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TRIZ-BASED TECHNOLOGY INTELLIGENCE

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Abstract:

"The intensified technological Darwinism demands new thinking!"

Technologies are the central and success-determining factors of every technology-oriented company. To ensure a solid and sustainable technological base that also withstands rapidly changing market requirements, an early focus on high-potential and forward-looking technologies is advised.

TRIZ-based Technology Intelligence is a method that assists technology managers in identifying competing technologies in order to forecast their development and to determine their potential. The development of the primarily technological but also customer-related surrounding is also taken into account to guarantee a holistic and simultaneously focused view.

To reach this objective, the Technology Intelligence method incorporates different tools of the TRIZ-methodology (the theory of inventive problem solving) such as the Trends of Technological Evolution and TRIZ-related methods. These related methods include, for instance, systems theory and morphology. The different methods are combined into a process comprising of four stages. Firstly, the relevant surroundings (super- and subsystems) with the competing technologies (alternative systems) are defined. After this the main parameters and functions that are relevant for the success of the systems are identified. On this basis, the future of the different systems can be anticipated and their potential can be estimated. Finally, the results are documented in a technology roadmap.

The outcomes of the TRIZ-based Technology Intelligence can be used to determine the threats and opportunities of competing technologies. On this basis, the critical technologies can be further monitored or used for an individual company's strategy. Hence, existing business areas can be expanded by technological optimisations and new business areas can be built up by generating new knowledge.

Keywords:
TRIZ, technology, product, intelligence, foresight, forecasting, evolution, morphology, function, system, roadmap

Introduction

Focusing on the right technological basis on time

It is a well known fact and has been shown throughout history, that new technologies can change the competitive situation in manifold ways (Zahn 1995), and that the early detection of changes in the technological surrounding is an important factor for the success of every technology-oriented company (Zweck 2002). This is true especially against the background of reduced product life cycles. An assumption of this paper is that while older products are substituted by newer products with increasing speed, in comparison, the technological basis develops much more slowly. Therefore, a lasting corporate success can be assured by a long-term strategy focusing on the right technological basis.

Companies have the possibility of short-term reactions to precise customer requirements and short-term shifts of the market. They can also try to anticipate future market developments. These market pull strategies are normally directed to the near future. The technology management as technology push approach can be used for long-term strategies, as technologies are long-lasting compared to market requirements (figure 1). At this point it has to be clarified that the demand for the fulfilment of primary functions also stays stable for a long time whereas the requirements of secondary functions and their characteristics change very quickly (Eversheim 2003).

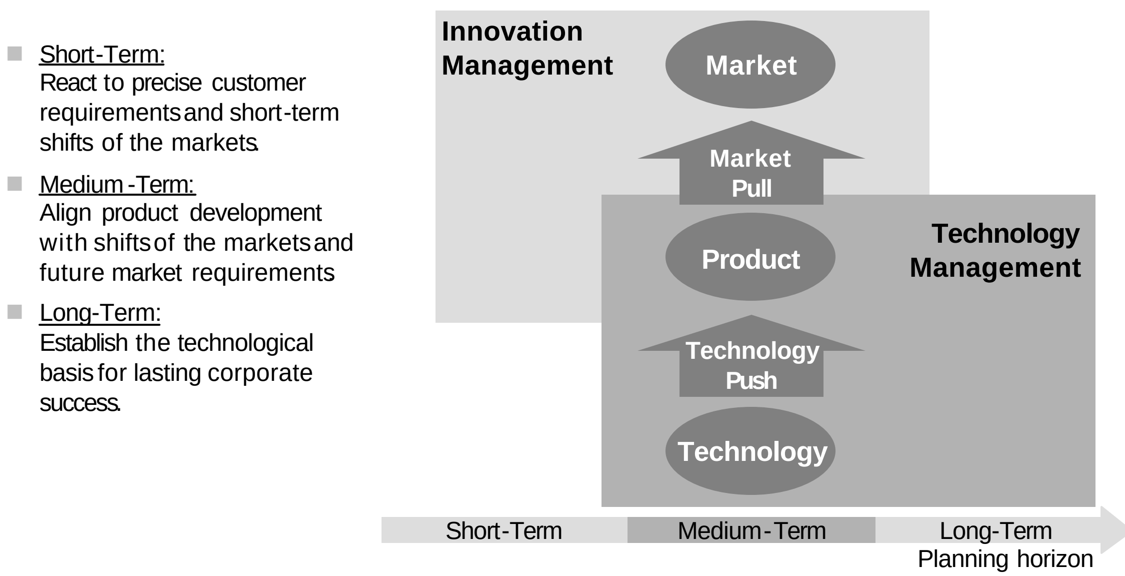

Figure 1: Planning long-term corporate success with technology management

Nowadays, companies use technology management to build up a solid technological basis. With this basis they can react to rapidly changing market requirements. Thereby, technology management is seen as the entirety of all planning activities that are necessary to ensure the company's success and to strengthen the market position by strategic changes of product and production technologies (Binder and Kantowsky 1996, Spur 1998), as well as information and material technologies.

The methodology

Identifying the appropriate technological basis with Technology Intelligence

Within the framework of technology management Technology Intelligence is used to identify promising (or dangerous) technological approaches, to show its potential as well as its limits and to prepare appropriate arrangements for the development of these technologies (Zweck 2002, Servatius 1992). In the relevant literature, this activity is described by different expressions (e.g. Technology Forecasting, Foresight, Monitoring, Scanning, Watch) without a single explicit definition or common understanding (Moehrle 2002). For this paper, Technology Intelligence is defined in accordance to Savioz as "activities that support decision-making of technological and general management concerns by taking advantages of a well timed preparation of relevant information on technological facts and trends (opportunities and threats) of the organisation's environment by means of collection, analysis and dissemination" (Savioz 2002). These are especially activities that anticipate technological development including technological potentials and limits in a defined framework. The Technology Intelligence is especially refined to all activities with the intention of anticipating market changes, like for example Scenario Techniques (Gausemeier 2001, Eversheim 2003) or Kondratieff Waves (Nefiodow 2001).

Unlike Technology Forecasting or Foresight and especially with the support of TRIZ (Moehrle 2002, Stelzner 2002, Kowalick 1997), Technology Intelligence is seen as an approach that takes the relevant technological surrounding and the correlation between different technological systems into account. Therefore, the framework of the TRIZ -based Technology Intelligence is defined according to Porter's Five Forces (Porter 1998) (figure 2).

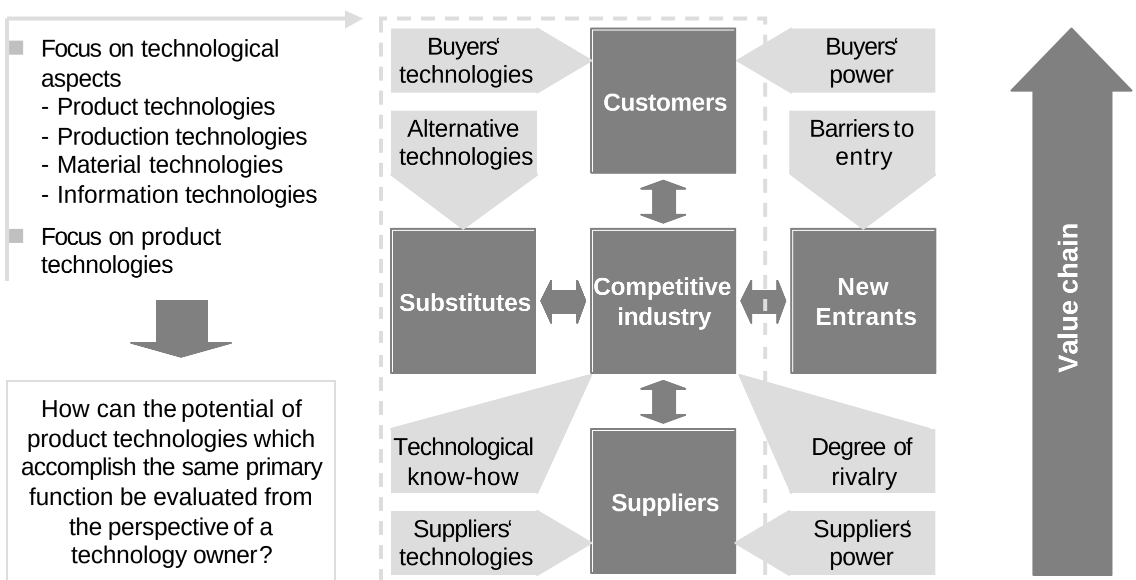

Figure 2: Framework of the TRIZ-based Technology Intelligence

Along the value chain suppliers technologies, alternative technologies and buyers' technologies are listed. In the middle of this framework is a specific technology. For the TRIZ-based Technology Intelligence, this technology has to be a product technology. It has to be taken into account that after the focus on product technologies aspects like production, material and information technologies, market development and competences of companies also have to be considered. The results of the TRIZ-based Technology Intelligence can be evaluated in accordance with these aspects and offer a basis to gain additional information.

Within the described framework and with the focus on product technologies, the main question the TRIZ-based Technology Intelligence will answer is how the potential of different product technologies which accomplish the same primary function can be evaluated from the perspective of a technology owner.

Therefore, a definition of the product technology, the relevant technological surrounding and the need for information has to be given as an input for the methodology. The output can be an Explorative TechnologyRoadMap describing the anticipated development of a technology and its surrounding. This also includes critical factors which on the one hand could influence the development of technologies and on the other hand directly influence a technology owner's decisions (figure 3). It is then the task of the technology owner to identify opportunities and threats on the basis of this RoadMap on a regular basis, to react to technological changes and to plan the corporate-specific TechnologyRoadMap.

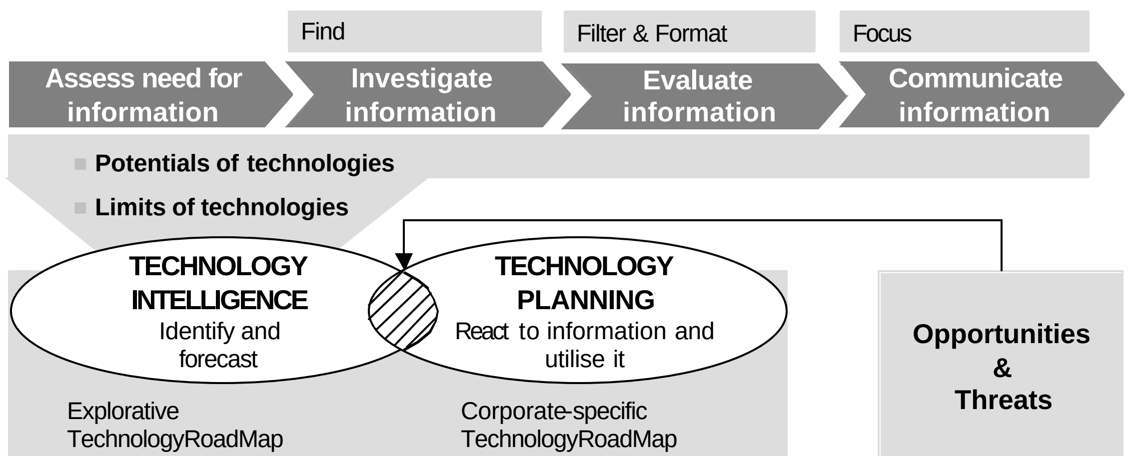

Figure 3: Technology Intelligence – basis for an active Technology Planning

Approaches and scientific background of TRIZ-based Technology Intelligence

For a better understanding of the TRIZ-based Technology Intelligence, three groups of existing approaches have to be explained. These are single methods used for forecasting, for the proceedings of Technology Intelligence, and methods from other fields. The latter ones have been adapted for the described methodology.

There are several methods that can be used to forecast the development of technologies. One way to categorise these methods is the differentiation between normative techniques and technology growth patterns. The latter ones are based on an analysis of past data that is extrapolated into the future using one of many techniques such as Trend-Extrapolation, the S-curve-technique etc. (Porter 1991). The objective of normative techniques is to achieve qualitative statements regarding future discontinuities. Examples are Delphi (Millet and Honton 1991), Relevance Trees (Twiss 1992), the morphological analysis (Twiss 1992, Ayres 1969) or Technology Impact Forecasting (Mavris 1999).

However, connections between these methods or an ability to choose the appropriate method in a specific situation are missing.

On the other hand, there are proceedings describing how to forecast the future of technologies (Klopp and Hartmann 1999, Lang 1998, Peiffer 1992). In general, they all describe the path, shown in figure 3. What is missing is a detailed description of which methods have to be used in what situation and how exactly they have to be used.

TRIZ-based Technology Intelligence is a proceeding including several methods. This methodology can be used if the future of a product technology and it's surrounding is to be anticipated. It helps to identify opportunities and threats of technological developments.

The methods themselves are described only briefly, as there is enough TRIZ-literature (e.g. Altschuller 1984, Mann 2002, Terniko et *al.* 1998) available. It shouldn't be difficult for a TRIZ-expert to adapt to the described methodology. As the TRIZ-methodology uses patterns of excellence, mainly to develop inventive solutions, a few of the TRIZ-methods also exist in other methodologies. These are for example systems theory (Bruns 1991, Patzak 1982, Haberfellner 1999) and design systematic (German: "Konstruktionssystematik") (Koller 1994, VDI 1993, Pahl and Beitz 1997).

Basis of TRIZ-based Technology Intelligence

Figure 4 shows the main approaches used for the TRIZ-based Technology Intelligence to gain the basis for an explorative and system-specific TechnologyRoadMap. These are systems theory, morphology and Technical Evolution. These approaches are more or less part of the TRIZ-philosophy but not exclusively part of TRIZ.

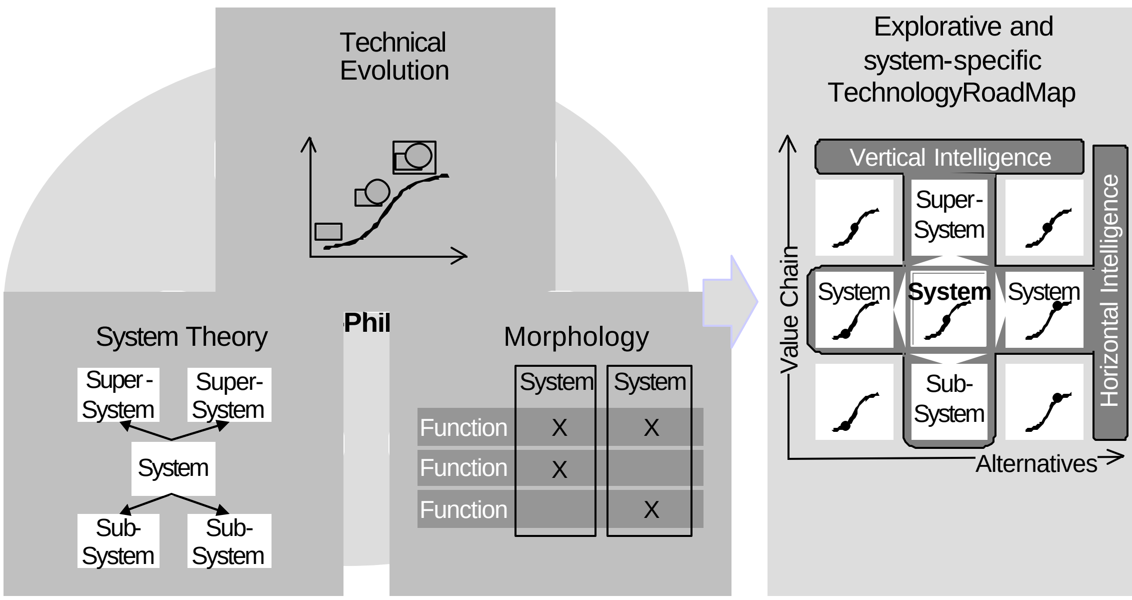

Figure 4: Approach of TRIZ-based Technology Intelligence

Systems theory includes the TRIZ-tools Function/ Attribute Analysis (Mann 2002) and System Operator (9-Windows) (Mann 2002). It is mainly used to define the surroundings to be analysed in order to identify relevant super- and subsystems. In this article, morphology is defined as the search for alternative systems. TRIZ offers, for example, effect databases (Invention Machine 1998) for the identification of alternative systems. For some applications, the effect databases (Koller and Kastrup 1998) or design catalogues (Beitz 1990) related to the design systematic seem more appropriate. Nevertheless, the implicit knowledge of experts or patent and internet research should be used. The third element of the methodology is Technical Evolution. This includes S-Curve Analysis (Mann 2002), Ideality (Mann 2002) and Trends of Technological Evolution, which are also called Patterns of Evolution (Salamatov 1999, Terninko 1998). As S-Curves are used in different approaches (Foster 1986, Krubasik 1982, Twiss 1992), the last two methods are a unique features of TRIZ. These three tools are used to anticipate the future of the relevant systems and to illustrate the assessed potential of alternative systems.

Procedure of the TRIZ-based Technology Intelligence

The TRIZ -based Technology Intelligence followes the procedure described in figure 3: First the need for information has to be assessed. Then the required information has to be investigated. To focus on the relevant information and to make the right decisions, the information has to be evaluated. This should happen at several stages in the procedure to reduce the quantity of information. Finally, the results have to be documented and communicated. The procedure described in this article focuses on the first two phases "assess need for information" and "investigate information".

Assess need for information

The first phase starts with the definition of a product technology. For a clearer understanding, a TFT/LCD-display-unit is chosen as an example of such a product technology (figure 5). The primary function of the technology has also been defined (to show variable images).

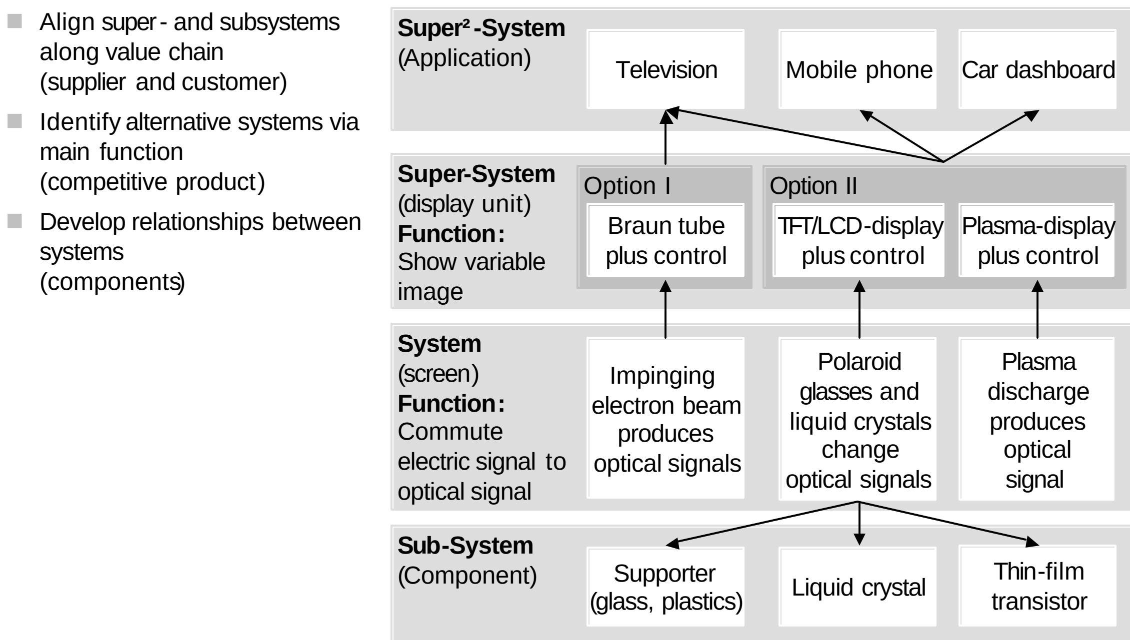

Figure 5: An example of how to analyse the system environment and the alternative technologies

In the next stage, the sub-functions (e.g. to generate light) and the components to fulfil these sub-functions (e.g. neon glow lamp) have to be identified. In practice, intermediate steps may become necessary or some components may fulfil several functions. Therefore, it is quite important that the level of the subsystem is defined appropriately.

This stage was a step back in the value line. The next stage will go forward: Now all supersystems (e.g. mobile phone) have to be identified. This stage can be supported by the marketing of a company.

After these three stages, the system tree as shown in figure 5 can be drawn. The system tree shows the actual state of a company. The approach used until now was the systems theory.

Investigate information

The next stages will expand this system tree by alternative technologies (systems, sub- and supersystems). These include already realised and possible technologies. It is suggested to start the identification of the alternatives on the systems level, to continue with the supersystem and to end with the subsystem. The methods that can be used were mentioned under morphology. To identify additional sub- and supersystems, the systems can be connected between the different levels. An alternative technology probably has other applications (customers), which could become interesting for the company and their technology in future.

Evaluate information

With these results a quite complex system net can be generated, which will prevent overlooking relevant technologies. Practice showed that it is very difficult to draw the system net and keep everything in view. Therefore, it is advised to reduce the system net to the relevant systems that could become interesting or critical for the company. Similar systems/ technologies can probably be clustered. After a reduction, the investigation can be continued.

Investigate information

Now the future of the different systems, sub- and supersystems has to be anticipated. A promising approach is the S-Curve Analysis. If the performance of a technology over the relevant time follows a S-curve and the position of the technology can be defined, the limit and potential of a technology can be derived. This would significantly support the decision to optimise an owned technology or to change the technology (figure 6).

TRIZ offers a method to define the position on the S-curve by patent analysis. Altschuller (1984) found that the number of inventions (applied patents), and the level of inventions followed special curves over the recorded time. These curves are related to the S-curve of a technology and its profitability (figure 5). If it is possible to draw a part of both curves on the basis of patent analysis and probably also to draw the profitability-curve, the position on the S-curve can be derived (Altschuller 1984). This could lead to the assumption that the position on the S-curve can be defined with mathematical accuracy (Clapp 2000, Gibson 1999, Mann 1999, Slocum 1999).

However, as practice has shown, the method is not so easy to handle and as universally valid as expected. The first problem is gathering the data, because patent descriptions are encoded, terms are not used precisely, precise allocation of patents to technologies is complex and obtaining sales data is not feasible for every technology. The second problem is analysing the data, because standardised definition of the amount of inventions is difficult, the determination of the amount of inventions for every patent is a very complex task and the determination of the current position on the S-curve and of the technological limits can only be done qualitatively.

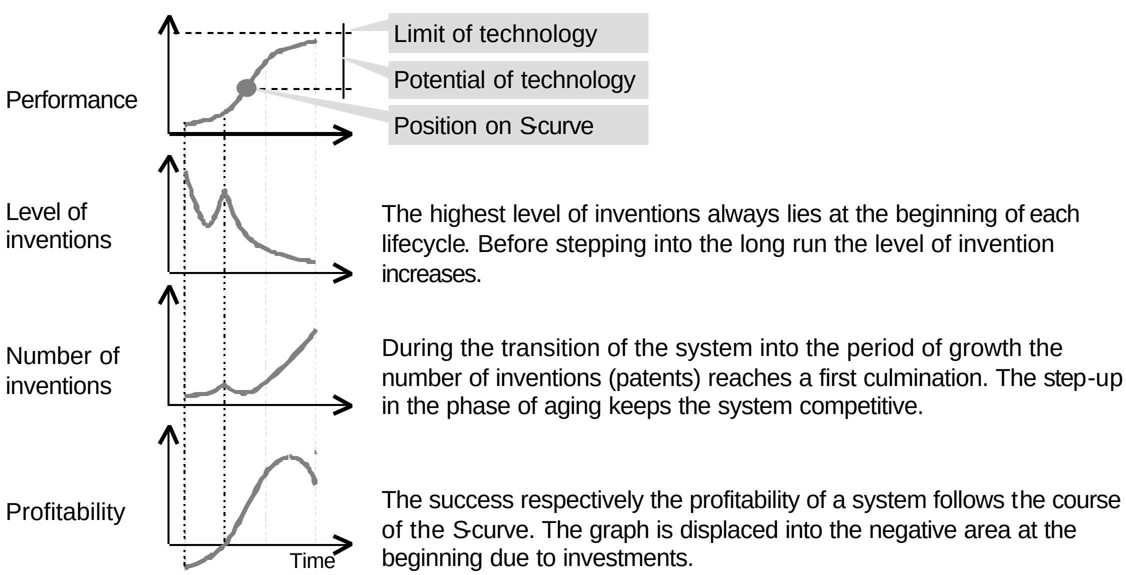

Figure 6: Defining the position on the S-curve by patent analysis

Nevertheless, S-curves are very useful to show the potential and limitations of a technology qualitatively, and patent analysis can deliver useful insights into the position on the S-curve. Additional indicators can be used for positioning on the S-curve. Intensified cost reduction is e.g. an indicator that a technology approaches the end of an S-curve. Additional information that can be used for positioning on the S-curve are for example:

- date of first patent application
- date of market entry
- dates of significant patent applications and technological breakthroughs
- technological limits of individual parameters
- indirect determination of sales volume
- focus of patent application over course of time
  (e.g. increase of performance, increase of efficiency, ...)

The future of a technology and its surrounding can be anticipated by two other methods: Ideality and Trends of Technological Evolution.

With the imagination of the "Ideal Product" the technology owner defines the product of the distant future that would satisfy the customer (supersystem) completely. This Ideal Product is not limited to one customer. It would fulfil the requirements of several supersystems. As systems develop towards Ideality (Altschuller 1984), this trick helps to imagine the development path of a technology. From this point of view, relevant parameters which will indicate the success of a technology can be derived. The question now becomes which technology has the highest potential to get closest to the "Ideal Product" (to fulfil the relevant parameters) and which technology is limited.

As the Trends of Technological Evolution are patterns of development which were observed by many different technological systems, they can be used to anticipate the future of other technologies. Within TRIZ this method is mainly used to generate ideas for future product developments (Terninko 1998). Within the TRIZ-based Technology Intelligence this method can be used to generate ideas for the future of a system and its technological surrounding. It is important to notice, that the Trends will not predict the future of a system, but can help to generate likely visions of the future. Therefore, the Trends have to be applied to the system, the sub- and supersystems and the relevant alternatives.

Figure 7 shows the application of the trend "Dynamisation and use of fields" on the display and one of its supersystems - a computer. The results of this final step are a vision of the technological development of the system, sub- and supersystems and their alternatives.

- Deduction of development directions of super- and sub-systems
- Analysis of the development potential of systems
- Finding of ideas in order to derive future development projects

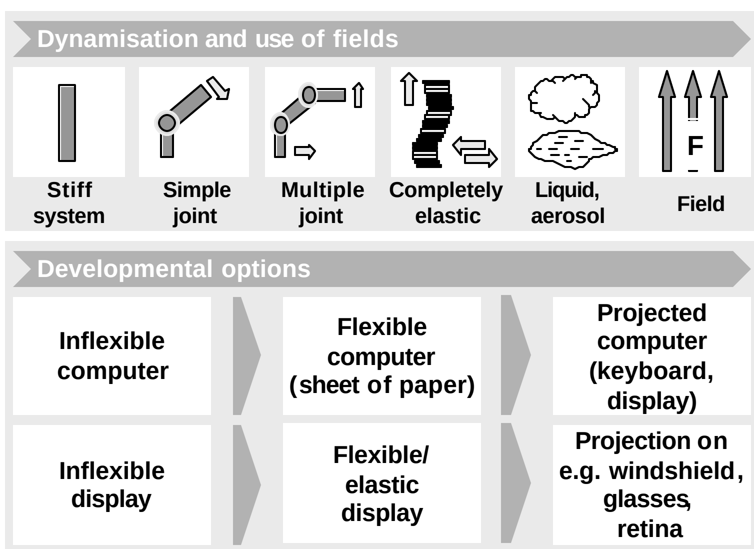

Figure 7: An example of how to anticipate the future of systems via evolutionary patterns

Evaluate and communicate information

When the visions of the future of systems, sub- and supersystems have been developed, these ideas have to be evaluated, documented and communicated. How this has to be done depends heavily on the specific situation.

Regarding the evaluation for example, it will be interesting how likely a vision will become reality and when it will happen, what will be the causes for this and what will be the effects. This knowledge will help to assume the potentials and the limitations of technologies. It will probably also lead to new ideas for product developments.

To gain the full use of this work it is important to realise that Technology Intelligence started at this point. The results have to be documented in a RoadMap – probably by S-curves. Missing information has to be collected. Opportunities and threats have to be derived. The results have to be communicated. Projects have to be initiated. Last but not least, the RoadMap has to be checked frequently and has to be kept up to date.

Summary and conclusion

It has been shown how important it is to provide the technological basis on time in order to secure a lasting corporate success. With this basis it is possible to react to rapidly changing market requirements. To build up the technological basis TRIZ-based Technology Intelligence helps to identify the promising product technologies.

Thereby, this methodology is based on three approaches: systems theory, morphology and technical evolution. Within this framework several methods of TRIZ and related methodologies are used. These are, most importantly, Function/ Attribute Analysis and System Operator (9-Windows), effect databases and design catalogues, Ideality and Trends of Technological Evolution.

It was demonstrated in this article, that TRIZ is an useful methodology to assess the need for information and to investigate these information. Furthermore, it was shown, that the different TRIZ-tools fit perfectly in the process of Technology Intelligence.

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