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Cross-Industry Innovations–Systematic Identification of Ideas for Radical Problem Solving

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***Abstract*—**Creativity is often based on an unorthodox recombination of knowledge; in fact: 80% of all innovations use given knowledge and put it into a new combination. Cross-industry innovations follow this way of thinking and bring together problems and solution ideas from different industries. Therefore analogies and search strategies have to be developed. Taking this path, the questions where to search, what to search and how to search have to be answered. Afterwards, the gathered information can be used within a planned search process. Identified solution ideas have to be assessed and analyzed in detail for the success promising adaption planning.

***Keywords*—**analogy building, cross-industry innovations, knowledge transfer, solution adaption.

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I. Increasing the Potential for Innovations

DUE to today's fierce competition, companies have to be proactive creators of the future by effectively developing innovations. Especially radical innovations allow high profit margins – but they also necessitate high risks. However, radical innovations are hard to realize and even harder to be planned [1]. Against this background, companies try to avoid the associated risks. To exploit the success potentials of radical innovations and overcome the risks, new paths of innovation need to be developed. One possibility is cross-industry innovation. They result, if the underlying development challenge and the proper solution originate from different industries. Proved solutions are transferred from its former application context to a new one and solve the underlying problem – crossing the industry lines [2]-[4]. Basically, this provides two advantages: 1) the efficiency of research and development increases as resources can be minimized. 2) cross-industry innovations often lead to a radical degree of innovation [5]. Taking this path, companies gain from the advantages of radical innovations while the associated risks can be minimized [6]. "Teflon" is a well-known example finding its way from the aerospace industry into the kitchen. Trying to find opportunities for cross-industry innovations, a systematic approach is crucial for the success.

The issue of cross-industry innovation can be allocated to the research field of open innovation. Following the work of Henry W. Chesbrough companies should take advantage of open innovation opportunities such as common idea and knowledge generation. Therefore, companies have to open their innovation and development processes [7], [8].

Besides the opening of the innovation processes, cross-industry innovations also require the systematic development of analogies [9]. They help to overcome industrial boundaries. Analogies are defined as the conformity of objects regarding specific attributes [10]. Identifying and using these analogies enables the solution transfer. To summarize: cross-industry innovations are innovations based on analogies between industries and the related knowledge transfer [2], [3].

Cross-industry innovations can be found in the area of products and technologies as well as e.g. in the field business models and services [11], [12].

While several methodologies and tools have been developed in the field of open innovation, the particular idea of systematical development of cross-industry innovation is only selectively analyzed. This paper presents a systematic method towards cross-industry innovations. The work is based on several scientific projects with an engineering background as well as on an industrial project. The industrial project serves as a validation example within this paper.

II. Application of Cross-Industry Innovations

Cross-industry innovations can appear in two directions: outside-in and inside-out. Outside-In: Solutions from outside the own industry can be used in order to solve own problems aiming at a low effort for the development of e.g. products and technologies. Optimally, complete solutions can be transferred without any additional development work.

Inside-Out: Own solutions can be transferred into foreign industries in order to solve problems targeting the identification of opportunities for diversification. The inside-out process is used to increase the revenue at low efforts. Within this publication we focus on the outside-in direction.

Both ways require the identification of analogies.

A. Best Practice Examples

There are a several examples showing how cross-industry innovations can be realized and which benefits result: The *BMW iDrive* uses the analogy to computer joysticks. One instrument now helps the driver to control an amount of functions instead of using hundreds of buttons and knobs [11]. *Fischer* succeeded in reducing the oscillation of a ski by the aid of a technology that is used in string instruments. They recognized similarities in the frequency range which enabled the identification of an analogy [5]. *Bernina*, a Swiss manufacturer of sewing machines, uses the optical scanning

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technology which is integrated in an optical computer mouse. This cost-efficient and widespread technology achieves a constant distance between steams at different speed levels of a sewing machine [2].



Fig. 1 Best practice examples

B. Advantages and Success Factors

There is a range of **advantages** provided by successful cross-industry innovations in comparison to a conventional, internal development: Cross-industry innovations are often radical innovations. Simultaneously, risks are minimized because the solution is often already mature. Beyond this, the efficiency of development is increased as solutions are available earlier and the time-to-market can be shortened. Finally, the transfer of solutions between different industries usually avoids conflicts: The former owner of a solution does not lose market share to the transferring company and can sometimes increase his revenue due to the diversification of e.g. his technologies. Furthermore, the way of thinking applied by other industries can make a valuable contribution to own creativity processes. New impulses increase the potential for own innovations in a significant way [3], [5], [13].

Former studies have shown important **success factors** that need to be taken under consideration realizing cross-industry innovations. A structured step-by-step approach matters most. Thereby, special attention should be paid at the abstraction of the addressed problem to solve. This is due to the fact that industries develop their own "specific language" during decades of working on product or technology development. The challenge: Other industries do not understand this "specific language". However, they might be talking about a comparable problem. Bridging this language gap, abstraction techniques need to be used. Based on the abstraction, the search process can be initiated. This shifts the risk from a development risk to a search risk. This search risk needs to be managed and minimized. Another important factor is the innovation culture. Open innovation requires employees realizing the valuable contributions that openness can contribute to their own work. Taking this path, the "not-invented-here"-syndrome can be avoided [3], [14], [15].

C. Requirements on a Method for Cross-industry Innovations

On the basis of scientific projects requirements on an integrated method have been deduced. The requirements needed to be fulfilled by the method to be developed for cross-industry innovations. Examples for identified requirements are:

- Usable in all kinds of industries
- Systematic problem abstraction
- Systematic risk management
- Assessment of search results
- Step-by-step adaption planning

D. Mapping Requirements to the State of Art

Mapping the defined requirements to the state of the art underlines the need for action. It was found out that there is no approach meeting the defined requirements.

Previous works came up with generic process models. They are valuable to understand the main phases while realizing cross-industry innovations. Following [11] the phases can be divided into "abstraction", "analogy" and "adaption". Other authors came up with the phases "exploration", "evaluation", "adaption" and "integration". Taking a look at the state of art, mainly every approach to cross-industry innovations follows these generic phases – consciously or unconsciously [5]. Almost all methods have in common that they are developed on very generic level and do not allow reproducing the results. However, there are a few works focusing on more detailed methods, e.g. [16], [17]. Nevertheless, it has been identified that they do not fulfill all requirements described above. Especially the missing of abstraction techniques and risk management create a need for action.

III. Method for Cross-Industry Innovations

Cross-industry innovations require a systematic approach. Otherwise, the search for analogies in different industries may dissipate. The approach presented in the following focusses on an outside-in oriented problem solving process. To ensure a better understanding, examples are named referring to an anonymized industrial project. Fig. 2 gives an overview of the five phases approach.

Applying the method leads to an adaption roadmap that shows opportunities and measures to solve a given problem by cross-industrial solutions. Each of the following paragraphs describes one phase.

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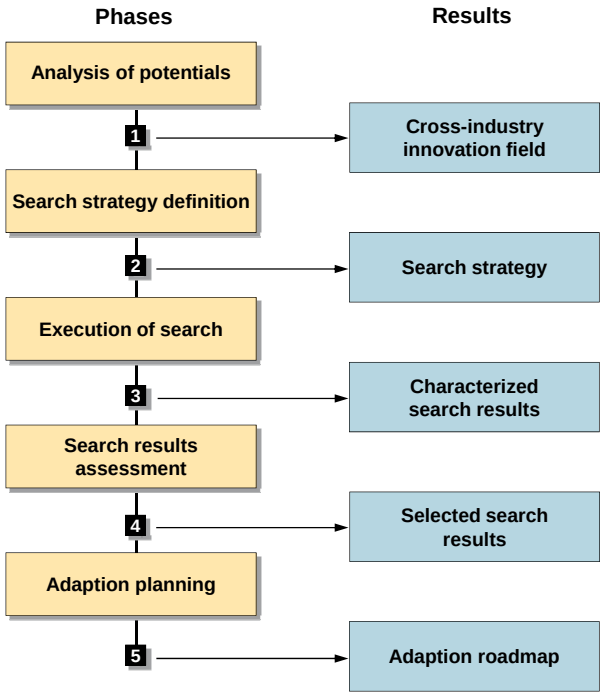


Fig. 2 Method for cross-industry innovations

A. Analysis of Potentials

Within the first phase development potentials respectively development problems are identified and assessed regarding the suitability for a search process in different industries. The main outcome of this phase is a so called cross-industry innovation field. It describes the underlying problem and limits the search field.

At first, a search is initiated in order to identify technical development problems. To support this process, established methods can be used such as technical system analysis or quality function deployment [18]. Additionally, a survey among the technical staff regarding known and unsolved technical problems is conducted ("call for problems"). These steps help collecting an amount of problems that need to be evaluated subsequently. The evaluation is designed in three stages based on a benefit analysis. First, the **problem criticality** is determined. It describes the difficulty of solving the problem. Further, the **required competency** is evaluated. This describes the amount of missing competency that is needed in order to solve a problem. Suitable problems for an external search frequently have a high problem criticality e.g. on account of being unsolved for a long period. Further, a distinctive demand for competency often can be explained by missing expert knowledge. By combining both dimensions, the externalization priority can be specified. In the next step, the **future relevance** of a problem is estimated. This is done by analyzing trends within the own industry. This step ensures the consideration of the long-term relevance of a problem. Visualized in a portfolio, all three aspects allow deciding which problem should be focused within a search for solutions in other industries (fig. 3).

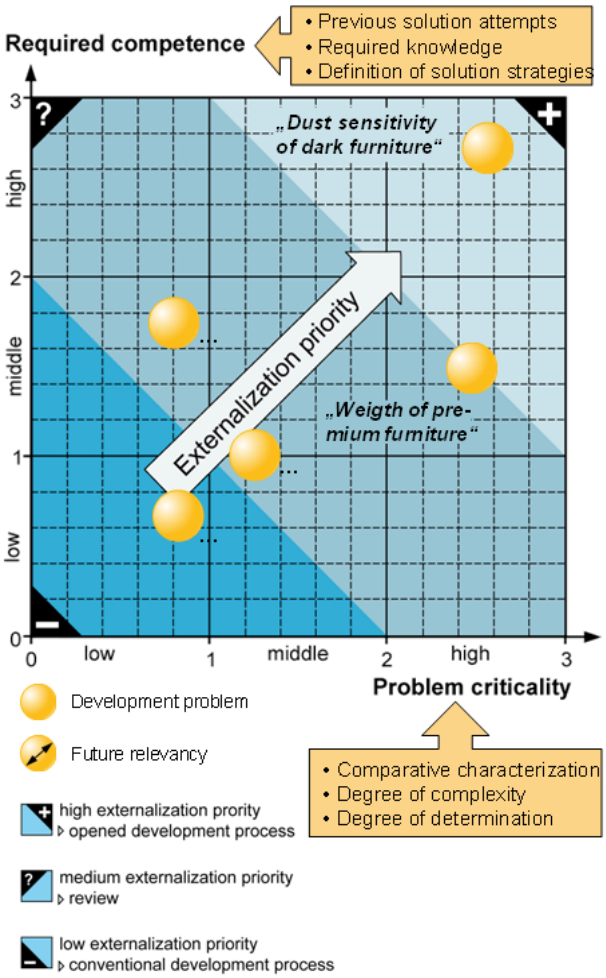


Fig. 3 Specification of problem externalization priority

Within the given example, problems had been collected in the furniture industry. The problem "dust sensitivity of dark furniture" had been selected according to the given recommendations.

B. Search Strategy Definition

A search strategy aims at a minimized search risk to end a search without suitable solutions. According to Markides [19] the **three questions** what, where and how should be taken under consideration while defining a strategy. Fig. 4 shows the topics a search strategy has to deal with according to the questions.

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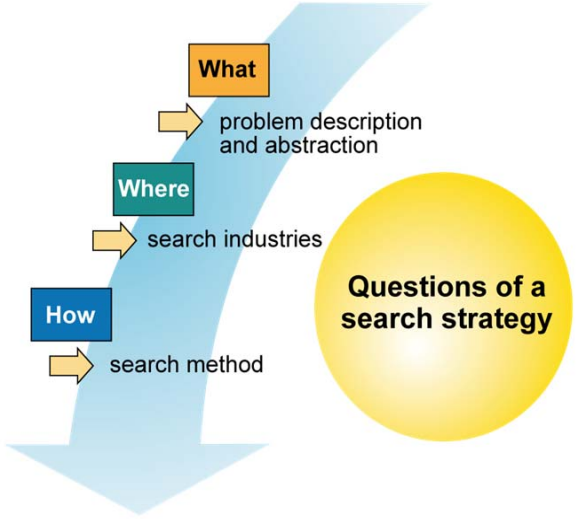


Fig. 4 Questions of a search strategy

"What to look for" requires a precise definition of the underlying problem. Thereby, the industry's specific language is used to describe the problem. This increases the chance of collecting all available information. This description is necessary but not sufficient to explain a problem to another industry: the problem needs to get abstracted [2], [20]. Previous projects pointed out that several iterations are necessary searching for cross-industry solutions if there is no appropriate problem abstraction. Instead of abstracting a problem the search was done in the "own language" – other industries were not able to comprehend. Therefore, an appropriate problem abstraction enables an opening of the cognitive solution space [15].

As none existing abstraction technique was suitable for the developed method, a problem abstraction technique had been developed based on principles from successful techniques.

It is as easy to use as most creativity techniques and can be handled intuitively. In the context of workshops, applying the technique leads to a modeled abstraction tree (fig. 5). An abstraction tree is separated into two parts: The upper part contains a formal concrete problem description. The lower part shows the abstract problem description. The separation follows the principle of TIPS (theory of inventive problem solving) according to Altschuller [21]. While abstracting a problem, three elements are used:

- **Problem elements** define a component of the concrete problem "dust sensitivity of dark furniture". For instance, the fact that "cleaning is necessary early again".
- **System elements** describe physical artifacts which are in interconnection to each other. Taking a look at the example, "piece of furniture" and "dust" had been identified.
- Both types of elements get converted step-by-step into **target elements**, the third type. Target elements describe the condition at which a search is aimed at. Within the example, the condition "antistatic" needs to be realized.

The definition of the three elements forces the user to think in defined categories which is an established principle in creativity techniques according to de Bono [22]. To improve the handling of the creativity technique, a list of questions provides support during workshops. By this means, problem, system, and target elements can be identified systematically. Applications in both practical and theoretical case studies provided a proof of functions. Doing so, the abstraction tree delivers a decomposition resp. aggregation of the single elements which is established in several technical as well as non-technical industries [23]-[25]. Beyond this, the abstraction tree meets the principle of the creativity technique synectics according to Gordon: In the beginning, the unknown gets analyzed to ensure a better problem understanding (concrete problem description). Subsequently, the understood problem is alienated (abstract problem description) [26].

The abstract problem description is the basis for the definition of search terms. These terms can be used e.g. to start a database research. In the present example three search items had been defined ("antistatic", "repel particles", "cycle enlargement"). We get back to these terms later.

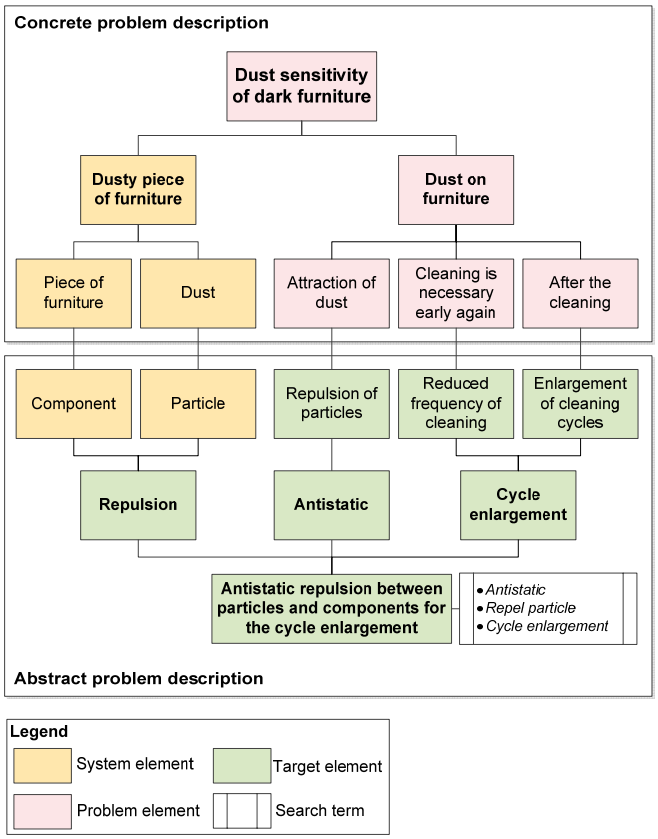


Fig. 5 Abstraction tree

"Where to look for" asks for the industries that are promising to take a closer look at. Previous works pointed out that this essential step is of high relevance and gets implemented – consciously or unconsciously – in each approach to cross-industry innovations [13]. An answer to this question finally aims at a well-defined combination of promising and heterogeneous search industries. In this

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manner, the risk can be minimized to find no qualified solutions in other industries. The selection of these industries is supported by the aid of a so called **search portfolio** that had been designed for the context of cross-industry innovations. Hereafter the steps are described leading to a search portfolio and the selection of search industries.

A search portfolio spreads possible industries over two dimensions: innovation dynamics and distances between industries. **Innovation dynamics** measures the emergence of new products, services, technologies, ideas, strategies and business models within each industry referring to a defined period of time (e.g. one year). Industries with different innovation dynamics suggest a different amount and different maturity levels of possible solutions. Taking this path, bothmature and long-term tested as well as radical new solutions for the own problem can be taken under consideration. The **distance between industries** evaluates the contextual and cognitive distance between the own and a foreign industry. Following the thoughts of Enkel and Gassmann the focus on a certain distance between industries can be avoided as close and far industries both are promising [4]. In doing so, industries are regarded according to the NACE classification (Nomenclature des activités économiques dans la Communauté Européene) [27]. This classification categorizes the economic activities over all industries. Against the background of cross-industry innovations it provides a valuable overview of all thinkable industries.

For each industry an assessment profile is developed (fig. 6). This assessment is without any relation to the underlying problem. Thus, the evaluation is needed only once and can be used in further projects.

		Search industry Electrical industry						
			Assessment profile					
			0	1	2	3	4	5
		Search industry Mechanical engineering industry						
			Assessment profile					
			0	1	2	3	4	5
		Search industry Automotive industry						
			Assessment profile					
			0	1	2	3	4	5
Innovation dynamic		Length of product and service lifecycles	(quasi) eternal	long	over-average	less than average	short	very short
		Length of organizational lifecycles	(quasi) eternal	long	over-average	less than average	short	very short
		Number of intellectual property rights	(quasi) none	few	less than average	over-average	many	very much
Distance to the industry		Cognitive distance	(quasi) none	slight	less than average	over-average	high	very high
		Congruence of technology focus	(quasi) congruent	high	over-average	less than average	slight	very slight

Fig. 6 Evaluation profiles of possible search industries

The evaluation is based on criteria which are explained in the following. **Innovation dynamics** are measured by:

- **Length of product and service lifecycles:** The average length of a market performance is taken under consideration.
- **Length of organizational lifecycles:** The average length of organizational concepts that influence the market position of company is taken into account. In particular strategies and business models are regarded.
- **Number of intellectual property rights:** It is evaluated how many intellectual property rights an industry generates in relation to a defined period (e.g. one year).

In order to estimate the **distance** between the own and a foreign industry the following criteria are considered:

- **Cognitive distance:** This describes the discrepancy of mental models and ways of thinking as well as the discrepancy of problem solving processes [28].
- **Congruency of technology focus:** This criterion evaluates whether two industries focus on nearly the same technologies or whether they have different core themes. Within this topic, the production process of an industry should be determinative for the assessment. A high congruency of the technology focus indicates a low distance between different industries.

Following these assessments the industries are positioned in the search portfolio resulting in the aimed diversification. Doing so, the problem abstraction has yet not been regarded. Therefore, the **problem relevance** needs to be considered. The problem relevancy examines how deeply the abstract problem is addressed in a particular industry. Two kinds of indicators are taken into account in order to determine the problem relevancy:

- **Amount of search results in databases:** The previously defined search terms (abstraction tree) are used for searching the content of literature or patent databases. Many “hits” in relation to a particular industry indicate a high problem relevancy [29].
- **Survey results:** Employees of the own company often have valuable experiences with foreign industries. They can be used to determine the problem relevancy in the context of surveys. To inspire the creativity employees only get to see the problem abstraction (lower part of the abstraction tree).

The results of the assessments are consolidated in a matrix. Calculating the sum leads to a ranking of all industries regarding the addressed problem. Fig. 7 shows an extract of the matrix. Industries ranked on leading places intensively deal with the abstract problem. They have a high probability to work with possible solutions. Due to this they should be considered first. Those industries ranked lower have a lower probability to deal with the abstract problem. They can be considered, if the search in leading industries fails.

Analysis Matrix

Question:
How many results (resp. average points) does an industry j (line) attain concerning an indicator i (column)?

	Indicators										
	Indicator 1: Patent database Derwent Innovations Index®			Indicator 2: Publication Database Sci-Verse® Scopus®			Indicator 3: Employee survey				
	Res.	Sh. [%]	RS_{ji} [%]	Res.	Sh. [%]	RS_{ji} [%]	Ø Res.	Sh. [%]	RS_{ji} [%]	TRS_j	R
Search industries											
Electrical industry	11029	12,02	43,39	59	6,80	39,60	8,90	6,03	114,1	77,80	1
Electrical appliances and whiteware	2565	2,80	10,09	46	5,30	30,87	5,70	3,86	64,04	42,26	8
Engineering	10124	11,03	39,83	22	2,53	14,77	5,67	3,84	63,71	45,50	7
Automotive industry	16193	17,65	63,70	56	6,45	37,58	7,43	5,04	83,48	67,06	3
Shipbuilding industry	1735	1,59	6,83	9	1,04	6,04	7,80	5,29	87,64	47,04	6

Legend:

G	Emphasis
Res.	Number of results concerning one industry in a database (e.g. SciVerse Scopus)
Ø Res.	Average result in a survey
Sh.	Share of one industry at all results
RS_{ji}	Relative share of an industry j concerning indicator i (share of the strongest industry except the own one)
TRS_j	Totalized and weighted relative share of an industry j
R	Rank of an industry

Fig. 7 Extract of analysis matrix for the ranking of possible search industries

Within the search portfolio, the problem relevancy determines the diameter of a bullet that represents an industry. Fig. 8 gives an idea of a search portfolio: For the diversification from each quadrant the industry ranking on the leading place should be chosen as a search industry. Concerning this example, the automotive industry (problem relevance rank 3), electric industry (problem relevance rank 1), plastics industry (problem relevance rank 2), and shipbuilding industry (problem relevance rank 6) should be selected.

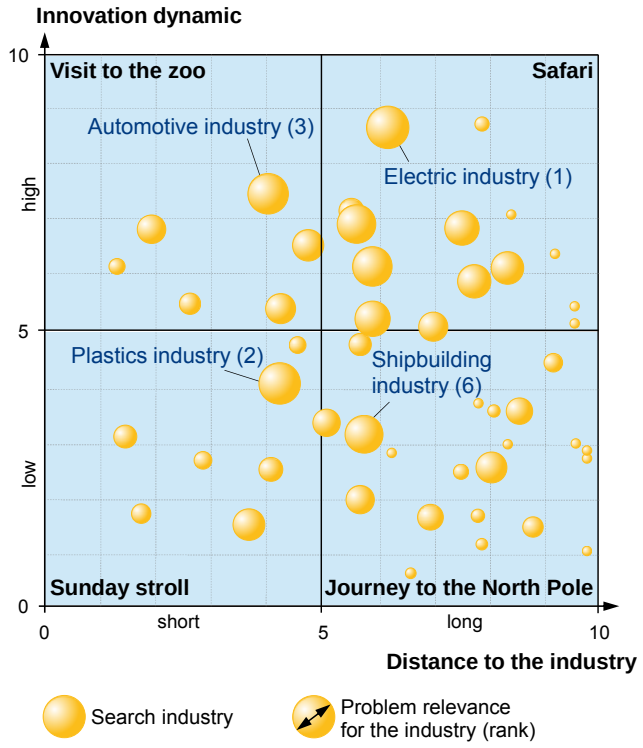


Fig. 8 Search portfolio for the selection of search industries

Within the portfolio, each quadrant is named characteristically. This gives a hint at the specific challenges that have to be faced while searching in one of the industries positioned in each quadrant:

- **Safari** (big distance; high innovation dynamic)**:** This is an innovative industry which is substantially far away from the own industry. "Safari" symbolizes a multitude of unknown problem-solving approaches. High innovation dynamics reveal a high potential for new ideas. The addressed challenge is to get an overview of the large number of ideas and select the most promising ones.
- **Visit to the zoo** (small distance; high innovation dynamic)**:** This industry has topical similarities with the own industry. Innovations are considered with high significance. "Zoo visit" symbolizes a multitude of highly innovative solutions that have overlaps with own topics. The challenge will be to review those solutions and limit them to the appropriate ones.
- **Journey to the North Pole** (big distance; low innovation dynamic)**:** The industry is thematically far away from the own industry. Further, low innovation dynamics lead to slower development of new solutions. This is symbolized by the metaphor of "north pole". As a consequence, the search has to be executed precisely. Potential solutions might be long-term established having a high maturity level.
- **Sunday stroll** (small distance; low innovation dynamic)**:** An industry having topical similarities with the own industry that promotes innovations slower as others on an average. The challenge is to review solutions that the own industry might be familiar with.

"How to look for": Answering this question provides the operational resources that should be used while searching for solutions in other industries. More precisely, the **definition of search methods** defines which kind of knowledge acquisition is preferable. Two ways can be distinguished:

On the one hand members of the own industry can acquire other industries' knowledge in order to discuss possible solutions (internal way). On the other hand the experts of a search industry can make vital contributions for the analogy building [30]. However, the search for analogies should be executed in a team. Three possible team combinations are possible: internal, external, or mixed teams. The preferred combination depends both on the **innovation culture** of a company as well as on the available **resources** [17]. The decisions can be based on a quick test that has been developed for the special case of cross-industry innovations (fig. 9).

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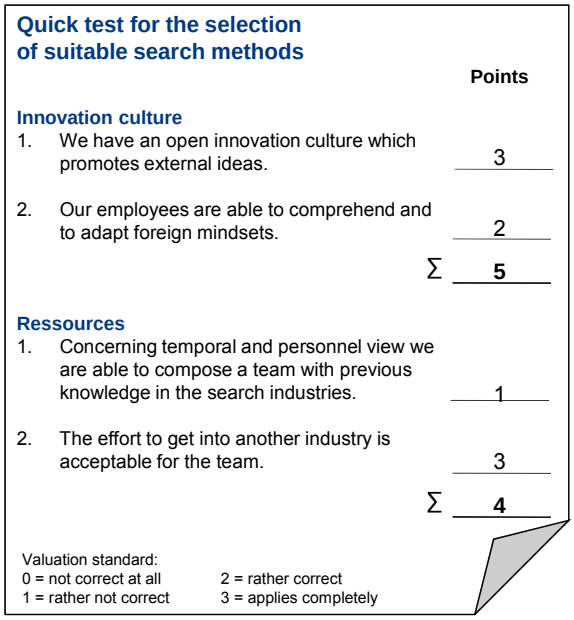


Fig. 9 Quick test for the selection of search methods

Based on the quick test, an indication for preferable team combinations can be deduced. Each team combination is linked to suitable search methods. Fig. 10 contains the corresponding portfolio as well as strategic recommendations:

- **On one's own:** The company has an open innovation culture. The staff is experienced dealing with external ideas, resources are available. Therefore, a totally internal team should be built up.
- **Get support:** The company has an open innovation culture commercializing even external ideas. Nevertheless, resources are missing concerning the context of the given cross-industry innovation project. The team should be extended with external experts to compensate weaknesses.
- **Keep a sharp eye on:** The staff lacks experience dealing with external ideas. Nevertheless, knowledge is present concerning the questioned search industries. Initially, an internal team should be built. In general there is a risk to miss or ignore promising solutions. In this case, external experts should be considered.
- **Trust in experts:** Neither the innovation culture nor resources provide a promising basis for the planned cross-industry project. Consequently, an external team should be built.

Against this background, different ways of knowledge acquisition can be derived for each team combination. A **total internal team** ("on one's own") should choose the following ways to identify analogies in other industries:

- **Own experiences:** Team members can contribute their experiences in other industries (e.g. former projects, employment) in order to identify analogies [17], [31].
- **Media research:** There is a whole amount of search methods is available. A media research can use the internet, databases, software, books, scientific journals or other types of publication.
- **Networks:** The personal network of an employee can make a valuable contribution to the search process. It should be kept in mind that personal networks are often limited to the own industry [11]. Thus, personal networks should be extended to new industries through e.g. visiting trade fairs or conferences.

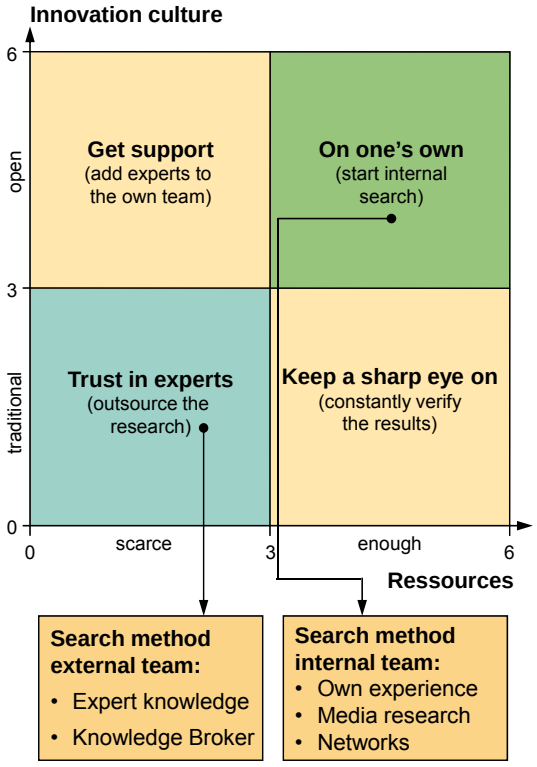


Fig. 10 Portfolio for the selection of a preferable team combination resp. search methods

A **total external team** ("trust in experts") should consider the following possibilities of knowledge acquisition:

- **Expert knowledge:** Experts of a certain industry can rely on several experiences and wide-ranging knowledge. Next to cognitive abilities, these experiences are a valuable basis for the analogy identification [9], [32].
- **Knowledge broker:** Knowledge broker act as intermediaries providing specific knowledge sources concerning a certain problem. They can establish new contacts [33], [34].

For each of the other quadrants a mix of search methods is recommended. Therefore, both internal and external experts need to be considered.

C. Execution of the Search

The previously developed search strategy specifies the problem abstraction, search industries and proper search methods. These specifications need to be taken into account while executing the search that is aimed at finding appropriate analogies in different industries. First, the **initiation of search** should define an (internal resp. external) expert that is responsible for a particular search industry. This is called a

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search mission.

In the next step, suitable sources are examined and a creative search process gets initiated [22]. Generally, two observations are made:

- A creative search process is not predictable. Thus, it is hard to be planned. This can be explained by the simple fact that identified information builds on each other but are unknown beforehand.
- A completed search process is hard to reproduce. This is due to the huge amount and interconnection of information that is usually taken into account while executing the search.

Both characteristics can be explained by the "pyramiding effect" which happens during a search process. A particular source hints at a further source that provides again new hints. By this manner, the knowledge gets gradually consolidated [35], [36].

Further, another issue should be taken into account: Identifying analogies is only possible by discussing the problems solved in the search industries [31]: The specific solution of a foreign industry needs to be analyzed cognitively in order to abstract the underlying problem which can be subsequently compared to the own problem. Thus, two abilities are necessary: Cognitive abilities for the identification of analogies as well as particular solution knowledge which had been specifically collected [31], [37]. To assist this challenge, the abstraction tree is taken under consideration again. With its aid the elements of the abstract problem description get allocated with concrete analogy elements. This enables a creative search and ends in a completed analogy building. Taking this path, the solution "nano coating" has been identified in the automobile industry in order to solve the problem "dust sensitivity of dark furniture".

Optionally, the analogy search can be supported by a software system. An **identification and analysis of relevant documents in patent and publication databases** reveals further ideas. Within a funded research project we developed a software system working in three steps: 1) The software identifies relevant (by means of search term and industry specific) documents by using interfaces of internet search engines and patent databases. 2) The documents are downloaded in an offline folder. 3) By using bibliometrics (especially co-word analysis) words connected with each other are identified and visualized [38]. Taking this path, the person searching for analogies gets additional hints what and where to search.

Finally, **the characterization of search results** covers the documentation. Therefore, idea profiles are an established instrument during idea processes.

Within cross-industry innovation projects often several new business opportunities come up which have not been taken under consideration at the beginning. This seems to be surprising but can be explained easily: Finding promising solutions in other industries means that these industries have problems that are – on an abstract level – similar to own problems. There are often several other unsolved problems related to the identified ones. Taking this path, it is thinkable to go the other way round and solve problems the own industry already can handle. As a sideline, new chances for diversification are identified and should be discussed strategically. This can be even brought to a head: Search results can also consist of formerly unknown problems and possible solutions. Taking this path, a new kind of innovation had been found. It can be called a "visionary adaption" (fig. 11).

	Problems inside the own industry	**Problems outside the own industry**
Solutions inside the own industry	**0** **Status Quo:** Does it really solve our problem?	**2.** **Diversification:** Which problems of other industries are we able to solve?
Solutions outside the own industry	**1.** **Adaption:** Which solution should be adapted?	**3.** **Visionary adaption:** Are there completely new visions for our industry?

Fig. 11 General courses of action for search results

It is also based on a knowledge transfer, but transfers both the problem and the solution from another industry to the own industry. If a possible search result is found, a new innovation potential is created that can be exploited easily and instantly with an existing solution. A plausible example might be the following one: The arriving of mobile internet in an automobile can be regarded as a visionary adaption. The customer problem of mobile communication had already been solved by the information and communication industry. Thus, the automotive industry was in the lucky position to transfer both the customer problem and existing technologies to the own one.

D.Search Results Assessment

Identified solutions need to be assessed in order to select the most promising ones. Thus, the assessment contains two assessments: solution quality and transferability [2]. For both dimensions certain criteria are defined. To make a selection of search results a portfolio with the dimensions transferability and the solution quality is suitable (Fig. 12). The portfolio helps to evaluate the **adaption priority** of identified solutions.

The **solution quality** requires an anticipation of the finally adapted solution blanking out the adaption process itself. The assessment covers the following three criteria:

- **Maturity level:** The maturity level describes the state of working on a solution. Solutions can be quite mature, e.g. long-term established technologies, but also can have the state of an idea. Mature solutions can make greater contributions to problem solving.
- **Profitability:** This evaluates the cost-benefit ratio of an adapted solution. A high additional benefit may justify higher costs. This does not address the profitability of the transfer process. Thus, no development costs are regarded.

Degree of novelty: The degree of novelty of a possible solution is evaluated in relation to the future application

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context. Taking this path, the novelty for the application context is decisive. Thereby, the chance for the occurrence of a radical innovation should be considered.

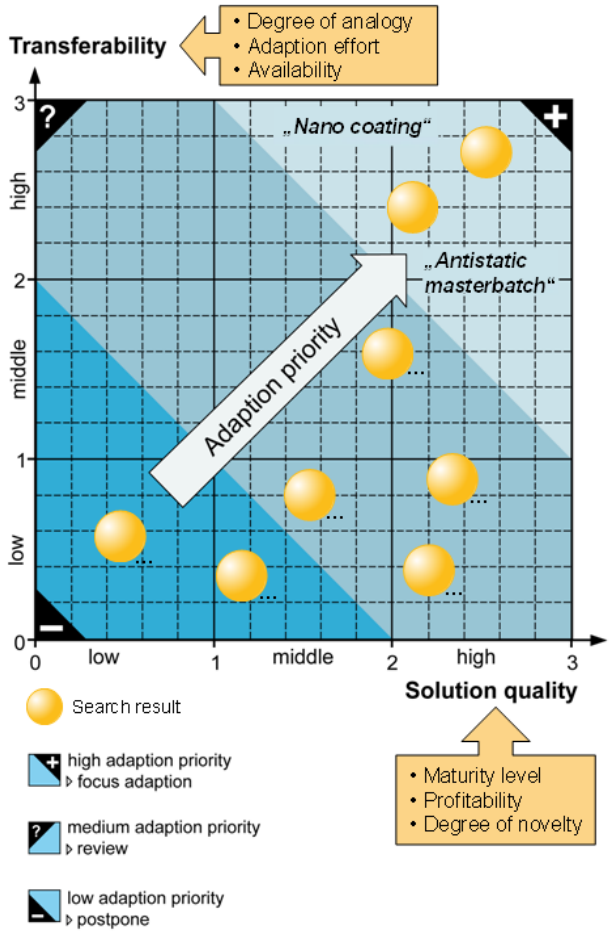


Fig. 12 Portfolio for the determination of an adaption priority

The evaluation of **transferability** takes a look at the expected adaption process. It also covers three criteria:

- **Degree of analogy:** The degree of analogy addresses the underlying problem. It is assessed how similar the own problem is to the underlying problem of the evaluated solution.
- **Adaption effort:** The adaption effort is used to estimate the effort within an adaption development until the solution is finally suitable to solve the own problem. Here, transfer process is focused
- **Availability:** This evaluates how accessible the possible solution is. Solutions can be spread over the whole industry or can be owned only by certain companies.

A. Adaption Planning

Within the adaption planning, the target is to make the identified and selected solution usable. Therefore a requirements catalogue is defined. The catalogue contains the requirements itself, a short description and a person responsible for the requirement.

At this point it is known where we are (selected solution) and where we want to go (requirements). Within the adaption process, several challenges can appear. Examples are technology patents or competition networks between the targeted industry and other companies in the own industry. To minimize the risk of failure, an adaption-FMEA (Failure Mode and Effects Analysis) can be executed. Only known and applied in development processes it can significantly contribute to the risk management. It especially allows anticipating challenges, evaluating them and deducting possible counter-measures. Fig. 13 shows an excerpt from the adaption-FMEA within the used example.

In the last step, the requirements, possible challenges and counter-measures are assessed regarding the required time effort and visualized in an adaption roadmap [29].

Adaption-FMEA

Search result: Nano coating
Search industry: Automotive industry
Last changes: June 1st, 2012
In charge: Niklas Echterhoff (N.E.)

Nr.	Potential problem during adaption	Potential effects	Severity	Potential cause of failure	Current controls to prevent	Occur-rence	Current controls to detect	Detection	RPN	Source
1	**Patent is refused**	Proprietary development necessary	4	Competition in own industry	Only achieving adaption from companies with no relation to own industry	2	Checking relation to competing companies	8	64	N.E.
2	**Transfer affects patent in own industry**	…	…	…	…	…	…	…	…	N.E.
3	**Health barriers prevent solution transfer**	…	…	…	…	…	…	…	…	N.E.
4	**Coat is incompatible with wood**	…	…	…	…	…	…	…	…	N.E.
5	**Costs exceed additional earnings**	…	…	…	…	…	…	…	…	N.E.

Fig. 13 Adaption-FMEA

IV. Conclusion

The present work describes a method to develop cross-industry innovations. Special attention should be given to the newly developed abstraction technique. There is a high probability that there are more applications in other methods requiring analogy building. Beyond this, the use of a FMEA for the anticipation of upcoming challenges besides the product development might be also promising.

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