STRATEGIC DECISIONS IN COMPUTER AIDED DESIGN DEVELOPMENT

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The primary goal of this paper is to present a decision-making process for managers of a design group. The aim of the process is to improve significantly the competitiveness of the company in such a way that it uses and supports: competence and development of individuals; creativity; and trends in CAD. The proposed approach for strategic decisions in CAD development (figure 1) consists of seven stages: the performance objectives for CAD development; selection of action plan; preliminary development project review; selection; managing the benefits, costs and risks during the implementation; post evaluation; competitive edge evaluation.

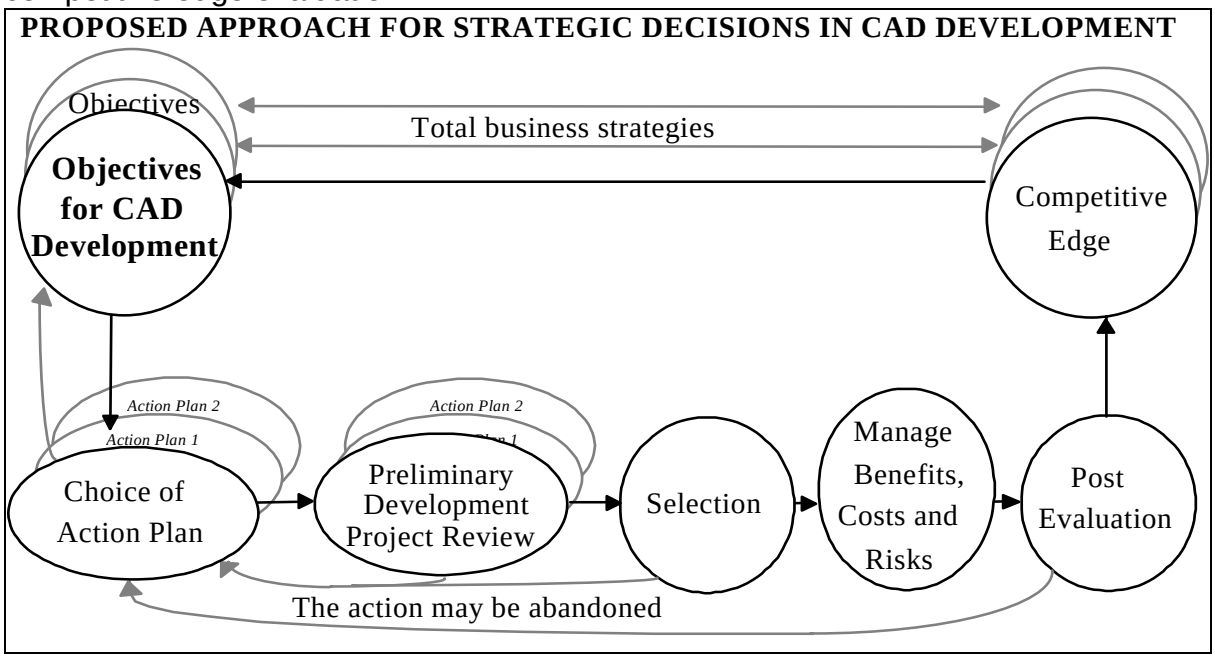

Figure 1. The proposed approach for strategic decisions in CAD development.

1. INTRODUCTION

The paper is based on research made in Tampere University of Technology. Supervisers of the research were Professor Raimo Salokangas and Dr. Tech. Tapio Majahalme. The approach was developed after interviewing fourteen companies. Nine of the companies made their business in the building industry, five in the mechanical industry. In addition, the approach was tested in three companies (two in the building industry, one in the mechanical industry).

The main challenge of the companies is that the pace for societal, economic and technological change quickens. The areas in which decision-makers have certainty become all the time more limited. This places a greater premium on understanding which significant factors are predetermined, which are controllable

and which are uncertain. So implications of time based change can be better assessed

The companies have to decide how the technology development is followed (figure 2). Sometimes the firms follow the continuous chaos line when controlled change is wanted even though it causes chaos. According to the other alternative, the changes are made step by step while comparing the risks of using the newest technology, suffering first from immaturity and then suffering from outdated software before a new strategic step is made to a new environment. The attitude of employees is very often a problem when the new tools are learned. The alteration resistance is significant when changes in working methods are implemented.

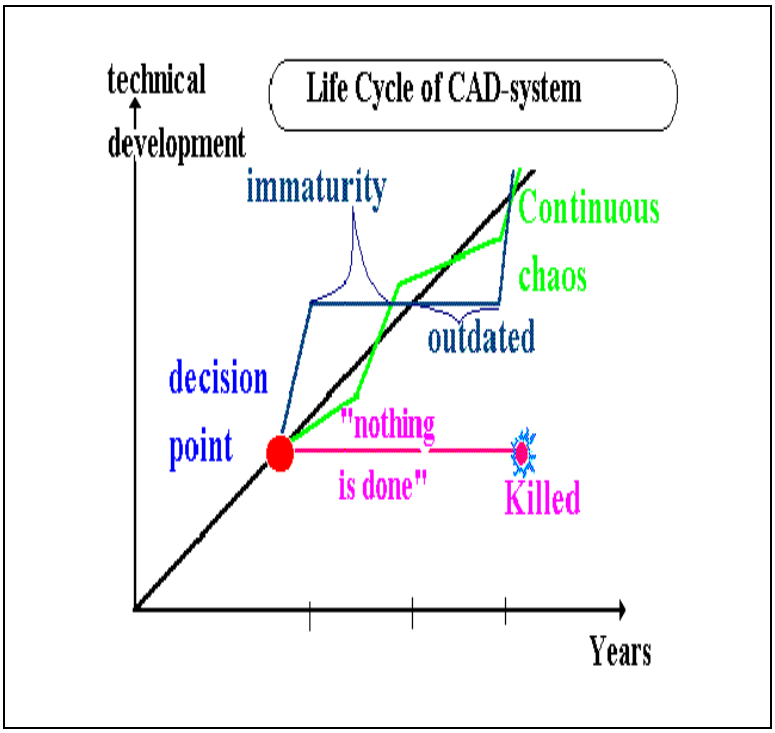

Figure 2. The question is how to follow the technology development while being as economical as possible.

New innovations are needed to create better services to people. The designers are the ones who are able to develop the products or buildings or services so that they can maintain sustainable development. Innovation does not appear in the idea of maintenance of existing solutions, so we need an environment where creativity is either accepted or even desired. The CAD environment can increase creativity by providing an exciting working environment and a feeling of having fun.

The whole life cycle of the product must be taken into consideration when choosing the new CAD system. For example, the greatest advantage may come from the facility management of the house, or that the production time is shorter because of the interactive use of information during the whole process. The designers can also benefit from the integration. The need of decreasing total cycle time challenges the designers.

The benefits and costs of new technologies are difficult to estimate. Many benefits and costs are intangible. The senior managers are often more aware of the costs, excluding hidden costs, than they are of the benefits. In addition they seldom have their own experiences of extensive use of computers. The alteration resistance of employees is also important when the opportunity costs are minimised. The benefits of information models have been proved by researchers. However, the practices in companies have not improved as could be expected.

Little evidence of direct competitive advantage from the use of CAD can be found, except in a few instances like new ìproductsî made by computer, for example, hypermedia presentations. However, benefits resulting from an innovative application of information technology can be more readily defended if the system exploits unique resources of the innovating firm so that competitors do not fully benefit from imitation. It can change the value of key recourses by reducing the cost of integrating and co-ordinating economic activities (compare Hogbin et al. 1994, p. 95).

2. THE PERFORMANCE OBJECTIVES FOR CAD DEVELOPMENT

The purpose of this phase is to set measurable objectives for the design group based on the business goals and strategies.

Corporate and business goals, for over five years, lays out the overall shape of the company. The goals are based on market, competitor, customer, and supplier analysis. Legal, political, economical and social frameworks and trends are assessed. A practical way of creating a plan is through the SWOT-analysis. The company also defines its competitive role in business.

Goals are set for medium or longer term. Objectives are set for a shorter period (1 to 3 years). Objectives should be measurable. Even the qualitative objectives can be assessed by interviews or observance.

The performance objectives for CAD development are defined using objectives, which are traced from the business goals (figure 3). The goals related to ìprofit increaseî are followed by ìdesign efficiency increaseî objective. The formula for design efficiency is:

design efficiency = quality of design / total cost of design.

The components of efficiency increase are a reduction of the total cost of and a raise of the quality of design. The total costs of design are caused by briefing, designing, redesigning, fault corrections in manufacturing, etc. and communication. The quality of design is divided into product, process, service and environmental quality. An increase of sales result has to result in improved services, and efficiency in design. The service improvement is separated from the other design functions since it is critical when the amount of designing increases. Time function is one part of the quality of design. Lead time is the time from design order to the time when production can begin. Cycle time means the time period from order to delivery. A decrease of lead or cycle times is often classed under performance objectives of design. Performance objectives can be related to service, product, process or environmental quality; working environment,

efficiency, learning organisation; new customers, improved integration grade, use of common design databases; competitive position; agreements e.g. improved subcontracting methods. The result of the first phase is measurable performance objectives for CAD development.

PERFORMANCE OBJECTIVES FOR CAD DEVELOPMENT		
GOAL	**OBJECTIVE**	**PERFORMANCE OBJECTIVE**
QUANTITATIVE GOALS		
Return on assets	Return on assets annually	Efficiency increase, quality and cost
Return on sales	Return on sales increase	Efficiency increase, quality and cost
Sales	Return on sales improves sales total	Efficiency increase , quality and cost Service improvements
Market share	Market share	Service improvements
Dividend	Dividend increase	Efficiency increase, quality and cost
Pollution prevention pays	Pollution prevention pays decrease	Quality increase
QUALITATIVE GOALS		
Quality	Service quality Customer satisfaction Fault rates Cycle time Product quality Process quality Integration No delays Environmental quality	 No reclamation Fault rate Lead time decreases Knowledge of expectations Use of specified components Improving symbol libraries Integration with other designers and manufacturing Energy consumption of the product Process pollution Improved salvage use
Teamwork	Working environment Team formulation Email in the internal mailing Efficiency Employees No extra personnel Creation of learning organisation	 Co-operation is enabled (time-resource) Skills to use email Efficiency, quality and cost Encouragement of the managers Efficiency, quality and cost Better atmosphere
Customer	New customers Improved integration grade Use of common design databases	 Use of email Use of common design databases
Safety	Amount of accidents decrease	Better design quality
Industrial relations	Competitive position Customers, co-operators and suppliersí opinions of the company Improving subcontracting methods Agreements	Efficiency, quality and cost Service improvement

Figure 3. Example of creating performance objectives for CAD development.

3. ACTION PLAN

The purpose of this phase is to choose the overall plan by which the performance objectives are pursued. An action plan of CAD development is selected on the basis of the objectives. Challenges of a design group are clarified. The action plan is the strategy by which the design group pursues performance objectives. Several selections of action plan are not recommended since too many

changes at the same time tend to fail. In addition, they may disturb the main design process.

The action plan is mandatory, if one of the following situations is realised:

* The regulatory requirements have changed so much that new tools are needed.
* Organisational requirements force changes to the policies.
* Competitive pressure is hard. For example, the company does not get work without greating CAD databases

The mandatory changes require control, too, since if they do not succeed, the company is in trouble. The action plans are chosen and the limits of the development projects are set. The timetable is set in order to give an overall information for the next phase. The action plan is flexible and is based on the vision.

4. PRELIMINARY DEVELOPMENT PROJECT REVIEW

The purpose of this stage is to screen opportunities of the CAD development and to study further those which show sufficient promises (figure 4). The action plan gives a general outline to reject unrealistic project ideas.

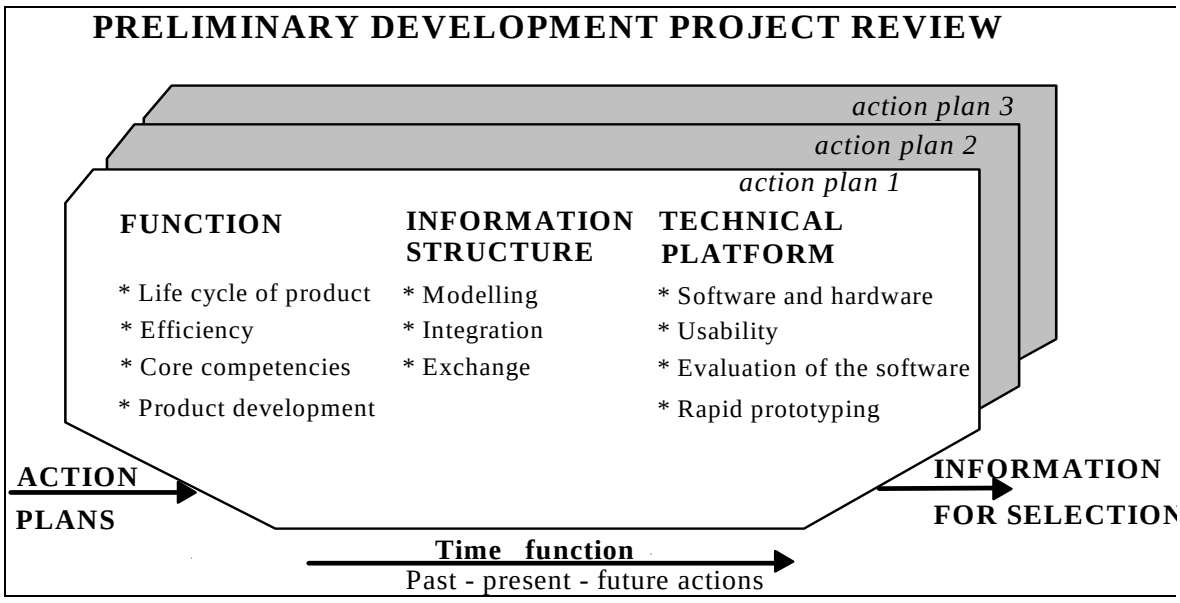

Figure 4. The preliminary project review.

The opportunities are scanned in the following order: function, information structure and technical platform. When the proposals are screened following questions are addressed:

* Is the proposal competitive with the action plan?
* Is the idea technically feasible?
* Do the required recourses (for example, skills, finance, time) exist?
* Does the proposal need further development?
* What are the future needs?

The result of this stage should be two or three projects, since it is neither feasible nor desirable to conduct a full scale evaluation of each opportunity.

CHOICE OF CAD SOFTWARE							
CRITERIA	**Weight (W)**	**Software A Perform-ance (P)**	**W*P**	**Software B Perform-ance (P)**	**W*P**	**Software C Perform-ance (P)**	**W*P**
USABILITY * easy to learn (use rate defines the importance) * adaptability * parametric and automatic design * design steps are easy, not too complicated menu structures * language of the interface * different user privileges are easy to be set in the computer network * time savings * dimensioning							
REQUIRED FUNCTIONS * 3D model * documents , e.g. list of parts, cost estimates * explode drawings							
INTEGRATION * strength calculation, simulation * other designers * production CAM, PPS							
INTELLIGENCE * artificial intelligent features * possibility to create own knowledge database							
PRESENTATIONS * photorendering * animation							
DESIGN DATABASES * internal and external libraries * object orientation							
FITS TO THE ARCHITECTURE * previous drawings * use of scanned drawings * documentation system							
LIFE CYCLE OF CAD SOFTWARE * references * trustworthiness of the development and other support							
ERGONOMY							
PRICE							
SUM							

Figure 5. Verifying CAD software with each other from user point of view.

Evaluation of software and hardware is made by the user during this phase. The savings and extra income opportunities are roughly studied in this phase. Later when the software alternatives are selected for further studies the calculation is more accurate. Each company has to add its own requirements to the list

presented (figure 5). The evaluation is made in minimum between the previous and new software. The limited amount of new alternatives are selected from the markets by rejecting those which donít fulfil the limits. Market analysis is profitable to make in fairs, reading magazines, etc.; the analyst should be the user. The designer have to weight the importance of the criteria. The criterias are evaluated so that the weight sum is 100 %. The criterias are grouped in ten categories: usability, required functions, intelligence, integration, design databases, presentations, life cycle of the CAD software, fitting to the architecture, ergonomy and price. The following questions need to be answered before investing in CAD: Do the working methods need development? Is the software helping the designer to understand better? Does the new system improve creativity?

The continuity is important. The past - present - future actions are screened and detailed schedule of future development steps is made. The future scenarios is used. The future actions plans need to be flexible. Human resource management need visions. The education and training programs need vision of the desired position. The gap between the desired and realised position is solved by education and technology development programs.

5. SELECTION

The purpose is to find such benefits which are greater than the costs, at least in the long run. The benefit, cost, risk assessment and future scenarios have an impact to the willingness to invest (figure 6). The organisation participates so that the whole design team is committed to the decision. The purpose is to find such

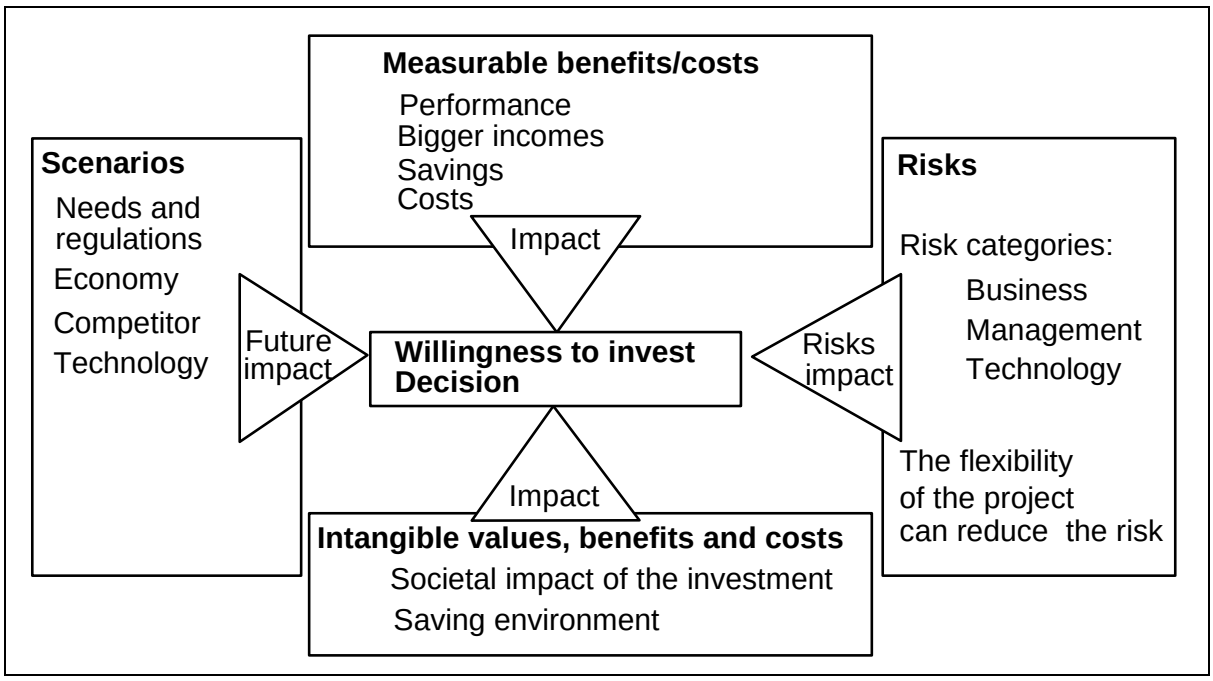

Figure 6. The benefit, cost, risk assessment and future scenarios have impact to the decision and willingness to invest.

benefits which are greater than the costs, at least in the long run. Risks and future scenarios are also studied to avoid unprofitable decisions. Many of the benefits and costs are intangible but still they canít be forgotten. The cost reduction and/or

revenue increasing are the key questions. A pilot project is needed first to realise the benefits if the investment is risky.

BENEFITS OF THE DEVELOPMENT PROJECT IN THE DESIGN OFFICE				
BENEFIT TYPE	**BENEFIT FOR DESIGN OFFICE**	**Weight (W)**	**Perform-ance (P)**	**P * W**
PERFORMANCE	Internal performance * Flexibility * More user friendly interfaces * Motivation becomes better * Efficiency improvements * Suitability of the development project with the performance Decisions * Control in real time and more accurate information than before the development project * Information for planning the processes Technical platform * Trustworthiness * Maintenance does not require special personnel * Faster (e.g. the waiting times when computer is calculating) * Flexibility Competitiveness * Customer connections to the system * Suppliers in better control * Competition advantages			
BIGGER INCOMES	Higher price created by product/ service quality * Fault rate _____% * Input only once * Better function * Shorter lead times _____% * Shorter total circle time _____% Increase of market share _____% New services and products New markets			
SAVINGS	Equipment * Less space required _____% * Smaller fault rate _____% * Easier to maintain _____% * Materials of the models Employees * Efficiency improvements (quality improves and total design costs reduce _____%) * Better communication with less work * More efficient control * Possible to use more time for more important things Assets * Faster invoicing * Possibility to plan better liquidity and the finance statements. Other * Smaller supplier costs * Travelling expenses			
TOTAL				

Figure 7. Benefits of the development project in design office.

Future scenarios are created by studying: company environment: interest groups like suppliers, customers, authorities, competitors; needs and regulations; technology development; the overall changes in economy. The forecasted changes give alternative strategies. For example, if the customers will require 3D models, new CAD software may become mandatory. The other scenarios could be that the production will be automated , since CAD software has to be integrated with production system. The importance of databases is more important than three dimensionality.

Benefits can be devided in three categories performance, incomes and savings. Benefits of performance are divided into improved internal working methods and decisions, better technical platform and competitiveness. Savings are resulted from savings in equipment, employee or assets (figure 7). Intangible benefits have to be assessed with questionnaires and interviews for example, reputation, ease of use, and large number of integration benefits, like motivation.

Costs are devided into development costs and ongoing expenses. The development costs have five categories: (1) development effort, (2) new hardware, (3) new software, (4) user training, and (5) other costs. The ongoing expenses consist of six categories: (1) maintenance, (2) incremental data storage expenses, (3) incremental communications, (4) updating software and hardware, (5) exchange, and (6) other. Additional incomes and savings are assessed on the same worksheet as the costs. ROI check is calculated for five years.

The risk source can be divided into three main parts; software, hardware and business risk. When risks are taken the following rules should be remembered :

* Donít take bigger risks than you can lose. The maximum lost amount of money is therefore important to calculate, or other unexpected effects need to be found.
* Donít risk too much for a little benefit.
* Consider probabilities and your own intuition. Think about how much you can effect on the results. Positive thinking can effect the results, you get what you are waiting for. Many psychologists have proved that if you have a positive attitude you get better results. Expectations effect the results. Fear of failure is the most common reason for not trying any reforms. People are afraid of what other people think and develop feelings of insecurity.
* When a group is assessing risk they tend to take bigger risks than individuals alone (Byrd 1982, p. 45).

To assess the degree of risk the table is filled and the points are given. The *Probable %* is the estimated probability of occurrence of the bad situation. *Weight* is the importance of the factor. The probable % are multiplied with the weight and the results are summed. The result is called risk point.

The proposed decision style is to let the visions impact the decision and use the ROI calculations to check that not too big risks are taken. In the calculation the discount rate of risky investment varies in the following way: low risk 10-14%, normal 15-24%, and high risk 25-40 %.

The decision of development project is made. The overall plan is written down and objectives are set. The cost/benefit and risk tables are used later in the post evaluation phase.

6. MANAGE THE BENEFITS, COSTS AND RISKS DURING THE IMPLEMENTATION

The development project is implemented in such a way that the estimated benefits are realised. The management of the implementation consists of check, organise, operate, control and documentation (figure 8).
The objectives are set together with the employees in such a way that the whole

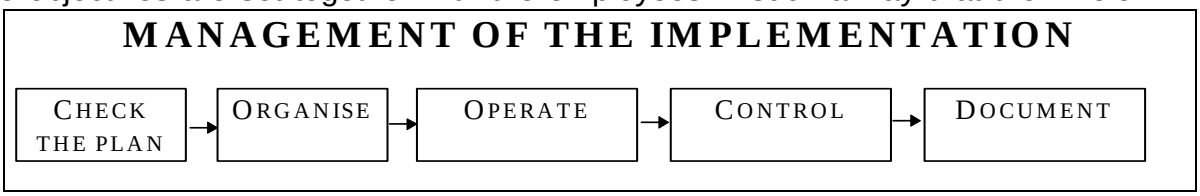

Figure 8. Management of the implementation

organisation knows what kind of efficiency improvements are needed and what kind of competencies they should have after the project. The learning organisation changes have possibilities to be realised as people commit to the vision and believe in it.
The learning of people must be ranked as a top priority. This means that the employees are encouraged to develop themselves and mistakes are tolerated. The designers need to have freedom to develop their work. However, the business environment provides limits.

7. Post evaluation

The sixth phase consists of post evaluation; new decisions and checkpoints are made. The evaluation is made in three levels: user, technology and business level (figure 9).

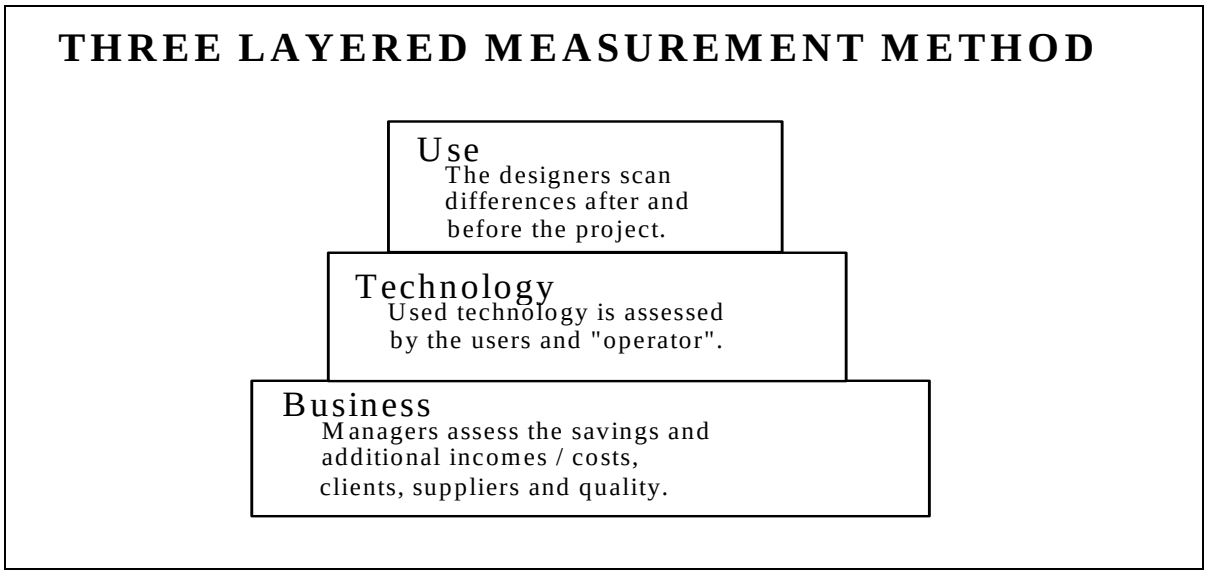

Figure 9. Three layered measurement method.

Post evaluation should take place after the new method has been in use for over twelve months. This evaluation verifies the realised performance to the objectives. The filled tables of benefits, costs and risks are used to verify the success to the planned.

8. COMPETITIVE EDGE

The competitive edge is realised when the competitiveness of the company has improved significantly. The goals are verified to the realised performance.

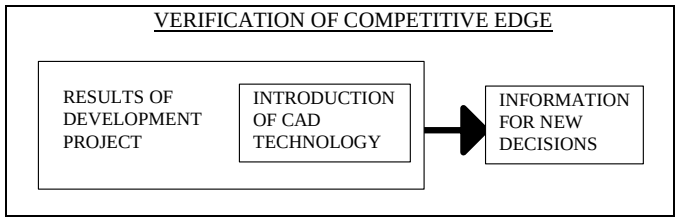

Figure 10. Verification of competitive edge.

Results of development project are verified to the goals. Future scenarios are updated and the position in the market is assessed. The manger is responsible of making the evaluation. The manager should ensure that the continuos chaos is not realised in the design department. If the chaos is realised the development project should be replanned.

The verification of competitive edge is bases for new decisions(figure 10). The new analysis is compared with the earlier analysis and desired position in markets and as well as image as CAD user. New goals and objectives can be set. Evaluation is made every year before new investment ideas are studied.

9. CONCLUSIONS

The approach is proposed to be used as a part of the annual budgeting process. Setting the objectives for CAD development and the evaluation stages are the bases for decisions. The employees give proposals every year for improvements. These opportunities are studied by using the decision-making approach. The action plan needs to be well defined and checked every year. Three companies tested the approach. **The companies believed that this kind of approach could help to make better decisions than their old methods could**. The approach was, according to the interviewees, practical and it revealed the important areas of CAD development for the companies. The approach supports the development of the company.

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