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THE CONTINOUS "FUZZY FRONT END" AS A PART OF THE INNOVATION PROCESS

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ABSTRACT
This work treats the method of creating and the importance of developing new product concepts as a basis for the future products development. Changes occurred in recent years have influenced shortening product's life cycle. Very intensive development of technology and market has significantly affected the process of new product development. Opportunities and ideas have become the main factors for the success of the new products. The basic criteria imposed in this process are to avoid mistakes by selecting weak concept that will engage significant product development resources and will not meet the expected market needs and expectation.
Idea generation and evaluation should not be considered only in a Fuzzy Front-End of innovation process but in today's condition it is necessary to be considered as a separate, continuous process with the task of analysing the opportunities and ideas and creating a satisfactory number of concepts for the future products with good market potential. Some of the information presented is gathered during the research and participation in the process of creating new products.

Keywords: Fuzzy Front End, Innovation process, Idea management, Product development

1. INTRODUCTION
Up until the second half of the 1990s, the need for new products was dominantly derived from entrepreneur, technology and market. A change occurred while moving from the information revolution to the practical phase could also be called a communication revolution, and the focus being directed towards products defined by social requirements and processes. In some papers quite a few years ago [1], we come across analyses and announcements of trends in shifting focus of innovation management (Figure 1).

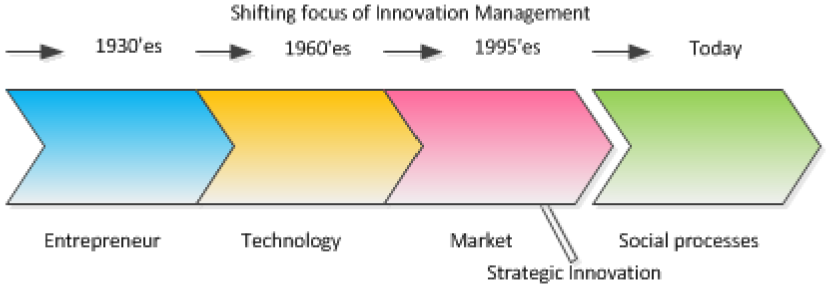

Figure 1. Shifting focus of innovation management (based on [1])

The communication revolution, which has brought the massive use of mobile communication resources (mobile telephony, mobile internet, etc.), has result in a situation when users have a new way of looking at all products. The perception of a permanent flow of everything and everywhere has created a whole series of habits and desires for permanent access to all other products and the searching for products that should satisfy completely new needs. Taking into account that technological leap has occurred; the essential implication is a leap in characteristics and possibilities of new products. It is no longer necessary only to develop improvements in existing products, but also to create the products that will be used in series with other products as well as products that are presented as radical changes on the market [2], leading all the way up to the need to create products that may be simply changed and upgraded (flexible product development) [3]. Strong communication links caused a strong social movement that, in the first instance, has emphasised the problem of sustainable existence and thereby initiated a new cycle of requirements for products containing totally different

characteristics in terms of efficiency and ecology. The manner of the already known movement and creation of products becomes gradually increasingly less useful. A good product implies not only acceptable functionality and added quality, but also the need for developing changes in materials, technologies and possibilities of exploitation and disposal. All of these are properties that stimulate the need for innovation. The innovative processes become the basis of a manufacturing existence while the possession of such products becomes the basis for competition. Companies that do not have products based on new inventiveness possess a clear path of extinction. As stated in [4], "*the future of innovation is bright: there is no future without innovation! Most known inventions, methods and products will ultimately be overtaken by new innovations, new methods and new products.*"
In the increasing acceleration rate of change in needs and habits, a significant increase is also in the utilisation of the product itself. The continuous reduction in product life cycle and the constant development of technology create business opportunities encouraging buyer needs for rapidly changing products. According to research [5], [8], a great difference between winners and loosers on the market actually occurs due to the quality of implemented preparations in a product development. The earlier phase of product development importantly determines how the product will be realised in terms of price, lead times and market success. This early phase is often called the "fuzzy front-end". Research [6], [8] has shown that only 6% of costs and 16% of time consumed relates to the initial phase of product development when compared to the total development of a new product. When successfully compared with poorly realised products, the result suggests that mistakes in the early phase have brought about increasing total costs a number of times. Studies show 70% of products life cycle are determined during the crucial product definition phase and that new products, not brand extrensions, have the biggest impact on a company's bootom line [7]. The recognition of new technologies, new needs, trends and future development processes can no longer be bypassed or considered only as an initial phase, especially when taking into account that an erroneous result in the initial phase may utilise all work resources on a product development with no future.
This paper considers the effects of product development in its early phase, which ends in the conceptual design. In brief, a summary of the development process models and engineering design process is presented along with the related key factors. Further on, presented are also research results and practical work covering a number of years that have resulted in the development of particular models, processes and procedures through development of a larger number of concepts and products in the area of telecommunications, multimedia, IT industry, mechanical engineering, construction industry and tourism. The presented results have the primary goal to encourage consideration and research in the segment which was due to its informality, unstructured manner and absence of a single tool for comparison, inadequately considered within engineering community.

2. LITTERATURE REVIEW

In order to standardise and protect its innovative endeavours, companies develop models for developing products and processes. These models often contain important common factors. The first models often arrive on the basis of practical experience and knowledge shown in "best practices". The scientific community creates new models, by analysing the existing models and scientific validations of their advantages and inadequacies. This is a continual and iterative process. In regards to today's position, we can assume that we have at our disposal tens and hundreds of process models [9]. The literature most often presents all the processes and builds on the basis of definition-process-verification. Consequently, almost all the models we know, depending on the type of process, may be viewed as iterative models for an innovative process resulting in a particular view on product or process features.

2.1 Process models – brief summary

A short overview of process models will begin with the recently mentioned distinction [3] of models based on origin of model into four groups:

- Descriptive models – Description and evaluation of actual practice
- Normative models – Recommendation of an ideal process
- Management tools – Visualization and systematization of development activities
- Didactic model – Visualization and simplification adopted for students

Besides this grouping according to the origin of its existence, process models are often categorised according to the time of their origin, and to the parameters that were taken into consideration. In the literature, therefore, find that some authors [10],[9] view process models in a different number of phases. According to the time of development the models, we can undertake viewing in a number of time phases, but the important step can be identified in the last twenty years. Here, we will not be involved in presenting particular models and their characteristics, but will instead mention some of the more important representatives. The phase-review processes [9] are characterized in phases and at the end of each phase a management review is conducted with a decision undertaken further on. These models do not afford special attention to technology and the market but are primarily directed towards the process itself.

The descriptive process model [11],[9], takes into consideration the current state of technical knowledge and the current state of market and social impact, developing the process model according to the principle of: problem recognition-idea-formulation-problem solving-solution. In comparison to the previous, which is more conceptuall, a stage–gate process model [9],[10] contains a number of concrete recommendations for process implementation. It is characterised by the initial idea and process implemented through a five-stage level (Scoping, Build Business Case, Development, Testing and Validating, Launch) between which are the gate levels (Quality of execution, Business rationale, Action plan, Delivery) and validation through the each gate phase existing according to the principle of go-kill-hold-recycle. Besides mentioned, it is important to state the normative process model [12],[9], the modified state–gate process [10], simultaneous development phases model [9], value proposition cycle [9], technology and product development process [9], scheme of the innovative process [8], process model including failures [13], process model including requirement specification and functional specification [9].

Most often, most the models have issues regarding orientated models that exist in a sequential series through a number of mutually divided phases and used solutions to partial problems, attempt to arrive at a complete solution. Each phase is more often interrupted by a validation procedure that verifies how successful the previous step was resolved and is it possible to move on to the next step. All models possess a significant level of structure and organisation and may be used as a starting point in considering not only general but also engineering issues.

2.2 The engineering design process

The engineering design process finally determines characteristics of the future product in all the details. This process may begin from the existing product and existing experiences but also from altogether new concepts seeking to be converted easily into new products. It is regularly innovative, and often, but not always, a creative process, depending on the level of appropriate new ideas and solutions.

In the literature we can found a whole series of processes that define the methodology in engineering operations. In principle, they occur from previously considered process models. They are characterised by sequential phases whose implementation using directed procedures arrives at the result –the product.

Using a mode simple presentation, the majority of process models considered were viewed as an engineering design process and may be presented using five characteristic parts: Identifying a need, Analysis of task, Conceptual design, Embodiment design, Detailed design and Implementation [14][15][16]. This process is often known to be inadequate in technologically demanding projects.

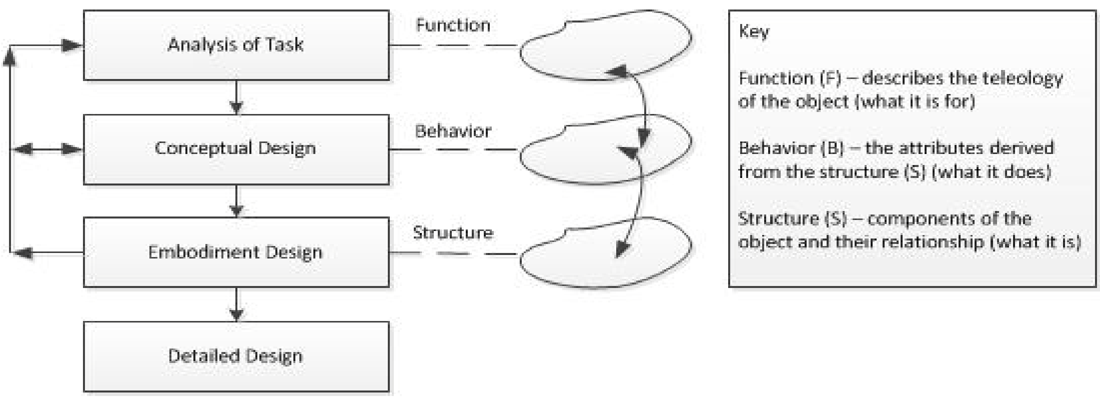

Figure 2. Relationship between the linear design process and FBS [16]

Takening the above into consideration, Gero [17] has developed a framework which replaces the evident inadequacies in particular technologies areas. The link of Gero's FBC framework and classical engineering design processes is presented in the stated paper [14][15][16] and is shown in Figure 2. From mentioned, are quite evident the links to the particular phases and particular frameworks of expected values, which is as a result necessary to define.

Besides the mentioned above, there also exists a significant number of other approaches and models. Of course, the knowledge driven design process C-K theory [18] can in no way be neglected, which is based on the central premise of linking two areas: the Concept area and the Knowledge area (a space of concepts C and a space of knowledge K). This relational model analyses the possible four relations between the C-K areas consequently leads to results and concepts.

This in no way concludes the list of very valuable works in the domain of engineering design process, but due to the characteristics of this work, it will not be further considered. The presented models have been chosen mostly due to their relationship and impact on practical experience.

3. THE PRACTICAL REVIEW

In this chapter we analyse some of the practical situations that have encouraged the drawing up of this work, and have occurred as a result of implementation and modification of known models and processes for some practical cases. Analyses of innovative process and its particular phases will be taken into consideration, followed by practical variants of fuzzy front-end in terms of the engineering design process and one non-linear model in the concept creation of a future product. The final section of the chapter presents an analysis of utilised metrics in validating ideas taken from the context of metrics of ideas for a particular IT education product.

3.1 Fuzzy Front End and Innovative process

What is the innovation? In order to use this term, we shall state one of the numerous definitions [19]. *"The design, invention, development and/or implementation of new or altered products, services, processes, systems organizational structures or business models for the purpose or creating new value for customers and financial returns for the firm."*

An innovative process, in terms of engineering, is most often initiated by the development of technology and/or by the market. Most of the first instance involves a pushed process while later it implies a pulled process. A pushed process is based on existing or newly invented technology, that the organization has access to, and tries to find profitable products to use this technology. A pulled process tries to find access where customer needs are not met, and then focus development efforts to find solutions to their needs [26]. To succeed, understanding of both, the market and the technical problems, are needed. [25].

The innovative process may be divided into three basic areas: the fuzzy front end (FFE) of product development, the new product development (NPD) with product requirements set and commercialization [20]. The first area, FFE, is the basis and nucleus of every process in creating a new product. It analyses and determines the manner in which a particular technology is to be applied, the resources to be used and what ideas and how will they be realised. It is the phase between first consideration of an opportunity and when it is judged ready to enter the structured development process [20]. It includes all activities from the search for new opportunities through the formulation of a germ of an idea to the development of a precise concept. The majority of previously analysed process models view this area as an initial or zero phasees in the innovative process.

And, while the NPD area in most process models is exceptionally well treated, the FFE area is much less treated with a significantly less number of practical works and research. FFE, is not a very expensive field, however it may often consume considerable time in the process and lead to erroneous decisions. It is especially important since it is responsible for determining the time and costs in developing a new product, its functionality, application and final appearance. Therefore, FFE cannot be viewed as "something prior to something else" but as a crucial factor responsible for a future new value. On the following figure, one of the possible concepts of an innovative process result is presented which is a new product on the market and the main characteristics for the particular area.

As shown, the basic characteristic for FFE is that it is an unstructured, unpredictable, and chaotic process. In comparison to FFE, NPD is a structured, predictable, and formal [process 20]. The starting point for FFE is the opportunity to be shown through the opportunity or idea definition expressed in the idea generation process, while the final result is the concept as a basis for a continuation of the process. In order for further consideration to become clearly, we mention one of the definitions for these three terms: opportunity, idea and concept [20].

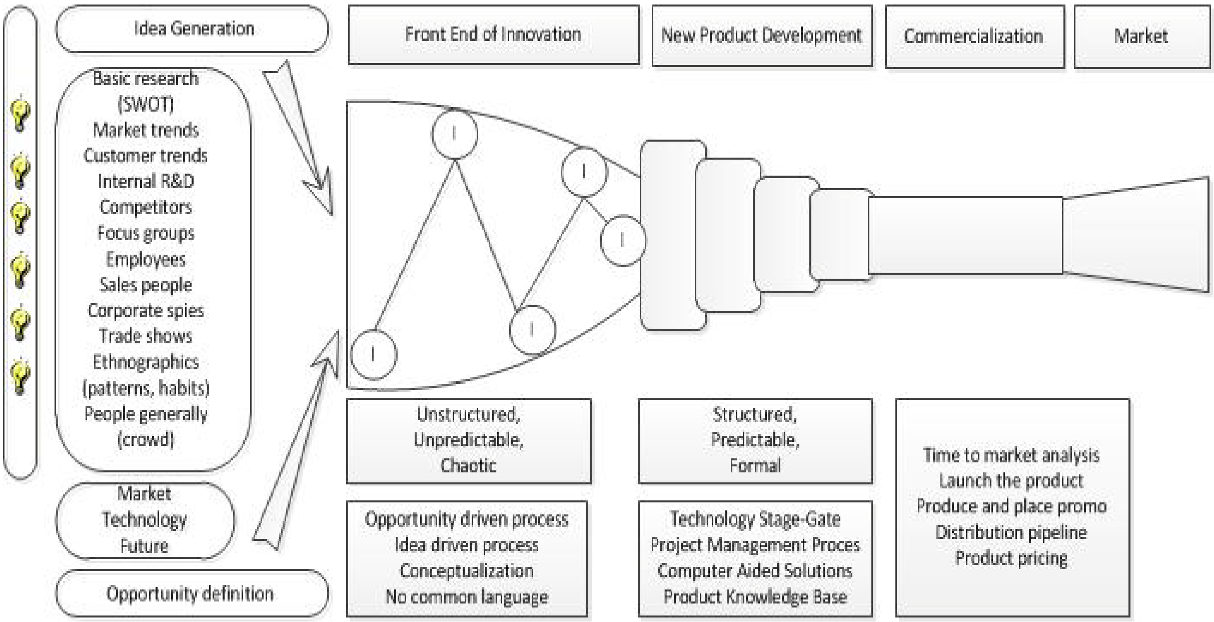

Figure 3. The innovation process (baseod on [20])

Opportunity: *A business or technology gap, that a company or individual realizes, that exists between the current situation and an envisioned future in order to capture competitive advantage, respond to a threat, solve a problem, or ameliorate a difficulty.*
Idea: *The most embryonic form of a new product of service. It often consists of high-level view of the solution envisioned for the problem identified by the opportunity.*
Concept: *Has a well-defined form, including both a written and visual description, that includes its primary features and customer benefits combined with a broad understanding of the technology needed.*
In practical situations which this paper refers to, there were situations and various opportunities that initiated consideration of new product creation. They were most often prompted by particular situations on the market and following dominance or accessibility of particular technology. Furthermore, we considered also products whose basic opportunities were the creation of particular changes in habits and perceptions of our buyers (software, new TV formats). On the other hand, the idea to be validated came from many sources. On the previous figure, areas are specified that allowed us to acquire ideas and the ability to use them in various software for gathering ideas as a reference point in the creation of ideas. The initial idea is most often the result of brainstorming, 6-3-5 or some other similar method of quickly generating ideas, while all other subsequent ideas may possess various sources. Naturally, gathering and basic evaluation of ideas would be altogether practically impossible to carry out without appropriate computer support (appropriate software, databases) and the ability to successfully communicate between the creator of ideas and the evaluator.

3.2 Front End of Innovation and Engineering Design Process

As indicated in (Figure 2) and presented in the works [16], there exist practical links between engineering design process and the FBC framework with results as expected during the particular process phase.
In Figure 4, one of the possible interpretations is presented linking the classical engineering process model, the FBC framework and the product development phase.
The phases of the classical model known as the Engineering Design Process are divided into two areas. We have called the first phase the *Front End of Innovation* or *New Product Designing* process and the other as the standard *New Product Development*. For the complete process we use the term *New Product Creation*. New Product Designing is viewed as a separate process and not only a phase. The phase is the rudimentary remain of the term from methodology viewing this complete procedure

only as a single pre-phase or pre-action for some other procedure. The changes that have occurred during the time in which the NPD area (Figure 3) has become structured, predictable, and formal for which exists a whole series of developed support tools (CAx and other tools). Since we have decided that the area Front-End is not only an entry into NPD but instead an essential factor in forming or not forming a successful future product, we have also decided instead of using the term "fuzzy Front-End" to use the term "Front End of Innovation" when we observing the process or term of "*New Product Designing*" under the conditions that involves only the product.

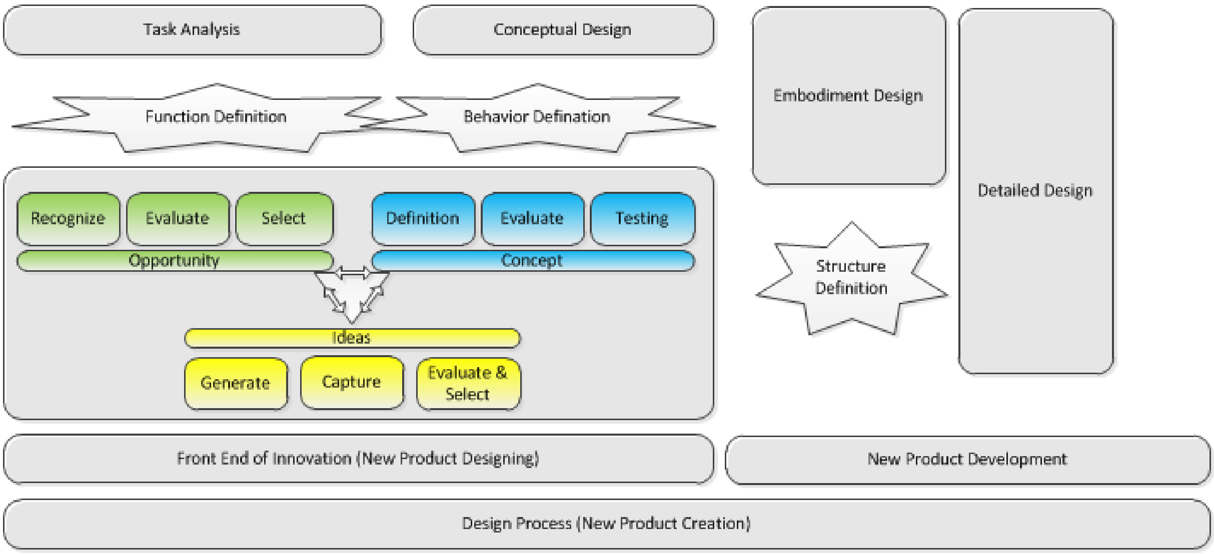

Figure 4. Front End of Innovation as a part of Engineering Design Process

The part Front End of Innovation deals with the consideration of opportunities and ideas. Using evaluation and selection of opportunities, ideas are analysed that may contribute to the realisation of an opportunity. Ideas are gathered in a great number of ways and for this purpose various sources are used. During the evaluation procedure, the chosen ideas that can significantly improve an opportunity and add a new value to a product. The product is created using a definition and development of concepts. Special attention is to be given to the concept evaluation and testing.

The fundamental task of the Front End of Innovation is to not allowe a poor concept to become a basis for continued work and development of a product.

NPD is a unit that requires significant resources and is surpassingly more expensive than the previous unit. We were often in a situation to see that only an additional iteration in the development of concepts would significantly contribute to improving a product, whereas the previous concept version assumed all resources in the need could lead to the failure.

3.3 Concept development model

During the work on the NPD concept, often exists the situation where it is not possible to carry out the process sequentially. In an environment containing much data and influencing parameters, there is an exceptionally strong interdependency and need for continual validation and adjustment. The sequential approach often resulted in a model similar as when in communication we exchange a word during a one hours. Therefore, it was logically deduced that the process Front End of Innovation resulting in the concept of product is in fact a single continual process with permanent interdependency between the particular processes and decisions. Taking into account the observed works [16] in which the Integrated Creative-Design Process Model [20] was presented the NCD (New Concept Development) model, considerations continued. Some requirements in developing product concepts which we were to treat in the realisation phase as final products has led us to particular data whereby we have adjusted the observed the model to the requirements (Figure 5).

The model intentionally uses a hexagon and not a circle, taking into consideration that the circle is an ideal form and the model itself is not. As is the case for the initial model [20] and here the basic structured is retained, in the centre is the Decision Area, the decision-making and responsibility area. They are representative for leadership, culture of innovation and business strategies. They are in a continual iterative process through accessible knowledge and communicate with three segments: the opportunity management segment, the idea management segment, and the concept defining segment. The opportunity management segment continually endeavours to carry out the definition of new opportunities and selection of opportunities which are appropriate for a product. The idea management segment continually carries out idea definition (gathering and validation of ideas) and idea selection of ideas appropriate for improving a product. The concept defining segment is continued for observing opportunities and ideas as the initiator of the process implements the development of concepts (technical, marketing, etc.) and the evaluation of the concept of procedural testing. The concept that has passed testing becomes the output concept for the continuation of the new product development.

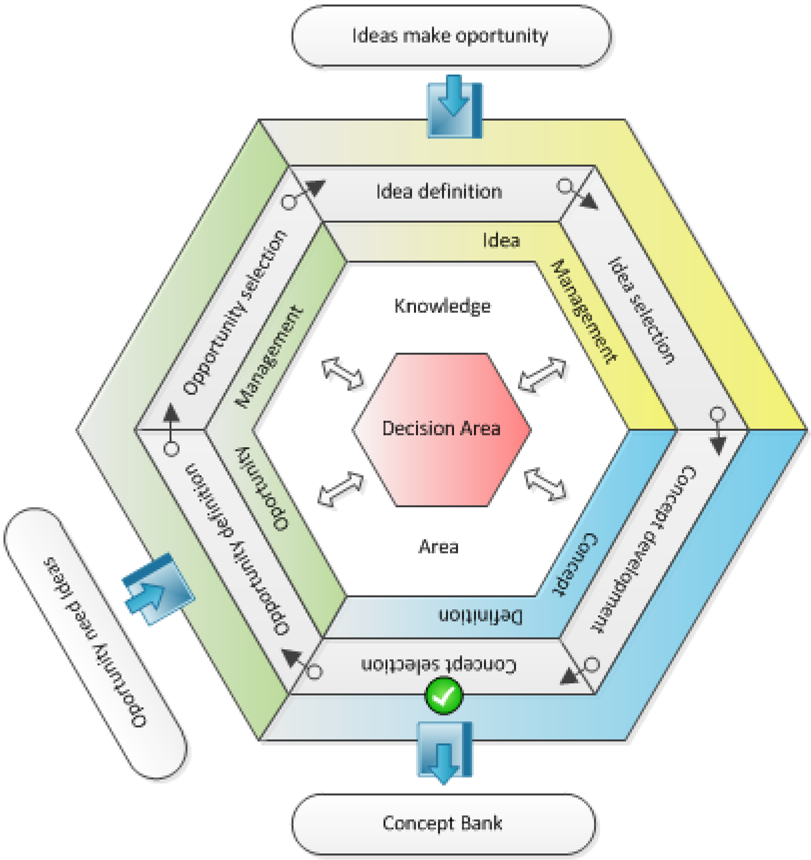

Figure 5. Concept development model (relationship model, based on [20])

We find it significant that in the model the full concept evaluation and selection is especially observed in this very phase of its creation in order that as a process result it may be observed as an independent concept appropriate for a continuation of the process but also for some future realisation.

3.4 Idea management

An especially important factor for successfully creating the concept of an innovative process is qualitative idea. Perhaps it is not always essential to think of a Nobel Prize winner Linus Pauling that was very often true: "*The best way to get a good idea is to get a lot of ideas.*"

Ideas became the turning point that ensures a good concept and good product. Gathering ideas is considered through the following five steps: Generate new ideas, Capture ideas, Evaluate ideas, Develop ideas and Launch ideas [21]:

Generating new ideas is an important factor due to at least two reasons. First, a large possible spectrum of ideas carriers are to be taken into consideration and allowed to implement in a particular manner motivation in presenting ideas. The other important aspect is the need for exiting regular sources of ideas that have often become self-limiting factors of creativity.

Capturing ideas is a procedure that is initially bidirectional. Capturing ideas essentially requires the presence of computer support by utilising a system of appropriate interfaces with minimal loading for the person accessing, and appropriate databases. It is important to incorporate a bidirectional path in the idea gathering procedure, and ensure feedback communication with the aim of improving ideas, treatment of ideas or notices for accepting / rejecting ideas.

Evaluation of ideas is a very important procedure that becomes particularly significant in systems which generate an enormously great number of ideas. In such situations, poor evaluation systems often lead to neglecting very good ideas.

Development of ideas implies the ability of the system to send gathered ideas for further development, either to conceivers of ideas, or for developing utilisation of parts from a number of ideas.

Taking into account the previously stated steps, we had more or less successfully implemented the capturing of ideas.

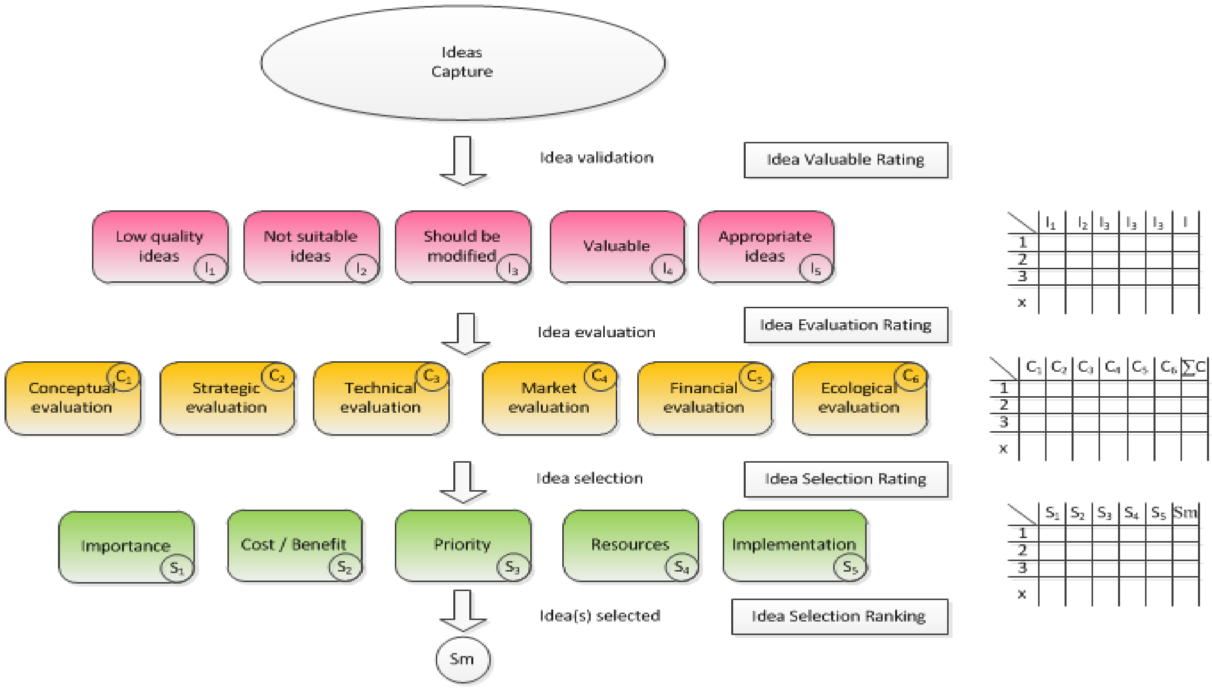

Figure 6. Idea management – how to select ideas

In order to utilise successful ideas, it is necessary to implement an adequate validation of ideas. This is the biggest and most fundamental problem in all systems used for mass data gathering. It is possible to use a number of methods in measuring gathered ideas, their quality and quantity [23]. Most often utilizations are evaluation of acceptable, non-redundant ideas and ranking of ideas in selected groups [22]. Some research uses also “linkography techniques” [24] which are based on the connection between ideas and measuring mutually related ideas.

Gathering ideas was primarily validated according to values for observed product concepts using the evaluation method on scale of 0-5 (Idea Valuable Rating). Zero is an eliminating factor while only the highest marks at 4 and/or 5 are taken into consideration.

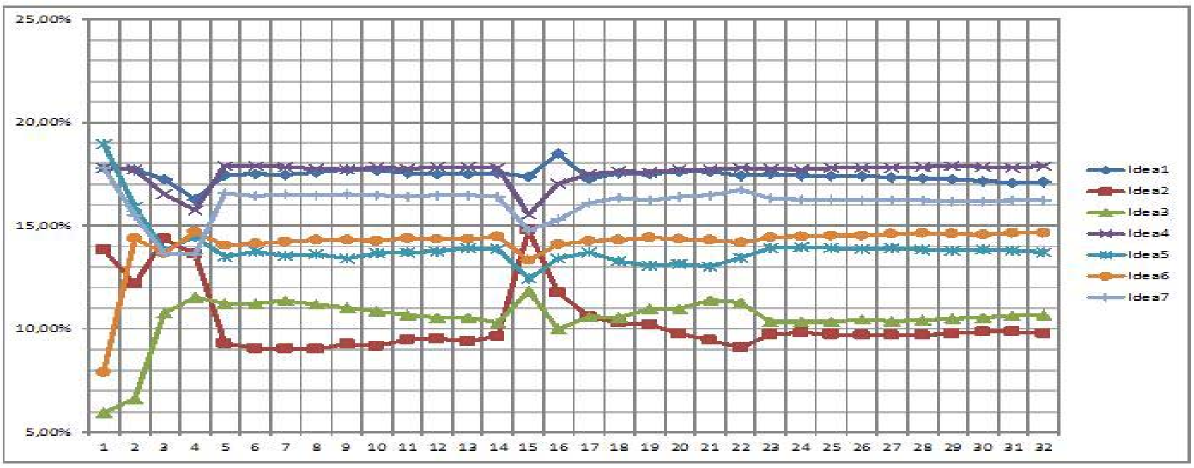

Figure 7. Idea selection – convergence as an aid in selecting

Following implementation of validation, evaluation of ideas is carried out using the given subset criteria. The most frequently recommended is the subset of 5-6 criteria, after which evaluation is conducted (Idea Evaluation Rating) for each of the defined criteria. Subsequently, each idea receives an (5-6) mark.

At the third level, idea selection is implemented. The selection is conducted at two levels. At the first level, Idea Selection Rating is carried out on ideas which have in the previous criteria passed the minimal level using fundamental technical and economic parameters, essential for product success. Following the conducted selection, at the second level Idea Selection Ranking takes place, the ranking of ideas which are assessed as favourable for further consideration. In providing assistance when finally choosing an idea (which is exclusively conducted at the Decision Area level), for the case of a large number of ideas, the method of converging validated values may be used. On the figure below, a result is shown for the convergence of marks in a single idea group. Following each mark, the percentage value is calculated of the gathered values for the idea in relation to the total gathered values for all ideas and the acquired values are presented. The sum of values for all presentations is 100, while the idea assessed by the evaluation system as the best validated is located at the top of the diagram. This result is significantly simpler implementation of ranking.

4. CONCLUSION

The paper has taken into consideration some of the methods involved in engineering and innovative processes. As a result of theoretical observations and practical requirements occurring on account of work on projects and research, adapted versions of models for new product development, engineering processes and processes for creating product concepts have been developed. Also take into consideration is the specific position of fuzzy front-end as well as a special segment of an innovative process and recommendations for future research. The area of developing a methodology in the process of creating concepts as a special process and not only parts of the process to create a new product is an open area. Emphasis is placed on the importance of the idea and the possible increase in competitiveness through a wide assortment of open innovation, an essential approach to creating a product which is to be not only technically sound but also reflect the primary need of the buyer as well as social and general attitudes.

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