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Methodological support for prospective studies in New Concept Development

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Abstract

Industrial leaders, in order to stay competitive, take decisions on the basis of estimations of what the future socio-economic environment will look like. Several approaches exist for the conduction of studies sought to make this estimation reliable. We distinguish the classical prospective approach, based on works of French philosopher Gaston Berger and approaches combining the works of G. Altshuller with the theory of logistic growth curves. In order to combine the advantages of the two strategies, we suggest the combination of several tools and methods for the "Opportunity Identification phase" of the cited New Concept Development Model. We then conclude the article with an applicative case study.

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Keywords: *TRIZ; prospective study; strategic foresight; New Concept Development*

1. Introduction

Today industrial companies face the following market related problems [1]: 1. Customers are increasingly demanding improved product performance and willing to replace products in ever shorter life cycles (the latter not being a problem as such). 2. Customers ask for tailor made products which perfectly suite their life style, their spending power, and the conditions they life in. These two problems lead to the issue that companies have to deal

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with ever shorter product life cycles in combination with ever more segmented and rapidly changing final customer demands. 3. Finally, customers pay an increased attention to sustainability, even if this is in contradiction with the need for ever new products. If companies do not operate within Business-to-consumer (BtoC) but in Business-to-Business (BtoB) markets, problems get even worse: the company now has to analyze the future needs of a customer who faces the above mentioned problems but also has to deal with supplier issues, competitors, as well asnational and international regulations. One means to engage the above mentioned problems are prospective studies. "Prospective" or strategic foresight is a study conducted to 'foresee the future'; developed in the 1950's by the French Philosopher Gaston Berger, it is based on decision science and is sought to provide decision makers in both politics and industry with valuable information for guiding key decision processes. It is 'an intellectual approach characterized by an all-encompassing and systemic vision […] [which] considers the future to be the result of free will, which, in turn, is strongly conditioned by human desires, projects, and dreams" [2, p. XVI]. However, even though basic societal motivators (like e.g. wealth, power, love and hate), that are to a large extend responsible for realization of the future, are invariant over time, prospective studies are not easy to conduct and often fall prey of certain biases. One example for such a bias is the overestimation of technological change by ignoring human social needs [2,3].

2. "Classical" Prospective Studies and TRIZ based Approach

Classical prospective studies are often based on a long term analysis involving considerable steering committees. Further, they rely on assumptions like e.g. S-curve like growth processes. In this chapter, an exemplary strategic foresight process will be outlined and limitations will be highlighted. Further the theory of S-curves or logistics curves and its limitations will be discussed.

2.1. Classical process and limitations

2.1.1. Process

Typical prospective studies deal with a mid to long term planning of the future up to 30 years ahead. These studies are generally managed through a specific committee and follow a multiple step process. The typical length of a study, on the basis of at least quarterly committee meetings, is often one year.

The structure of a typical prospective study (an approach used by defense and security authorities was chosen) is the following:

1. Definition of system-intrinsic operational requirements (connected with missions, context, environment and threats to be managed or countered…)
2. Identification of operational background and environment (can differ from "real" background at the time of the study, but the selection of the best (say theoretical) case for the intrinsic purpose of the study is preferred)
3. Functional analysis of requirements, and definition of global functional concepts or solutions. This is realized in order to avoid any a priori or bias due to any further consideration.
4. Proposal of Solutions (concepts and systems) that can fulfill operational requirements listed in step 1, by comparison (by means of e.g. a matrix) between requirements and potential concepts identified and listed in step 3.
5. Comparison and cross-evaluation of solutions (outputs of step 4), using theoretical and/or real operational conditions as defined in step 2. Criteria for choice are absolute or relative performance of the solutions.
6. General conclusions and recommendations (synthetic and detailed) for authorities on preferred solutions, based on step 5. These conclusive outputs have to include technological trade-offs, strategies, organizations and investments to be set up within short or mid terms in order to be able to develop thetechnologies necessary to to realize the preferred solutions.

2.1.2. Limitations

Some of the drawbacks of the above mentioned process, from the perspective of a participant (one of the co-authors) are:

7. The documentation of the study outcome appears in terms of rather large documents which are difficult to consult and interpret (noted as limitation classical process 1, i.e. LCP1
8. The length of the study can become a problem (LCP2) due to, respectively:
   a. Participants can have problems with engaging on an abstract project in this large time frame.
   b. Decisions on project financing can change and thread the overall project.
   c. When decisions have to be made quickly, the study outcomes risk not to be taken into account.
9. The most critical aspect of the outlined process is the lack of methodological support for the generation of ideas for how to deal with a future scenario (LCP3).

2.2. Logistic growth curves

2.2.1. Theory

The adoption of mathematical models to describe the evolution of biological species is well known since the 19th century in sociology, ecology and biology. The model which is mostly used is the exponential model of population growth, that is according to [4] characteristic for populations inhabiting favourable environments at low population densities. In this model, the constant grow rate is defined as (Births per unit of time b – Deaths per unit of time d). Always according to [4], a variety of factors can lead to the extinction of a population. Examples are extreme environmental events, a severe shortage of resources and the loss of habitat. Small populations can be more susceptible to various factors influencing b and d, as the breakdown of social structures in which the species is involved (so called Allee effect). A Logistic curve is a specific kind of exponential law, in which the concept of carrying capacity,

i.e. the maximum sustainable population size for the prevailing environment, is introduced; this limit is typically a function of the supply of resources. Implicit in the concept of carrying capacity is competition among individuals: the competition is called intra-specific if individuals are part of the same species; this phenomenon can affect both the development and the death ratio of a species. Lotka - Volterra equations have been developed in the 1920s for predicting the predator–prey evolution, and this model has been used in order to support technology forecasting [5]

Some researchers have worked on the link between TRIZ theory and logistic curves [6].

According to TRIZ, Laws of Engineering System Evolution (LESE) point to strategies for product improvements which fit to specific phases of the product life cycle. In order to localise a product or a technology on life cycle curves, TRIZ provides a theory [7] based on logistic [8] or S-shaped [e.g. 6] curves.

2.2.2. Limitations

Problems of logistic curves and consequently of TRIZ-based suggestion for product improvement emerge when the product is situated on phase III between the β- and γ- point of the curve, where, according to [7], either a technological change occurs or the technology continues to persist for a long time. According to logistic curves theory [8], the intersection between two subsequent 'niche filling' curves is a chaotic process difficult to predict (Figure 1) (noted as limitation logistic curve 1 LLC1).

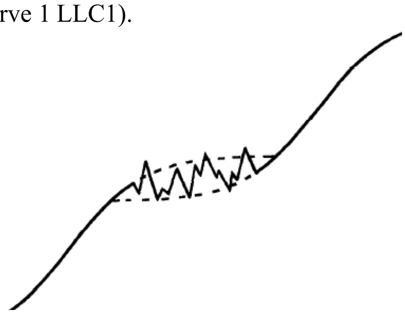

Figure 1: Transition between logistic curves [5]

Other difficulties are related to the Allee effect, that, in biology, indicates the fragility of the development of too small populations, in case of major external events. In order to apply this concept to technologies, an estimation made by some authors [9] suggests a minimum market share of 10% to be taken into account. This fact strongly limits application of the theory to emerging technologies (LLC2).

3. Application of prospective studies to industrial activities - New Concept Development

Besides the analysis of existing approaches, it is important to identify their importance for industrial activities. For research and development departments, technology forecasts serve one major purpose, New Product Development (NPD). As such, the prospective activity can be seen as part of the fuzzy front end of NPD. Koen and colleagues [10] provide a framework called New Concept Development (NCD) Model, which identifies five elements, the latter of which features close interactions with the NPD process. The five elements are:

1. *Opportunity identification*: The organization identifies technological and/or business opportunities which it wants to pursue. This can range from the development of a new business to the improvement or extension of a product (line).
2. *Opportunity analysis*: The previously identified opportunities are analysed further and are put into a technological and market context. During this step, major trends and first market estimations are carried out in order to seize the attractiveness of the respective opportunities.
3. *Idea Genesis*: The generation and iterative maturation of ideas about how to reach the previously identified opportunities occurs during this stage. Contact with other departments of the company as well as information about the customers' requirements are necessary.
4. *Idea Selection*: During this step, the company or the NPD team decides about which of the ideas generated in step 3 are chosen for further consideration. According to Koen and colleagues, due to the limited amount of reliable information, the selection process has to be 'less rigorous' (p. 51) than it is the case during the NPD process.
5. *Concept and Technology Development*: The last element involves the design of a concrete business, including cost estimations, quantified customer needs and investigation into unknown aspects about the chosen technologies. This element actually is sometimes considered as the first stage of the NPD process.

Unfortunately the model presented here gives only few indications about both its implementation and the methodology to use during the different steps (noted as limitation New Concept Development 1 LNCD1). In the authors' opinion, however, there exist powerful tools, stemming from TRIZ theory and its derivatives as well as from other innovation methodology, which help to carry out each of the NCD steps and which help to reduce a number of uncertainties the NPD team has to deal with.

4. Updated Approach for tackling identified limitations

The approach which is presented here allows overcoming most of the limitations of the classical and the logistic curve approaches which have been mentioned above as well as providing an enriched approach for Opportunity Identification:

LCP1: The documentation produced during a study realised with this approach should fit on a limited number of easy-to- use tools which are dominated by an integrative SOT sheet with hyperlinks to external documents.

LCP2: Using the presented approach in a highly concurrent manner, it should be able to perform a study in a few weeks. LCP3: Other than the classical process, the presented approach uses TRIZ tools which provide valuable methodological support for problem solving and idea generation.

LLC1: The combination of the SOT and the scenario analysis (SMIC) provides important information concerning e.g. the development of resource availability, which is important for the transition between logistic growth curves.

LLC2: The integration of sector experts for the crossing different developed scenarios the analysis of value chains using SMIC method and the RELEvent method [15] (Figure 2).

Concerning the LNCD1, tools from the TRIZ complex are already adopted and provide valuable support. However, the phase of opportunity identification is an exception. To the authors' knowledge, a systematic method for the application of TRIZ-based analysis tools has not been described in literature until now.

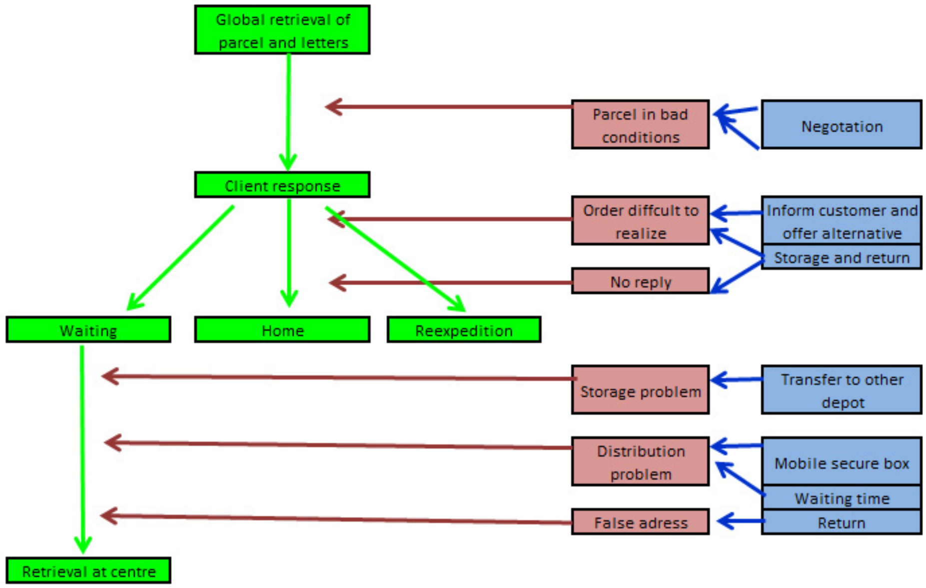

Figure 2: Example of the application of the RELEvent method

The opportunity identification phase consists essentially of three parts: the analysis of the business problem, the definition and analysis of the product or service, and the definition of socio-technical boundary conditions.

Often, business units are confronted with rather diffuse problem settings. Managers are required to develop business concepts which align corporate strategy with customer requirements by creating knowledge and value in order to generate sustainable profit. However, for managers, it is often difficult to generate a clear and easy-to-understand description of the problem state, the latter being a key requirement for a business development process. The method "task analysis" [11] from Synectics provides a good tool for the identification of the real nature of the problem, providing a quick alternative to ARIZ Step 0 suppressed from the latest official version of ARIZ85C [12]. Together with the TRIZ concept of the Ideal Final Result, a thorough problem statement can often be established within less than one hour. This stage allows the integration of relevant business management knowledge to the NCD process.

From empirical cases, one can identify one key question which results from Synectics Task analysis: How to predict future market requirements and future technological boundary conditions and how to align inhouse R&D and open innovation [13] processes in order to be able to propose the product or service the customers asks for in time? The first and the second TRIZ law of the evolution of technical systems have been used to carry out both a descriptive and prescriptive analysis of the products and services under investigation as well as a benchmarking with respect to current competitor products. The use of the system analysis tools allows the integration of technological knowledge into the NCD process.

The System Operator Tool (SOT) is known for its capacity to facilitate a socio-technological foresight at the desired degree of detail. However, the value of the conclusions of this type of analysis depend to a large extend to the reliability of the underlying assumptions. In order to improve this reliability, the combination of foresight methodology and TRIZ tools can be of value here.

For instance, it is possible to use the SMIC method (French acronym for Cross-Impact Matrices and Systems) [3] in order to assign probabilities to a certain number of scenarios if the latter are the result of the combination of several hypotheses. Special software (e.g. SMIC Prob Expert) allows the determination of scenario probabilities based on the probabilities given by the experts (Figure 3). Once, a manageable number of scenarios which incorporate a certain number of hypotheses are obtained, the identification of (1) super trends, (2) business and technical contradictions (3) and product usage environments with constraints is possible.

Figure 4 provides an overview on the Opportunity Identification phase and Figure 5 exemplifies the Scenario Analysis which represents the basis of the SOT analysis.

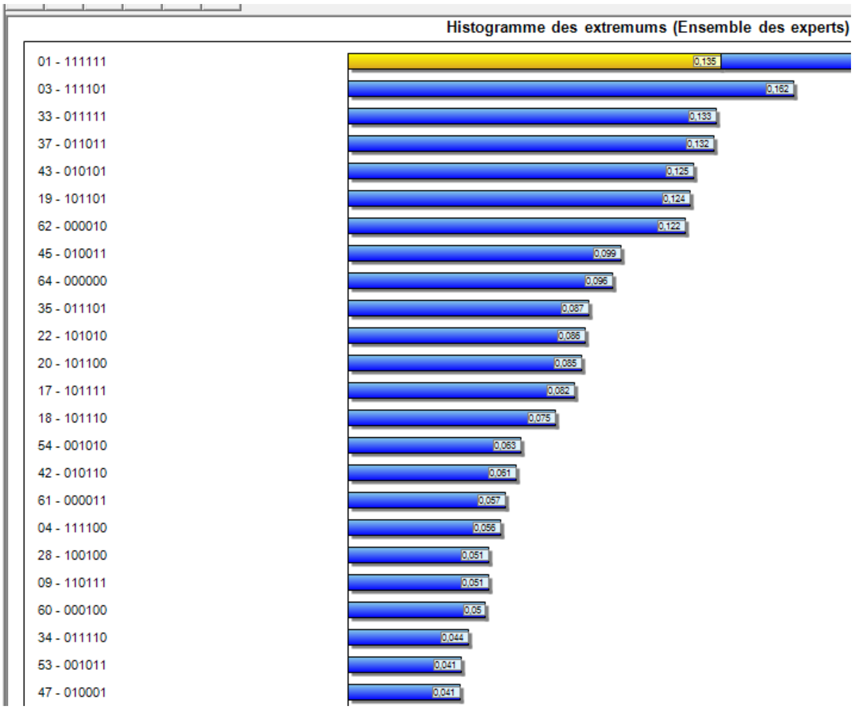

Figure 3: Probability of scenarios resulting from combinations ofhypotheses [13]

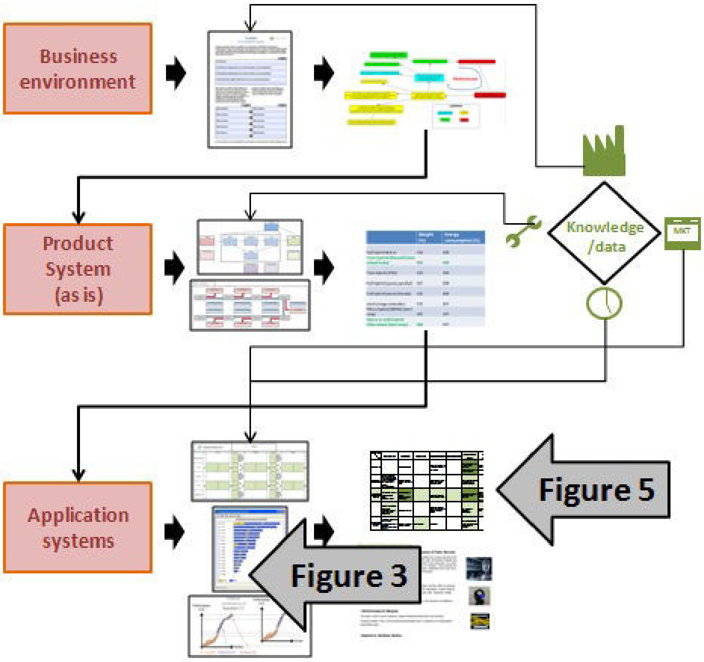

Figure 4: Overview on the Opportunity Identification Phase of the NCD process

Contexte / Tendances	Manual writing / prestamped postcards	Development of Robots	BtoB/BtoC Client visit	Strong BRIC development
Reruralisation	Recours éventuel à cette méthode de communication en cas de défaillance des réseaux (électricité, téléphone...) suite à une catastrophe climatique	- Letters and packets are distributed by robots in rural regions (je n'y crois pas; OK pour un tri robotisé, mais pas la distribution, trop complexe à programmer!)	- Infrastructure must be adapted - Business taxis - problèmes de coût et rentabilité des déplacements en cas de crise grave de l'énergie	- Delayed reruralisation - Space problems for China and India
Reduction of public services		- Automation of services (robots) --> hospitals and luxury niches	Développement de réseaux de transport/distribution privés, voire intégrés à l'entreprise (pour une communication sûre avec ses filiales par exemple)	- Problematic infrastructure --> packets and letters are harmed - Organized crime that steals packets - Pirates
Sustainable development & Recycling	Papier à lettres recyclé permettant de soutenir une cause (reboisement, protection d'espaces sensibles...)	- Robotic distribution consumes more energy? - Emballage robotisé direct au bureau de Poste (à base de carton recyclé)	- Virtual client visites - Advertissement boards BtoC or BtoB - Electronic display on letters (Samsung) - Optimisation ciblée du publipostage visant à une rentabilité maximale	- Need for sustainable transport strategies in poor infrastructure - Adaptation to agglomerations - Développement de véhicules à faible coût énergétique (voire transport animal) pour
		- Automated recycling into the desired product or	- Small post office at home	

Figure 5: Table of scenarios which combine two socio-technological hypotheses

5. Case study

In order to identify future business opportunities to increase the diversification of a mailroom equipment manufacturer, the following process was carried out.

1. Based on the Task analysis questionnaire, the problem owner, the innovation director was interviewed with respect to: (1) the Ideal Final Outcome of the project; (2) the problems to solve, once this outcome is generated, (3) alternatives to the solution of these subsequent problems; and (4) perceived key obstacles with respect to the achievement of the Ideal Final Outcome. The responses to the questionnaire allowed the joint identification of project goals and deliverables.
2. As it had been decided to base the project on current technological and business strength of the company, the project team was able to use the results of the system analysis study which has been carried out in a previous project. These results confirmed the need of the company to develop new business solutions because current products and services are related to technological (super) systems positioned in stage III of *the S-curve*. TRIZ theory provides the following strategies for the improvement of such systems in accordance with the Laws of System Evolution:
   a. Make the system more adaptable in order to better reply to the super system's changing requirements
   b. Focus on market niches where the system stays competitive
   c. Use resources stemming from the super system
   d. Integrate new functions in order to add value

3. In order to identify the changing super system, i.e. future markets and usage environments, the project team carried out an extended Multi-Screen Analysis. In order to identify future socio-economic super systems with a high degree of certainty, essentially two types of 'resources' were used. First, a sample of professional 'imaginators', i.e., in this case, five professional science fiction authors, some of them having professional prospective experience and a specific geographical location, were asked to provide insight on future mail systems; later on, there of them were invited to specific development workshop. Second, SMIC-Prob Expert methodology and software was used in order to establish a list of the most probable scenarios based on seven hypotheses like e.g. remote working or focus on BRIC countries

For the most probable scenarios, science fiction authors were asked to provide the workshop participants with a story telling which describes either the day of customer or the working environment.

6. Conclusion

As only the first stage of the NCD process, i.e. opportunity identification, is directly concerned by the prospective approaches, the present article will not detail the application of other tools in order to conduct the whole process. However, it shall be mentioned that the outcome of the first stage, i.e. a limited number of highly probably scenarios are very important for subsequent phases of opportunity analysis by analysis of technological problems (using e.g. the RELEvent method [15] or the contradiction models); idea generation (using e.g. TRIZ-based semantic patent search engines like FBOS [16]); and concept and technology development, for which a plethora of models and methods exist.

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