World Academy of Science, Engineering and Technology
International Journal of Industrial and Manufacturing Engineering
Vol:7, No:4, 2013

# Cross-Industry Innovations – Systematic Identification and Adaption

Niklas Echterhoff, Benjamin Amshoff, and Jürgen Gausemeier



***Abstract*****—**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 entail high risks. One possibility to realize radical innovations and reduce the risk of failure is cross-industry innovation (CII). CII brings together problems and solution ideas from different industries. However, there is a lack of systematic ways towards CII. Bridging this gap, the present paper provides a systematic approach towards planned CII. Starting with the analysis of potentials, the definition of promising search strategies is crucial. Subsequently, identified solution ideas need to be assessed. For the most promising ones, the adaption process has to be systematically planned – regarding the risk affinity of a company. The introduced method is explained on a project from the furniture industry.

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

## I. New Opportunities for Innovations

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. Especially radical innovations are often based on an unusual combination. 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 are cross-industry innovations. They result, if the underlying development challenge and the proper solution originate from different industries. Proved solutions are transferred from their 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.

Dipl.-Wirt.-Ing. N. Echterhoff is with Heinz Nixdorf Institute, University of Paderborn, 33102 Germany (phone: +49-5251-6264; fax: +49-5251-6268; e-mail: niklas.echterhoff@hni.upb.de).

M.Sc. B. Amshoff is with Heinz Nixdorf Institute, University of Paderborn, 33102 Germany (phone: +49-5251-6265; fax: +49-5251-6268; e-mail: benjamin.amshoff@hni.upb.de).

Prof. Dr.-Ing. J. Gausemeier is with Heinz Nixdorf Institute, University of Paderborn, 33102 Germany (phone: +49-5251-6267; fax: +49-5251-6268; e-mail: juergen.gausemeier@hni.upb.de).

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 and planning of cross-industry innovation is only selectively analyzed. This paper presents a systematic method towards cross-industry innovations including a systematic adaption planning. 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 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 technology which is integrated in an optical computer mouse. This cost-efficient and widespread technology achieves a constant distance between stitches 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 when it comes to 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.

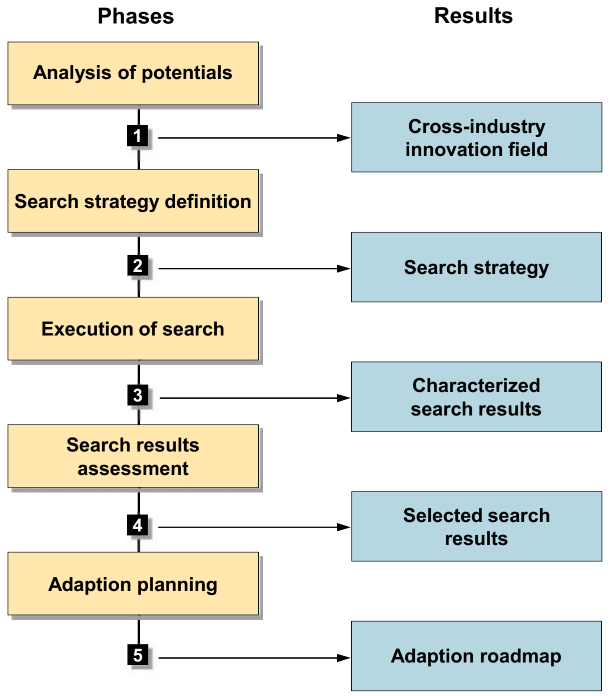


Fig. 2 Method for cross-industry innovations

*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 competence** is evaluated. This describes the amount of missing competence 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 competence 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).

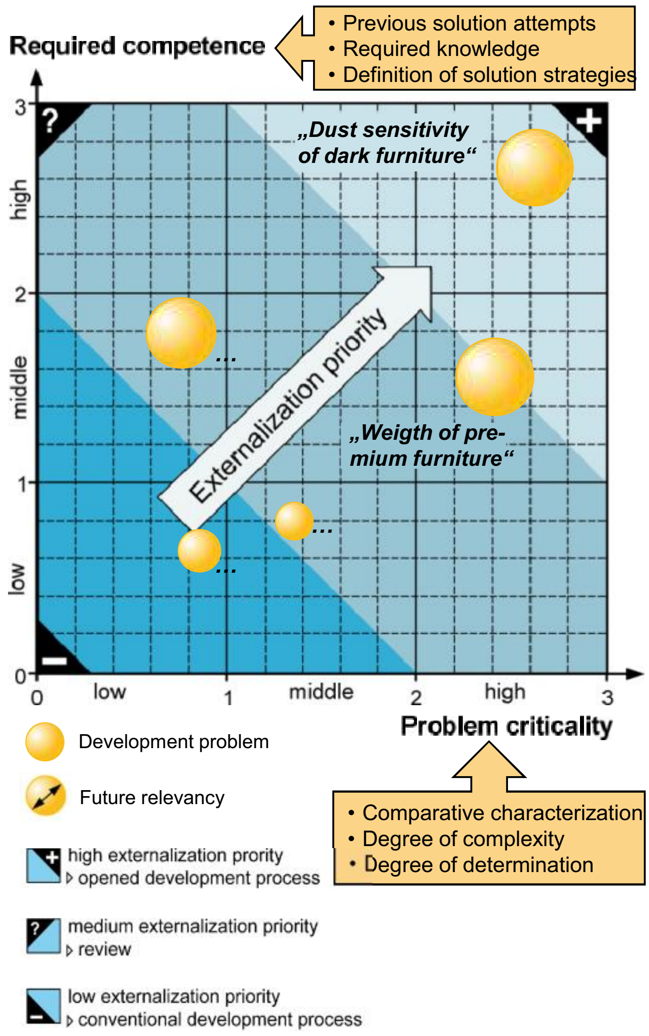


Fig. 3 Specification of problem externalization priority

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.

**"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].


Fig. 4 Questions of a search strategy

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.

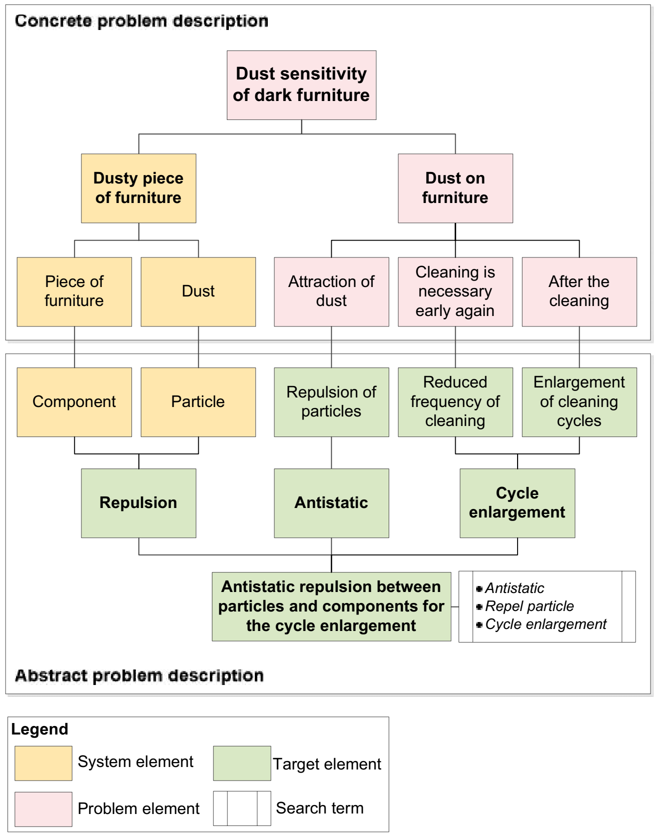


Fig. 5 Abstraction tree

**"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 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, both mature and long-term tested as well as radical new solutions for the own problem can be taken under consideration. The **distance to the industry** 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. This assessment is without any relation to the underlying problem. Thus, the evaluation is needed only once and can be used in further projects. The evaluation is based on criteria which are explained in the following. **Innovation dynamics** are measured by:

- Length of product and service lifecycles
- Length of organizational lifecycles
- Number of intellectual property rights

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.

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).

Within the search portfolio, the problem relevancy determines the diameter of a bullet that represents an industry. Fig. 6 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.

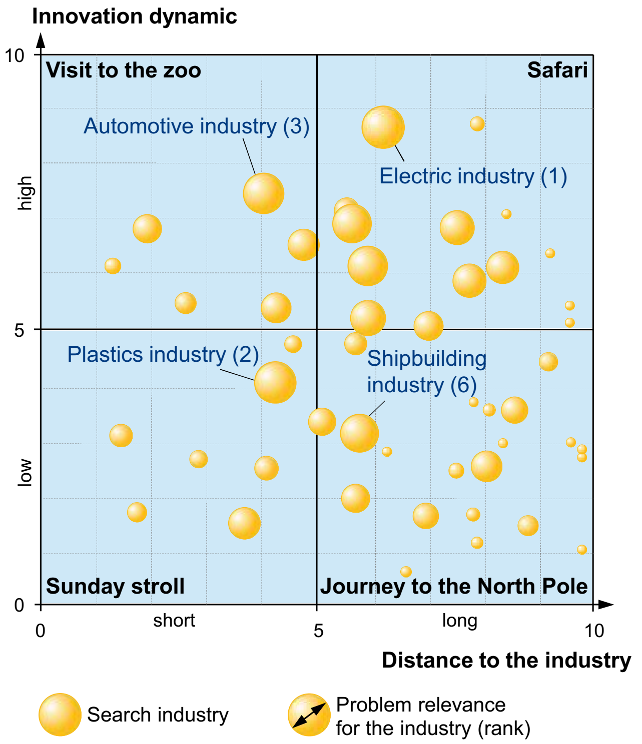


Fig. 6 Search portfolio for the selection of search industries

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. Based on the quick test, an indication for preferable team combinations can be deduced. Each team combination is linked to suitable search methods. However, the quick test as well as the resulting portfolio has been discussed in former work [31].

Against this background, different ways of knowledge acquisition can be derived for each team combination. A **total internal team** 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], [32].
- **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.

A **total external team** 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], [33].
- **Knowledge broker:** Knowledge broker act as intermediaries providing specific knowledge sources concerning a certain problem. They can establish new contacts [34], [35].

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 **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 [36], [37].

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], [38]. 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 [39]. 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. 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. 7).

| | 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. 7 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. 8). 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 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.

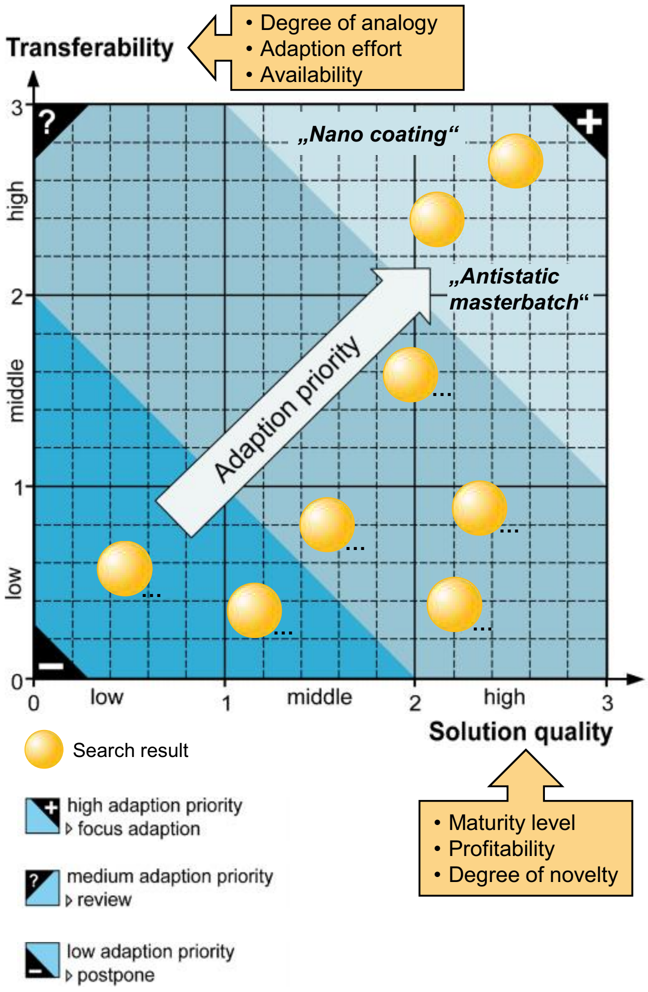


Fig. 8 Portfolio for the determination of an adaption priority

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.

*E. Adaption Planning*

Within the adaption planning, the selected solutions are being utilized – at this point usually more than one possible solution is considered. Therefore a requirements catalogue is defined. The catalogue contains the requirements itself, a short description and a person responsible for the requirement. Most parts of the catalogue can be used from the overall product development, including the originally identified and selected problem – these requirements are important for every solution idea. Against the background of each selected solution idea, additional, solution specific requirements result.

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 at a certain probability. These challenges need to be thought ahead. Assuming that the risk of failure within the adaption process can be decomposed into several risky challenges, the adaption planning should take care of these challenges and derive proper measures against the background of a risk minimization. Former work shows that an adaption-FMEA (Failure Mode and Effects Analysis) is a helpful tool. It allows anticipating challenges, evaluating them and deducting possible counter-measures [31]. This approach had been further developed arriving at an easy-to-handle instrument going without a FMEA-template. Initially, two kinds of challenges need to be distinguished: general and specific challenges.

**General challenges** can occur during each adaption process. A catalogue including several typical ones has been developed. Fig. 9 shows an excerpt of the catalogue of general challenges that can be observed frequently. The catalogue is separated into three categories of challenges addressing specific adaption steps. While discussing a solution, those general challenges threatening most should be taken into account.

**Specific challenges** result due to an assessment of the requirements against the background of the previously selected solution ideas. Therefore a matrix has been developed with the requirements from the previously introduced requirements catalogue in the lines and the selected product ideas in the columns (see fig. 10).

| Providing of solution | Integration of solution | Manufacturing of solution |
|---|---|---|
| • Refusing of patent<br>• Lack of providers<br>• Lack of information<br>• Attack of patent in own industry<br>• Health barriers<br>• Cost overrun<br>• Cooperation fail<br>• Communication difficulties<br>• … | • Cost overrun<br>• Technological fail<br>• Internal barriers of acceptance<br>• Exceeding of development period<br>• Internal cooperation fail<br>• Lack of capacity<br>• … | • Lack of technology<br>• Lack of capacity<br>• Productivity problem<br>• Quality problem<br>• Unusual manufacturing depth<br>• Efficiency problem<br>• Cost overrun<br>• … |

Fig. 9 Catalogue of general challenges during adaption (excerpt)

Taking this path, each solution is confronted with every requirement in detail. By doing so, challenges which might occur during the adaption process can be thought ahead. Beyond this, solution ideas creating more critical requirements can be easily identified by calculating the column sum.

**Adaption Assessment Matrix**
**Question:**
**How critical is the fulfillment of the adaption requirements (line) within the search result (column)?**

Evaluation scale
(assessment / weighting)

5 = high risk / importance
4 = increased risk / importance
3 = medium risk / importance
2 = reduced risk / importance
1 = low risk / importance
0 = no risk / importance

| | Search results | | | Antistatic masterbatch | | Electrostatic dust filter | | Nano coating | |
|---|---|---|---|---|---|---|---|---|---|
| | | | No. | 1 | | 2 | | 3 | |
| | Adaption requirements | No. | W | A | AxW | A | AxW | A | AxW |
| generic | Matte finish of the applied coating | 1 | 2 | 2 | 4 | 3 | 6 | 3 | 6 |
| generic | Resistance to cleaning | 2 | 3 | 1 | 3 | 3 | 9 | 2 | 6 |
| generic | Safety against flaking | 3 | 5 | 2 | 10 | 1 | 5 | 2 | 10 |
| generic | ⋮ | 4 | | | | | | | |
| specific | Wood-compatible nanoparticles | 22 | 3 | 4 | 12 | | | | |
| specific | Number of dust particles per m³ <600 | 23 | 4 | | | 3 | 12 | | |
| specific | Drying temperature min. 140 °C | 24 | 4 | | | | | 4 | 16 |
| specific | ⋮ | 25 | | | | | | | |
| | | | Sum | | 92 | | 105 | | 107 |

Fig. 10 Adaption assessment matrix

General and specific challenges are collected, listed formlessly and numbered. Subsequently they need to get evaluated in order to suggest a further handling. Therefore, two dimensions are taken under consideration:

- **Probability of occurrence:** It needs to be considered how probable the occurrence of a challenge is. For the assessment, five categories are used reaching from “not likely” to “certain”. Challenges with a high probability should be managed with priority.
- **Impact on adaption:** Herewith, it is determined how crucial the occurrence of a challenge is for the realization of an adaption. Evaluation categories reach from “adaption unhampered” to “adaption impossible”.

Challenges with high impact on the adaption should be primarily managed.

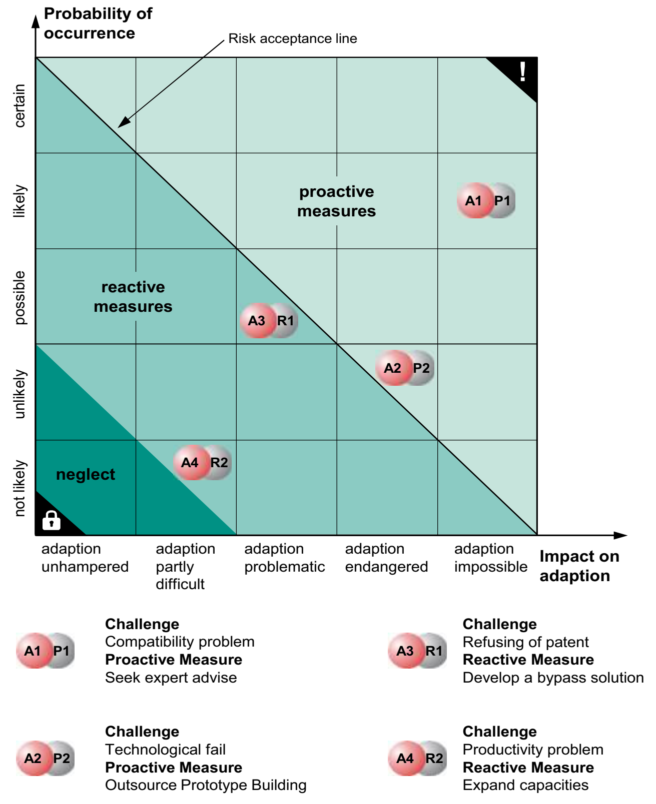


Fig. 11 Portfolio for the selection of proactive and reactive measures

The dimensions are used to create a portfolio in which both the specific and general challenges are placed according to the evaluation above (Fig. 11).

The aim of the portfolio is to identify those challenges that should be managed immediately as they can be critical for the success of the adaption process. Therefore, so called proactive measures are necessary. Proactive measures are implemented before a challenge may occur in the process. They aim at avoiding the occurrence of challenges. The other measures address challenges that only need to be handled in case of occurrence; these are so called reactive measures. Challenges that are not likely to happen and have low impact on the adaption can be neglected in the first instance.

To distinguish between these kinds of challenges resp. measures the resulting portfolio is separated by a so called risk acceptance line. Challenges positioned above the risk acceptance line need to be managed by proactive measures. Challenges positioned below the line are managed subsequently by reactive measures.

The risk acceptance line is scalable due to the risk affinity of a company. A high risk affinity shifts the line to the top right of the portfolio. This increases the space for reactive measures and minimizes the number of proactive measures. This might enable a faster adaption process but requires the acceptance of a higher development risk.

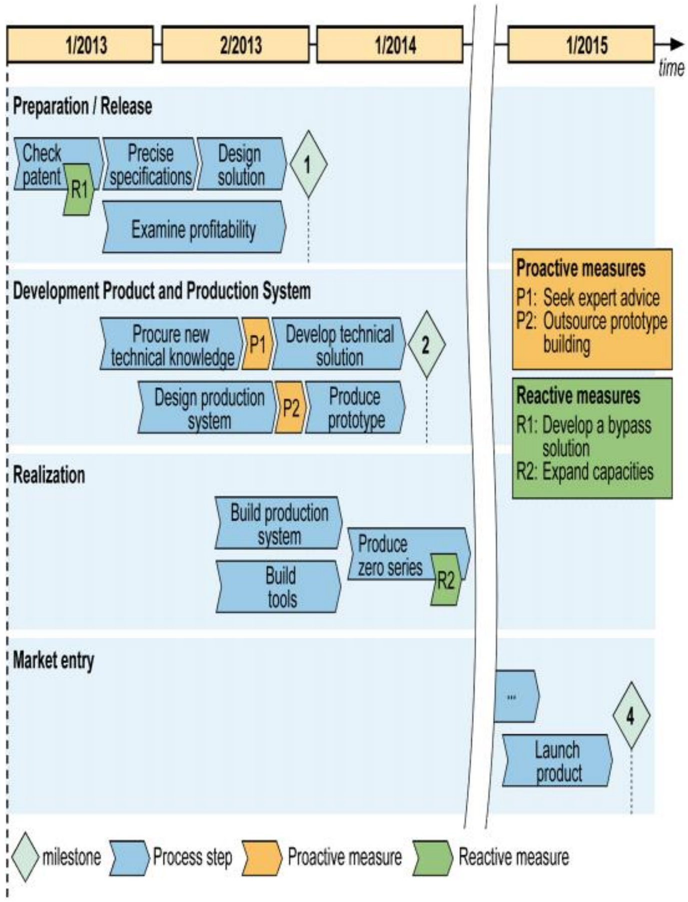


Fig. 12 Example of an adaption roadmap

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]. Fig. 12 gives an example of an adaption roadmap containing adaption process steps as well as proactive and reactive measures. The roadmap is structured by a timeline and swim lanes covering four generic phases from “preparation/release” until “market entry”. A phase is completed when reaching a milestone. To support the planning of adaption steps, a process handbook has been developed containing a useful collection of formerly proved process steps. This enables an easy individualization according to a specific project resp. adaption process.

The roadmap integrates proactive measures – as they have to be implemented – directly into the process chain. Reactive measures are only optional; thus they get assigned to fixed process steps.

The shown approach is based on a certain concept for the management of risks resp. challenges with proactive and reactive measures. Fig. 13 explains this concept and summarizes the types and sources of possible challenges during adaption processes: Adaption challenges can be divided into generic and specific challenges each resulting from certain sources. Both types of challenges are assessed and according to this managed by reactive resp. proactive measures.

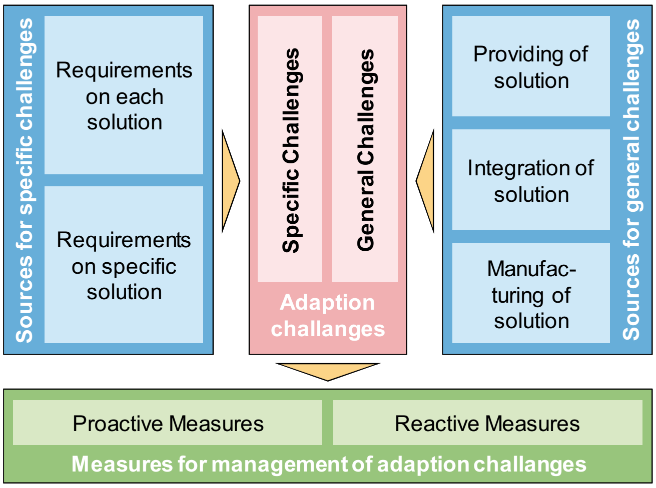


Fig. 13 Concept for management of challenges with proactive and reactive measures

## IV. Conclusion

The present work describes a method to develop and especially systematically adopt 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 systematic adaption planning can find application in different tasks.

## References

[1] T.J. Gerpott, *Strategisches Technologie- und Innovationsmanagement*. Stuttgart: Schäffer-Poeschel Verlag, 2005
[2] C. Dürmüller, „Der lohnende Blick über den eigenen Gartenzaun – Cross-Industry-Innovation“ in: *Innovation Management*, März-Juni 2007, Nr. 1, 2007
[3] C. Dürmüller, „Der Blick über den Tellerrand“ in: *io management*, Mai/Juni 12, S. 24-27, 2012
[4] E. Enkel, O. Gassmann, “Creative imitation – exploring the case of cross-industry innovation” in: *R&D Management*, 40, 3/2010, S. 256-270, Blackwell Publishing, Oxford, Malden, 2010
[5] O. Gassmann, P. Sutter, *Praxiswissen Innovations-management*. München, Wien: Carl Hanser Verlag, 2011
[6] E. Enkel, „Ideen aus anderen Branchen abgucken“ in: *VDI nachrichten*, 11. Dezember 2009, Nr. 50, 2009
[7] H.W. Chesbrough, “The Era of Open Innovation”. In: *MIT Sloan Management Review*, Spring 2003, Cambridge, 2003
[8] H.W. Chesbrough, *Open Innovation – The New Imperative for Creating and Profiting from Technology*. Harvard Business School Press, Boston, 2006
[9] D.W. Dahl, P. Moreau, “The Influence and Value of Analogical Thinking During New Product Ideation” in: *Journal of Marketing Research*, Nr. 39, S. 47-60, 2002
[10] Gabler Wirtschaftslexikon: *Analogie* from: http://wirtschaftslexikon.gabler.de/Archiv/4968/analogie-v8.html, last checked: August 2012
[11] E. Enkel, A. Horváth, „Mit Cross-Industry-Innovation zu radikalen Neuerungen“ in: S. Ili, *Open Innovation umsetzen – Prozesse, Methoden, Systeme, Kultur*. Düsseldorf: Symposium Publishing, 2010
[12] A. Lenz, „Cross Industry – Vom Wissen anderer profitieren“ in: *wissensmanagement*, 5/09, 2009
[13] O. Gassmann, M. Zeschky, „Dem Zufall auf die Sprünge helfen“ in: *Technische Rundschau*, Nr. 3/2007, 2007
[14] E. Enkel, C. Dürmüller, „Cross-Industry-Innovation – der Blick über den Gartenzaun“ in: O. Gassmann, P. Sutter: *Praxiswissen Innovationsmanagement*. München, Wien: Carl Hanser Verlag, 2011
[15] L. Ebersbach, O. Gassmann, S. Reinecke, „Neue Grenzen für Innovation“ in: C. Belz, M. Schögel, T. Tomczak: *Innovation Driven Marketing – Vom Trend zur innovativen Marketinglösung*. Wiesbaden: Gabler Verlag, 2007
[16] S. Brunswicker, J. Warschat, U. Hutschek, “Crossing Horizons – Applying Analogies to Source Technologies in the Front-End of the Innovation Processes” in: D.F. Kocaoglu, *Portland International Center for Management of Engineering and Technology – PICMET*, PICMET 2010, *Portland International Conference on Management of Engineering and Technology*, S. 736-743, Portland, 2010
[17] K. Kalogerakis, *Innovative Analogien in der Praxis der Produktentwicklung*. Wiesbaden: Gabler Verlag, 2010
[18] C. N. Madu, *House of Quality (Qfd) in a Minute: Quality Function Deployment*. Fairfield: Chi Publishers, 2006
[19] C. Markides, *So wird Ihr Unternehmen einzigartig – Ein praxisleitfaden für professionelle Strategieentwicklung*. Frankfurt am Main: Campus, 2002
[20] J. Terninko, A. Zusman, B. Zlotin, *Systematic Innovation – An Introduction to TRIZ*. Boca Raton, London, New York, Washington D.C.: St. Lucie Press, 1998
[21] H. Teufelsdorfer, A. Conrad, *Kreatives Entwickeln und innovatives Problemlösen mit TRIZ/TIPS*. Erlangen, München: Publicis MCD Verlag, 1998
[22] J. Gausemeier, P. Ebbesmeyer, F. Kallmeyer, *Produktinnovation – Strategische Planung und Entwicklung der Produkte von morgen*. München, Wien: Carl Hanser Verlag, 2001
[23] R. Klein, A. Scholl, *Planung und Entscheidung*. München: Verlag Franz Vahlen, 2011
[24] G. Pahl, W. Beitz, J. Feldhusen, K.-H. Grote, *Konstruktionslehre – Grundlagen erfolgreicher Produktentwicklung, Methoden und Anwendung*. Berlin, Heidelberg: Springer Verlag, 2007
[25] H.-C. Pfohl, Problemorientierte Entscheidungsfindung in Organisationen. Berlin, New York: de Gruyter, 1977
[26] W.J.J. Gordon, *Synectics – The Development of Creative Capacity*. New York, Evanston, London: Harper & Row, 1961
[27] Europäische Gemeinschaften, „*NACE Rev. 2 – Statistische Systematik der Wirtschaftszweige in der Europäischen Gemeinschaft*“. Luxemburg: eurostat, Methodologies and Working papers, 2008
[28] A. Stern, „Technology Orchestration“ in: S. Ili, *Open Innovation umsetzen – Prozesse, Methoden, Systeme, Kultur*. Düsseldorf: Symposium Publishing, 2010
[29] J. Gausemeier, C. Plass, C. Wenzelmann, *Zukunftsorientierte Unternehmensgestaltung – Strategien, Geschäftsprozesse und IT-Systeme für die Produktion von morgen*. München, Wien: Carl Hanser Verlag, 2009
[30] K.T. Ulrich, S.D. Eppinger: *Product Design and Development*. New York: McGraw-Hill, 2004
[31] N. Echterhoff, B. Amshoff, J. Gausemeier, “Cross-Industry Innovations – Systematic Identification of Ideas for Radical Problem Solving”, *WASET XXXIV. International Conference on Innovation and Management 2013*, to be published.
[32] O. Gassmann, M. Zeschky, “Opening up the Solution Space: The Role of Analogical Thinking for Breakthrough Product Innovation” in: *Journal compilation*, 2/08, 17, S. 97-106, Blackwell Publishing, 2008
[33] J.L. Cummings, B.S. Teng, “Transferring R&D Knowledge: The Key Factors Affecting Knowledge Transfer Success” in: *Journal of Engineering & Technology Management*, Nr. 20, S. 39-68, 2003
[34] O. Gassmann, M. Daiber, E. Enkel, “The role of intermediaries in cross-industry innovation processes” in: *R&D Management*, 41, 5, S. 457-469, 2011
[35] S. Nambisan, M. Sawhney, “A Buyer’s Guide to the Innovation Bazar” in: *Harvard Business Review*, 06/07, S. 109-118, 2007
[36] E.V. Hippel, N. Franke, R. Prügl, “Pyramiding – Efficient search for rare subjects” in: *Research Policy*, Vol. 38, Nr. 9, S. 1397-1406, 2009
[37] Poetz, M.K.; Prügl, R.: Crossing Domain-Specific Boundaries in Search of Innovation – Exploring the Potential of Pyramiding. In: Journal of Product Innovation Management, Vol. 27, Nr. 6, S. 897-914, 2010
[38] M.L. Gick, K.J. Holyoak, “Analogical Problem Solving” in: *Cognitive Psychology*, Vol. 12, Nr. 3, S. 306–355, 1980

[39] A.F.J. van Raan, "The use of bibliometric analysis in research performance assessment and monitoring of interdisciplinary scientific developments" in: Technologiefolgenabschätzung – Theorie und Praxis. Nr 1, 12. Year, March 2003

**Dipl.-Wirt.-Ing. Niklas Echterhoff** studied Industrial Engineering and Management with main focus on Innovation and Development Management at the University of Paderborn, Germany, and the Qingdao University of Science and Technology, China. In 2010, he graduated as best student of the year with honors. Since then, he is working as a research associate at the chair for Product Engineering (Professor Gausemeier) at the Heinz Nixdorf Institute. There, he is responsible for the team Strategic Planning and Innovation Management. His main research fields are foresight, product discovery and business planning.

**M.Sc. Benjamin Amshoff** studied Industrial Engineering and Management with main focus on Innovation and Development Management at the University of Paderborn, Germany. In 2012, he graduated with honors. Since then, he is working as a research associate at the chair for Product Engineering (Professor Gausemeier) at the Heinz Nixdorf Institute in the team Strategic Planning and Innovation Management. His main research fields are foresight and technology planning.

**Prof. Dr.-Ing. Jürgen Gausemeier** is Professor for Product Engineering at the Heinz Nixdorf Institute of the University of Paderborn. He received his PhD from the Institute for Machine Tools and Production Engineering at the Technical University of Berlin. His doctoral supervisor was Professor Spur. During his 12 year career in industry, Dr. Gausemeier was Head of R&D of CAD/CAM systems. His last position was Division Manager for process control systems at a well-known Swiss company. Beyond his university activities, he is active as a Member of the Board and Managing Director of the scientific society „Scientific Society for Product Development (WiGeP)". Furthermore, he is the initiator and Chairman of the Supervisory Board of the consultant company UNITY AG. Jürgen Gausemeier is Member of „acatech – German Academy of Science and Engineering" and since 2012 Vice-President. In 2012 he was reappointed to the German Council of Science and Humanities.