following steps: 1) plan (the preparation for the execution of the identified measures), 2) implementation (the conduction of the identified measures), 3) review (the analysis of the impact of the conducted measures) and 4) retrospective (i.e., the reflection of the approach, for instance with workshops or interviews). Example questions for a retrospective could be: what went well, what did not go so well, and what actions need to be taken to improve the approach of enhancing the roadmapping practice?

Operate: Finally, the phase "operate" consists of additional tests in order to ensure that the new measures are conducted in line with the needs of the company. Subsequently the measures should be integrated into the process landscape of the company to ensure continuous implementation.

9.2.1 Procedure for Analyzing which Dimension Promises the Most Benefit for Improvement

An important step of the product roadmap transformation approach is identifying the most promising dimensions for improvement. This is done in the sub-step "analyze" which dimension promises the most benefit for improvement in the product roadmap transformation process described above (see Figure 9.2). The dimension reliability was excluded since the adaptability of the roadmap is primarily based on the dimension roadmap items and roadmap detailing. In the case that the assessment with the DEEP model results in the overall maturity levels three, four, or five (i.e., the respective level that a company has reached after summing up the points of the nine dimensions), we recommend selecting one of the following dimensions: 1) roadmap items, 2) roadmap detailing, 3) product discovery, 4) confidence, 5) ownership, 6) responsibility, 7) extent of alignment or 8) prioritization. In contrast, if a company is on an overall maturity level of one or two, we suggest disregarding the two dimensions of "prioritization" and "extent of alignment." The reason why the dimension "prioritization" got excluded is that an essential success factor for an effective and efficient prioritization process in a dynamic and uncertain market environment is to understand the value that should be delivered to the customer and the business. If a user of the DEEP model selects a stage that considers the factor customer value (independent of the dimension), this leads to an overall maturity of level three or higher. Consequently, a company at level one or two does not include the customer value (which is crucial for the prioritization) in the roadmapping process, and thus an improvement of the dimension prioritization within these levels is not advisable. The reason for excluding the dimension "extent of alignment" is that the product roadmap should be in a sufficiently mature state so that the stakeholders are able to align their activities with the roadmap. Therefore, the dimension alignment should not be considered until the product roadmap has reached a higher level of maturity.

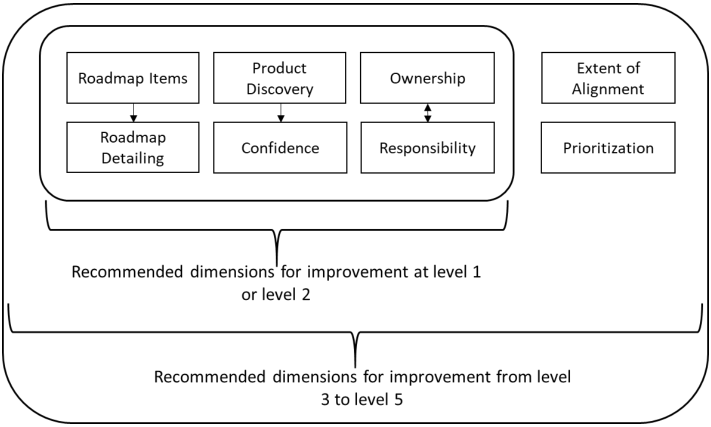

Figure 9.2: Process to identify the most promising dimension for improvement

Based on this pre-selection, the product roadmap transformation approach provides the following criteria as recommendations for the final determination of the dimensions to be improved:

- **Roadmap items and detailing of the roadmap:** We recommend considering improving the dimension "roadmap items" before improving the dimension "adequacy of item detailing based on the timeline (roadmap detailing)." The reason for this is that the usage of roadmap items of different granularity (such as products, themes, outcomes, and epics) is likely to lead to a correlation between the timeline and the level of detailing of the roadmap items. It should be noted that ideally, the short-term planning consists only of roadmap items with high confidence.
- **Product discovery and confidence:** We recommend considering improving the dimension "product discovery" before improving the dimension "confidence." "Product discovery" is the ability of a company to identify and validate products or features before implementation. Examples of this are conducting customer interviews, customer focus

groups, or rapid prototyping. The relationship between the dimensions "product discovery" and "confidence" can be explained in the following way: the conduction of product discovery activities aims at reducing the uncertainty to a level that allows starting to build a solution that provides value for the customers and the business. This includes high confidence that the planned solutions will greatly impact the customer and business goals. Therefore, conducting product discovery activities is likely to contribute to achieving confidence.

- **Ownership and responsibility:** The dimensions "ownership" and "responsibility" should be considered together. The dimension "ownership" describes who owns the roadmap (i.e., signs off and approves the roadmap), while the dimension "responsibility" answers the question of "who is responsible for defining the roadmap items and conducting the roadmapping process.
  - **Role and authority of the "change agents":** The role and authority of those who are responsible for the transformation of the product roadmapping practice in an organization must be considered. The extent to which improvement is promising and the extent to which improvement can be influenced must be weighed here.
  - **Company context and culture:** The corporate context and culture must also be taken into account when considering which dimension to select. Here, the impact of an improvement must be weighed against the associated effort.

9.2.2 Mapping Tables

After the conduction of the DEEP model and the analyses of the results of this assessment, including identifying the most promising dimension for improvement, the question arises of how this dimension can be improved. To answer this question, we developed two mapping tables which are shown in Figure 9.3 and Figure 9.4. These mapping tables aim to support practitioners on which measures can be selected to improve each dimension.

Goal Opportunity Map: The "Goal-Opportunity Map" in Figure 9.3 provides recommendations on how to improve a dimension of the DEEP model. For this purpose, the y-axis shows the dimensions of the DEEP model. Improving a dimension of the DEEP model can be achieved by creating artifacts (and the capabilities built through the artifact development) that are essential for the operation in a dynamic and uncertain market environment but are still missing in the current product roadmapping process. The artifacts included in the Goal-Opportunity Map were identified in the expert workshops.

Dimension / Artifact	Product Vision	Outcomes	Solution Ideas	Validated Learnings
Roadmap items	X	X	X	X
Roadmap Detailing		X	X	
Product Discovery		X	X	X
Confidence		X	X	X
Prioritization	X			X
Alignment	X	X		

Figure 9.3: Goal-Opportunity Map

Application of the Goal-Opportunity Map: The user can apply the “Goal-Opportunity Map“ (Figure 9.3) by entering the previously identified dimension (see y-axis) to obtain an artifact (see x-axis) that is needed to improve the corresponding dimension. This is marked in Figure 9.3 by the crosses that connect the dimensions and the artifacts. For example, the dimension “roadmap items” can be improved by developing the artifact product vision, while for the improvement of the dimension “product discovery,” the creation of outcomes can lead to an improvement. It should be noted that the "responsibility" and "ownership" dimensions have been omitted, as they cannot be significantly improved by artifact generation. The improvement of these dimensions depends very much on organizational aspects (such as the culture of the company) and less on the creation of artifacts. Therefore, we recommend using the assessment with the DEEP model as an eye-opener to discuss responsibility and ownership of the product roadmap with management (the decision of who is responsible and owns the product roadmap can usually only be changed by management). The application of the "Goal-Opportunity Map" does not provide an answer to the question of what measures must be performed to develop the artifacts on the y-axis. To answer this question, we developed a second map called Goal-Activity Map described in the following.

Goal-Activity Map: The purpose of the "Goal-Activity Map" (see Figure 9.4) is to propose concrete measures to develop the previously identified artifacts through the "Goal-Opportunity Map." In order to obtain such a measure, the user must enter the artifact obtained by applying the Goal-Opportunity Map. The crosses in the map indicate appropriate measures to create the corresponding artifacts. For example, a product vision can be created by conducting a product vision workshop. Building prototypes can help to obtain validated learnings (e.g., results from experiments, insights).

Measure / Artifact	**Product Vision**	**Outcomes**	**Solution Ideas**	**Validated Learnings**
Product Vision Workshops	X			
Customer Interviews		X		
Customer Surveys		X		
Impact Mapping			X	
MVP and Prototyping				X

Figure 9.4: Goal-Activity Map

9.3 Threats to Validity

We use the framework according to Yin [Yin09] as the basis for the discussion of the validity and trustworthiness of our study. **Construct validity:** A threat to the construct validity is that the participants in the expert workshops misunderstood the aim of developing the product roadmap transformation approach. For this reason, the goal and purpose of the expert workshop were explained to the participants in advance. In addition, technical terms were defined within the expert workshops. **Internal validity:** The expert opinions used to create the model may be incorrect or valid only in a context-specific manner. Therefore, several experts were consulted. **External validity:** The transformation approach was developed with the support of three practitioners operating in the software-intensive business. This limits the scope of applying the transformation approach to companies operating in such environments. **Reliability:** The reliability was supported by conducting the expert workshops systematically and repeatedly involving two researchers and three practitioners. Therefore, a replication of the expert workshops and a reduction of researcher bias is supported.

9.4 Conclusion

In this chapter, we present a product roadmap transformation approach as the second part of our solution approach. Based on the assessment of the DEEP model, first, our approach provides a procedure that enables practitioners to identify the dimension of the DEEP model that should be tackled for transformation. This means identifying those dimensions that promise the most benefit for improvement. Second, our approach enables practitioners to identify and conduct measures that aim to improve the corresponding dimension in the DEEP model. After the measures have been conducted, we recommend analyzing and evaluating the impact of the measures on current product roadmapping practices. For example, a cross-functional workshop could discuss whether conducting a product vision workshop that led to developing a product vision justifies selecting a higher level in the DEEP.

Chapter 10

Expert Interview Study to Validate the Product Roadmap Transformation Approach

This chapter describes the first step to validate the comprehensibility, applicability, and usefulness of the product roadmap transformation approach described in the previous chapter. Since the results of the DEEP model serve as input for the application of the product roadmap transformation approach, we have also made the DEEP model available to the participants. Therefore, through the validation process of our product roadmap transformation approach, we could further validate the comprehensibility, applicability, and usefulness of the DEEP model. This was done in the phase "evaluation of the artifact" of the design science process (see Figure 1.1). In order to achieve our objective, we have defined the following research questions.

- **RQ:** How do practitioners perceive the product roadmap transformation approach?

The chapter extends the following publication:

- S. Trieflinger et al. 'A transformation model for excelling in product roadmapping in dynamic and uncertain market environments'. In: *Product-Focused Software Process Improvement: 22nd International Conference, PROFES 2021, Turin, Italy, November 26, 2021, Proceedings 22*. Springer. 2021, pp. 136–151

10.1 Research Design

To answer our research question, we provide the product roadmap transformation approach along with the DEEP model to practitioners to use without detailed explanations and instructions. The practitioners who participated in the interviews were not involved in developing the DEEP model and were using it for the first time. Specifically, practitioners were asked first to conduct an assessment using the DEEP model. Then, using our proposed process, they were asked to identify the dimension that promises the most benefit for improvement in their respective company context. Finally, they were asked to use the mapping tables to identify appropriate measures to improve the identified dimension. This included assessing whether the measures received were useful from the practitioner's point of view. Afterward, we interviewed each participant to identify potentials for improvements (e.g., lack of clarity) in the product roadmap transformation approach. All interviews were conducted by the same researcher online. The average length of the interviews was 36 minutes, with the range being between 27 minutes and 42 minutes. To focus and structure the interviews and ensure thematic comparability, we developed an interview guide consisting of the following questions: 1) What do you think are the strengths and weaknesses of the product roadmap transformation approach? 2) Which phrases did you find difficult to understand? 3) In your opinion, would the model help your company to adapt the current product roadmapping practice to a dynamic and uncertain market environment? In total, we recruited 11 experts who operate in a dynamic market environment (e.g., smart home). As with the expert workshops mentioned in the previous chapter, the selection of the participants was based on their experience in product roadmapping and their role in their company. For the search for suitable participants, we used our company network as well as the platform LinkedIn. Table 10.1 gives an overview of the practitioners who participated in the validation process of the transformation approach. To conduct accurate data analysis, we took notes in each interview. This means that the main statements and quotes were handwritten. We analyzed these interview notes by extracting main responses, key statements, and key quotes.

Table 10.1: Participants of the interviews (first validation of the transformation approach), (size classification: small < 50, large > 250).

Interviewee	**Position**	**Experience**	**Company Size**
Interviewee 1	Product Manager	5 years	Medium
Interviewee 2	Product Owner	3 years	Medium
Interviewee 3	Head of Product Mgmt.	7 years	Large
Interviewee 4	Software Engineer	7 years	Large
Interviewee 5	Product Manager	2,5 years	Small
Interviewee 6	CEO	12 years	Large
Interviewee 7	Product Owner	6,5 years	Small
Interviewee 8	Product Manager	7 years	Medium
Interviewee 9	Head of Product Mgmt.	9 years	Large
Interviewee 10	Sales Representative	3 years	Medium
Interviewee 11	Product Manager	3,5 years	Large

10.2 Results

This section outlines the practitioner's perception of our approach, including the feedback gathered during the interviews. As mentioned above, the participants first conducted a self-assessment using the DEEP model, followed by applying the procedure to identify the most promising dimension for improvement and using the mapping tables to obtain suitable measures to improve the previously identified dimension.

Overall, our developed product roadmap transformation approach was perceived as comprehensible, applicable, and useful. For example, one participant mentioned: *"In my opinion, the whole approach is well structured and provides useful insights to adapt the currently applied product roadmapping practices."* (Product Manager). In particular, the focus of the approach on customer value was considered useful by the participants. One participant mentioned: *"What I particularly like about the model is that it addresses customer value. In our company, we don't think much about why a feature is being developed. I mean, it is not always clearly understood what value the features deliver to the customer and how it contributes to our goals. Therefore, I think the focus on customer value is very useful."* (Head of Product Management) The start of the approach with an assessment of the currently applied product roadmapping practices was well received. In this context, one participant mentioned: *"In my opinion, it makes absolute sense to start the transformation process with an assessment of the company´s current approach to product roadmapping. This enables the identification of weaknesses in the current product roadmapping approach and clearly communicates them. Therefore, the assessment provides a good basis for further discussions, for example, with the management."* (Product Owner) Another participant added: *"In our company, many people are not satisfied with the current product roadmapping approach. However, we struggle to identify a starting point for adapting product roadmapping practices to a dynamic and uncertain market environment. Here, the discussions go round and round in circles and lead nowhere. Therefore, the DEEP model offers us a systematic way to determine the optimal starting point for the transformation of our product roadmap."* (Head of Product Management) Finally, one participant indicates that an honest assessment through the DEEP model is the basis for the success of the subsequent procedure: *"In my view, the results of the DEEP model have a significant influence on the further process. This means that if the information in the DEEP model is incorrect, the subsequent steps will also be incorrectly defined. For this reason, I would invest as much capacity as possible to ensure that the DEEP Model has been applied truthfully. In other words, I would fill out the model with at* *least 10 participants from different departments and discuss deviations with all participants in a meeting."* (Product Owner)

Regarding the product roadmap transformation approach, the process of selecting the most beneficial dimension for improvement, and the two mapping tables, the interviews showed that each participant understood how to apply them. In the context of the product roadmap transformation approach, one participant stated: *"In my opinion, the structure and functionality of the approach were clear and understandable."* (CEO) Another participant mentioned: *"From the agile world and Scrum, the general structure of the approach is familiar. Therefore, I had no problems understanding the application of the approach.*" (Software Engineer) Nevertheless, the interviews revealed some potential for improving the product roadmap transformation process. In this context, two participants mentioned missing information when a process step was not fulfilled. *"In the approach, I lack instructions on acting if one or more measures do not contribute to achieving the defined goals. Should I first review the goal or keep the goal and define new measures?"* (Product Manager) In this context, *"it would be nice if the process would provide recommendations."* (Product Manager) Another participant commented: *"Let´s assume that the review has resulted in a negative finding within the improvement circle. Here, the process does not give any information about how I should behave. Would defining new measures or starting from the analysis make more sense?"* (Product Owner)

Regarding the process we developed to select the most promising dimension for improvement, there was no ambiguity for the participants. In detail, each participant understood that to determine the most promising dimension, a differentiation is made between levels one and two as well as levels three, four, and five. The explanation why the two dimensions "prioritization" and "extent of alignment" should only be considered from level three onwards was also comprehensible to the participants. Finally, the structure and application of the two mapping tables did not pose any challenge to most participants. One participant mentioned: *"After I had conceptually identified a dimension that should be improved, I understood that this is the input for the first mapping table.*" [i.e., the Goal-Opportunity Map]. "*Subsequently, I* *could determine without ambiguity the measure recommended to improve the dimension I had chosen."* (Head of Product Management). One participant had problems interpreting the crosses within the two mapping tables. *"When I first considered the mapping tables, it wasn´t clear whether the crosses were a default or just an example. However, when I took a closer look at the structure and content of the mapping tables, I realized how it was meant."* (Software Engineer) Finally, three participants noted that while the proposed measures in the Goal-Activity Map are useful, they would like to have more measures to choose from. One participant mentioned: *"In my view, the measures in the second table are helpful. Nevertheless, I would like to see a wider choice for the creation of each artifact."*(Product Manager) Another participant adds: *"I would like to see more measures in the second table* [i.e., the Goal Activity Map] *that are less known within product management."* (Product Manager)

Similar to the first expert interview study to evaluate the DEEP model, we analyzed the feedback and revised the product roadmap transformation approach based on that. First, the interviews revealed that two participants had difficulty understanding how the process behaves in the case that the review or retrospective yields in failures (e.g., the review or retrospective reveals that the defined measures did not contribute to the achievement of the objective). To provide guidance, we linked the subphase retrospective with the phase assessment. This is done with the intention that in case of failures in the subphase review or retrospective, we recommend returning to the phase "analyze". The reason for this suggestion is that taking into consideration the learnings gained during the conduction of the process and changes in the frame conditions that have occurred during the time might lead to different decisions regarding which dimension should be in focus and which measures will most likely support them.

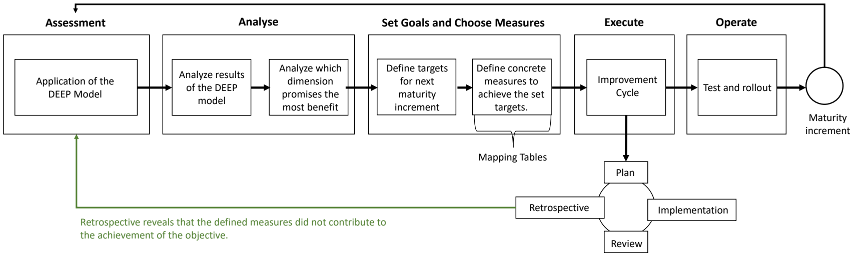

Figure 10.1: Product roadmap transformation approach V2.0

The second finding, the interviews, revealed the need for more concrete measures in the Goal-Activitiy Map. Therefore, we have expanded the measures in the Goal-Activity Map. The measures added in the Goal-Activity Map were identified through our grey literature analysis described in Chapter 5.3. Therefore, these are exclusively measures that have established valuable and useful tools in practice.

Measure / Artifact	Product Vision	Outcomes	Solution Ideas	Validated Learnings
Product Vision Workshops	X			
Mission Briefing	X			
Customer Interviews		X		
Observation		X		
Customer Surveys		X		
Jobs to be Done (Customer Focus Groups)		X		
Empathy Map (Customer Focus Groups)		X		
Impact Mapping			X	
Lightning Demos			X	
Opportunity Solution Tree			X	
MVP and Prototyping				X

Figure 10.2: Goal-Activity Map V2.0

Methods to create a product vision: To create a product vision, we recommend conducting product vision workshops or mission briefing workshops. The difference between this method is that mission briefing provides a framework for discussions among participants, while product vision workshops give the participants the freedom to set their own focus for discussions. Therefore, if a company has little experience in conducting workshops to create a product vision, we recommend using of mission briefing, otherwise, the independent structuring of product vision workshops can be considered.

Methods to create outcomes: First of all, it should be noted that identifying current customer problems and needs is the basis for the formulation of outcomes. For this purpose, we recommend applying the methods of customer interviews, observations, customer surveys, jobs to be done, or empathy maps. In the case that there is no knowledge base (such as which problems or needs the customers have) about the customers, we recommend using the methods of customer interviews, observations, and customer surveys to create such a knowledge base. Regarding the choice of which of these three methods to select, we recommend using customer interviews if a company has a small customer base. This occurs mainly in the business-to-business market. In contrast, we recommend using web surveys if the company has a large customer base. We suggest using observations when the environment in which the customers move is easily accessible (e.g., shopping malls or theme parks). It should be noted that these methods can be used individually, but a combination of these three methods is also possible. For example, observations or web surveys can validate findings from previously conducted interviews. In the case that a little knowledge base about the customer is available, we recommend the use of the methods jobs to be done or empathy maps. This can occur, for example, if knowledge about the customer is carried out by individual persons or departments rather than a company-wide process. This collected knowledge can be visualized using the empathy maps, and the method jobs to be done and expanded, for example, by conducting customer focus groups. Finally, if a large knowledge base (i.e., a wide range of customer problems and needs) about the customer exists in the company, this can be further used to formulate outcomes. An outcome describes the value a product team intends to create and deliver to the customers. In the other two cases (no knowledge base and little knowledge base), this condition is achieved by performing the proposed methods mentioned above. An example of the formulation of an outcome is "customers will be able to conduct the check out process of a product in less than one minute."

Methods to create solution ideas: We recommend applying the method lightning demo to develop solutions ideas. In this context, one or more previously identified outcomes should be used, for which ideas should be developed to achieve them. The result of the process of idea development should be at least 10 to 15 ideas per session. Subsequently, the two methods of impact mapping and opportunity solution tree can be used to display the connection between the outcomes and solution ideas. This means creating a figure showing which solution ideas contribute to the fulfillment of the outcome. Over time, a big picture emerges that displays the various outcomes and the path to their fulfillment. This serves the product team as a guide to defining and conducting the next step of product development.

Methods to create validate learnings: To validate solution ideas, we recommend developing Minimum Viable Products (MVPs) to conduct experiments. A MVP is a minimum version of the product designed to gain user feedback as quickly as possible to identify improvement potentials [All]. The appearance and form of an MVP depend on the kind of product being developed. A typical example of validating a checkout process for a webshop is the development of a dynamic mock-up.

10.3 Threats to Validity

We use the framework according to Yin [Yin09] as the basis for the discussion of the validity and trustworthiness of our study. Internal validity is not discussed since causal relationships were not examined in the study at hand. **Construct validity:** The goal and purpose of the interviews were explained to the interviewees prior to the interviews. In addition, the way of data collection through interviews allowed for asking clarifying questions and avoiding misunderstandings. **External validity:** The external validity is restricted due to the limited number of participants and the fact that each participant is employed in a German company. Thus, the results are not directly transferable to other industry sectors. However, an analytical generalization may be possible for similar contexts. **Reliability:** The reported results are based on the personal perceptions of each participant. The participants may have provided answers that do not fully reflect the reality of their companies. This threat is mitigated by the fact that the participants had no apparent incentive to polish the truth. In addition, the researchers contacted the interviewees in case of any ambiguities or questions.

10.4 Conclusion

In this study, we conducted the first validation of the product roadmap transformation approach. Overall, the structure and content of the product roadmap transformation process, the procedure to identify the dimensions that promises the most benefit for improvement as well the mapping tables were well received by the practitioners. Each participant could apply the DEEP model and, subsequently, use the transformation approach to identify the dimension that promises the most benefit for improvement. Based on that, we used our proposed mapping tables to identify measures that will improve the corresponding dimension. Major incompleteness or inaccuracies of the product roadmap transformation approach were not identified. Therefore, it can be concluded that the model is comprehensible, applicable, and useful. Nevertheless, we identified two aspects to improve the transformation approach.

In order to provide guidance in the case that the defined measures did not contribute to the achievement of the objective, we linked the subphase retrospective, with the phase assessment. This is done with the intention that in case of failures in the subphase review or retrospective we recommend returning to the phase analyze. The reason for this suggestion is that taking into consideration the learnings gained during the conduction of the process as well as changes in the frame conditions that have occurred during the time might lead to different decisions regarding which dimension should be in focus and which measures will most likely support them. Second, the interviews showed that practitioners would like to see a wider range of measures in the Goal-Activity Map. For this reason, we have added additional measures based on the findings our our previously conducted grey literature review (see Chapter 5.3).

The expert interview studies demonstrate the comprehensibility, applicability, and usefulness of the DEEP model and transformation approach based on impressions from individual practitioners. However, this does not include factors that are common in companies, such as the strong influence of the management or other executives or capacities and budget constraints. Consequently, this study has shown that the product roadmap transformation approach including the DEEP model is comprehensible, applicable, and useful for the target group of product managers (or similar roles). However, whether the product roadmap transformation approach fulfills our evaluation criteria in a real business context remains to be answered. Therefore, we conducted a multiple case study presented in the following chapter.

CHAPTER 11

Case Study to Validate the Product Roadmap Transformation Approach

As mentioned in the previous chapter, the product roadmap transformation approach, including the DEEP model, has been validated so far by applying by experts and by obtaining their opinions and impressions through interviews. However, this study does not provide any information on to what extent the product roadmap transformation approach and the DEEP model are comprehensible, applicable, and useful in a real-world business context. Therefore, we decide to conduct a multiple case study (phase "evaluation of the artifact" of the design science process, as shown in Figure 1.1). In more detail, two companies applied the DEEP model and the product roadmap transformation approach (both artifacts in version 2.0) in their company operation. We chose the research method case study since applying the product roadmap transformation approach in companies enables dealing with real-world environments and situations where there are many more variables (such as management influence, limited time, and resources). Such variables were not or only partially covered by conducting expert interviews. Therefore, this study aims to validate the DEEP model and the product roadmap transformation approach in a real business context. In order to achieve our objectives, we have defined the following research question.

- **RQ:** To what extend is the product roadmapping transformation approach applicable in a real world business context?

11.1 Research Design

To gain insight, we conducted a multiple case study involving two software-intensive companies. We selected these two companies because preliminary discussions revealed that the product management of both companies is not satisfied with their product roadmapping currently applied. To get buy-in and the necessary resources, the goal of the heads of product management of both case companies is to conduct a pilot project to make the current state of product roadmapping transparent to management and to demonstrate the process for transforming the product roadmapping practice currently in use. Moreover, both product management departments struggle to define a suitable starting point for a product roadmap transformation process.

To conduct the several phases of the product roadmap transformation process, a team was designated by each company's head of product management. These were employees who were either directly involved in developing the product roadmap or required content from the product roadmap to plan their activities. Table 11.1 gives an overview of the teams involved in the product roadmap transformation.

Table 11.1: Team composition for the product roadmap transformation of the particpating companies

Company A	Head of Product Mgmt. Product Manager Product Owner
Company B	Head of Product Mgmt. Product Manager Junior Product Manager

The table above shows those participants who have been continuously involved in the project of transforming the product roadmap. Besides this, for workshops to create artifacts for transforming the product roadmap, the opinions and views of further employees such as software engineers, marketing managers, or software developers were obtained.

Data Collection and analysis: In order to collect data, the product roadmap transformation approach was applied in both companies. As first step, the DEEP model was applied by each team member of the two product teams. After this was done, a team meeting was organized by each company's head of product management to reach a consensus, i.e., to create a final DEEP assessment. Consequently, the reasons for various assessments of the nine dimensions were discussed in these sessions, and agreement was reached on the final selection of the corresponding stage. After this session, each participant was interviewed, asking the following questions: 1) What do you think are the strengths and weaknesses of the model? 2) Which phrases did you find difficult to understand during the application? 3) Does the calculated score reflect the status of your current product roadmapping process? In this context, our previous findings were confirmed. Therefore, the results section does not provide a detailed explanation of the findings of these interviews. Impressions and quotes of the participants can be found in Trieflinger et al. [TMW+22].

Based on the assessment of the DEEP model, the dimension most promising for improvement was identified in both companies. For this purpose, we held separate meetings with the product teams of the participating companies, in which our process, as mentioned in Chapter 9.2.1, was applied. Subsequently, a goal was defined for each company based on the selected dimension to be tackled, and our proposed mapping tables (see Chapter 9.2.2) were applied. The latter means that the Goal-Opportunity Map was applied to identify one or more artifacts for improving the corresponding dimension. Subsequently, the Goal-Activity Map was executed to obtain suitable measures for creating the identified artifact(s).

The next step focused on the conduction of the identified measures by the Goal-Activity Map. In this context, we conducted customer interviews at both companies to identify current customer problems. In addition, we conducted two workshops to develop a product vision (Case Company A) and to create an Opportunity Solution Tree (Case Company B). We decided to conduct workshops since it enables the opportunity to combine different perspectives, which is essential for a successful product roadmap transformation. As part of the product roadmap transformation of Case Company A, we also conducted usability tests. Usability tests are an empirical method for evaluating the usability of a system, software, or website. The aim of usability tests is to identify weaknesses and potential for improvement. On this basis, optimizations can be made that will increase the system's usability [NNGS14]. Detailed information on the conduction of the interviews, workshops, and usability tests can be found in Subchapters 11.2.4, 11.2.5,11.3.4 and 11.3.5. After conducting the methods, we held a final meeting with each product team to analyze whether the selection of a higher level of the DEEP model was justified and which dimensions would be affected by an improvement. It should be noted that during all activities, one researcher was present to document the content of the discussion. To avoid influencing the participants, the researcher did not actively participate in the participants' discussions but acted as an observer.

11.2 Product Roadmap Transformation of Case Company A

11.2.1 DEEP Assessment (Case Company A)

The roadmap of Case Company A consists mainly of products and features, with the level of detail increasing the shorter the time horizon. Consequently, the features whose implementation lies further in the future are planned more roughly. The roadmap is subjected to permanent ad hoc adjustments. The items on the product roadmap are mainly defined based on expert knowledge, and the impacts of the roadmap items are not considered. The prioritization is based on the capability to deliver, i.e., features with less effort are implemented before features with higher effort. Regarding the dimension extent of alignment, the case company has several loosely connected product roadmaps for internal and external stakeholders. The responsibility and ownership of the product roadmap rest with product management in collaboration with other teams and stakeholders. The overall DEEP assessment of Case Company A is shown in Figure 11.2.

Dimension	Stage 1	Stage 2	Stage 3	Stage 4	Stage 5	Potential for improvements (reaching stage 5)
Roadmap Detailing	1	3	**8**	15	20	12
Roadmap Items	1	**3**	10	12	20	17
Reliability	**1**	3	8	12	16	15
Confidence	**1**	4	7	10	12	11
Product Discovery	1	**2**	4	8	10	8
Prioritisation	1	2	**3**	3	6	3
Extent of Alignment	1	1	**2**	3	6	4
Responsibility	1	2	3	4	**5**	0
Ownership	1	2	3	4	**5**	0
Score per column	**2**	**5**	**13**	**0**	**10**	
Total score					**30**	

Figure 11.1: Case Company A: Initial DEEP assessment

The conduction of the DEEP model leads to a final score of **30 points** which means an overall maturity level of two.

Maturity Level	1	2	3	4	5
Score	9 – 18 pts.	19 – 36 pts.	37 – 62 pts	63 – 87 pts	88 – 100 pts

Figure 11.2: Case Company A: Initial overall maturity level

11.2.2 Identifying the Most Promising Dimension for Improvement (Case Company A)

The overall product roadmap maturity of Case Company A is two. Therefore, according to our developed process for identifying the most promising dimensions for improvement (see Chapter 9.2.1), the following dimensions are candidates for improvement. 1) roadmap items, 2) roadmap detailing, 3) product discovery, 4) confidence, 5) ownership, and 6) responsibility. Regarding the dimension ownership the case company has reached the highest stages. Consequently, this dimension cannot improve any further, and it makes no sense to choose for an improvement. The dimensions prioritization (potential of 3 points) and extent of alignment (potential of 4 points) show a medium maturity but have a low impact of the enhancement of the overall maturity score if they were improved. Therefore, these dimensions are not suitable for improvement in the first iteration of the product roadmap transformation. The dimensions product discovery (potential of 8 points), confidence (potential of 11 points), roadmap items (potential of 17 points) and roadmap detailing (potential of 12 points) show the highest impact on the overall maturity score for improvement.

Considering our proposed process to select the most promising dimension for improvement, we recommend improving the dimension product discovery before the dimension confidence. The reason for this is that the conduction of product discovery includes the provision of insights into which roadmap items will have the highest impact on achieving customer and business goals.

The latter is the definition of the dimension confidence in the DEEP model. Consequently, improving the dimension of product discovery usually leads to an improvement of the dimension confidence. Therefore, the dimension confidence was excluded for improvement in the first iteration of the product roadmap transformation.

Next, it was discussed whether to improve the dimension roadmap detailing or the dimension roadmap items. Currently, the case company uses features with different levels of planning details that are not systematically created. As described above, this is due to the circumstances that those features were planned out in detail, which in the opinion of experts, have the greatest potential to bring success to the market. A systematic approach based on the customers' problems and opinions can be achieved by creating different roadmap items such as outcomes, hypotheses, and validated features. Since all these items have different levels of detail, improving the dimension roadmap items also leads to improving the dimension roadmap detailing. Consequently, the dimension roadmap detailing were excluded to improve in the first iteration of the product roadmap transformation.

Considering the potential for improvement of the dimension product discovery and roadmap items, it becomes apparent that the improvement of the dimension roadmap items achieves greater progress. Therefore, our proposed process to select the most promising dimension for improvement leads to the decision to tackle the improvement of the dimension roadmap items. With respect to our guiding questions, the head of product management has no restrictions on implementing and establishing new measures to improve this dimension. This means that prior to the execution of such measures, no permission or consent needs to be obtained from the management or other stakeholders.

11.2.3 Set Goals and Choose Measures (Case Company A)

As the next step, a target of the first iteration of the product roadmapping transformation process must be defined. In this context, the case company decided to improve the dimension of roadmap items from level two to level five. Applying our proposed Goal-Opportunity Map (see Figure 11.3), the improvement of the dimension roadmap items can be achieved by 1) developing a product vision, 2) defining and including outcomes in the product roadmap, and 3) deriving solution ideas and 4) validating as to whether the solution ideas lead to the fulfillment of the corresponding outcome. Since the conduction of these measures are too extensive for their execution and the analysis of whether the corresponding measure led to the achievement of the overall goal, it was decided to go through the execute phase twice. This means that the subphases of the phase execute are applied to develop the product vision, including a review and retrospective to validate whether this subgoal has been achieved. In the case that the subgoal of developing a product vision has been fulfilled, the subphases of the phase execute are performed again to define outcomes and solution ideas and to validate whether the solution ideas contribute to the fulfillment of the corresponding outcome. Otherwise, the product vision would need to be adjusted in a second iteration.

Dimension / Artifact	Product Vision	Outcomes	Solution Ideas	Validated Learnings
Roadmap Items	X	X	X	X
Roadmap Detailing		X	X	
Product Discovery		X	X	X
Confidence		X	X	X
Prioritization	X			X
Alignment	X	X		

Figure 11.3: Case Company A: Application of the Goal-Opportunity Map

Subsequently, suitable measures must be defined to create a product vision, outcomes, solution ideas, and validated learnings. Therefore, as the first step, the artifact product vision is entered in the Goal-Activity Map to obtain an appropriate measure to generate this artifact. As Figure 11.4 shows, this leads to the recommendations to conduct product vision workshops or mission briefing workshops. The method of mission briefing proposes a framework that encourages discussion among participants, while product vision workshops give the participants the freedom to structure the workshops independently. Since the product managers of the case company have experience in organizing, structuring, and conducting product vision workshops, they express the desire to structure the workshop themselves. This leads to the choice to conduct product vision workshops.

As the second step, appropriate measures must be obtained to create outcomes. For this purpose, the artifact outcome is entered in the Goal-Activity Map, resulting in the recommendation to conduct the measures 1) customer interviews, 2) observations, 3) customer surveys, 4) jobs to be done, or 5) empathy maps. As mentioned in Chapter 10, identifying current customer problems serves as the basis for formulating outcomes. If this knowledge is not available in the company, we recommend using the measures of customer interviews, observations, or customer surveys. In contrast, if there is knowledge about the customers' problems and needs, we recommend visualizing this knowledge using the measures jobs to be done or empathy map and, based on this extending the customer knowledge (e.g., customer focus groups). Since the case company has no current knowledge about the needs and problems of the customers, the measures jobs to be done and empathy map can be excluded. Regarding the selection of customer interviews, observations, and web surveys, we recommend the following (see Chapter 10): Interviews are used with a small customer base, while surveys are applied with a large customer base. Finally, observations can be used when the environment in which the customer move is easily accessible, regardless of the size of the customer base. Since the case company operates in the business-to-business market, they have a small customer base. In addition, it will be challenging to organize the conduction of observations, as this requires insights into the operational and confidential processes of the customers. For these reasons, the case company decided to conduct customer interviews to identify customer problems that build the basis for formulating outcomes.

Third, we applied the Goal–Activity–Map to obtain a measure for creating solution ideas. As Figure 11.4 shows, we received the recommendation to conduct the measures impact mapping, lightning demos or opportunity solution tree. In this context, the product team would like to conduct a brainstorming session as independently as possible rather than using a predefined framework. The reason was that the product team feared being forced into a corset by a framework, so important factors would be overlooked. As mentioned in Chapter 10, this requirement is best addressed by the measure lightning demo. Consequently, we chose the measure lightning demo to create solution ideas.

According to the Goal-Activity-Map, we recommend developing Minimum Viable Products (MVPs) to validate the solution ideas created. As already mentioned, the appearance and form of the MVP depend on the kind of product that should be developed. Since the idea to be validated is not yet known at this stage, it is not yet possible to determine which type of MVP is best suited for the validation process. Figure 11.4 shows the selected measures of Case Company A by applying the Goal–Activity Map.

Measure / Artifact	Product Vision	Outcomes	Solution Ideas	Validated Learnings
Product Vision Workshops	X			
Mission Briefing	X			
Customer Interviews		X		
Observations		X		
Customer Surveys		X		
Jobs to be Done (Customer Focus Groups)		X		
Empathy Map (Customer Focus Groups)		X		
Impact Mapping			X	
Lightning Demos			X	
Opportunity Solution Tree			X	
MVP and Prototyping				X

Figure 11.4: Case Company A: Application of the Goal-Activity Map

11.2.4 Execution of the Development of a Product Vision (Case Company A)

According to our proposed product roadmap transformation process, the next step is to perform the phase execute consisting of the four subphases: plan, implementation, review, and retrospective. Our activities regarding these four subphases are described in the following.

Plan: As mentioned above, the case company has decided to conduct product vision workshops. The goal of this workshop was to develop a product vision that guides activities for future product development. These workshops were attended by six participants with different roles, including a product owner, a product manager, a software architect, a UX designer, a software developer, and a project engineer. We recommended that the management and sales should also be included, but they could not attend the workshop due to limited availability. However, getting feedback and buy-in from all stakeholders regarding the product vision is important. Therefore, the findings of this workshop were discussed separately with management and the sales department. The workshop was moderated by the product owner of the case company. To develop the product vision, the template, as shown in Figure 11.5 proposed by Lombardo et al. [LMRC17], was adapted.

For: [target customer]
Who: [target customer’s needs]
The: [product name] Is a: [product category]
That: [product benefit/reason to buy]
Unlike: [competitors]
Our product: [differentiation]

Figure 11.5: Case Company A: Adapted product vision template based on [LMRC17]

Implementation: The duration of the workshop was 60 minutes, and the agenda consisted of the phases 1) introduction, 2) ideation, 3) presentation, 4) initial vote, 5) discussion, and 6) final vote. The workshop started with an opening part, which consisted of explaining the purpose of a product vision by the moderator. This was done to ensure that all participants were on the same level before the execution of specific tasks began. Afterward, the ideation phase started by asking the participants to write down the aspect they considered the most important for each category of the product vision template mentioned above. To complete this task, 10 minutes were given to the participants. Subsequently, the participants presented their created product vision statement to the audience (presentation phase). This allowed the participants to ask questions, clarify ambiguities, and encourage initial discussions. Since the discussions were to be addressed later in the agenda, the moderator stopped discussions that lasted longer than five minutes and marked them for the discussion phase. Then the identification of the most critical aspects took place within the phase initial vote. Therefore, each participant received one vote per category. Based on these results, the aspects that received zero votes were removed, and the participants put forward arguments regarding the suitability and importance of the remaining aspects (discussing phase). The categories “differentiation” and “target customer” were primarily discussed. Finally, the participants voted for a final result which led to the formulation of three versions of the initial product vision.

Review: The subphase review aims to analyze and evaluate the impact of the product vision workshops on the maturity of the product roadmapping practice. In other words, it should be evaluated whether the development of the product vision contributed to the achievement of the overall goal of improving the dimension roadmap items from stages two to five. First, we note that after the product vision was developed, the product managers and product owner started discussions about what problems the customers currently have and what outcomes needed to be fulfilled to solve these problems. This happens not only during the meetings but also informally, for example, during coffee breaks or in talks on the floor. This indicates that a product vision encourages discussing customer problems and outcomes rather than concrete solutions. Moreover, we observed that in the cross-functional meetings, the product managers and developers explicitly indicated that they had made certain decisions about future activities based on the product vision (even 1,5 years after conducting part of the case study). This shows that the product vision is accepted by the various employees of the case company and used to define future activities and prioritize them. Therefore, the product vision fulfilled its purpose by guiding the product team during the product development process. Finally, discussions with one product owner and one product manager of the case company revealed that the product vision increased motivation across the product team to make the product a success. The reason for this is that the product vision tells each team member what problems the product should solve in the future and how it should make the lives of the target group easier. This gives each employee a sense and purpose to develop the product further every day. Due to these findings, it can be concluded that the development of the product vision has a positive impact on improving the dimension roadmap items.

Retrospective: The subphase retrospective focuses on considering the strengths and weaknesses of the product vision workshops conducted. This includes a discussion about which aspects can be improved. Overall, we observed that the participants well received the format and structure of the product vision workshops. Moreover, the participants' feedback included that the workshop duration should be extended to 90 minutes to leave time for an additional iteration. The end of the workshop felt rushed as there was not enough time to discuss the issue of differentiating the product of the case company from other similar products. Therefore, the participants felt that they would have reached a better result with more time. Another suggestion was to perform the workshop with different groups, compare the results, and discuss them afterward.

11.2.5 Execution of the Development of Outcomes and Solution Ideas (Case Company A)

As mentioned above, the second iteration of the subphase execute consists of developing outcomes, defining each outcome's solutions, and validating which ideas fulfil the corresponding outcome. In this context, it should be mentioned that the case company offers a software that must be configured at the customer's site. In order to reach our objectives for this phase, we decided to apply the following approach: The first step was to conduct customer interviews to gain as many insights as possible about current customer problems. In an internal brainstorming session, these customer problems are prioritized by one product owner and two product managers. This led to the identification of 12 customer problems, with the most frequently mentioned customer problem being that the configuration time of the software at the customer´s site took more than two weeks. For this reason, the customer is annoyed due to this long time, as they expect to adapt their logistic processes as soon as possible. For the case company, this bears the risk that the customer loses confidence in the competencies of the case company already at the beginning of the cooperation.

To define an outcome that contributes to the solution of the problem, the insights from the customer interviews were used again. These interviews revealed that a configuration period of a maximum of five days is acceptable to the customers. Consequently, the formulated outcome was: *"If the configuration time is not more than five days, the customer is relieved and can take care of other important business things."* Since the information for formulating the outcome originated from customer insights, this outcome can be considered as a validated outcome.

To fulfill these validated outcomes, the next step was to identify solution ideas by adapting the measure of lightning demo. lightning demo was used in this case study to identify possible underlying reasons for the high configuration time. Therefore, participants were given 15 minutes to write their ideas on sticky notes. Subsequently, participants presented their identified reasons and discussed them with the group. Based on these discussions, the participants voted on the reason most likely responsible for the high configuration time. These discussions revealed that participants identified two possible underlying reasons for the high configuration time. Either the underlying reason for the problem was difficulties in operating the graphical user interface used for the configuration process, or the employees had difficulties accessing and acquiring the knowledge required for a quick configuration process. Based on these insights, the following solution hypotheses were formulated: 1) Improving the usability of the graphical user interface used in customer integration leads to a 50 percent time-saving in customer integration, 2) Improving the quality of documentation on configuration leads to a 50 percent time-saving in customer integration and 3) conducting employee training courses leads to a 50 percent time-saving in the customer integration. In this context, it should be noted that the user interface currently used is based on 20 years old technology. This brings with it the problems that adjustments of the configuration software are either only possible with high effort or not at all and that updates or frameworks for such programming languages are no longer available. In addition, this makes new hires difficult, as many potential employees are unfamiliar with such programming languages and would like to use the latest technologies. For these reasons, it was reasonable to assume that the cause was more in the use of the current version of the configuration software and less in the access to knowledge of the employees. Nevertheless, to gain evidence on this assumption, we decided to conduct interviews with employees responsible for the configuration process. Overall, one product owner, one product manager, and one member of the research team conducted interviews with eleven employees responsible for the configuration process on the customer´s site. These interviews were transcribed for analysis and documentation purposes and stored in the product management department at the case company. After the analysis, it becomes clear that the previously mentioned assumption was confirmed. Thus, the main reason for the long configuration time was the use of outdated configuration software. Other findings from the interviews were that employees were very satisfied with the number of training sessions related to the software and the process and content of those training. Therefore, we decided to rebuild the configuration software based on the latest technologies.

Finally, a Minimum Viable Product should be developed to validate whether the redesign of the configuration software reduces the configuration time. Therefore, as a first step, we conducted a workshop with eight employees. This workshop aimed for the participants to design the processes and content of the optimal journey of the configuration software from their point of view. For this purpose, the participants were divided into two groups consisting of four participants each. That the groups are able to work undisturbed and not influence each other, each group was assigned to a breakout session in Zoom. To visualize the results, each group was free to choose which tool to use. After creating the configurators, both groups were asked to present their findings to the other group and the moderators. This was done with the intention of tracing the participants' thoughts during the creation of the configurators and stimulating discussions between both groups. In summary, the proposed configurators include a login page, a configuration page where the customer's ordered modules could be selected, and specific detail pages for the specific settings of the corresponding modules.

Based on the findings of the workshop mentioned above, clickable wireframes were developed to perform usability tests. These tests were attended by eight employees who are responsible for the configuration process at the customer. When selecting participants, an essential factor is to recruit persons who have little knowledge about the test object. Since the clickable wireframe is a new development, this requirement is met by selecting the target group of configuration process configurators. The reason for choosing the number of eight participants was that, according to [Gro], eight subjects identified 98 percent of usability problems (see Figure 11.6).

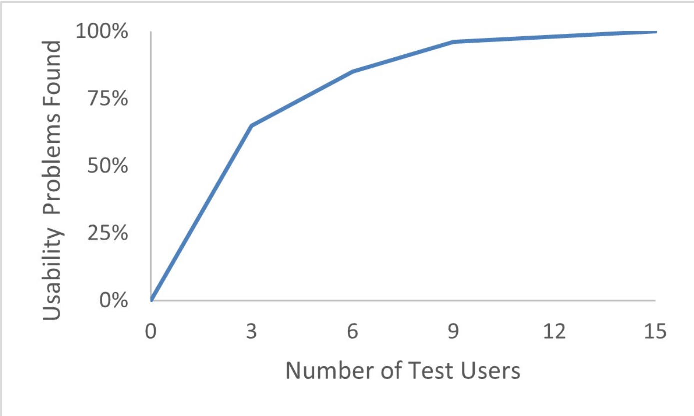

Figure 11.6: Number of test persons of the usability tests [Gro]

For the execution of the usability tests, test cases were defined and performed by each test person. To uncover potential for improvements, the execution of the test cases was recorded and streamed live to another room using a camera. In this other room, the product owner and a product manager track the execution of the test cases and document any steps of the test cases. To assess each test case, the following self-defined scoring was applied:

- **2 points:** The test person was able to perform the test case quickly and without problems

- **1 point:** The test person had slight problems while performing the test case
- **0 points:** The test person had great difficulties or could not solve the test case

The usability tests lead to the following cumulative results:

Table 11.2: Results of the usability test of the clickable wireframes

Test case	Accumulated points	Mean
Test case 1	16 points	2
Test case 2	11 points	1.375
Test case 3	14 points	1.75
Test case 4	12 points	1.5

As Table 11.2 shows, no major difficulties were encountered in the execution of the test cases. However, minor issues were uncovered, such as ambiguities regarding the navigation, which were fixed. According to the participants, the time for processing the test cases with the wireframes was lower than compared to the configuration software. This shows that redesigning the configuration software to improve usability contributes to reducing the configuration time. Consequently, user stories based on the wireframe were defined and handed over to the backlog of the department of software engineering for development.

Review of the process to define outcomes and derive solution ideas: As in the first iteration of the phase execute, the effect of the process of developing outcomes and deriving possible solution ideas on the case company´s product roadmapping practice was assessed. As the first step, the created product roadmap based on the findings of the process conducted after six months was presented by the product management of the case company to 30 employees within a department meeting. This means that the product management presented the identified customer problems, the formulated outcomes based on these problems, the interview insights that led to the decision to rebuild the configuration software, and the created customer journeys for the configuration tool. The applied approach was very well received by the participants of the meeting. In more detail, the participants liked that the approach is systematically structured and that the results in the form of action measures are comprehensible and thus sufficiently justified. This gives us a first impression that the approach to include outcomes in the roadmap and deriving possible solution ideas for them is accepted by the case company's employees, and there is confidence in the content of the product roadmap. However, the investigation time of six months was too short to make any empirical conclusions about the influence of outcomes and derived solution ideas on the product roadmap practices. To gain further insights, we conducted interviews with the stakeholder of the product roadmap of the case company after nine months after the case study. The purpose of these interviews was to identify how the involved employees perceived our proposed process and what long-term effects were associated with it. Overall, the interviews show that the creation of outcomes and solution ideas and including them in the product roadmap positively impact the case company's product roadmapping practice. First, we observed that outcomes help the product team to plan its capacity more effectively and contribute to avoiding waste. In this context, one participant stated: *"In the past, I have often worked on completing multiple features at the same time. In the end, often none of them has been fully operational. The outcomes we introduced on the roadmap helped me focus better on the essential things. This helps me communicate priorities better and plan my week more effectively."* (Product Manager) Furthermore.*"[...] at the beginning of the project* (case study) *a year ago, I was rather skeptical. However, the introduction of outcomes allows us to visualize current customer problems, communicate them transparently across departments, and find suitable solutions for them. On the one hand, this helps us to plan our priorities and, on the other hand, to better plan our capacities."* (Product Owner) According to another participant, *"In the past, we have only discussed which features to include in the roadmap based on our opinions. This leads to the problem that often features were developed that our customers have not used. As a result, capacities were invested in features that the customers didn´t need; therefore, these capacities could have been used more profitably.* But, *"since we are actively concerned with our customer's* *problems, we understand our customers better, and therefore we are able to deliver more customer-oriented products. Therefore, we use our capacities more effectively."* (Product Manager) Finally, we can observe that the introduction of outcomes leads to increased confidence in the roadmap. This means that employees are more confident that the product strategy visualized in the roadmap will lead to success. In this context, one participant stated: *"our previous roadmap included features that, in my opinion, did not always have a reason to exist. To be honest, this circumstance has lowered my motivation for implementing these features. The introduction of outcomes has had the effect of clearly communicating why we invest the effort of implementing a feature. This has strengthened confidence in the strategic management of our company."* (Product Manager) Another participant stated: *"From my point of view, the entire path from the customer problem to the solution is absolutely comprehensible. That´s why I have a good feeling that we are on the right track to developing the right products."* (Product Manager) Moreover, *"the change of not taking opinions and statements as sure, but instead, formulation hypotheses and validating them makes me confident that we will achieve our goals"* (Product Manager). Finally, another participant added: *"the change that the items on the roadmap are no longer prescribed by the management but are systematically identified by collecting customer feedback is, in my opinion, the right way that we achieve success in the market."* (Product Owner) However, several participants pointed out that, *"identifying outcomes is not a simple process. It is not just talking briefly with the customer. The most difficult part of the process is to analyze from the statements what the real problem of the customers is and what we need to do to solve this problem."* (Product Owner). Moreover, *"taking the customer´s perspective was a challenge. Especially when analyzing the different interviews, it is difficult not to distort the statements by own perceptions."* (Product Manager)

Case Company A: Retrospective of the process to define outcomes and derive solution ideas: Overall, the employees of the case company accepted our proposed process for defining outcomes and deriving solution ideas very well, i.e., they perceived the steps and contents to be logically structured and goal-oriented, and purposeful. Potential for improvements was identified in establishing measures for visualizing the defined outcomes, and the derived solution ideas. The reason for this is that the case company has the assumption that a clear visualization increases the motivation of employees to implement the product strategy and increases alignment between employees. Therefore, the case company plans to test measures such as impact mapping or the opportunity solution tree and integrate them into the product development processes if they are successfully applied. Successfully applied means that the measures run in accordance with the needs, requirements, and mindset of the case company.

11.2.6 Impact of the Conducted Measures of the Product Roadmapping Practices (Case Company A)

At the end of the case study, the research team repeated the application of the DEEP model in collaboration with the product management department of the case company. This measure aimed to decide whether the set goals had been achieved. In other words, the question was answered whether the selection of a higher stage of the DEEP model is justified and which dimensions are affected by an improvement. Figure 11.7 shows the results of the DEEP model before the case studies were conducted in light grey. The dark grey refers to the level achieved through implementing our proposed measures and the integration into the roadmapping processes. The case company reached a total score of 28 points before starting the product roadmap transformation approach, corresponding to an overall maturity level of two. As Figure 11.7 shows, the case company improved the dimension "roadmap items", "roadmap detailing", "reliability", and "confidence" by conducting the measures we proposed. The reasons for these improvements are explained in the following.

Dimension	Stage 1	Stage 2	Stage 3	Stage 4	Stage 5	Points gained
Roadmap Detailing	1	3	8	15	20	7
Roadmap Items	1	3			20	17
Reliability	1		10	10	16	9
Confidence	1				12	11
Product Discovery	1	2		8	10	6
Prioritisation	1	2	3	3	6	0
Extent of Alignment	1	1	2	3	6	0
Responsibility	1	2	3	4	5	0
Ownership	1	2	3	4	5	0
Score per column	0	0	15	23	42	
Total score						**80**

Figure 11.7: DEEP Assessment after the Case Study (Company A)

The goal of the first iteration of the transformation process was to develop a product vision that should align the various members of the product team and guide product decisions. The product vision was developed through workshops involving stakeholders of the product roadmap from several departments. This product vision is currently used by the product team of the case company to make decisions and prioritize measures. This shows that the product team members identify themselves with the product vision created and use the product vision to accomplish their tasks. This sufficiently justifies that the goal of developing a product vision has been achieved. However, developing a product vision and integrating it into the roadmapping processes alone does not improve the dimension of roadmap items in the DEEP model. The reason for this is that reaching level five requires establishing a product vision and including outcomes (ideally in the mid and long term) and validated features in the short term. Since a product vision has been successfully developed and established in the first iteration, only one part is fulfilled to reach stage five. Therefore, the first step of the second iteration was to identify current customer problems and formulate outcomes based on them. Subsequently, solution ideas were defined and validated as to whether they contribute to fulfilling the corresponding outcome. Overall, this approach helped the case company avoid waste and increased the confidence of the case company's employees that the content of the product roadmap would lead to success. Thus, the requirements for reaching the fifth stage in the dimension roadmap items are fully met.

Moreover, the case company improves the dimension roadmap detailing by conducting this case study. Before starting this case study, the case company used features of different levels of detail in their product roadmap. This results in stage three in the dimension roadmap detailing. The process applied in this case study produces the following roadmap items: 1) Outcomes in the long-time horizon of the product roadmap, 2) solution ideas in the mid-term of the roadmap, and 3) validated features in the short-term of the roadmap. Since these roadmap items have different granularity levels and are used in different time horizons of the roadmap, this leads to a clear correlation between time and the level of detail of the roadmap items. Therefore it is justified that the case company reached the fourth stage of the dimension roadmap detailing.

Another improvement relates to the dimension reliability. Before conducting this case study, the case company adjusts its product roadmap permanently arbitrarily. The latter means that adjustments were not regularly discussed between the various stakeholders, but the product management adjusted the roadmap based on their discretion. This procedure resulted in stage one regarding the dimension reliability in the DEEP model. 1.5 years after conducting this case study, we observed that the number of adjustments to the product roadmap has decreased. According to the product owner of the case company, this is because the previous product roadmap consists of features with various levels of detail. The problem with this approach is that the kind or characteristic of those features changes on a weekly basis, leading to permanent adjustments. In contrast, through the approach introduced by this case study, validated features can only be found in the short term of the product roadmap. This affected that adjustments related to features included only minor details such as the position or labeling of a button. As mentioned above, the mid-term of the roadmap included solution ideas and long-term outcomes. In this context, the case company's product team has introduced regular meetings to discuss the identified outcomes and the solution ideas. According to the product owner, these regular meetings lead to the adjustments of the solution ideas. Therefore, the case company adjusts the contents of its product roadmap within a regular cadence corresponding to stage three in the dimension of reliability. Consequently, the case company improves the dimension reliability from stage one to stage three.

Furthermore, this case study leads to an improvement of the dimension of confidence. Before conducting this case study, the case company does not consider the impacts of the roadmap items on customer or business goals which refers to stage one of the dimension of confidence. Within this case study, the outcome was not identified based on internal opinions but through the insight of conducting customer interviews. Furthermore, the case study includes validation to ensure that a solution idea fulfills the corresponding outcome. Both measures are designed to ensure that customer goals are focused in the product development process. Therefore, it can be said that the impacts of the roadmap items on customer and business goals were systematically validated. Consequently, it is justified that the case company improves the dimension of confidence from stage one to stage five.

Finally, the case company improved the dimension of product discovery. Before this case study, experts (such as product owners and product managers) determine the content of the product roadmap, which means stage two in the dimension of product discovery. As part of the case study, the company conducted customer interviews and rapid prototyping to identify the outcomes and validated features included in the product roadmap. This corresponds to the definition of stage four of the dimension product discovery: "several discovery activities are conducted, but they are not or only loosely integrated with delivery activities." Therefore, it is justified that the case company improves the dimension product discovery from stage two to stage four.

As mentioned in Chapter 11.2.1, the DEEP assessment prior to conducting the recommended measures to improve the product roadmapping practices, the DEEP assessment resulted in 30 points, corresponding to an overall maturity level of two. By creating a product vision and introducing outcomes, solution ideas, and validated solutions in the roadmap, the case company was able to improve the dimensions roadmap detailing by 7 points, roadmap items by 17 points, reliability by 9 points, confidence by 11 points and product discovery by 6 points. This leads to an improvement of 50 points, resulting in a total score of 80 points and, thus, an overall maturity level of four.

Maturity Level	**1**	**2**		**4**	**5**
Score	9 – 18 pts.	19 – 36 pts.	37 – 62 pts	63 – 87 pts	88 – 100 pts

Figure 11.8: Company A: DEEP level after the case study

11.3 Product Roadmap Transformation of Case Company B

11.3.1 DEEP Assessment (Case Company B)

The roadmap of Case Company B consists of two columns, “Now” and “Next”. The “Next” column contains topics such as "Smart Home" or “Robotic Process Automation”. Based on these topics, product management defines customer goals that are relevant from their point of view and derives features from them. Both the defined customer goals and feature ideas are included in the “Now column" of the product roadmap. Management makes the decision of which feature ideas are released for implementation. In more detail, the decision is made based on pitches from product management, which presents the feature ideas in the “Next” column to management. This presentation typically includes economic numbers such as expected sales, purchase costs, and sales prices. If the management is convinced of the success of a feature idea, it is released for implementation. The roadmap is adjusted reactively every 2-3 months. This means that product management analyses the market (i.e., conducting competitor analysis and identifying customer needs) and adjusts the roadmap accordingly. The responsibility to adjust the roadmap lies with product management, while management has the accountability of the roadmap. The overall DEEP assessment of Case Company B is shown in Figure 11.9.

Dimension	Stage 1	Stage 2	Stage 3	Stage 4	Stage 5	Potential for improvements (reaching stage 5)
Roadmap Detailing	1	3	**8**	**15**	20	5
Roadmap Items	1	**3**	10	**12**	20	8
Reliability	**1**	3	**8**	12	16	8
Confidence	**1**	**4**	7	10	12	8
Product Discovery	**1**	**2**	4	8	10	9
Prioritisation	1	**2**	**3**	3	6	4
Extent of Alignment	1	**1**	**2**	3	6	5
Responsibility	1	2	3	**4**	5	1
Ownership	1	**2**	3	4	5	3
Score per column	**1**	**9**	**8**	**31**	**0**	
Total score					**49**	

Figure 11.9: Case Company B: Initial DEEP assessment

The assessment with the DEEP model leads to a final score of **49 points** which means an overall product roadmapping maturity level of three.

Maturity Level	1	2	3	4	5
Score	9 – 18 pts.	19 – 36 pts.	**37 – 62 pts.**	63 – 87 pts.	88 – 100 pts.

Figure 11.10: Case Company B: DEEP level before the case study

11.3.2 Identifying the Most Promising Dimension for Improvement (Case Company B)

The overall product roadmapping maturity of Case Company B is three. According to our proposed process to identify the most promising dimension for improvement, the dimensions 1) roadmap items, 2) roadmap detailing, 3) product discovery, 4) confidence, 5) ownership, 6) responsibility, 7) extent of alignment, and 8) prioritization are candidates for improvement. Taking into account the potential for improvements, the following three dimensions are the most promising: confidence (potential of 8 points), product discovery (potential of 9 points), and roadmap items (potential of 8 points). The research team and the case company decided to improve the dimension of product discovery. This is justified as follows: As mentioned in the first case study, our proposed process recommends improving the dimension product discovery before the dimension confidence. The reason for this is that product discovery aims to reduce the level of uncertainty to a level that enables the building of a solution that provides value to the customer and the business. This creates confidence that the solutions discovered will have a high impact on fulfilling customer and business goals. Therefore, we recommend prioritizing improving the dimension product discovery before improving the dimension confidence. Moreover, establishing product discovery activities leads to identifying customer problems and needs, which serve as the basis for creating roadmap items such as outcomes. In addition, before this case study, the product team of Case Company B discussed introducing product discovery processes. However, there was a lack of evidence and arguments to convince critical stakeholders and justify the introduction of product discovery to management. Therefore, the results of the DEEP model provided these comprehensible arguments and evidence. This resulted in critical stakeholders agreeing to the introduction of product discovery and management allocating the budget to implement this project. For these reasons, together with the product team of the case company, we decide to improve the dimension product discovery before the dimension roadmap items.

11.3.3 Set Goals and Choose Measures (Case Company B)

The next step of the product roadmap transformation process is to define a target for the first iteration. This leads to the decision to improve the dimension of product discovery from stage one to stage four. The reason why the fourth stage was chosen and not the fifth stage is that reaching the fifth stage requires the integration of product discovery with product delivery. This is an extensive project that should be carried out based on existing product discovery processes, including their responsibilities. Since the case company has not introduced such processes with corresponding responsibilities, such a basis must be created first. This is the goal of the fourth stage of product discovery. Applying our proposed Goal-Opportunity Map, the dimension product discovery can be improved by creating the artifacts 1) outcomes, 2) solution ideas, or 3) validated learnings. Since the case company has not reached level four of the dimension of product discovery, the integration of product discovery and product delivery and development is out of scope. Due to time and capacity constraints, the case company decided to create the two artifacts' outcomes and solution ideas and postpone conducting experiments to generate validated learnings.

Dimension / Artifact	Product Vision	Outcomes	Solution Ideas	Validated Learnings
Roadmap Items	X	X	X	X
Roadmap Detailing		X	X	
Product Discovery		X	X	X
Confidence		X	X	X
Prioritization	X			X
Alignment	X	X		

Figure 11.11: Case Company B: Application of the Goal-Opportunity Map

As the next step, we applied the Goal-Activity Map to define appropriate measures for creating the artifacts outcomes and solution ideas. Enter the artifact outcome in the Goal–Activity Map leads to the recommendation to conduct the following measures: 1) customer interviews, 2) observations, 3) customer surveys, 4) jobs to be done, or 5) empathy map. Like Case Company A, Case Company B has no current knowledge about the customers' problems and needs and also has a small customer base. For these reasons, the measures of empathy map, jobs to be done, and web surveys can be excluded. A request by the case company to their customers to allow observations resulted in three commitments. However, two observations are not enough to gather sufficient evidence of the current problems and needs of the customers. It was therefore decided to conduct customer interviews and validate the insights from the interviews through observations. As the second step, we applied the Goal-Activity Map to obtain measures to create solution ideas. In this context, the head of product management of the case company mentioned that it would be important for the various teams to visualize the path of product development to guide the teams in the next steps. These requirements are best covered by the development of an opportunity solution tree. Therefore, it was decided to use the method opportunity solution tree for generating the solution ideas.

Measure / Artifact	Product Vision	Outcomes	Solution Ideas	Validated Learnings
Product Vision Workshops	X			
Mission Briefing	X			
Customer Interviews		X		
Observations		X		
Customer Surveys		X		
Jobs to be Done (Customer Focus Groups)		X		
Empathy Map (Customer Focus Groups)		X		
Impact Mapping				
Lightning Demos			X	
Opportunity Solution Tree			X	
MVP and Prototyping				X

Figure 11.12: Case Company B: Application of the Goal-Activity Map

11.3.4 Execution of the Identification of Customer Problems (Case Company B)

The next step in the product roadmap transformation process is conducting the execute phase. Our activities regarding the subphases of these phases are described below.

Plan: As mentioned above, we decided to conduct and establish the product discovery methods, customer interviews, and observations to reach stage four of the dimension of product discovery. Both methods aimed to identify problems in using collaborative robots and gain a deep understanding of the reasons behind each problem. In the context of the observations, we request various customers of the case company. This leads to the opportunity to observe the behavior of collaborative robots at three companies. These were three mid-size companies from Germany that actively use collaborative robots. To document the observation, we created a protocol containing the following aspects. 1) description of the situation (context), 2) activities performed by the collaborative robot, 3) safety equipment used, 4) problems of the collaborative robot.

For the customer interviews, it was decided to include potential customers of Case Company B. Therefore we developed an interview guide that is divided into two sections. The first section aims to determine the demographic data of the interviewees and includes the following questions: 1) What is your current position? 2) How long have you experienced with collaborative robots? 3) How many collaborative robots do you actively use? 4) How many employees does your company have? The second section of the interview guide aims to gain insights into the customers' problems of the case company. In this context, we defined three main questions, including sub-questions. The sub-questions have the purpose of gathering extensive knowledge about the respective topic of the main question and thus serve to gain broad and deep insights into the subject matter. The main questions are described in the following.

- **What task do you solve with cobots?** This question aims to identify how the user applies collaborative robots to complete a particular task. This includes determining whether there are one or more activities that such a robot can solve. This helps to get an overview and a better understanding of what kind of tasks companies use collaborative robots for.
- **Do you have problems customizing, operating, or maintaining your collaborative robots?** This question aims to identify if there are any problems with collaborative robots and in what areas. It should be noted that the previous experience of the case company was that

problems often occur during the customization of collaborative robots. Therefore, problems before or during the selection of a collaborative robot were also asked.

- **What is the consequence of each problem?** The purpose of these questions is to gain a deep understanding of what problems the users of collaborative robots face and the underlying reasons for each problem. This is accomplished by asking about the costs, time, and implications of each problem. In addition, this information provides us with initial insights about the prioritization of identified problems.

Implementation: After creating the interview guide, the search for suitable participants started. This took place via the social media platforms Facebook and LinkedIn. In more detail, we have directly written to experts who work with collaborative robots. Moreover, we created a post to encourage interested people to participate in the interviews and distribute it on the social media networks mentioned above. In addition, the post was shared in various expert groups on Facebook and LinkedIn that deal with collaborative robots. To assess whether interested people were suitable to participate in the interviews, we use the following questions: 1) Are collaborative robots used in the company of the interviewee? 2) Is knowledge related to collaborative robots available? 3) Can the interview be conducted in German or English? For an expert to be eligible for the interviews, answering "yes" to all these questions was necessary. After reviewing twenty potential interviewees for these questions, we are able to recruit twelve interviewees from 8 various companies. Table 11.3 shows an overview of the participants who participate in the interviews. The column "Experience" was classified into the following categories: 1) beginner (0 to 3 years of experience), 2) advanced (4 to 6 years of experience), and 3) expert (more than 6 years of experience). The company size "Small" refers to companies with less than 50 employees, companies with a number of employees between 50 and 250 were classified as "Medium" and companies with more than 250 emplyoees are marked as "Large".

Table 11.3: Participants of the interview for the identification of customer problems (Case Company B)

Position	Experience	Company Size	Country
CEO	Advanced	Small	Germany
Software Developer	Beginner	Medium	Hungary
Software Developer	Expert	Small	Germany
Head of Automation	Expert	Small	Norway
Sales	Expert	Small	Germany
Software Developer	Advanced	Large	Canada
Software Developer	Beginner	Small	Germany
Software Developer	Beginner	Small	Japan
Head of Automation	Expert	Medium	Germany
Head of Operations	Beginner	Medium	Germany
Software Developer	Beginner	Medium	China
Software Developer	Beginner	Medium	Germany

In preparation for the analysis, we transcribed each interview word for word. For the analysis of the transcriptions, Mayring [May15] distinguishes between a deductive or inductive approach. The deductive approach means that before analyzing the interviews, categories are formed based on existing scientific data. The collected data from the interviews are assigned to these categories during the analysis. In contrast, in the inductive approach, categories are built directly from the collected data. We decided to conduct the inductive approach since there is insufficient data (problems related to collaboration robots) to perform the deductive approach. The listing below shows the results of our categorization after summarizing the individual statements in the interviews. The categorization was conducted independently by a researcher and the product manager of the case company and then discussed in a joint session to build the final categories.

As mentioned above, in addition to the expert interviews, the behavior of the collaborative robot with its users was observed in active operation at the customer´s site. To ensure that the behavior of the user would not be affected by the observation, the participants did not know that they were being observed. After the observation, the employees were educated about the observation, and the findings were discussed. These observations allow us to gain practical insights into the environment in which collaborative robots were used and the daily tasks and problems faced by the employees responsible for the collaborative robots. This allows us to validate the statements through expert interviews with additional primary data. In this context, it should be noted that all statements made in the expert interviews were confirmed. In more detail, the statements "P7" and "P9" (see list below) were observed in operation, while the other statements were confirmed in the brief conversations with observation participants. To prioritize the problems, we quantify the mentioned problems of the interviews. Therefore, if a problem category was mentioned in an interview, we assigned a point to that category. As the list below shows, the three most frequently mentioned problems by customers are as follows: 1) A very deep understanding and knowledge of the production process is necessary to assess whether a collaborative robot is suitable for a use case, 2) when redesigning a technical system or changing the place of use of the collaborative robot, a risk assessment must be carried out, which is time-consuming and expensive and 3) the cooperation between humans and collaborative robots cannot be used as advertised.

- **P1:** A very deep understanding and knowledge of the production process is necessary to assess whether a collaborative is suitable for a use case. (11 points)
- **P2:** When redesigning a technical system or changing the place of use of the collaborative robot, a risk assessment must be carried out, which is time-consuming and expensive. (9 points)
- **P3:** The cooperation between humans and collaborative robots cannot be used as advertised. (8 points)
- **P4:** There is no in-house expert who acts as a contact person for the issue of collaborative robots. (6 points)

- **P5:** Limitation of the use of collaborative robots by reach, payload, and speed. (6 points)
- **P6:** The cost of acquiring the collaborative robot is higher than planned. (4 points)
- **P7:** Programming (e.g., a change or extension) of the software for the collaborative robot cannot be done by the customer. (3 points)
- **P8:** Software and hardware problems often occur with the collaborative robot. (2 points)
- **P9:** The collaborative robots are often subjected to incorrect mechanical loads. (2 points)

Moreover, we asked in the interviews how the participants use the collaborative robots and what impact the problems have on the business operations of the participating companies. In this context, all participants use collaborative robots as technical support within production. Examples, therefore, are assisting with soldering, welding, grinding, or as a support when lifting heavy loads. As consequences of the problems mentioned above, the participants indicate delays in production, failure to achieve the specific production quantity, and loss of employee confidence in the reliability of the collaborative robot.

11.3.5 Execution of the Creation of an Opportunity Solution Tree (Case Company B)

To create and visualize possible paths to solve the identified problem, we use the method opportunity solution tree according to Torres [Tor21]. As Figure 11.13 shows consist the opportunity solution tree of the four elements 1) outcomes, 2) opportunities, 3) solutions, and 4) experiments. An outcome represents the overreaching goal a company will achieve, such as increasing customer satisfaction or entering a new market. Based on this outcome, opportunities are derived that represent chances to reach the desired outcome. These opportunities serve as the basis for developing one or several solution ideas that may contribute to fulfilling the opportunity. One or more experiments are defined for each solution idea to validate whether a solution idea contributes to the fulfillment of the corresponding opportunity.

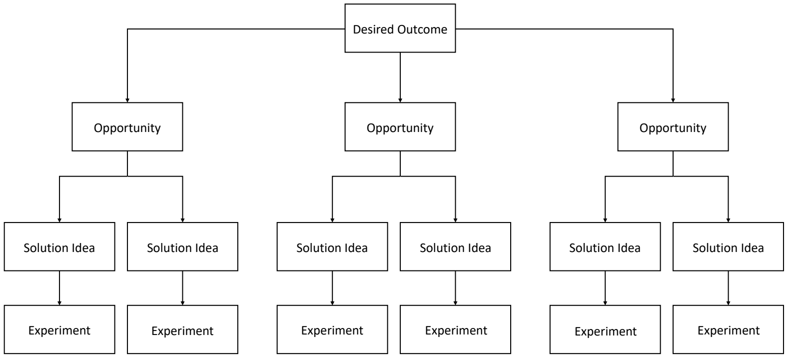

Figure 11.13: Opportunity Solution Tree

The opportunity solution tree in this case study was developed in a workshop with five employees of the case company. To include a broad perspective into the process, we should care that representatives from different business units of the case company participate in this workshop. Table 11.4 shows the participants of the workshop to create the opportunity solution tree.

Table 11.4: Participants for the creation of the opportunity solution tree

Participant	Role
Participant 1	Head of the Operations Department
Participant 2	Product Manager
Participant 3	Technology Strategy Manager
Participant 4	Product Manager
Participant 5	Chief Executive Officer

In preparation for building the opportunity solution tree, we decided to extend the existing prioritization by the opinions of the expert that participated in the workshop. Therefore, we designed the agenda of the workshops as follows: 1) Ranking of the problem categories from the expert workshops, 2) explanation of the method opportunity solution tree to the participants of the workshop, and 3) development of the opportunity solution tree.

Ranking of the problem categories: The aim of this phase was to extend the existing prioritization created based on expert interviews. This phase is intended to obtain a final prioritization to decide which problems to tackle first. This means answering the questions for which problems an opportunity solution tree should be created. Therefore, the first task for each participant in the workshop was to assess the problems identified by the customer interviews. The results of the ranking from the prioritization of the customer interviews were not presented to the participants to avoid influencing them. For the assessment, each participant was given five points to score the problem categories. If participants perceived a category to be highly relevant, they were allowed to award multiple points to a problem category. This approach leads to the results shown in Table 11.5. As can be seen, the prioritization of the experts largely coincides with the prioritization of the customers. This shows that the expert of the case company has a good understanding and empathy for the problems of their customers.

Table 11.5: Prioritization of customer problems after the workshop

Problem ID	**Score interviews**	**Score workshop**	**Sum**
P1	11	6	17
P2	9	4	13
P3	8	3	11
P4	6	4	10
P5	6	2	8
P6	4	3	7
P7	3	3	6
P8	2	0	2
P9	2	0	2

Considering both prioritizations, the three highest prioritized problem categories are as follows: 1) a very deep understanding and knowledge of the production process is necessary to assess whether a collaborative is suitable for a use case, 2) when redesigning a technical system or changing the place of use of the collaborative robot, a risk assessment must be carried out, which is time-consuming and expensive and 3) the cooperation between humans and collaborative robots cannot be used as advertised.

Creation of the Opportunity Solution Tree: The second phase of the workshop consisted of creating an opportunity solution tree, including the three highest priority problems as outcomes. It should be noted that Figure 11.14 shows an excerpt from the entire opportunity solution tree due to confidentiality constraints. The complete opportunity solution tree consists of 10 opportunities and 14 solution ideas, including one experiment for each. To stay focused, especially over a long time, we defined together with the product team an overreaching challenge as follows:

> “*How can we create an excellent user experience for our collaborative robots for our customers?*”

This overreaching challenge not only serves to guide the workshop participants but is also intended to guide the product team in future decisions. It should ensure that value creation for the customer is central to every activity. The reason for this is that satisfied customers are retained, and they will likely recommend the use of collaborative robots by the case company.

The next step in creating the opportunity solution tree is to put the three highest prioritized problems formulated as outcomes on the top of the opportunity solution tree. The workshop participants' first task was defining opportunities for each outcome. Figure 11.14 shows that for the outcome “gain a deep understanding and knowledge of the production process for the use of collaborative robots”, the opportunities “offer software solutions to support the customer in making decisions", and “offering consultation as a business" was defined. Then, solution ideas for each opportunity are derived. Therefore, participants were given twenty-five minutes to develop their solution ideas for each opportunity and one experiment to validate each idea. Subsequently, each participant presented their solution ideas, including the proposed experiment, which were discussed with all participants. This discussion resulted in the generation of the solution ideas shown in Figure 11.14, including their corresponding experiments.

The entire opportunity solution tree will serve the product team as a guide to the product team on the path to achieving the overreaching challenge. It should be noted that this opportunity solution tree is a living artifact. This means that new outcomes or opportunities can be added or removed based on new user research findings. The three highest prioritized problems, i.e., the outcomes of the opportunity solution tree, with their solution ideas and corresponding experiments, were included in the "Next" column of the product roadmap. On this base, the product management of the case company will conduct the defined experiments to validate which solution idea will contribute the most to achieving the associated opportunity. According to these results, those solution ideas that contribute most to the achievement of the opportunity should be moved to the “Now” column and released for implementation. Subsequently, further product discovery activities should be conducted to verify if the created opportunity solution tree needs to be adjusted.

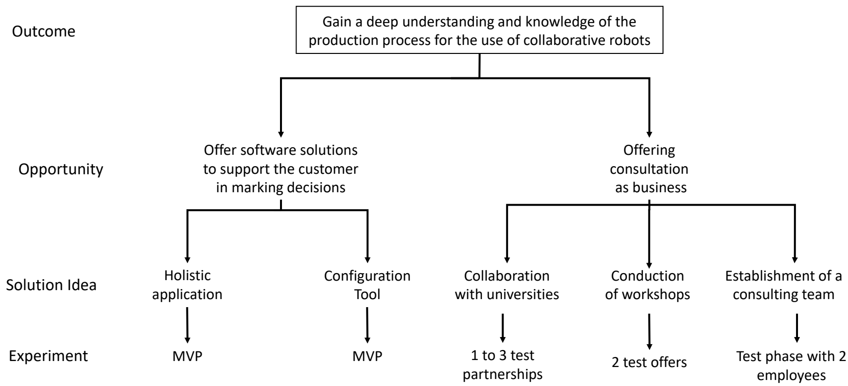

Figure 11.14: "Opportunity solution tree" created in the workshop (Excerpt)

Review: As in the first case study, we assessed with the case company's product team whether the activities contributed to the overall goal of improving the dimension of product discovery from stage one to stage four. To achieve this goal, as the first measure, we conducted interviews with the customers of the case company. Moreover, we systematically prioritized these problems using customer insights and expert experience. This enables the case company to uncover their customers' current problems and needs and to understand which problems customers are most concerned about. The prioritized problems serve as input for creating an opportunity solution tree within a workshop. During the workshop, we noted that employees from various departments discussed what solutions could be used to solve a current problem of the customers. These discussions incorporated the knowledge and experience of various disciplines, resulting in effective solution finding. This means that by combining different perspectives, a variety of conceivable and feasible solutions could be identified. In this context, one product manager of the case company stated: *"Such a variety of innovative solutions would probably not have been produced by the workshop with only one department"*. Moreover, holding a cross-functional workshop leads to saving time in developing potential solution ideas. The reason for this is that before conducting this case study, management decided which products to be developed based on pitches of solution ideas product management. This often entails long sessions to discuss and assess each solution idea. In this case study, solution ideas could be developed through a single workshop session. Moreover, the case company established the opportunity solution tree as a communication tool. This means that the opportunity solution tree communicates to the product team the next steps necessary to fulfill an overreaching challenge. Therefore, the opportunity solution tree has contributed to increasing transparency within product development and helps the product team to plan their next steps.

Retrospective: Overall, the employees of the case company were very receptive to conducting interviews and the approach to developing an opportunity solution tree. Consequently, product management, together with the case company's management, decided to integrate these methods into the product management processes to ensure continuous implementation. Regarding the interviews, one challenge, according to the product team of the case company, was to ask the right question to obtain useful information. In this context, creating an interview guide and its testing and iterative development prior to the interviews was a critical success factor. Regarding the product discovery method observation, the challenge was to find participants. This is because companies are often unwilling to give other companies insights into their internal processes. Therefore, only three observations could be made in the context of this case study. In conducting the workshops to create an opportunity solution tree, we noted that applying this method requires much explanation. Therefore, sufficient time should be allocated during this workshop to explain how to create an opportunity solution tree and answer questions. Otherwise, there is the risk that this method cannot reach its full potential.

11.3.6 Impact of the Conducted Measures of the Product Roadmapping Practices (Case Company B)

As in the first case study, we discuss with the product team of the case company whether the selection of a higher level of the DEEP model was justified and which dimensions would be affected by an improvement. As Figure 11.16 shows, the case company improved the dimension of product discovery, roadmap detailing, and responsibility. The reasons for these improvements are explained in the following.

Dimension	Stage 1	Stage 2	Stage 3	Stage 4	Stage 5	Points gained
Roadmap Detailing	1	3	8	15	20	5
Roadmap Items	1	3	10	12	20	0
Reliability	1	3	8	12	16	0
Confidence	1	4	7	10	12	0
Product Discovery	1			8	10	7
Prioritisation	1	2	3	3	6	0
Extent of Alignment	1	1	2	3	6	0
Responsibility	1	2	3	4	5	0
Ownership	1	2		4	5	2
Score per column	0	7	8	28	20	
Total score						**63**

Figure 11.15: Company B: DEEP Assessment after the Case Study)

The goal of conducting this case study was to improve the dimension of product discovery from stages one to stages four. Therefore, the product discovery methods of customer interviews and observations were successfully conducted. Successful means that the execution of such methods leads to the generation of artifacts (e.g., real customer problems) that provide evidence for the development of a specific product that contributes to the fulfillment of customer needs. This was achieved in the case study by generating validated customer problems that served as the basis for the formulation of outcomes and by creating the opportunity solution tree. Therefore, it can be justified that the case company moved from stage one to stage four in the dimension of product discovery.

Another improvement related to the dimension roadmap detailing. Prior to conducting this case study, the roadmap of the case company consisted of two columns, one containing topics and the other customer goals and feature ideas determined by the product management. This leads to stage four in the dimension roadmap detailing. The process of developing the opportunity solution tree creates the artifacts, outcomes, opportunities, and solution ideas with their corresponding experiments that are included in the product roadmap. Therefore, a third column named “Later” was introduced in which customer-oriented outcomes were included. In the “Next” column, the topics have been replaced by opportunities with corresponding solution ideas. The solution ideas are either in validation using the defined experiment or still being validated. If a feature is positively validated, it is moved to the "Now" column of the product roadmap. This ensures that only validated features are released for implementation. Since this approach is equal to the requirements to reach stage five of the dimension roadmap detailing, it is justified that the case company moved from stage four to stage five in this dimension. Moreover, we discussed whether this approach leads to the achievement of stage five in the dimension roadmap items. However, we noted that a product vision must be in place to reach this stage. For this reason, selecting stage five was not justified; thus, the case company remains at stage four.

Moreover, the case company improves the dimension of ownership. Before conducting this case study, the product management was responsible for the product roadmap, but management owns the roadmap, i.e., has approved the contents of the product roadmap. Through the results of this case study, management realized that it makes sense to give product management the responsibility and ownership of the product roadmap. According to the case company's management, the case study has shown that product management is closest to the market and customers of all departments through its task of product discovery. Therefore, product management can best evaluate at which point in time adjustments to the product roadmap are necessary. Furthermore, the rapid implementation of such adjustments in a digital environment is crucial to the success of a company. To adjust the roadmap as quickly as possible, it makes sense to hand over ownership of the product roadmap to product management. Therefore, it is justified that the case company improves the dimension of ownership from stage two to stage four.

Finally, we discussed improving the dimension of confidence from stages three to five. However, this case study included the definition of experiments but not their execution. Therefore, no data was collected on how the solution ideas developed in this case study impacted customers or business goals. Consequently, it was not justified to select stage four, thus, the case company remains at stage two.

As mentioned in Chapter 11.3.1, the DEEP assessment prior to conducting this case study resulted in 51 points. By conducting the recommended measures, Case Company B was able to improve the dimensions roadmap detailing (by 5 points), product discovery (by 7 points) and ownership (by 1 point). This lead to an improvement of 13 points, resulting in a total score of 64 points and, thus, an overall maturity level of four.

Maturity Level	**1**	**2**	**3**	**4**	**5**
Score	9 – 18 pts.	19 – 36 pts.	37 – 62 pts	63 – 87 pts	88 – 100 pts

Figure 11.16: Company B: DEEP Assessment after the Case Study)

11.4 Threats to Validity

In order to discuss the validity and trustworthiness of our study, we used the framework proposed by [Yin09] which consists of the four criteria construct validity, internal validity, external validity, and reliability. One possible threat to construct validity is the expressiveness of the study sample. This means that a monotonous sample consisting of only software engineers could bias the results of the study. To mitigate this threat, we selected multiple participants for each company to include various perspectives and opinions in the study. In addition, this case study includes two case companies with different processes, capabilities, and cultures, which increases the expressiveness of the results. The internal validity could be threatened by the expectancy bias of the researchers. This means that researchers could interpret the collected data in a way that meets their expectations. To address this threat, experts from the respective case companies were involved in the analysis of the data. In addition, we conducted preliminary interviews to ensure that the practitioners participating were suitable for our research. With regard to the external validity, it should be mentioned that the two companies that we investigated are not a representative sample of the software development industry. Therefore, the results of this study can only be generalized to the entire software-intensive industry to a limited extent. In addition, the case study was conducted with German companies, so differences with other cultures cannot be excluded. However, the case was deeply studied and understood through the collection of qualitative data that was systematically analyzed. Therefore, it can be assumed that the findings of this case study can be generalized in similar contexts. Regarding reliability, it would be conceivable that participants behave differently within the case study than outside the case study. An example of this would be that participants expressing incorrect opinions within the case study. This threat is mitigated by the fact that the participants had no motivation and incentive to falsify their behaviors. Moreover, all data was documented, and the extraction and analysis of the data were performed by several researchers and the practitioners involved.

11.5 Conclusion

We conducted a multiple case study to validate that our developed product roadmap transformation approach is comprehensible, applicable, and useful in a real business environment. We note that both companies perceived our approach as systematically structured and had no problems applying it in their respective business contexts. The study shows that one value of the transformation process is that the area of product roadmapping to be transformed is identified for each company based on an assessment. This ensures that those areas of product roadmapping are tackled for a transformation that delivers the most value for the progress of the product roadmap transformation and, thus, not unnecessarily, resources are invested in areas that brings no or little value. Within the transformation approach, this assessment serves as the basis for identifying which artifacts should be developed and which measures are suitable for developing those artifacts. This provides the value that management or other employees better understand the selection and prioritization of measures for the product roadmap transformation and makes it easier for product management to justify these decisions to third parties.

Overall, this case study shows that practitioners perceived our product roadmap transformation approach as well structured and that the content of our approach is suitable for a product roadmap transformation, according to the participants. However, it should be noted that this is not evidence that the artifacts proposed by our mapping tables lead to an improvement of the product roadmapping practices. Therefore, we analyzed the impact of the developed artifacts in this case study of the product roadmapping practice of the two case companies. In this context, we note that in Case Company A, the development of the artifacts outcomes, solution ideas, and validated learnings produces the following effects: The application of the transformation approach by Case Company A shows that the establishment of a product vision fosters the discussions about the needs and problems of the customers. This can be considered the first step in moving from a feature-driven mindset toward an outcome-oriented mindset. Moreover, the introduction of outcomes into the roadmap affects that employees invest their capacity in developing solutions (ideas) that contribute to solving real customer problems. This increases the motivation of the employees to engage in daily product development. In addition, the case study showed that including outcomes, solution ideas, and validated learnings affects the confidence of the employees regarding the content of the product roadmap have increased. This means that employees have more trust that the defined product strategy will lead to success. Finally, the case study showed that the number of unnecessary adjustments could be reduced compared to the previous roadmapping approach of the case company. This has the consequence that capacities (especially from the product owner) can be saved and thus lead to a waste reduction. The application of the transformation approach by Case Company B shows that the development of solution ideas based on outcomes leads to intensive discussions, which lead to a variety of solution ideas. Moreover, the cross-functional development of solution ideas with the associated experiments created alignment and commitment among all people involved in product development. The inclusion of these items into the roadmap effects that the developed product strategy is visible across the company, thus ensuring sustainable transparency. Furthermore, this helps the product team to plan the next and future steps of product development. Finally, conducting this case study fostered the establishment of an agile mindset. This was demonstrated by the activity that after this case study, management was willing to delegate the ownership of the product roadmap to product management. This allows product management to perform their activities according to market needs independently from management. Consequently, product management can immediately react to market changes and does not have to seek the opinion and approval of management beforehand. Based on these findings, it can be concluded that our product roadmap transformation approach in a real business context is comprehensible, applicable, and useful.

CHAPTER 12

The DEW Index and Integration Approach

As our previous case studies showed, product discovery provides important insights to create artifacts essential for product roadmapping in a dynamic and uncertain market environment. A typical example is the identification of customer problems on the basis of which outcomes are defined. Therefore, product discovery is an essential dimension for the success of product roadmapping in a dynamic and uncertain market environment. The state of practice has shown that product discovery is partly conducted in German companies. For companies considering introducing product discovery activities, our product roadmap transformation approach provides excellent guidelines. The state of practice has shown that those companies that conduct product discovery activities face two major challenges: On the one hand, such companies struggle to identify how much resources to invest in product discovery. The main reason for this is that resources for conducting product discovery are often severely limited; thus, not all feature ideas can be systematically discovered and validated. On the other hand, such companies face the challenge of integrating their product discovery activities with product development and delivery, which is required to reach the highest maturity in the DEEP model. Without such integration, there is the risk that the knowledge gained from the product discovery activities is not or is only partly considered in the software development and delivery process. Therefore, it is likely that the product to be developed does not fully meet the customers' needs. To counteract these two problems, we have developed two artifacts presented in this chapter. This was done in another execution of the phase "design and development of the artifact" in the design science process (see Figure 1.1). In order to achieve our objective, we have defined the following research questions:

- **RQ1:** How can a product owner or agile team decide how much effort is needed to apply product discovery to a particular backlog item?
- **RQ2:** What are the requirements for integrating product discovery into product delivery (except for assigning appropriate effort)?
- **RQ3:** How could the requirements for integrating product discovery into product delivery be fulfilled to reach maturity level five of the dimension product discovery in the DEEP model?

The chapter extends the following publication

- S. Trieflinger et al. 'The discovery effort worthiness index: How much product discovery should you do and how can this be integrated into delivery?' In: *Information and Software Technology* 157 (2023), p. 107167
- D. Lang et al. 'Tailored design thinking approach-a shortcut for agile teams'. In: *Software Business: 12th International Conference, ICSOB 2021, Drammen, Norway, December 2–3, 2021, Proceedings 12*. Springer. 2021, pp. 37–49

12.1 Research Design

In order to answer RQ1, we conducted a single case study. Yin [Yin09] describes a case study as an empirical investigation that examines contemporary phenomena in a real-world context. This method is particularly suitable when the boundaries between phenomenon and context are not clearly discernible sources of evidence. According to Plag [Pla07], the case study research method is suitable under the condition that the context of the complex phenomenon to be studied is of particular interest. Furthermore, a case study is suitable if current approaches and perspectives are to be broken open and new perspectives shall be defined. In addition, it is advantageous if the state of research tends to be in an early phase [Yin09]. With regard to this chapter, these conditions are met.

In this case study, Design Thinking (according to the approach as proposed by IDEO [IDE] was introduced into the regular process of a cross-functional Scrum team at Robert Bosch Smart Home GmbH. The Scrum team consists of one product owner, one scrum master, and a development team consisting of external and internal resources (IT architect, developers, marketing, logistics, and sales). In the case study, user stories were evaluated with Design Thinking to mark them as ready and thus incorporate them into sprint planning. First, some kind of benchmark was needed to develop a metric that allows the team to identify which effort should be invested into Design Thinking methods. Therefore, the backlog items of the case study team were analyzed in workshops with the support of two UX and Design Thinking experts to assign corresponding Design Thinking methods that promise the best input-output-ratio (see Figure 12.2). In workshops with the Scrum team, these assignments were reviewed and validated. While these assignments were set as the benchmark, we determined which dimensions were decisive in identifying the appropriate Design Thinking methods by asking the team and the UX and Design Thinking experts why they decided to pick a specific method and why they decided to spend the effort involved. These interviews with experts and team members revealed the major factors, called dimensions, used to come to the benchmark assignments. After identifying the decision-driving dimensions, the next step was to select a set of user stories from the team's benchmark and rate them with regard to the identified dimensions following the scrum poker principle of relative rating. That means one story for which the definition of the appropriate Design

Thinking method and, therefore, the appropriate effort was very clear got rated, and the following stories were rated in relation to it. The researchers decided to use a scale from one to ten for the rating, where ten means high, and one means low. This was chosen because a scale of ten offers enough variety but keeps the rating for the team simple, so adopting the approach is perceived as easy for the team. The zero does not appear since ideas or user stories with a clarity of zero or a potential value of zero won't appear in practice and, therefore, won't be handled by a product team.

When looking at the results of the dimension rating and the recommended effort by the UX and Design Thinking experts, a correlation between the dimensions and the effort worth spending was observed. Based on these results, a formula was developed that enables the product owner to independently determine a score that allows agile teams to identify how much effort should be spent with Design Thinking without the need to continuously involve experts in giving their recommendations. Depicting this on a more abstract level, the approach is as follows (see Table 12.1):

User Story A is rated on dimension one and dimension two. User Story B is now rated on dimensions one and two in comparison to User Story A. If User Story B seems too similar in dimension one but at least twice as relevant in dimension two, a possible rating on a scale of 1-10 would be like this:

Table 12.1: An example of the correlation between the dimensions

	Dimension one	Dimension two
User StoryA	5	3
User Story B	5	6

Since User Story A is well understood, there is a clear picture of which effort would be appropriate to be invested in Design Thinking for User Story A. User Story B can be rated in relation to User Story A, but the rating itself will not reveal which research effort would be appropriate. Since this appropriate effort depends on dimension one and dimension two, the relation between the dimensions and the effort must be determined then to derive the appropriate effort for User Story B. Consequently, the research approach for this research followed several phases: 1) create a benchmark by assigning research effort to a set of well-known user stories, 2) figure out the decisive dimensions that affected the effort assignment, 3) rate the user stories on the dimensions, 4) determine the relation between the dimensions, 5) calculate the DEW Index, 6) create mapping table with the relation between effort and DEW Index, and 7) select the appropriate effort for your team.

The relation between the dimensions that lead to the appropriate effort is the Discovery Effort Worthiness Index presented in this chapter. To determine this relation, a set of more than fifteen benchmark user stories, where the appropriate effort was known, was rated on the dimensions, and a formula that connects the dimensions was derived. While it has already been described how the dimensions and ratings were determined, the creation of the mapping table that is required to find the appropriate effort based on the DEW Index is not discussed yet. The creation of the mapping table can also be referred to as the 'calibration' step. Based on the benchmark set in step 1, the assigned Design Thinking methods (usually method bundles were assigned instead of single measures) were sorted according to their DEW Index. The scale of the DEW Index is based on a floating scale between one and ten and does not consider decimal places. The product owner can select methods from the ranges once, several times, or not at all, depending on the user story and DEW Index. This abstraction and the relative scoring enable the transferability of the approach to other teams and other discovery methods besides Design Thinking.

In order to answer RQ2 and RQ3, we conducted an expert workshop with three practitioners and one researcher. In this context, two members of the research team moderated the workshop. We selected the practitioners based on their practical experience regarding product roadmapping and their roles in their companies. The latter means that each of these practitioners is involved in creating and handling the product roadmap and the execution of product discovery. Regarding the selection of the participant, we took care to recruit a heterogeneous set, i.e., the participants differ in their industry sectors within the software-intensive business and the size of their companies.

This ensures that multiple perspectives are included in the discussions. The participants of the expert workshops are summarized in Table 12.2.

Table 12.2: Participants for the workshop for the creation of the integration approach (size classification: small> 50, Medium, large >250)

Part.	Position	Experience	Company Size
Part. 1	Chief Product Owner	7 years	Large
Part. 2	Product Owner	3 years	Medium
Part. 3	Product Manager	2 years	Medium
Part. 4	Researcher	3 years	-

The workshop took place on April 6, 2022, via Zoom and took 180 minutes. First, we introduced the context of the workshop to the participants. This includes an explanation of the motivation of the study, followed by a brief introduction of the DEEP model. Then we presented the DEEP dimension product discovery with its respective stages, including the key question for the workshop of how a company can get from stage four (several discovery activities are conducted, but they are not or only loosely integrated with delivery activities) to stage five (close integration of discovery and delivery activities). To discuss this systematically with the participants, we have taken the following approach: The first task was for participants to determine and discuss requirements to integrate discovery activities with product development and delivery. For this task, participants had five minutes to write their opinions. Subsequently, participants presented their ideas, which were then discussed with all participants in a 30-minute session. Therefore, we set the participants the following task: How can the requirements identified in the first task be fulfilled? In other words, how can a company reach maturity level five in the DEEP model? For this task, each participant had ten minutes to answer these questions. As in the first task, there was a 30-minute discussion session afterward. To document the ideas of the participants and to ensure collaboration among the participants, we used the online tool “Mural”. To prevent participants from influencing each other while working on the tasks, we used the blind mode provided by Mural in those phases, where each participant worked on the tasks separately. This caused each participant to see the other participants' answers only after the time for completing the task had expired. Within the discussions between the participants, one researcher acted as moderator, while another researcher noted the key statements in a separate document.

12.2 Results

12.2.1 Development of the DEW Index

To answer the first research question about how much effort should be spent on discovery activities in an agile context, we suggest the so-called DEW Index, which stands for **D**iscovery **E**ffort **W**orthiness Index. The DEW Index is a supportive tool for product owners and their teams to determine a suitable amount of effort that should be spent on Design Thinking activities. Looking at the backlog and discussing the selected Design Thinking methods that were assigned to the user stories by the team and the UX and Design Thinking experts, the interviews made clear that the DEW Index must be based on two dimensions that primarily affect the necessity for discovery and validation: 1) clarity about the user's need – how well understood is the actual demand of the user? 2) potential value – how much value does the feature deliver? It was observed that the need and willingness to invest time and resources is growing the higher the expected value and the lower the clarity about the customers' need is. Hereby, we determined that the impact of clarity is slightly higher than the expected value, therefore, this dimension needs to be weighted higher. This was observed by looking at a set of more than 50 user stories that were rated on both dimensions and their assigned Design Thinking effort, as described in the research approach. To find the right weight for the dimensions, this set of more than 50 user stories was compared regarding their assigned Design Thinking effort. Knowing the relation between the selected efforts and the dimension ratings allowed us to determine the relation between the dimensions and, therefore, the weights that support the expert assignments. The suggested weighting is 3:2 for clarity and potential value. The weighting is done because a low level of ambiguity and, thus, a high level of certainty about a user story particularly increases the need for Design Thinking. Furthermore, it is expected that a high level of uncertainty directly leads to a higher inaccuracy in the estimation and rating of the potential value, which means that higher unclarity also might influence the rating of the second dimension and therefore has more impact on the necessity of discovery and validation.

Considering this weighting, the approach to calculating the DEW Index is to rate each feature request relative to each other against both dimensions on a scale from 1 to 10, where 10 represents high potential and high clarity, respectively. The fact that the feature requests are rated relative to each other allows easy adoption to various projects and environments. To be able to do the calculation of the DEW Index, the clarity rating must be inverted since the effort for discovery increases with high unclarity. Finally, due to the different weights (3 for unclarity and 2 for potential value), the score must be divided by 5 to get the index. Therefore, the formula to calculate the DEW Index looks like:

$$DEWindex = \frac{3 * (10 - clarity) + 2 * (\text{potential value})}{5}$$

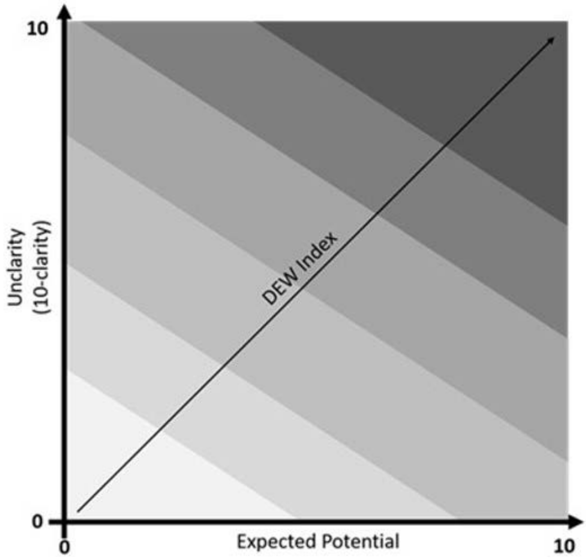

Figure 12.1: Dimensions of the DEW Index

12.2.2 Calibration of the DEW Index

The fact that the rating of the dimensions is done with a relative approach instead of absolute values leads to higher adaptability on the one hand but to the need for calibration on the other hand. To do the calibration, a company can proceed as follows: 1) assign corresponding Design Thinking methods to user stories from the backlog together with experts or based on experience, 2) rate this set of user stories from the backlog on the two dimensions, 3) calculate the DEW Index based on the rating, 4) map the corresponding Design Thinking methods to the results of the DEW Index calculation. That means that to enable product owners to easily select the appropriate measures from a mapping table and therefore optimize the effort spent for discovery and validation, a team must implement the DEW Index into their specific circumstances since the relative dimension rating from 1 to 10 can vary between different teams. This calibration is suggested to be done as follows: 1) First, a set of user stories gets assigned to suitable Design Thinking methods with the support of UX and Design Thinking experts or based on the team's experience. 2) Then, the stories are rated on the dimensions of clarity and potential value, and 3) the DEW Index gets calculated. Having done this, the team can 4) create a mapping table showing which DEW Index values suggest which methods and method bundles would be accurate. Here, the researchers observed that usually, this mapping consists of method bundles instead of single methods. Executing just one Design Thinking method is typically not sufficiently increasing clarity about the user demands or the expected value, so a bundle with a combination of methods can be more adequate. For example, such a bundle may consist of first conducting a brain storming, using the results for narrative interviews, and concluding the research with a Design Thinking workshop. The bundles in the mapping table should be understood as a recommendation and orientation, not as a default. This is also why the methods and method bundles are not assigned to an exact DEW Index value, and the table should not show decimals. The DEW Index depicts the suitable effort for discovery and validation in a simplified way on a range from 1 to 10, considering the relation of the items. That means that the methods and method bundles are also sorted in relation to each other and to the DEW Index in this table. The product owner can take the calculated DEW Index of a user story, investigate the mapping table, see which method range would be appropriate, and then individually pick the ones he sees as most feasible or promising. An example mapping can be seen in Figure 12.2

12.2.3 Application of the DEW Index

In the first step, the product team receives a new idea or a requirement that he needs to evaluate regarding the right effort for Design Thinking. Therefore, the product team (or product owner) rates the idea on the dimensions of clarity and potential value. At this point, the product owner is advised to do the rating in comparison to a reference user story to ensure that the result fits into the team's calibrated mapping. Once the product owner has assessed its clarity and expected potential, the next step is calculating the DEW Index with the above formula. After the product owner has performed the calculation, the calculated DEW Index is used to select one of the recommended Design Thinking methods or method bundles from the bundle mapping.

1				6		DEW-	Index	7		9		10
Bundle 1	**Bundle 2**	**Bundle 3**	**Bundle 4**	**Bundle 5**	**Bundle 6**	**Bundle 7**	**Bundle 8**	**Bundle 9**	**Bundle 10**	**Bundle 11**	**Bundle 12**	**Bundle 13**
Stakeholder	Stakeholder	Stakeholder	Stakeholder Map	Stakeholder	Stakeholder	Stakeholder	Stakeholder	Stakeholder	Stakeholder	Stakeholder	Stakeholder	Stakeholder
Desk	Desk	Desk	Desk	Desk	Desk	Desk	Desk	Desk	Desk	Desk	Desk	Desk
Brain Dump	Brain Dump	Brain Dump	Brain Dump	Brain Dump	Brain	Brain Dump	Brain Dump	Brain Dump	Brain Dump	Brain Dump	Brain Dump	Brain
Online	Online	Online	Online	Online	Online	Online	Online	Online	Online	Online	Online	Online
	Online survey	(Narrative) Interview 10<20	(Narrative) Interview >30	Online survey	Online survey	Online survey	(Narrative) Interview 10<20	(Narrative) Interview 10<20	(Narrative) Interview 10<20	(Narrative) Interview >30	(Narrative) Interview >30	(Narrative) Interview >30
	Semantic Analysis	Shadowing	DT-Workshop 4-8 pers.	Semantic Analysis	Semantic Analysis	Semantic Analysis	Shadowing	Shadowing	Shadowing	DT-Workshop 4-8 pers.	DT-Workshop 4-8 pers.	DT-Workshop 4-8 pers.
		Test of existing solutions					Test of existing solutions	Test of existing solutions	Test of existing solutions			
				+	+	+	+	+	+	+	+	+
				(Narrative) Interview 20<30	DT-Workshop 8-16 pers.	Prototype & Test <1 day	(Narrative) terview 20<30	DT-Workshop 8-16 pers.	Prototype & Test <1 day	(Narrative) Interview 20<30	DT-Workshop 8-16 pers.	Prototype & Test <1 day
				DT-Workshop 4-8 pers.	Role play	DT-Workshop >16 pers.	DT-Workshop 4-8 pers.	Role play	DT-Workshop >16 pers.	DT-Workshop 4-8 pers.	Role play	DT-Workshop >16 pers.

Figure 12.2: Overview of an example bundles

12.2.4 Requirements for Integrating Product Discovery into Product Development and Delivery Processes

In the context of requirements for successful integration of discovery activities such as Design Thinking, the following aspects must be taken into account: 1) strategic anchoring, 2) change management, and 3) knowledge transfer [Nud18]. Strategic anchoring is important for the teams to have a structure and for the company to not skip discovery due to missing priority and resources. A major part of strategic anchoring is analyzing and ideally modeling the current processes used to develop products and deliver them to the customer to create value. Having done this, an iterative approach is suggested to systematically add the determination of the DEW Index, identifying suitable discovery activities and executing the selected activities. It is also suggested to discuss the ideas and iterations with the affected team members to increase their commitment, which is already part of change management. Convincing the team of the approach by involving the team members in its definition is considered to be valuable as well as clearly showing the advantages of the new approach and of systematically conducting discovery. This could be done by depicting the effort saved for developing the wrong features or by letting them experience increased customer satisfaction for well-discovered products, features, or services. This involvement and the iterative approach where the team can inspect and adapt how to best integrate discovery into their daily routines also supports knowledge transfer since the team can learn step by step [Nud18; TLSM23].

Furthermore, the conducted workshop with practitioners revealed additional requirements and findings. One finding is that the discovery process might vary depending on the level of input already present in a user story, e.g., does the user story already represent a user demand? This is also reflected in the calculation of the DEW index since starting with a clear demand should increase the clarity dimensions and therefore decrease the Index value, which leads to less effort that is recommended to be spent on conducting discovery activities.

Another requirement mentioned during the workshop is that to successfully include discovery in the product development, and delivery processes, a cross-functional and agile mindset is required throughout the company and its hierarchies. Otherwise, it is likely to lose major key players on the way. This can also be avoided by fulfilling the requirement of informing the people about the new approach and the target to conduct discovery systematically. If people are informed and committed to systematically making use of discovery, the subsequent requirement is to be capable of running discovery activities. That means having the necessary expertise and capacities. To better plan and adjust resources and skills, it is also required to plan somehow and track the discovery tasks. This includes clarifying which roles that are already existing, e.g., scrum master or product owner, take which responsibility in the new process. Besides these operational requirements, there is also the need to include a strategy check before starting with any discovery since ideas should only be followed and taken up if they contribute to the company's overall targets and strategy. If an idea is expected to be valuable for the company's targets and strategy and a corresponding product or feature, or service was developed and delivered by including discovery activities, it is also required to measure its success. This should include measuring if customer satisfaction is increasing or investments in products, features, or services could be reduced due to more clarity achieved by discovery. Finally, a requirement found to be essential is that there needs to be a strong driver, ideally from management, pushing the topic until it becomes widely accepted.

12.2.5 Proposed Approach for the Integration of Product Discovery and Product Development and Delivery

As stated in answer to the second research question (RQ2), it is crucial to have someone driving the change to integrate discovery activities into the product development and delivery processes. The practitioners stated that having a dedicated person, ideally from the management level, being responsible can support this aspect since the topic becomes very visible in the company, and there is enough capacity to enforce the change actively.

Having enough capacity is considered to be an essential success factor since a conflict between operational excellence and innovation can be expected. If the people focus on delivering and keeping the processes running, change means additional effort and is likely to be avoided. Therefore, a dedicated person can take up those challenges and can also take care of making the details of the topic known and monitor its progress and success. A possible way of informing people about the new approach and the target to conduct discovery systematically is documenting the discovery capabilities with manuals for the teams and updating the process documentation with DEW Index and discovery activities included. Here, also some measuring procedures can be added. Monitoring the invested effort and the achieved customer satisfaction already in the early stages of transforming the discovery maturity from level four to level five in the DEEP matrix is recommended to track the progress and make improvements visible. Having said this, it has to be stated that, especially in that early stage, the teams must decide if they want to execute their discovery activities 1) themselves or if they want to handle it 2) externally. For 1), the team has the option to either build their own expertise or staff expertise from different functions, like the product management or user experience department. For 2), the team can either have a separate team or agile release train or outsource the discovery tasks to an external company. It depends on the individual situation of the team and which approach is the most appropriate.

The decision about who is executing the discovery activities is also affecting the roles and responsibilities, but also the possible way of integration. If a team is handling the discovery internally, it is suggested to add the discovery tasks as spikes in the team backlog and plan them the same way as classical development tasks. The approach to executing discovery activities in the team was also studied in a case study. The case study focused on the application and integration of Design Thinking in an agile web development team of Robert Bosch Smart Home GmbH.

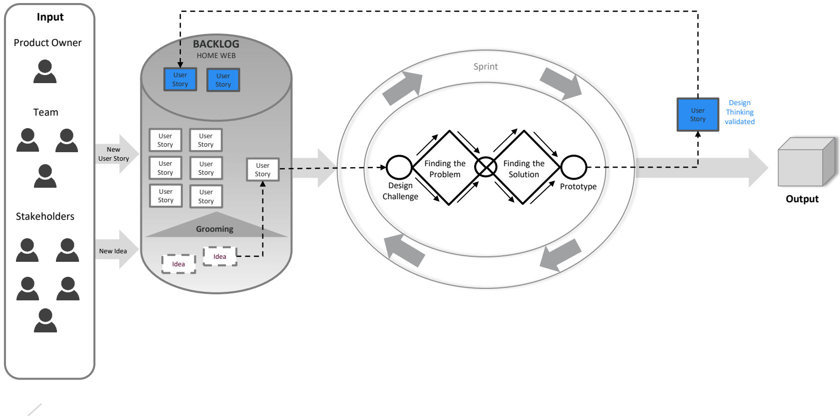

Figure 12.3: Integration of Design Thinking in SCRUM

Figure 12.3 shows our result, which was developed to fully integrate discovery activities into the regular scrum cycle, supporting the product owner in prioritizing the backlog. It also allows the product owner to fill the product roadmap with systematically determined and validated customer needs, desired outcomes, products, features, and services instead of opinions and therefore reach maturity level five of the product discovery dimension in the DEEP model.

12.3 Threats to Validity

To assess the trustworthiness and validity of our study, we use the framework according to Yin [Yin09]. Since we have used two research methods, the threats to validity are presented in two subsections in the following.

12.3.1 Threat to Validity of the Development of the DEW Index

Construct validity: In order to mitigate this threat, we involved several researchers in the preparation and conduction of this study. Especially when formulating the questions of the interviews and agenda for the workshop, care was taken to ensure objectivity and openness to avoid influencing the results. **Internal validity:** To mitigate this threat, we verified our results through the conduction of workshops with the scrum team of the case company. In addition, we presented and discussed our findings with employees of the case company who did not participate in this case study. **External validity:** The external validity of the case study is limited despite transferability being considered in the approach, as the results of the case study are only valid for the present framework conditions. Therefore, the results are not fully transferable to other research fields. It should be a team that already works successfully in an agile way and develops user-centered products. Furthermore, it must be noted that the distribution of the bundles on the scale was developed individually for a team in the context of the calibration. This strongly depends on the knowledge and experience of the expert on that team. To apply the approach in other teams, a new calibration is necessary. **Reliability:** The reliability is threatened due to the circumstance that participants may misunderstand the goal of the workshop. To mitigate this threat, we explain the goal and agenda at the beginning of the workshop. In addition, participants had the opportunity to ask questions at any time if any ambiguities arose.

12.3.2 Threat to Validity of the Expert Workshops

Construct validity: The construct validity is comprised of the threat that the experts participating in the workshop misunderstood the goal of developing and delivering an approach to integrate the two components of product discovery and product development and delivery. To counteract this, the goal and purpose of the expert workshop were explained to the participants in advance. This includes the definition and explanation of technical terms in the context of the experts' workshop. In addition, the participants had the opportunity to ask questions at any time during the conduction of the workshop. **Internal validity:** The opinions of the experts used to develop the approach may be incorrect or only valid in a specific context. Therefore, we recruited experts from various industry sectors and companies for the workshop. **External validity:** Our integration approach was developed with input from practitioners operating in the software-intensive business. This limits the scope of the approach to companies acting in such an environment. **Reliability:** To support the reliability, the expert workshop was conducted in a systematic manner. Moreover, two moderators were established to reduce researcher bias. Another threat is that the participants of the expert workshop have given input that does not fully reflect the experience and reality of their company. This is mitigated by the fact that the participants had no obvious incentive to polish the truth.

12.4 Conclusion

The developed Discovery Effort Worthiness Index offers a tool for companies and their product owners to determine how much effort they should spend on discovery methods to discover and validate features. It simplifies the complex relations and dependencies and suggests a comfortable way to get orientation when trying to determine the suitable effort for discovery and validation based on the two dimensions with the most influence. The approach of the DEW Index is that the effort worth spending for discovery activities increases when a high value can be expected, but the clarity about the user's needs is low.

The study showed that through assigning suitable effort and integrating discovery into the daily process, the acceptance of the employee of the case company for discovery activities had been increased. This is because through an iterative and closely coordinated development with many feedback rounds, the team was involved in the development at an early stage, and the effort for discovery research was optimized. The advantages of the approach were thus clearly recognized and understood by the team and accepted and considered positive based on the user-centered working method through the team's own input. A possible skepticism of the team towards the presumed additional work through implementing an adapted Design Thinking approach with the DEW Index was not confirmed.

Moreover, the developed approach allows transferability to different teams and situations since it does not use absolute ratings. Nevertheless, it requires calibration when being used in a new environment. Besides that, the researchers recommend including a review of the application of the DEW Index in the Scrum retrospective to improve or even recalibrate, if necessary, e.g., after circumstances have changed. This especially becomes true when there are no experts or if there is only low experience with discovery that could be used to create the benchmark needed for the calibration.

In addition, we developed an approach that practitioners can use to systematically integrate the product discovery component into the product development and delivery processes. This approach can be used to identify whether a customer problem to a user story exists, develop a solution to the identified customer problem, validate these developed solutions, and put the validated item in the backlog. This pursues the goal of ensuring that the findings of the conducted product discovery activities are incorporated into the operation of product development and delivery. In this way, product risks are analyzed systematically at an early stage, forwarded to product development and delivery, and thus increases the chance of product success. This is strongly recommended for companies operating in the software-intensive business to develop successful products in the a dynamic and uncertain market environment.

Chapter 13

Recommendations for Action

This chapter provides recommendations for actions practitioners can apply to develop and maintain product roadmaps in a dynamic and uncertain market environment. This includes nine good practices to support companies in understanding what aspects are required to conduct a successful product roadmapping in a dynamic and uncertain market environment. Moreover, we propose a product roadmap format to provide practitioners with guidelines on which structure and items a roadmap for the operation in a dynamic and uncertain market environment should at least contain and an approach to creating these items. Moreover, we answer the question of what conditions must be fulfilled so that an artifact can be moved from one column (e.g., Later) to another (e.g., Next). We derived these recommendations from the results of our previous study and discussed them with one practitioner operating in a large software-intensive company in Germany. In order to achieve our objective, we have defined the following research questions:

- **RQ1:** What good practices are recommended when developing product roadmaps in a dynamic and uncertain market environment?

- **RQ2:** How does a product roadmap for a dynamic and uncertain market environment look like?

The chapter extends the following publication

- S. Trieflinger, D. Lang, and J. Münch. 'Counter the Uncertainties in a Dynamic World: An Approach to Creating Outcome-Driven Product Roadmaps'. In: *Product-Focused Software Process Improvement: 23rd International Conference, PROFES 2022, Jyväskylä, Finland, November 21–23, 2022, Proceedings*. Springer. 2022, pp. 319–333

13.1 Good Practices for Conducting Product Roadmapping

In order to answer RQ1, we developed the good practices presented below. The good practices are intended to help managers and product managers to get a better understanding of what aspects are supportive for a successful product roadmapping in a dynamic market environment.

Good Practice 1: Connect the corporate visions to the product roadmap via product strategy: To identify the items to be included in the roadmap, it is highly beneficial to derive them directly from the company's product strategy, which should be determined by its vision. In developing and revising the product roadmap, the vision and strategy guide the product teams in making decisions. The product teams can also benefit from making use of a product vision. A product vision describes the ultimate reason for the development of the product as well as the positive changes the product should bring about. When creating the product vision, care should be taken to ensure that the product vision reflects the current problems and needs of the customers. This encourages a shift in discussion from "what should we develop" to "would decision A or decision B support us more in achieving the product vision"? To unfold a product vision's full effect, it is crucial that it is communicated and lived throughout the whole company. This motivates and inspires the various teams and external stakeholders to participate in making the product vision a reality.

Good Practice 2: Identify outcomes and include them in the product roadmap: A suitable product roadmap for a dynamic and uncertain market environment should contribute to delivering value to the customer and the business. Therefore, the product roadmap should not only describe what should be developed but also why it should be developed. To achieve this, it is necessary that outcomes are included in the product roadmap. Outcomes help clearly communicate the goals and purpose of the next product version to all stakeholders and support, including customer-oriented content for the next release. It should be noted that each outcome should contribute to fulfilling the product vision. One suitable method to uncover outcomes is the Jobs-to-be-done framework [Ulw16; Ulw17]. The framework says that people buy products and services to get a job done, i.e., to solve a problem. Therefore, the framework aims to identify customer needs and underserved areas. In this context, it is not enough to scratch the surface, but the underlying needs and desires of the customers must be identified and understood.

Good Practice 3: Fail cheap by spending effort at the latest possible point in time: In a dynamic and uncertain market environment, it only seems possible to plan a maximum of three months in advance. This can be observed and gets even enforced by the fact that many companies nowadays work in a quarterly cadence to respond to the challenges of a dynamic and uncertain market environment. One of these challenges is the high market volatility, which increases the likelihood of planning and long-term preparation becoming a waste of resources. Therefore, it is considered good practice to invest as little effort as possible into roadmap items and only focus on detailing them when they are successfully tested and close in time. Therefore, only those items on the product roadmap that are next for implementation should be more detailed and broken down to a feature level. This provides the flexibility to react to changes in the market (e.g., changing customer behavior) rapidly and efficiently since items can be replaced or removed from the roadmap with a low loss of effort. For example, the long time horizon should include outcomes formulated as hypotheses, the mid-term time horizon should contain confirmed outcomes with possible solution hypotheses that must be validated, and the short-term time horizon should include only validated outputs such as products or features.

Good Practice 4: Change your roadmap only systematically and transparently: Often, unfounded changes to the roadmaps cause those employees and stakeholders to lose trust in the product roadmap. To counter this circumstance, a product roadmap should be stable in a way that changes are only carried out justifiably and systematically. This requires a regular cadence for reviewing and updating the product roadmap involving all people involved in product planning (e.g., product managers, product owners, marketers, distributors, and engineers). This helps to get a better understanding of what contents of the product roadmap should be adjusted and avoid that uncertain features being seen as delivery promises.

Good Practice 5: Consider the confidence for each roadmap item: Confidence means the probability that a product or feature on the product roadmap will achieve the expected objectives or outcomes to acceptable costs and the confidence to deliver the corresponding output. Consequently, the factor of confidence should influence the decision of whether a feature should be developed or not. Hence, the short time horizon should only include items deemed to have high confidence in achieving their respective goals. A possible approach to work with confidence is to rate it using a Likert-type scale, as shown in Table 13.1.

Table 13.1: Confidence levels

Confidence	Description
1	Declining
2	Hesitant
3	Undecided
4	Confident
5	Convinced

Good Practice 6: Integrate product discovery activities into the product roadmapping process: Discovery, in this case, means a company's ability to identify needs and validate features on the product roadmap with regard to its ability to respond to those needs before they are developed.

This includes identifying and researching customer problems and finding solutions to those problems that are useful, feasible, and economically viable. Consequently, a benefit of product discovery activities is to avoid developing features that customers do not want or need. Concrete examples of the conduction of product discovery activities are interviews with customers, rapid prototyping, or customer focus groups. We consider the consequent integration of such discovery activities into the roadmapping process as a success factor since it supports the identification, validation, and detailing of the roadmap items. Additionally, this ensures that only validated solution outcomes that provide a valuable outcome enter the implementation backlog, leading to waste avoidance. A possible approach to how Design Thinking can systematically improve the roadmapping process is presented later in this chapter with regards to RQ2.

Good Practice 7: Make sure that priorities are set by the market and not by management or experts: In practice, it often occurs that management or experts (e.g., product managers or product owners) decide what should be delivered first. This brings the risk of not developing those features first that deliver the most value to the customer and jeopardizing the opportunity to develop them later. Therefore, a well-established product roadmap prioritization process is essential for the success of the product roadmap and the development of innovative and customer-oriented products. Overall, there are a variety of prioritization techniques that help to avoid biases with different approaches, such as mapping-based techniques (assumption mapping or the systemico model), scoring-based techniques (e.g., opportunity scoring or the RICE scoring model), or game-based techniques (e.g., buy a feature or feature buckets) [TMB+21]. In this context, it should be noted that each product manager has their own preferences and can choose his prioritization method accordingly. For example, product manager A prefers a games-based technique, while product manager B favors a scoring-based technique. However, what needs to be ensured when applying the technique selected is that the customer value and the ability to develop the product must be considered.

Good Practice 8: Create alignment around the product roadmap: A product roadmap is almost useless without alignment and buy-in from the key stakeholders. Alignment around the product roadmap is essential to ensure that each employee is aware of the outcomes of the product roadmap that should be achieved so that all product development activities can be orchestrated to achieve those outcomes. Therefore, we recommend sharing the roadmap internally and externally to get employees and customers excited about the features planned to come next. However, in this context, it is crucial to consider the audience for which the product roadmap is shared. The reason for this is that different stakeholders require different information. For example, the management will be interested in objectives and how to achieve them at an abstract level, while engineering or marketing, and sales need detailed information in order to perform their activities. Sharing the product roadmap with customers brings the advantage that feedback can be gathered early so that the customer feels involved and committed to the company. However, it has to be considered that all stakeholders require individual but consistent representations of a common roadmap that reflects their information needs. For this purpose, the creation of a central roadmap that enables to derive different representations for various groups of stakeholders is recommended. Besides this, various methods to achieve alignment exists. Examples, therefore, are the application of the methods objective and key results (OKRs), shuttle diplomacy, or the behavioural change stairway model [ESR20].

Good Practice 9: Assign responsibility and ownership of the product roadmap to product management: Responsibility answers the question of who is responsible for placing items on the roadmap and conducting the roadmapping process. The term ownership means who is accountable, i.e., signs off and approves the product roadmap. Especially the ownership has a strong influence on how the roadmapping process is lived and which values are practiced (e.g., management decides about the content of the roadmap vs. product discovery is being conducted). Therefore, the owner of the product roadmap has a high impact on the success of the entire product roadmapping process. Since product management usually has the task of shaping the future of a product or product portfolio and coordinating the various interests of all stakeholders involved, it is advisable to assign responsibility to product management. Also, the ownership should be with product management to fully enable them to take responsibility, increase their independency from stakeholders in a hierarchy and let them act according to market demands. In addition, this approach enables product management to define suitable validation measures and conduct them most quickly (without lengthy discussions with other parties). The management should focus on steering the entire company's direction by providing a vision and strategy while giving autonomy and trust to the product management on the future direction of the product portfolio.

13.2 Proposed Product Roadmap Format for a Dynamic Market Environment

In the following, we provide answers to RQ2 by presenting a product roadmap format. This product roadmap format aims to provide a flexible structure and deliver value to the customer and the business. The former is intended to react rapidly to changes and adjust the roadmap accordingly, while the latter strives to steer the focus on developing products that customers really want and need.

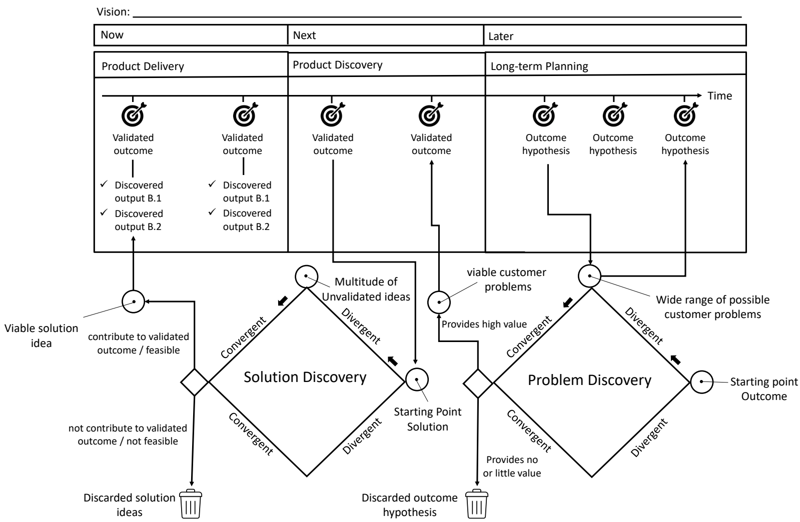

Figure 13.1: Proposed product roadmap format (own presentation)

The roadmap, as shown in Figure 13.1, indicates the time horizon by the three columns “Now”, “Next”, and “Later”. The “Now” column indicates what validated outcomes are currently being tackled with which outputs, i.e., which features are currently being implemented by the team. The “Next” column describes which validated outcomes are planned to tackle next, i.e., for which outcomes possible solutions will be researched. The “Later” column contains outcome hypotheses that are not validated and therefore prioritized lower for now but that should be considered in more detail later. One key aspect of this is that the team focuses the efforts on outcomes that are closer in time but still has an outlook on things to come without spending much effort.

To identify the corresponding roadmap items (outcome hypothesis, validated outcomes, and discovered outputs), we propose applying the double diamond process from design thinking [Cou07]. Overall, this process consists of the two phases “finding the problem” (problem discovery) and “finding the solution" (solution discovery). Problem discovery focuses on identifying and understanding problems from the customer's perspective. In contrast, solution discovery addresses the identification of concrete solutions in the form of a product, service, or feature for the previously identified problems. The separation of problem identification and solution finding is intended to counteract the behavior of focusing too early and exclusively on an identified solution. This means the risk of focusing on the first idea and rushing to implement it. As a result, no other potential solutions are accepted, and consequently, solutions that contribute more to solving the customer's problem are not considered. In the worst case, starting with the solution idea without understanding the customer problem first might lead to implementing outputs with no customer value. Therefore, the separate consideration should ensure that the first step is to capture the problem systematically, and subsequently, the creation of possible solutions is considered.

The process of creating and maintaining a product roadmap, as shown before, starts with the identification of possible customer pain points (outcomes) that are formulated as outcome hypotheses (see column "Later"). If necessary, the term outcome can also be defined more broadly in the sense of a customer outcome (pain point, need, desire) or a business outcome (that needs to be converted into customer outcomes). The outcome hypothesis articulates the overreaching problem to be solved and sets the scope for the next steps. Collecting possible customer pain points takes place in the first divergent phase in the diamond, "problem discovery". Divergent means that a wide range of possible problems is collected to find the most relevant customer problems. Typical examples of methods in this phase are conducting customer interviews, workshops, or customer focus groups. After finishing the collection, the large number of problems found is reduced by rating and validating them (see the convergent section of the diamond "problem discovery"). The validated problems can then be formulated as validated outcomes and added to the "Next" column of the roadmap. The problems (outcome hypothesis) that are not validated are discarded. In this case, we recommend documenting the reasons why the hypothesis is discarded so that decisions can be traced at any time.

Regarding the decision on which outcome hypotheses can be selected to be validated from the “Later” column to get shifted to the “Next” column, we recommend that each company choose its individual set of prioritization criteria like clarity about the customer need or potential value to be created. This includes also defining a minimum priority to invest effort in addressing the customer problem. The outcome hypotheses with a priority higher than this minimum are validated and then assigned to the “Next” column, while the outcome hypotheses with lower prioritization are assigned to the “Later” column. This fact might also lead to realizing the roadmap in a non-sequential order since outcome hypotheses with higher priority might be inserted before outcome hypotheses that have already been in the roadmap for a long time. Nevertheless, this only happens in the back part of the roadmap and does not majorly affect the “Now” and “Next” columns. To ensure this, the validation and testing of hypotheses should always be considered as an essential aspect in prioritization so that only customer problems that are very well understood and whose effects are proven should have high priority.

The next step focuses on determining solutions for the validated outcomes listed in the “Next” column. This is done in the diamond “solution discovery”. Therefore, as in the diamond “problem discovery”, the collection of ideas is conducted divergently, i.e., by applying a broad perspective and with the aim of collecting as many ideas as possible (see the divergent phase of the diamond “solution discovery”). To collect a large number of ideas, it is advisable to use techniques such as visual brainstorming. The result of this stage is a multitude of unvalidated ideas. Subsequently, these unvalidated ideas must be reduced into a smaller number of conceivable solutions in a converging section. For this purpose, the feasibility and technological implementation are discussed for each idea, as well as the costs in relation to the value generated. This includes conducting experiments (such as developing minimum viable products (MVPs) or prototypes) to verify that the solution idea contributes to achieving the corresponding outcome. In this context, it is recommended to formulate a hypothesis that includes a measure to verify this assertion and an indicator when the measure is reached.

The feasible ideas contributing to the achievement of the corresponding outcome are moved to the "Now" column, otherwise, the solution idea is discarded. If a solution is discarded, we recommend documenting the hypotheses. This approach ensures that only validated outputs are released for implementation. It should be noted that the product delivery track ("Now" column) and product discovery track ("Next" column) take place in parallel. For example, in the first quarter, the product delivery track implements those features that have already been successfully tested. At the same time, the discovery track identifies which outputs should be developed for the second quarter and which outcomes should be defined in the long term. Finally, it should be noted that after the implementation of the validated output, it should be tracked whether it is used by the customers and contributes to solving the identified problem.

13.3 Validation

The good practices and the proposed product roadmap format were developed to support practitioners in conducting their product roadmapping in a dynamic and uncertain market environment. Hence the practical value of our results should guide the validation process. Therefore, we organized a workshop with four practitioners from Germany that aims to discuss the comprehensibility, applicability, and usefulness of the results of this study. We have ensured through preliminary discussions that each participant is involved in the roadmapping process in the respective companies. Furthermore, we have included a heterogeneous set of practitioners, i.e., we made sure that the participants work in different companies of various sizes. This was done to ensure that the results of this study are developed not only based on the knowledge and experience of participants of large companies but also from the perspective of participants from small and medium-sized companies. The workshop was held online on 02 August 2022 with a duration of 2 hours. It should be noted that while these practitioners are from our network, they are not involved in the development of the findings of this study or otherwise in our research. During the workshop, we presented our results to collect feedback from the participants. One researcher acted as a facilitator to initiate and lead the group discussions. The discussions revealed that, from the participant's point of view, the good practices and the proposed product roadmap format are comprehensible, applicable, and useful. Nevertheless, some practices have been reformulated to clarify their utility. The use of the Design Thinking process to identify the items on the product roadmap was also perceived as useful, and the presentation using the double diamond diagram was found to be understandable. Practitioners' criticisms focus on the fact that when using this model, every employee involved must deeply understand how to apply Design Thinking. On the one hand, this means costs for training to ensure that any employee who does not already have this ability can acquire it. On the other hand, this limit hiring opportunities because not every potential product management candidate has this skill. In this context, it should be noted that the participants' companies are struggling to find employees for product management. Therefore, a further requirement would make it more difficult to find employees. An overview of the participants in the workshop to validate the results is shown in Table 13.2. The column "Experience" refers to the number of years in which the participants have been involved in product roadmapping activities.

Table 13.2: Participants in the workshop to validate the recommendations of actions

Participant	**Position**	**Experience**
Participant 1	Product Owner	5 years
Participant 2	Product Manager	3 years
Participant 3	Product Manager	2 years
Participant 4	Head of Product Mgmt.	8 years

CHAPTER 14

CONCLUSION

14.1 Summary of Contributions

In the Chapters 7 to 13, we have presented our solution artifacts to support companies to provide reliable product roadmaps for the operation in a dynamic and uncertain market environment. In the following, we briefly summarized our contributions and discussed their implications for research and practice.

C1: We provided an overview of the state of research regarding product roadmapping: By conducting a systematic literature review, we identified 53 scientific papers that address the topic of product roadmapping. We have assigned these papers to the following categories according to their discussion topic: 1) roadmap types, 2) processes for creating and updating roadmaps, 3) problems and challenges with roadmapping, 4) approaches to visualize roadmaps, 5) generic frameworks, 6) practical experience and lessons learned regarding product roadmaps, 7) product roadmap maturity models, as well as 8) the combination of roadmaps with other tools (e.g., business modeling).

C2:We provided an overview of the state of the practice regarding

product roadmapping: To identify the state of practice, we conducted three expert interviews, a web survey, and a grey literature review. In this context, we have outlined which product roadmapping approaches companies are currently applying and the challenges they are facing.

C3: We have developed a product roadmap self-assessment tool called DEEP: As the first artifact of this thesis, we have developed a tool that enables companies to assess the capabilities of their current applied product roadmapping practices. The model is especially suited for companies that operate in a dynamic and uncertain market environment.

C4: We have developed a product roadmap transformation approach: Based on the DEEP model, we developed a product roadmap transformation approach. This approach allows companies to identify the dimension of the DEEP model that is most promising for improvements. In addition, with the help of two mapping tables, companies are able to identify methods to achieve that improvement.

C5: We have developed a method with which companies can determine the effort required for product discovery activities: We have developed the Discovery Effort Worthiness Index, which offers a tool for companies and their product owners to determine how much effort they should spend on discovery methods to discover and validate features. This includes the recommendation of product discovery methods or bundles based on the calculated index.

C6: We have developed an approach that enables companies to integrate their product discovery activities with product development and delivery: The integration of product discovery with product development and delivery is intended to ensure that the findings of conducted product discovery activities are incorporated into the operations of product development and delivery. In this way, product risks are analyzed systematically at an early stage, forwarded to product development and delivery, and thus increases the chance of product success.

C7: We provided recommendation actions for companies to conduct successful product roadmapping in a dynamic and uncertain market environment: Finally, we have formulated nine good practices that are intended to help managers, product managers, or similar roles to get a better understanding of what aspects are supportive for a successful product roadmapping in a dynamic market environment. In addition, we have proposed a product roadmap format that guides practitioners in which structure and items a roadmap for the operation in a dynamic and uncertain market environment should a least contain and an approach to creating these items.

C8: We validated our developed artifacts in practice using scientific methods: Regarding the validation of the DEEP model and the product roadmap transformation approach, we conducted a 2-step validation approach. First, we validated both artifacts through expert interviews to demonstrate their comprehensibility, applicability, and usefulness. However, the interviews do not cover factors of a real-world business context, such as the strong influences of management. Therefore we conducted a multiple case study with two companies and successfully evaluated the comprehensibility, applicability, and usefulness in a real business context. The evaluation of the comprehensibility, applicability, and usefulness of the DEW Index and the integration approach took place within a workshop with a scrum team of the Robert Bosch Smart Home GmbH. Finally, we evaluated our recommendations for action by conducting a workshop with experts from various software-intensive companies.

C9: Our artifacts were implemented and continuously applied in a software-intensive company: After successful validation, our artifacts were implemented and established at a software-intensive company from Stuttgart. This means that these artifacts are currently being continuously applied, and there is the possibility for long-term research.

The development of artifacts C3 to C8 leads to the achievement of our overall goal to support product managers and product owners to create and maintain reliable product roadmaps in a dynamic and uncertain market environment. To identify current problems of practice and research gaps in product roadmapping, we have thoroughly analyzed the scientific literature and the state of practice. To solve the problems we identified, we developed six artifacts that are novel to science and practice. This includes recommendations for actions to guide companies to transform their product roadmapping practice to a dynamic and uncertain market environment. Figure 14.1 shows our identified challenges (associated research questions in brackets) and the artifacts that led to addressing the associated challenge. The entirety of our developed artifacts leads to the achievement of our overall goal.

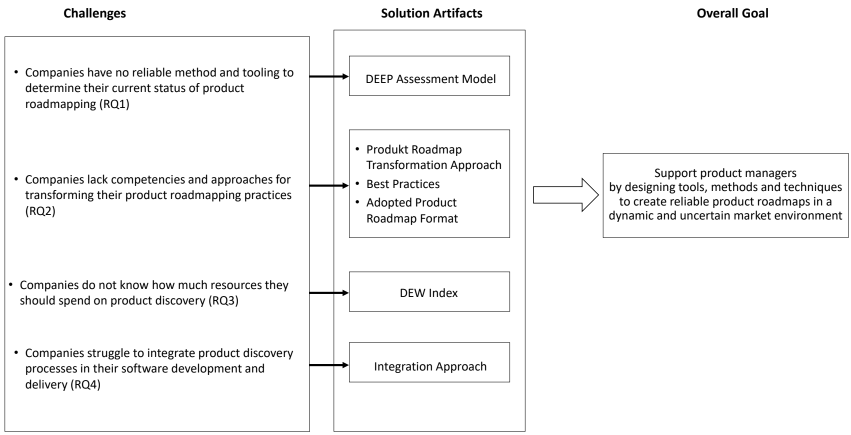

Figure 14.1: Goal achievement of this thesis

14.2 Discussion: Implications and Limitations

The previously presented contributions have several implications for practice and research. These implications will be discussed below, afterward, we will consider the limitations of these contributions.

14.2.1 Implication for Practice

This thesis offers practical insights for software-intensive companies to transform their product roadmapping practices to a dynamic and uncertain market environment. As mentioned above, the product roadmap assessment tool aims to provide product management with a tool to visualize and assess the current state of product roadmapping. In addition, the dimensions and stages of the DEEP model provide practitioners with an overview of which factors are essential for the success of product roadmapping in a dynamic and uncertain market environment. This contributes to improving their understanding of which methods and artifacts (e.g., product vision, outcomes) are essential to create and maintain a product roadmap and trigger the shift from a feature-driven mindset to an outcome-oriented mindset. Outcome-driven mindset means that all measures regarding product development contribute to solving real problems of the customers. In addition, the DEEP model conveys important cultural aspects in a digital environment, such as the handover of responsibilities from management to the operational level. This gives the employees the freedom to unfold, as they are able to determine and perform their measures independently. This leads to the ability to react more quickly to changing conditions and saves time (e.g., without lengthy arrangements). Therefore, the DEEP model also encourages to reflect on internal business processes.

Another benefit of the DEEP model is that the assessment can be used to demonstrate management current weaknesses systematically and thus convince management of the need for a product roadmap transformation. Therefore, the DEEP model acts as an eye-opener to realize the need to transform the product roadmap, leading to allocating budget and capacity to tackle this issue. As mentioned, we recommend that various stakeholders of the product roadmap first apply the DEEP model. Subsequently, a workshop should be organized to discuss individual assessments to create a final assessment for further processing. This fosters discussions about current procedures between various departments. Therefore, the DEEP model supports establishing cross-functional processes and helps break down silos.

Finally, the DEEP model acts as a motivator for all stakeholders around the product roadmap to conduct an honest assessment of the product roadmapping practices currently in use. Our research shows that the DEEP model, on the one hand, increases transparency with respect to the lived processes in a company. On the other hand, the assessment uncovers hidden activities that can help companies move towards an outcome-oriented company. For example, suppose individuals perform product discovery activities. In that case, this usually becomes visible through the application of the DEEP model, and the existing knowledge can be used to develop the existing processes further.

A valuable complement to the DEEP model is our developed product roadmap transformation approach. First, this approach enables practitioners to systematically identify those dimensions that promise the most benefit for improvement. This systematic procedure avoids selecting a dimension that risks investing many resources that add little or no value. Moreover, the mapping tables provide proven methods for developing artifacts that are essential in a dynamic and uncertain market environment but are still missing in the currently applied product roadmapping process. This expands the practitioners' knowledge gained from the DEEP model, i.e., fosters a better understanding of novel methods of product management. Moreover, the transformation approach includes the subphases review and retrospective, which stimulate discussions about the procedure of the implemented methods (proposed by the mapping tables) and their impact on the roadmapping practices. For this reason, the transformation approach supports the identification of weaknesses regarding these methods and encourages companies to adjust them to the processes and culture of the company where appropriate.

During our research, we noted that conducting product discovery activities is an essential factor in developing artifacts (outcomes, validated learnings) that are indispensable for product roadmapping in a volatile market environment. However, we note that many companies face challenges when conducting product discovery activities. For this reason, we have developed the DEW index and our integration approach to provide practitioners with a tool to improve their product discovery abilities. The application of the DEW

Index enables companies to apply a continuous and user-centered way of working in everyday agile working life, which ensures that UX-optimized solutions are developed, customer needs are correctly identified, and uncertainties are reduced through validation with the DEW Index. This is complemented by our proposed approach to integrating product discovery with product development and delivery. This approach can be used to identify whether a customer problem to a user story exists, develop a solution to the identified customer problem, validate these developed solutions, and put the validated item in the backlog. This pursues the goal of ensuring that the findings of the conducted product discovery activities are incorporated into the operation of product development and delivery. In this way, product risks are analyzed systematically at an early stage, forwarded to product development and delivery, and thus increases the chance of product success.

14.2.2 Implication for Research

In addition to the practical implication, this thesis provides novel insights for software engineering research. As the systematic literature review shows, research addressed the challenges of traditional product roadmapping in a dynamic and uncertain market environment. Examples therefore, are the studies from Komssi et al. [KKT+11], Kim, Yao, Agogino, et al. [KYA+15], and Maglyas, Nikula, and Smolander [MNS11]. However, so far, no empirical approach has been published with which companies can systematically address these problems. The results in this dissertation close this gap by providing novel approaches to help support companies transform their product roadmapping practices to a dynamic and uncertain market environment.

Moreover, methodological insights were gained for the discipline of software engineering. The empirical methods used in this thesis for data collection and validation of the artifacts have proven profitable. Thus, it was shown which aspects are essential for the further development of the discipline in software engineering when designing artifacts. Consequently, such a combination can be applied to develop successful artifacts in other areas, such as DevOps, requirements engineering, or release planning. Thus, the methodology used in this dissertation might be adopted for other research projects.

Finally, this thesis provides directions for the placement of future research. Therefore, we hope that this work encourages and inspires other researchers to address the topic of product roadmapping.

14.2.3 Limitations

Overall, we conducted two expert interview studies and a multiple case study to validate the developed artifacts. In this context, care was taken to select a representative population of participants. However, the effectiveness of the artifacts has not yet been evaluated in a large-scale industrial setting. Therefore, it can not be excluded that the artifacts present in this thesis can be applied to software-intensive companies in general. Moreover, the development and validation of the artifacts in this thesis were conducted with practitioners from Germany. Thus, cultural differences may lead to a reduction in the effectiveness of the artifacts.

The product roadmap transformation approach, including the DEEP model, provides guidance and recommendations for a successful product roadmap transformation. Final decisions, such as which dimension to select for improvement or the detailed execution of the proposed method of the Goal-Activity Map, are the responsibility of the user of this approach. Therefore, inaccuracies regarding applying the developed transformation approach cannot be excluded. To counteract this, our approach suggests conducting a review, i.e., discussing which aspects of the implemented methods can be improved. While the Goal-Opportunity Map is fully validated, the content of the Goal-Activity Map could only be partially validated within this thesis. Specifically, we have no reliable insights that the methods we propose in the Goal-Activity Map lead to the successful creation of the corresponding artifact. An example is that we have not conducted an empirical study to demonstrate that the method jobs to be done lead to the successful creation of outcomes. This is due to the reason that organizing and conducting further case studies would have exceeded the scope of this thesis. However, it should be noted that the proposed methods of the Goal-Activity Map are based on the findings of our conducted grey literature review. This means that the proposed methods are based on experience reports and success stories published by practitioners, e.g., in blogs or books. Therefore, it can be assumed that the proposed methods in the Goal-Activity Map provide a high degree of trustworthiness.

Furthermore, in Chapter 13, we give recommendations regarding the selection of the most promising dimension for improvement. These are based on our experience of how the dimensions affect each other, gained from the validation process. However, it should be mentioned that a limitation is that these effects have not been validated quantitatively, for example, by performing a correlation analysis.

Including the DEW Index in the everyday scrum iterations requires some effort for calibration, and the results vary based on the quality of this calibration. Therefore, we strongly recommend discussing the results of the DEW Index usage and the correctness of the calibration in the sprint retrospective to enable continuous improvement. The developed DEW Index depicts the suitable effort for discovery and validation in a simplified way. It is not designed to master the high complexity of determining the methods and amount of resources that should be spent for discovery and validation but to simplify this process for product owners and their teams by giving them orientation and avoiding wasting resources.

Regarding the suggested approach to integrating product discovery with product development and delivery, it should be mentioned that it is not yet considered if the product discovery activities are executed correctly and deliver the required clarity. This means that the integration of product discovery with product development and delivery supports the early consideration of product risks and the avoidance of waste, but it will not guarantee product success despite increasing the chances of achieving product success. Moreover, the rating of the stories is made by persons such as the product owner or the product manager. Therefore, individual misperceptions or biases may occur in the rating. For example, if a product owner rates a story that they helped to develop, this will probably lead to a higher rating in clarity or potential value than those stories where the product owner was not involved in the development.

14.3 Further Research

The result of this thesis provides several opportunities for further research. First, it can be researched whether the DEEP model can be extended by further dimensions or stages. In addition, the influence of the dimensions to each other can be explored. This can help to expand or adjust the recommendations regarding the selection of the dimension to be tackled for the transformation.

Furthermore, further research can include more validation studies to identify what impact on roadmapping the developed approaches in this thesis have in further companies. The development and validation of the artifacts took place with participants and data from Germany. Therefore, it can be researched whether these artifacts can be applied in an international context, respective which aspect would have to be adjusted for a successful application. In particular, the application of these artifacts in different cultural environments, such as the U.S. or Asia, would be of interest. In addition, it would be interesting to gain insights into whether the approaches developed in this thesis can be applied to other application areas (e.g., requirements engineering).

The research focuses on product roadmapping in the context of the future direction of a product or product portfolio within a company. Product roadmapping exceeding company borders, for example, in software ecosystems, is explicitly excluded. The reason for this is that product roadmapping within ecosystems involves more variables (e.g., the behavior of other actors in the ecosystem) that cannot be reliably isolated compared to product roadmapping within a company. Therefore, the approaches in this thesis have limited applicability to software ecosystems.

Finally, future research could address the question of whether and to what extent planning methods like roadmapping remain valid and helpful in companies that respond to the challenges of a dynamic and uncertain market environment with the adoption of agile product development. In addition, future work could look into an additional dimension that is the notion of the minimum viable feature/product/model mindset and how that can be supportive for companies in their processes from planning of features to business models.

14.4 Closing Remarks

In this thesis, we have addressed the issue of companies struggling to transform their traditional product roadmapping practice to a dynamic and uncertain market environment. First, we conducted a systematic literature review, which revealed that the topic of product roadmapping is only covered at an abstract level. Therefore, we have thoroughly analyzed the state of practice by conducting expert interviews, a web survey, and a grey literature review. This enables us to identify a range of practitioners problems and verify them through several studies. The analyses show clearly that many practitioners use traditional product roadmapping practices in the development of software-intensive products and have significant problems transforming them to a dynamic and uncertain market environment. This includes the following two problems: 1) Companies have no reliable method and tooling to determine their current state of practice, and 2) companies lack competencies and approaches for transforming their product roadmapping practice. In addition, our research revealed that the conduction of product discovery is essential for the success of product roadmapping in a dynamic and uncertain market environment. However, companies that conduct product discovery activities struggle to identify how much resources they should spend on product discovery activities and how to integrate them with product delivery and development.

To counter this problem, we provide six artifacts that have been validated in an industrial context. In more detail, we first developed the DEEP model, which enables companies to assess their organization's product roadmap capabilities. In addition, we developed a product roadmap transformation approach consisting of a process describing what steps are necessary to adapt the currently applied product roadmapping practice to a dynamic and uncertain market environment. This includes recommendations for selecting areas for improvement and two empirically based mapping tables for identifying and implementing methods for improving the corresponding dimension in the DEEP model. To address the problem of product owners or product managers not knowing how many resources to invest in product discovery activities and how to integrate them into their agile and iterative processes, we developed the Discovery Effort Worthiness (DEW), including an integration approach. With these tools, companies are able to allocate their resources sustainably and to analyze product risks systematically to increase the chance of product success. Overall, our entire approach developed in this thesis aims to support companies in identifying real customer problems and developing and delivering sustainable and innovative solutions to these problems. This increases the chance of product success and leads to a reduction of waste. Therefore our approach ensures that resources are used for the development of customer-oriented products and thus increases the sustainability of a company. As mentioned, our artifacts developed in this thesis were implemented and continuously applied in a software-intensive company. This is a great achievement and shows the relevance and usefulness of these artifacts. Therefore, we are optimistic that our artifacts will be established by further companies in their processes.

Finally, when we started our research, there were few publications that addressed the topic of product roadmapping only in an abstract way. After publishing our first papers and presenting and discussing our findings at international scientific conferences, we can observe that other researchers are gaining interest in this topic. For example, Chalk [Cha21] used the DEEP model as a basis for his master thesis. In this context, the results show that a high DEEP score is associated with better implementation of the strategy based on the product roadmap.

Bibliography

[AK03] R. E. Albright, T. A. Kappel. 'Roadmapping in the corporation'. In: *Research-Technology Management* 46.2 (2003), pp. 31–40 (cit. on pp. 41, 48).

[AK16] M. Arman, M. Kharrat. 'A new approach to designing a Roadmap: A case study for e-services with respect to rural and less developed regions in Iran'. In: *2016 8th International Symposium on Telecommunications (IST)*. IEEE. 2016, pp. 626–631 (cit. on pp. 72, 91).

[Ala10] S. C. Alan Hevnern. *Design Research in Information Systems*. " Springer New York, NY", 2010 (cit. on pp. 26, 27).

[Alb02] R. E. Albright. 'How to use roadmapping for global platform products'. In: *PDMA visions* 26.4 (2002), pp. 19–22 (cit. on pp. 20, 42, 49).

[Alb03] R. E. Albright. 'A unifying architecture for roadmaps frames a value scorecard'. In: *IEMC'03 Proceedings. Managing Technologically Driven Organizations: The Human Side of Innovation and Change*. IEEE. 2003, pp. 383–386 (cit. on p. 43).

[All] A. Alliance. *Minimum Viable Product (MVP)*. URL: https://www.agilealliance.org/glossary/mvp/ (visited on 02/28/2023) (cit. on p. 220).

[Alt15] E. A. Altameem. 'Impact of agile methodology on software development'. In: *Computer and Information Science* 8.2 (2015), p. 9 (cit. on p. 37).

[AP19] A. G. Al-Ali, R. Phaal. 'Design sprints for roadmapping an agile digital transformation'. In: *2019 IEEE International Conference on Engineering, Technology and Innovation (ICE/ITMC)*. IEEE. 2019, pp. 1–6 (cit. on pp. 53, 54, 57, 91).

[APK+16] T. Abrell, M. Pihlajamaa, L. Kanto, J. Vom Brocke, F. Uebernickel. 'The role of users and customers in digital innovation: Insights from B2B manufacturing firms'. In: *Information & Management* 53.3 (2016), pp. 324–335 (cit. on pp. 49, 50).

[Ass+97] E. I. R. M. Association et al. 'Technology roadmapping: Delivering business vision'. In: *Working Group Reports* (1997) (cit. on pp. 45, 74, 75).

[AWSR03] P. Abrahamsson, J. Warsta, M. T. Siponen, J. Ronkainen. 'New directions on agile methods: a comparative analysis'. In: *25th International Conference on Software Engineering, 2003. Proceedings.* Ieee. 2003, pp. 244–254 (cit. on p. 37).

[BB15] A. Bryman, E. Bell. 'Business Research Methods, 4th edn.,[e-book] New York: Oxford University Press'. In: *Available at: Google Books: books. google. com [Accessed 16 April 2020]* (2015) (cit. on p. 103).

[Bow21] M. Bowler. *The common pitfalls preventing product managers reaching their highest potential*. 2021. URL: https://www.productledalliance.com/the-common-pitfalls-preventing-product-managers-reaching-their-highest-potential/ (visited on 02/28/2023) (cit. on p. 157).

[BPP13] D. A. Beeton, R. Phaal, D. R. Probert. 'Exploratory roadmapping: capturing, structuring and presenting innovation insights'. In: *Technology roadmapping for strategy and innovation: Charting the route to success*. Springer. 2013, pp. 225–240 (cit. on pp. 71, 91).

[BSN+09] J. v. Brocke, A. Simons, B. Niehaves, B. Niehaves, K. Reimer, R. Plattfaut, A. Cleven. 'Reconstructing the giant: On the importance of rigour in documenting the literature search process'. In: (2009) (cit. on p. 60).

[BWSB10] W. Bekkers, I. van de Weerd, M. Spruit, S. Brinkkemper. 'A framework for process improvement in software product management'. In: *Systems, Software and Services Process Improvement: 17th European Conference, EuroSPI 2010, Grenoble, France, September 1-3, 2010. Proceedings 17*. Springer. 2010, pp. 1–12 (cit. on pp. 38–40, 337).

[Cag08] M. Cagan. *Inspired: How to create products customers love*. SVPG Press Sunnyvale, CA, USA, 2008 (cit. on pp. 22, 49, 155, 157, 158).

[CC08] T. Chow, D.-B. Cao. 'A survey study of critical success factors in agile software projects'. In: *Journal of systems and software* 81.6 (2008), pp. 961–971 (cit. on p. 37).

[CCFT14] M. N. Cheng, C. F. Cheung, S. H. Fung, K. K. Tsang. 'A hybrid roadmapping method for technology forecasting and assessment: A case study in an Information and Communication Technology Company'. In: *Proceedings of PICMET'14 Conference: Portland International Center for Management of Engineering and Technology; Infrastructure and Service Integration*. IEEE. 2014, pp. 2882–2890 (cit. on pp. 84, 91).

[CFL13] M. M. Carvalho, A. Fleury, A. P. Lopes. 'An overview of the literature on technology roadmapping (TRM): Contributions and trends'. In: *Technological Forecasting and Social Change* 80.7 (2013), pp. 1418–1437 (cit. on p. 41).

[Cha21] N. Chalk. 'Roadmaps and Software Product Management: How much theory is applied in innovation strategy management?' Masterthesis. The Open University, 2021 (cit. on p. 314).

[CHF+07] R. R. Cosner, E. J. Hynds, A. R. Fusfeld, C. V. Loweth, C. Scouten, R. Albright. 'Integrating roadmapping into technical planning'. In: *Research-technology management* 50.6 (2007), pp. 31–48 (cit. on pp. 68, 70, 77, 91).

[CL11] C. Cho, S. Lee. 'Taxonomy of technology roadmaps in service areas'. In: *First International Technology Management Conference*. IEEE. 2011, pp. 462–467 (cit. on pp. 77, 91).

[Cou07] D. Council. 'Eleven lessons: managing design in eleven global brands. A study of the design process'. In: *Design Council, London, Desk research report* (2007) (cit. on p. 298).

[Dal09] M. Dalton. *Are too many ideas killing your innovation efforts?* 2009. URL: https://innovationmanagement.se/2009/06/16/are-too-many-ideas-killing-your-innovation-efforts/ (visited on 02/28/2023) (cit. on p. 157).

[Dat19] A. Datta. *Building Product Roadmaps: Common Pitfalls and How to Avoid Them*. 2019. URL: https://rangle.io/blog/building-product-roadmaps (visited on 02/28/2023) (cit. on pp. 155–157).

[DeG00] G. DeGregorio. 'Technology management via a set of dynamically linked roadmaps'. In: *Proceedings of the 2000 IEEE Engineering Management Society. EMS-2000 (Cat. No. 00CH37139)*. IEEE. 2000, pp. 184–190 (cit. on p. 43).

[DGSO10] N. Dzamashvili Fogelström, T. Gorschek, M. Svahnberg, P. Olsson. 'The impact of agile principles on market-driven software product development'. In: *Journal of software maintenance and evolution: Research and practice* 22.1 (2010), pp. 53–80 (cit. on p. 37).

[Dhi22] M. Dhiman. *Mistakes to avoid while creating a product roadmap*. 2022. URL: https://www.mindtheproduct.com/mistakes-to-avoid-while-creating-a-product-roadmap/ (visited on 02/28/2023) (cit. on pp. 156, 158, 159).

[DPFP06] M. Dissel, R. Phaal, C. Farrukh, D. Probert. 'Value roadmapping: A structured approach for early stage technology investment decisions'. In: *2006 Technology Management for the Global Future-PICMET 2006 Conference*. Vol. 3. IEEE. 2006, pp. 1488–1495 (cit. on pp. 82, 91, 95).

[EB14] C. Ebert, S. Brinkkemper. 'Software product management–An industry evaluation'. In: *Journal of Systems and Software* 95 (2014), pp. 10–18 (cit. on p. 37).

[EH+92] M. A. Eisenhart, K. R. Howe, et al. 'Validity in educational research'. In: *The handbook of qualitative research in education* (1992), pp. 643–680 (cit. on p. 32).

[ESR20] P. Eißler, J. Schneider, B. Roling. 'Product roadmap alignment–achieving the vision together: a grey literature review'. In: *Agile Processes in Software Engineering and Extreme Programming–Workshops*. 2020, p. 50 (cit. on pp. 146, 150, 296).

[FDG09] D. Fenwick, T. U. Daim, N. Gerdsri. 'Value Driven Technology Road Mapping (VTRM) process integrating decision making and marketing tools: Case of Internet security technologies'. In: *Technological Forecasting and Social Change* 76.8 (2009), pp. 1055–1077 (cit. on pp. 70, 91, 95).

[Fel00] M. Felcman. *3 common mistakes in product discovery (and how to avoid them)*. 2000. URL: https://www.productboard.com/blog/3-common-product-discovery-mistakes/ (visited on 02/28/2023) (cit. on p. 158).

[Fel18] D. Feldmüller. 'Usage of agile practices in mechatronics system design potentials, challenges and actual surveys'. In: *2018 19th International Conference on Research and Education in Mechatronics (REM)*. IEEE. 2018, pp. 30–35 (cit. on p. 37).

[FHSP06] A. L. Fleury, F. Hunt, M. Spinola, D. Probert. 'Customizing the technology roadmapping technique for software companies'. In: *2006 Technology Management for the Global Future-PICMET 2006 Conference*. Vol. 3. IEEE. 2006, pp. 1528–1538 (cit. on pp. 71, 91, 95).

[Fin03] A. Fink. *The survey handbook*. sage, 2003 (cit. on p. 103).

[FOB+20] J. S. Freitas, M. G. de Oliveira, R. B. Bagno, L. D. R. de Melo Filho, L. C. Cheng. 'A bottom-up strategic roadmapping approach for multilevel integration and communication'. In: *IEEE Transactions on Engineering Management* 69.1 (2020), pp. 81–93 (cit. on pp. 72, 91).

[Gal98] R. Galvin. 'Science roadmaps'. In: *Science* 280.5365 (1998), pp. 803–804 (cit. on p. 41).

[GAV10] N. Gerdsri, P. Assakul, R. S. Vatananan. 'An activity guideline for technology roadmapping implementation'. In: *Technology Analysis & Strategic Management* 22.2 (2010), pp. 229–242 (cit. on p. 41).

[GFM19] V. Garousi, M. Felderer, M. V. Mäntylä. 'Guidelines for including grey literature and conducting multivocal literature reviews in software engineering'. In: *Information and software technology* 106 (2019), pp. 101–121 (cit. on pp. 146, 147, 151).

[Gil23] C. Gilley. *How to Get Organizational Alignment with your Product Roadmap*. 2023. URL: https://uservoice.com/blog/organizational-alignment-roadmap (visited on 02/28/2023) (cit. on p. 155).

[GLKP11] Y. Geum, S. Lee, D. Kang, Y. Park. 'The customisation framework for roadmapping product-service integration'. In: *Service Business* 5 (2011), pp. 213–236 (cit. on pp. 84, 91).

[GM10] C. Giachetti, G. Marchi. 'Evolution of firms' product strategy over the life cycle of technology-based industries: A case study of the global mobile phone industry, 1980–2009'. In: *Business History* 52.7 (2010), pp. 1123–1150 (cit. on p. 19).

[GM21] N. Gerdsri, N. Manotungvorapun. 'Systemizing the management of university-industry collaboration: assessment and roadmapping'. In: *IEEE Transactions on engineering management* 69.1 (2021), pp. 245–261 (cit. on pp. 83, 91).

[Got17] E. Gottesdiener. *7 Ways of Creating and Sustaining an Agile Product Roadmap*. 2017. URL: https://medium.com/@ellengott/7-ways-of-creating-and-sustaining-an-agile-product-roadmap-9e4410a25a60 (visited on 02/28/2023) (cit. on p. 155).

[GP10] Y. Geum, Y. Park. 'Development of technology roadmap for product-service system (TRPSS)'. In: *2010 IEEE International Conference on Industrial Engineering and Engineering Management*. IEEE. 2010, pp. 410–414 (cit. on pp. 75, 76, 91, 337).

[GPVT19] N. Gerdsri, S. Puengrusme, R. Vatananan, P. Tansurat. 'Conceptual framework to assess the impacts of changes on the status of a roadmap'. In: *Journal of Engineering and Technology Management* 52 (2019), pp. 16–31 (cit. on pp. 83, 91).

[Gra20] S. Grabmeier. *BANI versus VUCA: a new acronym to describe the world*. 2020. URL: https://stephangrabmeier.de/bani-versus-vuca/ (visited on 02/28/2023) (cit. on pp. 19, 20).

[Gro] N. N. Group. *Why You Only Need to Test with 5 Users*. URL: https://www.nngroup.com/articles/why-you-only-need-to-test-with-5-users/ (visited on 08/21/2023) (cit. on p. 239).

[Gro97] P. Groenveld. 'Roadmapping integrates business and technology'. In: *Research-Technology Management* 40.5 (1997), pp. 48–55 (cit. on pp. 40, 41, 49).

[GT15] D. Güemes-Castorena, M. A. Toro. 'Methodology for the integration of Business Model Canvas and technological road map'. In: *2015 Portland International Conference on Management of Engineering and Technology (PICMET)*. IEEE. 2015, pp. 41–52 (cit. on pp. 89, 91).

[Guo10] W. Guo. 'Technology roadmapping as a new tool of knowledge management'. In: *2010 Chinese control and decision conference*. IEEE. 2010, pp. 1658–1661 (cit. on p. 43).

[GVD09] N. Gerdsri, R. S. Vatananan, S. Dansamasatid. 'Dealing with the dynamics of technology roadmapping implementation: A case study'. In: *Technological Forecasting and Social Change* 76.1 (2009), pp. 50–60 (cit. on pp. 73, 91).

[Haa15] B. de Haaff. *3 ways expert product managers deal with new ideas*. 2015. URL: https://www.linkedin.com/pulse/how-skilled-product-managers-deal-new-ideas-brian-de-haaff/ (visited on 02/28/2023) (cit. on p. 157).

[HCHC10] A. Hevner, S. Chatterjee, A. Hevner, S. Chatterjee. 'Design science research in information systems'. In: *Design research in information systems: theory and practice* (2010), pp. 9–22 (cit. on pp. 27, 29–31).

[HH07] P. Hodgkins, L. Hohmann. 'Agile program management: Lessons learned from the verisign managed security services team'. In: *Agile 2007 (AGILE 2007)*. IEEE. 2007, pp. 194–199 (cit. on pp. 48–50).

[HO17] J.-Y. Ho, E. O'Sullivan. 'Strategic standardisation of smart systems: A roadmapping process in support of innovation'. In: *Technological Forecasting and Social Change* 115 (2017), pp. 301–312 (cit. on pp. 41, 73, 92).

[HO20] J.-Y. Ho, E. O'Sullivan. 'Toward integrated innovation roadmapping: lessons from multiple functional roadmaps beyond technology R&D'. In: *IEEE Transactions on Engineering Management* 69.1 (2020), pp. 155–167 (cit. on pp. 80, 92).

[HPF+20] Y. Hirose, R. Phaal, C. Farrukh, N. Gerdsri, S. Lee. 'Characterizing maturity levels for organization-wide roadmapping implementation'. In: *IEEE Engineering Management Review* 48.4 (2020), pp. 133–143 (cit. on pp. 51, 52, 57, 92).

[HT12] K. Hakkarainen, T. Talonen. 'Business model Roadmapping-a Practitioner's approach'. In: *ISPIM Conference Proceedings*. The International Society for Professional Innovation Management (ISPIM). 2012, p. 1 (cit. on p. 41).

[IDE] IDEO. *Design Thinking*. URL: https://designthinking.ideo.com/ (visited on 02/28/2023) (cit. on p. 273).

[Jan23] N. Janse. *Dual-Track Agile*. 2023. URL: https://www.delibr.com/post/dual-track-agile (visited on 02/28/2023) (cit. on pp. 157, 158).

[JP14] P. Johannesson, E. Perjons. *An introduction to design science*. Vol. 10. Springer, 2014 (cit. on p. 31).

[JPW+17] E. Jagroep, G. Procaccianti, J. M. van der Werf, S. Brinkkemper, L. Blom, R. van Vliet, et al. 'Energy efficiency on the product roadmap: an empirical study across releases of a software product'. In: *Journal of Software: Evolution and process* 29.2 (2017), e1852 (cit. on p. 48).

[JS06] S. Jantunen, K. Smolander. 'Challenges of knowledge and collaboration in roadmapping'. In: *2006 International Workshop on Software Product Management (IWSPM'06-RE'06 Workshop)*. IEEE. 2006, pp. 19–26 (cit. on pp. 89, 92).

[Kab21] E. Kabisch. *Escaping the roadmap trap*. 2021. URL: https://productcrunch.substack.com/p/escaping-the-roadmap-trap (visited on 02/28/2023) (cit. on pp. 156, 158).

[Kap01] T. A. Kappel. 'Perspectives on roadmaps: how organizations talk about the future'. In: *Journal of Product Innovation Management: AN INTERNATIONAL PUBLICATION OF THE PRODUCT DEVELOPMENT & MANAGEMENT ASSOCIATION* 18.1 (2001), pp. 39–50 (cit. on pp. 40, 42, 46–48, 337).

[KBA18] E. Kim, S. L. Beckman, A. Agogino. 'Design roadmapping in an uncertain world: Implementing a customer-experience-focused strategy'. In: *California Management Review* 61.1 (2018), pp. 43–70 (cit. on pp. 21, 52–54, 57, 92).

[KCBA16] E. Kim, J. Chung, S. Beckman, A. M. Agogino. 'Design roadmapping: A framework and case study on planning development of high-tech products in Silicon Valley'. In: *Journal of Mechanical Design* 138.10 (2016), p. 101106 (cit. on p. 54).

[Kee+07] S. Keele et al. *Guidelines for performing systematic literature reviews in software engineering*. 2007 (cit. on p. 60).

[Kit] H.-B. Kittlaus. 'Software Product Management: The ISPMA-Compliant Study Guide and Handbook, Edition 2'. In: () (cit. on pp. 55–57, 92, 337).

[KKT+11] M. Komssi, M. Kauppinen, H. Töhönen, L. Lehtola, A. M. Davis. 'Integrating analysis of customers' processes into roadmapping: The value-creation perspective'. In: *2011 IEEE 19th International Requirements Engineering Conference*. IEEE. 2011, pp. 57–66 (cit. on pp. 21, 79, 92, 95, 309).

[KKT+15] M. Komssi, M. Kauppinen, H. Töhönen, L. Lehtola, A. M. Davis. 'Roadmapping problems in practice: value creation from the perspective of the customers'. In: *Requirements Engineering* 20 (2015), pp. 45–69 (cit. on p. 20).

[KNFK06] A. Kameoka, K. Nakamura, T. Fujuwara, N. Kamada. '" Services Science" and Services Layer Added Strategic Technology Roadmapping'. In: *2006 Technology Management for the Global Future-PICMET 2006 Conference*. Vol. 4. IEEE. 2006, pp. 1956–1961 (cit. on pp. 75, 92).

[KP15] C. Kerr, R. Phaal. 'Visualizing roadmaps: A design-driven approach'. In: *Research-Technology Management* 58.4 (2015), pp. 45–54 (cit. on pp. 81, 92).

[KP19] C. Kerr, R. Phaal. 'Defining the scope of a roadmapping initiative: A checklist-based template for organizational stakeholders'. In: *2019 Portland International Conference on Management of Engineering and Technology (PICMET)*. IEEE. 2019, pp. 1–10 (cit. on pp. 54, 55, 57, 92).

[KS01] R. N. Kostoff, R. R. Schaller. 'Science and technology roadmaps'. In: *IEEE Transactions on engineering management* 48.2 (2001), pp. 132–143 (cit. on pp. 41, 42, 45, 46).

[KSB+20] E. Kim, L. W. Simonse, S. L. Beckman, M. M. Appleyard, H. Velazquez, A. S. Madrigal, A. M. Agogino. 'User-centered design roadmapping: anchoring roadmapping in customer value before technology selection'. In: *IEEE Transactions on Engineering Management* 69.1 (2020), pp. 109–126 (cit. on pp. 48, 49, 78, 92).

[KYA+15] E. Kim, S. Yao, A. M. Agogino, et al. 'Design roadmapping: Challenges and opportunities'. In: *DS 80-6 Proceedings of the 20th International Conference on Engineering Design (ICED 15) Vol 6: Design Methods and Tools-Part 2 Milan, Italy, 27-30.07. 15*. 2015, pp. 085–094 (cit. on pp. 79, 92, 95, 309).

[LJLS21] S. Lee, K. J. Jang, M. H. Lee, S. R. Shin. 'Roadmapping in the Era of Uncertainty: How to Integrate Data-Driven Methods with Expert Insights'. In: 15.2 (eng) (2021), pp. 39–51 (cit. on pp. 68, 92).

[LKK05] L. Lehtola, M. Kauppinen, S. Kujala. 'Linking the business view to requirements engineering: long-term product planning by roadmapping'. In: *13th IEEE International Conference on Requirements Engineering (RE'05)*. IEEE. 2005, pp. 439–443 (cit. on pp. 41, 42, 49, 87, 92).

[LKVK09] L. Lehtola, M. Kauppinen, J. Vähäniitty, M. Komssi. 'Linking business and requirements engineering: is solution planning a missing activity in software product companies?' In: *Requirements engineering* 14 (2009), pp. 113–128 (cit. on pp. 40, 41).

[LLL06] H.-K. Lee, C.-M. Liu, M.-H. Lee. 'Aligning the business roadmap to technology roadmap for managing the new product development project'. In: *Journal of the Chinese Institute of Industrial Engineers* 23.6 (2006), pp. 449–457 (cit. on p. 42).

[LMD+04] M. Lindvall, D. Muthig, A. Dagnino, C. Wallin, M. Stupperich, D. Kiefer, J. May, T. Kahkonen. 'Agile software development in large organizations'. In: *Computer* 37.12 (2004), pp. 26–34 (cit. on p. 37).

[LMRC17] C. T. Lombardo, B. McCarthy, E. Ryan, M. Connors. *Product roadmaps relaunched: how to set direction while embracing uncertainty*. " O'Reilly Media, Inc.", 2017 (cit. on pp. 19–22, 49, 52, 57, 92, 155–158, 234).

[LSHM15] J. Linaker, S. M. Sulaman, M. Höst, R. M. de Mello. 'Guidelines for conducting surveys in software engineering v. 1.1'. In: *Lund University* 50 (2015) (cit. on p. 123).

[LSTM21] D. Lang, S. Spies, S. Trieflinger, J. Münch. 'Tailored design thinking approach-a shortcut for agile teams'. In: *Software Business: 12th International Conference, ICSOB 2021, Drammen, Norway, December 2–3, 2021, Proceedings 12*. Springer. 2021, pp. 37–49 (cit. on p. 272).

[Mar23] J. Marshall. *5 Things That Can Ruin Your Roadmap*. 2023. URL: https://www.productplan.com/blog/5-things-that-can-ruin-your-product-roadmap/ (visited on 02/28/2023) (cit. on p. 155).

[May15] P. Mayring. 'Qualitative Inhaltsanalyse; Grundlagen und Techniken (Bd. 12)'. In: *Klagenfurt: Beltz* (2015) (cit. on p. 255).

[McC03] R. C. McCarthy. 'Linking technological change to business needs'. In: *Research-Technology Management* 46.2 (2003), pp. 47–52 (cit. on p. 49).

[McC19] H. McCloskey. *Yes, your agile team needs a product roadmap*. 2019. URL: https://www.usertesting.com/blog/agile-product-roadmap (visited on 02/28/2023) (cit. on p. 155).

[McM03] A. McMillan. 'Roadmapping—agent of change'. In: *Research-Technology Management* 46.2 (2003), pp. 40–47 (cit. on p. 41).

[Men21] P. M. Mentor. *Produktmanagement weltweit und im deutschsprachigen Raum*. 2021. URL: https://www.produktmanagementor.de/infografiken/produktmanagement-weltweit-und-im-dach-raum/?gclid=EAIaIQobChMIr42-6u7O_QIVge53Ch1DOgE3EAAYASAAEgJGmfI BwE#anker_download (visited on 02/28/2023) (cit. on p. 125).

[MH94] M. B. Miles, A. M. Huberman. *Qualitative data analysis: An expanded sourcebook*. sage, 1994 (cit. on p. 123).

[MIP13] M. G. Moehrle, R. Isenmann, R. Phaal. 'Technology roadmapping for strategy and innovation'. In: *Charting Route to Success. Berlin al. Springer* (2013) (cit. on p. 41).

[MNS11] A. Maglyas, U. Nikula, K. Smolander. ‘Software product management in the Russian companies’. In: *2011 7th Central and Eastern European Software Engineering Conference (CEE-SECR)*. IEEE. 2011, pp. 1–9 (cit. on pp. 81, 92, 95, 309).

[MS09] R. B. Mason, G. Staude. ‘An exploration of marketing tactics for turbulent environments’. In: *Industrial Management & Data Systems* (2009) (cit. on p. 21).

[MTB+20] J. Münch, S. Trieflinger, E. Bogazköy, P. Eißler, B. Roling, J. Schneider. ‘Product roadmap formats for an uncertain future: a grey literature review’. In: *2020 46th Euromicro Conference on Software Engineering and Advanced Applications (SEAA)*. IEEE. 2020, pp. 284–291 (cit. on pp. 21, 146, 150).

[MTH20] J. Münch, S. Trieflinger, B. Heisler. ‘Product discovery–building the right things: Insights from a grey literature review’. In: *2020 IEEE International Conference on Engineering, Technology and Innovation (ICE/ITMC)*. IEEE. 2020, pp. 1–8 (cit. on p. 49).

[MTL18] J. Münch, S. Trieflinger, D. Lang. ‘Why feature-based roadmaps fail in rapidly changing markets: a qualitative survey’. In: *Software-intensive business: start-ups, ecosystems and platforms: proceedings of the International Workshop on Software-intensive Business: Start-ups, Ecosystems and Platforms (SiBW 2018): Espoo, Finland, December 3, 2018.-(CEUR workshop proceedings; 2305)*. RWTH Aachen. 2018, pp. 202–218 (cit. on pp. 20–22, 99, 100, 103, 140).

[MTL19a] J. Münch, S. Trieflinger, D. Lang. ‘DEEP: the product roadmap maturity model: a method for assessing the product roadmapping capabilities of organizations’. In: *Proceedings of the 2nd ACM SIGSOFT International Workshop on Software-Intensive Business: Start-ups, Platforms, and Ecosystems*. 2019, pp. 19–24 (cit. on pp. 34, 174).

[MTL19b] J. Münch, S. Trieflinger, D. Lang. ‘Product roadmap–from vision to reality: a systematic literature review’. In: *2019 IEEE International Conference on Engineering, Technology and Innovation (ICE/ITMC)*. IEEE. 2019, pp. 1–8 (cit. on pp. 22, 33, 60).

[MTL19c] J. Münch, S. Trieflinger, D. Lang. 'The product roadmap maturity model DEEP: validation of a method for assessing the product roadmap capabilities of organizations'. In: *Software Business: 10th International Conference, ICSOB 2019, Jyväskylä, Finland, November 18–20, 2019, Proceedings 10*. Springer. 2019, pp. 97–113 (cit. on pp. 34, 190).

[MTL19d] J. Münch, S. Trieflinger, D. Lang. 'What's hot in product roadmapping? Key practices and success factors'. In: *Product-Focused Software Process Improvement: 20th International Conference, PROFES 2019, Barcelona, Spain, November 27–29, 2019, Proceedings 20*. Springer. 2019, pp. 401–416 (cit. on pp. 21, 22, 33, 49, 100, 102, 106, 112, 140).

[Naj] C. Naji. *7 tactics to solve Common product roadmap problems*. URL: https://www.modernanalyst.com/Resources/Articles/tabid/115/ID/3831/7-Tactics-to-Solve-Common-Product-Roadmap-Problems.aspx (visited on 02/28/2023) (cit. on p. 158).

[NNGS14] M. Niranjanamurthy, A. Nagaraj, H. Gattu, P. K. Shetty. 'Research study on importance of usability testing/User Experience (UX) testing'. In: *International Journal of Computer Science and Mobile Computing* 3.10 (2014), pp. 78–85 (cit. on p. 226).

[Nud18] G. Nudelman. 'Lean UX communication strategies for success in large organizations'. In: *Interactions* 25.5 (2018), pp. 80–82 (cit. on p. 283).

[OF15] M. G. Oliveira, A. L. Fleury. 'A framework for improving the roadmapping performance'. In: *2015 Portland International Conference on Management of Engineering and Technology (PICMET)*. IEEE. 2015, pp. 2255–2263 (cit. on p. 42).

[OFPG20] M. G. de Oliveira, J. S. Freitas, B. S. Pereira, P. V. Guerra. 'Exploring the involvement of experts in strategic roadmapping with large groups'. In: *IEEE Transactions on Engineering Management* 69.1 (2020), pp. 56–66 (cit. on pp. 87, 91).

[OVB15] A. M. Ozaki, E. P. de Vasconcellos, M. Bengtsson. 'Agile roadmapping: How Brazilian software companies evolve their products'. In: *ISPIM Conference Proceedings. The International Society for Professional Innovation Management (ISPIM)*. 2015, p. 1 (cit. on pp. 90, 92).

[PB99] D. Patnaik, R. Becker. 'Needfinding: the why and how of uncovering people's needs'. In: *Design Management Journal (Former Series)* 10.2 (1999), pp. 37–43 (cit. on p. 49).

[Per18] M. Perri. *Escaping the build trap: How effective product management creates real value*. O'Reilly Media, 2018 (cit. on pp. 20, 21).

[Per20] D. Pereira. *Why Most Roadmaps Make Poor Results Inevitable*. 2020. URL: https://medium.com/serious-scrum/why-most-roadmaps-make-poor-results-inevitable-dd3372b183c8 (visited on 02/28/2023) (cit. on p. 154).

[PFMP03] R. Phaal, C. J. Farrukh, J. F. Mills, D. R. Probert. 'Customizing the technology roadmapping approach'. In: *PICMET'03: Portland International Conference on Management of Engineering and Technology Technology Management for Reshaping the World, 2003.* IEEE. 2003, pp. 361–369 (cit. on p. 42).

[PFP01a] R. Phaal, C. Farrukh, D. Probert. 'Technology Roadmapping: linking technology resources to business objectives'. In: *Centre for Technology Management, University of Cambridge* (2001), pp. 1–18 (cit. on p. 43).

[PFP01b] R. Phaal, C. J. Farrukh, D. R. Probert. 'Characterisation of technology roadmaps: purpose and format'. In: *PICMET'01. Portland International Conference on Management of Engineering and Technology. Proceedings Vol. 1: Book of Summaries (IEEE Cat. No. 01CH37199)*. IEEE. 2001, pp. 367–374 (cit. on pp. 20, 41, 43, 46).

[PFP04] R. Phaal, C. J. Farrukh, D. R. Probert. 'Technology roadmapping—A planning framework for evolution and revolution'. In: *Technological forecasting and social change* 71.1-2 (2004), pp. 5–26 (cit. on pp. 41, 78, 92).

[PFP05] R. Phaal, C. J. Farrukh, D. R. Probert. 'Developing a technology roadmapping system'. In: *A Unifying Discipline for Melting the Boundaries Technology Management:* Citeseer. 2005, pp. 99–111 (cit. on pp. 41, 43, 75, 93).

[PGK06] S. Passey, N. Goh, P. Kil. 'Targeting the innovation roadmap event horizon: product concept visioning & scenario building'. In: *2006 IEEE International Conference on Management of Innovation and Technology*. Vol. 2. IEEE. 2006, pp. 604–607 (cit. on pp. 89, 92).

[Pic21] R. Pichler. *Product discovery tips*. 2021. URL: https://www.romanpichler.com/blog/product-discovery-tips/ (visited on 02/28/2023) (cit. on p. 157).

[Pla07] M. Plag. *Veränderungsmanagement in Bundesministerien: eine empirische Untersuchung auf Basis multipler Fallstudien*. Springer-Verlag, 2007 (cit. on p. 273).

[PM09] R. Phaal, G. Muller. 'An architectural framework for roadmapping: Towards visual strategy'. In: *Technological forecasting and social change* 76.1 (2009), pp. 39–49 (cit. on pp. 43, 45, 75, 77, 92).

[PR03] D. Probert, M. Radnor. 'Frontier experiences from industry-academia consortia'. In: *Research-Technology Management* 46.2 (2003), pp. 27–30 (cit. on pp. 40, 41).

[Pra16] Pragmatic. *Pitfalls in product decision-making*. 2016. URL: https://www.pragmaticinstitute.com/resources/articles/product/pitfalls-in-product-decision-making/ (visited on 02/28/2023) (cit. on p. 156).

[Proa] ProductPlan. *5 mistakes you're making When sharing Your product roadmap*. URL: https://www.productplan.com/learn/product-roadmap-sharing-mistakes/ (visited on 02/28/2023) (cit. on p. 159).

[Prob] ProductPlan. *The feature-less roadmap: Using themes and north stars to ground your product roadmap*. URL: https://www.productplan.com/webinars/feature-less-roadmap/ (visited on 02/28/2023) (cit. on p. 156).

[Pro23] ProductPlan. *6 reasons product roadmaps fail*. 2023. URL: https://www.productplan.com/learn/reasons-product-roadmaps-fail/ (visited on 02/28/2023) (cit. on pp. 156, 158).

[PSD08] R. Phaal, L. Simonse, E. Den Ouden. 'Next generation roadmapping for innovation planning'. In: *International Journal of Technology Intelligence and Planning* 4.2 (2008), pp. 135–152 (cit. on pp. 41, 85, 93).

[PTGT18] U. Pora, N. Thawesaengskulthai, N. Gerdsri, S. Triukose. 'Data-driven roadmapping turning challenges into opportunities'. In: *2018 Portland International Conference on Management of Engineering and Technology (PICMET)*. IEEE. 2018, pp. 1–11 (cit. on pp. 80, 93).

[PTRC07] K. Peffers, T. Tuunanen, M. A. Rothenberger, S. Chatterjee. 'A design science research methodology for information systems research'. In: *Journal of management information systems* 24.3 (2007), pp. 45–77 (cit. on pp. 31, 32, 337).

[Rex18] N. Rex. *Escape from the feature roadmap to outcome-driven development*. 2018. URL: https://www.mindtheproduct.com/escape-from-the-feature-roadmap-to-outcome-driven-development/ (visited on 02/28/2023) (cit. on p. 155).

[Rin04] M. Rinne. 'Technology roadmaps: Infrastructure for innovation'. In: *Technological Forecasting and Social Change* 71.1-2 (2004), pp. 67–80 (cit. on p. 43).

[SA19] S. Schimpf, T. Abele. 'How German companies apply roadmapping: Evidence from an empirical study'. In: *Journal of Engineering and Technology Management* 52 (2019), pp. 74–88 (cit. on pp. 87, 93).

[Sah18] S. Sahu. *Product Roadmap: A Dilemma*. 2018. URL: https://www.linkedin.com/pulse/product-roadmap-dilemma-suchismita-sahu/ (visited on 02/28/2023) (cit. on p. 154).

[Sch21] I. Schels. *Common product discovery pitfalls and how to avoid them*. 2021. URL: https://www.mindtheproduct.com/common-product-discovery-pitfalls-and-how-to-avoid-them/ (visited on 02/28/2023) (cit. on p. 157).

[Sch23] M. Scharphie. *Can you be successful if you have too many ideas?* 2023. URL: https://medium.com/help-yourself/can-you-be-successful-if-you-have-too-many-ideas-cdb2349d6acc (visited on 02/28/2023) (cit. on p. 157).

[SGF+10] M. Svahnberg, T. Gorschek, R. Feldt, R. Torkar, S. B. Saleem, M. U. Shafique. 'A systematic review on strategic release planning models'. In: *Information and software technology* 52.3 (2010), pp. 237–248 (cit. on p. 40).

[SR04] J. D. Strauss, M. Radnor. 'Roadmapping for dynamic and uncertain environments'. In: *Research-Technology Management* 47.2 (2004), pp. 51–58 (cit. on pp. 48, 88, 93).

[Sri21] M. Sridharan. *BANI – How To Make Sense Of A Chaotic World?* 2021. URL: https://thinkinsights.net/leadership/bani/ (visited on 02/28/2023) (cit. on pp. 19, 20).

[SSAS11] T. Suomalainen, O. Salo, P. Abrahamsson, J. Similä. 'Software product roadmapping in a volatile business environment'. In: *Journal of Systems and Software* 84.6 (2011), pp. 958–975 (cit. on pp. 21, 48, 49, 71, 93, 95).

[SSF+20] M. L. P. de Souza, W. C. de Souza, J. S. Freitas, L. D. R. de Melo Filho, R. B. Bagno. 'Agile roadmapping: a management tool for digital entrepreneurship'. In: *IEEE Transactions on Engineering Management* 69.1 (2020), pp. 94–108 (cit. on pp. 69, 91).

[Suo15] T. Suomalainen. 'Defining continuous planning through a multiple-case study'. In: *Product-Focused Software Process Improvement: 16th International Conference, PROFES 2015, Bolzano, Italy, December 2-4, 2015, Proceedings 16*. Springer. 2015, pp. 288–294 (cit. on pp. 86, 93).

[Sut23] D. Sutevski. *6 Things you can do when you have too many business ideas*. 2023. URL: https://www.entrepreneurshipinabox.com/9087/6-things-you-can-do-when-you-have-too-many-business-ideas/ (visited on 02/28/2023) (cit. on p. 157).

[SVS18] A.-A. Schaller, R. Vatananan-Thesenvitz, M. Stefania. 'Business model innovation roadmapping: A structured approach to a new business model'. In: *2018 Portland International Conference on Management of Engineering and Technology (PICMET)*. IEEE. 2018, pp. 1–9 (cit. on pp. 41, 70, 93).

[TBV11] A. Tang, T. de Boer, H. van Vliet. 'Building roadmaps: a knowledge sharing perspective'. In: *Proceedings of the 6th International Workshop on SHAring and Reusing Architectural Knowledge*. 2011, pp. 13–20 (cit. on pp. 88, 93).

[Tei19] P. Teixeira. *When Dual-Track and Product Discovery go wrong*. 2019. URL: https://www.linkedin.com/pulse/when-dual-track-agile-product-discovery-go-wrong-pedro-teixeira/ (visited on 02/28/2023) (cit. on p. 157).

[Tem21] M. Temmen. *BANI vs VUCA— a new acronym for a new world*. 2021. URL: https://marian-temmen.medium.com/bani-vs-vuca-a-new-acronym-for-a-new-world-59c7be2dddce (visited on 02/28/2023) (cit. on pp. 19, 20).

[TLM22] S. Trieflinger, D. Lang, J. Münch. 'Counter the Uncertainties in a Dynamic World: An Approach to Creating Outcome-Driven Product Roadmaps'. In: *Product-Focused Software Process Improvement: 23rd International Conference, PROFES 2022, Jyväskylä, Finland, November 21–23, 2022, Proceedings*. Springer. 2022, pp. 319–333 (cit. on pp. 35, 292).

[TLSM23] S. Trieflinger, D. Lang, S. Spies, J. Münch. 'The discovery effort worthiness index: How much product discovery should you do and how can this be integrated into delivery?' In: *Information and Software Technology* 157 (2023), p. 107167 (cit. on pp. 34, 272, 283).

[TMB+21] S. Trieflinger, J. Münch, E. Bogazköy, P. Eißler, J. Schneider, B. Roling. 'How to prioritize your product roadmap when everything feels important: a grey literature review'. In: *2021 IEEE International Conference on Engineering, Technology and Innovation (ICE/ITMC)*. IEEE. 2021, pp. 1–9 (cit. on pp. 146, 150, 295).

[TMKL20] S. Trieflinger, J. Münch, V. Knoop, D. Lang. 'Facing the challenges with product roadmaps in uncertain markets: experience from industry'. In: *2020 IEEE International Conference on Engineering, Technology and Innovation (ICE/ITMC)*. IEEE. 2020, pp. 1–8 (cit. on pp. 22, 33, 100–102, 112, 140).

[TMPL22a] S. Trieflinger, J. Münch, D. Petrik, D. Lang. 'Why Traditional Product Roadmaps Fail in Dynamic Markets: Global Insights'. In: *Product-Focused Software Process Improvement: 23rd International Conference, PROFES 2022, Jyväskylä, Finland, November 21–23, 2022, Proceedings*. Springer. 2022, pp. 382–389 (cit. on pp. 21, 34, 100, 101).

[TMPL22b] S. Trieflinger, J. Münch, D. Petrik, D. Lang. ‘Why Traditional Product Roadmaps Fail in Dynamic Markets: Global Insights’. In: *Product-Focused Software Process Improvement: 23rd International Conference, PROFES 2022, Jyväskylä, Finland, November 21–23, 2022, Proceedings*. Springer. 2022, pp. 382–389 (cit. on pp. 22, 150).

[TMS+21] S. Trieflinger, J. Münch, J. Schneider, E. Bogazköy, P. Eißler, B. Roling, D. Lang. ‘Product roadmapping processes for an uncertain market environment: A grey literature review’. In: *Lean and Agile Software Development: 5th International Conference, LASD 2021, Virtual Event, January 23, 2021, Proceedings 5*. Springer. 2021, pp. 111–129 (cit. on pp. 146, 150).

[TMW+21] S. Trieflinger, J. Münch, S. Wagner, D. Lang, B. Roling. ‘A transformation model for excelling in product roadmapping in dynamic and uncertain market environments’. In: *Product-Focused Software Process Improvement: 22nd International Conference, PROFES 2021, Turin, Italy, November 26, 2021, Proceedings 22*. Springer. 2021, pp. 136–151 (cit. on pp. 34, 200, 212).

[TMW+22] S. Trieflinger, J. Münch, L. Weiss, B. Roling, D. Lang. ‘Transformation Towards a Product-Led Company: Case Studies from Industry’. In: *2022 IEEE/ACM International Workshop on Software-Intensive Business (IWSiB)*. IEEE. 2022, pp. 9–16 (cit. on pp. 19, 34, 225).

[Too21] T. P. M. Toolbox. *Product roadmap Challenges*. 2021. URL: https://theproductmanagerstoolbox.com/product-roadmap-challenges/ (visited on 02/28/2023) (cit. on p. 156).

[Tor21] T. Torres. *Continuous Discovery Habits: Discover Products that Create Customer Value and Business Value*. Product Talk LLC, 2021 (cit. on p. 257).

[TW97] B. Tabrizi, R. Walleigh. ‘Defining next-generation products: An inside look’. In: *Harvard business review* 75.6 (1997), pp. 116–125 (cit. on p. 49).

[Uch07] N. Uchihira. ‘Future direction and roadmap of concurrent system technology’. In: *IEICE transactions on fundamentals of electronics, communications and computer sciences* 90.11 (2007), pp. 2443–2448 (cit. on pp. 88, 93).

[Ulw16] A. W. Ulwick. *Jobs to be done: theory to practice*. Idea Bite Press, 2016 (cit. on p. 293).

[Ulw17] A. W. Ulwick. 'Outcome-Driven Innovation®(ODI): Jobs-to-be-Done Theory in Practice'. In: *Strategyn, LLC Whitepaper* (2017) (cit. on p. 293).

[Umb17] H. Umbach. *Dear Product Roadmap, I'm Breaking Up with You*. 2017. URL: https://medium.com/fresh-tilled-soil/dear-product-roadmap-im-breaking-up-with-you-a47cfa6ca4f7 (visited on 02/28/2023) (cit. on pp. 156, 158).

[VJBJ11] K. Vlaanderen, S. Jansen, S. Brinkkemper, E. Jaspers. 'The agile requirements refinery: Applying SCRUM principles to software product management'. In: *Information and software technology* 53.1 (2011), pp. 58–70 (cit. on p. 37).

[VKM16] K. Vishnevskiy, O. Karasev, D. Meissner. 'Integrated roadmaps for strategic management and planning'. In: *Technological Forecasting and Social Change* 110 (2016), pp. 153–166 (cit. on pp. 84, 93).

[VLR02] J. Vähäniitty, C. Lassenius, K. Rautiainen. 'An approach to product roadmapping in small software product businesses'. In: *ECSQ2002), Conference Notes*. 2002, pp. 12–13 (cit. on pp. 40, 69, 93, 95).

[VLRP09] J. Vähäniitty, C. Lassenius, K. Rautiainen, P. Pekkanen. 'Long-Term Planning of Development Efforts by Roadmapping–A Model and Experiences from Small Software Companies'. In: *2009 35th Euromicro Conference on Software Engineering and Advanced Applications*. IEEE. 2009, pp. 300–305 (cit. on pp. 81, 93).

[VR08] J. Vähäniitty, K. T. Rautiainen. 'Towards a conceptual framework and tool support for linking long-term product and business planning with agile software development'. In: *Proceedings of the 1st international workshop on Software development governance*. 2008, pp. 25–28 (cit. on pp. 82, 93).

[VTM21] Y. Voigt, S. Trieflinger, J. Münch. 'Product roadmaps in the new mobility domain: state of the practice and industrial experiences'. In: *2021 IEEE International Conference on Engineering, Technology and Innovation (ICE/ITMC)*. IEEE. 2021, pp. 1–9 (cit. on pp. 100–102, 112).

[VTR92] B. Virany, M. L. Tushman, E. Romanelli. 'Executive succession and organization outcomes in turbulent environments: An organization learning approach'. In: *Organization Science* 3.1 (1992), pp. 72–91 (cit. on p. 25).

[VVB13] K. Vlaanderen, I. Van de Weerd, S. Brinkkemper. 'Improving software product management: a knowledge management approach'. In: *International Journal of Business Information Systems* 12.1 (2013), pp. 3–22 (cit. on p. 40).

[WCM01] R. Whittemore, S. K. Chase, C. L. Mandle. 'Validity in qualitative research'. In: *Qualitative health research* 11.4 (2001), pp. 522–537 (cit. on p. 32).

[WG15] R. Wilden, S. P. Gudergan. 'The impact of dynamic capabilities on operational marketing and technological capabilities: investigating the role of environmental turbulence'. In: *Journal of the Academy of Marketing Science* 43 (2015), pp. 181–199 (cit. on p. 25).

[Wic16] A. Wick. *What happens when you don't have a product vision?* 2016. URL: `https://www.ba-squared.com/blog/happens-dont-product-vision/` (visited on 02/28/2023) (cit. on p. 156).

[Wie09] R. Wieringa. 'Design science as nested problem solving'. In: *Proceedings of the 4th international conference on design science research in information systems and technology*. 2009, pp. 1–12 (cit. on p. 31).

[Wil09] D. Wilby. 'Roadmap transformation: from obstacle to catalyst'. In: *2009 Agile Conference*. IEEE. 2009, pp. 229–234 (cit. on pp. 86, 93).

[Won] A. Wong. *10 common mistakes or pitfalls new product managers should avoid*. URL: `https://productmasterynow.com/blog/tei-154-pitfalls-that-can-trap-new-product-managers-with-aero-wong/` (visited on 02/28/2023) (cit. on p. 156).

[WPFP04] R. Wells, R. Phaal, C. Farrukh, D. Probert. 'Technology roadmapping for a service organization'. In: *Research-Technology Management* 47.2 (2004), pp. 46–51 (cit. on p. 43).

[WR00] C. Wohlin, P. Runeson. 'und M. Höst'. In: *Experimentation in Software Engineering: An Introduction (International Series in Software Engineering)* (2000) (cit. on pp. 159, 160).

[WW14] R. J. Wieringa, R. J. Wieringa. 'Research goals and research questions'. In: *Design science methodology for information systems and software engineering* (2014), pp. 13–23 (cit. on p. 22).

[Yam73] T. Yamane. 'Statistics: an introductory analysis-3'. In: (1973) (cit. on p. 125).

[Yin09] R. K. Yin. *Case study research: Design and methods*. Vol. 5. sage, 2009 (cit. on pp. 120, 140, 185, 196, 209, 220, 266, 272, 273, 286).

[YPP08] B. Yoon, R. Phaal, D. Probert. 'Morphology analysis for technology roadmapping: application of text mining'. In: *R&d Management* 38.1 (2008), pp. 51–68 (cit. on p. 44).

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