Mikael Epstein

RISK MANAGEMENT OF INNOVATIVE R&D PROJECT

DEVELOPMENT OF ANALYSYS MODEL
A SYSTEMATIC APPROACH FOR THE EARLY DETECTION OF COMPLEX PROBLEMS (EDCP) IN R&D PROJECTS IN ORDER TO INCREASE SUCCESS IN ENTERPRISES

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The research topic emerged as the experience by the author from approximately thirty years' technical and commercial innovation in industrial and research projects. It became apparent that success of projects ought to be improved through a systematic analysis of the preconditions on beforehand.

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ABSTRACT
This dissertation is positioned in the theoretical framework of innovation management and risk management. The study aims at increasing the understanding of the development of a risk analysis tool for innovation projects and of such development work in cooperation with several pilot firms during analysis of their real innovation projects.

The research questions covered the building of an analysis system for risk in innovation projects and the integration of knowledge and resource based theory into the theories of risk, management and innovation.

The basic idea of the project and the resources intended to realize the project are analyzed in parallel. The idea and the resources are analyzed by systematically describing their essential attributes and components. The attributes describe those properties that one intends to improve. The components represent those factors by the help of which the properties will be improved. The attributes in combination with the components constitute pairs and determine which knowledge areas must be used to obtain the attributes. The attributes of the resources represent those abilities that the resources components possess and use when the attributes of the ideas of the project are realized. The resource components represent the resources available to realize the project.

After the attributes and components have been properly described the attribute-component pairs are rated in relation to the knowledge areas. Risk factors are calculated based on the rating numbers. The risk factors relate to the attribute-component pairs of the idea and the resources, respectively, and to the knowledge areas. Finally the risk factors pertaining to the idea and the resources are compared and the decision maker can see how well the resources are suited to realize the project based on the idea. With this system the knowledge and resource-based theory into the theories of risk, management and innovation were integrated.

A computer program was developed in order to facilitate the analysis process and the documentation as well as the reporting. Emphasis was put to improve the user friendliness through developing the interface in cooperation with several pilot firms. It proved advantageous to perform the development work in clearly defined stages. The pilot firms were encouraged to participate in the development work because thy felt their projects benefited from the analysis results.

Keywords: detection, problem, innovation, project, concept, resources, attribute, rating

1. Introduction

1.1 Identification of the Problem Area

The research area for this work is the development of tools for minimizing the hazards from risks in innovation projects. It involves innovation management and risk management as well as methods used in these functions. Technological knowledge is developing so rapidly that any one firm will have trouble staying among the leaders of innovation and the technological evolution is likely to be unpredictable, complex, and difficult to understand. Because the situations for the firms change continuously, they must accommodate to the various markets, to the technologies, to the industry environment, to social terms and to political facts. This increases the demand for flexibility that means the ability to change and the readiness to act. Pursuing such rapidly developing technologies creates technological uncertainty that is greater than it was previously when the firms used to work with more mature technologies that were available and more stable (Andersson and Laurila 1983, p. 39-40; Green 1995, p. 204). In order to manage this situation firms are increasingly forced to apply innovations in their operations and processes.

Innovation has been regarded as risky and hazardous e. g., by Schumpeter (1934, p. 89). Many investigators report empirical data about risks in innovation processes: only one of sixty product ideas brought into the innovation process reached commercial success, and five man-hours out of six are used on unsuccessful products in innovation ventures (Andersson and Laurila 1983, p.33). Furthermore, ca. 35% of products launched fail commercially, and approximately 45% of total new-product expenditures are allocated to unsuccessful projects (Halman and Keizer 1994, p. 75).

Merrifield (1981) and Kerzner and Hostelly (1984) state that innovation ventures carry considerable risks that cause more than one half of the individual innovation undertakings to fail, in certain classes of innovation fields the failure rate is still larger. The references that cover the most recent decades do not indicate any improvement in this relation.
In order to minimize the risk in innovation projects firms ought to investigate the propensity for success in their projects. Early and well-focused investigation of the projects that the firms want to engage in will save money.

1.2. Research Problem

This work is a constructive analysis of the building of a model for the early detection of complex problems (EDCP) in innovation projects. The developed model was based on the propositions of innovation management and risk management. Literature findings about project and about analysis were also regarded in connection to the model. The findings involve innovation as described by Schumpeter (1934, 1939, 1942, 1946, 1947, 1949)and Mintzberg (1999), they also include propositions on strategic action as interpreted by Ansoff (1974, 1989), Schumpeter and Zalenzik (1977). Furthermore propositions e.g., by Harrison (1993), Turner (1993,Duncan (1994), and Lundin (1999) about projects were regarded, as well as theories by Ansell and Wharton (1992), Virkkala (1994), Ansoff (1987, 1995) and others about analysis. Theories regarding risk and risk management are described in Chapter 1.3., and theories about innovation and about strategy in Chapter 1.4. Theories for project and about analysis are described in Chapter 1.5.

Risk management focuses on a risk analysis to answer different questions and the analysis method must possess a number of qualities. Some required qualities are condensed from Ansell and Wharton (1992, p. 37), Halman and

Keizer (1994, p. 79, 77), and Chapman and Ward (1997, p. 67, 80, 37-38). The essential purpose of risk management is to improve project performance via systematic identification, appraisal and management of project-related risk (Chapman and Ward, 1997, p. 9).

The literature further lists a number of analysis methods for innovation projects (Andersson and Laurila 1983, p. 8, 22-24, 48-49, Klus 1996, 2000). The literature also lists a large number of methods for risk management (Ansell and Wharton 1992, p. 109, Halman and Keizer 1994, p.76-79, Chapman and Ward 1997, p.93 108-9 136), Virkkala 1994,p. 219). The analysis methods involve risk analysis in connection with innovation projects (Andersson and Laurila 1983, p. 19, Ansell and Wharton 1992, p. 107-8, Halman and Keizer 1994, p. 77). Furthermore, methods that are intended for project management have been used for the analysis of innovation projects (Turunen 1991, p. 21-24, Urban and Hauser 1993, p. 340-8, Chapman and Ward 1997, p. 89-91). Project analysis methods are also mentioned (Andersson and Laurila 1983, p. 122 124 127-9; CEI-IEC 1160 1992, p. 9-27; Virkkala 1994, p. 217).

The terminology that will be used can be defined in accordance to some of the following key writers: The terms innovation, entrepreneur, entrepreneurial leadership and creative destruction will predominately be used here in the form presented by Schumpeter, and the terms risk and uncertainty as defined by Knight, Urban and Hauser, and Cooper. The terms attribute and component will be used as defined by Levitt and the term knowledge as defined by Nonaka and Takeushi, Mahoney and Panjan, Penrose, and Barney. The term resource will define those resources available to the firm for the realization of the project. Other frequently used terms are project, concept, firm, analysis, and deliverable, for these terms the conventional definitions found in dictionaries of the English language are used if not defined separately.

The literature study will be used to show voids in the field of methods for risk detection in innovation projects. Then a model will be constructed that covers these voids, and useful elements from models revealed in the literature study will be applied into the model.
This work is part of the scientific discussion about the management of innovation and about the development of tools for innovation management. The work aims at bringing a new aspect to the minimizing of risks connected to innovation projects.

Research Questions

The research problem presented as a question is ***how to build an EDCP model that can be applied in innovation and R&D projects in firms?***

The following sub-problems are presented:

1. ***How are knowledge and resource based theories integrated into risk theory, innovation theory, and management theory?***

2. ***How to develop a usable and useful analysis tool?***

   2.1. How can we select the firms that are best suited as pilots to serve the development of such an analysis method?

   2.2. How can we help the pilot firms to select the most suitable projects for the development of such an analysis method?

The term usable means that the model can be easily used in the practice, the term useful means that the results from applying the model are of use to the user.

The endeavor of the study is to develop a method that

- presents the concept of an innovation project in a form that allows analysis
- analyzes the concept in order to find the concentrations of requirements or demands within the concept
- analyzes the resources in order to find the lack or shortages in the resources that are employed to realize the project
- presents the risk concentrations of the project

A further endeavor is to find appropriate ways to develop an analysis model in cooperation with pilot firms that have innovative projects.
The work is also an analytic study of interactive development of a model in cooperation with pilot firms in practical application on the firms' innovation projects.

1.3. Central Concepts

1.3.1. Knight's Concept of Risk, and its Modifications

The essential fact, according to Knight, is that the word "risk" means, in some cases a quantity susceptible of measurement. At other times, however, its meaning is something distinctly not of this character, for instance Andersson and Laurila (1983, p. 8) as well as Knight (1985, p. 19) state that risk is when one cannot give a specific value to an occurrence.

Knight defines the term for a measurable uncertainty as " risk proper" and he regards it to be so far different from an unmeasurable one that it is not in effect an uncertainty at all. Knight, consequently restricts the term "uncertainty" to cases of the non-quantitive type (Knight 1985, p. 19). Knight thus uses the term "risk" when he describes the measurable quantity, and the term "uncertainty" for the non-quantitative.

Knight regards that it is this "true" uncertainty, and not risk that forms the basis of a valid theory of profit(s) and accounts for the divergence between actual and theoretical competition (Knight 1985, p. 19, Barreto 1989, p. 40). Both the degrees of risk and the genetic types of risk have been objects for research. Knight distinguishes between measurable and unmeasurable uncertainty. He uses the term " risk " to designate the former and the term "uncertainty" for the latter. He writes that the word " risk " ordinarily is used in a loose way to refer to any sort of uncertainty viewed from the standpoint of the unfavorable contingency. The term "uncertainty" is similarly used with reference to the favorable outcome; he speaks of the " risk " of a loss, the " uncertainty " of a gain (Knight 1985, p. 24).

According to the Random House Dictionary the word risk means exposure to the chance of injury or loss, a hazard or dangerous chance. In the insurance business risk means the hazard or chance of loss, or the degree of probability of such loss, or the amount that the insurance company may lose. The word risk came to use in the English language ca. 1655-65 (Random 1987). The origin of the word risk is thought to be either, the Arabic word risq or the Latin word risicum. (Kedar 1970). In the literature on the subject the word risk is used to imply a measurement of the chance of an outcome, the size of the outcome or a combination of both (Ansell and Wharton 1992, p. 4).

Risk-freeness has been defined primarily in the financial meaning. In the faculty of financial science the risk-free rate is defined as a default-free interest rate i.e., the interest rate for an asset that will not default or disappear. According to Pike and Neale (1993), no asset is totally risk free. Even governments default on loans and defer interest payments, but in a stable economic and political environment, government securities are about the nearest one can come to a risk free asset.

In financial considerations a measure of risk has been the equity risk premium, i.e., the difference between the return on common stocks and on government securities. In practice only two securities are used for this purpose, namely short-term treasury bills that are considered closest to a risk-free security, and long-term treasury bonds. Although long-term treasury bonds are free from default they are not risk-free securities. (Cornell 1999) Several researchers, Schumpeter (1928, 1934, 1939, 1942, 1946, 1947, 1949), Knight (1985, p. 24), as well as Andersson and Laurila (1983, p. 8) relate profit to the management of risk in business, at the same time they relate profit to offering of innovations before any of the firm's competitors. Thus profit can be seen as a link between innovation and risk, i.e., people undertake risk of innovation in the expectation of profit.

Ansoff linked innovation to risk through the entrepreneur, he used the term "entrepreneurial" to indicate an attitude to risk (Ansoff 1968 134). In Ansoffs view, "entrepreneurs" anticipate both problems and opportunities by conducting a continual search for strategic opportunities (Ansoff 1968, 208, Barreto 1989, p. 38). Schumpeter distinguished the entrepreneurial function from the function of the risk-bearing capitalist or the administrative direction of existing firms by the manager (Lintunen 2000, p. 211, Barreto 1989, p.30).

Many writers have presented studies about risks connected with innovation in different business activities e.g., product innovation has been proven to be one of the riskiest endeavors of the modern corporation. Kerzner and Hostelly (1984, p6-11) report an average success ratio for product development of 1:64, and Merrifield (1981, p. 13-18) estimates that one of twenty major started projects will produce positive cash flow.

Exposure to financial risks can be optimized carefully so that firms can concentrate on what they do best – manage their exposure to business risks. Considerable effort has been put into the management of financial risks, and many methods have been developed to assist management in managing these risks. Operational risks can vary from very minor ones to the critical. Legal

Risk type	Characterization
Business risks	firm willingly assumes in order to create a competitive advantage within its own industry. product market technological innovations product design marketing. Furthermore business risk includes exposure to macroeconomic risk that results e.g., from macroeconomic cycles.
Non-business risks	strategic risks e.g., fundamental shifts in the economy or political environment
Financial risks	relate to possible losses in financial markets, e.g., due to adverse movements in market prices credit risks liquidity risks
Operational risks	Failures of internal systems or people operating them
Legal risks	Arise from the prospect that contracts may not be reinforced health or environmental risks

From Jorion (2000, p. 4) and Dowd (1999, p. 3)

Jorion (2000, p. 4) and Dowd (1999, p. 3) group risks into business risks, non-business, financial risks, operational risks and legal risks. The risk types are characterized in the table above.

risks arise from the prospect that contracts may not be reinforced. Consequences of business activities may also cause legal risks (Dowd 1999, p. 4).

Examples of risks connected to the securities business are three fundamental risks: credit or counterpart risk, liquidity risk, and settlement risk (Stehm 1996, p. 19). Counterpart risk is connected to the creditworthiness of the counterpart (VM 1991, p. 10). Liquidity risk means that the other party of the deal does not commit itself to the delivery or payment in time (Stehm 1996, p. 16-17). Settlement risk deals with the situation when the delivery of the securities or the payment is annulled just before the planned realization time. It occurs when the seller can deliver the security but does not get paid by the buyer, or when the buyer can pay but does not get delivery (Stehm 1996, p. 19). Individuals perceive differences in the risks involved in the purchase of new products. These risks are in some way related both to the personal characteristics of the person perceiving this product, and to the newness of the product (Midgley 1977, p. 66). An important part of corporative activity is to manage risks. The risks should be monitored carefully because of their potential camage. Some firms passively accept risks others attempt to create a competitive advantage by judicious exposure to financial risk (Jorion, 2000, p.3).

Urban and Hauser (1993, p. 67) found that up-front investments pay back handsomely when trying to lower expected costs. Up-front strategy means that you take your risks when less is at stake. As proof the authors refer to results from studies by Booz, Allen, and Hamilton (1971) who found that firms must produce on an average 58 ideas for every success. When Booz et. al. they did a similar study eleven years later the authors found that the number had been reduced to seven ideas per success. Moore (1988) found up-front attention was paid to several management aspects in the firms. These aspects included strategically based idea search, preliminary market research, initial screening, etc.

According to Leskinen the entrepreneur carries a risk that can be e.g., business risk, social risk, psychological risk, or family risk and generally, entrepreneurs have a more optimal view on risk than the population generally. Leskinen also refers to two kinds of risks: “sinking the boat” and “being left behind”. Entrepreneurs tend to be “left behind” because the first opportunity is often the last possibility (Leskinen, 1999, p. 54-55).

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Common pitfalls or risks in the management of projects include non-fulfillment of technical requirements, encountering of unexpected scientific, technical or commercial difficulties, time schedule delay, overrun of budget, and communication problems. Often pitfalls are due to unexpected complexities encountered in some of the disciplines involved in the project. A decisive question is how many of the pitfalls could have been foreseen prior to embarking on the project and how the course of the project could have been re-directed, had these pitfalls been made evident in due time (Szakonyi 1988, p. 126-127, Wilkinson 1991, p. 19-29, Silverberg 1991, p. 46-49).

Efficient innovation management requires identifying of risks. Chapman and Ward (1997, p. 95-96) identified two specific tasks for the purpose of responding to risks. Firstly, searching for sources of risk and response, employing a range of techniques such as pondering, interviewing, brainstorming and checklists. Secondly, classifying to provide a suitable structure for defining risks and responses, aggregating/disaggregating as appropriate.

Urban and Hauser (1993, p. 57) like to achieve a balance between avoiding risk altogether (e. g., by doing nothing), and controlling risk while seeking to succeed. They refer to a study by Cooper (1984a, p. 5-18 and 1984b, p. 151-164) that identified roughly five types of strategies. Of these strategies Urban and Hauser found one winner strategy, namely the strategy that integrates marketing and technology by focusing on the customer and delivering benefits with the state-of-the-art technology.

Every firm, and particularly new growth enterprises are exposed to big risks. When a risk evaluation is included in the business plan, the potential investors see that the business plan is considered thoroughly, and that the plans are not founded on too optimistic a base. However, it is not good for the firm to be too pessimistic, and give the risks too much space in the business plan. Thus it is important to recognize and evaluate the risks. Typical business risks occur either because of the firm’s own activities or from changes in the business environment. Examples of risks within the firm are difficulties in finding key-resources, key-employees leaving the firm, or the unsuccessful prototype of an innovation. Environmental risks may include unfulfilled sales expectations, the sudden destruction of supplier's facilities through fire, the entrance of a superior competitive product into the market, the impossibility of obtaining a patent, or a distributor breaking an agreement. Risk evaluation usually involves foreseeing, because the evaluation can always be based on certain assumptions. The most important risks can be identified by means of sensitivity analysis, and the firm can then concentrate on eliminating the risks. (McKinsey, 2000, p. 123-4)

Urban and Hauser (1993, p. 425-426) further discuss reduction of risk, and suggest sequential testing. First the components of the product are tested, then the product design. Their key concept is to delay large testing expenditures until component risks are minimized. Urban and Hauser propose pretest-

Risks can be characterized according to different writers as shown below:

Writer	Character
Schumpeter (1928, 1934, 1939, 1942, 1946, 1947, 1949)	Risk is carried by the capitalist, not (primarily) by the entrepreneur
Ansoff (1968)	Relates risk through the entrepreneur
Kerzner and Hostelly (1984)	Estimation of success ratios or risk ratios
Knight (1985)	Measurable risk versus non-measurable uncertainty
Wilkinson (1991), Szakonyi (1988, Silverberg (1981)	Project risks include non-fulfillment of requisitions, unexpected difficulties, delay of schedule, overrun of budget
Stehm (1996), Jorion (2000)	Financial risk relate to losses in financial markets
Leskinen (1999)	Entrepreneur carries risk Differentiates between business, social, psychological and family risks

market-laboratory to reduce chances of failure in launch. After the components are rested the following step in the sequential testing the integrated product is tested through laboratory simulations and consumer panels. Urban and Hauser (1993, 27-28) further present proactive and reactive strategies to reduce risk.

Reactive strategy involves countering competitive new products, and in the proactive strategy the firm initiates change and takes an active role in the development of new products.

1.3.2. Schumpeter's, Ansoff's and other Writer's View's of Innovation

Some Types of Innovation

Innovation is one of the prerequisites for the development of business. Joseph Schumpeter (1883-1950) pioneered the scientific research of innovation in economic development. The most prominent factors he introduced to the scientific discussion were the entrepreneur and entrepreneurial leadership. The word entrepreneur entered the English language ca 1875-80 (Random 1987) i.e., not very long before Schumpeter started his research work.

Schumpeter (1939, p. 86) declared that innovation cannot be anything else than an effort to cope with a given economic situation. One can conclude that he linked innovation to profit(s), and thus to success in business.

Schumpeter defined innovation primarily with the statement that new combinations in the form of "the introduction of new good ... or a new quality of a good ... a new method of production... the opening up a new markets ... a new source of raw materials... the carrying out of new organization of any industry" (Schumpeter 1934, 66, Barreto, 1989, p. 28). He also distinguished innovation as the function of the entrepreneur as separated from the administrative function of the manager and from the risk bearing functions. Ansoff (1984, p. 224), again, regarded innovation as being a part of strategy where it represented the aggressiveness in strategic entrepreneurial management (Lintunen 2000, p. 267, 44; Virkkala, 1994, p. 7).

Schumpeter was of the opinion that the prerequisites for innovation are economic leadership, will power and energetic action. Consequently, Schumpeter introduced the idea of entrepreneurial leadership as being the source of creative energy for innovation and evolution (Schumpeter 1949, 1947, 1946, 1942, 1939, 1934). Economic leadership involves leading the process of innovation and conducting the entrepreneur's own energy and capacity, rather than that of others, toward fulfilment of the entrepreneurial function in various forms in an economy (Schumpeter 1934, p 93 in Lintunen 2000, p. 39)

Mintzberg's concept of visionary leadership, like Schumpeter's entrepreneurial leadership, makes human creativity the ultimate source of innovation. Schumpeter (1934, p 93 in Lintunen 2000, p. 39) saw that the entrepreneurial leadership quality may be built into the company personality, so that the entrepreneurial function may be fulfilled by the entrepreneurial team or group. In comparison, Mintzberg's concept of visionary leadership indicates leadership mainly through the activity of a single visionary leader (Mintzberg and Lampel 1999, p. 23).

What was distinctive about Schumpeter was his emphasis on discontinuous rather than continuous change. New combinations represent a sharp break from the past and bear no comprehensible connection to previous achievements (Schumpeter, 1934, p. 85).

Schumpeter introduced the concept of creative destruction as part of the innovation process. Shionoya (1997) proposes that creative destruction gives rise to the process of innovation, because innovation destroys old things and creates new ones (Shionoya 1997, 163). Steinbock interprets Schumpeter’s creative destruction as simultaneously being creative renewing, a regeneration that then translates into innovation (Steinbock 2001). Renewing may seem a more pleasant metaphor for innovation than destruction.

Schumpeter personified the entrepreneur as a generator of novel opportunities (an innovator), in opposition to the Austrian economists, whose theory rests on the search for opportunities (Dopfer 1994, 136, ed. Magnusson 1994, p. 125). He proposed that an entrepreneurial function is an act of will by an entrepreneur to introduce innovation into an economy, and a source of evolution into an entire society (Lintunen 2000, p. 16).

Schumpeter (1912, 1934, 1939, 1947, 1949,1954) stated that temporary monopoly profits are the reward to the entrepreneur for successful innovation.
He defined entrepreneurial profits as the premium put on successful innovation in capitalist society (Schumpeter 1939, p. 105), and he stated that entrepreneurial profits are the temporary monopoly return on the personal activity of the entrepreneur (Schumpeter 1949, 1928, 1934, 1939, 1942, 1947, 1949,1954). Consequently, he distinguished the entrepreneurial return from wages of managements and interest on owned capital or capital gains (Schumpeter 1954, 895-98, 1939, 105, 1934). Chantillon even uses a risk theory of profit as a means to identify entrepreneurship (Barreto, 1989, p. 35).
A conventional definition says that innovation is the making of a change in something established, a novelty (Webster 1999). The word innovation came to the English language ca. 1540-50 (Random 1987). According to Kotler (1991) "an innovation refers to any good, service or idea that is perceived by someone as new". Thus a new product or process may be an innovation to one person but not to another. Innovation can be viewed either as closely related to technological change and R&D, or mainly associated with the marketing process. Innovation can be regarded as the detection and fulfillment of unfilled needs and wants of potential customers. (Roman and Puett 1983). Another definition is to group innovation into product and process innovations. Product innovation is embedded in the product itself, process innovation is part of the production system (Kosnik 1990). Commercially discontinuous innovations bring about new ways to structure the markets as far as customer needs, or market segmentation, or the entire value system is concerned. Discontinuous

innovation can be produced by the use of an iterative probing process of trial and error (Christensen 1997, Lynn et al., 1997, Norling and Statz 1998).

A large number of methods have been developed for the management of innovation projects. Many of them will be presented in Chapter 2. The methods can be grouped in idea generation methods (Virkkala 1994), risk management methods (Ansell and Wharton 1992, Virkkala 1994, Chapman and Ward 1997), decision theoretical methods (Andersson and Laurila 1983, KlusTest home page 1996, Virkkala 1994), and general project management methods (CEI-IEC 1160 1992, Urban and Hauser 1993). Econometric methods and operation analysis methods have also been used for management of innovation projects (Andersson and Laurila 1983, Levitt 1980). Drucker (1986, p. 30) defines innovation as an economic or social rather than a technical term. He focuses on demand rather than on supply terms i.e., changing the value and satisfaction obtained from resources by the consumer. Drucker (1986, p. 27) also sees innovation as the specific instrument of entrepreneurship, through it the entrepreneur endows resources with new capacity to create wealth. Innovation does not have to be technical, it does not need to be a thing at all. Social innovations e.g., the newspaper, insurance and installment buying have transformed whole economies.

Innovation involves the use of new ideas. A number of methods have been developed for idea generation. Apparently the methods used for idea generation may include elements that can be of use in the development of risk analysis methods, and will be presented below. An innovation project may start by an observation of a possible coincidence of a need and a possibility. This coincidence is usually called an idea. Capability and willingness to create something useful of the idea will be necessary, in order to make the idea come true. (Virkkala 1994, p. 30) Besides the theoretical approach to innovations many writers have presented practical solutions to innovation problems. Much of the literature deals with creativity and the creative process. The word creativity entered the English language ca. 1870-75 (Random 1987), it was used first time in scientific context ca. 1955 (Ekvall, 1979 p. 7).

Harisalo and Miettinen (2000, p. 101) conclude that the creative process is a decision process, a creative individual tries to solve his problem by finding a solution of creative products. The creative process starts with discovering the problem. Forethought is the second stage of the process. A solution to the problem is sought for using subconscious thinking methods. By combining subconscious and conscious thinking methods the creative individual arrives at an insight of the solution to the problem. He will them be able to convince himself about the usefulness of the insight. (Harisalo and Miettinen 2000, p. 101-2; Osborn 1957, p. 212-28) Harisalo and Miettinen derive a number of factors within the creative processes (Harisalo and Miettinen (2000, p. 102), these factors can be organized into groups. The first group consists of preparation, forethought, insight, problem identification, problem perceiving and problem formulation. The second group covers fact finding, solution search, solution pondering, perception and synthesis of ideas. The third group contains idea evaluation, convincing, idea selection and idea utilization. The first group can be called problem presentation, the second solution processing and the third idea processing.

According to Sjölander (1985) as well as to Cooper and Kleinschmidt (1987, p. 175-189) one can distinguish between two basic models of the innovation process: the process-phase model preferred by scholars of economics and the idea and information flow models preferred by scholars of engineering. Another classification method in the scientific discussion characterizes innovations as radical or incremental. Green distinguishes four dimensions of radicalness: technological uncertainty, technical inexperience, business inexperience, and technology costs. He further classifies radicalness in terms of four basic issues (Green, 1985, p. 203):

1)the extent to which an innovation incorporates technology that is embryonic and rapidly developing in the general scientific community;

2) the extent to which an innovation incorporates technology that is new to a firm, but may be well understood by others;

3) the extent to which the innovation represents a departure from the firm's existing management or business practices;

4) the extent to which an innovation requires a sizable financial risk.

According to Lintunen (2000, p. 298), Mintzberg's concept of the entrepreneur is ingrained in Schumpeter's concept of the entrepreneur i. e., human creativity, intuition, vision and hence entrepreneurial leadership. Furthermore, Mintzberg's concept of the entrepreneur is connected with Hamel and Prahalad's concepts of core competence, strategic intent and stretch through their common roots in Schumpeter's thesis of leadership, or creative destruction.

Projects in their conception stage usually are not properly specified, their scope is not stabilized, and the interested parties have not yet found a consensus. No implementation methods have been selected, and part of the project may need further research. Projects have also developed into larger and more complex systems including elements of software, social impact and high technology. (Lichtenberg 1989, p. 46-51) An innovation in the economic sense is accomplished only when the first commercial transaction is performed that involves the new product, service, or process that has been innovated (Freeman 1974, p. 22). A project that is undertaken intending to accomplish such an innovation may be termed an innovation project or an innovative project.

Innovation can be characterized according to different writers as shown below:

Writer	Characteristics
Schumpeter (1928, 1934, 1939, 1942, 1946, 1947, 1949)	Involves the entrepreneur Linked to profit Innovation requires economic leadership, willpower, and energetic action Efforts to cope with the economic situation through new combinations Innovation is the generation of novel opportunities (through the entrepreneur) Innovation involves discontinuous change, creative destruction Innovation gives temporary monopoly that produces profit (to the entrepreneur)
Freeman (1974)	Innovation in economic sense is accomplished with the first commercial transaction
Roman and Pruett (1983)	Innovation is the detection and fulfillment of unfilled needs and wants of potential customers
Sjölander (1985), Cooper and Kleinschmidt (1987)	Present process-phase model and information flow model for innovation
Drucker (1986)	Innovation is a social or economical term, value changing Innovation is a special instrument of entrepreneurship
Ansoff	Innovation is part of strategy, represents aggression
Tirole (1988)	Innovation can be classified into drastic or non-drastic types (related to managerial cost)
Kotler (1991)	Innovation refers to any good, service, or idea that is perceived as new
Virkkala (1994)	Innovation involves use of ideas that can be generated systematically with the help of methods
Mintzberg (1999)	Human creativity is the ultimate source of innovation
Harisalo and Miettinen (2000)	Practical solutions to innovation problems through creative decision process

Strategy Concept as an Extension of the Ansoffian and Schumpeterian Notions

Schumpeter's vision of long-term economic change was that the entrepreneur incessantly introduces innovations. The adaptive managerial function covers the administration of existing firms, whereas the creative entrepreneurial function involves the incessant creation of new firms [innovations] (Schumpeter (1946), ed. Clemence 1997, p. 198-99) i.e., entrepreneurs create new firms in discontinuous processes whereas managers run existing firms as continuous processes. Ansoff and Schumpeter viewed strategy differently, Ansoff described strategy, first and foremost, as a system concept that gives coherence and direction to the growth of a complex organization (Ansoff 1968, p. 105). Ansoff's early concept of strategy as the product-market matrix, and the pattern of aggressiveness of innovation and marketing strategies in strategic management, parallels Schumpeter's concept of innovation or new combinations (Lintunen 2000, p. 267).

For Schumpeter, in his history-led theory construction, vision was the successful tool for describing and explaining economic life and its essentially evolutionary process of change (Schumpeter 1954, p.570). Thus one can conclude that Schumpeter's vision largely corresponds to Ansoff's strategy.

Ansoff's concept of strategy is meant to provide management with a practical tool for long-term corporate planning (Lahti 1991, p. 149, ed. Näsi 1994). This management tool contains many elements of an analysis, for instance perception of problems and opportunities, diagnosis of problems and opportunities and their effect on the firm, measurement of performance in relation to the objectives, and analysis of the probable consequences of the courses of action (Ansoff 1984, p. 241).

Ansoff (1984, p. 241) defined management as a problem-solving activity of a complex information process. Ansoff admitted that complex problems have important systemic properties, and the complexity of the real world is many times greater than the complexity-handling capacity of the human brain (Ansoff

1979, p. 218). Ansoff maintained that through a connected chain of activities the manager sets objectives, generates responses to problems and opportunities, and selects the preferred alternative. Ansoff further involves programming and budgeting of a selected alternative into the manager's duties. He further includes leadership in implementation including communication and motivation, observation of significant trends and possible discontinuities both inside and outside the firm, and recycling some or all of the preceding steps (Ansoff 1984, p. 241). From the above one can conclude that Ansoff sees management as a continuous process.

Ansoff (1987, p. 45) proposes a 'cascade' approach to a search procedure in arriving at a strategy. At the start the possible decision rules are formulated in gross terms and are then successively refined through several stages in the strategy making process. The procedure within each step of the cascade consists of first establishing a set of objectives, then the difference ("gap") between the firm's current position and the objectives is estimated, then one or several courses of action (strategy) are proposed, and, finally, the actions are tested for their "gap-reducing" properties. Figure 1-1 illustrates the overall decision and implementation flow in strategic activity. The 'cascade' property is represented by the progressive convergence of the decision process that starts with a broad choice of the firm's future business areas. It then progresses towards the selection of specific products or markets with which the firm will serve these market areas (Ansoff, 1987, p. 177-178). The dotted oval in the areas of generation of project alternatives and project selection indicates the position or place for a risk analysis in the course of the implementation of a strategic activity.

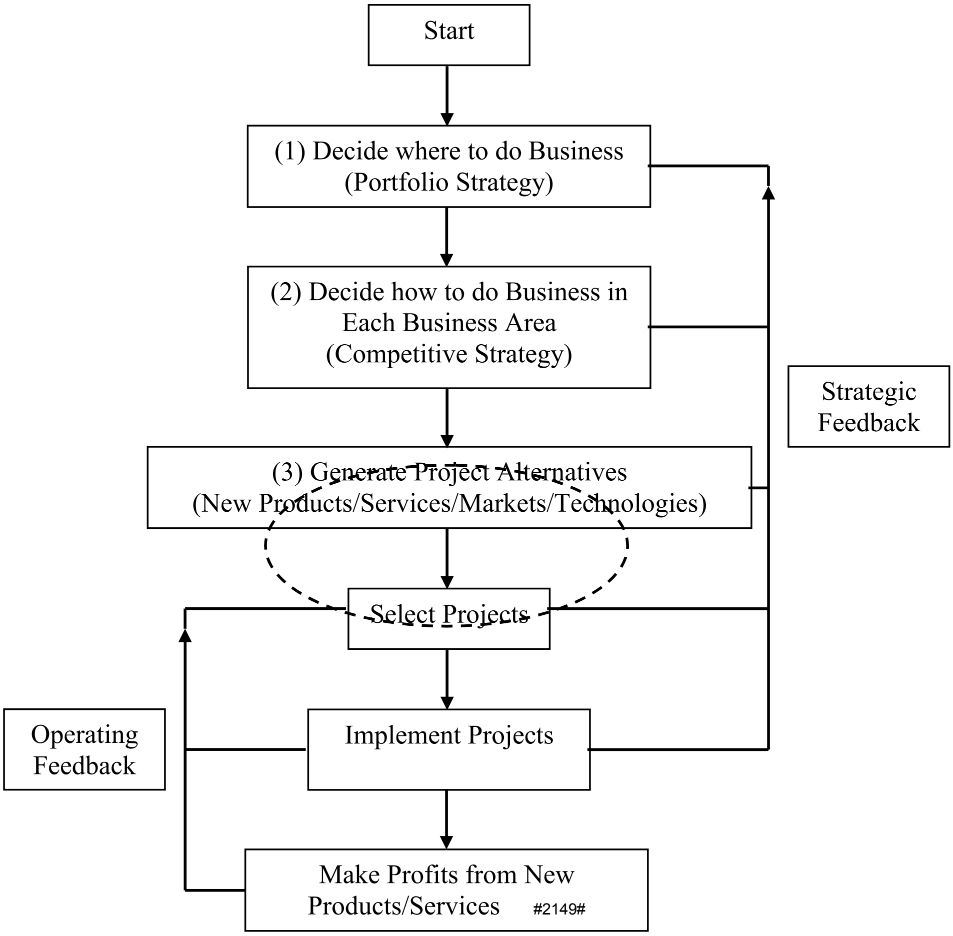

Figure 1-1. Action Cycle in Strategic Development (from Ansoff, 1987, p. 178), The dotted Oval indicates Position of a Risk Analysis Process for Projects.

Ansoff (1965, p. 38) also identified the strategic problem as the "misfit or imbalance between products of the firm and the demand of its environment." He sees the strategic decisions to be primarily concerned with the external, rather than the internal problems of the firm, specifically, when selecting the product-mix that the firm will produce and the markets to which it will sell (Ansoff 1968, p. 23-4). The firm can be seen as a part of its enviromnent, and in strategic planning the firm is then analysed from the external point of view. The goal of the firm is to find the niche in which its profit is the best possible (Lahti 1987, p. 16-21).

Simon states that complex systems are hierarchic. One reason for this is hierarchic systems composed of subsystems are the most likely to appear through evolutionary processes. The mechanisms of natural selection will produce hierarchies more rapidly than non-hierarchic systems because the components of hierarchies themselves make up stable systems. Furthermore, among systems of a given size and complexity, hierarchic systems require much less information transmission among their parts than do systems of other kinds. Simon sees a third reason for complex systems being hierarchic, the complexity of an organization as viewed from any particular position within it becomes almost independent of its total size when the organization has a hierarchic structure (Simon 1977, p. 111-113).

Also the need for the firm to take on challenges presents a need for analysis of projects. Prahalad points out that strategic intent must cause a "misfit' between aspirations and current resources and current approaches to using resources (Prahalad 1997, 175, ed. Tushman and Anderson). Creating stretch, ie. a misfit between resources and aspirations, is the single most important task senior management faces (Hamel and Prahalad 1993, p. 78). Strategic intent focuses on carrying out innovations; an obsession with winning means an obsession with innovations (Lintunen 2000, p. 146). One may conclude that Prahalad's request for "misfit" within the firm is to be seen as an invitation to the firm to take on challenges. It can also be termed as an urge to management to find challenges for the firm. This activity can be seen as a search for opportunities in line with the Austrian school. A risk analysis for innovation ought to consider the gap or misfit between the aspirations of the environment and the resources or products of the firm. The risks connected to the misfits require analysis in order to make the firms' management aware of the existence and amount of such risks.

Zaleznik explained that the management process consists of the rational assessment of a situation and the systematic selection of goals and purposes i.e., to answer the question: what is to be done? Furthermore it involves the systematic development of strategies to achieve these goals, and the marshalling of the required resources. Management process includes the rational design, organization, direction, and control of the activities required for attaining the selected purposes, and, finally, the motivating and rewarding of people to do the work (Zaleznik 1977, p. 68). Management is thus linked to the building of the firm's strategy through systematic and rational activities.

An entrepreneur must often make decisions when consequences are unforeseeable, because he operates in an uncertain environment (Knight in Barreto 1989, p. 34). Uncertainty, as defined by Knight, forces decisions to be made under ignorance, as actions are based on opinions rather than knowledge. Knight's entrepreneur never really knows in advance if his plans and expectations are correct, but yet he must decide what to do and be responsible for the decision. Knight even goes so far that he considers the entrepreneur responsible in a case where he did not make a particular decision (Barreto 1989, p. 40).

Danila (1989) distinguished between different types of strategies: institutional strategy, corporate strategy, business strategy, technological strategy and functional strategy (Fig. 1-2). The first two strategies refer to how the company defines and shapes its basic shape and vision and how it defines its long-term goal, respectively. The business strategy refers to product-market technology choices made by division or product-line management. The technological strategy covers several functional strategies such as R&D, engineering, process improvement and new product development.

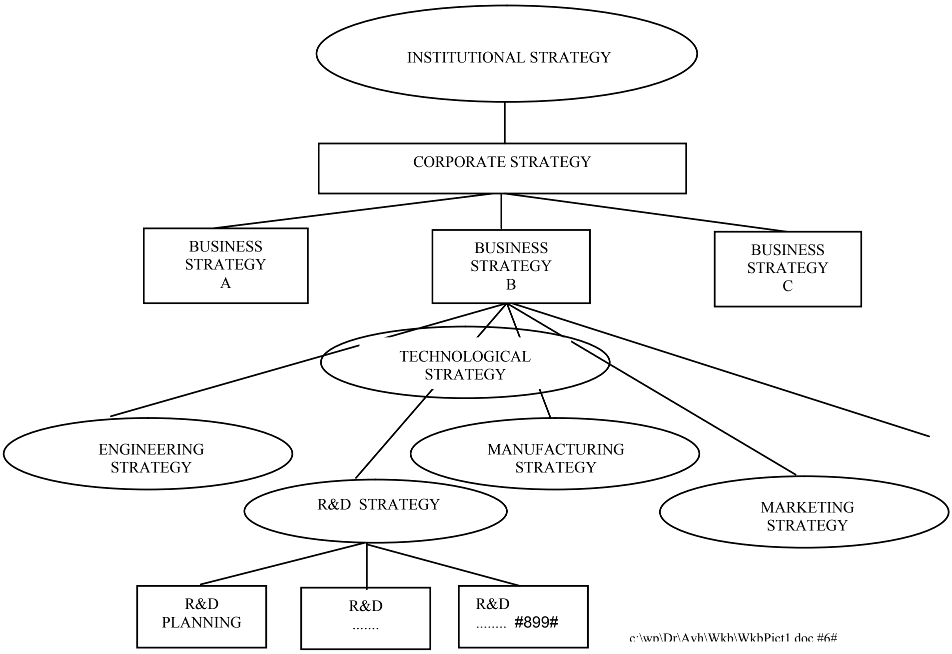

Figure 1-2. Connection between institutional, corporate and functional strategy (Danila 1989)

1.3.3. Project Management and Analysis

Management historians would probably point to the 1950s and 1960s as the birth era of the current approach to project management and to several large defense programs executed at that time (Fondahl 1987, Snyder, 1987, in Shenhar and Dvir). During those years, the project management procedures were established. (Moder 1988, p. 324, Shenhar and Dvir 1996, p. 608) Harrison (1993, p. 10) states that there exists no standard or universal definition for a project. The definition of projects varies according to the definer and the actual project type. Project Management Institute suggests as an official definition that a project is any undertaking that has a defined starting point and defined objectives by which completion is defined. Further, most projects have a limited amount of resources by which the objectives are to be accomplished (Duncan, 1994, p. 4).

Turner (1993, p. 8) proposes a definition, according to which a project is an endeavor in which human, material and financial resources are organized in a novel way, to undertake a new scope of work, of given specifications, within constraints of time and cost. The purpose of the project is to achieve beneficial change by quantitative and qualitative objectives. Projects within organizations are often divided into several project phases in order to provide better management control. These project phases are collectively known as the project life cycle (Duncan, 1996, p. 11). "Projectization" has been defined as the spreading of project usage into almost all facets of human lives (Lundin 1999, p. 190). According to Decom (1991, p. 13-16) a project passes through five phases, namely the conception, the definition or design, the realization, the acceptance and, finally, the operation phase. In order to understand project management one must first comprehend that which the project manager is managing. A number of academic explanations have been put forward. Wysocki et al. (1995, i. Shenhar and Dvir 1996, p. 607-632) and Artto (1998, p. 19) specify a project as a sequence of unique, complex, and connected activities having one goal or purpose or scope and that must be completed by a specific time, within budget, and according to specification. Turner (1993, p. 5) defines a project as a one-time unique endeavor by people to do something that has not been done that way before. He also separates the definition of project from that of operations saying that projects are unique but operations are repetitive.

Many writers have proposed a variety of typologies to distinguish among projects. Most of these typologies have classified projects according their level of change. For example, Blake (1978) suggested a normative distinction between minor change (alpha) projects, and major change (beta) projects. Wheelwright and Clark (1992), in a study on in-house product development projects, mapped such projects according to the degree of change achieved by their outcome within the company's product portfolio. Their typology included derivative, platform breakthrough, and R&D projects, and Pinto and Covin (1989, p. 49-62) addressed the differences in success factors between R&D and construction projects (Shenhar and Dvir, 1996, p. 609). The organization that undertakes the project is often referred to as the project owner. The project owner usually acts as the client for project management analysis activities (Chapman and Ward, 1997, p. 48).

Ansoff includes projects in his development plan that constitutes a part of his strategic approach to management. The projects make up the Development Planning part of the Strategic plan. Each project has its time horizon and duration, and the projects are impermanent. Different projects are often launched when needed at different times during the year. The projects are problem-focused, not (business) unit-focused and they usually require contribution from all key functions of the firm. Each project is disbanded when its strategic goal is achieved (Ansoff, 1987, p. 226).

Companies often apply a procedure that first generates ideas for building an idea portfolio, then, as part of the Exploration stage (see Fig. 1-3) select appropriate ideas often using some of the evaluation methods available. The ideas selected this way are then used, during the prototype stage as a base for R&D projects that are then managed in the more or less conventional way of project management. Figure (Fig. 1-3) shows how the level of R&D expenditures increase sharply throughout the different R&D stages (Wilkinson, 1991, p. 19-29). Therefore our model for the Early Detection of Complex Problems (EDCP) in R&D projects would be useful.

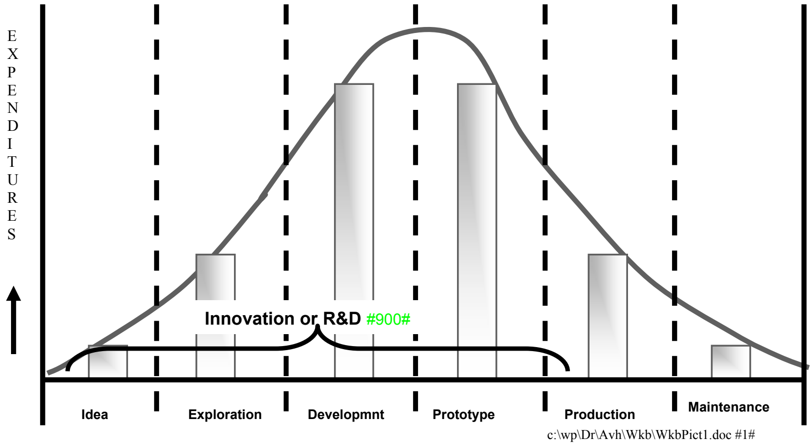

Figure 1-3. Expenditures for R&D during the course of a project (elaborated from Wilkinson 1991)

Based on the definitions by many researchers (e.g., Virkkala, Levitt) a project may be described as a composition put forward in the Figure 1-4 below.

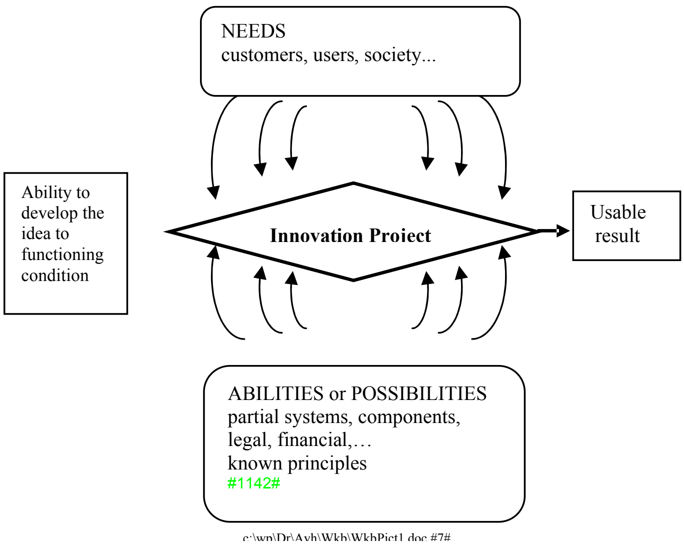

Figure 1-4. Composition of an innovation project (from Virkkala, 1994, p. 30)

Certain needs emerge from customers, users, society and others; the needs form the basis for an idea. There are a number of possibilities to develop the idea into a usable result with the aid of different partial systems that contain known principles. By applying abilities or possibilities in the form of partial systems, components, legal, financial and other known principles, the idea can be developed into a usable result. (Virkkala 1994, p. 30)

For the purpose of management the structure of the concept, the project boundaries, and the activities are examples of items that must be clarified, as will also the interrelations between them. The risk diagnosis can be enhanced by a project presentation that involves identification and description phases (Halman and Keizer 1994, p. 76). For instance, a define phase is useful for the purpose to consolidate and elaborate the nature of the project effort in order to define the project in a form suitable for the rest of the project risk management process (Chapman and Ward 1997, p. 68) According to Lichtenberg (1989, p. 47) project management has developed in three waves of generations. First came the manual, highly intuitive Gantt chart based generation. Then followed the computerized and highly detailed and logical network-based generation that disregarded the real world fuzziness, uncertainty as well as human lack of logic. The third wave was "humanized" and focused on personal management control and overview. It also involved consensus and flexibility, and it accepted uncertainty. It applied earlier generation tools to the extent that it served the above overall goals.

Analysis

Analysis is the separation of a whole into its component parts (Ansell and Wharton 1992, p. 6) and a statement of the results (Webster, 1999). Problem detection involves analysis of the circumstances connected to the project. Ansoff attempted to make a practical analytic framework for strategic or external decisions of the firm, compromising between mathematical precision and realism in the problem statement. Ansoff argued that the framework that emerged was "directly usable for solving real-world business problems" (Ansoff 1965, vii and ix). According to Virkkala, scientific problems, however are usually analyzed according to the sequence:

preparation
incubation
illumination
verification, proving.

In such a process no functioning entities are produced. The scientific analysis work is considered to be finished when the evidence is proved (Virkkala 1994, p.21). The analysis method must be so general that it can fit all firms or must be such that it can be applied for a certain firm. The method must be so simple that users are not repelled from it. The evaluation methodology must be simple and yet cover all aspects, the evaluation could preferably be done in a couple of sequences. Finally the method must not require more time than what simple intuition takes for a person to do. The method must also point out items that shall be improved rather than just reject projects. (Andersson and Laurila 1983, p. 61)

The evaluation at an early stage must be qualitatively directed but some type of rating numbers that tell whether to stake or not, can also be used. The output must be as qualitative as possible, and in some cases a checklist may replace the output. The method must be useful as a communication aid, and the communication can be formed into a meeting with a base (agenda) and a chairman who steers the discussion. It is important to get a wide view in the opinions, and it is important that the analysis is systematized and that it analyzes strong and weak sides in the product idea (Andersson and Laurila 1983, p. 191). Time requirement from inauguration to launching of a project must also be judged and comparable to other methods (Andersson and Laurila 1983, p. 86). A reference group is more useful than an evaluator group for steering the idea for continued work. The composition of the team shall be cross-functional with knowledge from marketing, production, product development, and economy, the team members shall have very little with the decisions to make, they give opinions. It is good to evaluate the persons who shall be included in the team. An evaluation method may, besides evaluating, help the firm to solve important problems by anchoring the project with the co-workers and it may reduce uncertainty during early stages. (Andersson and Laurila, 1983, p. 108)

The use of computer programs offers a number of advantages in idea generation processes, text alterations, zooming, grouping of features can be made, meeting notes are produced automatically. The program may act as a tutor because guidance features can be integrated into the computer program.
Guidance principles in analysis methods can be grouped into describing and questioning principles. Explaining guidance describes the operating principles in general or in detail, questioning guidance contains questions either so that the method asks the analyzer to present the answer to a question or so that the analyzer asks the method a question and gets an answer. A typical example of explaining guidance is manuals for analysis systems that are part of practically all analysis methods. Another example of explaining guidance occurs in checking list methods that involve rating according to different scales ranging from yes-no to different numerical or verbal scales. Here the guidance involves information on the type of answer e.g., yes-no, or scale and range of scale (Andersson and Laurila 1983, p. 124).

1.4. Framework

In his general “decision theory” Ansoff referred to Simon's four steps of problem solving in business: i) perception of decision need or opportunity, ii) formulation of alternative courses of action, iii) evaluation of the alternatives for their respective contributions, iv) choice of one or more alternative for implementation. Perception of need is a major issue in strategic decision-making. Different alternatives will present themselves during the planning period, and may cause conditions of partial ignorance about future opportunities. Thus such alternatives need to be evaluated. Ansoff criticizes the Capital Investment Theory (CIT) for a number of reasons. The CIT-method does not provide continuing intelligence activity needed for strategic action. CIT uses long-term profitability over the lifetime of a project as yardstick for evaluation, but this cannot handle the multiplicity of objectives or the problem of conflict between them (Ansoff 1987, p.38-40). Furthermore, Ansoff explained that the development of a strategic decision method must handle allocation of the firm's resources between opportunities in hand and probable future opportunities under conditions of partial ignorance, and it must evaluate joint effects (synergy) resulting from addition of new product-markets to the firm. The decision method must also single out opportunities with outstanding competitive advantages, and handle a vector of potentially antagonistic objectives (Ansoff 1987, p. 23).

Ansoff also described what he calls the adaptive search method for strategy formulation (Ansoff 1979, p. 6), that is based on a feed-back procedure called cascade. The cascade is a process that searches for the best solution; information may develop at later stages that cast doubt on earlier decisions. The procedure within each step of the cascade is similar. First a set of objectives is established, then the difference (the "gap") between the current position of the firm and the objectives is estimated. Thirdly one or more courses of action (strategy) is proposed and, finally, these are tested for their "gap-reducing properties." A course is accepted if it substantially closes the gap; if it does not, new alternatives are tried. (Ansoff 1965, 24-6, Lintunen 2000, p. 252-3). The research problem that is connected to the question of detecting failure causes early, obviously it regards a method by which the detection can be done. Such a method would be related to risk theories because failure causes involve risk. Business and society make up the environment for many innovation ventures. The method will consequently also be related to theories regarding business and society.

Fields of interest will thus include theories of innovation, enterprise, and knowledge and resources based theories. A study of these fields of theory will reveal how they link to each other, and these revelations will guide the development of a method that detects risks of failure early in innovation ventures that are typical in business and society. In order to become beneficial for business firms and society in general, the theoretically derived model needs to be made usable for firms and organizations. An analysis method must be generated that is based on the model. The generation of such a usable method will require testing in actual conditions within firms and organizations. This circumstance brings forward the following question: how shall a usable method for early detection of risks in innovation be created, which techniques ought to be used? The outcomes of the testing can be made to influence the further development of the model and thus generate an interactive process for the method development. Such a process can be managed to proceed in stages via successive phases towards a final practically usable analysis method. As a side effect the firms and organizations that take part in the testing will act as pilot firms and they may benefit from the outcomes of the test through the analysis results that the model produces.

The work involved the study of the literature. A theoretical structure of an ideal model for early detection of risks in innovation ventures will then be derived based on the literature. This theoretical model will then be gradually refined to form a practically usable method through interactive cooperation with pilot firms in analyses with their actual innovation ventures.

Figure 1-4 illustrates the main groups of theories that relate to a method for definition of failure risks in innovations.

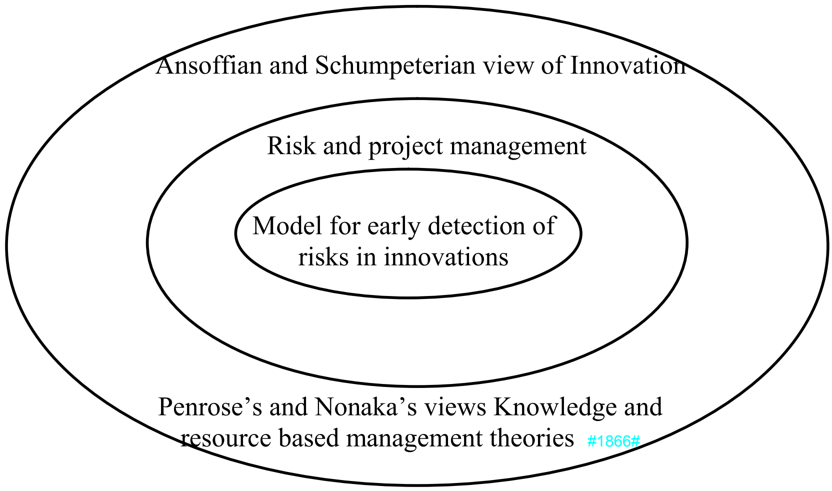

Figure 1-5. Theories that relate to a Method for Definition of Failure Risks in Innovations (Ex Ante model).

This work first presents in Chapter 1 those parts of innovation and risk management literature, as well as their relations that pertain to the development of a model for early detection of risk in innovation projects. From the relevant literature were found items that constitute a model for early detection of risks in innovation projects. In Chapter 2 current methods for the analysis of innovative projects and for risk analysis in projects are presented as well as some methods for idea generation. Shortcomings in these methods are presented as voids in the field of risk detection in innovative projects. Chapters 1. and 2. are based on findings from the literature study. Then the theoretical findings from the literature were used for the construction of a theory-based model for early risk detection in innovative projects (ex-ante model). This part is described in Chapter 3. Finally, the linkage of the above mentioned theories into a model for early detection of risks in innovation are described in Chapter 4, the empirical work.

1.5. Research Method

The selected viewpoints are those of the management of the innovative firm and the viewpoint of the model developer or analyst who will develop the analysis system. Furthermore, the knowledge of the management of contributing firms will benefit from the outcomes of the development process to construct an ex-post model. The framework will be based on the scientific discussions around the concepts: innovation theory and risk management. It also involves the management and analysis of projects. Furthermore the reference framework is based on the discussion in the fields of learning, of information transfer into and out of the model (interface, presentation) and of information transfer inside the model (guidance and computing). The research problem is to construct a model for early detection of problems in innovation projects and to create an analysis method based in this model that can be applied in innovation projects in firms.

An appropriate way to structure this work, which consists of a constructive model building, is to relate the work to both theory and praxis. The work will be structured into four main parts of which the first two deal with theoretical aspects, and the third with practical development and application and, finally, the fourth part compares the theoretical aspects and the findings from the practical work. Figure 1-6 illustrates this structure. #1888#

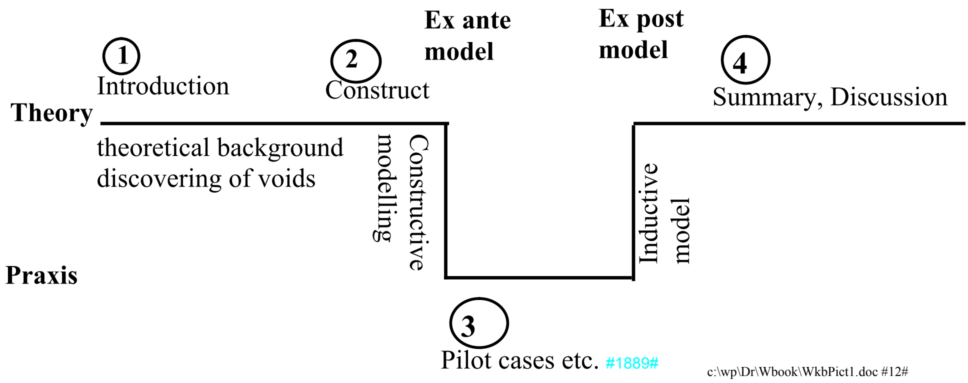

Figure 1-6. Illustration of the Structure of this Work.

The introduction, part (1), starts at the theory level and considers the literature study of existing theoretical background, and thus presents the fundamental theoretical base for the research work. The introduction is followed by a theoretical study based on the literature investigation of methods. Then follows the construct-making process, part (2), that produces the ex ante model that is based on the theoretical facts. After this follows the description of the development of a practically usable analysis method based on the ideal model. This development was continued in interaction with a number of pilot firms that provided real projects for analysis, and in the praxis level the model was developed into an analysis model in analyses of pilot firms' projects and in other practical activities (3). The practical work resulted in an interactive model of an analysis method. Finally, in the fourth part the summary and discussion (4) brings the work back to the theory level where the practical findings are related to statements from theory.

The study was done as a constructive multi-case research, qualitative as well as quantitative material was used (Kasanen et al. 1991). According to Kasanen et al. the construct is defined as an entity that gives the solution to some explicit problem. The development of a construct consists of problem solving that results in something clearly new and divergent compared to the earlier known e.g., by building a model, a diagram, a plan, an organization, or a machine. The problem ought to be connected to earlier knowledge, another specific property of the construct is that its function and newness must be verified. Kasanen et al. also consider constructive research as a form of applicable research that generates such new knowledge that aims at some application or purpose (Kasanen et al., 1991, p. 302-304). This view places constructive research in a central position surrounded by fundamental research, scientific problem solving, technology, and consulting (Kasanen et al., 1991, p. 303). When reporting constructive research answers must be presented about the intention of the constructive research, about where in the methodological field of business science the research is located, and about under which conditions the research can produce scientific knowledge (Kasanen et al., p. 304). Within the four-field of concept-analytic, decision-methodological, action-analytic, and nomotetic research grips (Kasanen et al., 1991, p. 315) constructive research is placed connected to the decision-methodological and action-analytical research grips, in the combined normative and empirical field, (Kasanen et al. 1991, p. 317).

In practice constructive research work can be divided into specific sequences (Kasanen et al., 1991, p. 306) e. g.,

1. problem-finding
2. pre-study of the research area
3. innovation-stage, model construction
4. testing of the model and demonstration of its rightness
5. demonstration of the connections to theory and the scientific newness
6. verification of the area of application for the model.

The constructive research work often first proceeds stage-wise (stages 1. - 3. above), then follows reliability testing (stage 3. above), and finally verification of the model (stages 5. – 6.above) (Kasanen, et al. 1991, p. 320). In an analytical study on how expert knowledge could be relevant for foresight on innovations Kuusi (1999, p. 231) concludes that a study can have its "practical side" and its "theoretical side". He is also of the opinion that it is impossible to develop the practical side without good background theories. However, Kuusi states, one must not trust nice theories too much.

2. Methods for Generation and for Analysis in Innovation Projects

2.1 Methods for Risk Analysis and Risk Management

Risk management requires a risk analysis to answer different questions and the analysis method must possess a number of qualities. Halman and Keizer (1994, p. 75-76) developed the Risk Diagnosis and Management (RDM) method at the Philips corporation, and it represents an example of the outline for a risk analysis method. It was developed to be executed by a project consultant and by the project management, and to be carried out by a risk team. The key assumptions for the use of a risk analysis process are exemplified by Chapman and Ward (1997, p. 67) in their description of the formal risk management process (RMP). This process can be applied at all steps of a project cycle by clients, by contractors and by other parties associated with a project. Chapman and Ward (1997, p. 80), when pondering the considerations for risk analysis, suggest considering the risk management action as a project in its own right.

Ansell and Wharton (1992, p. 207-208) describe experiences from risk management in connection with offshore North Sea projects. They list necessary constituents for models and they point out that the implications of the use of the model must be understood in detail. In his description of an idea-generating program Virkkala (1994, p. 219) presents an outline of evaluation criteria that enhance the development of innovative ideas and promotes their acceptance in organizations simultaneously with guidance towards appropriate criticalness. When dealing with the key assumptions for a risk analysis process Chapman and Ward (1997, p. 37-38) observe that risk analysis can serve separate roles in relation to trade-offs between risks and expected performance. They also mention (on p. 95-96) two tasks to do (search and classify) and other actions to avoid in risk analysis processes. Finally they point out (on p. 83) the key players in the focusing phase of the analysis.

Some required qualities mentioned by these writers are condensed in Table 2-1. The table discerns the requirements for, and the qualities of a risk management method. Eight requirements are listed and between two and seven qualities for each requirement. The table gives an overview of the most important considerations for risk management in an organization. The content of the table is also supported by Ansoff's reference to decision theory, particularly by the considerations for risk analysis and by the outline of analysis criteria. The essential purpose of risk management is to improve project performance via systematic identification, appraisal and management of project-related risk (Chapman and Ward 1997, p. 9).

Ansoff's methods contain several constituents that are applicable in a risk analysis method for innovation projects i.e., Simon's four steps, resource allocation, vectors of antagonistic objectives, and constituents of the cascade process. Successful risk management requires linked and integrated models, it needs expertise and also special skills. Risk perception is recognized as the first step in risk analysis (Ansell and Wharton 1992, p. 37). Once the potential technological, organizational and commercial risk factors have been identified, the focus in the risk-diagnosing process changes from identification to valuation of the project-risks (Halman and Keizer 1994, p. 77). This can be considered as a part of the "gap"-reducing steps in the cascade process of Ansoff.

Table 2-1. Considerations for risk management method #1108#

Requirements	Qualities
Outline of project risk analysis method Halman and Keizer, 1994, p75	risk identification risk validation risk quantification decision making for risks draw up and execute risk management plan
Key assumptions for risk analyze process Chapman and Ward, 1997, p. 67	client perspective initiation in project's planning stage comprehensive risk management plan
Considerations for risk analysis Chapman and Ward, 1997, p.80	who wants risk analysis who undertakes risk analysis why risk analysis when to do risk analysis what form of risk analysis how to carry out risk analysis what resources for risk analysis
Risk management method requires Ansell and Wharton, 1992, p. 37	flexible, general set of graphical and mathematical models family of related models expertise and specialist skills integration of models, methods and software
Outline of evaluation criteria Virkkala, 1994, p. 219	"opportunity" for idea need for idea conditions for idea's utilization benefit to customer or user benefit to own organization risks for user risks for own organization
Key assumptions for design of analysis process Chapman and Ward, 1997, p. 37-38	diagnose desireable changes in plans demonstrate implications of changes facilitate, demonstrtate and encourage 'enlighted gambles'
In analysis: avoid Chapman and Ward, 1997, p. 95-96	waste time on considerations if first thought effective overlook key responses overlook apparently minor problem that cannot be fixed
In analysis: do Chapman and Ward, 1997, p. 95-96	identify opportunities with implications beyond risk explore deeper levels of risks if particularly important
Focusing phase for analysis: Key players Chapman and Ward, 1997, p.83	senior managers other relevant managers technical experts risk analyst or risk analysis team

A common feature of brainstorm sessions is that the members are suggested to let their ideas flow freely without allowing critique or any other hampering activity during the session (Osborn 1965, p. 176-179). Consultants can have a very important role in the implementation of risk management processes and the execution of specific studies. Most organizations cannot effectively self-start in this area. However, project managers and project teams more generally cannot simply buy a risk analysis from a consultant, nor should they attempt to do so (Chapman and Ward 1997, p. 92). In most methods, a lot of time is spent in group-sessions to identify the risks of a project. In group-sessions negative group effects are likely to occur. In a group differences between the participants in terms of seniority and reputation can, not necessarily explicitly, severely disturb the free exchange of thoughts and ideas about what can go wrong in a project. In order to prevent the group effects e.g., in the Risk Diagnosis and Management (RDM) method, the members of the risk analysis team are individually interviewed to determine potential factors (Halman and Keizer 1994, p. 79-80). Consultants can also have a "neutralizing effect in sessions".

2.2. Description of Project Analysis Methods

For the purpose of this work a typifying according to use and function seems most appropriate. It is presented in Table 2-2 and it will be used in the following description of methods found in the literature search. However, many analysis methods cannot be unambiguously assigned to one certain method type because simultaneously they have properties that are characteristic of several types. Primary requirements are that the method is easy to use and to understand for the users, it must be flexible, fast and selective. The method must further analyze strengths and weaknesses in the project, it must counteract locking in the work and it must project the prerequisites of the project. The method shall also make possible steering, adjustments and re-formulations of the project.(Andersson and Laurila 1983, p. 57)

Table 2-2. Typification of project analysis methods #1557#

Decision theoretical methods	Project management methods
	Program evaluation and review technique (PERT)
Check list	Graphical evaluation and review technique (GERT)
Profile scheme	Program evaluation and review technique (SCERT)
Ranging methods	Quality Function Deployment 1 stage (QFD1)
Klustest	Quality Function Deployment 2 stage QFD2
Design reviews	Quality Function Deployment 3 stage QFD3
Idemap	Quality Function Deployment 4 stage QFD4

Risk Management methods	Econometric models
Fault modes and effect analysis (FMEA)	Profitability methods
Fault modes, effect and criticality an. (FMECA)	Index methods
Risk evaluation	Operation Analysis
Iderisk	Mathematical programming
Fault tree	methods

A number of analysis methods for innovation projects are described in the literature, we have typified them as shown in Table 2-2. Some of them will be shortly described below. First will be presented decision theoretical methods, then risk directed methods, and finally project management methods. Analysis for innovation projects has additional requirements compared to general project analysis. It must consider the important constituents of innovation and innovation management, such as new combinations, entrepreneurship, entepreneurial leadership, creative destruction or renewal, and strategy. Qualitative evaluation is based on knowledge, experience and intuition.

Methods based on decision theory in descriptive form are often used for this purpose. Quantitative methods involve a judgment based on calculations, and they produce some sort of numerical values. (Andersson and Laurila 1983, p. 8) Many of the evaluation methods are directed towards analysis of risk. Within both of the groups mentioned above representatives of the different structural types can be found.

In the following paragraph are descriptions of decision theoretical methods, risk management methods, project management methods, and econometric methods.

Decision theory methods often consist of a number of criteria of dimensions by the means of which ideas or project suggestions are evaluated. The evaluation can be qualitative, quantitative or a combination of these. Risk management methods focus on finding risk within projects, and on managing these risks. Project management methods deal with aspects regarding management of projects.

Econometric methods are used to measure the economy for something. They are based on assessment of future incomes and costs and they may be combined with some sort of risk or unsafety analysis (Andersson and Laurila 1983, p. 22-24).

The firm must see the evaluation process as a component of a larger system that can be called the product development process. This is a prerequisite for the idea evaluation to function effectively in the firm. In analysis of the performance of a project, e.g., of an R&D project it is important to define clearly what aspect of the performance will be dealt with in the analysis and define the levels and units of the analysis. Andersson and Laurila conclude that the type of method to select depends on the stage of the project at the time for evaluation. They refer to Albala who says that “the tool must fit the need”. Thus the following table of stages and methods (Table 2-3):

Table 2-3. Table of stages and methods #2079#	
Idea stage	checking lists
Pre study stage	profile or ranking methods
development stage	Econometric methods and index methods
commercialization stage	economic evaluation, sensitivity analysis

(from Andersson and Laurila, 1983, p. 48-49).

2.2.1. Decision Theoretical Analyses

Andersson and Laurila (1983, p. 22-24) refer to certain analysis methods as decision theoretical methods, and they state that these methods are based on decision theory. Examples of these models are checking lists, ranging methods, the KlusTest, design reviews, Fluvius and Idemap methods.

Checking lists include

- checking list
- profile scheme
- Idemap

Checking list

A number of questions are posted. They can be answered according to different scales ranging from yes-no to different numerical or verbal scales. Checking lists may also be used successively according to scales that gradually become more requiring (Andersson and Laurila 1983, p. 122). These questions often appear in standardized question lists, this makes the method quite inflexible. The outcome of the analysis may become dependent on whether an appropriate list has been selected.

Profile scheme

A profile scheme can be defined as a structured checklist, each factor is assigned a value on a scale. The values are presented visually as a profile line. A profile scheme is an explanation in order to guarantee a fair comparison for the different projects in a project evaluation process. The factors can be divided into different groups e.g., market-related, technical etc. The advantages of profile schemes are assurance that the most important aspects of the project are regarded, profile schemes point out the strong and weak sides of the project and they offer discussion bases as aids for decision-making. The method gives an average of subjective evaluations, this is regarded as a disadvantage. Andersson and Laurila refer to experiences in which profile schemes have been successfully used as discussion bases for decision making and as prioritizing instruments in the evaluation work (Andersson and Laurila 1983, p. 124).

Ranging methods

Ranging methods pass judgment on products and project ideas according to a number of factors that have significance for the selection and evaluation. The number of factors must be limited mainly to critical factors. Then a value scale for each factor is decided. It can be either numerical or verbal (Andersson and Laurila, 1983, p. 127-129).

KlusTest

The KlusTest was developed by John Klus of the University of Wisconsin under an industry supported grant. It is a wholly computer based decision support tool providing expert diagnostic information for new product evaluation. The software tool provides a structured procedure for “concept” stage product evaluation where uncertainty is high. The program has the following functions:

- assists product evaluators
- identifies contributing factors to product success
- provides consultation rather than specific recommendations
- develops an understanding of the company's success and failure characteristics

The KlusTest evaluation tool incorporates multiple methodologies, identifying critical issues that contribute to making the overall evaluation decision. A company knowledge base is created from the three existing models that comprise the KlusTest:

- ProCon Evaluation model, a product screening model that combines the opinions of multiple evaluators; ProCon is based on an internal database of industry wide success parameters arranged much like a pre-set questions list
- Market/Technology Analysis tool that profiles the newness of the market and technology to the firm as a graphics presentation. It also details the course of action that the firm ought to take
- Competitive Advantage Ratings instrument that examines the relative protectability of the product concept. It is arranged around a number of pre-set questions

This test produces a diagnostic recommendation, but does not produce the complete answer. It presents more information within a systematic framework to better understand the relationships between market, technology, business and competitive advantage factors within the context of the company-specific considerations in determining product success. However, it involves no creativity, it does not allow item combinations or inter-influence analysis. Klustest is composed of 63 preset questions that are answered by rating on a scale 1-10, that makes it inflexible. Once the analysis is performed the computer program does not allow any adjustments without performing the whole analysis from the beginning. The test is to be operated on one, or several computers. Each evaluator answers questions displayed on the screen. When all evaluators have responded, all data can be consolidated on one computer for generating the analysis. The final report is produced to a disk file and can also be printed. The KlusTest program is recommended at the concept stage but it may also be used at other stages of the development cycle. Company specific advantages of the test are that the opinions are reviewed within a standard framework and that company knowledge and experience is retained in the database after the company "experts" have left the organization. KlusTest also acts as a "learning tool" to help new srtaff develop experience faster. (KlusTest home page 1996, private discussions with John Klus, May 2000)

Design reviews

The principal objective of a design review program is to ensure that the requirements of the product are correct and will be met, and will result in a reliable, useful and saleable product.

Particularly the design review process is designed to ensure:

- the product meets specified requirements cost-effectively
- the product satisfies customer needs
- the product and its elements can be safely and economically analyzed
- required design, manufacturing and installation methods are being used
- costs have been optimized after considering all product requirements
- scheduling considerations are taken into account
- components are used within their specified performance and stress ratings

Design review facilitates assessment of the status of the design. It identifies weaknesses and guides the project team toward appropriate corrective action.

It further accelerates maturing of the product or process by reducing the time needed to stabilize design details, and allows production to proceed without frequent interruptions. Design review also stimulates early improvement of the product (CEI IEC 1160 1992, p. 15).

There are different design reviews that depend on the stage of the project (CEI IEC 1160 1992, p. 13):

- preliminary design review
- detailed design review
- final design review
- manufacturing design review
- installation design review
- use design review

Design reviews are separate from planning and scheduling reviews. They should complete one another. The persons executing a design review are assigned clearly specified task jobs to perform during the analysis process. The task jobs include chairman, secretary and a number of specialists. A project manager should not conduct Design reviews. Consequently, the chairperson should consult the project manager to plan and schedule design review activities of the project. Design reviews should be conducted just before taking major decisions, which may prove costly, time-consuming, or difficult to reverse. (CEI IEC 1160 1992, p. 27)

Design review facilitates assessment of the status of the design, it identifies weaknesses and guides the project team toward appropriate corrective action. It accelerates maturing of the product or process by reducing the time needed to stabilize design details, and allows production to proceed without frequent interruptions. Design review also stimulates early product improvement (CEI IEC 1160 1992, p. 13). Another analysis method is the formal design review, a formal and independent examination of an existing or proposed design for the purpose of detection and remedy of deficiencies in the requirements and the design which could affect such things as reliability performance, maintainability performance maintenance support performance requirements, fitness for the purpose and the identification of potential improvements (CEI IEC 1160 1992, p. 9).

Fluvius

Fluvius is a program that has been developed particularly for teamwork. In this program the use of a distant thought model has the central part. This program also includes idea evaluation with weighted rating points and it calculates the correlations between ratings made by different evaluators. The use of this program is rather time consuming partly because of the evaluation process. Normally the analysis of one problem requires two full workdays. (Virkkala 1994, p. 217)

Idemap

The program Idemap enhances the formation of a total mapping of a problem situation. The problem situation is described, the pertaining facts as well as opinions, visions or wishes are listed, a number of alternative ways of approaching the problem are suggested. Based on these items a number of ideas are generated and evaluated. The program contains forms to guide the analyzers in their work. Each object of mapping is written in two forms, as a short summary and as a larger presentation. This helps the analyzers to apply a distant view as well as a detailed view of the problem. Idemap is, in the first hand, intended for the guidance of innovation projects to a better direction at the early stage. A computer combined with a projector is used in teamwork sessions. (Virkkala 1994, p. 218)

2.2.2. Non-financial Risk Management Methods

Risk management process (RMP) can be considered a collective name for certain methods. The methods are characterized by certain properties. RMPs are highly structured, but they do not imply a rigid 'paint by numbers' approach. The process ought to stimulate Creativity, lateral thinking and imagination, and not discourage. RMPs are, in many important respects, largely a formalization of the common sense that project managers have applied for centuries. RMP is not a new way of thinking, or the engine of an intellectual revolution, which requires a significant change in mindset to be appreciated (Chapman and Ward 1997, p. 64). Risk management methods will include verbal, graphical and mathematical models; often several models will combine one method. Different models frequently need to be linked together by means of computer programs. Risk management processes further require expertise and specialist skills and the experience in leadership.

Undertaking risk management is a high-risk project in itself, especially if embedding effective risk management in the organization as well as in the project in question is the objective (Chapman and Ward 1997, p. 93). The formalization involved in RMPs is a central part of the communication processes involved. The level and kind of communication RMP can generate can lead to significant culture complex and fundamental changes within organizations. Because RMPs can be concerned with very complex issues, it is very important to have "keep it simple" as a guiding principle, adding complication only when benefit from doing so is perceived. The iterative nature of RMP is central to 'keeping it simple', using early passes of the process to identify the areas that need more detailed assessment in later passes (Chapman and Ward 1997, p. 64). In this respect the RMPs remind one of Ansoff's cascade process (Ansoff 1965, 24-6).

Failure mode analyses

A failure mode is the effect by which a failure is observed in a system component

There are two common ways of classifying failure modes:

a) identification of general failure modes, as derived from the definition of reliabily

b) by listing, as completely as possible, all generic failure modes

The most important failure modes are common mode failure (CMF), human factors and software errors (FMEA 1985, p 19).

The Fault Modes and Effects Analysis (FMEA) investigates for every component the consequences of all defined modes of failure. The investigation is usually carried out for each component in isolation from the analysis of other components, since if combinations were considered the task would become intractable. This analysis method has the drawback that specific combinations of basic events or component failures, which may cause failure of a system, may be overlooked. The outcome of the study will usually be a report for each component giving details of failure modes, consequences and, where appropriate, action to be taken (Ansell and Wharton 1992, p. 109). This limits the use of the FMEA method predominately to analysis of products. Examples are material and equipment failures and categories of systems based on different technologies (electrical, mechanical, hydraulic, etc.), and combinations of technologies. FMEA is extremely efficient when it is applied to the analysis of the elements that cause a failure of the entire system (FMEA 1985, p13). FMEA may also be used for the study of software and human performance (FMEA 1985, p9). Marketing or administration issues cannot easily be analyzed (Ansell and Wharton 1992, p. 109). FMEA and other system reliability and availability analyses may be combined within a project, or FMEA (or FMECA) can be used alone. FMEA is often used to complement other approaches, especially deductive ones, because it is systematic. At the design stage both inductive and deductive approaches are combined in processes of thought and analysis. For risk identification in industrial systems the inductive approach is preferred and therefore FMEA is an essential design tool. It is recommended to supplement FMEA with other methods e.g., where multiple failures and sequential effects must be studied (FMEA 1985, p 23). However, FMEA may be difficult and tedious for the case of complex systems that have multiple functions consisting of a number of components. This is because of the quantity of detailed system information that must be considered. This difficulty can be increased by the number of possible operating modes, as well as by considerations of the repair and maintenance policies (FMEA 1985, p 13). A logical extension of the FMEA is the consideration of the criticality and probability of occurrence of the failure mode. This criticality analysis of the identified failure modes is widely known as FMECA (Fault Modes, Effects and Criticality Analysis)(FMEA 1985, p 9).

Risk diagnostics methods

A frequently used method is the Risk Diagnosis & Management method (RDM). This method consists of four parts: project identification, validation of project risks, decision making for diagnosed risks and executing a risk management plan. The purpose of a risk diagnosis is to detect those factors that may jeopardize the successful realization of the project objectives. In product-innovation projects, these risks can be differentiated in terms of their technological, organizational and commercial factors. Specific to the approach in the Risk Diagnosis & Management Method (RDM) is the focus on the detection of gaps between available and required technological, organizational and commercial knowledge, skills and experiences. A specific virtue is also, that in RDM data is gathered by the project-consultant, so that he individually interviews the members of the risk team. The RDM is so far perceived as being a valuable tool to detect the key risks in technologically complex product-innovation projects. The assumption is made in RDM that the impact of a risk not only depends on the likelihood of its occurrence but also of the ability or the inability to influence the situation. The impact does not either depend on the consequences of occurred risk. Thus Halman and Keizer (1994, p. 76-79) characterized risky activities by:

- The likelihood of it occurring is great
- The ability to influence the course of action is small
- The potential consequences are severe

The Risk Diagnosis & Management (RDM) method also diagnoses possibly desirable changes in plans, demonstrates the implications of such changes in plans and facilitates, demonstrates and encourages 'enlightened gambles' (Chapman and Ward 1997, p. 37-38).

Iderisk

Iderisk is a program for minimizing risks in innovation projects. It is based on an analysis of propensity to disturbances, i.e., potential problem analysis. The team should include external experts. The program guides the team to firstly ponder systematically which disturbance might occur in connection to the idea, secondly how each disturbance could be avoided and, thirdly how to prepare the salvation of the situation should the disturbance appear. The program is computer based, and it lists the possible disturbances; the likelihood and the seriousness of each disturbance is rated on a numerical scale, the means to avoid the disturbance is rated on a numerical scale and, finally the ways of salvation are listed. The computer program makes changes in the texts easy, it automatically presents a document and it makes it easy to continue the meeting after a break or after the project has proceeded and new situations occur. The program further offers a Help-function that provides the analyzers with advice on how to proceed in the analysis. Iderisk also attempts to record cases in which it is particularly important to continue to create ideas for remedies and preservations. (Virkkala 1994, p. 219)

Fault-tree and event tree analysis

Two common approaches used in a system-failure analysis context, namely Fault-tree analysis and Event-tree analysis (Chapman and Ward 1997, p. 136). Fussell pioneered Fault-tree analyses. It produces a description of the relationship between the set of basic events and some specified top event. The top event is the event of interest, in a risk analysis it would be the particular risk under study. Starting with this risk, the next stage would be to explore how the event could have arisen from contributing events (Fussell 1976, p. 133-162). Event tree analysis involves identifying a sequence of events that could follow from the occurrence of particular risk driver configurations, and representing the possible scenarios in a tree diagram where each branch represents an alternative possibility (Chapman and Ward 1997, p. 136). Event tree analysis is often used in project planning activities that do not necessarily involve risk analysis.

2.2.3. Project Management Methods

Activity planning methods

Several methods have been presented for use in project planning and control. The most known are the critical path method (CPM), the program evaluation and review technique (PERT), the graphic evaluation and review technique (GERT) and the Gantt chart. According to Elmaghraby (1983, p. 26-57) numerous computer programs are available for application of these methods. Analysis can be made for possible project overruns and accelerations. Silverberg (1991, p.46-49) presents a graphical process to predict R&D project events and assign error bars to the predictions. The process is based on the same basic presumptions as GERT, i.e., projection from past events. The prediction dates of the key project milestones, like first product ship date, against the date of projection (Figure 2-1). A very important element of the graph is the completion line where the predicted date of completion equals the actual date of completion. Well-managed projects approach the completion line horizontally, i.e., they do not change their schedules. Poorly behaving projects approach erratically or nearly parallel to the completion line for long periods of time. One notable feature is a kink that can often be detected in the line for some projects, e.g., Project 2 in Figure 2-1.

The project planning team may provide a high-risk environment for risk analysis because e.g., if project management is ineffective. The project team members may not be familiar with effective project risk management processes, are familiar with inappropriate risk management processes, come from very difficult cultures or they come from competing organizations or

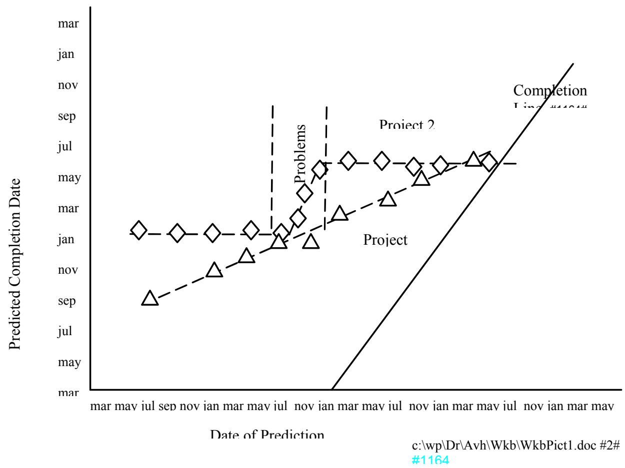

Figure 2-1. Prediction of project completion (Silverberg 1991).

departments (Chapman and Ward 1997, p. 93). The EDCP must therefore also examine the analysis team.

The simplest project activity planning models, which explicitly consider risk are PERT (Programme Evaluation and Review Technique) models. They portray project activity structure via an activity-on-arrow or activity –on-node diagram representing precedence constraints and uncertainty associated with the duration of each activity directly via a probability distribution, which may be pictured as a cumulative probability curve. First introduced in the late 1950s (Moder and Philips, 1970), these models are still the basis of much of the current project risk management. A key shortcoming of basic PERT models is the assumption that activity probability distributions are independent, both causally and statistically. PERT estimates time requirement of project activities. However, it does not consider the state of the project system nor does it address the transition between time periods. PERT did not consider risk.
A second shortcoming of basic PERT models is the need for direct estimates of how long an activity will take. Some further developments were made to overcome the shortcomings.

The shortcomings of PERT were recognized and partly resolved as part of the GERT (Graphical Evaluation and Review Technique) approach. It uses a Markov or semi-Markov process model, which can be embedded in a generalized PERT model. In a Markovian process one probability distribution defines the 'state' the system is in (how much of the activity has been completed) and another defines the 'transitions' between time periods (activity rates of progress) that are used to upgrade the 'state'. Graphical PERT or GERT defines the state of the project system as well as the transitions between different time periods. Synergistic PERT or SCERT involves a fault tree or event tree model embedded in a GERT model. The shortcoming of GERT is the need to understand the nature of the risk realized before considering effective responses. The shortcoming of the need to understand the nature of the risk realized before considering effective responses was recognized and resolved in the mid 1970s as part of the SCERT (Synergistic Contingency Evaluation and Review Technique) approach (Chapman 1979, in Chapman and Ward 1997). The SCERT approach involves a fault tree or event tree model embedded in a GERT model (Chapman and Ward 1997, p. 89-91).

Quality Function Deployment (QFD) consists of a series of four different analyses of which QFD1 focuses on the concept. QFD2 focuses on product structure, QFD3 on the production process, and QFD4 on production. The analyses depend on each other in a consecutive way. QFD is characterized as a fairly simple tool, but it requires processing of quite large amounts of data. (Turunen 1991, p. 21-22) A comprehensive analysis of a project requires all four analyses and means a time consuming work.

The use of a QFD-approach links customers to engineering and manufacturing decisions so that products can be manufactured efficiently and exactly. By linking houses, the new-product team assures that the voice of the customer is deployed through to manufacturing. Some organizations find QFD overall formal and burdensome. This may be true because construction of a set of houses for QFD can take a tremendous amount of time (Urban and Hauser 1993, p. 347-348). The advantage of the House of Quality is that it displays the key information that the new product team needs for a successful design. By making this information explicit it removes hidden agendas and helps the team avoid unnecessary mistakes (Urban and Hauser 1993, p. 347-348). By various claims QFD has reduced design time by 40% and design costs by 60% while maintaining or enhancing the quality of the design (Hauser and Clausing 1988 in Urban and Hauser 1993, p. 340).

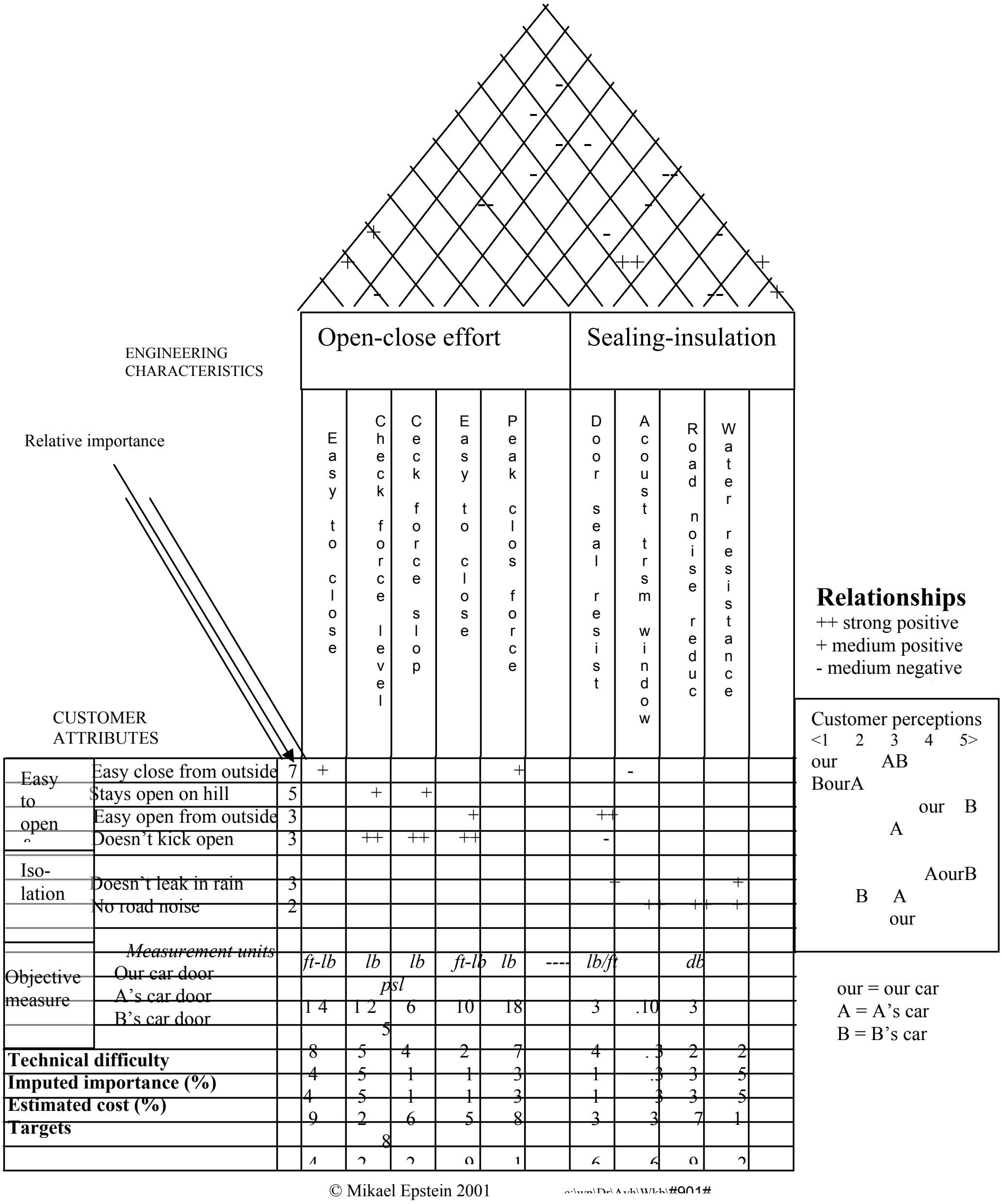

Figure 2-2. The House of Quality.

The linking of Customer Needs to Engineering Characteristics marks the House of Quality Approach. One convenient diagram to help in linking engineering variables to the detailed customer needs is shown in Figure 2-2. Because of the distinctive shape it is called the "House of Quality." The inter-functional team i.e., marketing, engineering, R&D, production and so on puts the house together. (Urban and Hauser 1993, p. 340) The House of Quality links the "whats," the customer needs, to the "hows," the engineering characteristics. The following task is to take the engineering characteristics as the "whats", and link them to another set of "hows"-parts characteristics or product features. Thus a repetitive changing of the "how" to "what" produces an analysis chain (Turunen 1991, p. 33). One approach to this task is to us the house diagram gain, but in a revised manner. The engineering characteristics become the rows of the next house, while parts characteristics become the columns as shown in Figure 2-3 (Urban and Hauser 1993, p. 347-348).

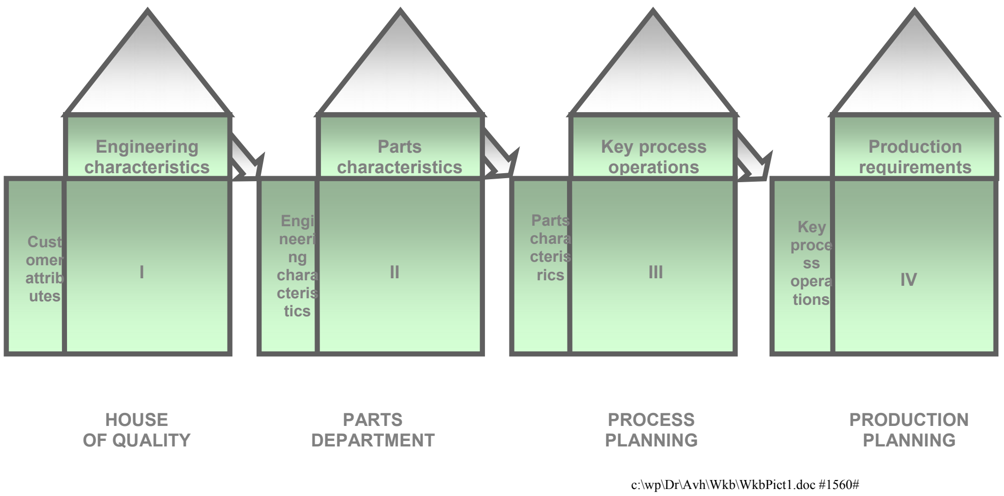

Figure 2-3. The four stages of QFD are linked together by repetitive change from the "how" to the "what" when transferring from one House of Quality to the next.

Econometric models

Over the years a large number of econometric evaluation methods have been developed. Econometric models are primarily used to evaluate projects. They do not focus on risk, but risks may become apparent through indications of low economic performance. They include commercial estimation, as well as technical and financial estimations. A common property for most econometric methods is that they involve various degrees of calculation work, but some basical factor must be estimated. Often this estimated factor has a big, sometimes decisive impact on the analysis result. Econometric methods consider the time factor separately, they are simple to use, they can be combined with risk evaluation and they can give an indication of the sales volume for breakeven. However, the econometric methods do not consider non-quantifiable factors, they require information that is difficult to obtain at early stages and they cannot consider multiples of evaluation dimensions simultaneously. They do not optimize or maximize. They produce numerical values that can steer the thinking. Econometric methods express the output as one single value and they are suitable for use at later stages. (Andersson and Laurila 1983, p. 27) Econometric methods involve calculation work, based on data that may be difficult to obtain at early project stage. Therefore some basic factors must be estimated, and they often have a big impact on the analysis result. Literature offers at least 14 different econometric methods. Econometeric models use concepts and methods from accounting. A number of econometric methods are listed in Appendix 1.

Operation analysis method

Operational analysis models are often based on exact economical data that is difficult to obtain at an early stage. Operation analysis methods are based on mathematical program models. They consider the time factor as well as multiples of evaluation dimensions simultaneously. They consider resource limitations and they allow testing of several strategies. However, operation analysis methods require hard-to-get data, they are costly, they put high demand on the user and they require a computer. Operation analysis methods have the advantage that they consider the time factor separately, they consider multiples of evaluation dimensions simultaneously and they consider resource limitations. They allow testing of several strategies (Andersson and Laurila 1983, p. 11 and 27).

2.3. Characteristics of Different Methods

Findings from the literature

Andersson and Laurila made an examination about the use of idea and project evaluation methods in Swedish industrial firms. Their investigations show that circa 50% of the investigated firms use some sort of product evaluation method. In Sweden 68% of 125 examined large firms used some evaluation method(Andersson and Laurila 1983, p. 18).

They also found that the order of priority when choosing analysis method is as follows:

1. degree of commercial reduction of insecurity
2. degree of overrun
3. degree of technical reduction of insecurity

(Andersson and Laurila 1983, p. 108)

Fahmi and Spätig (1990) suggest a set of guidelines for the choice of project evaluation and selection models and identify five key issues that make a route to the appropriate project selection method. The issues are: concentration on most critical problems; degree of quantification of relevant factors; degree of interdependence between projects; consideration of single or multiple objectives; and, finally, degree of risk.

The extent of use of project evaluation methods depends on the influence of background variables. The variables include inter company environment, company structure, surroundings, extent of R&D activity. Therefore the evaluation system must be designed to take into accountancy the special circumstances in the company (Andrén 1980). Danila lists the following 13 main types of R&D evaluation methods: ratio, score index, programming, portfolio, matrices, systemic, checklist, relevance trees, table, multicriteria, consensus, graphic and integrative. On the basis of the description of the methods and on discussions with representatives of French and Japanese industries Danila rated the methods for use for R&D planning and for R&D strategy with respect to their formulation and implementation. He found that excellent to very good rating for use in R&D planning can be obtained by one of the matrix methods, and that checklists and consensus methods offer very good rating. Danila further noticed an excellent to very good rating in one integrative method, and very good rating in one consensus and one integrative method. Both for R&D planning and strategy the excellent ratings occurred in the formulation process, none for project implementation (Danila 1989). A risk analysis system is part of strategy development, as it fits into the project generation and selection step of the action cycle in strategic development (Ansoff, 1987, p. 178). Chapman (in Ansell and Wharton 1992, p 35-39) states that the design of a method e. g., an analysis method, involves choosing or developing an appropriate model/method/ software combination. This is also true when developing a risk analysis method for a particular kind of risk management in a particular context, for instance to analyze risk in innovation projects. He further mentions that the time and money available to perform the analysis, and the expected future use, are obviously important considerations, as well as the immediate task. The design of a method is also necessarily a process, which is dependent upon experience and intuition.

A very detailed treatment of sources of risk and responses involves considerable expenditure in terms of staff effort and information requirements. It has important benefits, however. A method for project planning can yet be designed to make use of simpler models, following a fairly obvious sequence of simplifications (Chapman in Ansell and Wharton 1992, p. 36). This suggests that a model for risk detection also can be developed as a combination of several simple models. Because the result of a risk analysis in an innovation project may influence the project planning the design of a risk analysis method for innovation projects must strike a balance between detailed treatment and use of simpler methods. The analysis criteria can be classified or grouped in several ways. Andersson and Laurila (1983, p 25) group them according to three main groups of characteristics: properties of the method, application of the method and area of use. The groups are further divided into sub-groups.
A purposeful way to group the criteria for the analysis process is to first determine appropriate main groups and then, within them sub-groups. The five main groups are:

i. application
ii. deliverables
iii. inputs
iv. intermediates of analysis (concept and resources)
v. uses

This grouping will be used in this work.

Application covers the type of activity in the project that shall be analyzed, deliverables describe the types of result or outcome that the analysis is required to produce and inputs represent the types of data entered into the analysis, and the way they are entered. Intermediates of analysis include the individual items of the project that will be subject to examination during the analysis. Finally,

Table 2-4. Analysis Criteria #1561#	
CRITERIA GROUPS	CRITERIA SUB-GOUPS
A P P L I C A T I O N	Possible to test several strategies
	Pre-projecting
	Product development
	Administration
	Production planning
	Market introduction
	The method expresses value in absolute numbers
DELIVERABLES	The method expresses value in relative numbers
	Verbal table
	Graphical presentation
	Report
INPUTS	Brainstorm type
	Includes non-quantifiable factors
	Guidance
	Rating
	Requirements on in-data
INTERMEDIATES OF ANALYSIS	Project character, environment and boundaries
	Concept, generally
	Concept attributes
	Concept components
	Knowledge
	Resources, explicitly, generally
	Resource components
	Resource ability
	Optimal resource allocataion considering resource limitations
	Time factor treated explicitely
	Includes multiple criteria
	Considers insecurity explicitely
U S E S	Requirements on user
	Cost of introduction
	Cost of use
	Requires computer
	Teamwork
	Guidance
	Requires database

the group called uses deals with items connected with the use of the different methods. Totally 35 analysis criteria were found in the literature study. Table 2-4 lists the groups and sub-groups of analysis criteria. There are five groups, the number of sub-groups within each group of analysis criteria varies between four and twelve.

Within the application-group the sub-criteria strategy testing, pre-projecting, product development and market introduction are related to innovation. The sub-criteria administration, and production planning relate to management. Within the intermediates of analysis-group the sub-criteria concept, concept attributes, and components relate to the theories of Levitt, the sub-criteria knowledge and resources relate to the theories of Hedlund, Penrose, Nonaka and Takeuchi.

The majority of technical innovation projects were initiated by “need pull”. The opposite, “need push”, that stems from new technical inventions seeking application is scarce. Also the success of “need pull” projects has been better (Virkkala 1994, p. 28).

Most of the literature about innovation describes technical innovations. Innovations in other business fields are much less frequently described.

Sjölander (1985) indicates that in an analysis of the performance, e.g., of a R&D project, it is important to define clearly what aspect of the performance will be dealt with in the analysis. One must also define the levels and units of the analysis. Innovation performance may, e.g., be related to two dimensions: frequency and value. Two independent measures can be applied: degree of innovation and economic value.

Frequently many of the methods are referred to by means of acronyms. A list of some common method names and acronyms is presented below.

Risk directed methods

formal design review	FDR
preliminary design review	PDR
manufacturing design review	MDR
use design review	UDR
detailed design review	DDR
installation design review	IDR
final design review	FDR
fault modes and effect analysis	FMEA
fault modes, effect and criticality analysis	FMECA
common mode failure analysis	CMF
risk diagnosis and management method	RDM
risk management process	RMP

Management directed methods

quality function deployment	QFD
programme evaluation and review technique	PERT
graphical evaluation and review technique	GERT
programme evaluation and review technique	SCERT

Conclusions about different methods

A project analysis model can be characterized by the item within the project that it focuses on, or by the aim that the analysis results are being used for. Examples are methods that focus on activity, on components of existing products, on the relation between products and market, on product structure, or on production process. Other examples are analyses where the results are going to be used as risk indicators for financiers, or where the results will be used for developing a firm's strategy.

The methods can also be classified according to their structure. The structure may involve lists, tables, and graphs. The analysis may approach the project starting from its details, working towards larger entities i.e., a bottom-up-approach, or oppositely, the project may be approached from the top working towards the details i.e., the top-down-approach (Ansell and Wharton, 1992, p. 107-108). The structure also depends on the manner or execution of analysis e.g., whether the analysis is done by a team or by individual analyzers, whether the analysis is done in writing or verbally. The method of the presentation of analysis results has a big influence on the conception of the model e.g., whether it shall be presented in report form, to an auditorium, or whether the results shall be distributed to a large number of receivers. The presentation is usually composed of different deliverables e.g., text, lists, tables, graphs or reports. The medium in which the analysis is performed has a big influence on the composition of the model. For instance an analysis done in writing e.g., with paper and pencil, may require a different structure than an analysis performed with the aid of a computer, its peripherals and program. The latter make up a carrier for the analysis model. Most of the analysis methods found in the literature are performed in writing. Many of them are structured as lists, tables and graphs, some also use rating and algorithms.

Common structural constituents of an analysis model are inputs, research objects, intermediates of analysis, model carrier, and deliverables. The results of the literature study were used to examine in what respect each method covered the different criteria of analysis. The study involved a total of 24 different methods involving risk management methods, decision theoretical methods, project management methods, econometric models, and idea generators The number of analysis criteria covered by each method was counted. Table 2-5 exhibits how many criteria for each analysis were covered within each one of the five criteria groups. The table shows that of the 24 individual test methods only six methods covered more than 15 analysis criteria. Seven methods left at least one entire criteria group without coverage, of these four methods left two or more entire groups uncovered. The largest coverage (24 individual criteria) was reported for Klustest, the risk evaluation method covered 19 criteria. All the method types exhibited quite a large dispersion in the number of criteria covered by the individual analysis procedures within each type group. Five separate tables that show which methods deal with different criteria sub-groups within the groups of criteria are presented in Appendix 2. There is one table for each group of criteria. Also the project management methods, as well as the econometric, operation analysis and idea generation methods were analyzed in a similar way. They are tabulated in Appendix 1. The results from the literature study further reveal that the different analysis methods deal with quite different analysis criteria within the criteria-group intermediates of analysis. Table 2-5 (Intermediates of analysis) is an example of a table that shows which method deals with sub-criteria within the criteria-group of intermediates of analysis. The table shows that most of the analysis methods cover concept-related criteria. Only four methods, Klustest, Risk evaluation, QFD3 and Profitability method cover also resource-related

criteria. The table also shows that six methods consider only one or none of the sub-criteria. Apparently such methods cannot penetrate either the concept or the resources of a project too thoroughly. Most of the methods can be applied for product development, production planning and pre-projecting. Administration and marketing innovation can be analyzed only by a few of the

Table 2-5.Number of Items per Analysis Criteria covered by different Analysis Methods #1572#

Criteria groups / Methods / Number of items covered		Appli cation	Delive Rables	Inputs	Intermediates of analysis	Uses	Total number items covered
Decision theoretical methods							
	Check list	1	1	2	1	3	8
	Profile scheme	1	1	2	1	3	8
	Ranging methods	1	1	2	2	3	9
	Klustest	4	4	4	7	5	24
	Idemap	2	2	4	1	3	12
Risk Management							
	PERT	1	2	3	5	4	15
	GERT	1	3	3	5	4	16
	SCERT	1	3	3	5	4	16
	FMEA	1	2	0	3	3	9
	FMECA	1	2	1	3	3	10
	Risk evaluation	5	2	1	7	4	19
	Iderisk	1	1	1	1	4	8
	Fault tree	2	1	1	1	3	8
Idea generators							
	Idegen	3	2	3	1	7	16
	TRIZ	3	0	1	0	6	10
	CyberQuest	3	1	1	0	2	7
Project Management							
	Design reviews	1	1	1	2	4	9
	QFD1	2	3	1	3	5	14
	QFD2	0	0	0	2	0	2
	QFD3	0	0	0	3	0	3
	QFD4	0	0	0	1	0	1
Econometric models							
	Profitability methods	4	2	1	3	4	14
	Index methods	2	0	1	3	3	9
Operation analysis							
	Mathematical programing methods	2	1	1	4	4	12

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methods. Very few of the individual methods cover several objects of analysis in the same method. Klustest covers most of the concept and resource related characteristics as well as knowledge. Klustest can be characterized by being quick and self-explanatory (requires little guiding), but with its preset questions it is inflexible and does not allow item combination or inter-influence in the analysis process. However, QFD is flexible, allows inter-influence between intermediates of analysis and inter-comparison of items (correlation). It focuses on product/market/production relation, and is less applicable for services or administration projects. However, a comprehensive analysis including all four stages is a very time consuming task. There is no information on guidance in QFD-analysis methods in the literature.

Only Klustest and Idemap offer guidance during input; PERT, GERT and SCERT have limited guidance in some applications. Klustest and QFD offer deliverables as absolute and relative numbers, it also presents tabular lists as well as a report. Profile schemes, the profitability method, FMEA, FMECA and the risk evaluation methods offer graphical presentation. Also the project management methods, as well as the econometric, operation analysis and idea generation methods were analyzed in a similar way. They are tabulated in Appendix 1. The risk management methods are primarily intended for risk management in connection to product design or project planning. Each one of the decision theoretical methods depends on fixed questions or question lists that must be answered, respectively. Each one of the project management methods focuses on components of product or on fault, on product-market relation, product structure, or production, respectively. The econometric methods are based on economical factors only.

An internet-investigation indicated that computer based versions of analysis methods presently can be obtained. QFD, FMEA and certain FDR-analyses are examples of this.

2.4. Voids in the Field of Risk Detection in Innovation Projects, a Place for Contributions to Science

As seen from the Tables 2-5 and 2-6, the literature survey revealed that no one single method was encountered in the literature that covered a combined analysis of concept attributes and components, knowledge, and resources attributes and components. No method could, in addition to this offer the possibility to correlate different items during the analysis process. Furthermore no method was available that could accommodate the guidance functions to the nature of the project. These shortcomings represent the knowledge voids detected in the research object.

Table 2-6. Intermediates of Analysis
#1574#

Analysis criteria / Methods	Project character, environment and boundaries	Concept, generally	Concept attributes	Concept components	Knowledge	Resources, explicitly, generally	Resource components	Resource ability	Time factor treated explicitely	Includes multiple criteria	Considers insecurity explicitely	Intermediates covered
Intermediates covered *)												
Decision theoretical methods												
Check list x										X		1
Profile scheme										X		1
Ranging methods					X					X		2
Klustest			X	X	X	X	X	X		X		7
Design reviews		X			X							2
Idemap		X										1
Risk management methods												
FMEA x	X	X		X								3
FMECA	X	X		X								3
Risk evaluation	X	X			(X)	X			X	(X)	X	7
Iderisk		X										1
Fault tree											X	1
# items covered	3	6	1	3	(4)	2	1	1	1	(5)	2	

*) (X) indicates that criterion regarded to a limited extent

The fundamental void in the field of methods for risk detection in innovation projects was the lack of a model and an analysis method that satisfactorily analyses both the concept of the project and the resources available to realize the project in one analysis process. This void represents shortcomings that necessitate the use of several analysis methods for a good coverage in the risk analysis of innovation projects.

No reports were found that describe the creation of a method that analyses both the concept of the project and the resources available to realize the project. The development of such a risk analysis method would include a contribution to the science of risk analysis methods for innovation and R&D projects. Such a method would also be an answer to the research questions presented in connection with the research problem in Chapter 1.2.

3. A theoretical Model for Early Detection of Complex Problems (EDCP) in Innovation Projects

3.1. Basic Elements in Characterizing an Innovative Project

3.1.1. Background

A theoretical model for Early Detection of Complex Problems (EDCP) in Innovation Projects was developed, partly based on certain theories of management and innovation, and partly on the writer's personal experience. The fundamental theories are Levitt's (1980, 1977) theory about attribute and component, the knowledge and resource based theories of Nonaka and Takeushi (1995), Mahoney and Panjan (1992), Majumdar (1998), Penrose (1959), and Barney (1991). Also the theories of risk by Knight (1985) contribute to the fundamental base for the model. #2021#

For analysis purpose, the project can be the disintegrated into attributes and components i.e., attribute-component-pairs, and thus the EDCP directs the attention towards specific needs of the project, during the resource selection process. This way the most valued resources get selected for the project (Oliver 1997, p. 703). Successful risk management requires linked and integrated models, expertise and special skills. Risk perception is recognized as the first step in risk analysis. Data arranged in a matrix pattern in a table helps the analyst or a team of analysts in the second step to balance changes to ensure that important customer benefits are not inadvertently adversely affected (Urban and Hauser, 1993, p. 344). Such an arrangement may also help to enhance customer benefits. Kotler states that attractive ideas need to be developed into finer product concepts if they are to be tested. A product concept is an elaborated version of an idea expressed in meaningful consumer terms. A product image is the particular picture that customers acquire of an actual or potential product (Kotler 1988, p. 418). In the analysis the concept, and resources parts of the project can be interconnected by the knowledge areas that represent the knowledge required when the resources realize the concept of the project. The structure of the EDCP analysis system and the interconnection between the elements are seen in Figure 3-1.

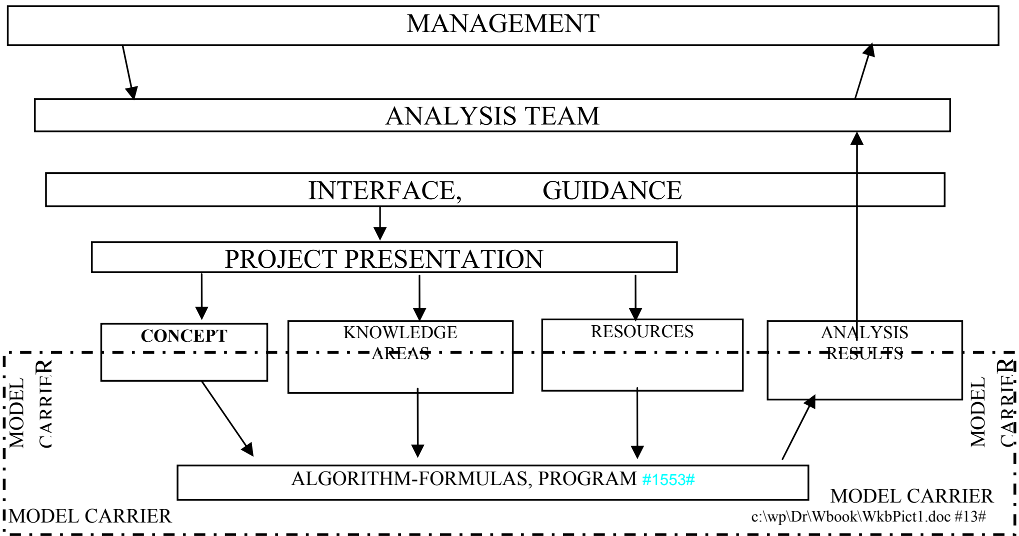


Figure 3-1. Interconnection between the elements of an EDCP-analysis model, management and analysis team.

The involvement of the management and the analysis team in the operation of the analysis work represents influence of project management theories. They apply e.g., Ansoff's theory about strategy development in defining the project. The concept presentation involves the use of attributes and components and it thus relates to innovation theories e.g., by Levitt and Schumpeter. The combination of the knowledge areas and the resources represent the knowledge and resource based theories of Penrose and Nonaka and Takeushi. The risk theories e.g., of Knight are introduced into the model through the algorithm formulas that produce measures for the risk in the analysis results.

Management corresponds with the analysis team that is familiar with the project. The analysis team interacts with the model via an interface to perform the analysis. The EDCP model consists of a primary model by means of which a representation of the project is formed, and of an extended model that enhances the analysis of the project. The primary model integrates knowledge and resource based theories into risk theory, management theory and innovation theory. The extended model is an extension of the primary model into a usable and useful tool. In the following the construct of a basic analysis model will be described. First we describe the construction of the concept and resource analysis tools that consist of attributes and components as well as of knowledge areas. Then the constituents of the analysis process and the deliverables will be presented. The analysis process deals with the rating for the evaluation process and the deliverables deal with how the analysis results are presented to management.

3.1.2. Attributes and Components

Products are combinations of the tangible and the intangible. For example an automobile is more than just a machine, it is differentiated by a number of attributes e.g., color, design, size. It may be even a symbol denoting status, taste or rank, these are also attributes of the product. The customer never just buys the "generic" product like steel, or wheat, or subassemblies, or engineering consultancy. He buys something that transcends these designations and what that "something" is, helps determine from where he will buy. Attributes cause characteristics or distinctions that differentiate products from each other. (Levitt 1980)

The “marketing concept” explains that business success is customer oriented rather than product oriented. A business ought to view itself as buying customers rather than as selling goods. Selling is to make the customer want what the seller has. Marketing is to offer what the customer wants. Marketing means thinking of customers’ needs; customers do not buy goods or services, they buy expectations or promises to solve the problem (Levitt 1977). Levitt (1980) states that the satisfaction that determines the customer’s minimal purchase conditions is represented by the attributes of the product. The attributes are realized in the product or service through different components, or media e.g., packaging, stationery etc. The “wants” of Knight thus correspond to the attributes of Levitt, and Knight’s means or resources correspond to Levitt’s media or components. Stewart defines a product feature as a physical and functional characteristic or component of the basic product that can be used to distinguish it from competing products. As examples Stewart proposes materials or methods of construction, kind or method of performance, or construction of a part (Stewart 1959). Also the needs of customers, users, society, etc. mentioned by Virkkala (1994, p. 30) can be regarded as attributes, and the possibilities of Virkkala represent the components (Fig. 1-4).

Webster (1999) defines attribute as that which is assigned or ascribed, a characteristic. Synonyms are property and quality. An attribute is what we conceive a thing to be, a quality is what it ought to be. A property is what belongs to one thing as its own particular possession. Webster (1999) defines a component as a constituent part, and medium as means, agency, instrument, or intermediate means. Lists of important attributes are important models for individuals to form judgments and preferences about objects. A list of important attributes is also a useful help in multi-person, extensive problem-solving situations (Lilien et al. 1992, p. 22-23). This is because the consumer considers various product attributes, and each consumer sees a given product as a bundle of attributes (Kotler 1988, p. 197).

A product can be described by its performance of multiple attributes. The multiple attributes of a product can be classified according to two classes; monotone attributes and non-monotone attributes. Monotone attributes are attributes for which all consumers agree in their preference ranking of the various attribute levels. A non-monotone attribute can be ordered so that the prices that the consumers' are willing to pay (reservation prices) are increasing in the level of the attribute. Monotone attributes are attributes on which people have different preference orderings. A non-monotone attribute cannot be ordered so that all consumers' utility-functions are increased in the level of the attribute (Lilien et al. 1992, p. 222-223). The term attribute has been used in marketing literature in connection with the relationship between producer and customer as an instrument for characterizing a product or service. Willkie (1986, p. 57) states that all products can be described in terms of some number of characteristics or features. These he terms, technically, attributes. The attributes represent the characteristics that the consumers are seeking from a product, and so they form an important means for the customer to realize his wants.

3.1.3. Knowledge and Resources

Webster (1994) defines knowledge as acquaintance with facts, truths, principles, or branch of learning as for study, investigation, sight, experience or report, and resources as available means afforded by the minds of personal capabilities; source of supply, support, or aid. The combination of existing facts into new combinations (Schumpeter 1934, p. 66) requires knowledge about the facts. For characterization purpose knowledge has been grouped into two main categories, explicit and tacit knowledge (Nonaka and Takeuchi 1995). Hedlund

(1994, p. 74-75) refers to articulate knowledge that can be equalled with explicit knowledge. Explicit or articulate knowledge can be communicated in text, drawings or computer programs. Tacit knowledge, however, dwells within people as a kind of experience gained through practice or intuition. When tacit and explicit knowledge interact, an innovation emerges. Organizational knowledge creation is a continuous and dynamic interaction between tacit and explicit knowledge. This interaction is shaped by shifts between different modes of knowledge conversion, which are in turn induced by several triggers (Nonaka and Takeuchi 1995, p. 70-71).

Several researchers relate knowledge to resources. Penrose (1959, p. 25) as well as Nonaka and Takeushi (1995, p. 34) link knowledge with the firm. Barney (1991, p. 101-2) equals the attributes of resources with resource abilities. Distinctive competence is a function of the resources that a firm possesses at any point in time (Mahoney and Panjan (1992), p. 365). This is an example of how knowledge is bonded to a firm's resources. In order to improve its competitiveness the firm must also be able to generate distinctive competences. Firms accumulate knowledge as a strategic asset through research and development and learning, some of it incidentally in their production process. Strategy formulation concerns a constant search for ways in which a firm's unique resources can be re-deployed during changing circumstances. This way Rumelt (1981) combined the Schumpeterian perspective with the resource-based view. (Mahoney and Panjan (1992), p. 369)

Schumpeter, in connection with defininig innovation as "new combinations", emphasizes the importance of combining explicit knowledge. In fact, he pointed out that the emergence of new products, production methods, markets, materials, and organizations results from new "combinations" of knowledge. However, "combination" is only one mode of knowledge creation (Schumpeter

1951, p. 66 in Nonaka and Takeuchi 1995, p.32-33). When specifying a knowledge area a decision maker or analyzer moves the basis for decision making from the state of opinion towards a state of knowledge i.e., from uncertainty towards risk in Knight's terms, and thus brings risk management into the decision making. Even if the decision maker or analyzer does not possess the proper knowledge he attempts to show the direction where it can be found (Barreto, 1989, p. 39-40, Knight, 1985, p. 19)

Hamel and Prahalad relate skills and technologies to a core competence that offers means for firms to compete in the market (Hamel and Prahalad 1994, 223-24 in Lintunen 2000, p. 139). Ansoff, again, relates the competence components to strategic thrust in order to meet the market's demand. Hamel and Prahalad (1990, 79-91) described the core competencies as a bundle of skills and technologies. The core competencies of the company represent the collective learning of the organization i.e., how are its skills and technologies coordinated and integrated. Hamel and Prahalad (1994, 224-28, 1990, 83-4) propose three tests for identifying the core competencies. The core competencies

i. provide "potential access to a wide variety of markets"
ii. "should make a significant contribution to the perceived customer benefits of the end-product
iii. "should be difficult for competitors to imitate"

(ref. Mintzberg et al. 1998, 218 in Lintunen 2000, p. 177)#1255#

According to Penrose, "it is never resources themselves that are the 'inputs' in the production process, but only the services that resources can render (Penrose (1959)p. 25). Services are a function of the experience and knowledge accumulated within the firm, and thus firm specific. In essence, the firm is a repository of knowledge (Nonaka and Takeuchi (1995), p. 34). Thus the statements of Penrose and Nonaka and Takeuchi link knowledge to resources as indicated also by the definition of capabilities and resources. Barney's conception is that a resource component that owns the potential of sustained competitive advantage must possess four attributes: it must be valuable, it must be rare among the firm's competitors, it must be inimitable and there must not be substitutes for it. These represent general attributes of a resource component. Other important abilities include availability and special abilities related to different knowledge areas (Barney, 1991 p. 105). In his article Barney specifies firm resources with those attributes of the physical, human, and organizational capital resources that enable the firm to conceive of and implement strategies that improve its efficiency and effectiveness (Barney 1991 p. 101-102). Thus Barney equals the attributes of the resources with the resource abilities mentioned above. Majumdar represents a somewhat narrower view when stating that resources include physical, intangible human and organizational resources. The resources are transformed into tangible outputs via identification of activities and contribution of resources (Majumdar, 1998 p. 811). Selection of appropriate resources to realize a concept is of decisive importance for a successful outcome of a project. Majumdar thus states that analysis efficiency in resource analysis reveals skills in the use of the resources. Such skills produce lasting benefits in terms of outcomes such as new product introductions or investment that can be made with the resources that are accumulated because of competent usage. Superior firms are likely to have better strategies for resource utilization (Majumdar (1998) p. 810).

Resource abilities determine the value of the resources to the firm. According to Oliver valued resources are those with the greatest rent potential among the resources currently available for acquisition by firms. Valued resources refer to the firm's strategic assets i.e., those assets that are valued for their potential to create the firm’s competitive advantage (Oliver (1997) p. 703). Competition for resources, such as and "knowledge" means that agents operate under conditions of "radical," "paradigmatic," and/or "structural" uncertainty. At the same time an agent's economic behavior is better understood as being part of a learning process over time than as being a static function of mere maximization (Magnusson, ed. 1994, p. 5). Thus Magnusson links resources to knowledge and innovation. The firm is dependent on the resources in its expansion and thus also in its innovation activities. For instance, Mahoney and Panjan note that fundamentally the resources of the firm limit the markets that the firm may enter, and the profit it may expect. Shortage of labor, shortage of finance, lack of suitable investment opportunities, and lack of sufficient managerial capacity are important resource restrains (Mahoney and Panjan (1992), p. 365). Ansoff’s requirements for making strategic decisions also include the allocation of the firm's resources e.g., between opportunities in hand and probable future opportunities under conditions of partial ignorance (Ansoff, 1987, p. 41).

Analyzers create a mental picture of the innovation concept by listing attribute-component pairs that characterize the innovation according to the theories. By listing the necessary knowledge areas the analyzers identify the requirements for realizing the concept. Simultaneously they identify the knowledge areas as links to the resources that shall realize the project. By rating certain items an evaluation of the propensity for success or failure of the innovation can be carried out. This indicates that an analysis for early detection of complex problems (EDCP) in innovation projects is possible by systematic tabulation of items related to the innovation and its realization.

3.1.4. Rating

In customer analysis self-rated importance is performed so that each customer rates the importance on a given scale, usually a 5-, 7- or 9-point scale. The additive model is probably the most commonly used utility model, but many other models have been suggested and implemented (Tell and Wallenius 1979, p. 5-6). For instance, in ranging methods judgement of product and project ideas is passed according to a number of factors that have significance for the selection and evaluation. The number of factors must be limited mainly to critical factors. Then a value scale for each factor is decided. It can be either numerical or verbal. The criteria are assigned weights according to their significance for the firm. Ranging is then performed for each project by passing judging the different factors, then a ranging number is calculated (Andersson and Laurila 1983, p. 127-129). The lexicographic approach assumes the decision maker to be able to rank the criteria in a descending order of importance. The most important criterion is first to rank the actions. Only if any two actions are non-separable according to this criterion is the second, third, etc. criterion- used to rank the non-separable actions. The ranking method may suggest certain ranges (1-3, 1-5, 1-7, etc.) inside which the evaluators must select their rating number. Often the numbers must be digits (Tell and Wallenius 1979, p. 5).

3.1.5. Deliverables

An analysis produces information that must be prepared into deliverables that have a form appropriate to the recipients within the firm. The presentation must report the analysis results in a form that allows written as well as oral presentation.

The report shall contain logically organized verbal and numerical data, preferably in the form of lists or paragraphs, separate or combined. Furthermore, paragraphs for comments about the results as well as for conclusions of the analysis are needed for a useful presentation. The model must provide for easy and clear verification of the analysis results. It must be possible to trace the logic of how the analysis results are arrived at and how they are organized. If the model contains calculation operations, the calculations must be easy to trace back to the entered data e.g., to rated numbers. The mathematical formulas used in calculations must be visible for verification to the project owner. The report shall present a qualitative model of project risk, ideally summarized in diagrams, with underlying computer-based models, to handle changes where appropriate and feasible. The richer the information generated in the Identify phase, the greater the need for care in the Structure phase, to provide a sound basis for inferences to follow (Chapman and Ward 1997, p. 141).

Risk analysis can serve three separate roles in relation to trade-offs between risk and expected performance. Two roles are almost (but not quite) directly analogous to those associated with risk efficiency, the third somewhat different (but complementary):

1. diagnose possibly desirable changes in plans
2. demonstrate the implications of such changes in plans
3. facilitate, demonstrate and encourage ‘enlightened gambles’.(Chapman and Ward 1997, p. 37-38)

The Review stage of the Project Life Cycle (PLC) method involves a documented audit after delivery of the product. Missing important lessons means mistakes will be made again. Not having such a stage explicitly identified almost guarantees the realization of this risk (Chapman and Ward 1997, p. 21). There are two primary purposes for documentation of activities. The first is to provide a means for following-up of action items and recommendations. The second is to create a record to assist in establishing the state-of-the-art and development history of the product (CEI IEC 1160 1992, p. 39). The documentation can include information in a wide variety of forms, describing activities, risks, responses, decisions taken, and identified trigger points (Chapman and Ward 1997, p. 44). A report shall present a qualitative model of project risk, ideally summarized in diagrams, with underlying computer-based models, to handle changes where appropriate and feasible (Chapman and Ward 1997, p. 141).

3.2. The Basic Model

An innovation project is an undertaking by which an organization wants to serve its customers, its own activities, society or any other entity by adding value. The organization that undertakes the project is regarded as the project owner. The firm, or the organization often appear as project owner.

The primary model for early detection of complex problems in innovation projects (EDCP) is based on an analysis of the concept together with an analysis of the resources. Both analyses are performed using one system. The concept involves the elements of innovation in the project, and the resources are those that are available to the firm for the solution of the problems of the concept. An analysis of the knowledge areas involved in the concept links together the two analyses mentioned above. The presentation of the concept utilizes the attribute and the component as defined by Levitt (1977) and the knowledge according to Majumdar (1998) and Penrose (1959).

A team of analyzers performs the analysis. The EDCP model organizes the elements of the project in tabular form appropriately for a systematic analysis of the project. Figure 3-2 illustrates the structure of the analysis process. First the concept of the innovation is presented as inputs and then the resources are also presented as inputs. The analysis results are processed from the presented inputs.

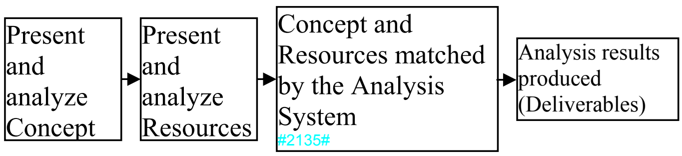


Figure 3-2. The structure of the analysis process

The table for concept analysis organizes the attributes and components by listing them into their respective column in the "Concept-analysis" table (Fig. 3-3). First, the team lists the attributes and then the components that realize the attribute. One attribute may require several components and thus is a member of several attribute-component pairs. In the table they form attribute-component pairs; each component is joined to the attribute that it realizes. The analyzers can then conclude from the attribute-component pairs what knowledge will be needed to realize each attribute and the necessary knowledge areas are then listed in their column in the "Concept-analysis" table. The listings in the "Concept-analysis" table consist of answers to particular questions e.g., the attributes are listed as answers to a prompt or requirement to list properties that make the product or service or activity better for the user, the customer. The components are listed as answers to the question "whereby or how do we carry the attribute into effect", the attribute being to the left of the component in question. The knowledge areas are listed as answers to the question "what (additional) knowledge area can contribute knowledge to realize the attributes by means of the components”?. The method of deducting the necessary knowledge areas from the attribute-component pairs of the concept is new, and was not encountered in any of the literature sources. The attribute-component pairs and the knowledge areas provide a representation of the concept in the project, and they are organized in tabular form appropriately for analysis. Starting from the contents of the “Concept-analysis” table an analysis of the resources is performed. The analyzers conclude from the attribute-component pairs what resources will be needed to realize the attributes by means of the components. The resources i.e., the resource components are then listed in the “Concept-analysis” for analysis.

An example of the “Concept-analysis” table is shown in Figure 3-4 below. The table is structured into separate columns for attributes and components, and these are placed so that attribute-component pairs are formed, each attribute

CONCEPT ANALYSIS #2038#

			Knowledge areas				
Attributes	**Components**	**Knowledge areas**	durability calculus	plastics matl. technol.	plastics seam technol.	Testing technol.	Machine design
Durability	Geometry	durability calculus	4	3	4	3	
Durability	support plate material	plastics matl. technol.				2	5
Durability	surface film	plastics seam technol.					
Durability	Seam method	testing technol.				[illegible]	1
Replaceability	Geometry	machine design		5	2		1
Replaceability	Seams	plastics processing				4	
space effectiveness	Geometry	Wood processing	4	3	4		2
space effectiveness	Surface film	industrial design				4	
Functionality	Geometry	quality technol.	5	5	5		
Functionality	Surface film	Networking					
Outlook	Geometry	patent law		2			5
Outlook	Finish	Knowledge area				2	
Cost	Material selection	Knowledge area					2

Knowledge

Grid

Attribute-component

This is an excerpt from a larger table!

Figure 3-3. The “Concept-analysis” table of the primary model.

and corresponding component is located side-by-side. The pairs can be readily observed in the table. There is also a separate column where the knowledge areas are listed. As seen from the figure the same knowledge areas that are listed in the column also appear listed in a horizontal row in the upper part of the table. This row allows the formation of a matrix grid that offers the possibility to analyze each attribute-component pair relative to each knowledge area.

In the “Concept-analysis” table the primary EDCP model creates a representation of the concept of the project by listing the attributes, components and knowledge areas that relate to the project and arranges them in tabular form appropriate for analysis. The analysis results show risk concentrations to certain attribute-component pairs and to certain knowledge areas.

The resources of the firm include all assets, capabilities, organizational processes, firm attributes, information, knowledge etc. that are controlled by the firm. The firm resources can be classified into three categories: physical capital resources, human capital resources, and organizational capital resources.

The resource components represent the carriers of the abilities of the resources. The resource components use their abilities, or they put their abilities to the use of the firm to attain the concept attributes of the project. The resource abilities represent the abilities evaluated for the respective categories of resource components e.g., human abilities, properties of machinery, services etc.

The resource analysis is performed in the “Resource-analysis” table (Figure 3-4). The attribute-component pairs from the “Concept-analysis” table appear in a column in the left part of the table. Immediately to the right of this column a separate column is provided for listing the resource components that will realize the attributes by means of the components of the concept table. The analyzers list the resources as answers to the question, “what resources shall create the attribute by means of the component”?. The attribute and component in the question are taken individually from the attribute-component pair left of the actual resource in the "Resource-analysis" table. When completed, the table thus exposes the attribute-component-resource groups that realize the project. The groups are formed by those attributes, components, and resources, which are located side-by-side in the columns of the table. The groups can be readily viewed in the table. Similar to the "Concept-analysis" table, the "Concept-analysis" has a row that lists the same knowledge areas as in the "Concept-analysis" table. This row appears in the upper right of the table, and it allows the formation of a matrix grid for analysis of each attribute-component-resource group relative to each knowledge area.

In the "Resource-analysis" table the primary model further includes the resources in the representation so that the representation finally includes the whole project. In the resource-analysis the analysis results show risk concentrations in certain resource groups and knowledge areas. Finally, the analysis results for the concept and resource analyses are compounded to show the risk concentrations for the attribute-component-resource groups and the knowledge areas of the whole project.

The EDCP analysis procedure is described more in detail later in the text. The EDCP model assumes that the risks in the "Concept-analysis" table are directly proportional to the significance of the attribute to the project. The risk in EDCP is understood in the sense defined by Knight's (1985) proposals. It also assumes that the risk is directly proportional to the significance of each of the knowledge areas in realizing the attribute by means of the component. This is logical since the more significant an attribute is to a project, the more risk it is likely to bring into the project. A significant knowledge area also likely brings more risk to the project than a less significant one. The risks are appreciated for each attribute-component pair in the "Concept-analysis" table.

An example of the "Resource-analysis" table is shown in Figure 3-4 below.

RESOURCE ANALYSIS #2039#

Attribute-component pairs	Resource components (persons, machines, contractors, etc. that realize Attributes)	Knowledge areas: durability calculus	plastics matl. technol.	plastics seam technol.	Testing technol.	Machine design
R1 durability & geometry	KV, PJ, PK, JM, TV, VT, Varo Co, Kotay	2	3	3	2	
R2 durability & support plate material	Varo Co,				2	5
R3 durability & surface film	KV, PJ, PK, JM, TV, VT, Varo Co., Kotay	2	3	2		
R4 durability & seam method	KV, JM, TV, SR, Varo Co., Kotay, TKK,				3	1
R5 replaceability & geometry	KV		5	5		1
R6 replaceability & seams	KV, JM, VT, PJ, JS, SR, PS, KM,				3	
R7 space effectiveness & geometry	KV, JM, VT, PJ, JS, SR, PS, KM, PK,	4	2	4		2
R8 space effectiveness & surface film	KV, JM, VT, PJ, PK, TV., Kotay				3	
R9 functionality & geometry	KV, JM, VT, PJ, PK, TV., Kotay, Varo Co.	3	4	2		
R10 functionality & surface film	KV, JM, VT, PJ, TV., Kotay, Varo Co., TKK				5	
R11 outlook & ge[illegible]	[illegible]		4	4		5
R12 outlook & fi[illegible]	[illegible]				2	
R13 cost & material selection	KR, C-EW, PH, TV, JM, Kota Ky, Varo Co.,					2
R14 cost & contractors	KR, C-EW, PH, TV, Kota Ky, Varo Co.,					
R15 cost & size of series	KR, C-EW, PH, JM, Kota Ky, Varo Co.,	4	5	2		

Attribute-component-resource groups

Mikael Epstein 1997, 1998, 2001

This is an excerpt from a larger table!

Figure 3-4. The "Resource analysis" Table.

The risks in the "Resource-analysis" table are directly proportional to the significance of the concept attribute. It is inversely proportional to the availability as well as to the ability of the resource component. This is logical since also from the point of view of the resources a more significant concept attribute brings more risk to the project than a less significant one. Better availability and better ability of resource components lowers the risk brought into the project, hence the inverse proportionality to the risk. The risks are appreciated for each resource component in the "Resource-analysis" table. The risks of the whole project are appreciated by compounding the risk of each attribute-component pair in the "Concept-analysis" table and the risk of the corresponding resource component in the "Resource-analysis" table. Thus the risks are appreciated for each attribute-component-resource group. The risks connected to the knowledge areas are appreciated separately in the "Concept analysis" table and in the "Resource-analysis" table. In the "Concept-analysis" table the risk is proportional to the significances of each knowledge area with respect to the attribute-component pairs, in the “Resource-analysis” table it is inversely proportional to the ability of the resource components with respect to the attribute-component pairs. The risks are expressed by introducing numerical ratings for significances, availability, and ability into the EDCP model and the resulting risk values are calculated by formulas so that direct proportionality is represented by additional type functions, and inverse proportionality by division. In EDCP the risks are regarded independently of each other, no consideration is made to their interdependence.

The tables form an illustration of how the primary model links together the knowledge and resource based theories into management and risk theories in the analysis of the project, and presents an answer to the first research question.

Why is the EDCP Model better than other Methods available for Risk Analysis of Innovation Projects?

A comparison was made between EDCP and the methods investigated in the literature. Table 3-1 shows the number of items per analysis criteria covered by EDCP. It is collected in a similar way to Table 2-5. It can be seen that the number of items per analysis criteria covered by EDCP exceeds the number of items covered by any of the methods reported in Table 2-5. This is the case for each different group of criteria as well as for total number of items covered per criterion. Most of these methods cover only a fraction of the number of items compared to those covered by EDCP, as can be seen from Table 2-5.

Table 3-1. Number of items per analysis criteria covered by EDCP #2019#	
Group of criteria	Items covered for each criterion
Application	5
Deliverables	4
Inputs	5
Objects of analysis	10
Uses	6
Total number of items covered	30

Table 3-2 lists the number of intermediates of analysis covered by EDCP, it is collated similarly to Table 2-6. Table 3-2 shows that EDCP covers nine intermediates of analysis, and this exceeds the number of intermediates covered by any one of the compared methods. From Table 2-6 it can be seen that the two methods that came closest (fulfilling seven criteria) are more limited as to their analysis flexibility or to their extent of analysis.

Table 3-2.Intermediates of analysis covered by EDCP #2020#	
Concept, generally	X
Concept attributes	X
Concept components	X
Knowledge	X
Resources, explicitly, generally	X
Resource components	X
Resource ability	X
Optimal resource allocataion Considering resource limitations	X
Time factor treated explicitely	
Includes multiple criteria	X
Considers insecurity explicitely	
Total number of intermediates covered	9

Thus no one single method was available in the literature that covered as many analysis criteria as EDCP, not to speak of ability to analyze the concept as well as the resources, in the same process, in a flexible manner.

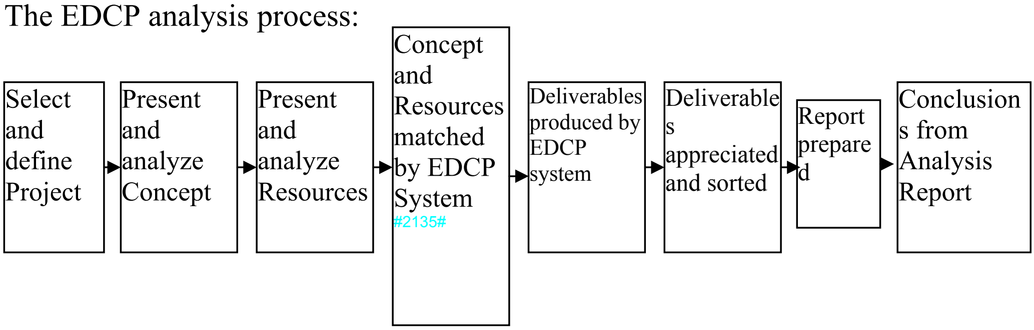
The primary model constitutes the main contribution to this work. It helps the project owner to structure the project in such a way that an analysis can be performed in order to detect the risks of the project by pointing out the risk concentrations. The model integrates the knowledge and resource based theories into risk theory, innovation theory, and management theory.

3.3. The Extended Model

However, the primary model as such is not sufficient to offer a usable and useful analysis tool for risk detection in innovation projects. In order to present an answer to the second research question the primary model must be enhanced with extensions. In order to form an extended model for the technical analysis tool, procedures and methods familiar to aspects from other analysis systems are combined in new ways and integrated into the primary model in appropriate ways. This extended model will enhance the use of the model thus making it usable. It will also present analysis results in such a form that they will be clearly and easily presented to the project owner, thus making the model useful.

The proceeding of the analysis process is illustrated in the scheme below. First the project is defined, then follow presentation of concept and resources.

The EDCP analysis process:



The EDCP analysis system matches the analyses of concept and resources, and produces deliverables. The deliverables are then appreciated and sorted, and an analysis report is prepared on the basis of the sorted deliverables. Finally, conclusions are made about the risks in the project.

The Structure of the EDCP Analysis System

The EDCP analysis involves both internal and external actors. Internal actors are, on one side the analyzers i.e., the team that performs the analysis and, on the other side the resource components that will realize the Concept. Part or all of the resource components may be the analyzers themselves. The customers, the users and the suppliers constitute external actors that must be taken into consideration when performing the analysis.

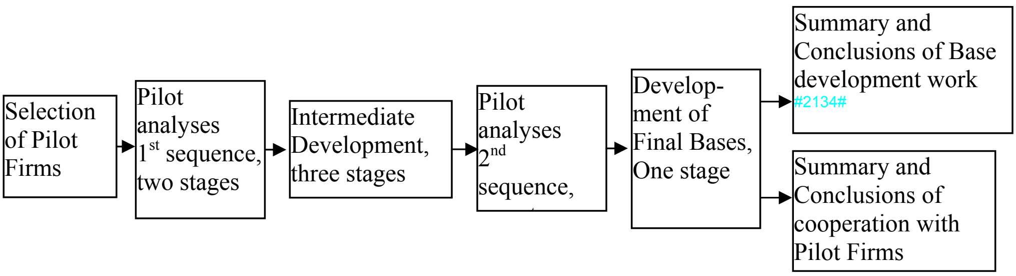
The EDCP analysis system is structured into an input part, a processing part and an deliverables part. The input part describes the project and it consists of intermediates and guidance. The intermediates define the project and the guidance system instructs the analyzers by means of questions to find appropriate intermediates. The processing part consists of the rating processes and algorithms. The rating is performed according to one numerical scale in all rating applications throughout the entire analysis. The questions guide the analyzers when rating singular intermediates and combinations of intermediates. The output part exhibits the results of the analysis. It consists of a presentation part and an editing part. The presentation part contains tables and graphs, and in the editing part a report of the analysis is prepared according to the formal requirements agreed to with the firm for which the EDCP analysis is made i.e., the project owner. Thus the main constituents of the analysis system are the project presentation, and the analysis of the concept and the resources under guidance of the guidance system. The deliverables that present the outcome of the analysis to the project owner are also constituents of the analysis system.

The analysis is performed by a team of persons who must be familiar with the project as well as with the firm. The team must have the support and the backing of the top management of the firm. Sometimes the analysis indicates that representatives of external actors ought to be included in the analyzing team. In the analysis process analyzers must process different items connected to the project. These items must be characterized and grouped appropriately for use in the analysis process. They form intermediates of the analysis.

4. The Empirical Work

The presentation of the empirical work consists of three main parts. First, the development of the EDCP model is described practically, in chronological order. Then follows a description of the analysis work with the pilot firms. Finally, the results from the empirical work i.e., on one hand the impact of the research work on the development of the model, and on the other hand the benefit of the results from analyses for the case projects and the pilot firms. A considerable part of the development work involved changes to the tables and graphs that constitute the main part of the analysis system. The most important changes to the tables are illustrated in Appendix 3.

A scheme of the empirical work is presented below:



4.1 Development of the EDCP Analysis System

The improvements to the extended model included the development of means to characterize the project in terms appropriate for analysis, and the improvement of the “Concept-“ and “Resource-analysis” tables to suit practical analysis work. Another important improvement was the means to present the analysis results to the project owner.

This study can be said to have its “theoretical side” and its “practical side”. The theoretical side was described earlier, the practical side that will be described below and follows by some basic theories. A large part of the finished model, however, came to consist of matter added the “practical way”. In this respect the development work can be said to follow Kuusi’s (1999, p. 231) advice of “not trusting nice theories too much”. The description of the practical work, in which the primary model was extended, presents the answer to the research question about how to develop a usable and useful analysis tool for early detection of risks in innovation projects.

The spreadsheet program Microsoft Excel® , later referred to as Excel, was chosen as the model carrier for EDCP at a very early stage in the development process, all practical development work using the EDCP model was carried out using Excel. In the beginning version Excel 4 was used, later Excel 5. The tables or groups of tables that composed the model carrier in the various versions of development are called base. In most other respects the prevalent vocabulary for spreadsheets is used: column, row, cell and formula refer to the corresponding items in the spreadsheets. The word grid refers to a rectangle containing many cells of similar form and content.

Documentation of the empirical work was done in three different ways.
Firstly, the whole development work for the model, and all analysis cases were done using the computer, and each different stage in the development work was filed individually. The files thus formed the basic documentation source. In the first three pilot analyses the analysis work was started using paper forms of the “Concept-“ and “Resource-analysis” tables. These forms documented activities during the start of the analysis work in these first analyses.

Secondly, printouts were made of individual stages and analyses, and comments were made on these printouts, particularly during and immediately after the analysis sessions.

Thirdly, interviews were held with the individuals involved in the development work after the conclusion of the development project. A standard form was used in the interviews. Samples of notations and interview forms appear in Appendix 4.

4.2. Progress During the Development Work

The presentation of the development work is divided chronologically into phases. Each base is then divided into stages. The phases involve preliminary structuring, pre-testing and the selection of pilot firms and next the first phase of interactive development through testing with pilot cases. Then followed intermediate development work, the second phase of interactive development through testing with pilot cases, and finally the development of the commercial EDCP analysis system. In the analysis system the EDCP model was applied into the model carrier in the form of tables in a spreadsheet computer program. The files of the spreadsheet program are referred to as bases. Each base represents a development stage of the tables. All significant development stages are presented in consecutive order in Appendix 3.

Table 4-1. Phases in the development of EDCP bases #1736#

Phase	**Number of stages in phase**
Extension structuring and Pre-pilot analyses	5
Pilot analyses, 1. sequence	2
Intermediate development	3
Pilot analyses, 2. sequence	1
Development of final bases	1

Each phase is divided into several stages that describe the changes during the phase. The changes are typified according to one of two main groups: structural changes and functional changes. Structural changes relate to the model itself

Table 4-2. Types of changes in the EDCP bases during the development work #1737#	
Structural changes	**Functional changes**
Whole analysis	Listing
Project Presentation table	Rating
Concept table	Use/Interface
Resources table	Result value
Result table	Manual transfer/automatic transfer
Deliverable	Intermediate process

e.g., tables or spreadsheet functions. Functional changes deal with activities during the analysis process e.g., listing, rating, or data transfer. The phases are presented in the Table 4-1 and the types of changes in the Table 4-2.

4.2.1. Extension Structuring and Pre-testing

In the phase called “Extension structuring and Pre-pilot analyses” the “Concept-“ and “Resource-analysis” tables were enhanced with facilities to express risk concentrations by means of result presentation facilities and structuring facilities for report preparation. This phase involved the four first development stages.

The facilities for presenting risk concentrations include numerical rating for certain intermediates, as well as the calculation of numerical risk factors from the ratings. These factors express risk concentrations. Rating in the “Concept analysis” table included significance (to the project), marketing benefit and technical problems for each attribute. Further rating was performed for the significance, difficulty and newness of each knowledge area in connection to each attribute-concept pair. In the “Resource analysis” table the significance, ability and experience of each resource component in each knowledge area was rated for each attribute-component pair. Risk factors for attribute-component pairs were calculated separately in the “Concept-analysis” table, and risk factors for the resource components were calculated separately in the

"Resource analysis" table. Risk factors regarding the knowledge areas were also calculated in the "Resource analysis" table. The "Concept-" and "Resource analysis" tables were filed as separate files (Figures 1.1. – 1.3. in Appendix 3). The grid structure for analysis was introduced (Fig. 2.1. in Appendix 3). Another important improvement was to incorporate all tables in the same Excel file (Fig. 3.1. and 3.2., Appendix 3). Furthermore, weighted corresponding risk factors were calculated for all risk factors mentioned above, the weighting was calculated according to the number of rated items (Fig. 4.1. and 4.2. in Appendix 3). The tables were situated either besides or on top of each other, as seen in Figures 1.1 – 4.1, in Appendix 3. The stage 5-type base was later extended with a table for reporting analysis results (Figure 4-1). This table contains columns for concept, resources and technologies and their respective risk factors and weighted risk factors. Data and values were automatically transferred from the "Concept-" and "Resource analysis" tables to their respective places in the table. Examples of transferring formulas are shown in the figure.

The phase of "Extension structuring and Pre-pilot analyses" took place in five consecutive stages during which the tables and facilities were gradually developed. The model was tested in analyses of a small number of projects, some of which were fictive. Figures 4-1 and 4-2 show the state of development when the pilot firms were introduced into the project of model development. The improvements are indicated by means of arrows and text boxes in the figures. Figure 4-1 also indicates terms used in the description of the development work. The term table refers to a table usually of a spreadsheet that is used either for analysis work or to display results of the analysis. *Column* refers to a column in the table, and group refers to a group of tables. *Cell* means a single cell of the table and *grid* means a rectangular group of cells. The algorithm or formula is located in a cell and it calculates a value of numbers entered into other cells.

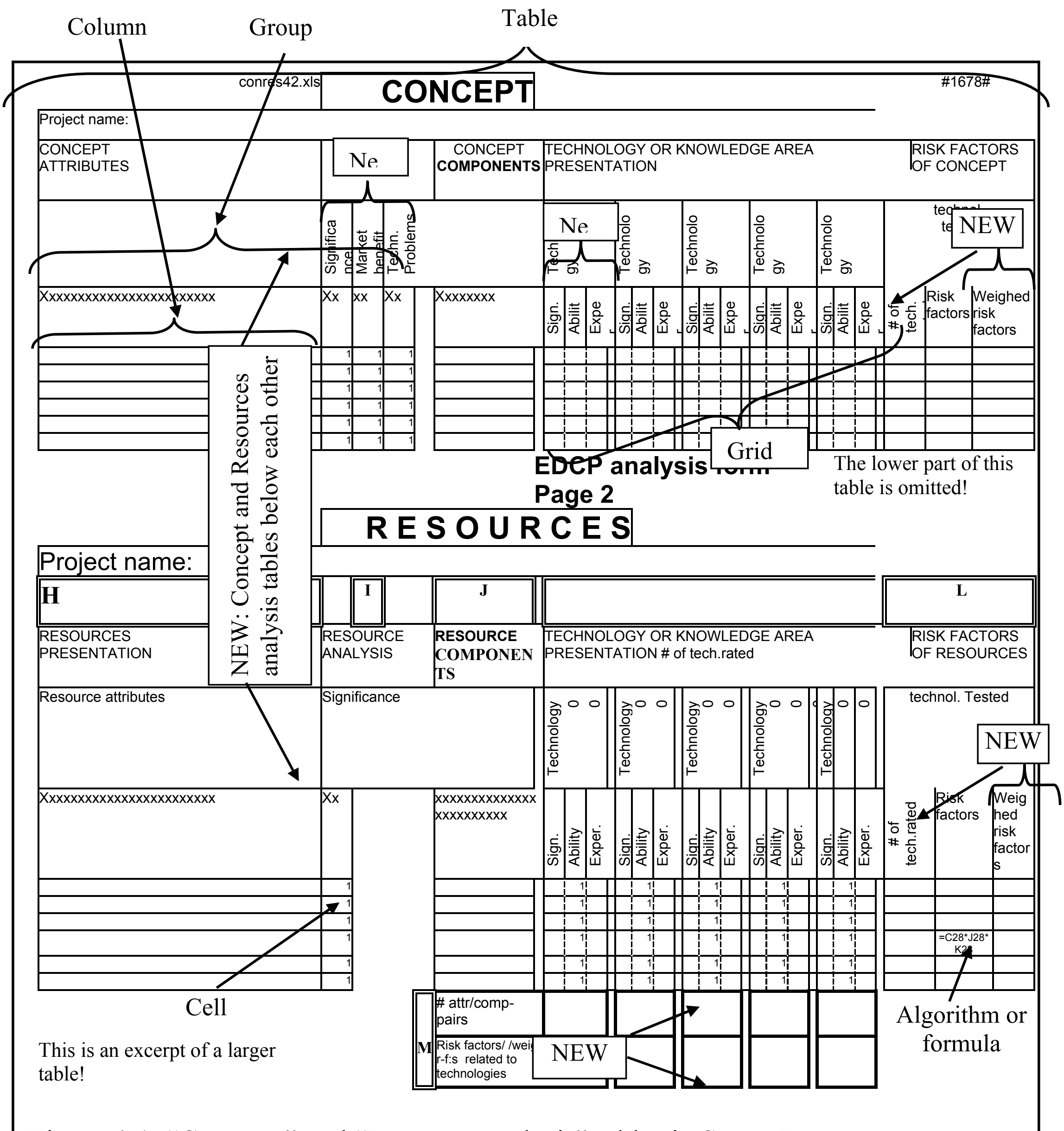


Figure 4-1. “Concept ” and “Resource analysis” tables in Stage 5.

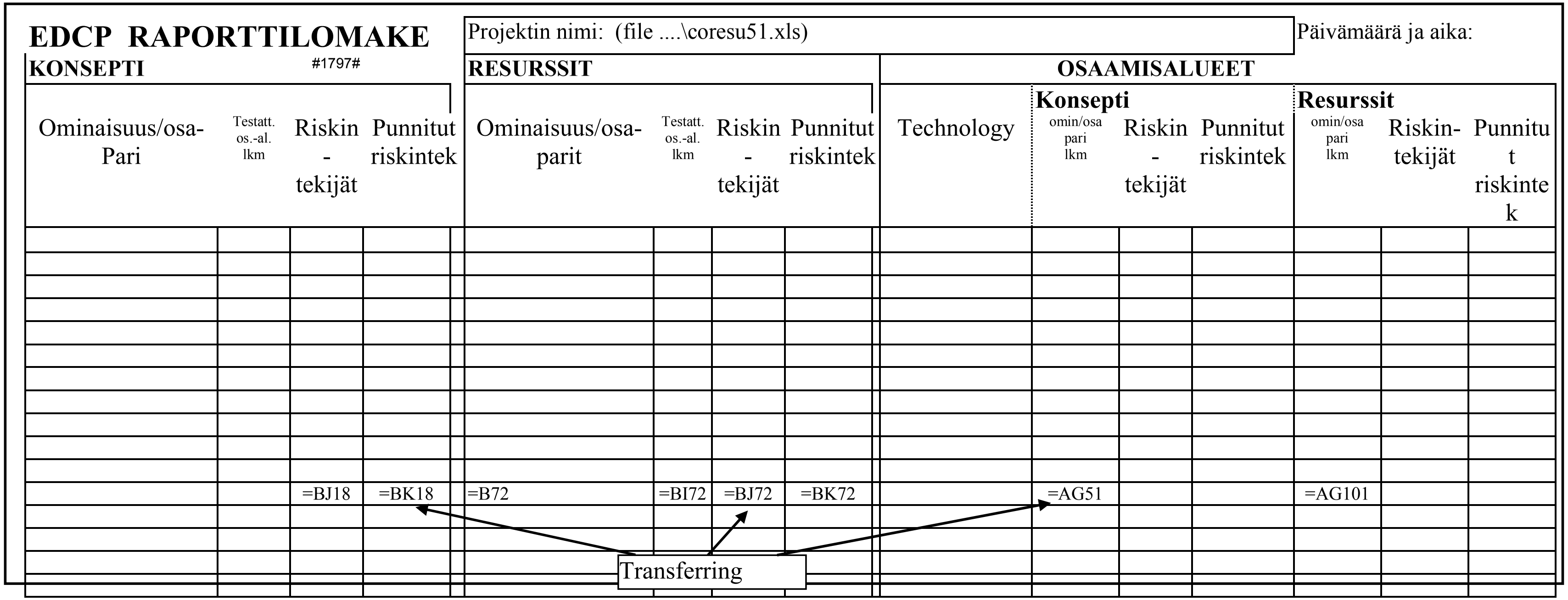


Figure 4-2. Report form, Stage 5, data and values are transferred via the transfer formulas from the analysis tables to their respective places in the report table.

4.2.2. Selection of Pilot Firms

The work in stages 1 – 5 revealed that further development of the EDCP model required access to actual innovation projects that could be used as exercise objects for the developer. This aim was approached by combining the effort in the exercise projects with the obtaining of funds for further development of the model.

Pilot firms were selected through contacts from Helsinki School of Economics and Business Administration (HKKK), Innopoli Mentor Program, Technical Research Centre of Finland (VTT), the National Technology Agency (TEKES), and through personal contacts.

Table 4-3. Selection of Pilot Firms for the EDCP Project #1752#

Source	Number of firms	
	total	selected
Innopoli Mentor Program	13	6
Helsinki School of Economics and Business Administration (HKKK)	3	2
Laatutieto Oy	7	2
Finnish Food Industry's Federation	10	---
Technical Research Centre of Finland (VTT)	2	2
Sesam Consulting Oy	1	1
Mikael Epstein	1	1
other pilot firm	1	1
TEKES	1	1
Total	39	16

Table 4-3 shows the sources of contacts and the number of firms involved. Table 4-4 presents the firms approached through the different sources. For reasons of confidentiality the firms' names have been coded.

The selection process resulted in a group of 16 firms having annual turnover of 1 – 1200 million marks, and employing 1- 12500 persons. The firms represented manufacturing and development companies.

Contact to the firms was made first by telephone, then by telefaxing a short description of the model (Appendix 5). After this the formal paper work for connecting each pilot firm to TEKES's project was undertaken. The selected firms are categorized in Table 4-4.

During the selection process means were developed to present the EDCP development project to prospective pilot firms and to financiers. The means included a short description of EDCP (Appendix 5) and forms for fax correspondence with the firms.

Table 4-4. Categories of Pilot Firms #1753#

Code *)	Source	Turnover mmk	Personnel
H	HKKK		1,5
L	Laatutieto Oy	370	600
E	VTT		3
C	Sesam Consulting Oy	25-30	36
M	Innopoli Mentor Program	3	5 + sub-contract
O	VTT		1
P	Innopoli Mentor Program		2
J	Innopoli Mentor Program	11	12
B	ME	60	50
D	Innopoli Mentor Program	12	9
K	HKKK		
N	Innopoli Mentor Program	1	2
G	Innopoli Mentor Program	stays alive	1
I	Laatutieto Oy	160	270
A	other pilot firm	55	80
F	TEKES	2000	12.500

*) names of pilot firms are coded because of confidentiality reasons

4.2.3. The Analysis Sessions

The first session in each pilot firm involved presentation of the EDCP method and its basic principles.

The time invested for each analysis proved to be one of the most important factors for the pilot firms. The representatives of most of the pilot firms repeatedly pointed out the importance of a fast analysis method. Lack of time was also a frequent reason for the postponement of analysis sessions.

EDCP analysis tables in Excel containing data of a fictive project (demo analysis) provided a vehicle for demonstration of the different features of EDCP analysis system. It also served as an instruction tool for the EDCP analysis process. The first session acted as the main instruction occasion for the analysis team. The demo analysis and the instruction occasion during the first session were the only means needed for instruction purposes. After the introduction procedure the first project was selected, and in some cases the analysis work was started immediately. The analysis processes were started with a definition of the project in the self-explanatory "Project presentation" table. During the first session the premises and the equipment for performing the analysis were chosen. The first session used to follow the same pattern in all pilot firms, the first two firms formed an exception; only a written description of EDCP was used instead of the demo analysis.

The researcher made notes about observations regarding the development of the model during the sessions in addition to his work as the facilitator of the session. The notes were often done on the spot on the printouts of the analysis tables. Appendix 6 shows some examples of tables.

#1726#

During the second and the following sessions the analysis was continued. In the “Concept-analysis” table the attributes were first listed, their significance, marketing benefit, and technical problems were rated. Then the components for each attribute were listed and rows were added when needed. Thus the attribute-concept pairs that identified the concept were generated. Thereafter the knowledge areas were listed, the team members listed the knowledge areas based on their personal experience and knowledge of the requirements of the attribute-component pairs. Then followed rating of the significance, difficulty and newness of every knowledge area for each attribute-component pair. This rating took place in the grid below the row of listed technologies or knowledge areas. When the rating was finished the risk factors of the concept were available, and in many analysis cases they were discussed with the analysis team. In some cases graphs were produced at this moment during the session if a printer was available.

When the concept analysis was finished the resource components (resources) were listed in the “Resource analysis” table for each attribute-concept pair. The analysis team listed the resources based on their personal knowledge about the firm’s own resources and external resources. Data from the attribute-component pairs was copied automatically from the “Concept-analysis” table to the appropriate column in the “Resource analysis” table. The availability of the resource components was rated, and then followed rating of the resource’s significance, ability and experience in respect to each knowledge area. This rating was performed in the “Resource analysis” table’s grid. Table 4-5 presents the items listed and rated during an EDCP –analysis. They appear practically in the order in which they were dealt with during the proceeding analysis.

Table 4-5 Items listed and rated during EDCP Analysis

#2126#

Table	Item	Purpose
Concept	Attributes listed	Characterizes concept
	Significance of attribute to project rated	Rates attribute
	Market benefit of attribute to project rated	Rates attribute
	Technical problems rated	Rates attribute
	Concept components listed	Characterizes concept
	Knowledge areas rated	Characterizes concept, links concept to resources
	Comments to concept listed	Characterizes concept
	Significance of knowledge area for realization of attribute rated	Rates knowledge area
	Difficulty of attribute-component pair in knowledge area rated	Rates knowledge area
	Newness of attribute-component pair in knowledge area rated	Rates knowledge area
Resource	Resource components listed	Characterizes resources
	Ability of resource components in knowledge area rated	Rates resource component
	Experience of resource components in knowledge area rated	Rates resource component
	Availability of resource components rated	Rates resource component
	Comments to resources listed	Characterizes resources
Project presentation	Business area indicated	Characterizes project
	Stage of development indicated	Indicates character of project
	Place in organization indicated	Indicates character of project
	Related projects listed	Indicates place in organization
	Limits of project listed	Defines borders of analysis
	Sequences of realization listed	Organizes analysis

After the resource analysis was finished the data feeding part of the analysis work was completed. The “Analysis result”-tables and -graphs were printed during the final session in those pilot firms that possessed printing facilities, for other firms the developer did the printing work. The final session also included a concluding discussion about the consequences of the analysis results for the project, and about necessary improvements for the analysis method.

The type of premises for the sessions varied between a negotiating room, an office of analysis team-member or another office. In about half of the pilot firms the premises varied from session to session. The equipment (computer) was provided either by the firm or by the researcher. In about half of the projects both the researcher's and the firm's computers were used. The equipment changed from session to session in slightly less than half of the pilot firms, two of the pilot firms used the researcher's computer for all sessions. The researcher operated the computer during all sessions in six of the pilot firms. In the other firms team members learned how to operate the EDCP-system on the computer so that they could operate the program after at least the third session. Changes occurred in the composition of the team in half of the pilot firms. A large change, affecting approximately 60% of the members, occurred in two pilot firms.

4.2.4. Pilot Analyses, First Sequence

Stage 6

The analysis work in the first seven sessions was done using printed paper-forms of the "Concept-" and "Resource analysis" tables that were filled in by hand. After the analysis sessions the researcher transferred the data from the paper forms into the computer using his own facilities. This method proved awkward because changes to the notes in the form were very difficult to perform, as seen from Appendix 6. This prompted analysis to be made direct on the computer. Experience was gained with the base (Figures 4-1, 4-2) from 10 different projects. Problems encountered were: difficulties in putting questions and in sorting out unneeded items, as well as in documenting the discussion and in co-ordination between different parts in the table. There were also difficulties to define attributes and components in the "Concept-analysis" table, and the table also grew awkwardly big during the progress of the analyses. Visibility in the table was also poor, when the tables appeared on computer screens. Rating was considered dull and problems arouse about how to rate e.g., "resource components of the future" Awkward situations were encountered with “old” knowledge areas from which unexpected problems could come. Difficulties with manual row additions in the analysis tables became apparent. Some members of the analysis teams presented wishes about “automated” row addition. Important changes included improvements of the visibility by choosing larger font, by printing practically all headings horizontally (instead of vertically, as in Fig. 4-1). A translation of the headings to the Finnish language was introduced on request by many analysis teams. The deliverables were also improved by reporting the number of attribute-component pairs analyzed for each knowledge area, Figure 6.1. in Appendix 3. A separate table of the knowledge areas and their risk factor values was also provided.

An exemplar case (Firm M) is described in chapter 4.1.1. Four more projects were started using the stage 6-type base in the commencing sessions. The analyses were later transferred to the further developed base of stage 7. In Appendix 7 exemplar cases of firms B, C, E, I, and K are shown as examples of some pilot projects analyzed.

Ideas were also given by the pilots about series of questions, about the use of a report generator, as well as of the use of multi-spreadsheet structure. The bases described so far were developed in Microsoft Excel 4® that has only one spreadsheet, the newer MS Excel 5® offered several sheets and became commonly available among the pilot firms during the time of the development work. Wishes were further made of a “lighter” program. A two-step approach to the analysis performance was also suggested. The first step would check whether the concept was fit for analysis, the second step would involve a deeper analysis.

The suggestions given by the pilot firms gave guidelines for the development of a new base. This base, representing stage 7, utilized the multi-spreadsheet structure of Excel 5. Separate sheets were provided for the “Concept-” and

"Resource analysis" tables and for the table presenting the Knowledge area risk factors. The structures for the analysis tables and for the table of Knowledge area analysis results were the same as those in the stage 6 base. Because each sheet occupied only one table more space became available and visibility could further be improved by means of larger font. Easier transfer between tables in the multi-sheet structure of Excel 5 also improved the ability to quickly view items on different tables. Separate sheets were also provided as holders of diagrams of the analysis results for the concept, the resources and the knowledge area.

Stage 7

Data of four unfinished project analyses were transferred from stage 6-type bases to the new base. Three new project analyses were initiated on the stage 7-base (see Figures 7.1. - 7.2. in Appendix 3). Appendix 7 shows examples of such project analyses. During the progression of these analyses columns and rows for comments to attribute-concept pairs and for knowledge areas were added to "Concept-" and "Resource analysis" tables. To satisfy the wants of the pilot firms, the rating work was made easier through rating two attribute-related ratings ("difficulty for us" and "newness in general") in only one site for each knowledge area, the corresponding values in the rows below were filled-in automatically. Separate collating tables were created for risk factors and the comments from "Concept-" and "Resource analysis" tables. A separate table for knowledge related risk factors was also introduced in the stage 7-version. In connection with the stage 7-base a list of the algorithms was provided to the pilot firms (see Appendix 8). Three projects were started using the Stage 6-type base. These projects are shown in more detail in Appendix 7.

Based on experiences from a number of projects, and on requests by pilot firms, an individual sheet for project presentation was provided, it contained one partition for characterizing the project, branch, for reporting the stage of development and organizational site. Another partition was intended for pre-analysis of the project (stage one of the two-stage analysis, see Figure 7.1 in Appendix 3). A more developed version of the Project presentation table is presented in Figure 9.1., Appendix 3.

4.2.5. Intermediate Development

Stage 8

Stage 8 involved the improvement of the interface between model and user, achieved by the gradual development of automation using MS Visual Basic ® programmed macros that are part of the MS Excel ® program. The primary objective for developing macros was the need for the addition of rows, and for the co-ordination of the rows in the "Concept-analysis" and the "Resource analysis" tables that were located on separate sheets. This was desired by those pilot firms who themselves did the analysis work, and also the researcher's own experience prompted such improvements. By coordinating the rows of concept attribute-component pairs in the "Concept-analysis" table with the corresponding attribute-component-resource group rows in the "Resource analysis" table computerized calculations could be done for matching "Concept-" and resource related risks. Furthermore, programmed row-addition and -deleting enhanced inserting of additional attributes and components between existing ones. The pilot firms' teams appreciated this feature immediately upon its appearance. #1693#

Guidance of the analyzers was another objective when improving the interface between user and computer model. The MS Visual Basic ® program was also used to create macros that provided the analyzers information on how to fill in the columns with text or rating numbers. When appropriate, this function was linked to text earlier entered by the analyzers into the columns of the analysis tables so that terms used by the analyzers became integrated into the guidance messages (Figure 4-3).

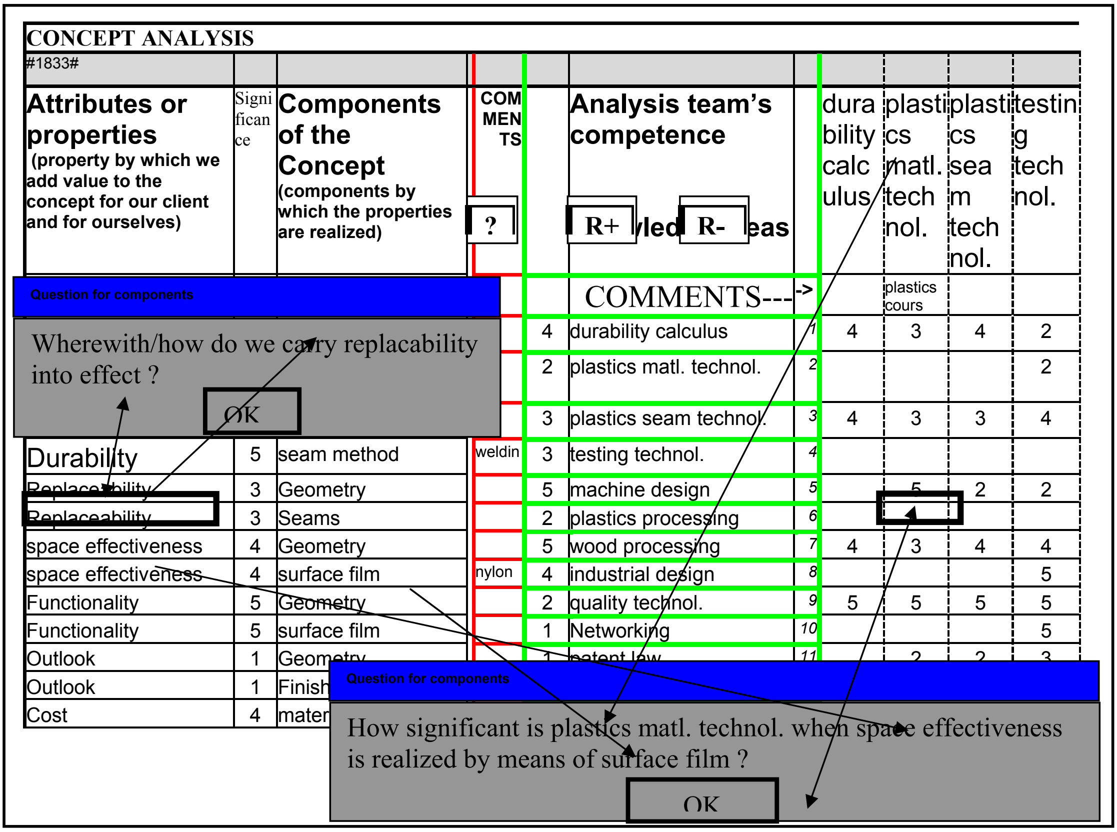


Figure 4-3. The figure shows how the guidance system presents answers in message boxes depending on where the analyser has placed the cursor. The arrows show how the answers are built up using words that the analysers have entered into the analysis table. The leftmost message box was produced when the cursor was in the cell containing the word "Replacability", the lower box with the cursor in the cell containing the number "5" (Note that most spreadsheet programs can present only one answer box at each time). This is an excerpt from a larger table!

The guidance system was first applied for the attribute-, significance- and component-columns. Later on, the guidance was extended to the grid area for rating the knowledge areas. This entire development was done using the stage

7-type base, without the pre-analysis sheet and linked rows. An example of the guidance feature is shown in Figure 4-3. Appendix 9 lists all the questions, suggestions and explanations included in the guidance system.

Stage 9

The idea of a quick and simple analysis was realized in stage 9. This was the answer to the wish of several analysis teams for a "lighter" analysis system. One important aim of the version was to prohibit the analyses to expand excessively and thus to become difficult to handle effectively. Two similar tables were placed under each other, "Concept-analysis" table on top and Resources analysis table below (see Figures 9.2. and 9.3. in Appendix 3). The number of ratings for the attributes was reduced so that only the significance for the knowledge areas was rated in the "Concept-analysis" table. The rating for significance included both regarding of significance to customer and the regarding of market benefit. The rating of technical problem was omitted. This reduced the requirements of rating by two ratings for each attribute. Also in the "Resource analysis" table the number of ratings was reduced to deal only with the ability of the resource component. The base was gradually enhanced by placing the "Project presentation" table on a separate sheet, and by enlarging it with a column for sequences of the project's progression. Ratings in the grid of the "Concept-analysis" table were made to copy to the "Resource analysis" table, for indicating cells of that table to fill in. This version had no row-addition or –deletion functions. 30 rows and 20 knowledge areas were sufficient for work with this version. This work resulted in a base as shown in Figure 4-4. The development involved interaction through 13 pilot analyses.

Finally, a separate sheet was provided for presentation of the project (Figure 9.1. in Appendix 3). It contains spaces for characterizing the project's business area, stage of development and organizational site. Furthermore, linked projects are listed, as well as limits to the project. Space was also provided for listing of the planned sequences for project realization for cases with advanced project planning.

During Stage 9 additional guidance macros were developed using a multi-sheet base. Measures were also taken to avoid mistakes when using the macros. Such mistakes included non-intended row-additions or –deletions in inappropriate rows. Macros that coordinated the structure of analysis tables on two Excel-sheets were also developed. This work was done separate from the development of the simplified version described above.

Stage 10

The “Concept-analysis” table and, correspondingly the “Resource analysis” table, of the stage 7 type base were divided into four separate identical tables situated below each other. This was done in order to facilitate the grouping of the analysis for appropriate purposes. Each one of these tables could be used separately so that four independent analyses could be carried out in the same base. This type is shown in Figure 10.1. in Appendix 3. Additional features involved sorting tables for analysis results and tables for preparing an analysis report. These tables were located on separate sheets (Fig. 10.2. in Appendix 3).
#1699#

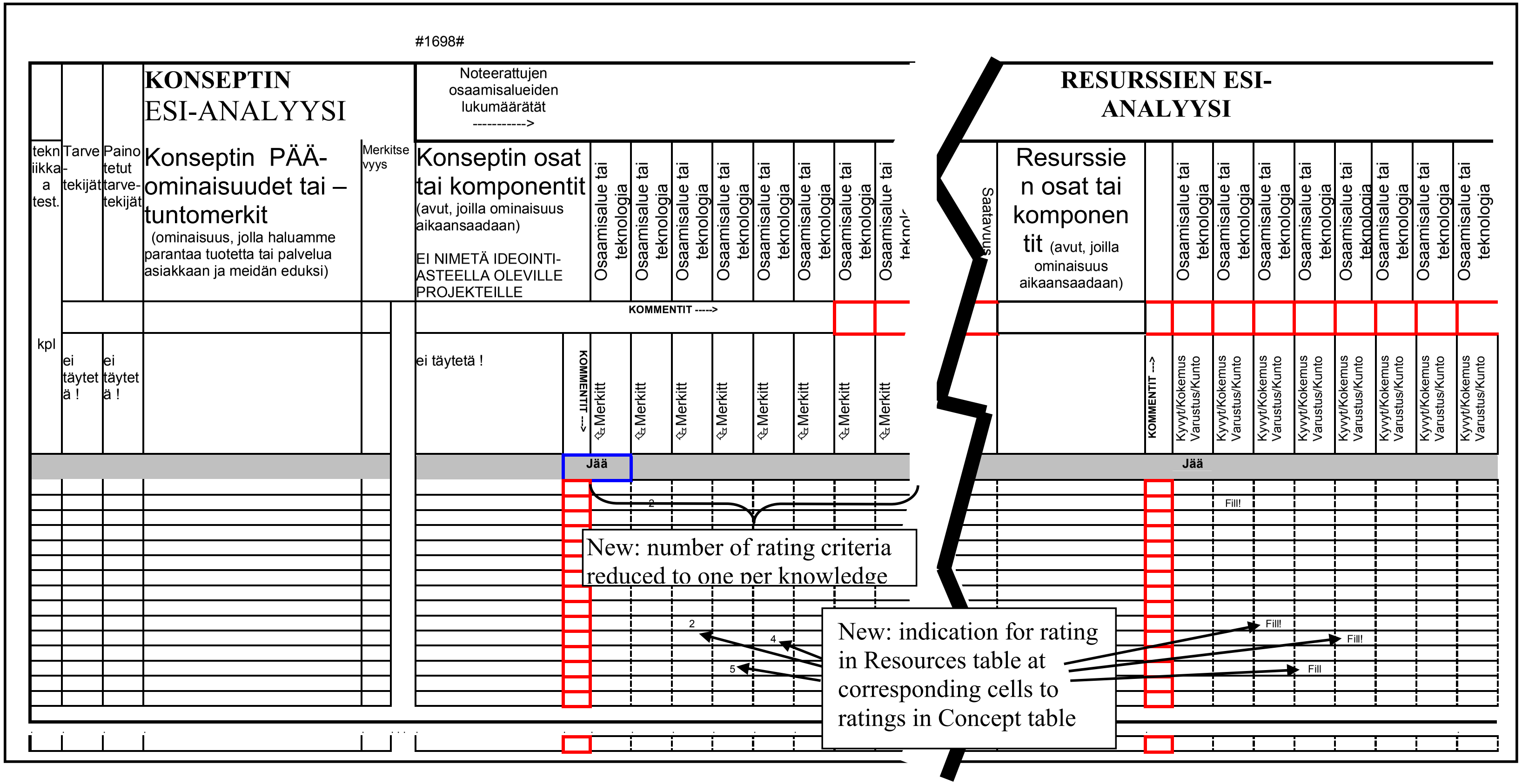


Figure 4-4. “Concept-analysis” table, and to the right an excerpt of the Resources table.

4.2.6 Pilot Analyses, Second Sequence

Stage 11

Trials were made to develop an individual base for one particular pilot firm. The development was performed in interactive co-operation with several members of the firm's analysis team. The work was done in three steps during which parts from the stage 7- and stage 10-bases were assembled together and transformed. The development work aimed at improving the focusing of the project definition, at identifying challenges and important items of the project. Evaluation of the availability of resource components and integration of the concept- and resource-analysis functions were also objectives of the development. The pilot firm furthermore strove to simplify the EDCP-analysis work. Primary targets for improvement were the analysis tables, the deliverables, and the algorithms. The work involved development of the input operation, the algorithms and the deliverables. It also involved improvement of the macros to fit the interface requirements of the firm. Starting point for the work was the stage 10-base. The changes included a column for listing all the needs of project prior to listing the attributes. The term "Technical problems" was changed to "Technical challenges", furthermore, new terms were added: "Importance" (equals sum of ratings for "Significance" and "Market benefit" of attribute), and "Criticality" (equals "Importance" value divided with rated value for "Technical challenge"). A column for rating the availability of each resource component was introduced. The number of ratings for the knowledge areas in the "Resource analysis" table was reduced to cover only the "Quality" of each resource component, and this reduced the number of ratings by two for each attribute-component-resource group for each knowledge area.

The most important contributions in Stage 11 were the reduction of the number of ratings in the “Resource analysis” table and the introduction of the rating of the availability of resource components.

4.2.7 Development of the Final Bases and the Final Analysis System

Stage 12

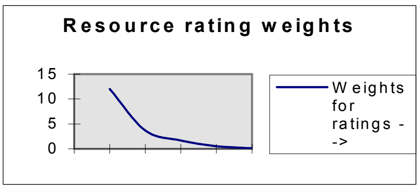
<u>The Tables</u>

Based particularly on the experiences from the large number of analyses with the stage 9-type base and also on the experiences from the development work in stage 11 we decided to develop a base that combines simplicity and an effective interface. The stage 9 base type (Figure 4-4) formed the starting point for the development that involved the structure, algorithms, deliverables and interface. Structural development involved situating “Concept-“ and “Resources analysis” tables besides of each other on the same analysis sheet. The rating work was simplified by limiting the rated items to one per attribute-component pair for each knowledge area in the grids of both the “Concept-” and “Resources analysis” table. The significance of each knowledge area to the realization of each attribute through the component was rated in the “Concept analysis” table and the ability of the resource component for each attribute-component pair was rated in the “Resource analysis” table. Furthermore a separate column was introduced for listing the knowledge areas instead of listing them directly in each knowledge area column atop of the grid. A new type of formula was developed for calculating the risk factors related to the resources. This formula involves numeral weighing with parameters for the different rating numbers (5-1) so that the sensibility of the analysis can be controlled. That formula was used the “Resource analysis” table:

$$\textit{lack factor} = \frac{\textit{significance to project}}{\textit{availability of resource}} \; (\#^{*)}\ 1{:}s\ \textit{in row} \times 12 + \#\ 2{:}s\ \textit{in row} \times 3.7 + \#31{:}s\ \textit{in row} \times 1{,}7 + \#\ 4{:}s\ \textit{in row} \times 0{,}5 + \#\ 5{:}s\ \textit{in row} \times 0{,}1)$$

*) # = number of

Here the inverse proportionality of the ratings for the goodness of the resource components is represented by the sum of products of the rated digits in one row and parameters. The weighting parameters represent the decrease of risk with increasing goodness. The representation functions so that the weighting parameter for the lowest rating digit (1) is considerably bigger (12) than the parameter (0,1) for the highest rating digit (5). The model also allowed changing of the weighting parameters and this made a change of the sensitivity of the evaluation of the ratings possible. In the model the sensitivity is illustrated by a graph, and by an Excel adjustment table below for entering the weights for ratings (Figure 4-5).
A list of all formulas in EDCP appears in Appendix 8.



Conc Res	CG9 1	CH9 2	CI9 3	CJ9 4	CK9 5
Rating------------------>	1	2	3	4	5
Weights for ratings →	12	3,7	1,7	0,5	0,1

Figure 4-5. The profile diagram and adjustment table of the sensitivity of the analysis.

The analysis tables of stage 12 appear in the Figures 4-6, 4-7, 4-8, and 4-9. This development required five intermediate versions of bases, seven pilot cases were involved in the development of this base.

NEW:
Knowledge areas listed horizontally

CONCEPT ANALYSIS #1856#

		?	R	R-		Knowledge areas		
Attributes	Significance	**Components**	COMMENT	Analyzers' competence	**Knowledge areas**	durability calculus	plastics matl. technol.	plastics seam technol.
					COMMENTS →		plastics cours	
Durability	5	Geometry		4	durability calculus	4	3	4
Durability	5	support plate material		2	Plastics matl. technol.			
Durability	5	surface film		3	Plastics seam technol.	4	3	3
Durability	5	Seam method	weldin	3	Testing technol.			
Replaceability	3	Geometry		5	machine design		5	2
Replaceability	3	Seams		2	Plastics processing			
space effectiveness	4	Geometry		5	wood processing	4	3	4
space effectiveness	4	Surface film	nylon	4	industrial design			
Functionality	5	Geometry		2	Quality technol.			
Functionality	5	Surface film		1	Networking			
Outlook	1	Geometry		1	Patent law			
Outlook	1	Finish			Knowledge area			
Cost	4	Material selection			Knowledge area			

New:
Only one rating per knowledge area

This is an excerpt from a larger table!

Figure 4-6. The "Concept-analysis" table.

<u>Deliverables</u>

The analysis results were presented in two tables, the "Collation table for analysis results" (Figure 4-8) and the "Collation table for knowledge areas" (Figure 4-9). The "Collation table for analysis results presented" the risk factors for each attribute-component-resource group, and it also presented the comments to the attribute-component-resource groups from the concept- and resource analyses. The "Collation table for the knowledge areas" presented the risk factors for each knowledge area as well as the comments for the knowledge areas from the "Concept-" and "Resource analysis" tables. The interface development involved macros for guidance, explaining calculation formulas in the "Collation table for analysis results". Furthermore macros were provided for narrowing and widening the columns for abbreviations as well as the column for listing knowledge areas.

RESOURCE ANALYSIS #1857#

		? R+ R-			Knowledge areas		
Attribute-component pairs	Significance	Resource components (persons, machines, contractors, etc. that realize Attributes)	Resource availability	Comments	durability calculus	plastics matl. technol.	plastics seam technol.
		COMMENTS		->			
R1 durability & geometry	5	KV, PJ, PK, JM, TV, VT, Varo Co, Kotay	3	depen	2	3	3
R2 durability & support plate material	5	Varo Co,	5	Depe			
R3 durability & surface film	5	KV, PJ, PK, JM, TV, VT, Varo Co., Kotay	4		2	3	2
R4 durability & seam method	5	KV, JM, TV, SR, Varo Co., Kotay, TKK,	1				
R5 replaceability & geometry	3	KV	1			5	5
R6 replaceability & seams	3	KV, JM, VT, PJ, JS, SR, PS, KM,	3				
R7 space effectiveness & geometry	4	KV, JM, VT, PJ, JS, SR, PS, KM, PK,	4	Shoul	4	2	4
R8 space effectiveness & surface film	4	KV, JM, VT, PJ, PK, TV., Kotay	4				
R9 functionality & geometry	5	KV, JM, VT, PJ, PK, TV., Kotay, Varo Co.	4		3	4	2
R10 functionality & surface film	5	KV, JM, VT, PJ, TV., Kotay, Varo Co., TKK	2	Depe			
R11 outlook & geometry	1	EK	4			4	4
R12 outlook & finish	1	EK, C-EW,	2				
R13 cost & material selection	4	KR, C-EW, PH, TV, JM, Kota Ky, Varo Co.,	3				
R14 cost & contractors	4	KR, C-EW, PH, TV, Kota Ky, Varo Co.,	5				
R15 cost & size of series	4	KR, C-EW, PH, JM, Kota Ky, Varo Co.,	1		4	5	2

This is an excerpt from a larger table!

Figure 4-7. The "Resources Analysis" table.

The results of the concept analysis are presented as a numerical "Requirement factor" for every attribute-concept pair, for the resource analysis the results are expressed as a numerical "Lack factor" for each attribute-component-resource component group. The "Requirement factor" expresses how much staking each attribute requires for making the attribute come true. The more requirements it poses the more potential risk it causes for the project. The "Lack factor" expresses the shortcomings of each resource component when it realizes each attribute by means of its component. The bigger the “Lack factor”, the bigger is the potential risk that the resource component causes to the project. The risks of the project as a whole are expressed as a numerical “Risk factor” for each attribute-component-resource component group.

The risks of each knowledge area are presented as numerical “Dependency factors” relative to the concept, and “Deficiency factors” relative to the resources and as a “Risk factor” relative to the project as a whole. The “Dependency factor” expresses to which extent the project depends on each Knowledge area in order to realize. The “Deficiency factor” expresses how much deficiency in each knowledge area the resource components have when they realize the concept of the project. The “Risk factor” of each knowledge area combines the “Dependency-“ and “Deficiency factors”.

The EDCP analysis points out the position of each risk in the project by presenting numerical values. The analyzer is able to see which individual attributes and which individual attribute-component pair contribute to the risks of the project. It also points out which resource components cause risk. Furthermore, it indicates which knowledge areas the concept demands for its realization and points to those knowledge areas for which the resources are insufficient. The risk factors of the project as well as the risk factors of the knowledge areas give a general impression of how the risk is structured in the project. From the risk factors the analyzer may go backwards to the requirement factors and to the lack factors as well as to the dependency factors and the deficiency factors. The analyzer may even want to trace back to the individual combinations of attributes, components, resources and knowledge areas and the ratings for these.

To assess the risks connected to the project one first looks for those attribute-concept-resource component groups that exhibit the biggest numbers for the risk factors in relation to the project as a whole. Then one investigates whether the risks of these groups are related more to the concept or to the resources. For this

COLLATION TABLE FOR ANALYSIS RESULTS #1649#

Attribute-Component-Resource-groups	wghtd Requirement factor	Requirement factor	Wghtd Lack factor	Lack factor	weighted Risk factor	Risk factor	# knowl areas evaluated	Comments from Con ? analysis	Comments from Resource analysis
R1 dura & geomet & design , Var,Kot	14	155	1,55	17	241	2651	11		
R2 dura & suppor & Varo	8	60	3,50	28	210	1680	8		depends on edging machine
R3 dura & surffi & design , Var,Kot	16	175	4,88	54	854	9392	11		depends on edging machine
R4 dura & seammt & r&d, Var,Kot, T	10	20	30,00	60	600	1200	2	Welding, riveting	
r5 repl & geomet & KV	8	48	0,30	2	14	86	6		
r6 repl & seams & t&d, mark	11	45	1,50	6	68	270	4		
r7 spac & geomet & r&d, mark, purc	14	108	3,10	25	335	2678	8		should the group be splitted
r8 spac & surffi & design , Kotay	11	56	2,13	11	119	596	5	nylon, polyester	
r9 func & geomet & r&d, Var,Kot	23	180	2,92	23	525	4200	8		
r10 func & surffi & r&d, Var,Kot, T	14	70	3,77	19	264	1318	5		depends on edging machine
r11 look & geomet & EK	3	18	0,68	5	12	86	7		
r12 look & finish & EK, C-EW,	2	6	0,03	0	0	1	3		
r13 cost & m sele & export, Kot,Var	17	84	2,80	14	235	1176	5		
r14 cost & contra & export, Kot	15	60	1,50	6	90	360	4		
r15 cost & si ser & export, Kot	17	84	2,34	12	197	983	5		

Figure 4-8. Collation Table for Analysis Results.

purpose the relative size of the concept “Requirement factor” is compared with the resource “Lack factor” for each group. The assessment procedure is enhanced by means of the sorting function of the spreadsheet program. The attribute-component-resource groups, as well as the knowledge areas, can be ordered according to the different risk factors. The sorting is quickly performed in the tables, and separate printouts can be made for different risk functions e.g., “Requirement factor”, “Lack factor”, or “Risk factor” for whole project.

The analysis results are presented in two stages, the first stage being the “Collation Table for Analysis Results” and the “Collation table for the Knowledge areas”. The “Collation Table for Analysis Results” appears filled with the output data at the end of the analysis process. The “Collation table for Analysis Results” is shown in Figure 4-8, the “Collation table for the Knowledge areas” in Figure 4-9. In addition to the Collation Table the first stage contains four diagrams: a diagram showing the requirement factors, a diagram showing the lack factors and a diagram showing the risk factors, all in relation to the attribute-component pairs.

The analysis program also produces nine diagrams that show the profiles of the different risk categories. The tenth diagram shows a profile for the competence of the analyzing team relative to the knowledge areas. These tables and diagrams appear instantly during the analysis process and are ready for use directly at the end of the analysis, when the team evaluates analysis-results.

The second stage of results presentation consists of a report presented by the consultant. The data for this report is edited on the Edit sheet where different tables can be edited according to the requirements of the project owner. The report consists of a verbal part prepared on a form in MS Word® and a number of diagrams prepared from tables edited in the editing sheet.

Collation table for the knowledge areas **#1650#**

Knowledge area	Dependency factor (Risk of Knowl. area rel to Concept)	weighted Dependency factor	Deficiency factor (Risk of Knowl. area rel to Resources)	weighted Deficiency factor	Risks of Project rel to Knowl. Areas	weighted risks of Knowl. Areas rel to Project	# Knowl areas evaluated	**Comments**	
Diagram No	8	9	10	11	12	13		**relative to Concept**	**relative to Resources**
durability calculus	22	4	10	2	227	45	5		
Plastics matl. Technol.	26	4	8	1	216	31	7	plastics course	
Plastics seam technol.	29	4	18	2	513	64	8		
testing technol.	39	4	15	1	601	55	11		
Machine design	29	3	19	2	545	55	10		
Plastics processing	38	3	17	1	654	54	12		designers to Interplas exhibition in Germany!
wood processing	30	3	25	3	762	85	9		
industrial design	23	3	9	1	216	24	9		
Quality technol.	22	3	23	3	515	64	8		
Networking	33	3	27	2	904	82	11		
Patent law	21	2	23	2	477	48	10	patent law course	make contract with patent attorney
Knowledge area									
Knowledge area									
Knowledge area									

Figure 4-9. Collation Table for Knowledge Areas.

An example of a diagram showing the risk concentrations for certain attribute-component-resource groups in a project is shown in the Figure 4-10. The x-axis lists each attribute-component pair (the text is abbreviated). The pillars express the weighted requirement factors for each attribute-component pair, the solid line the corresponding (non-weighted) requirement factors. Other examples of diagrams are presented in Appendix 10.

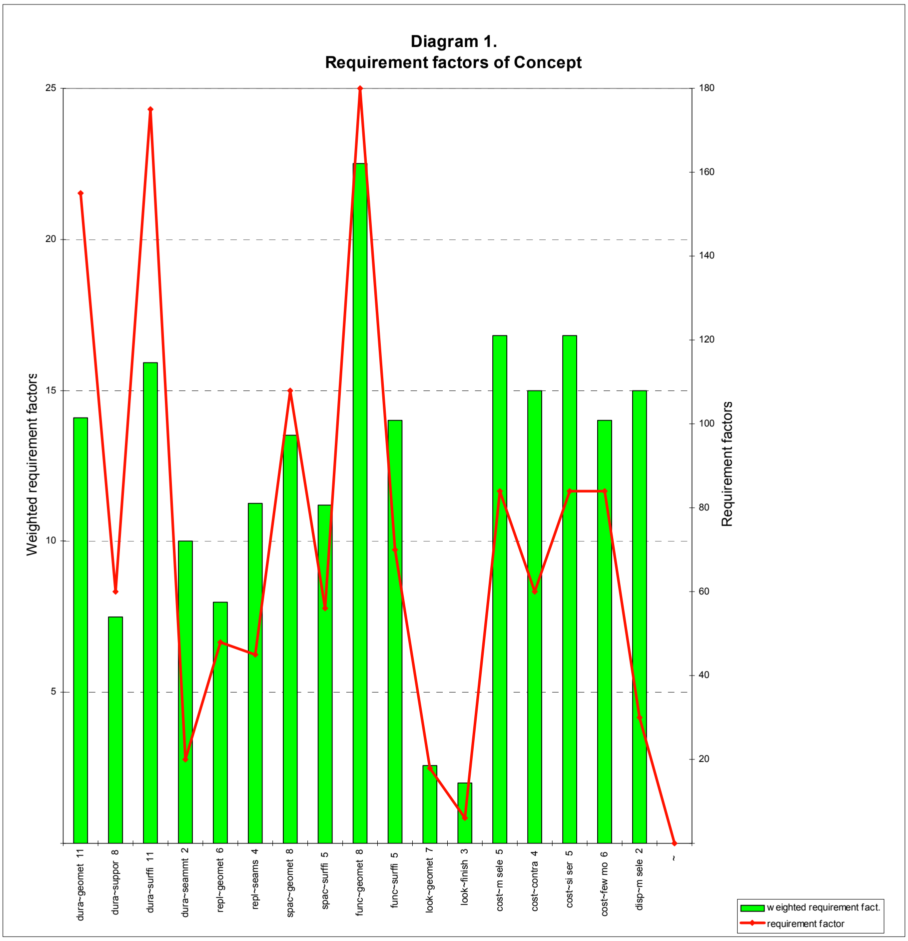


Figure 4-10. Diagram showing the risk factors for the attribute-component pairs of the Concept analysis in a project.

Interpretation of the Analysis Results

The analysis results were interpreted at two different occasions, during the analysis sessions and after the project analysis was completed. At certain intervals during the sessions copies of the analysis tables were printed and, particularly at the end of each session graphs were also printed. This practice proved very useful for the motivation of the analyzers to continue, as they could vision the results of their work during the progress of the analysis. Very little attention was, however, paid by the analyzers to the risk values in the analysis tables during the progress of

COLLATION TABLE FOR ANALYSIS RESULTS #2133#

Attribute-Component-Resource-groups	wghtd Requirement factor	Requirement factor	Wghtd Lack factor	Lack factor	weighted Risk factor	Risk factor	# knowl areas evaluated	Comments from Concept analysis	Comments from Resource analysis
R3 dura & surffi & design , Var,Kot	16	175	4,88	54	854	9392	11		depends on edging machine
R4 dura & seammt & r&d, Var,Kot, T	10	20	30,00	60	600	1200	2	welding, riveting	
r9 func & geomet & r&d, Var,Kot	23	180	2,92	23	525	4200	8		
r7 spac & geomet & r&d, mark, purc	14	108	3,10	25	335	2678	8		should the group be splitted
r10 func & surffi & r&d, Var,Kot, T	14	70	3,77	19	264	1318	5		depends on edging machine
R1 dura & geomet & design , Var,Kot	14	155	1,55	17	241	2651	11		
r13 cost & m sele & [illegible]	17	84	2,80	14	235	1176	5		
[illegible]									
r11 look [illegible]	3	18	0,68	[illegible]	2	86	7		
r12 look & finish & EK, C-EW,	2	6	0,03	0	0	1	3		

(This is an excerpt of a larger table)

Figure 4-11. The top part of "Collation Table for Analysis Results" after sorting to investigate risk concentrations for the whole project.

the analysis. When the analysis was completed prints were taken of the analysis tables and all graphs. Prints were also made of the Analysis results tables as soon as they became available in the bases due to the basis development. The prints were made in the pilot firm using their printer. Copies of all printed material were handed over to the pilot firm. For many of the projects an Analysis Report form (MS Word ®) was prepared.

An example of an interpretation of the analysis results is demonstrated in Figure 4-11, showing the "Collation table for analysis results" after a sorting procedure (only the top part is shown in the picture). Here the weighted risks (the sixth column of the table) have been sorted in descending order. This shows that the three biggest risks are concentrated to obtaining durability by means of surface film with resources Varo Co. and Kotay (R3 dura & surffi & design , Var,Kot), followed by obtaining durability by means of seaming method with resources Varo Co., Kotay and TKK (R4 dura & seammt & r&d, Var,Kot, T), the third biggest risk concentration being the obtaining of functionality by means of geometry with resources r&d, Varo C. and Kotay (r9 func & geomet & r&d, Var,Kot).

Correspondingly, risk concentrations pertaining to the concept are shown by sorting the weighted requirement factors (second column of the above-mentioned table, and the risks concentrations from the resources by sorting the weighted lack factors (fourth column).

In the same manner risk-concentrations among the knowledge-areas can be shown by sorting the "Collation table for the knowledge areas", as illustrated in Figure 4-12. Here the column for "Weighted risks of Knowledge Areas" relative to the project was sorted, and consequently the three most risky knowledge areas are

Wood processing, Networking and Plastics seam technology. Appendix 11 shows the interpretation and report of a demonstration project.

Collation table for the knowledge areas #1650#

Knowledge area	Dependency factor (Risk of Knowl. area rel to Concept)	weighted Dependency factor	Deficiency factor (Risk of Knowl. area rel to Resources)	weighted Deficiency factor	Risks of Project rel to Knowl. Areas	weighted risks of Knowl. Areas rel to Project	# Knowl areas evaluated	Comments	
Diagram No	8	9	10	11	12	13		relative to Concept	relative to Resources
wood processing	30	3	25	3	762	85	9		
Networking	33	3	27	2	904	82	11		
Plastics seam technol.	29	4	18	2	513	64	8		
Quality technol.	22	3	23	3	515	[illegible]	8		
M[illegible]									
Know[illegible]									

(This is an excerpt of a larger table)

Figure 4-12. Top part of Collation Table for Knowledge Areas, after sorting the column for Weighted risks of Knowl. Areas rel to Project.

<u>Analysis</u> <u>Report</u>

The analysis form was prepared after the final analysis session by the researcher or by some other facilitator. This work was done in the facilitator's premises outside of the pilot firm. Attributes, components and attribute-component-resource groups as well as the calculated risk values were copied from the analysis tables into the MS Word® form of the "Analysis Report". Counts of individual attributes, components, resources and identical pairs and groups were performed and the different data-groups were transferred into tables in the report form. The attribute-component pairs and the attribute-component-resource groups were sorted according to largeness of their respective risk factors. After sorting the different categories were tabulated into tables in the "Analysis Report" form. An example of the report is available in the Appendix 12.

Conclusions of Analysis

Conclusions of the analysis were drawn based on the data from the tables. The conclusions were written into reserved spaces in the form. The report form could be adapted to the need of the pilot firm e. g., by adding or leaving out portions. In some cases conclusions were made separately for the analyses of concept and resources, and for the analysis of the whole project. In other cases comments were presented only for the whole project.

As complements to the Analysis Report Form prints of all graphs were supplied to the pilot firm.

Presentations

The results of the analysis were normally presented to the representatives of the pilot firm in a concluding session, the presentation often took the form of a discussion. A few of the project the analyses were finalized only by mailing the Analysis Report form.

4.2.8 Risk Analysis without Mentioning the Word Risk

The listing procedures in EDCP resemble brainstorming in that the analysis team is asked to provide attributes, components, knowledge areas and resource components. Osborne (1965) recommends that the members of a brainstorming team must be able to work in a relaxed environment. Because the thought of risk might act as a disturbing element to a team of persons that are intimately involved an the project they analyze, EDCP has been designed so that no reference to risk appears to the analyzers during the whole analysis procedure.

None of the headings in the tables used during the analysis contain any words referring to the word risk nor do any of the statements in the guidance system. The word risk appears only in the tables for analysis results that will be used after the analysis is completed.

4.3. Summary of the Base Development Work

The base development work took place in six phases. The character of the phases was dictated partly by the development work of the researcher, partly on the work with the pilot firms. The phases can be grouped into three groups, the first group when the researcher developed the model based partly on theory, partly on experience. The next group of phases included work with the pilot firms' projects involving subsequent development of the bases, the work being supported by experience in co-operation with the pilot firms. The final group regarded testing of the new bases in analyses with pilots' projects and the development of the final base.

This stepwise approach allowed continuous application of experience from the pilot firms and also the possibility to continuously benefit the pilot firms with analysis results.

Introduction of Items into the Bases

After the model was conceived, as described in Chapters 3 and 4, items were changed, and new items were added to or removed from the model in different phases and stages. We apportioned the changes of the model into structural items and functional items. Structural items are visible in the model, they can be ascribed item classes e.g., tables, columns, rows, headings, data, or changes to the configuration of tables. Functional items deal with the function of the model e.g., activities like entering or transferring data, calculation of result or intermediate data. Also changing of some structural item, for instance the vision of a table is a functional item, as is guidance of the analyzers. The algorithms form a third class of items that are involved in the model.

Table 4-6 shows how many items have been changed during the different stages during the pilot related development work. Most of the changes involved the addition of new items; other changes included omitting or altering items. The number of items was counted so that each different class of item was counted as a new item e.g., each different type of column, row, cell, table, formula, or each different type of entering, transfer, calculation of data was counted, and them summed. Many of the items originated in requirements, requests or wishes from the pilot firms. Other items were created on the researcher's own initiative. Appendix 13 lists the individual types of improvements made in each stage.

The Preliminary structuring and the Pre-pilot analysis phases (stages 1-5) generated the Ex Ante model. The Ex Post model emerged during the 1st and 2nd sequences of the Pilot analyses phases, and during the Intermediate development phase and the Development of the final bases (stages 6-12). All development during the Ex Post phases occurred under the influence of the cooperation with the pilot firms.

Table 4-6 also lists development of algorithms. Because the structural items are connected to the appearance of the model they can be considered to represent the interface part of the model. The functional items and the algorithms involve the operation of the analysis tool and thus represent the model itself. The alterations and omissions of parts within the model have been shown only to give an impression of the nature of the development work.

As seen from Table 4-6 clearly more than half of both structural and functional items were introduced during the Ex Ante development. The number of structural items was practically twice that of the functional items, during every one of the development phases. The two parts of the Ex Post phases produced practically equal numbers of structural, functional and algorithm changes. The changes to algorithms were only one third compared to the functional items. A small number of alterations were made constantly to items during each phase of the development work.

Table 4-6. New items and changes to bases in each stage **#1993#**

Phase	Stages	Structural	Functional	Algorithms	Alterations	Omissions	Total
Ex Ante	1-5	82	42	9	2	2	137
ExPost 1st sequence	6-9	27	16	5	2	2	52
ExPost 2nd sequence	10-12	39	17	7	2	0	65
Total number of improvements, ExPost 1st +2nd	6-12	66	33	12	4	2	117
Total number of items	1-12	148	75	21	6	4	254

In Table 4-6, the number of structural items is large when compared to the numbers of functional items and algorithms. This indicates that the pilot firms were able to contribute more to interface related improvement than to development related to the model itself. The relatively small number of alterations and omissions reveals that the development work proceeded in a regular manner avoiding any dramatic changes.

Table 4-7 presents the distribution of items between the different parts of the model. The parts represent those parts that have been described earlier in this work (Chapters 3. and 4.2.2.). Configuration refers to changes in the appearance or in the placement of tables and other constituents of the model.

Table 4-7. The Distribution of Items to the different parts of the Model #1994#

Phase	Stage	Configuration	Concept	Resources	Project presentation	Deliverables	Algorithms
Ex Ante, total items	1-5	15	45	51	-	16	9
Ex Post 1st sequence	6-9	1	8,5	4,5	27	-	6
Ex Post 2nd sequence	10-12	13	22	9	-	10	7
Total number of improvements Ex Post 1st +2nd	6-12	14	30,5	13,5	27	26	13
Total number of items	1-12	29	75,5	64,5	27	26	22

The “Resource analysis” table of the Ex Ante model contained slightly more items than the “Concept-analysis” table. However, during the Ex Post development phases, and particularly during the later phase, there was a considerable increase of items in the “Concept-analysis” table. Slightly less than one half of the items in the “Concept-analysis” table of the final model became introduced during the Ex Post development work.

The other parts of the model i.e., “Project-presentation” table, “Deliverables table” and algorithms contained considerably fewer items than the “Concept-“ and “Resource analysis” tables. Table 4-7 further reveals that means for project presentation appeared only during the Ex Post development whereas items were introduced to deliverables parts during the Ex Ante phases and then later during the 2nd sequence of the Ex Post phase. Introduction of algorithms proceeded smoothly during the development process although there was a slight acceleration during the later Ex Post phase. Changes to the configuration of the analysis tables occurred mainly in the Ex Ante phase (one half of the items) and the second Ex Post phase.

Conclusions about the Base Development Work

We conclude that the “Concept-” and “Resource analysis” tables attracted main attention during the whole development process. The deliverables received clearly less development action, as did also the project presentation. The data in Table 4-7 indicate that attention was paid to project presentation only after the requirements for such operation had appeared in the pilot analyses. Also the increased development of deliverables in the second Ex Post phase indicates the need became apparent towards the latter parts of the development process. The smooth development pace for algorithms indicates that the logic behind the analysis method developed as more was learned from the analysis cases about the needs for analysis of innovative projects. The slight acceleration of algorithm development towards the end of the development work apparently stems from wants to produce more sophisticated formulas that produced more precise analysis results. The changes to the configuration of the analysis tool that occurred late in the development work indicate a concentration of effort to incorporate experiences into the final base.

4.4. Description of the Analysis Work with the Case Projects of the Pilot Firms

The cases consisted of individual innovation projects provided for analysis by the pilot firms. The firms elected the projects from their idea portfolios, in many firms a final selection was made together with the researcher prior to the start of each analysis. All cases represented real projects related to the business of the pilot firm.

The 45 pilot case projects are listed in Table 4-8. For confidentiality reasons, the projects as well as the firms are coded, the firms with letters and the projects with numbers combined with the firm's code.

The projects are typified with regard to their technological and commercial character. The technology is characterized as high, medium or low, there were also a few projects that could not be characterized as technically related at all. In commercial respect, the projects were classified as either directed towards the external market, indirectly towards the market, or towards administrative use; a few projects were related to the whole operation, and a few others had no commercial connections. The projects that were directed indirectly towards the market often regarded components of products, processes or services that were to be integrated into one or several externally marketed products.

Both the technological and the commercial uncertainty of the projects were rated on the scale A-D, were A represented the highest degree of uncertainty, D the lowest. Each project was further classified according to its degree of innovation, and according to its size. Innovation was rated into the degrees radical, incremental and application; application representing only the application of existing knowledge.

Table 4-8. The Pilot Cases #1717#

Code of pilot firm	P-code	Project type: Technological Character	Technological Uncertainty *)	Commercial Character	Commercial Uncertainty *)	Innovation	Size
A	A1	---	A	administrative	B	incremental	small
B	B1	Med	B	administrative	C	application	large
B	B2	Med	B	market, indirect	C	incremental	med
B	B3	High	B	market, indirect	B	incremental	med
B	B4	High	B	---	C	radical	med
B	B5	High	C	---	B	incremental	large
C	C1	High	C	market, indirect	C	radical	large
C	C2	High	C	market, ext	B	radical	large
D	D1	High	C	market, ext	B	radical	med
D	D2	High	C	market, ext	B	radical	med
E	E1	Med	B	market, indirect	A	radical	med
E	E2	Med	B	market, ext	A	radical	med
E	E3	High	B	market, ext	A	radical	med
E	E4	High	C	market, ext	A	radical	med
E	E5	Med	B	market, ext	A	radical	med
F	F1	High	C	market, indirect	A	radical	large
F	F2	High	C	market, indirect	A	radical	large
F	F3	High	C	market, ext	A	radical	large
F	F4	High	C	administrative	A	incremental	med
F	F5	Med	C	administrative	A	incremental	med
F	F6	High	C	market, ext	A	incremental	large
F	F7	High	C	market, ext	A	incremental	large
G	G1	Low	B	market, ext	C	radical	med
G	G2	Low	B	market, ext	C	radical	med
H	H1	High	C	marketing, ext	C	radical	Med
I	I1	Med	A	market, ext	B	incremental	large
I	I2	Med	A	market, ext	B	incremental	Med
I	I3	Med	B	market, ext	B	incremental	Med
I	I4	Med	C	market, ext	B	incremental	large

Table 4-8. The Pilot Cases (continuation) #1717"							
J	J1	---	A	market, ext	C	incremental	Med
J	J2	Low	A	market, ext	B	incremental	small
J	J3	Low	B	market, ext	B	incremental	large
J	J4	Med	B	market, ext	B	incremental	med
J	J5	Low	B	administrative	C	incremental	small
K	K1	---	A	administrative	B	incremental	small
L	L1	Med	B	market, ext	B	incremental	med
L	L2	Med	B	market, indirect	B	incremental	med
L	L3	High	B	---	B	incremental	large
M	M1	Low	B	Total	B	incremental	med
M	M2	---	A	market, ext	C	incremental	med
M	M3	---	A	market, ext	B	incremental	small
N	N1	High	B	market, ext	A	radical	med
O	O1	Med	A	administrative	C	incremental	small
O	O2	High	C	---	C	radical	small
P	P1	High	C	Total	C	radical	large
*) A =minimum, D =maximum for uncertainty evaluation							

Projects were categorized as "large size", over one million FMK, "medium size", over 100.000:- FMK, and "small projects", below 100.000:- FMK. In a number of cases the pilot firm was unable or unwilling to disclose costs for their projects, in these cases the characterization of project size was left to the firm, using classes large, medium or small size.

4.4.1. Categorization of the Cases

A clear majority of the 45 pilot projects analyzed can be classed as high or medium technological projects (20 projects), six projects were of low technology and five were not related to technology at all. The technological uncertainty was medial for most projects (19 of class B and 17 of class C), nine projects were rated as highly uncertain (class A). Over one half (25 of 45) of the projects were aimed

for direct external marketing, seven were indirectly related to marketable products or services. Seven other projects dealt with administrative activities for use internally within the firms. Finally, two projects dealt with the business idea of the entire firm. The representatives of the firm appreciated the commercial uncertainty intuitively. The commercial uncertainty was more evenly distributed between the projects the than the technological uncertainty (13 A, 19 B and 13C, respectively).
#1776#
The classification of the degree of innovation indicated that there were somewhat more incremental (25) than radical (19) innovations, and one application among the projects. Finally, the projects were classified according to size. There were 14 large, 23 medium sized and seven small projects.

Table 4-9 presents an overview of the classification of the projects.

Table 4-9. Categories of Cases #1712#

Technical				Commercial				Innovation		Size	
Character	#*)	Uncertain	#	Character	#	Uncertain	#	Type	#		#
High	20	A	9	external	25	A	13	Radical	19	large	14
Medium	14	B	19	internal	7	B	19	incremental	25	medium	23
Low	6	C	17	administr.	7	C	13	Application	1	small	7
---	5			---	4						
				Total	2						

*) # = number of pilot case projects

The analysis of four of the 45 projects was not finished for different reasons, and consequently these projects are not regarded in the further description of the

EDCP development process. Thus the result from the analysis of 41 pilot projects, from 16 pilot firms forms the data for the presentation of the development work.
In the following one exemplar case is described. It is selected among the projects that gave something to the development of EDCP. In the descriptions of other exemplar cases the same codification is also used.
First the pilot firm is described, in terms of character, industry, structure, size, and research background. Then a short definition of each project follows. Next the persons (description, character) and changes in the team are described. Then follows a paragraph about the proceedings of the analysis process: on one hand the consecutive (calendarial) proceedings, and on the other hand the structural proceedings of the analysis work. The latter includes descriptions of preparation and facilities used for analysis work, the listings and the ratings used in the analysis. The paragraph about the proceedings also presents the progress of the listings and ratings. This part contains one table that monitors the listings and ratings of the different items and one table that presents the progress of the analysis. The project description further includes an explanation about which bases were used, on the monitoring of the analysis work, on preparation of the "Analysis Report". Finally, the description lists the results of the analysis. The description of some additional exemplar analysis cases in the Appendix follows the same pattern as the above exemplar description, and the presentations are extended with copies of the actual analysis tables and graphs used in the analysis.

Case Description
Firm M

1. **Company description**

   Character, industry, structure, size, research background
   The company was started in 1994 as a producer and developer of high-tech textiles. The firm can be defined as a R & D enterprise and classified as a small enterprise. One of the base ideas is to develop textiles from turf.

3. **Project definition**

   The project was defined as an analysis of the business idea of the firm. This wide definition of a project was partly due to the project being the third project analyzed within the EDCP development project.

4. **Team**

   Persons (description, character), changes
   The team consisted of the managing director (md) of the firm, a marketing person with academic degree (m), and a representative (inv) of an investing organization. The team in total was present in the two first sessions, in the third (m) and (inv) participated, in the fourth (m) alone, in the fifth (md) and (m), and in the last two sessions (m) and (inv).

7. **Proceeding of analysis process**

   Calendar: time elapsed between sessions, postponements, number of sessions
   The analysis proceeded in seven sessions, and a last recollection session. 4 weeks elapsed between first and second analysis, ½ week between second and third, 3 weeks between third and fourth, 1½ weeks between fourth and fifth, 4 weeks between fifth and sixth analysis, and 6 weeks between the two last analyses. The recolecting session occurred 3 weeks after the final analysis.

   Analysis proceeding
   <u>Preparations and facilities</u>
   The three first analyses were performed in the office of the investment firm using their computer. This was the first pilot analysis, where direct data feeding into the computer was used. The following sessions were held in the office of the firm, using their computer.

   <u>Listings: (attributes, components, knowledge areas, resources, number of items, time</u>
   The first session involved a short description of the function of EDCP, then the analysis started with work directly on the computer. All attributes 10 different attributes, 34 rows of attribute-component pairs and 13 knowledge areas were listed. Significance values for all attributes, one row of knowledge area values in the grid were rated to show an example of the rating procedure. A printout was made of the "Concept-analysis" table and (m) finished the rating with paper and pencil, and faxed the result to the researcher who entered the data into the computer, and also printed a diagram of the analysis results for the analyzed concept and knowledge areas.

   In the second session the intermediate results were discussed. Three additional knowledge areas and 18 more attribute-component pairs were listed, (m) rated remaining knowledge area groups in grid later on own computer.

During the third session a copy of the “Resource analysis” table was printed for later filling-in. The Concept analysis was finished with a total of 49 attribute-component pairs. The results from (m)’s rating were analyzed using tables and diagrams printed.

For the fourth session (m) had pre-filled the “Resource analysis” table. The ratings for attribute significance was transferred manually from the Concept to the “Resource analysis” table.

During the fifth analysis session eight rows of knowledge area groups were rated in the grid of the “Resource analysis” table, but no more progress could be made due to the absenteeism of the (md).

In the sixth session the number of resource groups in the “Resource analysis” table increased to 69, 24 more rows of knowledge area groups were rated in the grid. Diagrams of risks from concept and resources were printed .

In the seventh session 31 more rows of knowledge area groups were rated in the grid. The “Resource analysis” table in this analysis contained 69 rows whereas the “Concept-analysis” table contained 49. During the seventh session tables of the analysis results (Risks of Concept and Risks of Resources and Risks of Knowledge areas) were printed, as well as corresponding diagrams. Areas representing interesting items were encircled in the graphs during the discussions.

The stage 6-type base was used in all sessions.

Table 1. Listings and ratings					
Concept analysis sheet					
Listings	#	Sess #	# Ratings	#	Sess #
Attributes			Signif / Attr	49	1
Components, tot.	49	1	Market benefit	-	
Components, diff.	39	1	Technical problems	-	
Knowledge areas	15	1	Knowl. area groups		
			#rows & knowl. areas	49&15	
			total matrix grid area	735	
			# cell groups rated	342	2
			% grid area rated	46,5	
Resources analysis sheet			#rows & knowl. areas	69&15	
#Res. Comp. groups, tot.	69	1	total grid area	1035	

#Res. Comp. groups, diff.	38	1			
			# cell groups rated	412	3
			% grid area rated	39,81	

Progress of the analysis work

Four of the analysis sessions lasted four hours, one 4½ hours, and two lasted three hours. The analyses went smoothly when they got started, and the initiative and preparedness of (m) to do much of the rating work alone contributed to the progress. Due to the wide scope of the project the analysis grew so large that it hampered the perspicuity of the analysis. The progress of the analysis work was retarded when (md) was unable to participate in two sessions dealing with resources.

Table 2 shows the progress of the analysis.

Table 2.								
Listing & rating progress								
Session #		1	2	3	4	5	6	7
Stage, base		6	6	6	6	6	6	6
Time per sess., h		4	4	4,5	3	3	4	4
Cumulat. time , h			8	12,5	15,5	18,5	22,5	26,5
Listings								
attrib-comp pairs		49						
components,diff.		39						
resources, diff								
Knowledge areas		13	16					
Ratings								
sign. etc. for attrib.		49						
cons.knowl.area matrix			342					
Res knowl.areamatrix				73	224	412		

Monitoring of the analysis work

The analysis was monitored for the team by making printouts of the Excel sheets at the end of each session, and sometimes at the end of significant stages, totally 14 sets of printouts were prepared.

Interpretation of analysis results

A discussion of the analysis results was held with (md) and (m) during the final session.

Preparation of analysis report

Separately the researcher prepared an Analysis Report in the Analysis Report form (MS Word) of 3½ pages.

8. **Result of analysis process in this case**
Results for the benefit of the EDCP analysis process
The proceeding of the analysis is presented in Table 2 that shows dates, times used during each session.

Found faults
Difficulties were noticed in the ability to put questions and to sort out unneeded (unnecessary) componts i.e., rules were needed for "jumping over items". A suggestion of work organization within the team was suggested so that one person reads and the other(s) answer.

Feedback from firm, solutions in interactive co-operative work
The large scope of the analysis prompted means to define the project better e.g., wide/coarse analysis vs. project-part analysis or analysis-in-detail. Also means to better document the discussion were deemed necessary as was means to coordinate the decision of the rating weighting of the components.

Input from this analysis, new features added to analysis base
This analysis contributed to initiate the transfer of the intermediate calculating formulas out of the grid area. It also contributed to the development of the Project presentation sheet and to the use of Excel's comments-function, and later to the Comments-columns.

Results for the benefit to the firm
The firm got a tool that enabled analysis of items and the ability to perform them. It presented a possibility to ponder things and simultaneously to get several points-of-view on them, especially for the team. The analysis results could easily be used as an appendix to applications for financing.

4.5. Outcome of the Analyses

Two aspects supported the idea of bringing case projects into the EDCP development work. Firstly, it was necessary to test the model on real projects and to obtain feedback from the pilot firms for the benefit of the EDCP development work. Secondly, the analysis results were needed as a contribution to the firm, and to act as an incentive for the management to offer money, time and personnel for the development work. The uses or advantages were documented firstly in notations by the researcher during, and immediately after the analysis sessions, and secondly in interviews using a form. These interviews were conducted with the management of the pilot firms after the EDCP development project was concluded. Some sample interviews are shown in Appendix 4.

Consequently, the usefulness of the analyses can be characterized as usefulness for developing the model, and usefulness to the firm.

4.5.1. Usefulness of the Analyses to the Development Work of EDCP

Table 4-10 presents the improvements of each of the 14 projects that contributed to the development of the EDCP model. The projects were provided by nine of the pilot firms. These projects represent practically one third of all the 45 pilot projects analyzed. The table lists the starting date of each analysis, the codes of the firm and the individual project. The table describes each individual improvement contributed to the development of the EDCP-model during each project. A contributing improvement represented a structural or functional change initiated during the analysis of a project. The table also lists the number of individual improvements provided by each project as well as a description of the improvements. The table lists those items, useful to the pilot firm that some of the analyses produced and, finally, the median date of the analyses.

Table 4-10. Projects that were useful to the development of EDCP #1754#						
Date of start of project analysis ***)	Code of firm	Code of project	Usefulness to EDCP i.e., improvements	Classification	# (**	Usefulness to firm
2.4.1996	K	K1	¤ question set introduced	I	1	
3.6.1996	M	M 1	¤ structural, functional change ¤ direct computer feed introduced	I I	2	
20.1.1997	B	B1	¤structure change ¤ Proj_pres-sheet introduced ¤ quality improvement ¤ team size & -work improved ¤ own ad-hoc "mutu" analysis done by pilot	I M I M M	5	
5.2.1997	I	I1	¤ connection concept ~ resources tables, "mutu"-analysis, good repetitiveness achieved (unconsciously)	I M	1	¤ anlysis on own initiative
10.2.1997	D	D1	¤ row-add/delete, guidance message box, question definition, separate rating for evaluating criteria in each project introduced ¤ "central rating" introduced	I I	2	
14.2.1997	E	E1	¤ step towards multi-table, development of diagrams	I	1	¤ Pointed out risks so that considerable time savings were acheived.
21.3.1997	F	F1	¤ Develop 2-step application to see if concept fits for analysis. ¤ 2-step approach to Knowl. Areas to be developed later ¤ Algorithms to avoid "1:s". ¤ Additional copy-down for Difficulty & Newness of Knowl. Areas in Cons. Blocks of Attrib. groups with partition headings	M I I I	4	

*) M=model related improvement, I=interface related improvement
**) # indicates number of improvements per project to EDCP development
***) the median of all start dates was 22.3.1997
¤ indicates individual case of usefulness

Projects that were useful to the development of EDCP (continuation) #1754#						
Date of start of project analysis ***)	Code of firm	Code of project	Usefulness to EDCP i.e., improvements	Classification	# (**	Usefulness to firm
24.3.1997	C	C1	¤ added number of knowledge areas ¤ "top-ten" diagram introduced ¤ sort table introduced	I M M	3	¤ "aha"-experience. ¤ EDCP became part of project planning process, and pointed out many things
30.4.1997	F	F2	¤Proj_pres-sheet improved and enlarged ¤ hints of formula coordination problems ¤ two columns removed from atttribute ratings (simplification)	M I M	3	
16.6.1997	O	O1	¤hints of formula problems in Sort-fct:n	I	1	
4.11.1997	F	F3	¤ "Fill!" indicator needed in Res table	I	1	
22.2.1998	F	F5	¤ deliverables developm (chart-types) ¤ research on rating theory (scales 1-3,... 1-?), and algorithms, 1 new evaluating criterion; team size, working manners developed	I M	2	
25.2.1998	F	F6	¤ two rating columns per Knowledge area removed in grid (simplification) ¤ name abbreviation columns for concept attribute, component. and resource components	M I	2	
4.8.1998	F	F7	¤deviation, max. value, # groups eval. -> deliverables, guidance to all columns, Analysis report	M	1	

*) M=model related improvement, I=interface related improvement
**) # indicates number of improvements per project to EDCP development
***) the median of all start dates was 22.3.1997
¤ indicates individual cases of usefulness

The contributions to EDCP considered either the model itself or the interface. The contributions to the model included new tables e.g., "Project presentation" table, sorting table, or new diagrams or new reports. The addition or the removal of ratings was also regarded as contributions to the model, so were e.g., comparisons to other analysis methods and changes of work methods. Contributions to the interface included e.g., changes to the structure of tables, computer use, guidance tools or formulas. The Table 4-10 also shows that three of the fourteen projects and their pilot firms also benefited from the analyses and thus were useful for the firms.

Table 4-11 presents detailed characteristics for the work with the firms that contributed to EDCP. It also lists the number of contributions to the EDCP model that each firm made, and it lists the contributions that the firms got from the analyses. Furthermore, it presents the number of projects of each firm that provided contributions to EDCP, and the total number of projects analyzed by each firm.

Table 4-11. Details of Projects and Pilot firms that contributed to EDCP #1711#

Firm code	E	M	B	K	I	F	C	D	O
#*) contributions to EDCP	2	2	5	1	1	14	3	1	1
# contributions to firm	6	2	1	---	1	---	3	---	---
# projects that contributed to EDCP	1	1	1	1	1	6	1	1	1
# projects, total	5	3	5	1	4	7	2	2	2
Fraction contributive projects (%)	20	33	20	100	25	86	50	50	50
# sessions	14	11	14	4	7	20	10	5	4
# postponements (-)	3	---	3	3	---	2	1	2	---
# analysers	2	3	6	2	5	9	6	3	2
Contributive points	18	17	22	4	16	34	17	8	8
*) # = number of									

Table 4-11 additionally exhibits the fraction of contributing projects for each firm. It lists the numbers of projects and sessions as well as the number of analyses done with each firm. These numbers can be considered to reflect the effort that each firm invested in the development work. The number of postponements can be

considered to reflect the ability or willingness of the firm to organize the participation in the development work. The fraction of contributing projects in each firm varies between 20 and 100% of the total number of projects processed by each firm, the average being 48%. The table also shows that of the 16 pilot firms nine contributed to the development of EDCP, and of these nine five firms simultaneously benefited from the analyses.
The impact of the individual pilot firms on the EDCP development can be characterized by a number that represents the sum of the numbers of projects, sessions and analyzers, reduced by the number of postponements for each pilot firm. This number is termed contributive points in Table 4-11, and calculated according to the equation:

Contributive points = (#[*)]projects + # sessions + # analyzers - # postponements) per firm
[*)]#=number of.

The values of that number varied between four and 34 for the nine firms that contributed to the development of the EDCP model. The average value for the contribution points is 16,0 between all contributing firms. As seen from the table those two firms (B and F) that gave the largest number of contributions to EDCP also had the highest contributive points number. Table 4-11 indicates good correlation between contribution to EDCP and the number of sessions and the number of analyzers per firm. Also the correlation between contribution and the number of projects per firm is relatively good. Among the factors that may have an influence on the ability to contribute are the number of projects and the number of sessions. The number of sessions may directly influence the number of contributions because of more contact between firm and developer. Also the number of analyzers may influence the number of contributions to EDCP.

4.5.2 Usefulness of the Analyses to the Pilot Firms

One half of the firms that contributed to EDCP were also able to benefit from the analysis. There is, however, no correlation between the number of contributions to EDCP and the number of contributions to each one among the nine firms in Table 4-11. Thirty of the pilot analyses did not give any specific contribution to the development work for EDCP. However, the EDCP analyses benefited eleven of the projects from seven pilots. Table 4-12 shows detailed data for the firms and

Table 4-12. Details of Projects that were useful to Firms #1788#

Date of start of project analysis*)	Code of firm	Code of project	Contribution to firm
24.4.1996	H	H1	¤ pointed out risk (that realized)
24.2.1997	J	J1	¤ pointed out considerable risks ¤ put project on hold
9.5.1997	G	G1	¤ probably used in TEKES application
7.4.1998	E	E2	¤ used in TEKES application
21.4.1998	E	E3	¤ used in TEKES application
21.4.1998	E	E4	¤ used in TEKES application
4.5.1998	M	M2	¤ decision instrument for individual project
5.5.1998	E	E5	¤ used in TEKES application
4.9.1998	C	C2	¤ pointed out new things to include
11.9.1998	A	A1	¤ caused change in project ¤ pointed out new items
19.9.1998	B	B4	¤ reinforced opinions
5.11.1998	M	M3	¤ decision instrument for project

The median of all start dates was 30.4.1998

projects that did not contribute anything to EDCP. The table lists corresponding items to Table 4-10, except stage of development of project, contributions to the development work and number of contributions. It also lists the cases when the firm benefited from the analysis, and finally, it lists the median date of the analyses.

Table 4-13 illustrates the characteristics of the work with the firms that gave something to the EDCP development project. It is structured similarly as Table 4-12. Table 4-13 shows that the contributive point values vary between two and 12 for the seven firms that did not contribute to the development work, the average number being 6,3. There were three firms representing five projects that did not give anything to the EDCP development, and who did not gain anything from the analyses. The average of their contributive points is 3,6.

Table 4-13. Pilot Firms that Gave Nothing to EDCP #1710#

Firm code	L	P	J	N	G	A	H
# *) contributions to firm	---	---	2	---	1	2	1
# projects contributive to firm	---	---	1	---	1	1	1
# projects	2	1	5	1	2	1	1
# sessions	3	4	7	1	5	2	7
# postponements (-)	1	5	3	---	---	2	---
# analysers	1	3	3	1	1	1	3
Contributive points	5	3	12	3	8	2	11

*) # = number of

Table 4-14. Comparison between Contributive and Non-contributive Firms of Input per Pilot Firm

	Pilots that contributed		Pilots that did't contribute	
	max	min	max	min
# *) projects	7	1	5	1
# sessions	20	1	7	1
# postponements	3	---	5	1
# analyzers	9	2	3	1

*) # = number of

Table 4-14 compares the input given by the firms that gave and those that did not give something to EDCP. As seen, there are big differences between the maximum inputs for number of sessions and number of analyzers. There is practically no difference between the minimum inputs between the two types of firms.

4.5.3 Conclusions about the Usefulness of the Analyses

The largest number of individual improvements given by single project to the EDCP development was five. Among the projects that gave one or two improvements the number of large projects equaled the number of medium sized projects (four).

Table 4-15 presents a comparison between the pilot firms that gave contributions to the development work and those that did not.

Table 4-15. Comparison of Activities for Contributing and Non-contributing Pilot Firms #1709#

	Pilots that gave to EDCP 9 firms		Pilots that did not give to EDCP 7 firms	
	Total	per firm	total	per firm
# *) projects	31	3,4	13	1,9
# sessions	89	9,9	29	4,1
# postponements (-)	14	1,5	11	1,6
# analyzers	38	4,2	13	1,9
# contributions to EDCP	30	3,3	---	---
# contributions to firm	13	1,4	6	0,9
contributive points, average **)	16,0		6,3	

*) # = number of
**) according to equation in Chapter 6.2.1.

The number of projects per firm was ca. 44% bigger, the number of sessions ca. 60% bigger, and the number of analyzers ca. 55% bigger per firm in those pilot firms that contributed to EDCP as compared with the firms that did not. This indicates that the firms that took more active part in the development work contributed to the development of EDCP. The table further indicates that the firms that contributed to the development of EDCP also were able to benefit more from the results of the analyses. However, the number of postponements per firm did not differ, that indicates that their capability to organize their work did not influence their ability to contribute to the development work. Table 4-16 lists the benefits from EDCP reported by the firms in the questionnaire at the conclusion of the EDCP development project. Between seven and five firms noted one of the benefits. Seven pilots got “something extra” during the analysis sessions, also seven firms were ready to use EDCP again. Six firms found that the analysis pointed out concrete risks. Five firms found that EDCP offered help for planning and continuation of their project, and that EDCP pointed out things to add or remove in project; finally, five firms found that EDCP increased comfort feeling in decision situations.

Table 4-16. How firms benefited from EDCP #1755#c

Benefit for firm	Number of firms who benefited
Firm got something extra during sessions	7
Firm would use EDCP	7
Analysis results pointed out concrete risks	6
EDCP offered help for planning continuation of project	5
EDCP pointed out things to add/ remove in project	5
EDCP increased comfort feeling	5

4.6. The Influence of the Character of the Projects on the Development of EDCP

Table 4-17 presents the character of all 41 projects that were involved in the development of the EDCP model. The table lists the starting date for of analysis, the codes of the firm and the individual project. It lists the innovation type, the

Table 4-17. Character of the analysis Projects #2004# Bascol13.xls						
Date of start of project analysis	Code of firm	Code of project	Innovation	Size	Usefulness to EDCP	Firm
2.4.1996	K	K1	incremental	small	X	
24.4.1996	H	H1	radical	Med		X
3.6.1996	M	M1	incremental	Med	X	
10.1.1997	P	P1	radical	Large		
20.1.1997	B	B1	application	Large	X	
30.1.1997	L	L1	incremental	Med		
5.2.1997	I	I1	incremental	Large	X	X
10.2.1997	D	D1	radical	Med	X	
14.2.1997	E	E1	radical	Med	X	X
24.2.1997	J	J1	incremental	Med		X
21.3.1997	F	F1	radical	Large	X	
24.3.1997	C	C1	radical	Large	X	X
30.4.1997	F	F2	radical	Large	X	
9.5.1997	G	G1	radical	Med		X
13.5.1997	D	D2	radical	Med		
16.6.1997	O	O1	incremental	small	X	
3.7.1997	G	G2	radical	Med		
4.11.1997	F	F3	radical	Large	X	
24.11.1997	I	I2	incremental	Med		
29.12.1997	J	J2	incremental	small		
22.2.1998	F	F5	incremental	Med	X	
25.2.1998	F	F6	incremental	Large	X	
22.4.1998	B	B2	incremental	Med		
27.4.1998	I	I3	incremental	Large		
27.4.1998	I	I3	incremental	Med		
4.5.1998	M	M2	incremental	Med		X
5.5.1998	E	E5	radical	Med		X
14.5.1998	B	B3	incremental	Med		
20.5.1998	J	J3	incremental	Large		
7.7.1998	J	J4	incremental	Med		
4.8.1998	F	F7	incremental	Large	X	

Table 4-17. Character of the analysis Projects (continuation)						
11.8.1998	L	L2	incremental	Med		
18.8.1998	O	O2	radical	small		
4.9.1998	C	C2	radical	Large		X
11.9.1998	A	A1	incremental	small		X
19.9.1998	B	B4	incremental	Large		X
21.9.1998	L	L3	incremental	Large		
7.10.1998	J	J5	incremental	small		
9.10.1998	N	N1	radical	Med		
16.10.1998	B	B4	radical	Med		
5.11.1998	M	M3	incremental	Small		X

project size and the stage of development of the project at the time of the analysis. The table is arranged according to the date when the analysis was started.

Table 4-17 indicates that the majority of usefulness for EDCP development occurred clearly in the first time period of the development course, whereas the usefulness to the firm occurred more evenly during the development period. Table

Table 4-18. Influence of Innovation Type on Usefulness
#2006#

Distribution of projects, %

			Usefulness		
		Total	To EDCP	to firm	to none
	# *) projects	41 proj.	14 proj.	12proj**)	18 proj.
Radical	16	39,0	42,9	50,0	33,3
Incremental	24	58,5	50,0	50,0	66,7
Application	1	2,4	7,1	-	-
N	41	100%	100%	100%	100%

*) # = number of
**) 3 of these projects were simultaneously useful to EDCP and to firm

4-18 presents the influence of innovation type on the usefulness of the analyses. It does not indicate any big differences in the distribution of projects regarding the usefulness to the development of EDCP or the usefulness to the firms. However, there seems to be an indication towards incremental type innovations for projects that were useful to none.

Table 4-19 presents the influence of the project size on the usefulness of the analyses. There seems to be a slight inclination towards large projects among those that were useful to the EDCP development, and a slight inclination towards medium sized projects among those that were useful to none. The distribution among projects useful to the firm was almost identical to distribution among all projects.

Table 4-19. Influence of Innovation Size on Usefulness
#2007#

Distribution of projects, %

			Usefulness		
		Total	to EDCP	to firm	to none
	# *) projects	41 proj.	14 proj.	12 proj*)	18 proj.
Large	14	34,2	57,1	33,3	22,2
Medium	20	48,8	28,6	50	61,1
Small	7	17,1,	14,3	16,7	16,7
N	41	100%	100%	100%	100%

*) # = number of
**) 3 of these projects were simultaneously useful to EDCP and to firm

4.7. Conclusions from the Analyses of the Case Projects

The selected projects were real projects provided by the pilot firms. The projects were characterized and typified according to technology, commercialization, the degree of innovation and size. They were further classified according to technical and commercial uncertainty and to stage of development at the time of analysis. Of the totally 41 project 14 projects, or 32% of the analyzed projects, contributed to the development of the EDCP model, as seen from Table 4-13. The largest groups of projects involved technical projects and projects for the external market, and projects of medium size.

The number of sessions and the number of projects as well as the number of analyses reflect the ability of each pilot firm to contribute to the development of the EDCP method. However, as seen also from Table 4-14, limited input from the firm does not necessary exclude the ability to contribute to the development of an EDCP-method.

Contribution to method development is more likely to come from large projects of a technical character. The type of innovation (radical or incremental) does not seem to have an influence. There is an inverse correlation between the number of improvements per project and the number of projects involved in the development work per firm. Neither the commercial character of the project, nor the stage of development of the project at the time of analysis had any considerable influence on the contributiveness.

The firms experienced usefulness from the analyses both during the sessions and when drawing conclusions from the analysis results. The firms' representatives felt they got something extra during the sessions, risks were pointed out and advice was gained for the administration and continuation of the projects.

Table 4-15 presents a comparison between pilot firms that contributed to the development of the EDCP process and the other firms. From the table one can conclude that the contributive firms provided more than twice the number of sessions and analyses, per firm, compared with the non-contributive firms. Also the number of projects was almost double for the contributive firms. The contributive firms also managed to utilize the results of the analysis results two thirds more than the other firms. The average numbers of contributive points, (16,0 for the contributive firms, 6,3 for the non-contributive firms), confirm this case further. The number of postponements per firm was practically the same for both category, it may indicate that the ability to organize the work does not influence the firm's ability to contribute to method development.

Finally, the big difference between median dates for contributive and non-contributive analyses (Tables 4-10 and 4-12) indicates that the pilot firms begun to benefit from the analyses when the model was developed further. Probably the fact that the analyzers in the pilot firms became more acquainted and used to the EDCP analysis method made it possible for the firms to benefit more from the analyses.

Information about later impact of the pilot analyses on the pilot firms proved practically impossible to obtain. Too much time had elapsed to permit clear enough recollections and much of the firms' documentation had become unavailable as employees had changed jobs.

4.8. Commercial Analysis of Projects

When the project of developing EDCP in cooperation with the pilot firms was concluded a consulting firm begun to market the EDCP model as a consultant's tool. The Stage 12 base, with slight modifications to the Visual Basic program part, was used.
Data from eight commercial project analyses in seven firms was made available in this work as a comparison to the pilot analyses.

One of the customer firms was a previous pilot firm that bought the EDCP analysis on a commercial basis, the other six firms were all new to EDCP. One firm bought EDCP-analysis related to different aspects of the same project.
Firms as well as projects differed from those in the development work in that they were clearly bigger. Five of the firms are classified as large firms, two as medium sized. All projects were classified as large according to the scale used for the pilot projects.

The sessions differed from those of the pilot analyses in that considerably more of the analysis time (ca. 1/3 of total time) was reserved for definition of the project.
Six projects involved incremental innovations, two regarded radical ones.
Within the commercial analyses the majority of the projects concerned the first EDCP analysis for the firm, the two repetitive analyses involved the previous pilot firm and the firm that bought two analyses. The average size of the analyses resembled the data for the analyses of the 2nd sequence, particularly the number of rows, knowledge areas and, consequently the number of rating sites. The number of ratings (403 versus 281 in the pilot analyses) and the fraction of sites rated

(59,3 versus 45,3) were clearly larger for the commercial analyses, the analysis time increased slightly in the commercial analyses.

One can conclude that basically the character of the commercial analyses were close to, or identical to the character of the pilot analyses of the 2nd sequence. The increased analysis time and larger number of ratings may be interpreted as an endeavor towards more thorough analysis work than in the pilot analyses, the firms paid a consultancy fee for each analysis.

5. Discussion

5.1. The Structure of the Work

The work is structured in three parts: the theoretical background, derivation of the ideal EDCP model and the development towards the final model in cooperation with the pilot firms.

5.2. Reliability and Validity

Reliability expresses the repeatability of the research work. This means that another investigator will obtain the same findings and conclusions as the primary investigator if he follows exactly the same procedures as the primary investigator, in conducting the same study all over again (Yin 1994, p. 36). Yin further points out that the other investigator ought to do the same case study and not replace the results of another case study. Good documentation enhances reliability because it makes possible the later repetition of the research. Reliability also diminishes faults and distortion in the research (Yin 1994, 36-37). Reliability can be achieved if the researcher consistently uses the same methods of interpretation (Uusitalo 1991, p. 84, Miles and Huberman 1994, p. 278). The reliability of conclusions can be assessed in qualitative research by considering how logically conclusions explain the results and data (Alasuutari 1994, p. 132).

The connection of the EDCP model construction to the pertinent literature has been demonstrated so that a secondary investigator would arrive at a similar model, if he uses the same literature sources. The development of the model was done by means of the intense use of a computer, documenting all steps of development in individual time-indicated data files. This provides good documentation of the data, and thus enhances the reliability. The repetitive function of the analyzer's work and operation with the model is secured through the use of given computer tables with headings. Also the computerized guidance system secures that the inputs will be done the same way in repetitive use of the model. Because the model calculates the analysis results with permanent formulas the reliability of the calculations is secured.

The validity illustrates that the research work measures the correct items. Validity can be divided into construct, internal, and external validity. Construct validity involves the selection of a correct means to explain the matter of research. One ought to use several different information sources in order to secure the construct validity. Internal validity is applied primarily to investigative research work (Yin 1994, p. 33-36). External validity illustrates how well the research results can be generalized for purposes other than the actual research work (Uusitalo 1991, p. 86, Yin 1994, p. 35). The construct of the model is valid because of the logical order of the proceeding of the analysis process. First, the concept of the innovation is analyzed by listing the concept attributes and components, this is followed by the knowledge areas. Then the resources are analyzed by listing the resource components, the concept being linked to the resources via the knowledge areas.

The validity of the construct is further secured through the logic of the formulas for the calculation of the risks. The function of the model is validated externally through the use of pre-set computer tables and a guidance system that makes investigators act in the same manner in repetitive analyses even if the object or purpose of analysis varies. The pilot analyses of different types of innovation cases of demonstrated the external validity; the external validity of the model is expressed when the analyzed risks materialized in some cases.

5.3. Relations to the Research Questions

How to build an EDCP Model that can be applied in Innovation and R&D Projects in firms?

An EDCP model for the application on innovation and R&D projects in firms can be derived in relation to risk theory, innovation theory, management theory, and resource- and knowledge-based theories. These theories are integrated to form one model that analyses the concept of the project and the resources that realize the project. The necessary knowledge areas link the concept and resource analyses together and contribute to exposing the risks. Useful features from existing methods for risk analysis, project management and idea generating can be incorporated into the EDCP model. Disadvantageous features in existing methods ought to be avoided and excluded.

Relation of the Model to Risk Theory, Innovation Theory, Management Theory, and Resource- and Knowledge-based Theories

The project presentation phase shall clarify project boundaries, it is often useful to recognize pervasive activities sometimes associated with pervasive risks

(Chapman and Ward, 1997, p. 128). In the “Project presentation”-table, the analyzers define the project boundaries for an EDCP analysis.

An appropriate number of attribute-component pairs can describe the concept of an innovation project. Such a set of attribute-component pairs form a model that represents the customer’s needs and so defines the market requirements. The components represent what the producer must combine in order to satisfy the customer. Thus the statements of Levitt (1977, 1980) link the model of the innovation project’s concept to management theory. The attribute-component pairs may form a link from management theory to innovation theory because they can form a representation of new combinations, and Schumpeter defined innovation primarily as new combinations, here represented by the list of attribute-component pairs.

Lintunen (2000, p. 298) presents a linkage between Mintzberg’s and Schumpeter’s concepts of the entrepreneur, and Hamel and Prahalad’s concepts of core competence and she thus points to a link between innovation theory and knowledge and resource based theories.

The ability to select appropriate components in the formation of attribute-component pairs requires knowledge. Several researchers e.g., Penrose (1959, p. 25), Nonaka and Takeushi (1995, p. 34) relate knowledge to resources, either in individuals, or as accumulated knowledge in the firms. This way management theory, as represented by Levitt is integrated into the knowledge and resource based theory as represented by Penrose, Nonaka and Tekeushi. In a model of an innovation project the representation of the concept must be developed with the aid of a list of knowledge areas necessary to select the components for the attribute-component pairs. The model of an innovation project further requires a description of the resources that are intended to realize the attributes through the components. Through the statements of Penrose, Nonaka and Tekeushi mentioned above, a representation of the resources involved in the innovation project can be created using a description of the components and attributes of the resource.

A model for an innovation project can be composed of the model of the concept and the model of the resources. In this combination of models the knowledge areas function as the link that unifies the two models to form the model for an innovation project. In this combined model the knowledge areas illustrate the interdependence between the concept and resources of the innovation project. Thus the knowledge of the team-members act as links between concept and resources.

The deliverables of the EDCP analysis consist of the reports that the computerized analysis system provides in the form of tables and graphs. The computerized analysis system further provides means for editing the analysis results into reports for the analysis team and for the management of the firm. This way EDCP processes the analysis results into an appropriate form so that the firm accumulates knowledge through learning, as mentioned by Mahoney and Panjan (1992) by fulfilling the requirements for reporting stated by Chapman and Ward (1997) and CEI IEC 1160, (1992).

Knight, Andersson and Laurila, Tell and Wallenius, Halman and Keizer define the connection between risk theory and the knowledge and resource based theories. Knight (1985, p. 24) differentiates between measurable “risk” and unmeasurable “uncertainty”, Andersson and Laurila state that risk is when one cannot give a specific value to an occurrence. Halman and Keizer (1994, p. 77) specify the risk according to five-point scales. Tell and Wallenius (1979, p. 5-6) propose several different types of evaluation procedures.

The rating system of the EDCP allows the evaluation of the individual risk concentrations related to concept, resources and knowledge areas as well as to the whole project. The individual risks are related towards the individual attribute-component-resource groups and the individual knowledge areas. Thus the model can be designed to evaluate risks according to Tell and Wallenius' and Halman and Keizer's statements. Chapman and Ward (1997, p. 93) propose that the project planning team may provide a high-risk environment for risk analysis. In innovation projects the team members often represent the innovator or the innovating firm (Dopfer 1994, 136, ed. Magnusson, p. 125). They can be considered to represent Schumpeter's (1934, 1939, 1942, 1946, 1947, 1949) and Ansoff's (1968, p 134, 208) entrepreneur. Since the team members have knowledge about the innovation project they simultaneously represent the knowledge and resource based theories. Thus the team members create a link between the knowledge and resource based theories and the innovation theory, and since they also provide a risk they provide a link to risk theory. In the EDCP analysis system the analysis team is asked to assess their own ability to perform the EDCP analysis.

Comparison of EDCP with several other Methods

Several existing methods for project management and risk evaluation were found in literature. Some of these methods have a few features in common with EDCP, although most methods have considerable differences from EDCP.

The second step of the quality function deployment method (QFD-2) considers attributes, components and resources, but it requires prior analysis with the precedent QFD-1 method, that is flexible, inducible, involves rating, and allows inter-influence between data. Neither method considers knowledge areas, none of the literature sources mention any kind of guidance. Particularly QFD-1 has proved time consuming and tedious in use (Urban and Hauser 1993, p. 340-348, Turunen 1991, p. 22.24). Interviews with pilot firms that tried QFD-1 confirmed this opinion about time requirement and tediousness. Fault modes and effects analyses (FMEA and FMECA) deal with components of existing products or processes through breaking them down to elements. The methods produce tables of failure modes for each element. However, FMEA focuses on failure and failure modes and limits the analysis to the existing product or, in the case of FMECA (Ansell and Wharton 1992, p. 109, FMEA 1985, p. 9-23). Design reviews focus on existing commercial and physical components of existing products and on customers' requirements. They focus on fault and derive their input data from specs, drawings, test results, photos, etc. They produce fault lists as deliverables (CEI IEC 1160 1992, p. 9-27). Neither of these methods is intended for project analysis. They do not consider resources or knowledge. Klustest includes resources, knowledge, and ratings. It is also self-explanatory and requires little guidance. However, its 63 preset questions together with its lack of verbalilization and with its structure make it inflexible and non-inductive. Klustest does not allow item combinations or inter-influence analysis. The Checklist methods involve fixed questions and rating. They focus on product policy. The Profile scheme is a project comparison method with a list of evaluation criteria. The above mentioned methods are inflexible, and Klustest does not analyze attributes or component of the idea concept, and the Checklist methods additionally do not consider knowledge and resources (Andersson and Laurila 1983, p. 122-124).

None of the methods encountered in the literature integrated knowledge and resource based theories into risk theory. They did not integrate features from innovation theory, management theories, knowledge and resource based theories, or risk theory into their models of method.

How does Project Management Assess the Constructed Model?

Items introduced into the Analysis (Input)

The project presentation phase shall consolidate and elaborate the nature of the project and define the project in a form suitable for the project risk management process. This phase involves e.g., consolidation of relevant existing information in suitable form, and elaborating the project management activities in order to fill in any gaps uncovered in the process e. g., by stimulating the project team to develop their plans and processes (Chapman and Ward 1997, p. 68). It shall also describe the product, the process and the production (Halman and Keizer 1994, p. 76). The representatives of the pilot firms indicated a need for a project presentation phase, and so the "Project presentation"-table was introduced into the model during the first sequence of pilot analyses.

The changes to evaluation principles involved the scales for rating, applying individual rating principles for each project, and explaining the theories behind rating principles to the representatives of the pilot firms. Direct reference to the research by Tell and Wallenius considering evaluation techniques was conveyed to representatives of the pilot firms. In customer analysis self-rated importance is performed so that each customer rates the importance on a given scale, usually a 5-, 7- or 9-point scale. The additive model is probably the most commonly used utility model, but many other models have been suggested and implemented (Tell and Wallenius 1979, p. 5-6). In the EDCP method the scale 1 – 5 was selected for all ratings throughout the model after a short initial period when 1 – 10 was used.

#211, #179

Improvements to the structure of the analysis process and the analysis tool dealt with changes to the preliminary structure that was based on Levitt's, Knight's, Stehm's, Jorion's and Penrose's theories that are presented in Chapters 1.3. and 1.4. The improvements involved the means and methods of connection between the "Concept-" and "Resource analysis" tables, the addition of knowledge area columns, and the removal of rating columns.

A fault modes and effects analysis (FMEA) investigates for every component the consequences of all defined modes of failure. Investigation is usually carried out for each component in isolation from the analysis of other components, since if combinations were considered the task would become intractable. Marketing or administration issues cannot easily be analyzed (Ansell and Wharton 1992, p. 109). Representatives of the pilot firms that have experience in FMEA assessed that EDCP considers the whole project from several aspects whereas FMEA concentrates on analysis of details of existing products.

Methods based on decision theory are easy to use also for comparing several strategies because they pay attention to several evaluation dimensions simultaneously. Decision theory methods also take into consideration non-quantifiable factors and they do not necessarily require quantifiable data. Thus the methods based on decision theory are considered suitable for early stages in the development process (Andersson and Laurila 1983, p. 2). Therefore a good EDCP can preferedly be decision theory based, it should allow the use of non-quantifiable factors. The QFD (House of Quality) determines the primary customer needs i.e., customer perceptions of competitive products with respect to those needs, and the Core Benefit Propositions (CBP). In QFD the CBP represent a summary of the key benefits when designing a profitable product and marketing strategy for the identified product (Urban and Hauser 1993, p. 164). This can be said to be the way QFD determines the attributes of the concept. Pilot firms where QFD had been discussed also noticed resemblance with EDCP in this respect. However, they all recognized considerable differences in time requirement to the advantage of EDCP. Changes were also suggested to the procedure during the analysis sessions. These suggestions involved the brainstorming, direct feeding of data into the computer, team-work, documentation, and functional activities.

The selection of team members was discussed prior to the start of many pilot project analyses. Findings from the literature were used as reference in the selection procedure in some of the pilot firms. For instance Andersson and Laurila (1983, p. 58, 61) notice that the evaluators must include people with competence, experience and feeling for different areas. It is important to select the right person for project leader.

Some writers also suggest that the team shall include a chairperson, a secretary and several specialists not involved in the development of the product or process under review (independent members). Furthermore, designers and developers (members of the project team) shall be included (CEI IEC 1160 1992, p. 19). In the EDCP sessions the developer usually took the role of secretary, although some pilot firms assumed the duty towards the end of the EDCP development project. Documentation of the activities during the sessions was important for the analysis itself and also for the purpose of the research work. There are two primary purposes for documentation of activities. The first is to provide a means for the following-up of action items and recommendations. The second is to create a record to assist in establishing the state-of-the-art and development history of the product (CEI IEC 1160 1992, p. 39). A report shall present a qualitative model of project risk, ideally summarized in diagrams, with underlying computer-based models, to handle changes where appropriate and feasible (Chapman and Ward 1997, p. 141). These purposes were recognized in many pilot analyses. Follow-up occurred between the analysis sessions in some of those cases that involved successive sessions with longer intermediate intervals. The results from the previous session had been taken into consideration in the management of the project under analyzis. Also the general documentation of the project by EDCP was considered important by the pilot firms. The written final "Analysis report" presented a qualitative model of the project risk with tables and diagrams that were discussed in the final session for each project. The interface between user and model proved an important focus for development. The interface is comprised of the computer and its peripherals as well as of ways to use the model.

Typically, explaining guidance in the form of manuals for analysis work is part of practically all analysis methods. One example of explaining guidance occurs in checking list methods that involve rating according to different scales ranging from "yes-no" to different numerical or verbal scales. Here the guidance involves information on the type of answer e.g., yes-no, or scale and range of scale (Andersson and Laurila 1983, p. 124). Some idea creating programs contain information packages that can also serve as a quick-course for persons who are unfamiliar to the method (Virkkala 1994, p.215). The guidance system in EDCP proved a most important need from the very start of the cooperation with the pilot firms. Improved headings for the columns and rows in the analysis tables as well as typed manuals were the first useful steps in the development of the guidance system. They were followed by an activated guidance system that was integrated into the computer program. This system was gradually improved so that it eventually covered practically all columns and rows in both the analysis and the result tables. It could be activated at any time during the analysis process. Guidance included both advice on how to operate the analysis model and explanations about the meaning and the calculation of the results.

Other items that particularly increased the convenience in using the model included the row addition and deletion features. They made adding, moving or deleting analysis objects easy during the analysis sessions and during the editing. This interface improvement made the analysis work very flexible compared to e.g., work with paper forms or with regular spreadsheets or word processing programs. The improvement of the calculating formulas was also aimed at an increase in the using comfort of the model. For example listings and ratings were made to copy automatically to several places in the analysis table when needed.

Cooperation with the pilot firms also helped to reveal hidden faults in formulas and in the function of the computer program. The presentation of the analysis results also proved to be an important part of the analysis process. This was accentuated by the fact that the analyzed projects were integrated with the operation of the pilot firms, and thus the analysis results represented direct interest to the firms.

The deliverables from the EDCP analysis includes diagrams, charts and reports. Cooperation with the firms became still more directly involved in the development of the instruments for the presentation of the analysis results than in the work with the analysis tables. This is understandable because the analysis results represented the ultimate interest to the management of the pilot firms. Particular tables for the most important analysis results were developed, as were sorting tables for editing the results according to the requirements of the individual pilot firms. The Excel computer program fulfilled certain needs by fitting the form of tables to the requirements of the chart drawing function. #1939#

The project management perceived their interaction with the analysis model through the use or advantage that the pilot firms gained through the analyses. Three types of uses could be differentiated among the answers from interviews with representatives from the pilot firms. Firstly, the analysis results pointed out certain items to the firms, secondly, they resulted in certain savings for the firms and, thirdly, the analysis results acted as decision aids.

Items Pointed Out

The method pointed out risks in several analyses, it pointed out new things, and several things to regard in the managing the project in three cases. Thus the statements that the method must also point out items that shall be improved rather than just reject projects (Andersson and Laurila 1983, p. 61) can be considered to be realized by the EDCP model in practice.

Savings

The advantages included considerable time savings in the realization of several projects, and it also aided in the attempts to put some project on hold. The results from the analysis also made management make changes to the project. Thus EDCP fulfils the requirements e.g., on Fault tree and Event tree analysis that is used to find reasons for possible project overruns and means for accelerations. For instance, Silverberg (1991) presents a graphical process to predict R&D project events and assign error bars to the predictions. Also several of project management methods e.g., PERT, GERT, SCERT act as methods to control the realization of projects (Chapman and Ward 1997, p. 89-91).

Decision Aid

The types of decision aids included the service of EDCP as a general decision instrument for some pilot projects. EDCP also reinforced opinions and gave "aha-experiences" for the decision makers. One pilot firm experienced the analysis model to become part of the project planning process. Finally, the analysis results were used as part of the finance applications for several pilot projects.

Also in these respects the method fulfilled the requirements put forward e.g., by Chapman and Ward (1997, p. 89-91) and Wilkinson (1991).

5.4. How did the Research Questions got Answered?

How to Develop a Usable and Useful Analysis Tool?

The relation of the EDCP model to usability and to usefulness was tested in the case analyses provided by the pilot firms. Usability is interpreted through the assessment of project managers for the constructed model. Usefulness is interpreted through management's perception of the interaction with the analysis model.

The development of a usable and useful analysis tool is advantageously performed in a sequence of clearly defined stages. The initial phase ought to be the formation of the theoretical base for building the model of the analysis tool. In the case of EDCP this involved the study of the theoretical discussions of Levitt (1980), Nonaka and Takeushi (1995), Penrose (1959), Knight (1985), Andersson and Laurila (1983), Mahoney and Panjan (1992), and Majumdar (1998). Based on the findings from the study of theory a preliminary model was structured. In the case of EDCP this stage produced a preliminary model that was tested on hypothetical cases or cases of old projects. The model was developed into a state that could be demonstrated for potential interests. The advantage of using computers became apparent already in the preliminary modeling stage, supporting the statements of Virkkala (1994, p. 30). Working with paper and pencil proved utterly awkward.

The preliminary modeling stage can be succeeded by a pre-pilot analysis stage where selected projects are analyzed, primarily for the purpose of testing the analysis tool. The selected projects may be familiar to the developer. In the case of EDCP the outcome from these analyses resulted in several improvements to the model. For instance collation tables for analysis results, and graphs were introduced as recommended e.g., by Chapman and Ward (1997, p. 44) and CEI IEC 1160 (1972, p. 39). The pre pilot analysis stage indicated the usefulness of model development in connection with continuous testing of the model in cooperation with pilot firms. In the development process for the EDCP a selection process for pilot firms and pilot projects was initiated and carried through. This included arrangement for financing of the development work; evaluation of pilot firms by academic experts was also part of this process. Development of means for presenting the EDCP project to the potential pilot firms and to the financiers took place during this process.

The development work for a usable and useful analysis tool should be structured into a number of subsequent stages. The contents of the different stages must be arranged to link to each other in a flexible manner.
The development of the EDCP model was done in three consecutive sequences, the first sequence consists of pilot analyses, and intermediate development, and the second sequence of pilot analyses. This arrangement allowed the developer to

flexibly integrate experience form the first sequence into the model for testing in the second sequence.

Improvements during the first sequence included improvements to the interface e.g., the direct use of computer in the analysis work that made the model easy to use by a team as compared to other methods e.g., paper forms and subsequent transfer into the computer, not to speak of manual computation. Thus the model answers to Andersson and Laurila's (1983, p. 57) request of easy use and computer utilization. The improvements also regarded model related features e.g., addition of certain listing and rating items. Improvements also involved model related means to enhance project definition, in accordance with Chapman and Ward (1997, p. 68). The intermediate development stage involved introduction of macro-based automation of the analysis operations during the session i.e., improvements to the interface. These included row addition and guidance that made work easier, this in accordance with Virkkala's (1994, p. 30) statement to use computer to enhance the work with models, and with Andersson and Laurila's (1983, p. 57) statement that the model must be easy to use in order not to repel the users. The intermediate development stage also included method related changes such as simplifications to the model in order to save time in the analysis sessions. This was an attempt to shorten the analysis time compared to those required in other methods, as mentioned by e.g., Halman and Keizer (1994, p. 79-80). In the second pilot analysis stage, method related activities included the work on different approaches to rating and on the sensitivity in connection to rating e.g., referring to Tell and Wallenius (1979, p. 5-6). A means for rating the analysis team's competence was also introduced, in relation to Chapman and Ward (1997, p. 93), who indicate that the members themselves create a considerable risk. In the second pilot analysis stage interface related items included the use of a computer-connected projector to facilitate the work during the sessions, in accordance with Andersson and Laurila (1983, p. 57), who recommend that the method be easy to use. In the concluding stage of the development of a usable and useful analysis tool, the experience from the pilot analyses ought to be condensed into a final model. In the case of the EDCP a few pilot cases were tested using the final version of the analysis tool.

This study was performed as a constructive research work. Its construct was defined as the explicit solution for the early detection of problems in innovation projects. The construct involved a model for the analysis, in one single analysis process, of the concept of the project and of the resources applied in the realization process. Thus the study resulted in something new and divergent compared to the analysis practices earlier known. These facts show that the model fills the requirements for constructive research put forward e.g., by Kasanan et al. (1991, p. 302, 304). The literature study revealed that the research problem was connected to earlier knowledge, it filled several voids in the knowledge field of analysis of risks in innovation projects, and this verifies the requirement of newness put by constructive research (Kasanen et al. 1991, p. 302, 304).

The analysis work is positioned so that the literature study also anchors the study to fundamental research, and the model is largely based on the application of findings from this scientific literature and so represents scientific problem solving. The application of the computer ties the model to technology, and the use of the model in the pilot firms connects the method to consulting. This position is another indication of the constructive character of this research work (Kasanen et al. 1991, p. 303). Constructive research also ought to be connected to the decision-methodological and action-analytical research grips (Kasanen et al. 1991, p. 315).

EDCP analysis supports decision-making in connection with the action in innovative projects, and thus fulfills requirements for constructive research.

Practical constructive research work can be divided into specific sequences (Kasanen et al. 1991, p. 317). In the case of EDCP the problem finding stage is represented by the researcher's own experience, the pre-study stage is represented by the literature study of the research area and consecutive void finding in the knowledge actual field, and the innovation- stage is represented by the construction-stage for the basic model. Further, the model was tested, and its rightness demonstrated during the model-extension- and pre-analysis-stages. The connection to theory was demonstrated through the literature study, as was the scientific newness of the model. Finally, the area of application for the model was demonstrated through the different types of innovative projects analyzed with the model in the pilot and the commercial analysis projects.

How can we select the Firms that are best suited as Pilots for the Development of an EDCP-Method?

Input in the form of projects, time and analyzers by the pilot firm increased the benefits for the development of EDCP in this work. Of the 16 pilot firms the nine firms that contributed gave clearly more input for the aforementioned forms. These firms also benefited from the analyses. We must therefore assure that the firms selected as pilots are prepared to supply sufficient inputs for the development work in the form of a sufficient number of analyzers and sufficient number of sessions i.e., time. Furthermore it is important that the firms benefit from the analyses.

How can we help the Pilot Firm to select the most suitable Projects for the Development of an EDCP Method?

The results from this work indicate that the project should have the potential to gain something from the analysis. The project should also be of medium or large size rather than of small size. Furthermore projects involving only incremental innovation should be avoided.

6. Theoretical Implications and Contributions

6.1. Theoretical Implications

The EDCP-system was developed largely in cooperation with the pilot firms, yet, as notable from earlier chapters, particularly from the discussion, it is supported by many fundamental theories. These theories include risk theory, innovation theory, project management theory as well as knowledge and resource based theories.

The model itself may be considered as rather complex. However, since it was developed on real R&D- and innovation projects in close cooperation with the pilot firms it also reflects the nature of real-life R&D- and innovation projects: they are complex.

A most important theoretical implication is that this model is in simultaneous concordance with several of the theories listed above. This indicates that it is possible to develop analysis models based on business science theories. On the other hand this type of practical development work produced a working analysis model that has been successfully commercialized. The model can also be shown to be in accordance with rules set by the theories mentioned above. Consequently the model also indicates that the theories agree with reality, and that several theories simultaneously do this.

The preliminary analysis step i.e., the project presentation supports the first step in Ansoff's problem solving method so that the perception of decision need or opportunity will be considered (Ansoff, 1987, p. 38). Furthermore, it is part of strategy development, as it fits into the project generation and selection step of the action cycle in strategic development (Ansoff, 1987, p. 178). The EDCP-analysis supports Knight's definition of measurable risks vs. un-measurable uncertainty (Knight 1985, p. 19) in that the analysis puts a measure on the risk concentrations that it detects. The analysis system is also in accordance to the fourth step of Ansoff's (1987, p. 38) problem solving method because the classified risk concentrations indicate which alternatives to avoid in the choice of alternatives, for successful implementation.

The EDCP-method also supports Levitt's theories of definition for product or service using attributes and components. This is a consequence of the fact that this was the only theory that was applied to the model development work from the start. The use of attribute-component pairs to characterize the product or service i.e., the concept, supports Schumpeter's (1934, p. 66) theory of innovations being new combinations because the pairs represent new combinations in the model. The attribute-component pairs also define the innovation in such a way that, in the analysis the risks involved are detected. Such risks in innovation are predicted by Schumpeter's theory of innovation being risky (1934, p. 89). Even Schumpeter's definition of creative destruction can be considered supported by the analytical separation of the project into its constituents i.e., into attributes, components, knowledge areas and resources.

The guidance questions for listing attributes and components support Schumpeter's view of innovation (new combinations) via Levitt's definition of product or service. The questions for listing knowledge areas and resources support Nonaka and Takeushi's, Barney's and Penrose's knowledge and resource based theories. They also support the statements of Ansoff (1965, p. 19) regarding allocation of resources. The questions to guide the ratings of significances of attribute, knowledge area and the ratings of goodness and availability of the resources support Knight's theory of risk vs. uncertainty. By rating these significances the decision basis is transferred towards measured risks from un-measured uncertainty. Finally, the guided explanations for the formulas in the result tables support the statements of Ansell and Wharton (1992, p. 207-208) that the model must be understood in detail.

These implications indicate that an analysis method for the detection of risks in R&D- and innovation projects can be constructed by following the theories of risk, innovation, project management, and the knowledge and resource based theories. The implications also show that a model can be practically constructed that covers the wide range of items that must be considered in an R&D- or innovation project. The model will coincide with the theories mentioned above if the practical work is performed in intimate contact with real-life projects. #2146#

The question of integrating different theories to form a model was answered by linking together the statements of important researchers in the areas of innovation, risk, management, knowledge and resource handling. Particularly the integration of knowledge and resource based theories into risk theory became apparent by linking the objects of these theories e.g., team members, entrepreneurs and capitalists. These objects also linked knowledge and resource based theories and risk theory to innovation theory. Risk management further links management theory to the theories mentioned above.

6.2. Contributions

The contributions in this work relate to three levels i.e., the theoretical level, the modeling level and the conceptual level.

The theoretical contributions consist of creating a model in a multidisciplinary approach that incorporates constituents from risk theory, from innovation theory, from management theory, and from knowledge and resource based theories. Constituents from innovation theory include the concept of innovation related risk; from management theory the constituents are attribute and component; and from risk theory, the concept of rating in order to assess the value of the risk. From the knowledge and resource based theories, the model contains the constituents of knowledge areas and resources. The multidisciplinary character of the model is also demonstrated by the close connection between risk theory and knowledge and resource based theories through the measurable risk factors that make up an important part of the outcome of the analysis with the model. #2151#

The contributions on the modeling level include the arrangement of the constituents from the theory into appropriate groups to create a meaningful analysis method. They also include the presentation of the project, the concept, the knowledge areas, and the resources, including the grouping of rating activities as well as the generating of risk factors and arranging them into proper groups. Finally, the structure of the model determines the order in which different groups of constituents are dealt with when the model is operating.

The contributions on the conceptual level consist of arranging the groups of theoretical constituents into a system for appropriate for carrying out risk analysis of innovation- and R&D-projects. The contributions also involve the appropriate combination of the groups with instruments to create an effective interface between the elements in model i.e., the analysis system, and the user. Examples of individual conceptual contributions are the analyses of the concept of the project and the resources in the same analysis procedure, and the derivation of the knowledge areas from the concept of the project. Another example is the use of the knowledge areas as a link between the concept and resource analyses. The calculation of the risk factors related to individual attribute-component-resource groups constitutes a conceptual contribution. Basing the risk evaluation on the principle that a demanding attribute-component pair and a weak resource combine to a big risk, constitutes another conceptual contribution. #2153#

7. Suggestions for Further Research

Based on the findings in this work some suggestions for new research can be put forward. They can be divided into two groups, theoretically inclined research and development of applications.

Theoretical research topics include research into the influence of the character of the project on the development work. This work was not structured from the beginning to provide exhaustive answers to these questions. Further research ought to follow up the impact on development work affected by a more selective choice and classification of the size, and the stage of the development of the project. Also the type of innovation or invention and other relevant parameters must be regarded. Furthermore, the dependence of the analysis time on different factors needs investigation. Knowledge of the influence of the character of the project enhances the development work for analysis tools because it avoids the selection of projects that are useful to neither the development work nor the participating organizations.

The character of the participating firms and analysis teams must also be investigated more thoroughly than in this work. The characteristics include firm's size and research intensity. Another factor worth investigation is the research directedness of the analysis team. Knowledge of firm related parameters and variables enhance the selection process so that such pilot firms will be selected that are useful for the model development, and that can also benefit from the analysis process and results.

Further development for the applications includes the development of methods for more specific purposes e.g., SWOT-analyses, specific risk analyses (mentioning the word risk), and project planning methods. The EDCP base can be used as a platform for the development of other methods.

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Appendix 1.List of econometric methods

Pay back time

Present value method

Internal interest method

Return-on-investment diagram (ROI)

Index methods

Pacifico's method

Risk calculation method

Profit method

Square root method

Relative value index

Sobelman's investment value

Insecurity and risk evaluation methods

Pay-back-risk-analysis

Sensitivity analysis

(Andersson and Laurila, 1983, p 134)

Appendix 2. Analysis Criteria covered by different Analysis Methods, Finds from literature search

A P P L I C A T I O N 11.5.01

	METHODS	Possible to test several strategies	Pre-projecting	Product development	Administration	Production planning	Market introduction	# items covered
Risk Management								0
	PERT		X					1
	GERT		X					1
	SCERT		X					1
	FMEA					X		1
	FMECA					X		1
	Risk evaluation	X	(X)	X		X	X	5
	Iderisk		X					1
	Fault tree		X			X		2
Idea generators								0
	Idegen		X	X			X	3
	TRIZ	(X)	X	X				3
	CyberQuest		X	X	X			3
Decision theoretical methods								
	Check list		X					1
	Profile scheme		X					1
	Ranging methods		X					1
	Klustest		X	X		X	X	4
	Idemap		(X)	X				2
Project management								0
	Design reviews			X				1
	QFD1			X		X		2
	QFD2							0
	QFD3							0
	QFD4							0
Economic models								0
	Profitability methods		(X)	X		X	X	4
	Index methods		(X)	X				2
Operation Analysis								0
	Mathematical programing methods	(X)		X				2
	# items covered	3	16	11	1	7	4	

DELIVERABLES

	METHODS	The method expresses value in absolute numbers	The method expresses value in relative numbers	Verbal table	Graphical presentation	Report	# items covered
Risk Management							
	PERT	(X)		X			2
	GERT	(X)		X		X	3
	SCERT	(X)		X		X	3
	FMEA			X	X		2
	FMECA			X	X		2
	Risk evaluation	X			X		2
	Iderisk			X			1
	Fault tree				X		1
Idea generators							
	Idegen			X		X	2
	TRIZ						0
	CyberQuest			X			1
Decision theoretical methods							
	Check list			X			1
	Profile scheme				X		1
	Ranging methods			X			1
	Klustest	X	X	X		X	4
	Idemap		X	X			2
Project management							
	Design reviews					X	1
	QFD1	X	X	X			3
	QFD2						0
	QFD3						0
	QFD4						0
Economic models							
	Profitability methods	X			X		2
	Index methods						0
Operation Analysis							
	Mathematical programing methods	X					1
	# items covered	8	3	13	6	5	

INPUTS

	METHODS	Brainstorm type	Includes non-quantifiable factors	Guidance	Rating	Requirements on in-data	# items covered
Risk Management							
	PERT			(X)	(X)	M	3
	GERT			(X)	(X)	M	3
	SCERT			(X)	(X)	M	3
	FMEA						0
	FMECA				X		1
	Risk evaluation					M	1
	Iderisk			X			1
	Fault tree					M	1
Idea generators							
	Idegen	X		X		L	3
	TRIZ	X					1
	CyberQuest	X					1
Decision theoretical methods							
	Check list		X			L	2
	Profile scheme		X			L	2
	Ranging methods		X			L	2
	Klustest		X	X	X	L	4
	Idemap	X	X	X		L	4
Project management							
	Design reviews					H	1
	QFD1				X		1
	QFD2						0
	QFD3						0
	QFD4						0
Economic models							
	Profitability methods					M	1
	Index methods					M	1
Operation Analysis							
	Mathematical programing methods					H	1
	# items covered	4	5	7	6	15	

INTERMEDIATES OF ANALYSIS / METHODS		Project character, environment and boundaries	Concept, generally	Concept attributes	Concept components	Knowledge	Resources, explicitly, generally	Resource components	Re Resource ability source ability	Optimal resource allocataion considering resource limitations	Time factor treated explicitely	Includes multiple criteria	Considers insecurity explicitely	# items covered
Risk Management	PERT		X	X				(X)link			X		X	5
	GERT		X	X				(X)link			X		X	5
	SCERT		X	X				(X)link			X		X	5
	FMEA	X	X		X									3
	FMECA	X	X		X									3
	Risk evaluation	X	X			(X)	X				X	(X)	X	7
	Iderisk		X											1
	Fault tree												X	1
	Idegen		X											1
Idea generators	TRIZ													0
	CyberQuest													0
Decision Theoretical methods														
	Check list											X		1
	Profile scheme											X		1
	Ranging methods					X						X		2
	Klustest			X	X	X	X	X	X			X		7
	Idemap		X											1
Project Management	Design reviews		X			X								2
	QFD1		X	(X)	(X)									3
	QFD2		X		X									2
	QFD3		X				X	X						3
	QFD4		X											1
Economic models	Profitability methods		X				X				X			3
	Index methods		X								X		(X)	3
Operation Analysis	Mathematical programing methods									X	X	X	(X)	4
	# items covered	3	16	5	5	4	4	5	1	1	7	6	7	

U S E S

	METHODS	Requirements on user	Cost of introduction	Cost of use	Requires computer	Team work	Guidance	Requires database	# items covered
Risk Manage-ment	PERT	M	L	L			(X)		4
	GERT	M	L	L			(X)		4
	SCERT	M	L	L			(X)		4
	FMEA	H	M	L					3
	FMECA	H	M	L					3
	Risk evaluation	H	M	M	X				4
	Iderisk	H			X	X	X		4
	Fault tree	M	M			X			3
Idea generators									
	Idegen	L	M	L	X	(X)	X	X	7
	TRIZ	M	H	H	X	(X)		X	6
	CyberQuest				X			X	2
Decision theoretical methods									
	Check list	L	L	L					3
	Profile scheme	L	L	L					3
	Ranging methods	L	L	L					3
	Klustest	M	M	L	X	X			5
	Idemap				X	X	X		3
Project management									
	Design reviews	M	M	M		X			4
	QFD1	H	H	H	X	X			5
	QFD2								0
	QFD3								0
	QFD4								0
Econometric models									
	Profitability methods	L	L	L	(X)				4
	Index methods	L	L	L					3
Operation Analysis									
	Mathematical programing methods	H	M	H	X				4
	# items covered	19	18	17	10	8	6	3	

NUMBER OF ITEMS COVERD BY DIFFERENT ANALYSIS METHODS								
		# items covered	Application	Deliverables	Inputs	Objectgs of analysis	Uses	Total # items covered
								0
	METHODS							
Risk Management	PERT		1	2	3	5	4	15
	GERT		1	3	3	5	4	16
	SCERT		1	3	3	5	4	16
	FMEA		1	2	0	3	3	9
	FMECA		1	2	1	3	3	10
	Risk evaluation		5	2	1	7	4	19
	Iderisk		1	1	1	1	4	8
	Fault tree		2	1	1	1	3	8
Idea generators								0
	Idegen		3	2	3	1	7	16
	TRIZ		3	0	1	0	6	10
	CyberQuest		3	1	1	0	2	7
Decision theoretical methods								
	Check list		1	1	2	1	3	8
	Profile scheme		1	1	2	1	3	8
	Ranging methods		1	1	2	2	3	9
	Klustest		4	4	4	7	5	24
	Idemap		2	2	4	1	3	12
Project management								0
	Design reviews		1	1	1	2	4	9
	QFD1		2	3	1	3	5	14
	QFD2		0	0	0	2	0	2
	QFD3		0	0	0	3	0	3
	QFD4		0	0	0	1	0	1
Economic models								0
	Profitability methods		4	2	1	3	4	14
	Index methods		2	0	1	3	3	9
Operation Analysis								0
	Mathematical programming methods		2	1	1	4	4	12
	# items covered							0
EDCP	EDCP-method		5	4	5	10	6	30

Appendix 3. Important Stages in the Development of the EDCP Analysis System

The improvements are indicated by text boxes and shadowing in the figures.

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Column Group Base or Table

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#1666#

CONCEPT

Project name: Kahlúte protective garment

A	B				A		F	G		
CONCEPT PRESENTATION	CONCEPT ANALYSIS				CONCEPT COMPONENTS		TECHNOLOGY PRESENTATION	TECHNOLOGY COMPETENCE ANALYSIS		
Concept attributes	Significance	Market benefit	Technical problems		Concept components		Technologies or sciences involved	Significance	Difficulty	Newness
pass cutting test	10		x		Composite		cutting resist knowledge	10	10	10
lighter than present	8	x	x		fiber,yarn,fabric types, materials		testing ability	10	4	2
warmer than present	8	x			fiber material		fabric making	8	7	5
Hygienic	8	x			test methods		composite making	6	5	2
long life	6	x					apparel making	6	2	2
economic ref. to present	7	x								
B	C	D	E	F	G	H	I	J	K	L

Row

C		D	E			
KEY ATTRIBUTES		KEY COMPONENTS	RISKS OF CONCEPT			
	Significance	Concept components	Rating of technology risks	Difficulties ref. competator	Newness in general	Risk factor
pass cutting test	10	Composite	cutting resist knowledge	10	10	1000
pass cutting test	10	test methods	testing ability	4	2	80
lighter than present	8	fiber material	fabric making	7	5	280
warmer than present	8	Composite	fabric making	7	5	280
Hygienic	8	fiber,yarn,fabric types, materials	apparel making	2	2	=C28*J28*K28

Figure (Skekah01.xls)

Cell

Algorithm or formula

Figure 1.1. The Concept analysis table. Stage 1

#1668#

Resource analysis

Project name: Kahlúte protective garment

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Significance	Resource attributes	Ability: Ability	Ability: Dimension
8	Mach. developm	2	y:r
10	marketing ability	20	y:r
10	product theory	1E-04	y:r
8	Materials knowled.	0,2	y:r
10	communicat. skills	0,5	y:r
8	difficulty analysis	1E-04	y:r
9	Testing ability	1E-04	
8	Machinery	0,8	

Resource components		
Owner		
Machine man		
Machinery		

Complexity

Significance	Technologies, sciences or activities involved	Difficulties ref. competotors	Newness in general	Difficulties X Newness
10	cutting, stabbing	10	10	100
10	testing; stabbing, comfort	4	2	8
8	marketing	1	1	1
6	fabric making, diff. fiber matl.	7	5	35
6	composite making	5	2	10
	apparel making	2	2	4
				=M15 *N15

A B C D E F G H I J K L M N O P

A: Significance	B: Key attributes	C: Ability
10	marketing ability	20
10	product theory	1E-04
10	communicat. Skills	0,5
10	Patent	0,2
10	cash flow	
10	Financ:l strength	
9	Testing ability	1E-04
8	Mach. Developm	2
8	materials knowled.	0,2
8	difficulty analysis	1E-04
8	Machinery	0,8

F: Significance	G: Resource requirements	H: Ability
10	product theory	1E-04
8	materials knowled.	0,2
10	communicat. Skills	0,5
9	testing ability	1E-04
10	product theory	1E-04
8	mach. Developm	2
8	Machinery	0,8
8	Machinery	0,8
8	Machinery	0,8
10	marketing ability	20
10	communicat. Skills	0,5

K: Significance	L: Rating of risks from resources, single or combined	M: Difficulties ref.	N: Newness in general	O: Difficulties X Newness	P: Risk factor = (diff X newn) / ability
10	cutting, stabbing	10	10	100	1000000
10	cutting, stabbing	10	10	100	500
10	cutting, stabbing	10	10	100	200
10	testing; stabbing, com	4	2	8	80000
10	testing; stabbing, comf	4	2	8	80000
8	fabric mkg, diff. fib mat	7	5	35	17,5
8	fabric mkg, diff. fiber m	7	5	35	43,75
6	composite making	5	2	10	12,5
6	apparel making	2	2	4	5
10	marketing	1	1	1	0,05
10	marketing	1	1	#=M38*N38	#=O38/H38

Figure 1.2. The Resources analysis table. Stage 1

M

#1670#

MATCHING OF CONCEPT AND RESOURCES

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E

RISKS OF CONCEPT

Rating of technology risks	Difficulty	Newness	Risk factor
cutting resist knowledge	10	10	1000
Testing ability	4	2	80
Fabric making, diff. fiber matl.	7	5	280
Fabric making, diff. fiber matl.	7	5	280
apparel making	2	2	32

L

RISKS OF RESOURCES

Technology	Significance	Difficulty	Newness	Diffic. X Newn	Risk factor
cutting resistance knowledge	10	10	10	100	**1E+06**
cutting resistance knowledge	10	10	10	100	500
cutting resistance knowledge	10	10	10	100	200
testing ability	10	4	2	8	80000
testing ability	10	4	2	8	80000
fabric making	8	7	5	35	17,5
fabric making	8	7	5	35	43,75
composite making	6	5	2	10	12,5
apparel making	6	2	2	4	5
Marketing	10	1	1	1	0,05
Marketing	10	1	1	1	2

K

RESOURCES REQUIREMENTS

	Significance	Ability
product theory	10	0
materials knowled.	8	0,2
communicat. skills	10	0,5
testing ability	9	0
product theory	10	0
mach. developm	8	2
Machinery	8	0,8
Machinery	8	0,8
Machinery	8	0,8
marketing ability	10	20
communicat. skills	10	0,5

Figure (Scekah03.xls)

Figure 1.3. Table for matching concept and resources. Stage 1

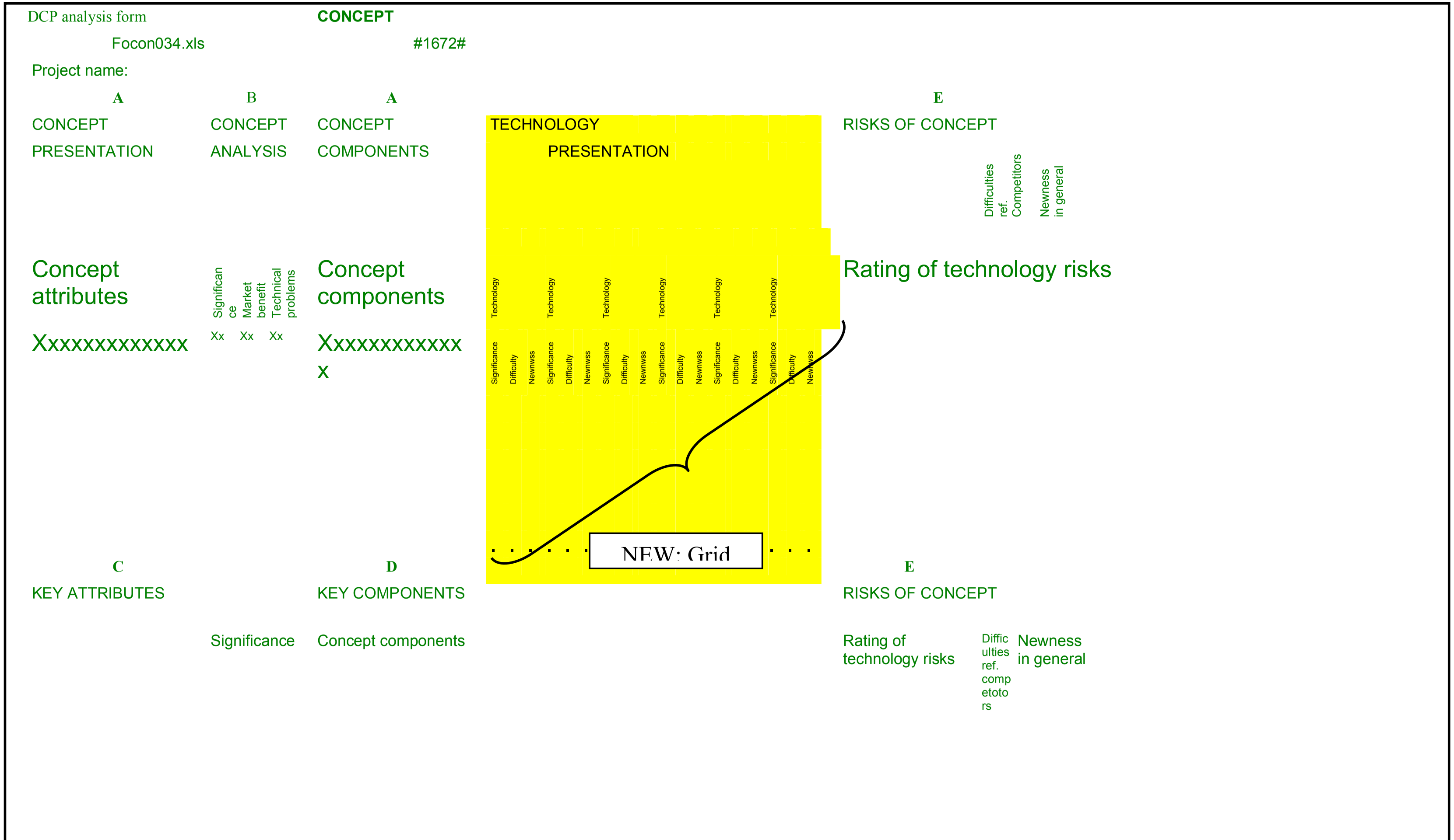


Figure 2.1. Concept analysis table, Stage 2.
Greyed text indicates features from older base, shadowing and black text indicate improvement.

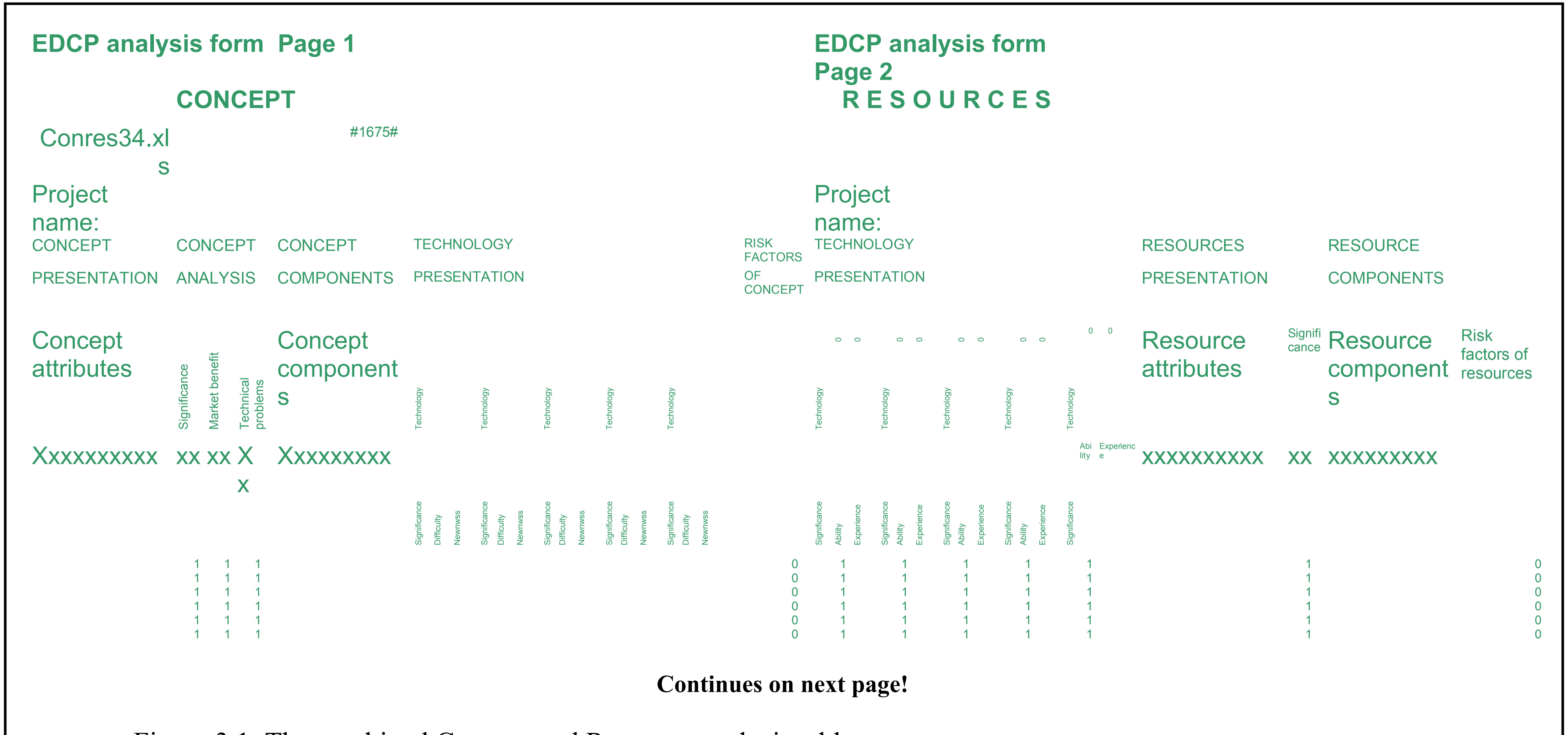


Figure 3.1. The combined Concept and Resource analysis tables developed in Stage 3.

Continuation from previous page!

EDCP analysis form
Page 3

CONCEPT key factor analysis

R E S O U R C E S, key factor analysis

Project name:

CONCEPT PRESENTATION
CONCEPT ANALYSIS
CONCEPT COMPONENTS
TECHNOLOGY PRESENTATION
RISK FACTORS OF KEY CONCEPTS
TECHNOLOGY PRESENTATION
RESOURCES PRESENTATION
RESOURCE ANALYSIS
RESOURCE COMPONENTS

Key concept attributes
Significance
Market benefit
Technical problems
Key concept components
Technology
Technology
Technology
Technology
Technology
0
0
Technology
Technology
0
Key resource attributes
Significance
Key resource components
Risk factors of key resources

xxxxxxxxxxx
X x
xx
X x
Xxxxxxxx
Significance
Difficulty
Newnwss
Significance
Difficulty
Newnwss
Significance
Difficulty
Newnwss
Significance
Difficulty
Newnwss
Significance
Difficulty
Newnwss
0 0 0 0
Significance
Difficulty
Newnwss
Significance
Difficulty
Newnwss
xxxxxxxxxx
xx
xxxxxxxxx
key resources
0 0 0 0

NEW: Concept and Resource analysis tables in one spreadsheet, in one Excel-file

Figure 3.2. The combined Concept and Resource analysis tables developed in Stage 3, Key factor analysis tables.

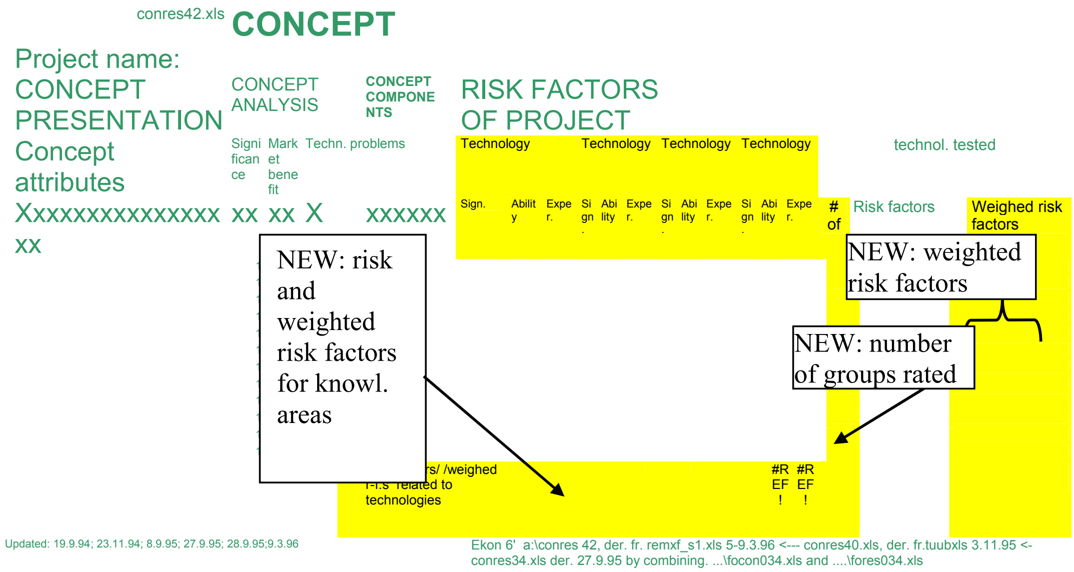


Figure 4.1. Concept analysis table, Stage 4

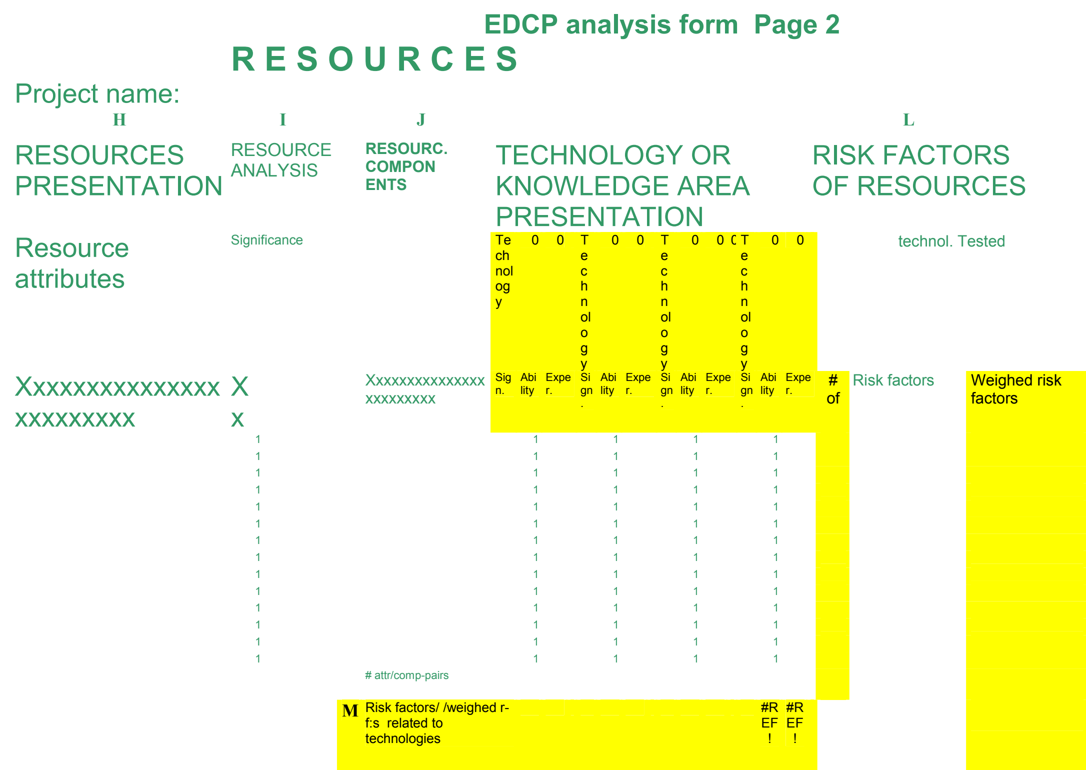
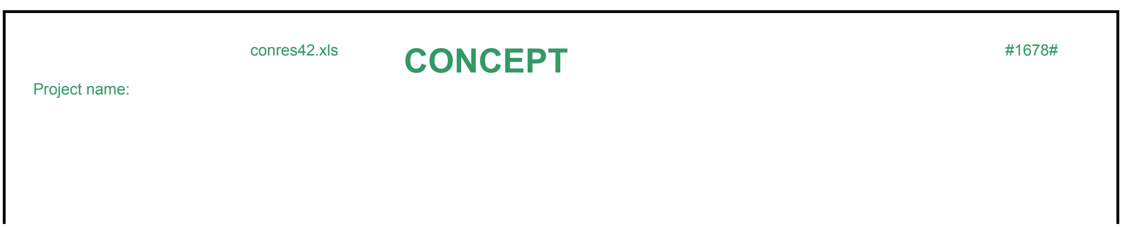


Figure 4.2. Resource analysis table, Stage 4



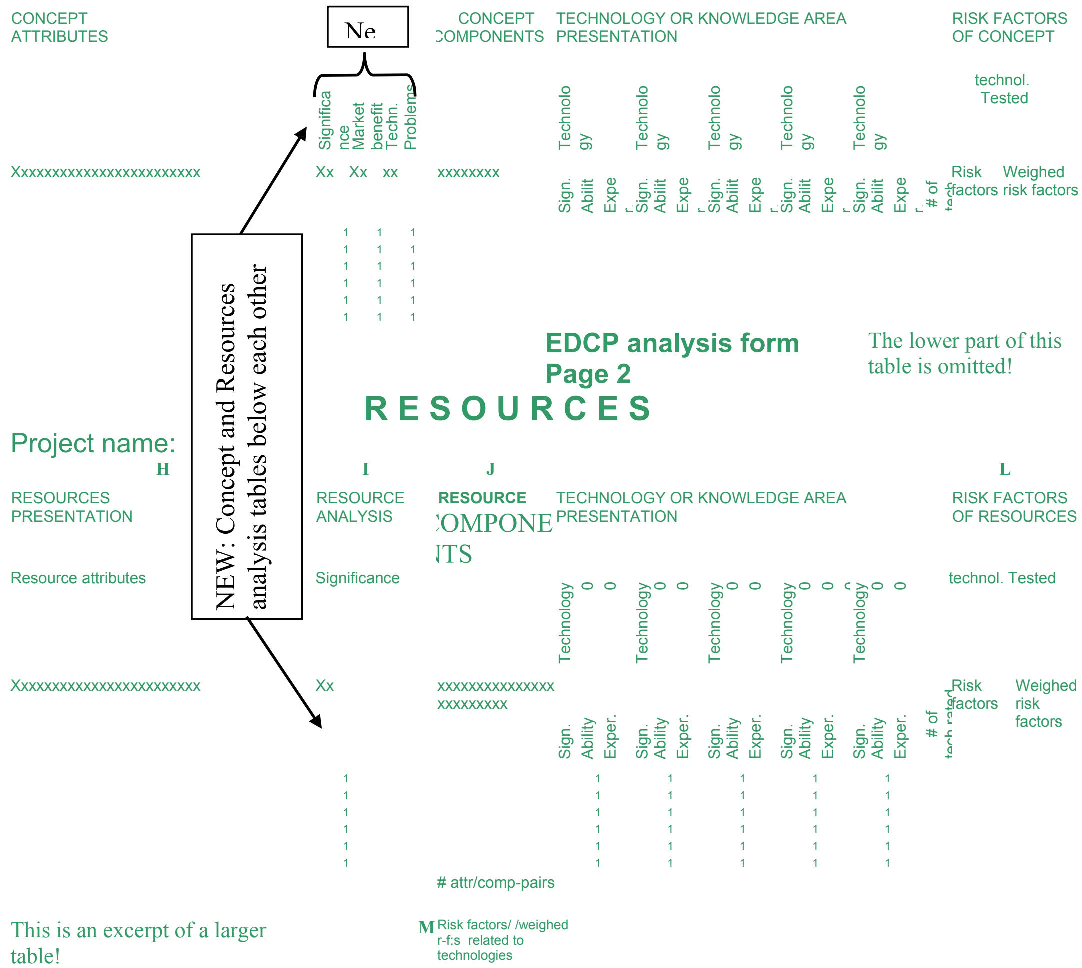


Figure 5.1. Concept and Resource analysis tables in Stage 5.

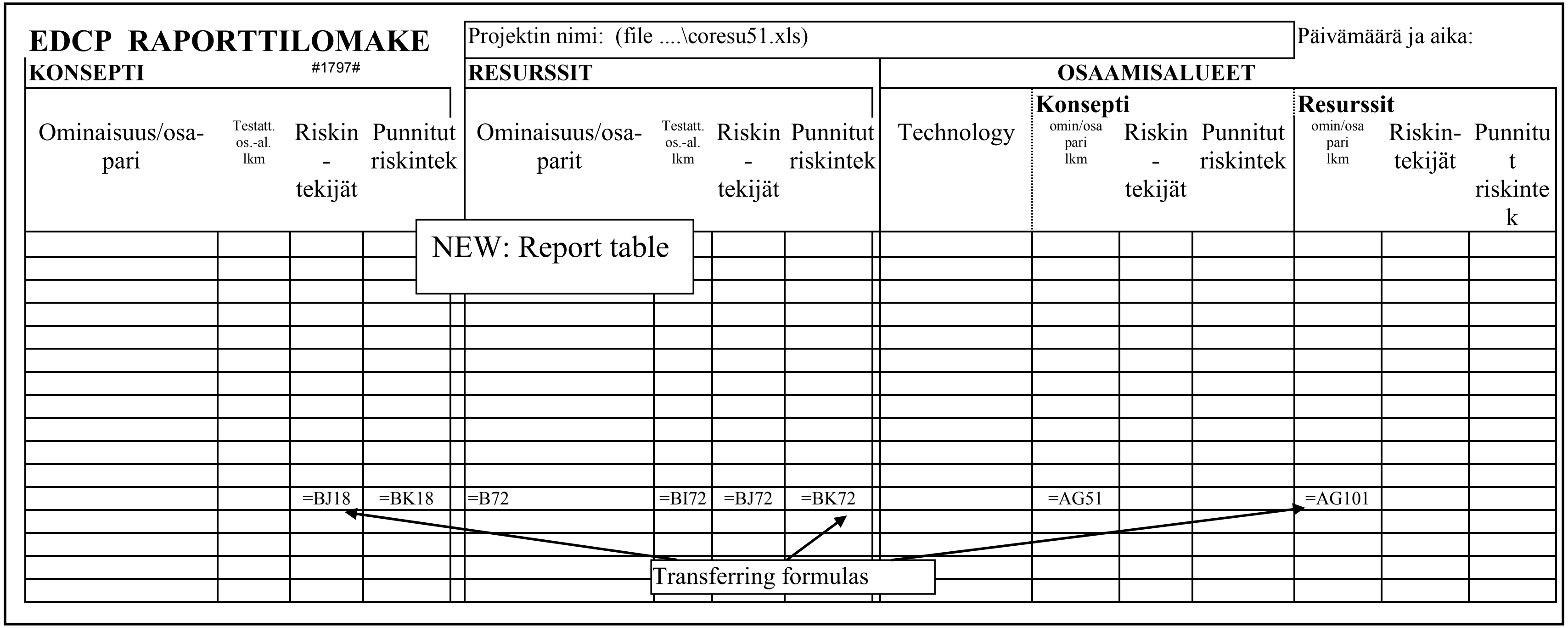


Figure 5.2. Report form, Stage 5, data and values are transferred via the transfer formulas from the analysis tables to their respective places in the report table.

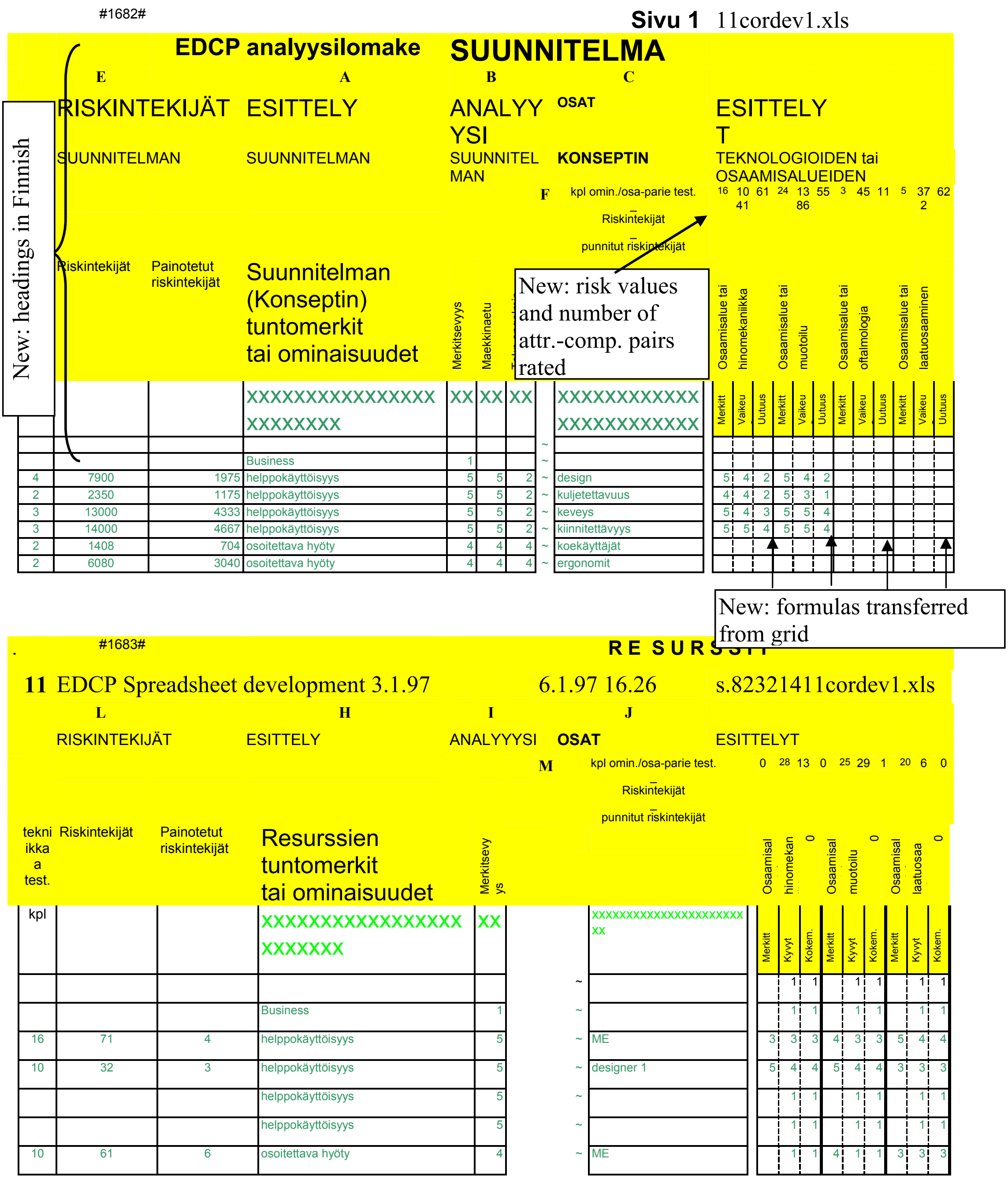


Figure 6.1. Concept and Resource analysis table, Stage 6.

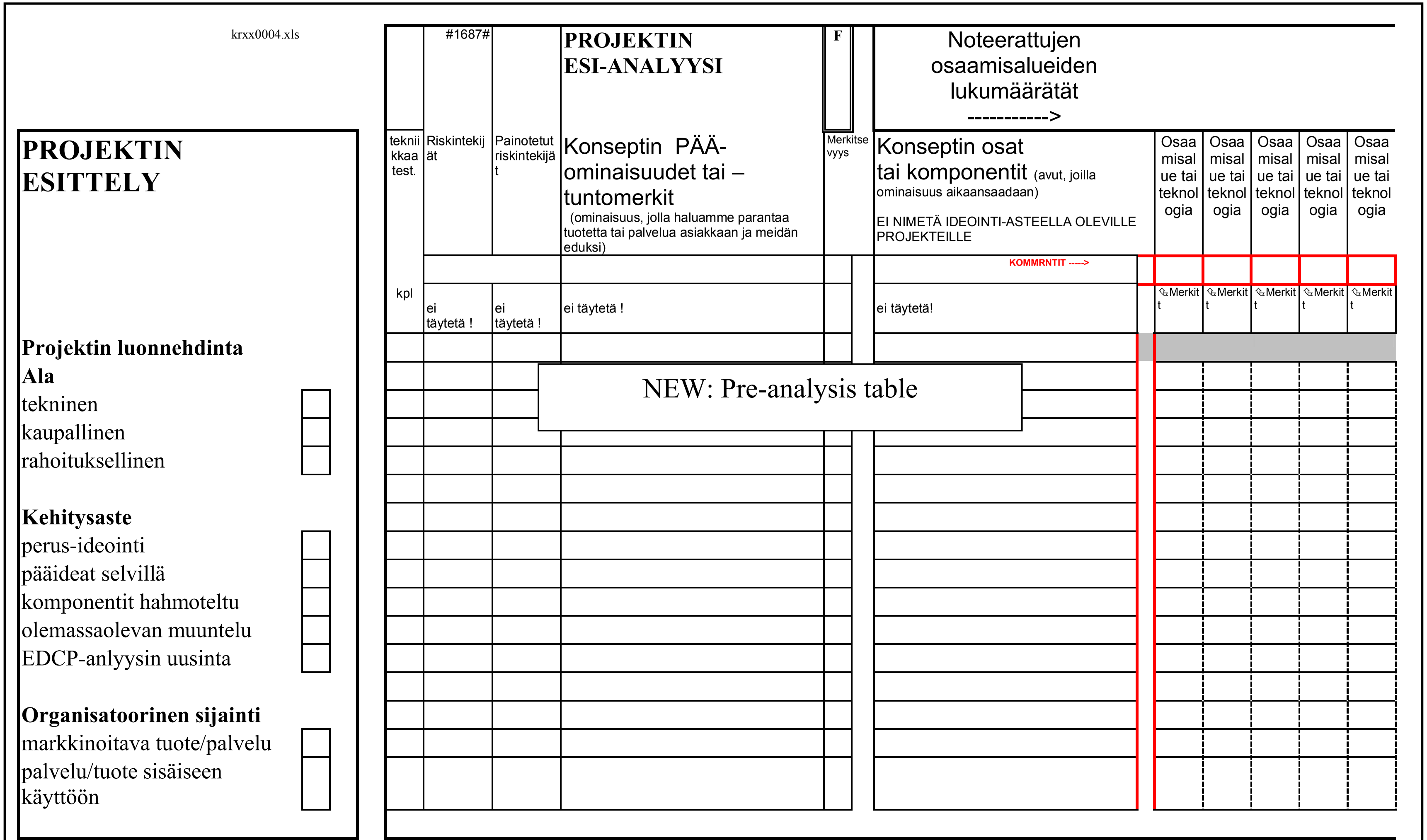


Figure 7.1. Pre-analysis sheet, Stage 7.

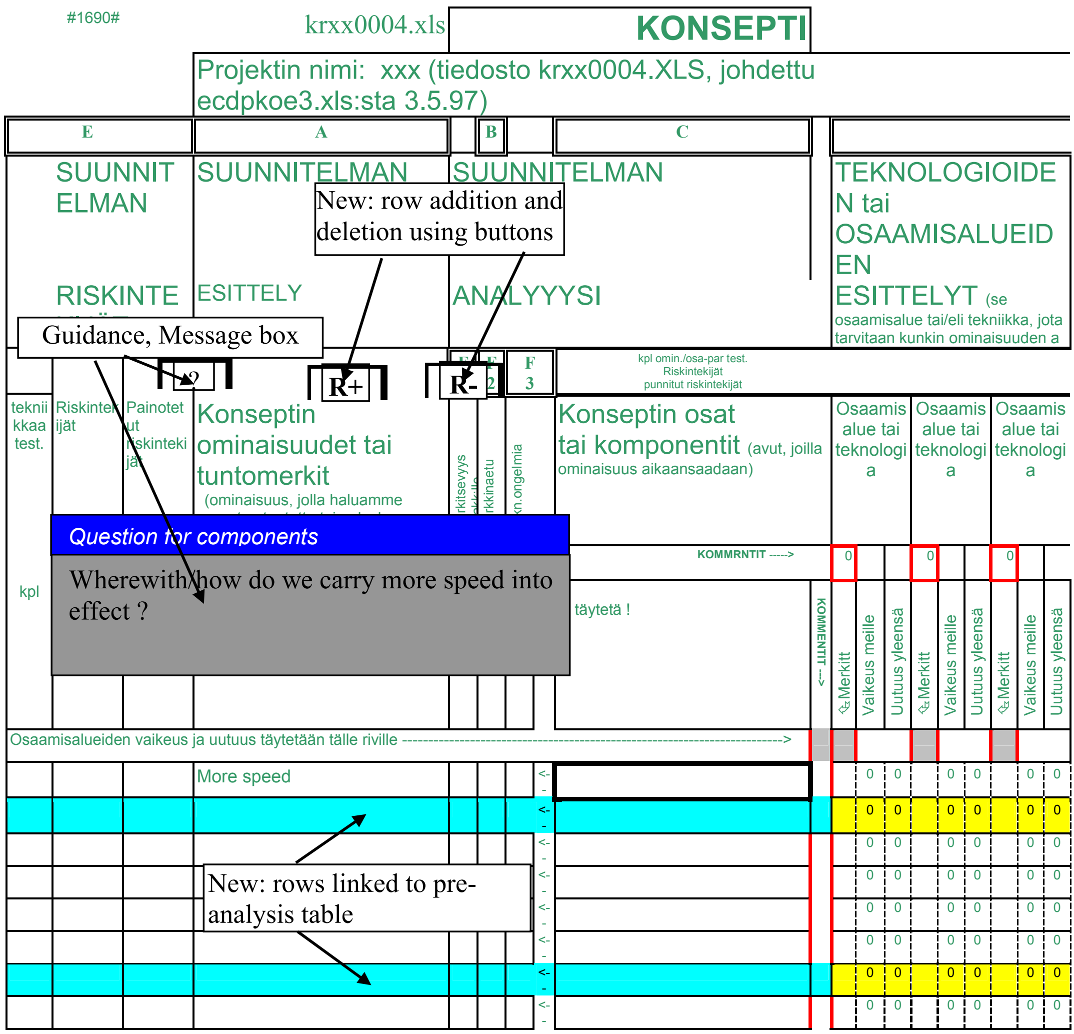


Figure 7.2. Concept analysis sheet with rows linked to pre-analysis sheet. Stage 7

Cursor was here when “?”-button was pressed

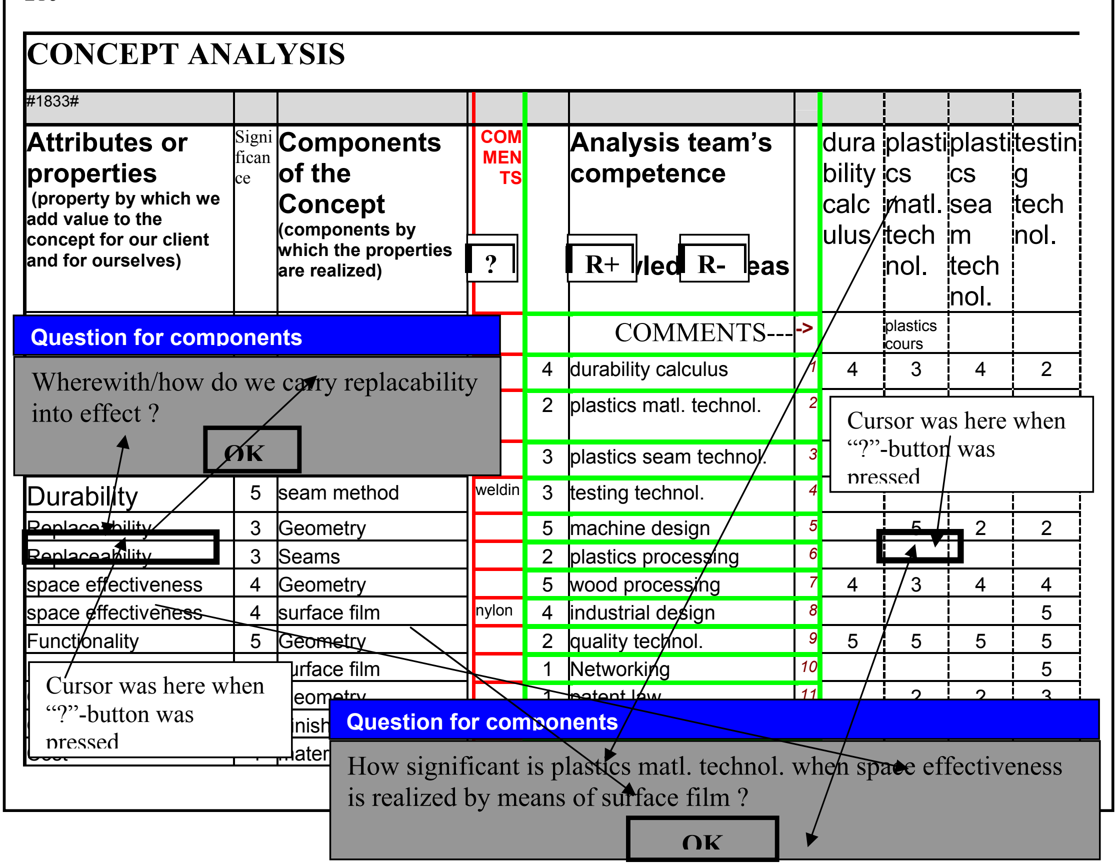


Figure 8.1. The figure shows how the guidance system presents answers in message boxes depending on where the analyser has placed the cursor. The arrows show how the answers are built up using words that the analysers have entered into the analysis table. (Note that most spreadsheet programs can present only one answer box at each time). Part of base of Stage 8. This is an excerpt from a larger table!

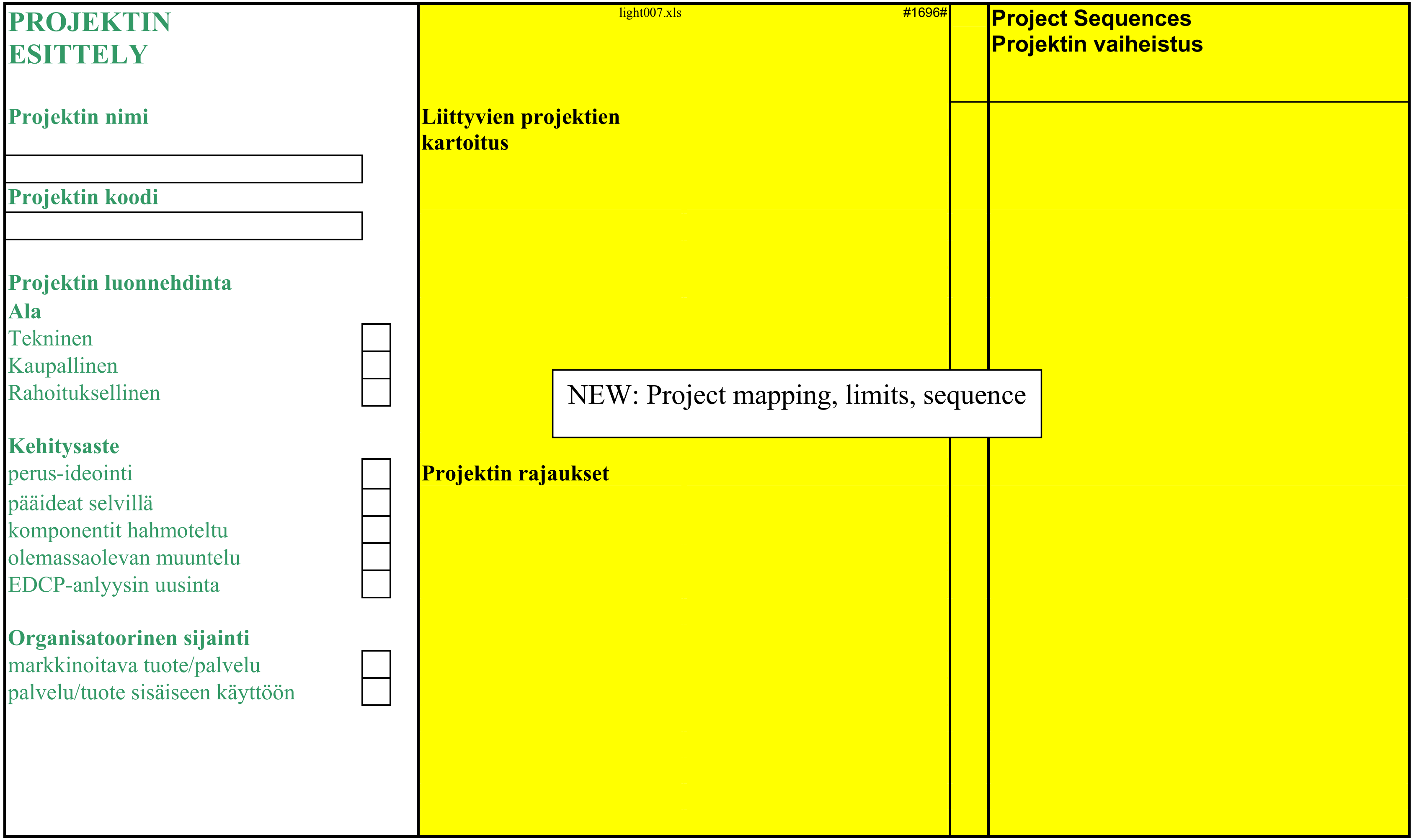


Figure 9.1. Project presentation table, Stage 9.

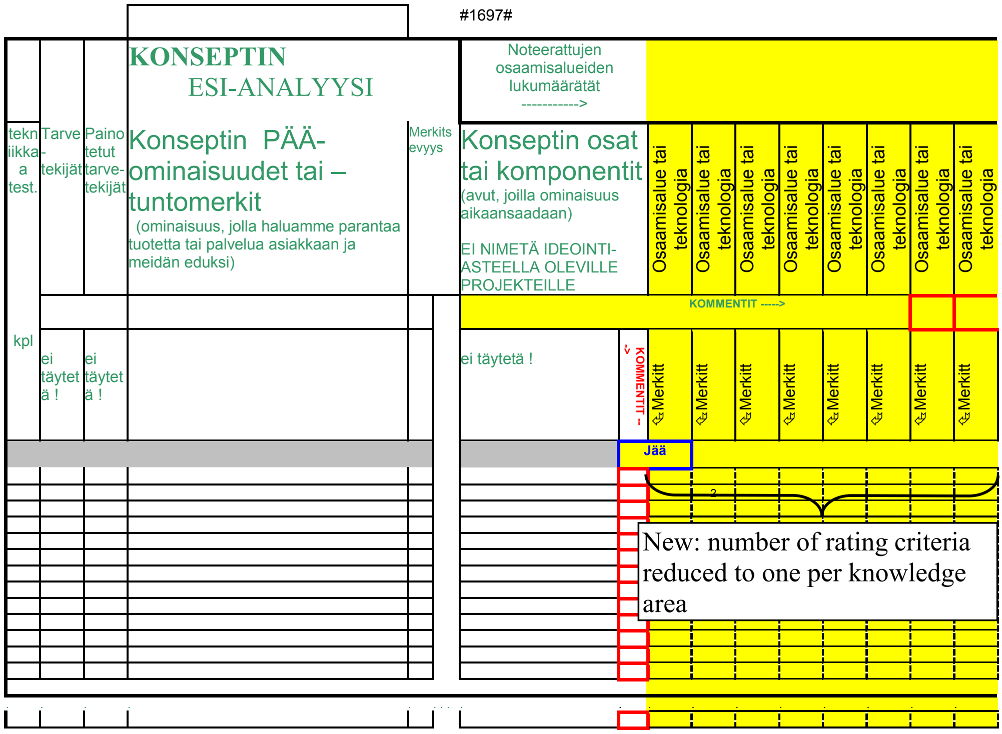


Figure 9.2. Concept analysis sheet, Stage 9.

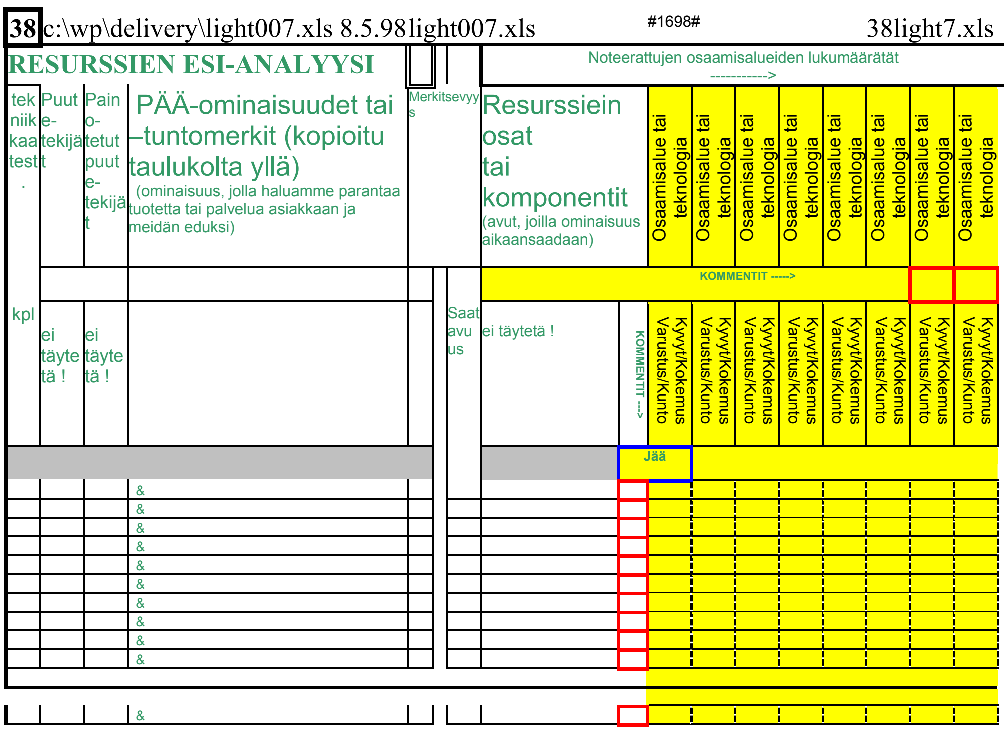


Figure 9.3. Resource analysis sheet, Stage 9.

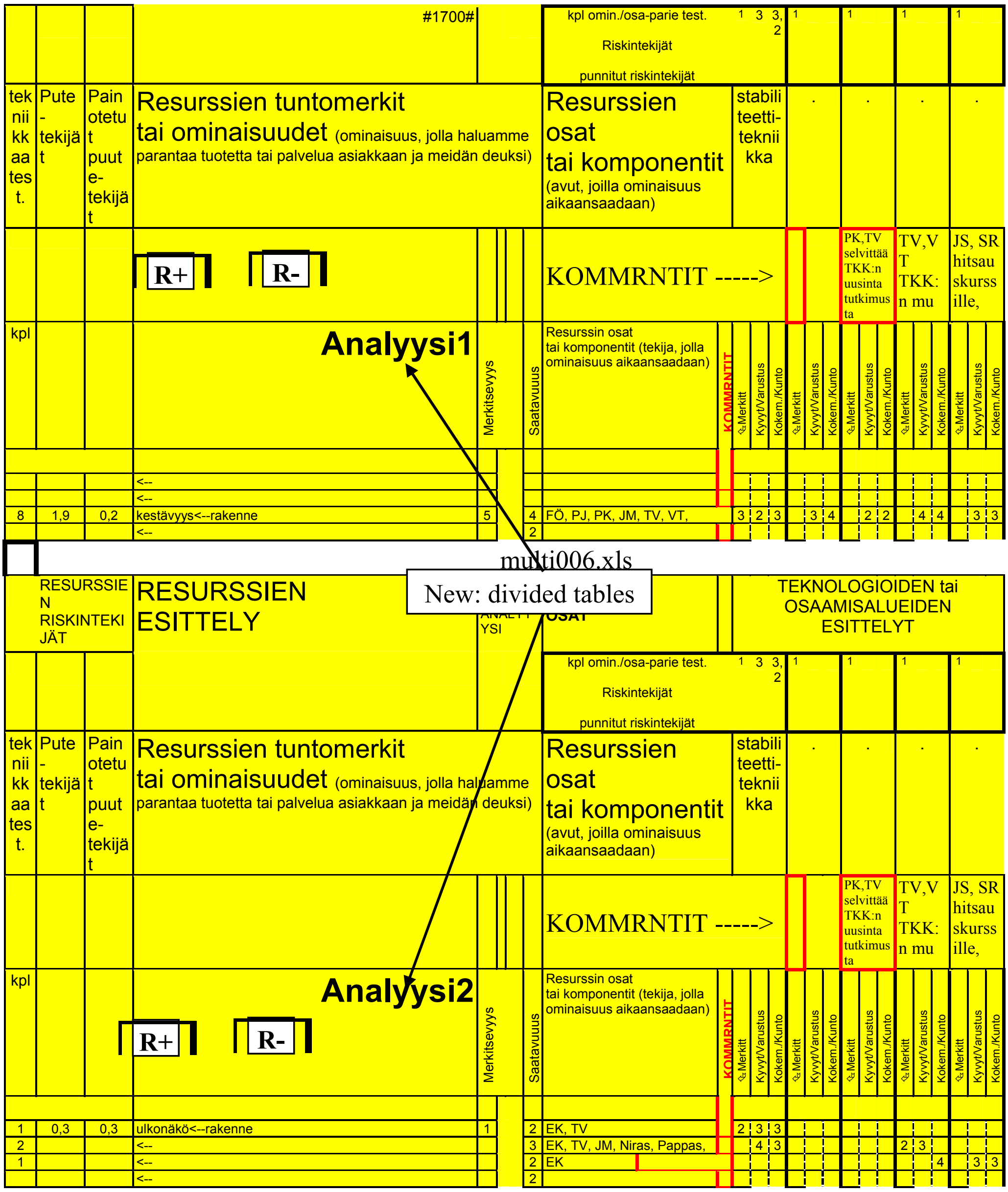


Figure 10.1. Resource analysis table, Stage 10

Kopioi Resurssein KOKOOMATAULUKKO viivan alle Paste special/Values:lla			"Tentop" Analyysi 1 £££1	multi006.xls	
ANALYYSI 1 KOKOOMATAULUKKO Resurssit			Konseptin ja resurssien riskianalyysi	#1792#	
Ominaisuus ~ Osa	Painotetut		Ominaisuus ~ Osa	Painotetut riskitekijät	Kpl. os.al. testattu
kestävyys<--pintalevymateriaali<				212930	8
kestävyys<--rakenne<-FÖ, PJ, PK, JM, TV, VT, Pappas, Niras, TKK, VTT	141696	8	kestävyys<--rakenne<-FÖ, PJ, PK, JM, TV, VT, Pappas, Niras, TKK, VTT	141696	8
kestävyys<--liitäntämenetelmä<-FÖ, JM, TV, W-SD, Pappas, Niras, TKK,	75469	4	kestävyys<--liitäntämenetelmä<-FÖ, JM, TV, W-SD, Pappas, Niras, TKK,	75469	4
toimivuus<--rakenne<-FÖ, JM, VT, PJ, PK, TV., Niras, Pappas, TKK	44020	5	toimivuus<--rakenne<-FÖ, JM, VT, PJ, PK, TV., Niras, Pappas, TKK	44020	5
kestävyys<--tukilevymateriaali<-FÖ, JM, TV, EK, Pappas, Niras, TKK,	33633	8	kestävyys<--tukilevymateriaali<-FÖ, JM, TV, EK, Pappas, Niras, TKK,	33633	8
tilatehokkuus<--rakenne<-FÖ, JM, VT, PJ, JS, W-SD, PS, KM, PK, EK, TV.	26760	7	tilatehokkuus<--rakenne<-FÖ, JM, VT, PJ, JS, W-SD, PS, KM, PK, EK, TV.	26760	7

NEW: table for presenting most important risk factors

Figure 10.2. Example of sorting table, Stage 10

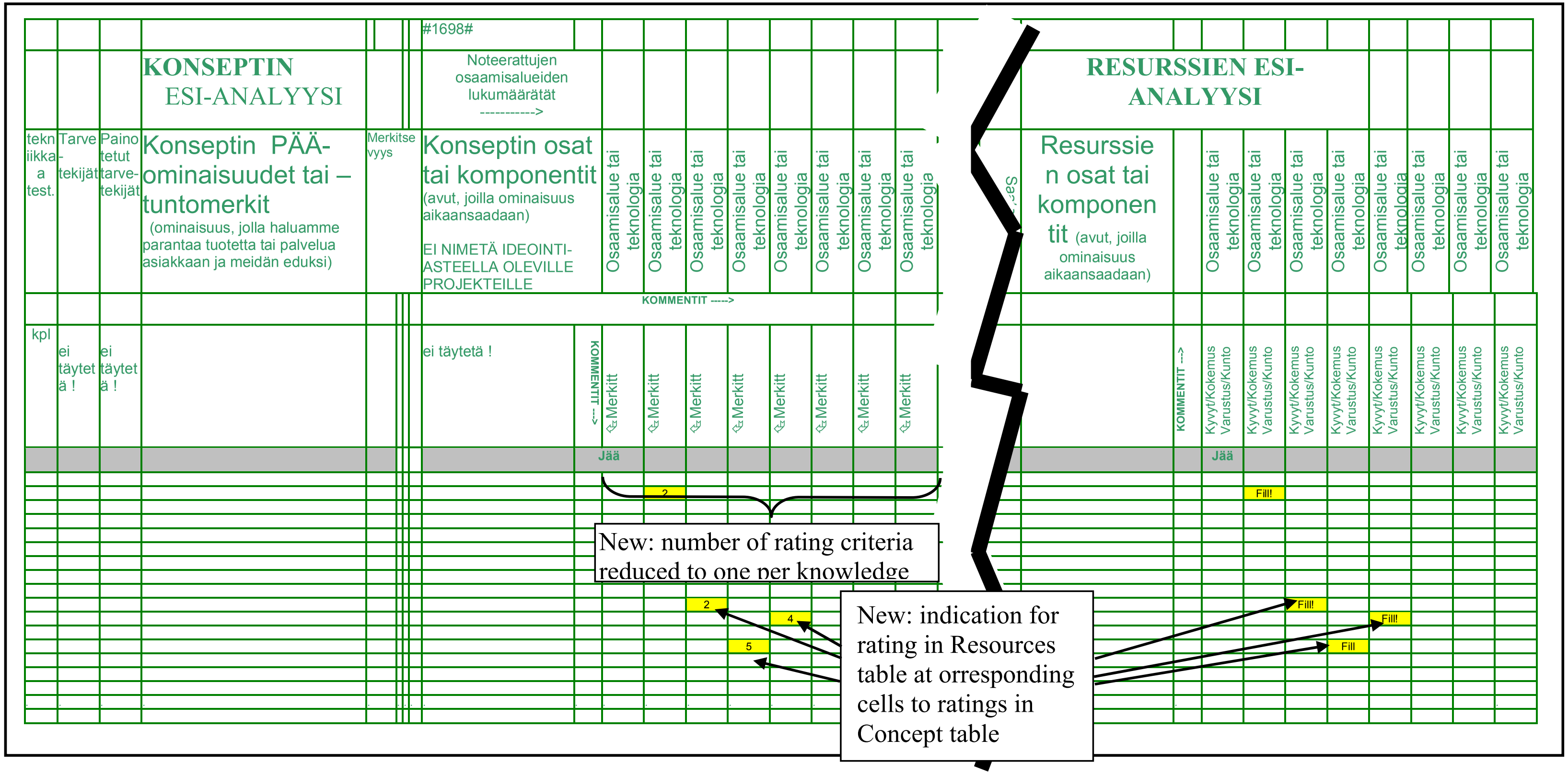


Figure 11.1. Concept analysis table, and to the right an excerpt of the Resources table, Stage 1

Appendix 4. Interview Form used in Pilot Firms after the End of the EDCP Development Project

c:\wp\dr\dr2\market\interv-1.doc

INTERVJUGUIDE

Datum:

Företagets namn

Intervjuad person

Företagets bakgrund

- historia
- branch
- underleverantör eller huvudleverantör
- storlek
- personal

Aanalyserade projekt, storlek: mk/arb.tid; direkt utveckl. / följd

- proj.1
- proj.2
- proj.3
- proj.4
- proj.5

Är företaget med som en del av TEKES-projektet eller som en separat betalande kund?

Varför kom företaget in i projektet?

- företaget hade vissa speciella projekt som man ville analysera
- företaget kartlägger aktivt nya analyssätt & instrument
- projektet var ett enkelt & billigt sätt att få assistens i projekt

- företaget hade ett allmänt intresse för projektet och Fo & U-problematiken

- nyfikenhet

Hur kom företagen in i projekten?
- företagets interna beslutsprocess

- Tekes & VTT:s roll som imagebärare

Vilka förväntningar hade företagen på projektet?
Hurdan uppfattning hade företagen om analysmetoden i början av projektet?
- Hurdan Fo & U-bakgrund hade företaget

- Hade företaget använt sig av QFD eller FMEA

Hurdan uppfattning hade företagen om konsulterna i början?

DEN TEKNISKA KVALITETEN OCH PROCESSKVALITETEN
Hurdan uppfattning hade företagen om helhetskvaliteten?

Den tekniska kvaliteten
- inmatningen av data

- kvaliteten på ADB-mjukvara som användes vid analyssessionerna

- den tekniska kvaliteten på analysresultaten

    1. EDCP som kartläggningsinstrument och tankeväckare

    2. kvalitetet på parametrarna i analysen

3. är slutresultaten användbara

- konsulternas sakkunskap och det mervärde detta bidrog med
    1. om EDCP och analysmetoder i allmänhet

    2. allmänkunskap om industrier

    3. industrispecifik kunskap

    4. datorkunskap

Den funktionella kvaliteten

- under diskussionerna innan projektet

- under diskussionerna under projektet

- under diskussionerna efter projektet

Konsulternas attityd och tjänstevillighet i allmänhet och speciellt under analyssessionerna

Fortlöpandet av analysen och problem i detta

- kritiska händelser & återhämtningar

- den interna klimaten bland sessionsdeltagarna och dess inverkan på analysen och analysresultaten

    -tyckte ni att ni kunde bidra till att ge något till analysen och dessutom till utvecklingen av analysmetoden

- relationerna mellan konsulterna och sessionsdeltagarna

    - har konsulterna tid till era problem?

    - förstår konsulterna era problem?

- kände ni att ni fick någonting extra av dessa sessioner?

- pekade analysresultaten ut några konkreta risker i något av de analyserade projekten, vilka risker?

- verkade analysen som ett hjälpmedel till planeringen av projektets fortsättning, hur?

- bidrog analysen till att utpeka nya saker, som skall tagas med i innovationsprojektet, vilka?

- bidrog analysen till att utpeka nya saker, som skall lämnas bort från innovationsprojektet, vilka?

- bidrog analysen till att öka säkerhetskänslan ("komfortkänslan", comfort level) hos beslutsfattarna?

Har ni fortlöpande kontakt med konsulterna?

- problemfrågor och lösning av dessa

- utveckling av idéer / projekt

TEKES' roll

- profil

- som en byrokratisk maskineri
  -rapporteringsbyrokratin & hur mycket detta tär på företgets resurser / föder frustration

Kunden som merproducent

1. under analysprocessen

2. som idémakare / problemlösare

Kände Ni att Ni hade en roll i denna utvecklingsprocess?

Hur mycket av analysresultaten anade Ni redan innan analysen?

Vilka var positivaste sakerna med EDCP-processen?

Vilka var de största bristerna med EDCP-processen?

Kunde Ni tänka Er att använda Er av EDCP-processen även i fortsätningen?

Hur mycket skulle Ni vara beredda att betala / göra andra uppoffringar?

Appendix 5. Description of EDCP to prospective Pilot Firms

OY SESAM CONSULTING AB

EDCP - Early Detection of Complex Problems

EDCP on ongelmien ratkaisumenetelmä, minkä avulla päättäjät projektin varhaisessa vaiheessa pystyvät kartoittamaan T&K -projektin heikot kohdat.

Tuotekehitysongelmat tulevat monasti “sivusta”.
Innovaatio-, tutkimus- ja kehitysprojekteissa törmätään usein yllättäviin ongelmiin työn edetessä. Nämä arvaamattomat pulmat eivät useinkaan johdu projektin varsinaisesta aiheesta, mutta niiden ratkaiseminen osoittautuu monesti varsin vaikeaksi, työlääksi ja kalliiksi. Projektin kustannusten kannalta on edullisinta ratkaista pulmat mahdollisimman varhaisessa vaiheessa.

Mihin EDCP soveltuu ?
EDCP soveltuu parhaiten idea-asteella oleviin projekteihin. EDCP-menetelmää voidaan soveltaa sekä teknisiin että kaupallisiin ja hallinnollisiin hankkeisiin.

Mitä EDCP-menetelmässä analysoidaan ?
EDCP-menetelmässä analysoidaan rinnakkain perusidea ja resurssit kuvaamalla näiden oleelliset ominaisuudet ja osat. Idean vahvistettavia ominaisuuksia verrataan idean toteuttamiseksi käytettävissä olevien resurssien ja osien ominaisuuksiin. Resursseja ja osia ovat mm. työvoima, asiantuntijat, patentit, erilaiset järjestelmät ja laitteet sekä aika ja pääoma.

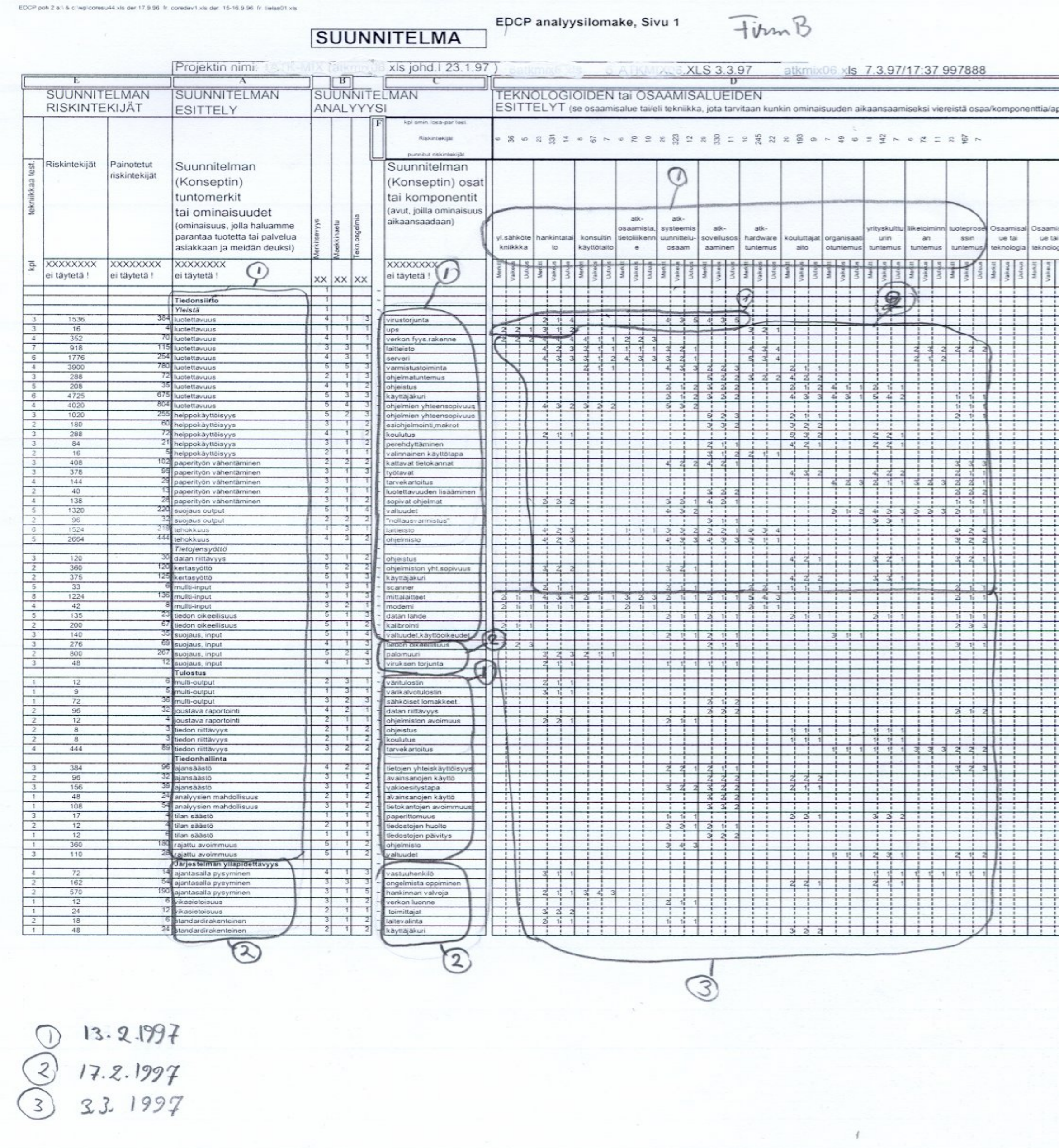
Mitä EDCP’llä saavutetaan ?
Menetelmä parantaa projektin osanottajien keskinäistä vuorovaikutusta. Samalla se ohjaa päättäjiä löytämään ne osa-alueet, joihin voimavaroja kannattaa keskittää. Menetelmä auttaa päättäjiä ratkaisemaan voidaanko projektia jatkaa, tarvitaanko projektin syvällisempää analyysia, pitääkö projektin rakennetta muuttaa vai pitääkö projekti mahdollisesti lopettaa.

Miten analyysi tehdään käytännössä ?
EDCP-menetelmässä projekti-idean ja resurssien ominaisuudet ja osat pisteytetään projektin vaatimusten perusteella. Vertailemalla analyysien tuloksia voidaan päätellä kuinka hyvin resurssit soveltuvat projektin läpiviemiseksi.

Testattu menetelmä nyt käytössä.
EDCP on nyt saatavana tietokonesovelluksen muodossa. Sesamin konsultit ovat valmiit suorittamaan nopean EDCP-analyysin yhdessä asiakkaan kanssa. Analyysin perusteella konsultit voivat opastaa jatkotoimenpiteistä. Luottamuksellinen työskentely ja projektien salassapitäminen on meille elinehto.

Oy Sesam Consulting Ab
PL 127; 02401 Kirkkonummi
Puh & Fax 09 - 298 9001

Appendix 6. Exemplar cases of actual analyses papers (including notations etc.)



EDCP analyysilomake, Sivu 1

Firm B

SUUNNITELMA

Projektin nimi: xls johd.l 23.1.97) .XLS 3.3.97 atkmix06 xls 7.3.97/17:37 997888

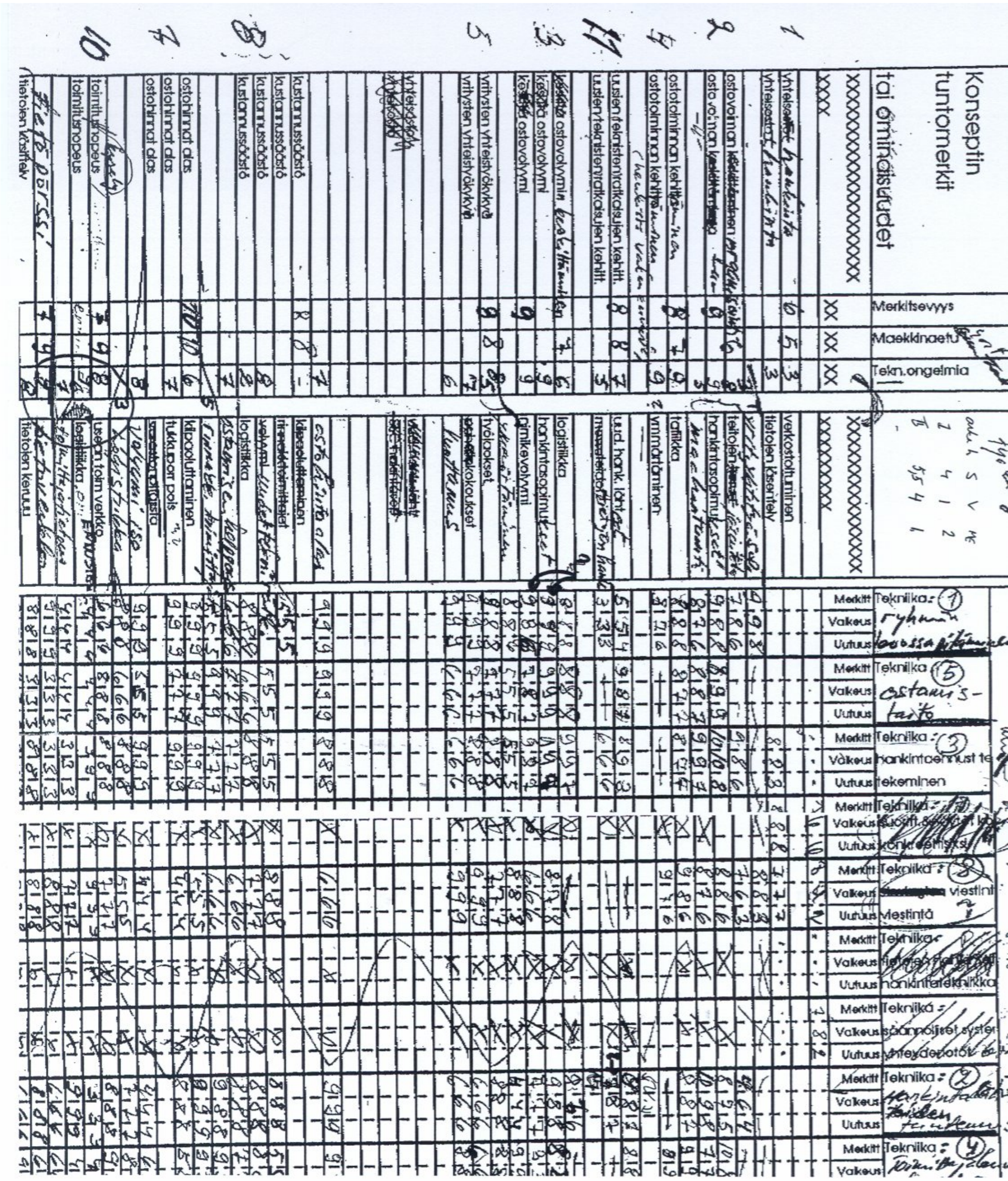
kpl (tekniikkaa test.)	E: SUUNNITELMAN RISKINTEKIJÄT – Riskintekijät	Painotetut riskintekijät	A: SUUNNITELMAN ESITTELY – Suunnitelman (Konseptin) tuntomerkit tai ominaisuudet (ominaisuus, jolla haluamme parantaa tuotetta tai palvelua asiakkaan ja meidän deuksi)	B: SUUNNITELMAN ANALYYYSI – Merkitsevyys	Maekkinaetu	Tekn.ongelmia	C: Suunnitelman (Konseptin) osat tai komponentit (avut, joilla ominaisuus aikaansaadaan)
	XXXXXXXX ei täytetä !	XXXXXXXX ei täytetä !	XXXXXXXX ei täytetä ! (1)	XX	XX	XX	XXXXXXXX ei täytetä ! (1)
				1			
			Tiedonsiirto	1			
			Yleistä	1			
3	1536	384	luotettavuus	4	1	3	virustorjunta
3	16	4	luotettavuus	1	1	1	ups
4	352	70	luotettavuus	4	1	1	verkon fyys.rakenne
7	918	115	luotettavuus	3	3	1	laitteisto
6	1776	254	luotettavuus	4	3	1	serveri
4	3900	780	luotettavuus	5	5	3	varmistustoiminta
3	288	72	luotettavuus	2	1	3	ohjelmatuntemus
5	208	35	luotettavuus	4	1	2	ohjeistus
6	4725	675	luotettavuus	5	3	3	käyttäjäkuri
4	4020	804	luotettavuus	5	4	3	ohjelmien yhteensopivuus
3	1020	255	helppokäyttöisyys	5	2	3	ohjelmien yhteensopivuus
2	180	60	helppokäyttöisyys	3	1	2	esiohjelmointi,makrot
3	288	72	helppokäyttöisyys	4	1	2	koulutus
3	84	21	helppokäyttöisyys	3	1	2	perehdyttäminen
2	16	5	helppokäyttöisyys	2	1	1	valinnainen käyttötapa
3	408	102	paperityön vähentäminen	2	2	2	kattavat tietokannat
3	378	95	paperityön vähentäminen	3	1	3	työtavat
4	144	29	paperityön vähentäminen	3	1	1	tarvekartoitus
2	40	13	paperityön vähentäminen	2	1	1	luotettavuuden lisääminen
4	138	28	paperityön vähentäminen	3	1	2	sopivat ohjelmat
5	1320	220	suojaus output	5	1	4	valtuudet
2	96	32	suojaus output	2	2	2	"nollausvarmistus"
6	1524	218	tehokkuus	4	3	1	laitteisto
5	2664	444	tehokkuus	4	3	2	ohjelmisto
			Tietojensyöttö				
3	120	30	datan riittävyys	3	1	2	ohjeistus
2	360	120	kertasyöttö	5	2	2	ohjelmiston yht.sopivuus
2	375	125	kertasyöttö	5	1	3	käyttäjäkuri
5	33	6	multi-input	1	3	1	scanner
8	1224	136	multi-input	3	1	3	mittalaitteet
4	42	8	multi-input	3	2	1	modemi
5	135	23	tiedon oikeellisuus	5	1	3	datan lähde
2	200	67	tiedon oikeellisuus	5	1	2	kalibrointi
3	140	35	suojaus, input	5	1	4	valtuudet,käyttöoikeudet
3	276	69	suojaus, input	4	1	3	tiedon oikeellisuus
2	800	267	suojaus, input	5	2	4	palomuuri
3	48	12	suojaus, input	4	1	3	viruksen torjunta
			Tulostus				
1	12	6	multi-output	2	3	1	väritulostin
1	9	5	multi-output	1	3	1	värikalvotulostin
1	72	36	multi-output	3	2	3	sähköiset lomakkeet
2	96	32	joustava raportointi	4	2	1	datan riittävyys
2	12	4	joustava raportointi	2	1	1	ohjelmiston avoimuus
2	8	3	tiedon riittävyys	2	1	2	ohjeistus
2	8	3	tiedon riittävyys	2	1	2	koulutus
4	444	89	tiedon riittävyys	3	2	2	tarvekartoitus
			Tiedonhallinta				
3	384	96	ajansäästö	4	2	2	tietojen yhteiskäyttöisyys
2	96	32	ajansäästö	3	1	2	avainsanojen käyttö
3	156	39	ajansäästö	3	1	2	vakioesitystapa
1	48	24	analyysien mahdollisuus	2	1	2	avainsanojen käyttö
1	108	54	analyysien mahdollisuus	3	1	2	tietokantojen avoimmuus
3	17	4	tilan säästö	1	1	1	paperittomuus
2	12	4	tilan säästö	2	1	1	tiedostojen huolto
1	12	6	tilan säästö	1	1	1	tiedostojen päivitys
1	360	180	rajattu avoimmuus	5	1	2	ohjelmisto
3	110	28	rajattu avoimmuus	5	1	2	valtuudet
			Järjestelmän ylläpidettävyys				
4	72	14	ajantasalla pysyminen	4	1	3	vastuuhenkilö
2	162	54	ajantasalla pysyminen	3	3	3	ongelmista oppiminen
2	570	190	ajantasalla pysyminen	3	1	5	hankinnan valvoja
1	12	6	vikasietoisuus	3	1	2	verkon luonne
1	24	12	vikasietoisuus	2	1	1	toimittajat
2	18	6	standardirakenteinen	3	1	2	laitevalinta
1	48	24	standardirakenteinen	2	1	2	käyttäjäkuri

D: TEKNOLOGIOIDEN tai OSAAMISALUEIDEN ESITTELYT (se osaamisalue tai/eli tekniikka, jota tarvitaan kunkin ominaisuuden aikaansaamiseksi viereistä osaa/komponenttia/ap

yl.sähkötekniikka | hankintataito | konsultin käyttötaito | atk-osaamista, tietoliikenne | atk-systeemisuunnittelu-osaam | atk-sovellusosaaminen | atk-hardware tuntemus | kouluttajataito | organisaatiotuntemus | yrityskulttuurin tuntemus | liiketoiminnan tuntemus | tuoteprosessin tuntemus | Osaamisalue tai teknologia | Osaamisalue tai teknologia

(1) 13.2.1997
(2) 17.2.1997
(3) 3.3.1997

Example of analysis form with markings of progress done by the researcher.



Example of analysis when the analysis form was filled in by hand.

Appendix 7. Descriptions of the Analysis Cases from Firms B, C, E and I

Case description

Case: Firm B Date: 31-10-98 Updated: 1.11.98; 23.3.99; 8.5.01; 18.5.01

0,5 **15,25**

1. **Company description**
   Character, industry, structure, size, research background
   1971 Teknos started to make black and white master batches for the plastics industry. 1980 Premix Oy was founded. The development has since brought out semi conducting master batches for plastics for electronics etc products.
   Turnover 60 mmk/year, personnel slightly under 50 persons.
   Research background
   The company does research and development continuously for their manufacturing process and product development for their customers.

3. **Project definition**
   The project referred to the renewal of the firm's data processing system. It included setting of objectives, tasks, allotment of resources, and assigning responsible persons. An action plan was to be set up. The plan included system planning, invitation of offers and treatment of offers. The realization of the project included coordination and supervision of the work as well as the documentation of the system. Finally the project regarded the continuous follow-up of the resource budget and total assessment of the project.

4. **Team**
   Persons (description, character), changes
   The original team included the administrative director (responsible for the project), two representatives for product development, one representative each for production quality, and sales.
7. **Proceeding of analysis process**
   Calendar: time elapsed between sessions, postponements, number of sessions
   The project was analyzed in five sessions, analysis results and conclusions were presented in a sixth session. Time elapsed ca. 2 weeks between 1st and 2nd analyses, 3-5 days between the following.
   Analysis proceeding
   Preparations and facilities
   The two first analyses were done in a meeting room using computer and a big screen. The following analyses were performed in the office of the administrative director.
   The researcher acted as analysis moderator and computer operator in all sessions. During the first analysis the background of the project was thoroughly presented and the plan for implementing of the project was explained by the administrative director. The principles of EDCP were also explained to all the members of the team. In the following sessions the analysis proceeded in the logical succession of EDCP.

   Listings: (attributes, components, knowledge areas, resources, number of items,

time)
The analysis started in the Concept analysis table. 17 attributes, 45 components and 12 knowledge areas were listed in the first session. Rating of attributes for Significance, Market benefit and Technical problems were also done in the first session. Totally 61 attribute-component pairs were formed. Rating in the grid was started in five groups.

In the second session 3 attributes and 7 components were added, and rating was continued under the grid.

In the third session the rating under the grid of the Concept analysis table was finished, totally 182 knowledge area groups were rated. In the Resource analysis table 14 resource-components were listed, 42 resource groups were formed. In this analysis the Note function of Excel was used for making comments to items during the analysis.

In the fourth session the rating in the Resource analysis table was finished, the result tables for Concept, Resource and Knowledge area analyses were printed and discussed and graphs were printed.

Table 1.					
Listings and ratings					
Concept analysis sheet					
Listings	#	Sess #	Ratings	#	Sess #
Attributes	20	3	Signif / Attr	61	3
Components, tot.	61	3	Market benefit	61	3
Components, diff.	52	3	Technical problems	61	3
Knowledge areas	12	1			
			#rows & knowl. areas		
			total matrix grid area	732	
			# cell groups rated	182	3
			% grid area rated	24,9	
Resources analysis sheet			#rows & knowl. areas		
#Res. comp. groups, tot.	42	3	total grid area	504	
#Res. comp. groups, diff.	14	3			
			# cell groups rated	116	4
			% grid area rated	23,0	

Progress of the analysis work

The analysis sessions lasted from 3 to 4 h. Table 2 gives an overview of the proceeding, totally 12 h. were used to finish the analysis work. In the Concept analysis table the listings of attributes, components and knowledge areas were finished during the first session, as were ratings for significance, market benefit and technical problems for the attributes, and five knowledge area groups in the grid. Rating under grid was continued in the second and third sessions. Rating was finished during the third session. In the Resource analysis table resources components were listed and all the knowledge area groups in the grid were rated during the third session. In the fourth session the analysis result tables for concept, resources, and knowledge areas were printed and discussed, as were the correspondent graphs.

The stage 6 type base was used in all sessions.

Analysis progress
11.2.97: Now worked 2 sessions: 1st 3h/6p.; 2nd 3h/4p. Experience: see improvement suggestions.... "Rating is dull".
13.2.97: Originally intended computer (386) did not function, analysis was transferred to RK's machine ("586"). Visibility poor at the beginning. .After enlarging the font. After enlarging the font visibility increased so much that reading from paper printout became unnecesseary for Knowledge area text.
Printing of Excel notes was done.
3.3.97: Resources: Concreteness and assigning. How do with the resources that will be available in the future and with their rating in field under K ? NO AUTOMATIC transfer of attribute-comp.-pairs from Cons. to Res.was used at this stage.

Table 2.							
Listing & rating progress							
Session #		1	2	3	4	5	6
Stage, base		6	6	6	6		
Time per sess., h		3	3	4	2		
Cumulat. time , h		3	6	10	12		
Listings							
attrib-comp pairs		61					
components,diff.		52					
Ratings							
sign. etc. for attrib.		61					
cons.knowl.area matrix		5	81	176	182		
res knowl.areamatrix					116		

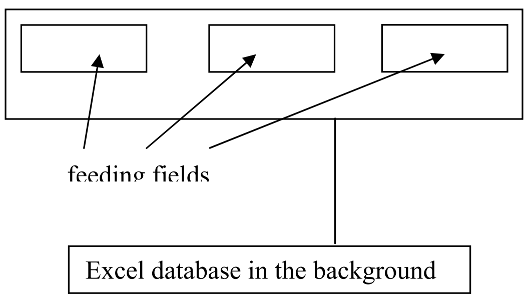
Monitoring of the analysis work
The analysis work was monitored for the team by making printouts of the Excel sheet at the end of each session and, in the first session at the end of significant analysis stages. Totally four printouts of the Excel sheets were made. The analysis work during the sessions was monitored for research purpose by the researcher besides of his promoting

of the analysis process itself. The monitoring consisted of notations on a pad and on the Excel sheet printouts.

Interpretation of analysis results
The team interpreted analysis continuously during the progress of the work. After the fourth session an interpretation of the analysis results was performed with the team.

Preparation of analysis report
The Analysis report was prepared by copying the listings and the calculated analysis results from the Excel sheets to their appropriate sites in the form and then typing comments and conclusions in their appropriate places.

8. **Result of analysis process in this case**
Results for the benefit of the EDCP analysis process
One team member rejected navigating in the spreadsheet, and the outlook of the window itself. Suggested to split the window into three partitions.



<u>Found faults</u>

<u>Feedback from firm, solutions in interactive co-operative work</u>
Suggestions for improvement, Development
11.2.97: It would be more descriptive to display the table on the wall or on paper Row size and font size must be adjustable. Names: Tekn. ongelma -> Implement. ongelma, Suunnitelma -> Konsepti, Osa -> Komponentti. Make all headings visible at once. Avoid repetitions of matters Rating is dull work.
Conc. sheet.\7\: Attrib & Comp.columns questions with small font, texts must be visible on prints.
13.2.97: Experiments done with different font sizes and text directions in the Knowl. area headings.
7.3.97: Suggestions for improvements
Make a report generator that transfers the appropriate results automatically to the report form. Use separate worksheets (ATKMIX was done on the old one-sheet bottom originally made on and for Excel 3).
When data is fed one often gets trivial answers. It is difficult to keep three things (eg., attribute, component, knowledge area) in mind, then trivial answers are given. Difficult to name the knowledge areas for totally new concepts.

Input from this analysis, new features added to analysis base
New, more explanatory heading names.

Results for the benefit to the firm

Case description
Case: Firm C Date: 31-10-98 Updated: 1.11.98; 23.3.99; 8.5.01; 18.5.01
0,5 **15,25**

1. **Company description**
Character, industry, structure, size, research background
The firm was a subsidiary (Inc.) of a large corporation that is more than 100 years old. It is mainly active in different industrial sectors than the subsidiary although there are some divisions that use similar technology. The subsidiary may purchase certain components and service functions from other sectors. Since 1993 the subsidiary develops, produces and sells large machinery units for environement processes and is a forerunner in technical development and holds a number of patents. The technology is based on an idea created in 1988 by an independent inventor, the rights were bought by the firm in 1992. It is a major player internationally in its industry. It operates quite independently from the mother corporation.
Turnover of firm was ca. 40 mmk/year, manpower was 25 persons of which 14 academics, 5 professionals and 6 workers.

Research background
The company had done research (continually), now they were in a stage where the research work was the main purpose. They had not used other formal methods e. g., QFD or FMEA.

3. **Project definition**
The first project was selected together with the R&D director and the technical director. The object for EDCP analysis was a key technical component of one of the new machine models that was to be commercialized soon. The machine utilizes a number of physical processes and new material applications that have never been used before. The concept of the innovation can be classified as radical with regard to both processes and to materials.

The object of the first analysis involved an improved version of an existing component theat was to be installed in a prototype of a commercially used machine. Particularly material selection and design configuration of elements of the machine were involved in the project. Chemical resistence and plastics processing were the main areas of interest.

Project size was 4,3 mmk, the EDCP-analysis costs to the firm were calculated to 67.526:--

4. **Team**
Persons (description, character), changes
The initial team consisted of the R&D director, the technical director and two research engineers. In later sessions one of the research engineers or the technical director were absent.

7. **Proceeding of analysis process**
Calendar: time elapsed between sessions, postponements, number of sessions
This project was analysed in five sessions, two additional sessions were held for the presentation of the results. Time elapses between sessions were 2, 2 and 1,5 weeks, total time from analysis start to finish was 5,5 weeks. There were no postponements of scheduled sessions.

Analysis proceeding
<u>Preparations and facilities</u>
During all analyses the analysis team convened around the conference table in the office of the R&D director. The HP Omnibook 5000 CTS laptop computer connected to a larger screen acted as analysis tool. Printing of Excel tables for monitoring purposes during the sessions was done on a printer of the firm.
The researcher acted as analysis moderator and computer operator. During the first session the background and function of the EDCP system was explained to the team in ca. ½ h. The R&D director explained the reason for choosing the particular project for analysis. After this the analysis work was started.

<u>Listings: (attributes, components, knowledge areas, resources, number of items, time</u>
The analysis work was started on the Concept analysis sheet. All 16 attributes were listed during the first session.
During the second session the listing of the 26 different components as well as that of 18 knowledge areas were completed. Totally 45 attribute-component pairs were formed. Rating of all attribute-component pairs for Significance, Market benefit and Technical problems was completed during session 2.

The stage 6 type base was used during sessions 1 and 2.

The rating of Significance, Difficulty and Newness of all attribute-component pairs with respect to the knowledge areas was finished during session 4. As seen in Table 1 28% of all the matrix grid area was rated.
On the Resources analysis sheet 32 different resources component groups were listed during session 4. The rating was completed during the fifth session. As seen from Table 1, 24,4% of all the matrix grid area was rated on the Resources sheet.

The stage 7 type base was used during sessions 3-7.

Table 1.					
Listings and ratings					
Concept analysis sheet					
Listings	#	Sess #	Ratings	#	Sess #
Attributes	16	1	Signif / Attr	45	2
Components, tot.	45	2	Market benefit	45	2
Components, diff.	26	2	Technical problems	45	2
Knowledge areas	18	2	Knowl. area groups	193	4
			#rows & knowl. areas	45	
			total matrix grid area	810	
			# cell groups rated	193	4
			% grid area rated	23,8	
Resources analysis sheet			#rows & knowl. areas	45	
#Res. comp. groups, tot.	45	4	total grid area	810	
#Res. comp. groups, diff.	32	4			
			# cell groups rated	198	5
			% grid area rated	24,4	

Progress of the analysis work

The analysis sessions lasted from 3 to 6 h., sessions longer than 3 h. were interrupted for lunch. Table 2 gives an overview of the proceeding, totally 22,5 h. were used to finish the analysis work. The listings of attributes, components, knowledge areas and resources components were finished during the third session. Ratings for significance, market benefit and technical problems for the attributes was finished during the third session, ratings for significance, difficulty and newness of the knowledge areas for the attribute-component pairs was finished during the fourth session. Rating of the ability/equipment and competence/condition of the resource components for the knowledge areas was finished during the fifth session.

Table 2.							
Listing & rating progress							
Session #		1	2	3	3	4	5
Stage, base		6	6	7	7	7	7
Time per sess., h		6	3	1	3	5	4,5
Cumulat. time , h		6	9	10	13	18	22,5
Listings							
attrib-comp pairs		39	45	45	45	45	45
components,diff.		21	26	26	26	26	26
Ratings							
sign. etc. for attrib.				45	45	45	45
cons.knowl.area matrix				27	75	193	193
res knowl.areamatrix							193

Monitoring of the analysis work
The analysis work was monitored for the team by making printouts of the Excel sheet at the end of each session and sometimes at the end of significant analysis stages e. g., after the listings were finished. Totally six printouts of the Excel sheets were made. The analysis work during the sessions was monitored for research purpose by the researcher besides of his promoting of the analysis process itself. The monitoring consisted of notations on a pad and on the Excel sheet printouts.

Interpretation of analysis results
A preliminary interpretation of the analysis results was made with the R&D director and the technical director using the printouts of the Excel tables and diagrams.
A task list for further action was prepared. A table of the algorithms was wanted, three groups of faults in diagrams needed correction. Further more a table of "Top ten" items was required and use was made of new names for the risk factors for different categories (see later under the heading "input from this analysis").
The corrections and improvements were included in a renewed version of the analysis table.
After this the researcher prepared an Analysis report using the form anarap.doc.

Preparation of analysis report
The Analysis report was prepared by copying the listings and the calculated analysis results from the Excel sheets to their appropriate sites in the form and then typing comments and conclusions in their appropriate places.

8. **Result of analysis process in this case**
Results for the benefit of the EDCP analysis process
The proceeding of the analysis is shown in Table 3 that shows dates, time used per session, participants, activities and results as well as observations and suggestions.

Technical quality and process quality
feeding of data: facilitator did all feeding

Quality of software
Problems in the beginning but it worked anyway, there was constant improvement.

Quality of parameters
Parameters were logical and necessary.

Found faults
Font too small for easy reading. Some of the headings difficult to understand. Wrong parameter order in charts. Wrong pair listings (reference displacement) in Resources sheet and missing formulas after addition of knowledge area columns.
Feedback from firm, solutions in interactive co-operative work
Make program "lighter" looking, remove (empty) lines make font larger.
Copying the significance ratings from the Concept sheet to the Resources sheet facilitated the analysis work.
New, more explanatory names were created for the risk factors for different categories:
risks from concept --> requirement of concept
risks from resources --> shortages of resources
risks from knowledge areas --> weakness in knowledge areas

Input from this analysis, new features added to analysis base
New, more explanatory names for the risk factors, "Top ten" table for the ten biggest risk factors in selected categories, need for clearer view of the Excel table on the screen. Division of large diagrams to facilitate display and printing.

Results for the benefit to the firm
According to the R&D director the project benefited from the EDCP analysis because it provided a documented list of things to be taken care of. The rating provided guidance to the importance of the different items relative to each other. Gave thought provokers. The analysis process itself was equally important as the (end) results.
The cost to the firm for the EDCP analysis in the form of salaries assigned to the analysis work was approximately 1,6% of total project costs.

Case description

Case: Firm I Date: 31-10-98 Updated: 1.11.98; 23.3.99; 8.5.01

0,5 16,0

1. **Company description**

   Character, industry, structure, size, research background

   The firm is 46 years old, now owned by foreign concern. Products include plastics, lighting fixtures for vehicles and like, personal reflectors. The firm is both a subcontractor as systems supplier to automotive industry and a main supplier of own products. The firm employs 270 persons, and has a turnover of 160 mmk per year.

3. **Project definition**

   The project involved a product group, the development costs were 3mmk (including molds), and it lead to product turnover of ca. 3 mmk/year.

4. **Team**

   Persons (description, character), changes

   The team consisted of the technical manager (tm), a research engineer (re) and a designer (d). The team stayed consistent through the whole analysis.

7. **Proceeding of analysis process**

   Calendar: time elapsed between sessions, postponements, number of sessions

   Two weeks elapsed between the two analyses.

   Analysis proceeding

   <u>Preparations and facilities</u>

   The analysis was made in (re)'s office using his machine. The project was selected at the start of the first session, and shortly described.

   <u>Listings: (attributes, components, knowledge areas, resources, number of items, time</u>

   In the first session 17 groups of attributes were listed, after that five different attributes were listed under the group headings and then 14 knowledge areas in the knowledge area row above the grid. Significance, Market benefit and Technical problems were rated for 9 attributes. 55 rows of components were listed and five rows of knowledge area groups were rated as an example. After the first session the team continued on their own and finished the listing of attributes and components. Furthermore the team rated the Significance, Market benefit and Technical problems for the remainder of the attributes so that the Concept analysis table consisted of 151 rows. Some of the attributes were changed. The analyzers were unable to print diagrams on their own.

   During the second session resources were listed in the Resource analysis table without any guidance. Then the results and diagrams were printed. No Analysis Report was prepared.

   For the first and second sessions the stage 6 type base was used, for the third session the data was transferred to the stage 7 type base for demonstration purpose.

   The listings and ratings in the Concept and Resource Analysis tables are presented in Table 1.

Table 1. Listings and ratings					
Concept analysis sheet					
Listings	#	Sess #	Ratings	#	Sess #
Attributes	45	1	Signif / Attr	45	2
Components, tot.	151	2	Market benefit	45	2
Components, diff.	59	2	Technical problems	45	2
Knowledge areas	14	1	Knowl. area groups	428	2
			#rows & knowl. areas	151&14	2
			total matrix grid area	2114	2
			# cell groups rated	420	2
			% grid area rated	19,9	2
Resources analysis sheet			#rows & knowl. areas	90&14	2
#Res. comp. groups, tot.	90	2	total grid area	1260	2
#Res. comp. groups, diff.	5	2	# cell groups rated	389	2
			% grid area rated	30,9	2

Progress of the analysis work

The analysis work progressed in two sessions, the first lasting 3, and the second 7 hours. Between the sessions the team worked several hours completing the analysis.

Table 2.							
Listing & rating progress							
Session #	1	2	3	4	5	6	7
Stage, base	6	6	7				
Time per sess., h	3	7					
Cumulat. time , h	3	10					
Listings							
attrib-comp pairs	55						
components,diff.	35						
resources, diff		5					
Knowledge areas	14						
Ratings							
sign. etc. for attrib.	9						
cons.knowl.area matrix	18	420					
Res knowl.areamatrix		389					

Monitoring of the analysis work
The analysis team monitored the analysis work on their own.

The firm additionally had an ad hoc analysis of the project performed by a group of persons familiar with the project but totally unaware of EDCP.

Interpretation of analysis results
The interpretation of the analysis results was done by the analysis team.

Preparation of analysis report
No Analysis Report was prepared for this analysis.

8. **Result of analysis process in this case**
Results for the benefit of the EDCP analysis process
This analysis gave incentive to develop multi-sheet structure.

Found faults
It was difficult to get people enthusiastic, difficult to commit people when plenty of (other) work.
It was also difficult to define the project, the attributes and components. The spreadsheet grew too big e.g., compared to QFD.

The analyzers were unable to produce the staple diagrams themselves.

Feedback from firm, solutions in interactive co-operative work
Of the found risks most were guessed on beforehand, the analyzed projects had no newness value. EDCP works well particularly for projects with more newness value than those presented for analysis by the firm.

The knowledge areas ought to be defined on beforehand based on the knowledge of the firm, and supplemented later. The knowledge areas in the Resource analysis table ought to be rated before the resource components aare selected. The ability and experience of the resource components can be rated later when the resources are selected. Better grouping was also deemed necessary for the attribute-component pairs. Data sorting was deemed necessary in the result tables for the risk factors.

A better manual was needed for selection and generation of attributes and components as well as for the rating. Furthermore a description of the algorithms are needed in the manual.

The resource analysis was deemed to be more difficult than the concept analysis in independent work because no previous structuring had been done to the project prior to the analysis. The Excel spreadsheet proved to be difficult to handle because of “navigating problems”. Suggestions were made to abandon Excel in favor of own program ware.

The ad-hocanalysis produced quite different results as risk factors than EDCP, and it was not nearly as detailed. In the comparison below the ad-hoc column shows all listed items, but the EDCP column shows only the most important items.

Ad-hoc analysis	EDCP-analysis
Attributes	Attribute-component pairs
version control	acceptability ~ color
heat problems	reflector ~ affixing
mechanical design/small size	acceptability ~ photometry
Uni-color problems	
	Resources
Resources	mechanics designer
per-design/teamwork in pre-design stage	

Input from this analysis, new features added to analysis base

Need for multi-sheet structure in Excel as well as need for manual and guidance during analysis.

Results for the benefit to the firm

Through EDCP several persons can be connected to think about the risks, EDCP shows them, the riks will be commonly considered, and they will not be only the “order of the boss”. EDCP can increase the comfort level of the decision makers to a certain extent, when one gets something to show and everything is not only talk. The EDCP analysis results helped, they aided conscious directing of resource and time allocation., and they were good as reminder of items to observe and consider.

Appendix 8. List of the Formulas

Concept

$$concept\ wants_{attribute|component|pair} = [(significance_{attibuter} \times market\ benefit_{attribute} \times techn.problems)\ ] \times \sum[(significance \times difficulty \times newness)_{rated\ knowl.area}$$

$$weighted\ concept\ wants = \frac{concept\ wants}{number\ of\ rated\ knowledge\ areas}$$

Resources

$$resources\ lack_{attribute|component|pair} = \frac{significance_{attribute|component|pair} \times \sum significance_{knowl.area}}{(ability|equipment_{resuorce\ compon\cdot} \times experience|condition_{resuorce\ compon\cdot})_{rated}}$$

$$weighted\ resource\ lack = \frac{resources\ lack}{number\ of\ rated\ knowledge\ areas}$$

Knowledge areas

for concept analysis: $dependency_{knowl.area} = \sum(significance \times difficulty \times newness)_{rated\ knowl.are}$

for resources analysis: $deficiency_{knowl.area} = \dfrac{\sum significance_{knowl.area}}{(ability|equipment_{resuorce\ compon\cdot} \times experience|condition_{resuorce\ compon\cdot})_{rated}}$

for concept analysis: $weighted\ dependency_{knowl.area} = \dfrac{dependency_{knowl.area}}{number\ of\ rated\ attribute|component|pairs_{concept\ analysis}}$

for resources analysis: weighted deficiency $_{knowl.area} = \dfrac{deficiency_{knowl.area}}{number\ of\ rated\ attribute|component|pairs_{concept\ analysis}}$

$$Risk_{knowl.area} = weighted\ dependency_{knowl.area} \times weighted\ deficiency_{knowl.area}$$

Risks from attribute-component pairs to project

$$Risk_{project} = wants_{concept} \times lack_{resources}$$

$$\text{weighted risk}_{\text{project}} = \frac{risk_{project}}{\sum number\ of\ rated\ knowledge\ areas}$$

Appendix 9. List of all Questions, Suggestions and Explanations in the Guidance System

c:\wp\dr\Avh\Wbook\Guide01.doc

Question for Attribute: Find one more property that makes the product, the service or the activity better fot the client and for ourselves, i.e., gives ADDED VALUE !

Question for components: Wherewith / how do we carry **this Attribute**[*)] into effect ?

Question to the significance for the client, for ourselves: How important is **this Attribute** for the client and for ourselves ? 5 most, 1 least

Question to Knowledge area: Which additional Knowledge area can contribute with knowledge to realize the Attributes by means of the Components listed here? Please note that the Attributes give ADDED VALUE to the concept !

Question for judging the ability of the analyzing team: How good are You, who now are doing this EDCP-analysis at **this Resource**?

Question to the significance of the Knowledge area for the Concept: How singificant **is this Knowledge area** when **this Attribute** is realized by means of **this Component** ?

Question för Resources: What resources shall create **this Attribute** by means of **this Component** ?

Question för Resource availability: How well available are the Resources **this Resource** to realize **this Attribute** by means of **this Component** ?

Question to Resurse quality/competence in Knowledge area: How good are/is **this Resource** at **this Knowledge area** to realize **this Attribute** by means of **this Component** ?

Comments to Attribute-Component pair: Comments to **this Attribute** and **this Component**

Question to the comments for knowl. areas: Comments to the konwledge area **this Knowledge area** in connection to the resources!

Comments to Resources: Comments to Resources **this Resource** in connection to **this Attribute** and **this Component**

[*)] notations in bold style represent words that the guidance system picks from the actual column in that row where the cursor is located e.g., **this Attribute** will represent the name of the attribute in the Attribute-column in that row where the cursor is

Table (Guide)

Ex1
Explanation to formula for Requirement factor: Requirement factor represents the requirements that the it takes to realize the attribute with the component on this row. The formula is: requirement factor = signficance of attribute to project * sum (significances of knowledge areas)

Ex2
Explanation to formula for Shortage factor: Shortage factor represents shortage of resources when realizing attribute with component on this row. The formula is: shortage factor= (significance to project/availability of resource)*(# "1:s" in row*12 + # "2:s" *3,7 + # "3:s" * 1,7 + # "4:s" * 0,5 + # "5:s" *0,1

Ex3
Explanation to formula for Weighted Requirement factor: Weighted Requirement factor= requirement factor/ # rarted knowledge areas in row. Always evaluate Weighted Requirement factor together with Requirement factor, because the number of knowl. areas may infuence the risk!

Ex4
Explanation to formula for Weighted Shortage factor: Weighted Shortage factor= requirement factor/ # rarted knowledge areas in row. Always evaluate Weighted Shortage factor together with Shortage factor, because the number of knowl. areas may infuence the risk!

Ex5
Explanation to the formula for Project's risks: Project's risk factor = requirement factor * shortage factor in row. Always evaluate Weighted Risk factor together with risk factor, because the number of knowl. areas may infuence the risk!

Ex6
Explanation to formula for Weighted Project's risks: Weighted Risk factor= risk factor/ # rarted knowledge areas in row. Always evaluate Weighted Risk factor together with Risk factor, because the number of knowl. areas may infuence the risk!

Ex7
Explanation to formula for the Number of Knowledge areas rated: The formula counts the number of rated Knowledge areas in this row, the non-rated cells remain uncounted.

c:\wp\dr\Avh\Ques01.doc

Answer to Attribute text abbreviation	Abbreviate	to max.	4	signs for diagram text !
Answer to Component text abbreviation	Abbreviate	to max.	6	signs for diagram text !
Answer to Resource text abbreviation	Abbreviate	to max.	10	signs for diagram text !

Vc1
Question: comments to resources: Comments to and

Question for comments to resources comments Comments to the knowledge area in connection to the concept!

Appendix 10 Collection of Graphs from Analysis Report

Diagram 1.
Requirement factors of Concept

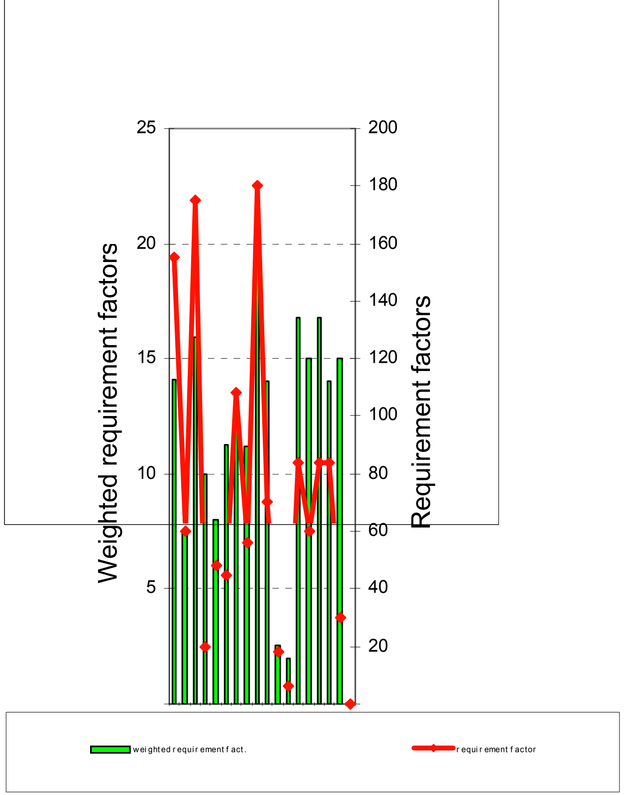


Diagram 2.
Lack factors of Resources

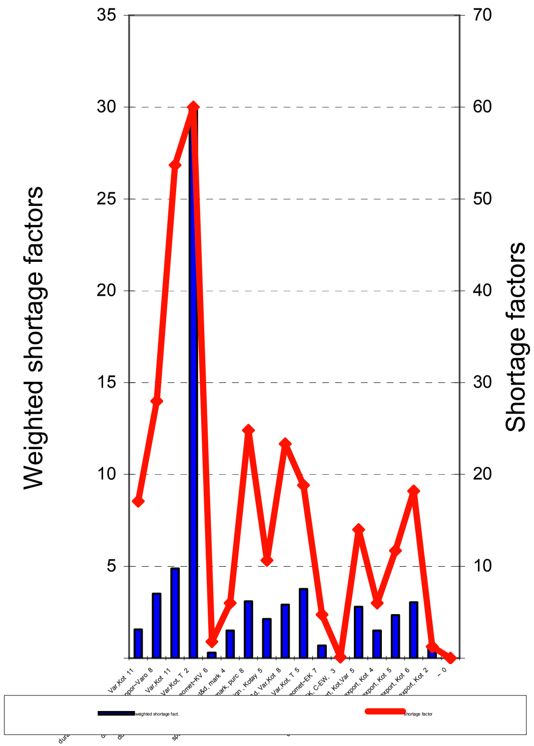


Diagram 3. Risks of Project

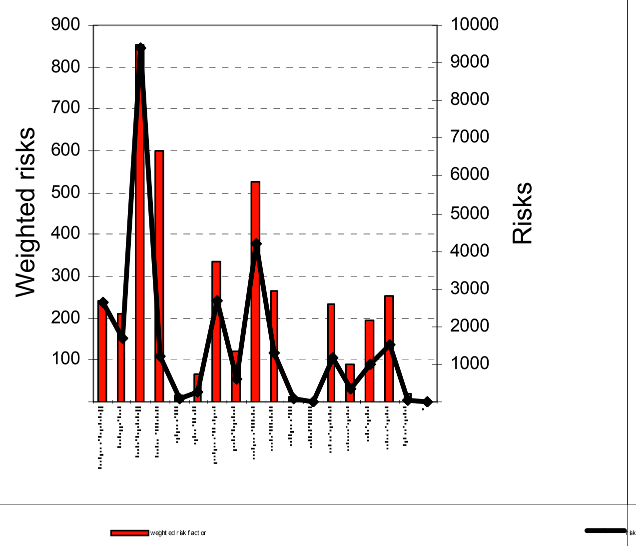
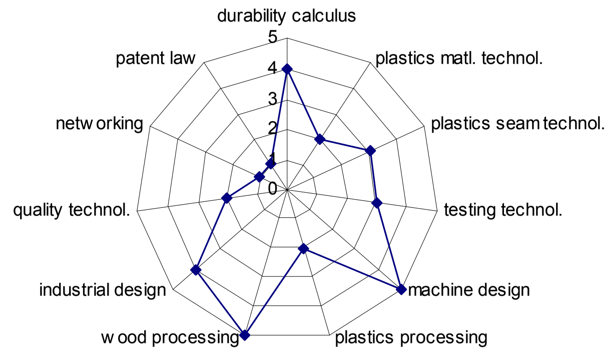


Diagram 4. Team's Competence



Appendix 11. Explanation of Analysis Progress, Analysis Interpretation and Preparation of Analysis Report

PROJECT PRESENTATION	Connecting projects Limiting factors	Stages or sequences in the realization of the Project
Name of Project Support plate **File name & path** C:\wp\delivery\EDCP250e.xls **Character of Project** **Branch** Technical [X] Commercial [ ] Financial [ ] **State of development** idea creation [ ] main ideas clear [ ] components sketched [ ] modification of something existing [X] repetitive EDCP-analysis [ ] **Placing within Organisation** product or service for sale [X] activity or product for internal use [ ]	**Mapping of connecting /-ed projects** Car body design Serviceability Export project **Limitations to the Project** not logistics not cargo body not African markets no new production line service only for France and Italy	Listing of available solutions Find out main properties from customers Explain main properties to production Selection of surface material Selection of core/fill material Compression Fire tests **Team members and sessions** session 2.10.1998 Peter Justice, Tina Varese, Paul Hall, I. Hawethorne session 13.10.1998 Peter Justice, Tina Varese, Keith gordon, I. Hawethorne, Pauline Storm

Project presentation

Concept presentation

	#1611#			CONCEPT ANALYSIS													
	# eval. knowledge areas	Requirement factors	Weighted req. factors	**Attributes or properties** (property by which we add value to the concept for our client and for ourselves)	**Abbre-viation column**	Significance	**Components of the Concept** (components by which the properties are realized)	**Abbre-viation column** ?	COMMENTS	R+	**Analysis team's competence** R- **Knowledge areas**		durability calculus	plastics matl. technol.	plastics seam technol.	testing technol.	machine design
											COMMENTS--->			plastics cours			
1	11	155	14	durability	dura		geometry	geom			durability calculus	1					
2	8	60	8	durability	dura		support plate material	supm			plastics matl. technol.	2					
3	11	175	16	durability	dura		surface film	sufi			plastics seam technol.	3					
4	2	20	10	durability	dura		seam method	s met	weldin		testing technol.	4					
5	6	48	8	replaceability	repl		geometry	geom			machine design	5					
6	4	45	11	replaceability	repl		seams	seam			plastics processing	6					
7	8	108	14	Space effectiveness	sp e		geometry	geom			wood processing	7					
8	5	56	11	Space effectiveness	sp e		surface film	sufi	nylon		industrial design	8					
9	8	180	23	functionality	func		geometry	geom			quality technol.	9					
10	5	70	14	functionality	func		surface film	sufi			networking	10					
11	7	18	3	outlook	outl		geometry	geom			patent law	11					
12	3	6	2	outlook	outl		finish	fins			Knowledge area	12					
13	5	84	17	Cost	cost		material selection	m sel			Knowledge area	13					

Resource presentation

	#1615#		RESOURCE ANALYSIS											
# eval. knowledge areas	Lack factors	Weighted Lack factors	**The Attributes (properties) and Components of the Concept** (property by which we add value to the concept for our client and for ourselves as well as the components that are used for this)	Abbre-viation column	Significance ?	**Resource factors** (persons, machines, contractors, etc. realize Attributes) R+ R-	Abbre-viation column	Availability	COMMENTS	durability calculus	plastics matl. technol.	plastics seam technol.	testing technol.	machine design
						COMMENTS		----	----->					
11	17	1,6	r1 durability & geometry	dur geo	5	KV, PJ, PK, JM, TV, VT, Varo Co, Kotay	KPPJ..+	5	depends on edging					
8	28	3,5	r2 durability & support plate material	dur spm	5	Varo Co,	Va	1	depends on edging					
11	54	4,9	r3 durability & surface film	dur suf	5	KV, PJ, PK, JM, TV, VT, Varo Co., Kotay	KPPJTV+	3						
2	60	30,0	r4 durability & seam method	dur sme	5	KV, JM, TV, SR, Varo Co., Kotay, TKK,	KJTS..+	2						
6	2	0,3	r5 replaceability & geometry	rep geo	3	KV	K	1						
4	6	1,5	r6 replaceability & seams	rep sea	3	KV, JM, VT, PJ, JS, SR, PS, KM,	KJVPJ…	2						
8	25	3,1	r7 space effectiveness & geometry	spe geo	4	KV, JM, VT, PJ, JS, SR, PS, KM, PK,	KJVPJ….	2	should the group					
5	11	2,1	r8 space effectiveness & surface film	spe suf	4	KV, JM, VT, PJ, PK, TV., Kotay	KJV...+	5						
8	23	2,9	r9 functionality & geometry	fun geo	5	KV, JM, VT, PJ, PK, TV., Kotay, Varo Co.	KJV...+..	3						
5	19	3,8	r10 functionality & surface film	fun suf	5	KV, JM, VT, PJ, TV., Kotay, Varo Co., TKK	KJV...+…	3	depends on edging					
7	5	0,7	r11 outlook & geometry	outl geo	1	EK	E	2						
3	0	0,0	r12 outlook & finish	outl fin	1	EK, C-EW,	EC	3						
5	14	2,8	r13 cost & material selection	cos m s	4	KR, C-EW, PH, TV, JM, Kota Ky, Varo Co.,	KJV...+..	4						

Concept analysis

	#1611#			CONCEPT ANALYSIS													
	# eval. knowledge areas	Requirement factors	Weighted req. factors	**Attributes or properties** (property by which we add value to the concept for our client and for ourselves)	Abbre-viation column	Significance	**Components of the Concept** (components by which the properties are realized)	Abbre-viation column ?	COMMENTS	R+	**Analysis team's competence** R- **Knowledge areas**		durability calculus	plastics matl. technol.	plastics seam technol.	testing technol.	machine design
											COMMENTS--->			plastics cours			
1	11	155	14	durability	dura	5	geometry	geom		4	durability calculus	1	4	3	4	2	2
2	8	60	8	durability	dura	5	support plate material	supm		2	plastics matl. technol.	2				2	1
3	11	175	16	durability	dura	5	surface film	sufi		3	plastics seam technol.	3	4	3	3	4	3
4	2	20	10	durability	dura	5	seam method	s met	weldin	3	testing technol.	4					
5	6	48	8	replaceability	repl	3	geometry	geom		5	machine design	5		5	2	2	
6	4	45	11	replaceability	repl	3	seams	seam		2	Plastics processing	6					
7	8	108	14	space effectiveness	sp e	4	geometry	geom		5	wood processing	7	4	3	4	4	3
8	5	56	11	space effectiveness	sp e	4	surface film	sufi	nylon	4	industrial design	8				5	2
9	8	180	23	functionality	func	5	geometry	geom		2	quality technol.	9	5	5	5	5	5
10	5	70	14	functionality	func	5	surface film	sufi		1	networking	10				5	2
11	7	18	3	outlook	outl	1	geometry	geom		1	patent law	11		2	2	3	4
12	3	6	2	outlook	outl	1	finish	fins			Knowledge area	12					
13	5	84	17	cost	cost	4	material selection	m sel			Knowledge area	13				3	5

Resources analysis

	#1615#		RESOURCE ANALYSIS											
# eval. knowledge	Lack factors	Weighted	**The Attributes (properties) and**	Abbre-viation column	Significance	**Resource factors** (persons, machines, contractors, etc. realize	Abbre-viation Column	Availabi		durability	plastics matl.	plastics seam	testing technol.	machine

? R+ R-

areas		Lack factors	**Components of the Concept** **(property by which we add value to the concept for our client and for ourselves as well as the components that are used for this)**			**Attributes)**		**lity**	**COM MEN TS**	calculus	technol.	technol.		design
						COMMENTS		----	----->					
11	17	1,6	r1 durability & geometry	dur geo	5	KV, PJ, PK, JM, TV, VT, Varo Co, Kotay	KPPJ..+	5	depends on edging	2	3	3	2	5
8	28	3,5	r2 durability & support plate material	dur spm	5	Varo Co,	Va	1	depends on edging				fill !	fill !
11	54	4,9	r3 durability & surface film	dur suf	5	KV, PJ, PK, JM, TV, VT, Varo Co., Kotay	KPPJTV+	3		2	3	2	5	3
2	60	30,0	r4 durability & seam method	dur sme	5	KV, JM, TV, SR, Varo Co., Kotay, TKK,	KJTS..+	2						
6	2	0,3	r5 replaceability & geometry	rep geo	3	KV	K	1			5	5	5	
4	6	1,5	r6 replaceability & seams	rep sea	3	KV, JM, VT, PJ, JS, SR, PS, KM,	KJVPJ…	2						
8	25	3,1	r7 space effectiveness & geometry	spe geo	4	KV, JM, VT, PJ, JS, SR, PS, KM, PK,	KJVPJ….	2	should the group	4	2	4	3	5
5	11	2,1	r8 space effectiveness & surface film	spe suf	4	KV, JM, VT, PJ, PK, TV., Kotay	KJV...+	5					2	3
8	23	2,9	r9 functionality & geometry	fun geo	5	KV, JM, VT, PJ, PK, TV., Kotay, Varo Co.	KJV...+..	3		3	4	2	3	2
5	19	3,8	r10 functionality & surface film	fun suf	5	KV, JM, VT, PJ, TV., Kotay, Varo Co., TKK	KJV...+…	3	depends on edging				3	2
7	5	0,7	r11 outlook & geometry	outl geo	1	EK	E	2			4	4	4	2
3	0	0,0	r12 outlook & finish	outl fin	1	EK, C-EW,	EC	3						
5	14	2,8	r13 cost & material selection	cos m s	4	KR, C-EW, PH, TV, JM, Kota Ky, Varo Co.,	KJV...+..	4					4	4

Deliverables, Concept and Resource analysis results

COLLATION TABLE FOR ANALYSIS RESULTS #1649# ?

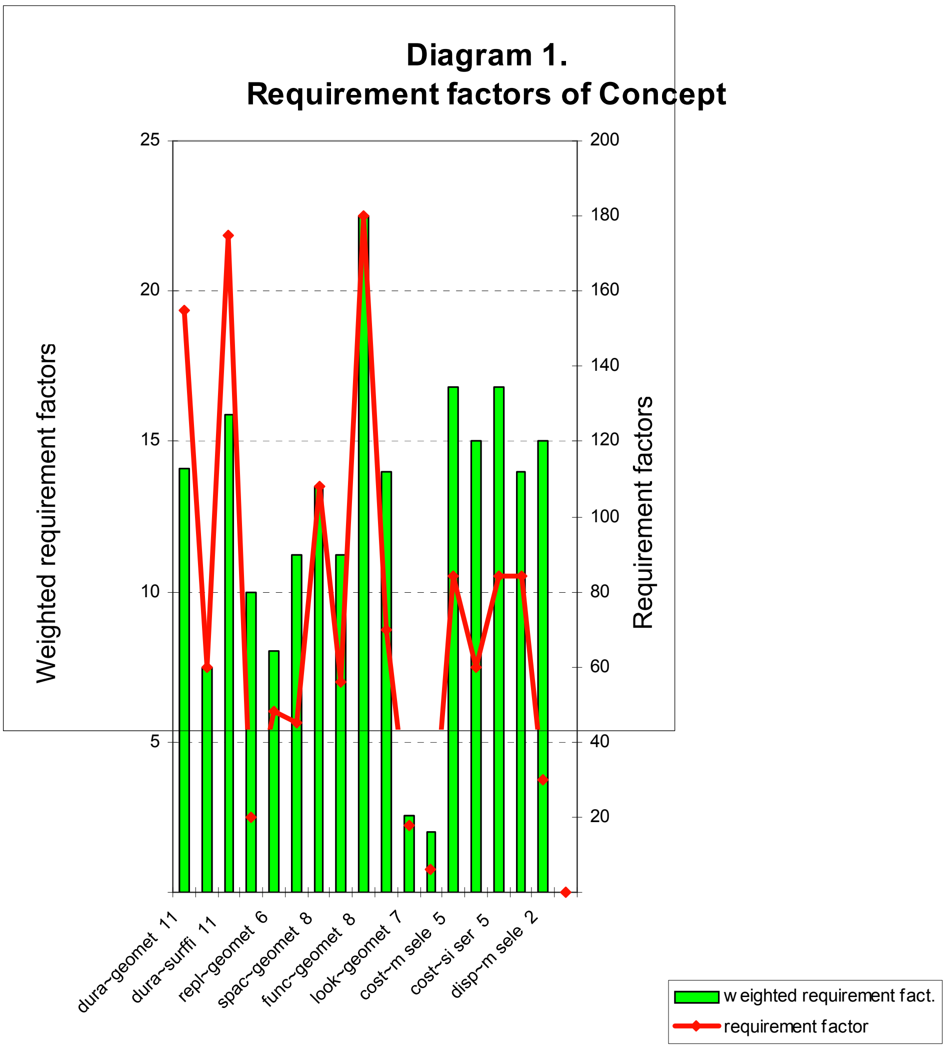
Attribute-Component-Resource-groups	wghtd Requirement factor	Requirement factor	wghtd Lack factor	Lack factor	weighted Risk factor	Risk factor	# knowl areas evaluated	Comments from Concept ar New: guidance for	Comments from Resource analysis
r1 dura & geomet & design , Var,Kot	14	155	1,55	17	241	2651	11		
r2 dura & suppor & Varo	8	60	3,50	28	210	1680	8		depends on edging machine
r3 dura & surffi & design , Var,Kot	16	175	4,88	54	854	9392	11		depends on edging machine
r4 dura & seammt & r&d, Var,Kot, T	10	20	30,00	60	600	1200	2	welding, riveting	
r5 repl & geomet & KV	8	48	0,30	2	14	86	6		
r6 repl & seams & t&d, mark	11	45	1,50	6	68	270	4		
r7 spac & geomet & r&d, mark, purc	14	108	3,10	25	335	2678	8		should the group be splitted
r8 spac & surffi & design , Kotay	11	56	2,13	11	119	596	5	nylon, polyester	
r9 func & geomet & r&d, Var,Kot	23	180	2,92	23	525	4200	8		
r10 func & surffi & r&d, Var,Kot, T	14	70	3,77	19	264	1318	5		depends on edging machine
r11 look & geomet & EK	3	18	0,68	5	12	86	7		
r12 look & finish & EK, C-EW,	2	6	0,03	0	0	1	3		
r13 cost & m sele & export, Kot,Var	17	84	2,80	14	235	1176	5		

Deliverables, Knowledge analysis results

Collation table for the knowledge areas #1650#

Knowledge area	Dependency factor (Risk of Knowl. area rel to Concept)	Weighted depsndency factor (weighted risk rel to Concept)	Deficiency factor (Risk of Knowl. area rel to Resources)	Weighted deficiency factor (weighted risk rel to Resources)	Risks of Project rel to Knowl. areas	weighted risks of Project rel to Knowl. areas	# Knowl areas evaluated	**Comments**	
Diagram No	8	9	10	11	12	13		**relative to Concept**	**relative to Resources**
durability calculus	22	4	10	2	227	45	5		
plastics matl. technol.	26	4	8	1	216	31	7	plastics course	
plastics seam technol.	29	4	18	2	513	64	8		
Testing technol.	39	4	15	1	601	55	11		
machine design	29	3	19	2	545	55	10		
plastics processing	38	3	17	1	654	54	12		designers to Interplas exhibition in Germany!
wood processing	30	3	25	3	762	85	9		
industrial design	23	3	9	1	216	24	9		
quality technol.	22	3	23	3	515	64	8		
networking	33	3	27	2	904	82	11		
patent law	21	2	23	2	477	48	10	patent law course	make contract with patent attorney
Knowledge area									
Knowledge area									
Knowledge area									

Example of Diagram: Requirement factors of Concept



Example of Diagram: Risks of Project

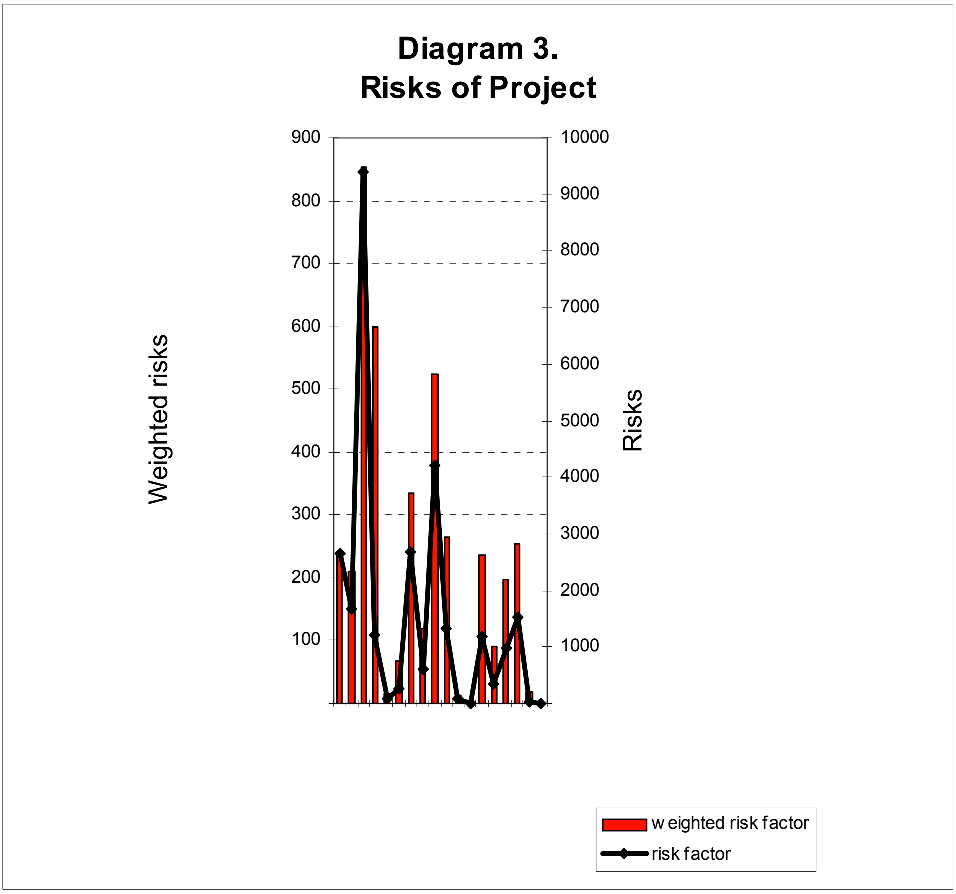
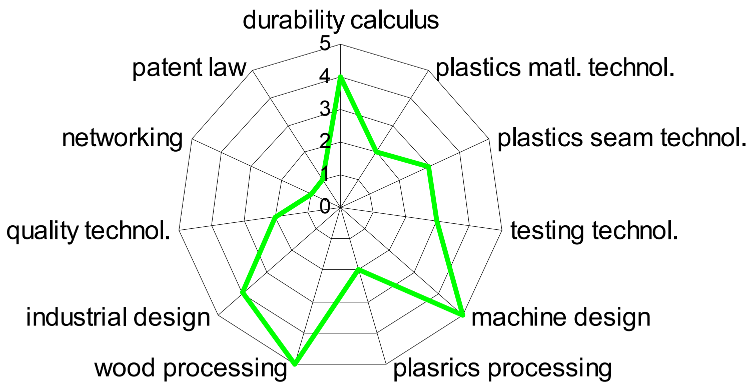


Diagram 3.
Risks of Project
Weighted risks
Risks
900
800
700
600
500
400
300
200
100
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
w eighted risk factor
risk factor

Example of Diagram: Analysis team's competence, from self-rating in Concept analysis table

Diagram 4
Analysis Team Competence for Knowledge Areas



Preparation for Analysis report: Collation table for analysis results sorted for Weighted requirement factor

COLLATION TABLE FOR ANALYSIS RESULTS #1649# ?

Attribute-Component-Resource-groups	wghtd Requirement factor	Requirement factor	wghtd Lack factor	Lack factor	weighted Risk factor	Risk factor	# knowl areas ev at	Comments from Concept	Comments from Resource analysis
r9 func & geomet & r&d, Var,Kot	23	180	2,92	23	525	4200	8		
r13 cost & m sele & export, Kot,Var	17	84	2,80	14	235	1176	5		
r3 dura & surffi & design , Var,Kot	16	175	4,88	54	854	9392	11		depends on edging machine
r1 dura & geomet & design , Var,Kot	14	155	1,55	17	241	2651	11		
r7 spac & geomet & r&d, mark, purc	14	108	3,10	25	335	2678	8		should the group be splitted
r10 func & surffi & r&d, Var,Kot, T	14	70	3,77	19	264	1318	5		depends on edging machine
r6 repl & seams & t&d, mark	11	45	1,50	6	68	270	4		
r8 spac & surffi & design , Kotay	11	56	2,13	11	119	596	5	nylon, polyester	
r4 dura & seammt & r&d, Var,Kot, T	10	20	30,00	60	600	1200	2	welding, riveting	
r2 dura & suppor & Varo	8	60	3,50	28	210	1680	8		depends on edging machine
r5 repl & geomet & KV	8	48	0,30	2	14	86	6		
r11 look & geomet & EK	3	18	0,68	5	12	86	7		
r12 look & finish & EK, C-EW,	2	6	0,03	0	0	1	3		

New: guidance for algorithms

Preparation for Analysis report: Collation table for Knocledge area results sorted for Weighted dependency factor

Collation table for the knowledge areas #1650#									
Knowledge area	Dependency factor (Risk of Knowl. area rel to Concept)	Weighted depsndency factor (weighted risk rel to Concept)	Deficiency factor (Risk of Knowl. area rel to Resources)	Weighted deficiency factor (weighted risk rel to Resources)	Risks of Project rel to Knowl. areas	weighted risks of Project rel to Knowl. areas	# Knowl areas evaluated	**Comments**	
Diagram No	8	9	10	11	12	13		**relative to Concept**	**relative to Resources**
durability calculus	22	4	10	2	227	45	5		
plastics matl. technol.	26	4	8	1	216	31	7	plastics course	
plastics seam technol.	29	4	18	2	513	64	8		
Testing technol.	39	4	15	1	601	55	11		
machine design	29	3	19	2	545	55	10		
plastics processing	38	3	17	1	654	54	12		designers to Interplas exhibition in Germany!
wood processing	30	3	25	3	762	85	9		
industrial design	23	3	9	1	216	24	9		
quality technol.	22	3	23	3	515	64	8		
networking	33	3	27	2	904	82	11		
patent law	21	2	23	2	477	48	10	patent law course	make contract with patent attorney
Knowledge area									
Knowledge area									
Knowledge area									

Appendix 12. Example of Analysis Report

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EDCP A N A L Y S I S - R E S U L T S R E P O R T

Report of analyzed case: Support plate (c:\wp\Demo\En\Anademe.doc)

Concept

Attributes and components

The following Attributes were selected and they were rated for significance relative to the project according to the table below

Attribute	Significance
durability	5
functionality	5
disposability	5
space effectiveness	4
cost	4
replaceability	3
outlook	1

The folliwing Attribute-Concept pairs emerged, they appear in the order of their Requirement factor in the table below

Attribute-Component pair	weighted Requirement factor	Requirement factor
functionality & geometry 8	23	180
cost & material selection 5	17	84
cost & size of series 5	17	84
durability & surface film 11	16	175
cost & contractors 4	15	60
disposability & material selection 2	15	30
durability & geometry 11	14	155
functionality & surface film 5	14	70
cost & few models 6	14	84
space effectiveness & geometry 8	14	108
replaceability & seams 4	11	45
space effectiveness & surface film 5	11	56
durability & seam method 2	10	20
replaceability & geometry 6	8	48
durability & support plate material 8	8	60
outlook & geometry 7	3	18
outlook & finish 3	2	6

Knowledge areas

The following Knowledge areas were selected based on the Attribute-Component pairs. The adjacent number expresses the team members' rating of their competence in the Knowledge areas

Knowledge area	**Team's competence**
durability calculus	4
plastics matl. technol.	2
plastics seam technol.	3
testing technol.	3
machine design	5
plasrics processing	2
wood processing	5
industrial design	4
quality technol.	2
networking	1
patent law	1

The Dependency factors (relative to the Concept) of the Knowledge areas is expressed in the table below, sorted according to weighted Dependency factors

Knowledge area	Dependency factor (Risk of Knowl. area rel to Concept)	weighted Dependency factor	# Knowl. areas evaluated
1 durability calculus	22	4,4	5
2 plastics matl. technol.	26	3,7	7
3 plastics seam technol.	29	3,6	8
4 testing technol.	39	3,5	11
7 wood processing	30	3,3	9
6 plastics processing	38	3,2	12
10 networking	33	3,0	11
5 machine design	29	2,9	10
9 quality technol.	22	2,8	8
8 industrial design	23	2,6	9
11 patent law	21	2,1	10

Conclusions about the Concept

Attribute-Component pairs

The Attribute-Component pair functionality & geometry (on row 8) clearly exhibited the biggest requirement, both the weighted and non-weighted requirement factors were the biggest in the table. From the Concept analysis table can be seen that this pair is strongly dependent on many significant knowledge areas (six knowledge areas were rated to 5).

Knowledge areas

The Dependency factors of the knowledge areas were fairly evenly distributed. Durability calculus, plastics materials. technology., plastics seam technology and testing technology exhibited the biggest weighted dependency factors.

Resources

The Attribute-Component-Resource groups, sorted according to decending weighted Lack factors appear in the table below. The table also shows the non-weighted Lack factors. The r-number in front of each group expresses the row number in the analysis tables, for possible further reference

Print time 21-02-99 11:34			
COLLATION TABLE FOR ANALYSIS RESULTS			
Attribute-Component-Resource-groups	weighted Lack factor	Lack factor	# knowledge areas evaluated
r4 durability & seam method 2 r&d, Var,Kot, T	30,00	60	2
r3 durability & surface film 11 design , Var,Kot	4,88	54	11
r10 functionality & surface film 5 r&d, Var,Kot, T	3,80	19	5
r2 durability & support plate material 8 Varo	3,56	29	8
r7 space effectiveness & geometry 8 r&d, mark, purc	3,15	25	8
r16 cost & few models 6 export, Kot	3,03	18	6
r9 functionality & geometry 8 r&d, Var,Kot	2,98	24	8
r13 cost & material selection 5 export, Kot,Var	2,88	14	5
r15 cost & size of series 5 export, Kot	2,34	12	5
r8 space effectiveness & surface film 5 design , Kotay	2	11	5
r1 durability & geometry 11 design , Var,Kot	1,55	17	11
r6 replaceability & seams 4 t&d, mark	1,50	6	4
r14 cost & contractors 4 export, Kot	1,50	6	4
r17 disposability & material selection 2 export, Kot	0,75	2	2
r11 outlook & geometry 7 EK	0,70	5	7
r5 replaceability & geometry 6 KV	0,00		6
r12 outlook & finish 3 EK, C-EW,	0,00		3

The Deficiency factors (relative to the Concept) of the Knowledge areas is expressed in the table below, sorted according to weighted Deficiency factors

Knowledge area	Deficiency factor (Risk of Knowl. area rel to Resources)	weighted Deficiency factor	# Knowl. areas evaluated
9 quality technol.	23,4	2,9	8
7 wood processing	25,4	2,8	9
10 networking	27,4	2,5	11
11 patent law	22,7	2,3	10
3 plastics seam technol.	17,7	2,2	8
1 durability calculus	10,3	2,1	5
5 machine design	18,8	1,9	10

4 testing technol.	15,4	1,4	11
6 plasrics processing	17,2	1,4	12
2 plastics matl. technol.	8,3	1,2	7
8 industrial design	9,4	1,0	9

Conclusions about the Resources

Attribute-Component-Resource groups

The Attribute-Component-Resource group durability & seam method 2Rr&D, Varo, Kotay, TKK exhibited clearly the biggest Lack factor. From row 4 in the Resource analysis table can be seen that this group is dependent on two knowledge areas with abilities rated only to 1, furthermore the availability of the resources on this row has been rated only to 2. The next biggest lack factors belong to rows 3, 10, 2 and 7. On row 3 the group durability & surface film design office, Varo,Kotay the resource abilities were rated to 1 once and to 2 three times, on row 10 the group functionality & surface film 5 R&D, Var,Kot, TKK exhibits resource ability ratings of 2 for two knowledge areas. On row 2 the group durability & support plate material 8 Varo suffers from resource availability of 1. On row 7 the group space effectiveness & geometry & R&D, marketing, purchase was rated to 2 for ability of two resources, and their availability was rated to 2

Knowledge areas

The knowledge areas quality technology, wood processing and networking represent the biggest deficiency factors both as weighted and non-weighted.

General conclusions

The Attribute-Component-Resource groups appear in the following table sorted according to weighted Risk factor

COLLATION TABLE FOR ANALYSIS RESULTS

Attribute-Component-Resource-groups	weighted risk	Risk	# knowledge areas evaluated
r3 durability & surface film 11 design , Var,Kot	854	9392	11
r4 durability & seam method 2 r&d, Var,Kot, T	600	1200	2
r9 functionality & geometry 8 r&d, Var,Kot	536	4290	8
r7 space effectiveness & geometry 8 r&d, mark, purc	340	2722	8
r10 functionality & surface film 5 r&d, Var,Kot, T	266	1330	5
r16 cost & few models 6 export, Kot	255	1529	6
r13 cost & material selection 5 export, Kot,Var	242	1210	5
r1 durability & geometry 11 design , Var,Kot	241	2651	11
r2 durability & support plate material 8 Varo	214	1710	8
r15 cost & size of series 5 export, Kot	197	983	5
r8 space effectiveness & surface film 5 design , Kotay	120	600	5
r14 cost & contractors 4 export, Kot	90	360	4
r6 replaceability & seams 4 t&d, mark	68	270	4
r17 disposability & material selection 2 export, Kot	23	45	2
r11 outlook & geometry 7 EK	13	88	7
r5 replaceability & geometry 6 KV			6
r12 outlook & finish 3 EK, C-EW,			3

Knowledge areas

Knowledge area	Risks of Project rel to Knowl. areas	Weighted risks of Project rel to Knowl. areas	# Knowl. areas evaluated
7 wood processing	762	85	9
10 networking	904	82	11
3 plastics seam technol.	513	64	8
9 quality technol.	515	64	8
4 testing technol.	601	55	11
5 machine design	545	55	10
6 plasrics processing	654	54	12
11 patent law	477	48	10
1 durability calculus	227	45	5
2 plastics matl. technol.	216	31	7
8 industrial design	216	24	9

General conclusions about the project Support plate

The Attribute-Component-Resource-group durability & surface film 11 design , Var,Kot (on row 3) clearly represents the biggest risks both as weighted and non-weighted. The group r4 durability & seam method 2 D&D, Varo,Kotay, TKK represented the second biggest weighted risk factor, from row 4 in the Analysis collation teble can be seen that the lack factors in the resource column are relatively large, but the requirement factors in the concept column are not so. From row 4 in the Resource analysis table it can further be seen that the ability has been rated to 1 for both knowledge areas involved.

The risk factors of the Knowledge areas are quite evenly distributed. The biggest risk factors are represented by wood processing and networking.

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Appendix 13. Tables of Improvements to bases during the Development of the EDCP Analysis System

Items introduced to the Concept analysis table of the model in stage 1 #1789#						
Stage	**Base**	**Table / Graph**	**Group**	**Column / Row**	**Activity**	**Algorithm**
1	1.1	Concept	Concept presentation	Conc. Attributes	listing	
			Concept analysis	Attr. Significance	rating	
				Market benefit	rating	
				Techn. problem	rating	
			Concept components	Concept components	listing	
			Technology presentation	Technologies or sciences	listing	
			Technology competence analysis	Technology significance	rating	
				Technology difficulty	rating	
				Technology newness	rating	
			Key attributes	Key attribute	listing, manual transfer	
				Key attribute significance	rating, manual transfer	
			Key components	Key components	listing, manual transfer	
			Risk of concept	Risk of concept	listing, manual transfer	
				Difficulty rel. competitors	rating, manual transfer, sorted	
				Newness	rating, manual transfer, sorted	
				Risk factor, concept		Risk factor

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Items introduced to Resource analysis table of the the model in stage 1						
Stage	**Base**	**Table / Graph**	**Group**	**Column / Row**	**Activity**	**Algorithm**
1	1.2 #1790#	Resour-ces	Resources attrib.	Res. Attributes	Listing	
				Attr. signif.	Rating	
				Attr. Ability	Rating	
				Ability dimension	Listing	
			Resource component	Resource component	Listing	
			Technologies, sciences	Technology significance	Rating	
				Difficulty rel. competitors	Rating	
				Newness	Rating	
				Difficulty × Newness		diff. × newness
			Key attributes	Key attribute	listing, manual transfer	
				Key attribute significance	rating, manual transfer	
				Key ability	rating, manual transfer	
			Resource requirement	Key resource requirement	rating, manual transfer	
				Key res. req. significance	listing, manual transfer	
				Risks fr. resources	listing, manual transfer	
				Significance, risks of resources	rating, manual transfer	
				Difficulty relative to competitors	rating, manual transfer	
				Newness	rating, manual transfer	
				Difficulty × newness		difficulty × newness
				Risk factor, resources		risk factor

Items introduced to the Matching table of the the model in stage 1 #1791#					
Stag	**Bas**	**Table / Graph**	**Group**	**Column / Row**	**Activity**

1	1.3	Matching of Cons. and Res.	Risks of concept	Rating of techn. risks	listing, manual transfer
				Difficulty	rating, manual transfer
				Newness	rating, manual transfer
				Risk factor	value, manual transfer
			Risks of resources	Technology	listing, manual transfer
				Significance	rating, manual transfer

Items introduced to Concept analysis table of the the model in stage 2 #1741#						
Stage	**Base**	**Table / Graph**	**Group**	**Column / Row**	**Activity**	**Structure**
2	2.1	Concept	Technology presentation	individual technology columns	listing	grid structure
				Significance	rating	for each technology
				Difficulty		
				Newness		

Items introduced to Resource analysis table of the the model in stage 2 #1742#						
Stage	**Base**	**Table / Graph**	**Group**	**Column / Row**	**Activity**	**Structure**
2	2.2	Resource	Technology presentation	individual technology columns	listing	grid structure
				Significance	rating	for each technology
				Difficulty		
				Newness		

Items introduced to Concept and Resource analysis tables of the model in stage 3 #1797#					
Stage	**Base**	**Table / Graph**	**Group**	**Column / Row**	**Structure**
3	3.1	Concept	Technology presentation	formula columns for each technology	Concept and Resources tables besides of each other in same sheet
		Resources	Technology presentation	formula columns for each technology	

Items introduced to the Analysis tables and Graphs of the model in stage 4 #1798#				
Stage	**Base**	**Table / Graph**	**Group**	**Structure**
4	4 (not shown)	Graphs	risks of concept	Concept and Resources tables below each other in same sheet
			risks of conc. relative to technology	
			risks of res. relative to technology	
		Key factor	Key attr., comp and tech.	Tables removed from Cons. and Res. tables

Items introduced to the Analysis tables and Report form of the model in stage 5 #1745#					
Stage	**Base**	**Table / Graph**	**Group**	**Column / Row**	**Algorithm**
5	5.1 and 5.2	Concept	Risk factor of concept	number of technologies rated	counts rated technologies
				weighted risk factor	weighing formula
		Resources	Risk factor of resources	number of technologies rated	counts rated technologies
				weighted risk factor	weighing formula
5	Coreen51.xls	Report form	Concept	Attr-comp-pair	
				# tech tested	
				risk factor	
				w. risk factor	
			Resources	Attr-comp-pair	
				# tech tested	
				risk factor	
				w. risk factor	
			Technologies	Technology	
				Conc: #a/c-pairs test	
				Risk factor	
				W risk factor	
				Res: #a/c-pairs test	
				Risk factor	
				W risk factor	

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Items introduced to Concept analysis table of the model in stage 6 #1746#						
Stage	**Base**	**Table / Graph**	**Group**	**Column / Row**	**Activity**	**Structure**
6	6.1	Concept analysis	Grid	Knowledge areas	Knowledge area introduced as term for Technology	Formulas removed from grid to separate formula arera
						Risk values of technologies displayed at top of table
						Larger font

Items introduced to Analysis tables of the model in stage 7 #1747#							
Stage	**Base**	**Table / Graph**	**Group**	**Column / Row**	**Activity**	**Structure**	**Algorithm**
7	7.1 and 7.2						
		Project pre-sentation	Project characterization	Branch	"x-rating"		
				State of developm.	"x-rating"		
				Organiz. placement	"x-rating"		
			Pre-analysis of project	Main attribute	listing		
				Significance	rating		
				Components	listing		
				Knowledge areas	listing		
				Signif. of Knowl.Ar.	rating(1/Kn.ar.)		
				# knowl. areas rated			Count Kn.ar.
				Risk factor			Risk factor (new f.)
				Weighted risk fact.			Weighting formula
				Comments	listing		
		Concept and Resources Tables		Comments to attr/comp-pairs, resources and knowledge areas		Multi-sheet structure	
				Intermediate "heading" rows linked to Pre-analysis table			Automatic copy from Pre-analysis table Central filling for Difficulty and Newness

Items introduced to the EDCP model in stage 8 #1748#				
Stage	**Base**	**Table / Graph**	**Macro**	**Activity**
8	7-type base, without pre-analysis sheet and linked rows	Concept and Resources Tables	Row addition	adds row
			Row deletion	deletes row
			Guidance	guides analysers

Items introduced to Analysis tables of the model in stage 9 #1749#							
Stage	**Base**	**Table / Graph**	**Group**	**Column / Row**	**Activity**	**Structure**	**Algorithm**
9	9.1-9.3	Project presentation	Connected projects	Connected projects			
				Limitations			
			Stages in realization	Stages in realization			
		Concept table		Techn. problems and Market benefit removed	number of ratings reduced	Both tables in same Excel-sheet	
		Resources table	Knowledge area grid	Attr-comp-pairs	Auto-copy		
				only one column (significance)/Knowl. areas	"fill in" notation in grid		New risk value formula

Items introduced to the EDCP model in stage 10 #1750#						
Stage	**Base**	**Table / Graph**	**Group**	**Column / Row**	**Structure**	**Algorithm**
10	10.1 and 10.2	Concept and Resources			Tables divided into 4 separate individual anlysis tables	
		Sorting table	Tentop			automatic transfer from analysis tables
			Tentop knowledge areas			
			Analysis collation table	Concept		
				Resources		
				Knowledge areas		
				Sorting areas		

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Items introducedto the EDCP model in stage 11 #1713#					
Stage	**Base**	**Table / Graph**	**Column / Row**	**Activity**	**Algorithm**
11	11.1	Pre-analysis	Needs pf project	listing	
			Technical problems -> Challenge	listing	
			Attribute-Component pairs		
			Importance		importance = signif. to customer + marketing benefit
			Criticality		criticality = importance × challenge
		Concept	Significance to customer for each knowledge area /attr.-comp. group cell in grid	rating	
		Resources	Knowledge area ratings reduced to one per knowledge area/attr.-comp. group cell in grid, and named Resource quality	rating	

Items introduced to the Analysis table in stage 11 #1720#					
Stage	**Base**	**Table / Graph**	**Column / Row**	**Activity**	**Algorithm**
11	11.2	Analysis table	Attribute	listing	
			Significance	rating	
			Market benefits	rating	
			Components	listing	
			Technical challenge	rating	
			Risk for importance		importance = significance + marketing benefit
			Risk for Criticality		criticality = importance/technical challenge

Items introduced to the EDCP model in stage 11 #1719#						
Stage	**Base**	**Table / Graph**	**Group**	**Column / Row**	**Activity**	**Algorithm**
11	11.3	Concept		Resources (removed from Resource table)	listing	
				Availability of resources (removed as above)	rating	
		Resource		Resources and Res. availability columns removed	listing rating	
				Attribute-Component-Resource group		
				Importance/availability		=importance/availability
				Risk of each Attr-Comp-Resource group in grid		
		Sorting	Shortage of Resource components	order of columns changed		
		Graph	Shortage of Resource components			
			Risk factor of Resource components			

Items introduced to Analysis tables of the model in stage 12 #1751#						
Stage	**Base**	**Table / Graph**	**Column / Row**	**Activity**	**Structure**	**Algorithm**
12	EDCP250.xls	Concept table	Knowledge areas feeding column	listing	Tables besides of each other in Excel-sheet	Algorithms for lack factor with weighted parameters for rating values
			Team self-rating	rating		
		Resources table				

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