Available online at www.sciencedirect.com

ScienceDirect

Procedia CIRP 119 (2023) 903–912

www.elsevier.com/locate/procedia

33rd CIRP Design Conference

Improving Understanding of new or Emerging Technologies - Development of a Technology Characterization Canvas

Sarah I. Manthey[1*]

[1] *Karlsruhe Institute of Technology, Kaiserstraße 12, 76131 Karlsruhe, GERMANY*

* Corresponding author. Tel.: +49 721 608-48977. *E-mail address:* sarah.manthey@kit.edu

Abstract

Technology Application Selection (TAS) is crucial for the success of technology-push innovations, but still supporting approaches for the process and the respective steps are sparse. To improve the understanding of this issue to further develop the TAS process and to build a supporting approach, this study focuses on the first step in the TAS process, the technology characterization. Therefore, an analysis of existing tools and influencing criteria for technology description is carried out to determine which factors are most relevant to understand the technology in depth. The results are translated into a technology canvas, tested with several patents, and evaluated by experts.

Keywords: Technology Push Innovation; Technology Application Selection, Technology Description, Technology Characterization, TAS Process

1. Introduction

The competitiveness of technology-oriented companies depends on their ability to identify opportunities from technological developments and to turn them into innovations [1]. Particularly young university spin-offs or technology-based startups built up on an existing technology hoping for its commercialization in the market [2], but also for technology-based companies it is becoming increasingly crucial to identify innovative applications for new or existing technologies [3]. Since future success depends on the recognition and coordination of opportunities resulting from technological developments, technology-push innovations become essential [4]. Still, less focus and consideration in literature and practice led to an underdeveloped and hardly understood technology push process [5].

One of the most important steps of the "technology push" is the analysis of chosen technologies to identify suitable applications [6]. To be able to carry out this step in a well-founded manner, information about the technology in question must be collected [7] as understanding technology attributes, especially unique benefits, is a key element to identify opportunities [5]. Further, as an in-depth understanding of the technology provides the necessary information about its capabilities and limitations this can be used to identify if the underlying technology is the most appropriate for the later identified application in the engineering design. In addition, a technology description can provide information on costs, performance characteristics, and other key factors that may influence the engineering design process [8].

For this purpose, several approaches exist, such as the “Technology Canvas (TC)”, which is used to describe new technologies by answering six key questions to retrieve the most important information about the technology [5], or the “Voice of Technology”, which combines elements of a SWOT analysis with technological relevant aspects like product or material [9].

Literature reveals that most approaches for describing technologies rarely build upon each other and are rather

2212-8271
10.1016/j.procir.2023.02.169

designed for a respective issue [10]. Furthermore, existing tools are mostly not evaluated in practice, except for a few examples [5]. Therefore, this study's purpose is to explore how technologies are currently described in the literature and which tools exist. As the TC of Terzidis and Vogel [5] represents one of the few evaluated technology description tools, the results of further investigation will be compared with this tool to evaluate the status quo and analyze potential improvements.

Based on the findings of the literature review, a compilation of factors to be integrated in a tool will be derived, which consist of theoretical contributions as well as practical perspectives of experts in the field of technology transfer. Comparing these findings with the existing TC, the compilated factors will be transferred into a tool, and consequently tested with existing technologies to evaluate the practicality. Furthermore, expert interviews will be conducted to reveal shortcomings, redundancies, and practical applicability.

The outcome aims to support the process of describing technologies in a complete and comprehensive manner in a practical context to support the process of identification of applications for new or existing technologies. Considering the importance of a deep understanding of underlying technologies for application identification, this paper follows the main objective of answering the following research questions:

RQ1. What literature exists for technology-describing tools and which relevant factors are mentioned?

RQ2. Which factors should be used for the further development of the TC and how should they be implemented?

RQ3. How does an implementation look like & is it suitable for practical application?

The contribution of this paper to ongoing research is threefold. First, it provides insights for the technology transfer community by compiling existing literature on the topic of technology description tools and respective factors. Second, based on the practical implementation with the example of Karlsruher Institute of Technology (KIT) patents, practical applicability can be estimated, as these patents display limited information and that shows if a transfer of this information in a developed tool is possible. Third, the discussion with experts about the derived, refined, and complied factors of the design tool further proves its applicability in practice.

2. Methodological approach

To answer the research questions the research process is carried out in sequential phases: Compiling theoretical findings and existing tools, deriving relevant factors for a potential tool, comparing the results with the existing TC by Terzidis and Vogel [5] and testing the final factors with practical implementation and discussion with experts. In the end, the final design requirements and factors are stated.

To address the first research question, the existing literature needs to be identified and analyzed. For the second and third research questions, relevant technology description factors will be derived based on the findings from RQ1 to create the basis for a scientifically based technology description tool. Consequently, the findings will be compared with the existing TC and its factors, to derive similarities and differences to decide, which factors should be included in the further developed tool. Furthermore, to test the practicability of the derived factors, the developed tool will be filled out with recent technologies based on KIT patents. Hence, the developed tool will be discussed with experts from the field of technology transfer to test its practical applicability.

For the data collection, a systematic literature review (SLR) was chosen to evaluate the existing body of literature and answer the first research question [11]. Based on the PICOC criteria (Population, Intervention, Comparison, Outcome, Context), the necessary terms for the search string were derived in a two-step process to enclose the results to a legit amount [11]:

Table 1. Core concepts of PICOC.

Core Concepts	Keywords
Population	Founder, Inventor, Innovation manager
Intervention	Patent, Technology canvas, new technology, Invention, Innovation
Comparison	Description of technology, Description of patents, Explanation of technology, Explanation of patents, Technology description, Patent description
Outcome	Patent description, Patent explanation, Patent utilization, Patent exploitation, Patent catalog, new technology canvas, further developed technology canvas, technology implementation, technology application, technology utilization
Context	Academia, Experts, Start-Up, entrepreneurial, entrepreneurship

The search string needed some adjustment since the number of results with the search string derived from the PICOC criteria delivered too many results (a couple of million). In conclusion, the following search string was derived to be used in the databases Scopus, Web of Science, and ScienceDirect:

(Patent OR Technolog*) AND ((Appl* OR Exploit* OR Utiliz* OR Implement* OR Found* OR Descri*) OR (Canvas OR Framework OR Tool OR Method OR Model)) AND (Founder OR Inventor OR "Innovation manager" OR Experts OR Start-up OR entrepreneur*) AND Academia

This search was extended with the google scholar search engine, using only the terms "technology canvas" and "description of technology" to include further literature that might be relevant but has not been found in the three aforementioned databases. Moreover, a forward and backward search was conducted, sustained by an author search for the most frequent mentioned authors. Following

the methodological approach of Kitchenham and Charters [11], inclusion and exclusion criteria were applied, with the only exclusion criterion, in this case, being language, as only English and German documents were considered. Given the research focus, there was no apparent reason to exclude specific journals, authors, research designs, or publication dates.

While the SLR was conducted to collect data for RQ1, data for RQ2 and RQ3 were collected separately in a two-step process. First, by filling in the refined technology canvas by the author and a colleague, possible application limits, difficulties and gaps could be identified and a revised version developed. Second, by conducting interviews with experts in the field of technology transfer, following the approach of Döring and Bortz [12], necessary insights were gathered. Aiming to analyze the practical relevance, usability, and the importance of the factors, the developed interview guideline is based on the methodology of problem-centered interviews by Witzel [13] that combines an inductive and deductive procedure. Hence, only a few key guiding questions will be prepared and asked [14]. The goal is to have a conversation where the expert can openly communicate his thoughts and opinion rather than having a static interview. To analyze the transcripts of the interviews the Gioia method will be used [15].

3. Results

3.1. Systematic literature review

The search process resulted in 32 tools without duplicates. This includes the digital libraries, internet search, titles resulting from the citation analysis und Author search. Based on these findings, the tools and descriptive factors were analyzed to extract relevant factors to describe a technology by categorizing these individual factors into generalized main terms and ordering them based on the most frequently mentioned factors (see table 2). Thereby, the factors that are most frequently used across all methods, tools, and frameworks can be identified.

Table 2. List of relevant factors for technology description (shortened).

No.	Main term	Factors	Source
1	General description	e.g. features, functional characteristics	[4, 7, 10, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25]
2	Market	e.g. market segments, trends	[4, 6, 9, 20, 21, 22, 25, 26]
3	Design	e.g. picture, design and development	[6, 7, 9, 10, 16, 19, 27, 28, 29]
4	Performance/ Testing	e.g. reliability, failure rates	[7, 16, 22, 23, 24, 25, 26, 28, 30, 31]
5	Application	e.g. application domain maturity, product	[6, 7, 9, 23, 25, 31, 32, 33, 34, 35]
6	Function	To achieve some specific purpose	[23, 25, 26, 28, 29, 33, 34]
7	Risk/ Weak Spots	e.g. disadvantages, weaknesses	[6, 9, 10, 18, 20, 26, 35, 36]
8	Social Outcomes, Environment & Safety	e.g. impact, sustainability	[21, 24, 26, 30, 37, 38, 39]
9	Cost	e.g. cost-effectiveness; cost structure	[10, 17, 19, 24, 26, 30, 31]
10	HR / Company culture	e.g. people & capability; ways of working (culture)	[6, 19, 26, 39]
11	Product roadmap	e.g. testing and preproduction; product vision	[18, 27, 31]
12	Quality	e.g. perceived quality; quality Assurance	[6, 16, 17, 21, 26, 35, 37, 38]
13	Advantage	e.g. strengths, Improvement	[6, 9, 10, 26, 30]
14	Resources	e.g. unique software, critical materials	[10, 18, 31, 33, 35]
15	Business Context	e.g. business strategy, business case	[6, 9, 18, 19, 20, 39]
16	Regulatory	e.g. conformance, security	[9, 16, 19, 21]
17	Potential	e.g. growth potential, technological potential	[4, 21, 35, 38, 39]
18	Competitiveness	e.g. competition	[21, 26, 38]
19	Ecosystem	e.g. extendibility, combability	[19, 30, 38]
20	Outcome	e.g. change, manipulation	[17, 19, 32]
21	Supply/ Partners	e.g. supply track record, partners	[17, 19, 26]
22	Innovation	e.g. innovativeness	[30, 38]
23	Monitoring	e.g. data, availability	[19]
24	Service	e.g. serviceability, value-added service	[16, 17]

Accordingly, these results will be compared to the existing TC of Terzidis and Vogel [5], consisting of the factors ‘problem’, ‘technology description’, ‘technology benefits’, ‘state of the art’, ‘drawing’ and ‘technical novelty’. Based on commonalities and differences between the findings of the SLR and the TC a further developed technology description tool was designed (see Appendix A.).

Several commonalities were found during the comparison, e.g. the ‘technology description’ of the TC matches the ‘general description’, as it contains both the ‘technology/product description’ and the ‘technology

features'. In addition, the 'technology description' aligns with the 'features' as it asks how the problem is solved. In addition, both include the representation of the technology and/or its functionalities, and 'design' and 'drawing' are common features.

'Application' and 'problem' can be in line, as they both answer the question of what problem is solved by the technology. 'Advantage' and 'technical benefit' both address the issue of the (technical) advantage that the technology provides. Finally, 'innovation' and 'technical novelty' can go together as they both cover the improvement with respect to the state of the art, but interestingly, 'innovation' was mentioned only twice in the literature.

Since the SLR resulted in 24 factors and the current TC has six, differences were foreseen. Firstly, the TC does not cover the 'market' factor. The factors of 'performance/testing'; 'risks/vulnerabilities'; 'social impact', 'environment & safety'; 'product roadmap', and 'cost' are also not covered by the referenced TC. Given that these factors depend to some extent on the nature of the application of the technology and that TC was originally developed by Terzidis and Vogel (2018) to describe a technology, these differences are appropriate.

This also relates to the other factors that were not included in the TC: 'HR/corporate culture', 'business context', 'competitiveness', 'supply/partners', 'ecosystem', 'monitoring', and 'service'. These factors are more of an add-on or extension of the technology once implemented.

The factors 'quality', 'resources', 'regulation', 'potential', and 'outcome' are usually dependent on the technology itself and can therefore be part of the tool being developed but are also not part of the initial TC.

Following the design principles stated by Terzidis and Vogel [5] the tool needs to be easy to understand and easy to repeat. Consequently, a new, lean tool has been derived, containing the factors in Table 3. The factors are respectively expanded by supporting questions.

Table 3. Relevant factors building upon the TC of Terzidis and Vogel (2018)

Factors	Supporting Questions
Name	Name of the technology
Technology Description	What is the main idea and how does it solve the problem? What are its features and functions?
Benefits	What are the technical benefits of the technology? What advantage derives from using this technology instead of an alternative?
Technical Novelty	What makes the technology unique? How is it different from the state of the art? What makes the technology innovative? What are its potentials?
Market	What is the intended market/ industry? What are current solutions for the problem and in which markets are they active?
Resources	What resources are needed for the technology itself or its potential applications? Are costs, supply and partners known?
Application	What problem is solved by the technology? What are potential applications?
Depiction	How can the functionality or application of the technology be depicted?
Quality	How is the performance/availability? Does the technology fulfill specific standards/norms? How is the feasibility/ maturity of the technology?
Further	What is unique, different, or worth mentioning about the technology (e.g. sector, regulatory, risks, social or environmental outcome)

3.2. Testing of technologies

For testing the derived and integrated factors, technologies from the KIT technology platform will be used. The latest published technologies were selected from different categories to have some variety, resulting in (1) "Biodegradable parylene coatings" [40] and (2) "Experience smart machines and IIoT" [41] to be transferred into the tool by the author and a colleague using the patent descriptions on the KIT website as a single resource. The testing highlighted several findings.

The patent (1) was hard to understand and thereby it was difficult to answer the factors, for someone not related to this field. Identifying 'disadvantages, risks, or weak spots' was not possible given the sources and the missing knowledge about those fields. Thereby the factor 'Further' was rarely answered.

(2) was easier to describe since there were fewer technical terms in the listing on the KIT technology platform. Still, the factors 'Further' and 'Regulatory' are empty, since there was no information provided about any 'disadvantages, weak spots, risks', or the 'regulatory' of this kind of technology. Generally, several insights were generated:

- The factors 'Market' and 'Sector (Further)' are similar. It can be difficult to distinguish between these two.
- The factor 'technical novelty' will most likely already cover the advantages of the technology, which is also asked under factor 'Benefits'.
- The factor 'Technology Description' asks "how" the problem is solved while the factor 'Application' asks about the "what". This leads to the difficulty to distinguish between these two.
- Gathering information for the factors 'Resources', and 'Further' (disadvantages, weak spots, risks) turns out to be difficult since information was missing.
- The factors 'Benefits', 'Technology Description', 'Application', and 'Depiction' were provided by the KIT technology platform.

Overall, the testing revealed interesting insights. On the one hand, the patent description provided on the website only shows limited information, which is not sufficient to fill out the tool as it was asking for further factors not mentioned in

the description. On the other hand, as the database is designed for interested companies who are searching for technologies, the most relevant factors in practice are mentioned: ‘technology description’, ‘benefits’, ‘application’, and ‘depiction’.

3.3. Expert interviews

Before preceding with a refinement of the factors based on the testing, further insights and a practical perspective are necessary. Therefore, experts in the field of technology transfer were interviewed to further develop and enhance the technology description factors for usage in practical settings. The interviews were conducted following a semi-structured questionnaire.

In most cases, the experts already use a tool to describe technologies and thus make them easier and more understandable, which enhances the technology transfer process. Nevertheless, they were very interested in new tools, as some of them were already trying out different new tools themselves to improve their process. Similarly, there were some who were absolutely satisfied with the current tool and therefore had no requests for improvement. All of them stated as a necessary condition that the tool should be simple and easy to use, but also offer the possibility to fill it out on their own. Currently used tools and methods mentioned by the experts were taking notes, keeping a log, a self-developed tool with a user interface containing key information, patent form, storage systems, the TAS framework, and Atriflow by Atrineo [42].

Furthermore, specific key information was aggregated to enhance the quality of the technology description tool, including the order, wording, redundancy, simplicity, additional factors, explicity, guidance, and setting a clear objective of the tool.

In general, the experts stated a need for a technology description tool, also highlighting the importance of an adequate design and layout for autonomous usage and an appropriate user experience. Besides that, some factors need to be exchanged to reduce redundancy and instructions integrated. Furthermore, factors that were not frequently mentioned in the literature were stated by the experts as very relevant and need to be considered. Moreover, the current order of the wording needs to be revised, to make the design of the tool more tangible. In addition, an explicit goal of the tool should be stated.

3.4. Prerequisites for further developed TC

Translating the findings of the literature, the practical testing, and the expert interview into a further developed technology canvas, several prerequisites were derived:

Defining a goal of the technology canvas. In this case, the technology description tool should support the process of identifying potential applications for the technology by providing a deep understanding of the underlying technology. This also involves the confinement of integrated factors and leads to the next prerequisite.

Limiting the description factors. For that, several factors found in the literature were not taken into account for the further developed canvas, e.g. ‘HR/Company culture’; ‘Business context’; ‘Competitiveness’; ‘Supply/Partners’; ‘Ecosystem’; ‘Monitoring’; and ‘Service’ as they are relevant for already implemented technologies, but rarely suitable for new or emerging technologies without existing applications.

Step-by-step analysis of the technology. To enable an analysis building upon each step, steps including different factors should be integrated. In the first step, the ‘function’ and ‘visualization’ (former: Depiction) of the technology should be focused on, as well as the required ‘resources‘ and the ‘life cycle’ of the technology, the ‘state of the art’ and the ‘problem’, that should be solved by the technology. By asking for a description of the technology in a few sentences while avoiding too complicated technical terms, the second step can be used to test whether the technology has already been understood at a basic level. In the third step, technological features can be evaluated to deepen the understanding of the technology and to deal more with it. By that, a general comprehension is enabled before digging deeper into the technology.

Taking emerging factors into account. Compared to the experts, the literature indicates different factors as highly relevant. This might also be based on the shift in awareness of several components of a technology, precisely the ‘resources’ and the ‘life cycle’. The importance of these factors is rising within the last few years and will be of high importance in the future [35].

Enabling an assessment of different factors. Depending on the ‘underlying technology’ it might be difficult to assess factors like ‘performance’ or ‘potential’, as well as ‘maturity’, ‘novelty’, or ‘costs’. In individual cases, it can be specified by research, but as this tool should be used at a very early stage in the application identification process, an assessment with respective reasoning is reasonable.

Supporting noting further information. To cover also factors not indicated as relevant or also not stated by literature or experts, but also first ideas for potential applications while analyzing the technology, the option should be given to note several aspects within the further developed canvas. This is highly relevant, as technologies differ, and the tool cannot be designed to suit each technology appropriately without losing its simplicity.

Usage of relevant resources to gather information. For a better understanding of the technology not only patents or individual sources should be considered, rather several perspectives of several sources should be integrated. This is also the case if the technology description is filled out by the inventor, to avoid potential pitfalls due to potential blinders, which can occur by not integrating other perspectives.

The prerequisites presented serve as a guideline for the design of a further developed Technology Canvas with the goal of describing technologies more comprehensively and

holistically without losing the necessary simplicity. Although various approaches are known in literature and practice, there are few known derivations or evaluations of the description tools used.

4. Discussion

While the relevance of the TP innovation process is widely recognized, it is still a field with high uncertainty. However, since every TP process starts with a new or emerging technology, special attention must be paid to this first step. A technology description tool is important for a TP process as it enables clear and detailed information about the underlying technology. Further, it can support engineering design by providing a means to communicate the technical details of a design accurately and efficiently. This description should include information about how the technology works, its capabilities, and its potential applications. This information can be used to identify diverse and alternative applications, which increases the likelihood of radical innovation but also to identify relevant niches and areas that change current thinking. Further down the line, the structured and rich information base can educate potential customers and partners about the technology, generating interest and facilitating its adoption. Also, a technology description tool can enable other people besides the inventor or technical staff to provide necessary information to the environment, as it supports understanding also for the wider audience. In addition, a technology description tool can help identify potential challenges or limitations of the technology, which in turn can influence the development and commercialization strategy. Overall, a technology description tool is an essential tool for effectively communicating and promoting a new technology in a technology push process.

In literature and practice, different approaches exist to identify applications based on the technology, with a special focus on the description of the technology to derive potential applications and to estimate what is possible with the technology. Based on the literature review 32 tools were identified, resulting in 24 factors after merging similar factors with different naming and eliminating duplicates. Despite the high frequency of some factors, the practical insights revealed that the frequency should not determine the relevance of the respective factors. The factor ‘market’ was mentioned the most but is usually not suitable to describe a technology in the first place as in TP processes the market is not even clear and a focus at this early stage would hinder exploring potential promising applications for the technology. In comparison, the factor ‘innovation/novelty’ was mentioned only twice in the literature but was clearly assigned a high level of importance, as it can be an enabler for radical innovation and thereby also gathers awareness by potential investors, enabling a higher chance for further development of the technology.

Still, no commonly used tool to describe technologies to investigate their benefits and limitations is existent and despite being a widely recognized topic, the investigation of technology description tools is sparse. While some tools are designed to be generally applicable and can thus describe a wide range of technologies, other tools specifically address individual use cases with a very specific focus, thereby not being applicable to other cases. This differentiates the depth of content of the tools and the results they produce, which in turn affects the usability of the tools, but also their overall use. Consequently, the resources needed for the tools but also the target groups of the identified tools vary widely.

The expert interviews also revealed that there are differentiated views on the need for such a tool, despite the fact, that most experts already work with a given tool and some even ask and are actively searching for improvement. Specifically in the technology transfer area, where people try to identify suitable and promising applications for a new or emerging technology, the technology description tool offers a base for further investigation of the technologies and is thereby of high importance for the user group. Furthermore, it was shown that the efficiency of the TC with its included factors and guiding questions is dependent on the user, their preferences, and their use case. While some criticized missing factors and guidance in the tool, others required general applicability, by involving less guidance to get rid of potential bias. Consequently, usability and applicability are important factors, as different user groups with several backgrounds involved in the technology transfer processes need to be able to use it.

5. Conclusion

This research enables a better understanding of relevant factors to describe a technology, which sets the fundament for the development of a technology description tool. It revealed several technology description tools existing in literature and practice and derives relevant factors in this regard. Based on theoretical evidence, practical testing, and interviewing experts, who are working in the technology transfer area and have already been in touch with these kinds of tools to exploit potential applications for new or emerging technologies, the most important factors to describe technologies were revealed.

By transferring the factors and the insights of the study into prerequisites of a potential technology description tool, a further developed technology canvas was designed (see Appendix B.). As former technology description tools were not based on empirical investigation, this tool represents a valid starting point for further studies that can focus on the practical implementation and further testing.

The findings show that further research needs to be done in the field of technology description tools to meet the needs of the respective use cases, as the one presented shows a generalized tool to fit all kinds of technologies. Further, it does not take different user groups into account, as it tries to be suitable for every kind of user. Consequently, future work should further test and evaluate the existing tools in order to investigate different use cases and user groups, but also to compare the theoretical findings with practical needs. Also,

special attention should be paid to the comparison of hardware and software, as there might be some important differentiations to be aware of. Based on feedback from the experts, an appropriate user experience and autonomous use are also assumed. This aligns with a corresponding layout or design of the tool, which was not the focus of this study and should therefore still be investigated. Moreover, the design and layout of the technology description tool are crucial for the final rating of its usability and need to be further analyzed, as no particular focus was put on this aspect.

The following limitations should be considered when interpreting the results of this study: Due to the focus on technology description tools in academia, potential interesting tools might have been excluded and thereby shift the ranking of frequency of mentioned factors. Furthermore, the testing was just carried out with two examples of patents on the KIT website. This revealed relevant aspects for the development of the tool, but is very narrow, as testing with a wide variety of technologies in different manners could have led to further relevant insights. In addition, although the experts provide an initial assessment of the overall situation, this is certainly not representative of the technology transfer community. In addition, the area of technology transfer was chosen because attempts are made here to transfer scientific research into commercialization, but other institutions also pursue this approach and are working with technology description tools. Also, the design of the final technology description tool was highlighted as very important, but not part of this study.

References

[1] Schumpeter JA. Business Cycles. A Theoretical, Historical and Statistical Analysis of the Capitalist Process. New York, Toronto, London: McGraw-Hill Book Company; 1939.

[2] Kivimaa P, Boon W, Antikainen R. Commercialising university inventions forsustainability – a case study of (non-) intermediating ‘cleantech’at Aalto University. Science and PublicPolicy 2017; 44(5):631-644.

[3] Danneels E, Frattini F. Finding applications for technologies beyond the core business. MIT Sloan Management Review 2018; 59(3):73-78.

[4] Maier M, Hofmann M, Brem A. Technology and trend management at the interface of technology push and market pull. International journal of technology management; 72(4):310-332.

[5] Terzidis O, Vogel L. A unified model of the Technology push process and its application in a workshop setting. In Technology Entrepreneurship. Cham: Springer; 2018. p. 111-135.

[6] Manthey SI, Terzidis O, Tittel A. Technology Application Selection–the TAS Framework: Finding promising applications for new and emerging technologies; 2022.

[7] Bishop GL. A comprehensive model for technology push product development. Brigham Young University; 2004.

[8] Hamzeh R, Xu X. Technology selection methods and applications in manufacturing: A review from 1990 to 2017. Computers & Industrial Engineering; 2019; 138:106-123.

[9] Lyne MB. Aligning R&D with business strategy. Research-Technology Management; 2003; 46(6):44-46.

[10] Lipsmeier A, Bansmann M, Roeltgen D, Kuerpick C. Framework for the identification and demand-orientated classification of digital technologies. 2018 IEEE International Conference on Technology Management, Operations and Decisions (ICTMOD); 2018. p. 23.

[11] Kitchenham B, Charters S. Guidelines for performing systematic literature reviews in software engineering; 2007.

[12] Döring N, Bortz J. Forschungsmethoden und evaluation. Wiesbaden: Springerverlag; 2016.

[13] Witzel, A. The Problem-Centered Interview. Forum Qualitative Sozialforschung 2000; 1(1).

[14] Leedy, PD, Ormrod E. Practical Research: Planning and Design. Munich: Pearson; 2015.

[15] Gioia DA, Corley KG, Hamilton AL. Seeking qualitative rigor in inductive research: Notes on the Gioia methodology. Organizational research methods 2013; 16(1):15-31.

[16] Schenkl SA, Rösch C, Mörtl M. Literature Study on Factors Influencing the Market Acceptance of PSS. Procedia CIRP 2014; 16:98-103.

[17] Brixner D, Maniadakis N, Kaló Z, Hu S, Shen J, Wijaya K. Applying Multi-Criteria Decision Analysis (MCDA) Simple Scoring as an Evidence-based HTA Methodology for Evaluating Off-Patent Pharmaceuticals (OPPs) in Emerging Markets. Value Health Reg Issues; 2017. p. 1-6.

[18] Sundaram P. Align Your Tech and Product Teams with the Technology Product Canvas. In: https://www.toptal.com/product-managers/product-development-managers/technology-product-canvas; 2019.

[19] Mike. No Such Thing As a Technology Canvas? Now there is. In: https://productcoalition.com/no-such-thing-as-a-technology-canvas-now-there-is-7a2d1e84ea1c; 2020.

[20] Felkl J. Advanced technology innovation mapping tool to support technology commercialization; 2013.

[21] Moncada-Paternò-Castello P, Rojo J, Bellido F, Fiore F,Tübke A. Early identification and marketing of innovative technologies: A case study of RTD result valorisation at the European Commission's Joint Research Centre. Technovation 2003; 23:655-667.

[22] Henkel J, Jung S. Identifying Technology Applications Using an Adaptation of the Lead User Method; 2010.

[23] Nelson A. A Detailed Approach for Concept Generation and Evaluation in a Technology Push Product Development Environment. Theses and Dissertations 2005; 726.

[24] Lerede D, Bustreo C, Gracceva F, Saccone M, Savoldi L. Techno-economic and environmental characterization of industrial technologies for transparent bottom-up energy modeling; 2021.

[25] Wall M, Gausemeier J, Peitz C. Technology Push based product planning – future markets for emerging technologies. International Journal of Technology Marketing 2013; 8(1):61 - 81,

[26] Wohlfeil F, Terzidis O. Critical Success Factors for the Strategic Management of Radical Technological Innovation; 2014.

[27] Golish BL, Besterfield-Sacre ME, Shuman LJ. Comparing Academic and Corporate Technology Development Processes; 2007.

[28] Linton JD, Walsh ST. Acceleration and Extension of Opportunity Recognition for Nanotechnologies and Other Emerging Technologies. International Small Business Journal 2008; 26(1):83–99.

[29] Trapp S, Warschat J. Potenzialanalyse komplexer Technologien mit Technologienetzen. Zeitschrift für wirtschaftlichen Fabrikbetrieb 2020; 115(4):200-209.

[30] Plüddemann A, Heneghan C, Thompson M, Roberts N, Summerton N, Linden-Phillips L, Packer C, Price CP. Prioritisation criteria for the selection of new diagnostic technologies for evaluation; 2010.

[31] Wick R. The Developing Science and Technologies List (DSTL); 2006.

[32] Britannica, The Editors of Encyclopaedia. technology. Encyclopedia Britannica. In: https://www.britannica.com/technology/technology; 2022.

[33] Study.com. What Is Technology? - Definition & Types. In: https://study.com/academy/lesson/what-is-technology-definition-types.html; 2021.

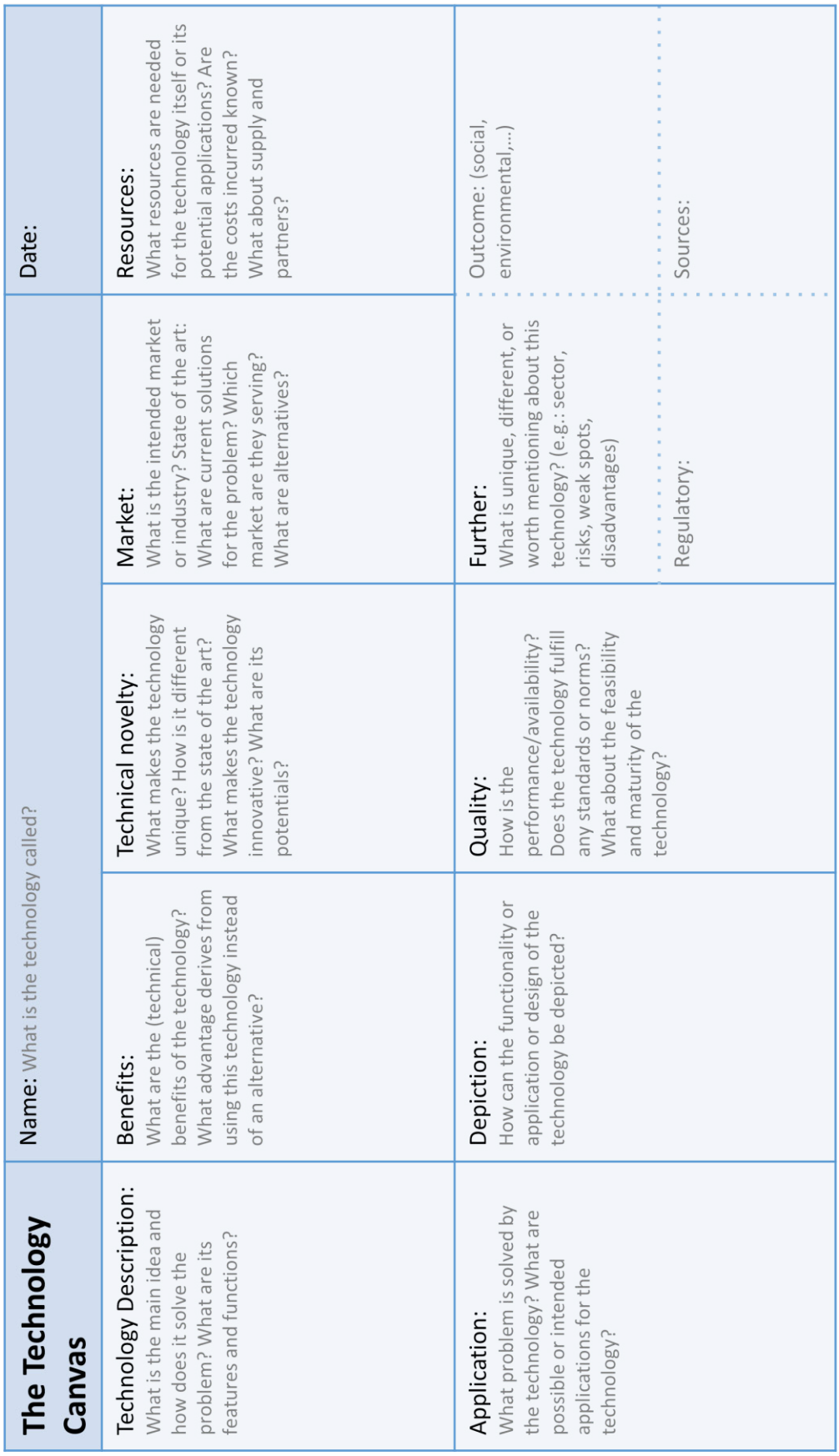
[34] Merriam Webster. Technology. In: https://www.merriam-webster.com/dictionary/technology; 2023.

[35] Strøm, R. Identification of Applications to Technology in the CERN Knowledge Transfer Group (Master's thesis, NTNU); 2018.

[36] Burgaud P, Moreau C, Ruelloux D. Infrared technologies characterization in CELAR. Comptes Rendus Physique 2003; 4(10):1159-1166.

[37] Huang L, Zhang Y, Guo Y, Zhu D, Porter AL. Four dimensional Science and Technology planning: A new approach based on bibliometrics and technology roadmapping. Technological Forecasting and Social Change 2014; 81(1)39–48.
[38] Hsu YG, Tzeng GH, Shyu JZ. Fuzzy Multiple Criteria Selection of Government-Sponsored Frontier Technology R&D Projects. IO: Productivity; 2003.
[39] Rieke T, Klasen AS. Einführung von digitalen Technologien in KMU – Vorgehensmodell und Technology Evaluation Canvas. In: Linssen O, Mikusz M, Volland A, Yigitbas E, Engstler M, Fazal-Baqaie M, Kuhrmann M (Hrsg.). Projektmanagement und Vorgehensmodelle 2019 - Neue Vorgehensmodelle in Projekten - Führung, Kulturen und Infrastrukturen im Wandel. Bonn: Gesellschaft für Informatik e.V; 2019. p. 97-109.
[40] KIT. Experience smart machines and IIoT. https://www.kit-technology.de/en/export-as-pdf/?type=89142&proposalID=703.
[41] KIT. Biodegradable parylene coatings. https://www.kit-technology.de/en/export-as-pdf/?type=89142&proposalID=705.
[42] Atrineo. Atriflow - Software for Knowledge- and Technologytransfer. In: https://www.atrineo.com/transferinformationsystem-218.html; 2022.

Appendix A. Further developed Technology Canvas – Version 1



Appendix B. Further developed Technology Canvas Version 2

SYSTEMATIC TECHNOLOGY APPLICATION SELECTION

en› techn ›on

KIT Karlsruher Institut für Technologie

Big Picture

PHASE 1: UNDERSTAND → PHASE 2: IDEATE → PHASE 3: DECIDE → PHASE 4: DEFINE → PHASE 5: SHARPEN

Objectives

- ✓ Deep understanding of technology
- ✓ Reflect on the core essentials
- ✓ Assessing the features

Team Name: _____ **Name of the Technology:** _____

1 Technology Characterization — Fill in the fields with information about the technology — 00:20

Visualization
How can the functionality, application or design of the technology be visualized?

Function
What are underlying functions of the technology (e.g. Transformation, transportation, storage of energy, matter, information)?

Resourcen
What resources are needed for the technology itself or ist potential applications? (human, capital, time, knowledge)

Life-Cycle
What does the development, usage, and recycling/disposal of the technology look like? What are possible social or environmental outcomes?

Problem
What is the problem to solve by this technology?

State of the Art
Which kind of current products or services dealing with this problem?

2 Put it all together in one sentence! — Explain the technology in 1-2 simple sentences based on 1) — 00:05

3 Technology Features — Assess the following factors for your technology based on 1) and 2) if possible. Rate the values on the scale, tick the most appropriate value & name the reason for ticking. — 00:15

Maturity
How close to market is the technology? What is the technology readiness level?

TRL 9 / TRL 8 / TRL 7 / TRL 6 / TRL 5 / TRL 4 / TRL 3 / TRL 2 / TRL 1

Potential
Unmet need, effectiveness in R&D, New applications

What is the growth potential of an application of the technology in the future?

LOW | MID | HIGH | SUPER HIGH — Fill out the reason

Novelty
Extraordinary, New representations, Surprising, new stimuli

What is the uniqueness or innovativeness of the technology?

LOW | MID | HIGH | SUPER HIGH — Fill out the reason

Performance
More efficient, faster, improved competencies intelligent, better than in the past, power, in-time...

How can the performance of the technology be rated in comparison to current alternatives?

LOW | MID | HIGH | SUPER HIGH — Fill out the reason

Cost
Cheap, Middle-class, High-class

How costly is this technology?

LOW | MID | HIGH | SUPER HIGH — Fill out the reason

Idea Open Space & Concept Box

Let your mind wander:
What is unique, different, or worth mentioning about this technology?
Are there any regulatories around this technology?
What could be another interesting fact around the technology?
Did some applications already came to your mind?
Do you know some interesting markets to look into?

Sources
Which sources have been used to fill in this canvas? Is there any publication, pitch or patent? Did you conduct interviews?

☐ Talked to inventor ☐ Publication: _____ ☐ Desk Research: _____ ☐ (...): _____
☐ Patent ☐ Expert: _____ ☐ Team

PHASE 1: UNDERSTAND →

☐ Did we identify the advantages and limitations of the technology?
☐ Could we explain it to my grandmother?

To-Do: Transfer 2 into the Output-Zone

For feedback or further information please contact us:
sarah.manthey@kit.edu
http://etm.entechnon.kit.edu/