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AHP in High Tech Production Decisions

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Abstract

Many companies in the consumer electronic business and other commodity industry sectors have for many years been faced with continually decreasing product life-cycle times and with quick market changes. Nowadays this is true also for high-tech businesses that involve exceptionally high assets to product development and where trading has been based on fixed, long term contracts. This combination of requirements, ability to react quickly to market needs and technically demanding products, sets new challenges to increase the organizations ability to make cruicial decisions fast and still maintain a wide commitment. Without a comprehensive commitment from all levels of the organization it is not possible to implement quick changes in practise. Not only the marketing and development decisions but also decisions concerning production technology need serious improvement considerations .

After several pilot cases that were run in the University of Oulu during the years 1985-1986, the Analytical Hierarchy Process and especially the "Expert Choice" sofware have proven to be very effective and useful tool for production technology decisions. This paper describes three practical cases done at Nokia Telecommunications , Transmission Systems factory. The cases are typical for front edge manufacturers in the electronic sector: choosing the best placement machine, manufacturing strategy decision making and selecting the best way to carry out a software project. Besides the models there are also experiences showing how to organize decision processes and how to gain comprehensive commitment to decisions.

1. Introduction

Nokia Telecommunications supplies telecommunications equipment and systems for use in public telecommunications networks, mobile telephone networks and didicated networks for use by companies and authorities. The main markets are in Europe but revenue from other countries is increasing gradually. Nokia can be considered a medium size company in this business and cannot thus take significant volume advantage in international competition. The success of Nokia is and will also in the future be based on superior product properties and quality, short development cycle, customer oriented production and advanced production technology.

In such a business situation it is essential that production technology plays an active role in strategical and operational decision making. Nowadays production technology is more and more considered to be an equally important business factor as R&D and marketing. Previously production technology has been considered as a passive machine, where only productivity has to be optimized. Decision making in the past was in a way easy; just to calculate the monetary incomes and outcomes and choose the alternative that produces the biggest profit. For the challenges of today the requirements for decision making in high-tech production are more demanding. The decision making process has to be shorter, decisions have to be done at the same time as the product design goes on, failure in decision making can directly risk the whole business. The old decision making models and team work habits do not function in this world any more. Nokia decided to do something to improve the organizations ability to run decision processes as well as to make use of modern software tools. The company had already for some years had co-operation on this field with the local university. This paper describes briefly some points of method development and three examples of decision processes. The main requirements and benefits are included at the end. This paper concentrates more on the process not so much on the tool.

2. Method development

The start point was in 1985 when a research project to study design methodologies was launched in the University of Oulu, Machine Design department. A factory wide perspective was for the first time taken into account in the automation decision processes. The Method-Development project was carried out with industry partners and it was obvious from the very beginning that for real industry applications the business related points of view also had to be considered. It is not enough to optimize only the technical points but also customer behaviour, economical criterias and risks had to be included.

One target in the project was to find a Decision Support Software (DSS) suitable for research as well as for industrial needs. A most important criteria for DSS is that its function is easy to understand, it is "straight forward", and it is quickly adaptable in practice.
Analytical Hierarchy Process (AHP) was found to fulfill to a large extent these criterias and when this method was also supported with a software tool, "Expert Choice", it was tested in some pilot cases in this University project.

This phase of method development ended up with recommendations like:

- steps in decision process
- organizing a decision project
- the roles of group members and computers
- how to use a computer directly in the meetings
- advices to construct a decision hierarchy

One detail of this method is a general recommendation to divide the decision process into several steps (fig 1).

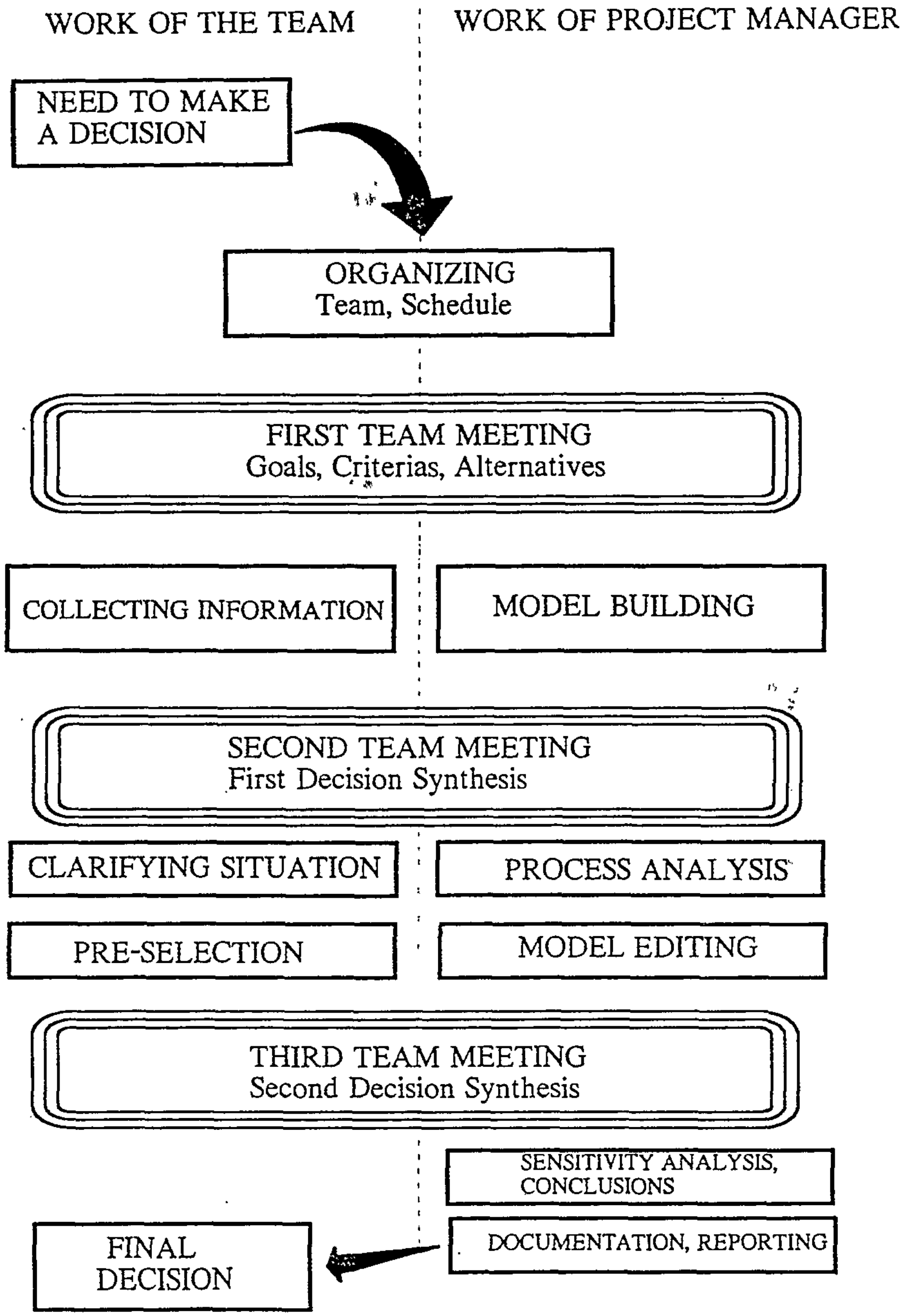


Fig.1 A decision process can be divided into steps and tasks

3. Industry applications

3.1. Background description

Nokia Telecommunications was partner in the university project and that is why it was easy to apply DSS in practise. The same method (AHP) and the same software (Expert Choice) were still considered to be the most suitable tools.

The following three applicatons are developed at the companys Transmission Products factory in Haukipudas, Finland. The factory produces digital multiplexing and terminal units for telecommunication networks. The production is based on SMD- and ASIC-technologies. For many years production has been geared towards flow production with short lead times and without any set-up times. A lot size of one can be produced as effectively as a lot of 100 units.

The next three cases describe typical cruicial decision problems where AHP has proven its power in structuring and synthesising opinions in group decision making. In this paper it's not necessary to go through the details of each model. Instead only the essential background information will be given:

- composition of decision group
- organizing the process
- the model
- the basic influences at business level

3.2. Case 1 ; Selection of manufacturing strategy

When a new product generation is coming onto the market, its chances of success against competition are influenced by the way it will be produced. Alternatives for production strategy are:

- to build a totally new production line,
- to utilize present production lines,
- to use subcontractors or
- to chance the production philosophy of the factory.

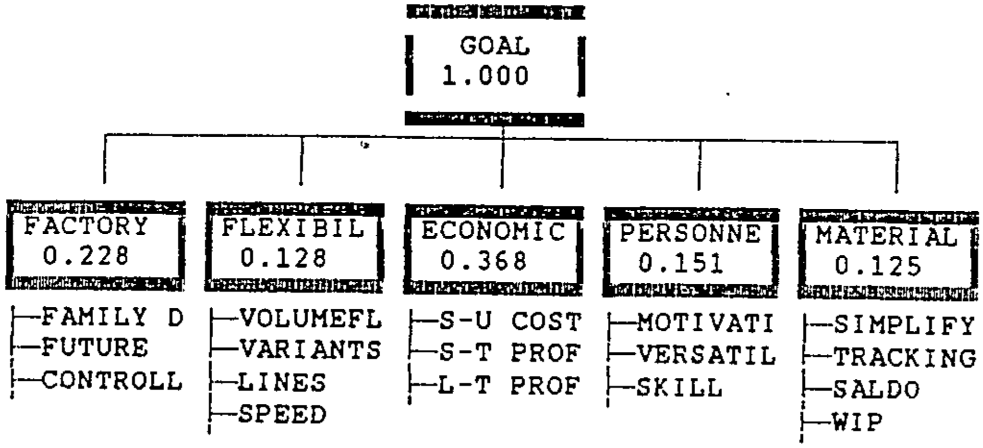
This kind of strategy selection is a challenge for management, because it is not faced every year and is always a very special situation. In this case there were only a few detailed criterias, the decision was mostly based on qualitive, factory level judgements. That is why the decision group was composed of the managers:

- factory manager
- production managers (three)
- material manager
- quality manager
- production technology manager (project coordinator)

The decision process followed exactly the flow chart in fig 1. Time between the first and last group meetings was three months. The model is shown in fig 2.

In this case there was a goal from the very beginning towards a simple model based on the outline of the problem and not on details. The decision problem was the difficulty to compare very many important objetives with each other. For example it is difficult to say if the flexibility is more important than the economical points of view. The thoughts of decision makers had to go down to the roots of the companys business foundations.

BEST MANUFACTURING STRATEGY FOR A NEW PRODUCT GENERATION



Alternatives: LINE 2
LINE 3
L2 + CELL
L3 + CELL
FUNCTION

GOAL: BEST MANUFACTURING STRATEGY FOR A NEW PRODUCT GENERATION

CONTROLL --- CONTROLLABILITY OF THE WHOLE FACTORY.
ECONOMIC --- ECONOMICAL OPTIMIZATION
FACTORY --- FACTORY OPTIMIZATION
FAMILY D --- BEST DEVIATION OF PRODUCT FAMILIES.
FLEXIBIL --- MAINTAINING FLEXIBILITY
FUNCTION --- REORGANIZING THE WHOLE FACTORY TO A FUNCTIONAL FORM.
FUTURE --- PREPAREDNESS FOR FUTURE CHALLENGES.
L-T PROF --- LONG TERM PROFIT (CUMULATIVE FROM FIRST THREE YEARS).
L2 +CELL --- AUTOMATIC ASSEMBLY ON LINE 2 , TESTING IN CELL.
L3 +CELL --- AUTOMATIC ASSEMBLY ON LINE 3, TESTING IN CELL.
LINE 2 --- NEW GENERATION WILL BE MANUFACTURED ON PRODUCTION LINE 2.
LINE 3 --- NEW GENERATION WILL BE MANUFACTURED ON PRODUCTION LINE 3.
LINES --- FLEXIBILITY BETWEEN PRODUCTION LINES.
MATERIAL --- MATERIAL MANAGEMENT CONSIDERATIONS
MOTIVATI --- MOTIVATION.
PERSONNE --- CONSIDERATION OF PERSONNEL' QUESTIONS.
S-T PROF --- SHORT TERM PROFIT (FIRST YEAR).
S-U COST --- START-UP COSTS.
SALDO --- SALDO MANAGEMENT.
SIMPLIFY --- SIMPLIFYING MATERIAL FLOWS.
SKILL --- MOST SKILLED PEOPLE CAN BE HIRED ON THE NEW LINE.
SPEED --- ABILITY TO GET NEW PRODUCTS QUICKLY INTO PRODUCTION.
TRACKING --- POSSIBILITY TO TRACK MATERIALS.
VARIANTS --- ABILITY TO MANUFACTURE LARGE VARIETY OF PRODUCTS.
VERSATIL --- VERSATILITY OF JOB CONTENT.
VOLUMEFL --- VOLUME FLEXIBILITY.
WIP --- MINIMIZING WORK-IN-PROCESS

Fig.2 The AHP-model for the case 1

3.3. Case 2 ; Comparison of placement machines

This case is a typical investment decision; the decision making group has to choose the best placement machine for SMD (Surface Mounted Devices). SMD's are electrical components that have no leads to go through the small holes in the printed circuit boards (PCB) but will be soldered directly on the surface of the PCB. This new assembly technology has made it possible to integrate more functions on the same PCB and thus to increase the competitiveness of the product. In this case the main problem is that SMD technology is relatively new and developing fast . There are no traditions nor standard priority settings for the comparison of different machines. It is now, after some years experience, that the users have learnt what are the most important criterias.

In this case the decision group was:

- factory manager (he was present only when the top level of hierarchy was under consideration)
- production technology manager
- engineer for production machines
- machine operator (he was present only when the bottom level of hierarchy was under consideration)
- reseach engineer from the university (project coordinator)

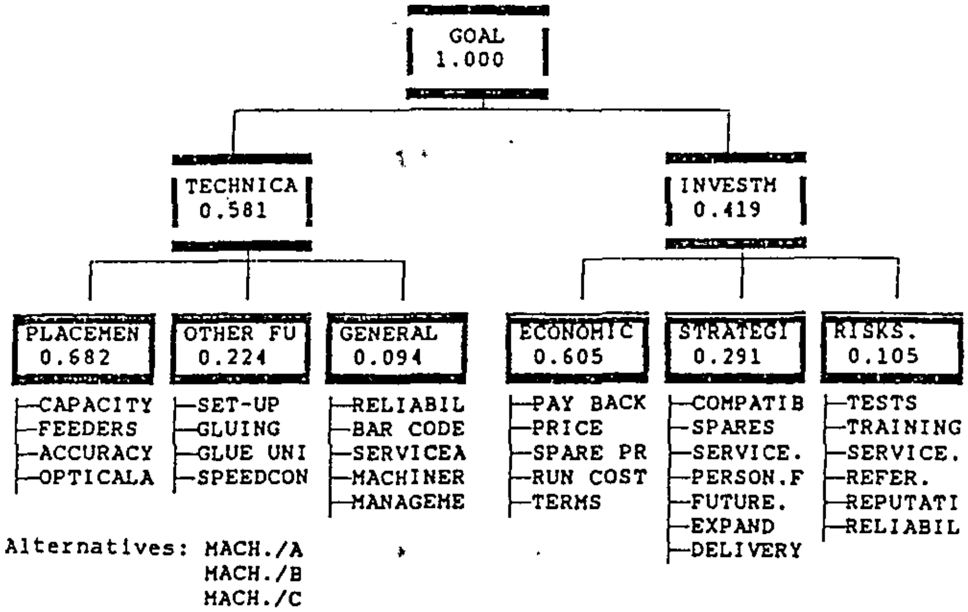
Also this decision process followed the flow chart in fig 1. The most time consuming part was the information collection from the machine suppliers. Many trips had to be made to become familiar with the references in other factories.Time between the first and last group meetings was two months. In the beginning there were four alternatives but after the first comparison two of the alternatives were dropped. After this the decision group found it a little difficult to compare by Expert Choice only two alternatives because the pairwise comparison is not available now. There was a feeling that the scale was reduced to "good" or "bad". When there are more than two alternatives the pairwise comparison mode gives autimatically the scale.

The model in this case is divided to four levels:
- the goal
- the objectives
- the independent criterias
- the alternatives

Fig 3 shows the entire model.

In this case the most important benefit on the business level was the learning process that indirectly followed the well organized decision process. The organization learnt to know "what we want from a good placemant machine" as well as what is the relationship between technology and the "soft properties" (service, etc.) of machine supplier.

BEST SMD-PLACEMENT MACHINE.



ACCURACY	---	PLACEMENT ACCURACY.
BAR CODE	---	POSSIBILITY TO CONTROLL THE MACHINE BY BAR CODE.
CAPACITY	---	CAPACITY (CHIPS/HOUR).
COMPATIB	---	COMPATIBILITY TO OLD MACHINES.
DELIVERY	---	DELIVERY TIME.
ECONOMIC	---	ECONOMICAL POINTS OF VIEW.
EXPAND	---	POSSIBILITIES TO EXPAND THE MACHINE.
FEEDERS	---	NUMBER OF FEEDERS.
FUTURE.	---	FUTURE NEEDS.
GENERAL	---	GENERAL TECHNOLOGY.
GLUE UNI	---	CONTROLL PROPERTIES OF GLUING UNIT.
GLUING	---	GLUING CAPACITY.
INVESTM	---	BEST INVESTMENT.
MACH./A	---	MACHINE A (from UK).
MACH./B	---	MACHINE B (from Japan).
MACH./C	---	MACHINE C, (from USA).
MACHINER	---	GENERAL MACHINERY.
MANAGEME	---	MANAGEMENT SYSTEM.
OPTICALA	---	OPTICAL ALIGNMENT SYSTEM.
OTHER FU	---	OTHER FUNTIONAL PROPERTIES.
PAY BACK	---	PAY BACK TIME.
PERSON.F	---	FITTNESS INTO PRESENT PERSONELL.
PLACEMEN	---	PLACEMENT PROPERTIES.
PRICE	---	INVESTMENT PRICE.
REFER.	---	REFERENCIES.
RELIABIL	---	RELIABILITY.
REPUTATI	---	REPUTATION OF SUPPLIER.
RISKS.	---	RISKS INVOLVED.
RUN COST	---	RUNNING COSTS.
SERVICE.	---	SERVICE IN FINLAND AND EUROPA.
SERVICEA	---	SERVICEABILITY OF THE MACHINE.
SET-UP	---	SET-UP TIME.
SPARE PR	---	PRICE OF SPARES.
SPARES	---	SPARE PART AVAILABILITY.
SPEEDCON	---	SPEED CONTROLL.
STRATEGI	---	STRATEGICAL POINTS OF VIEW.
TECHNICA	---	TECHNICALLY BEST MACHINE.
TERMS	---	TRADE TERMS.
TESTS	---	TEST RESULTS.
TRAINING	---	TRAINING ORGANIZED BY SUPPLIER.

Fig.3 The AHP-model for the case 2

3.4. Case 3; How to run a CIM-project ?

Nokia Telecommunications is advanced in customer oriented production. This means that production lot is started only on placed orders. Customer oriented production requires high flexibility, short lead times and short set-up times from production. To be able to implement this requirements into practise the control of production and production machines is based on CIM (Computer Integrated Manufacturing). The main structure of the computer network to run the whole Transmission system business and the shop floor level CIM-applications are illustrated in fig 4.

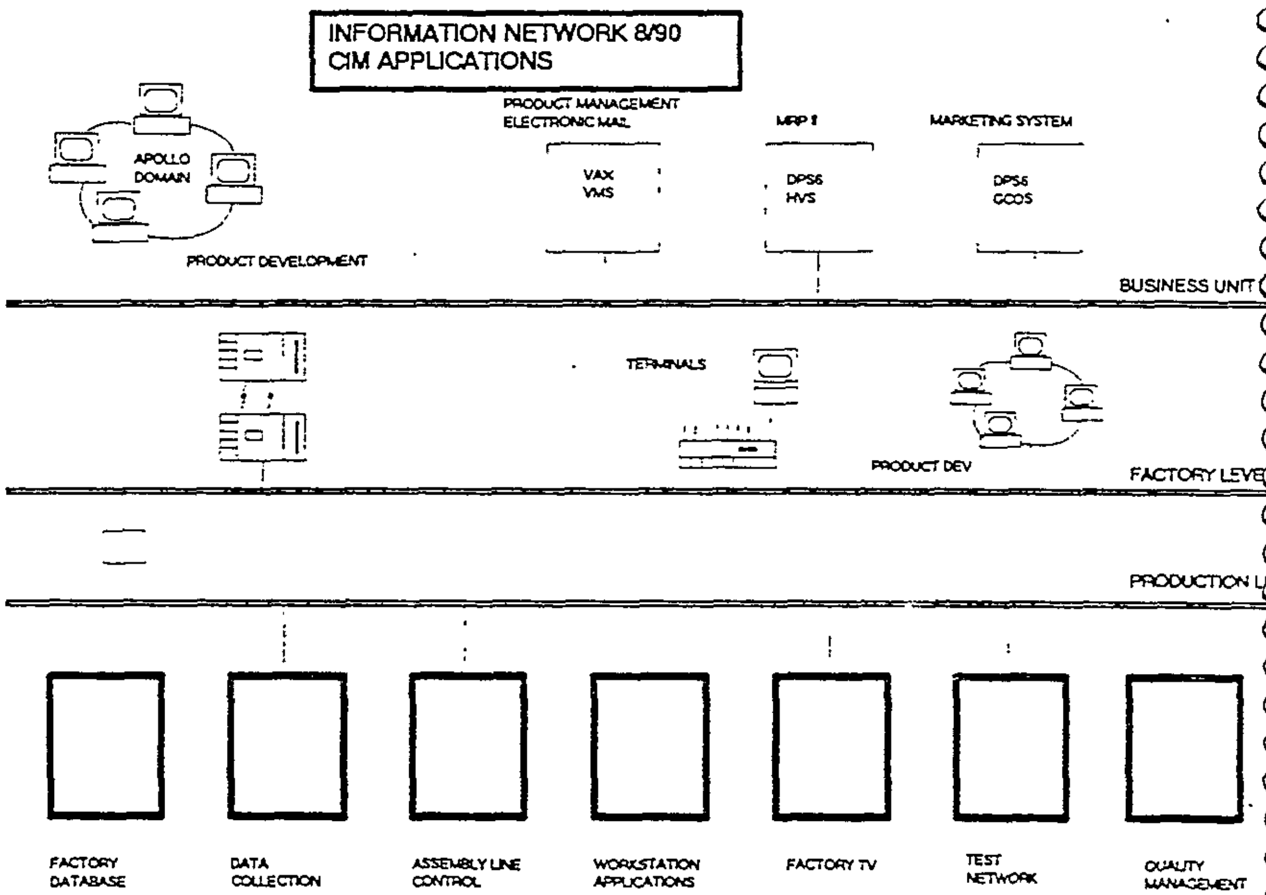
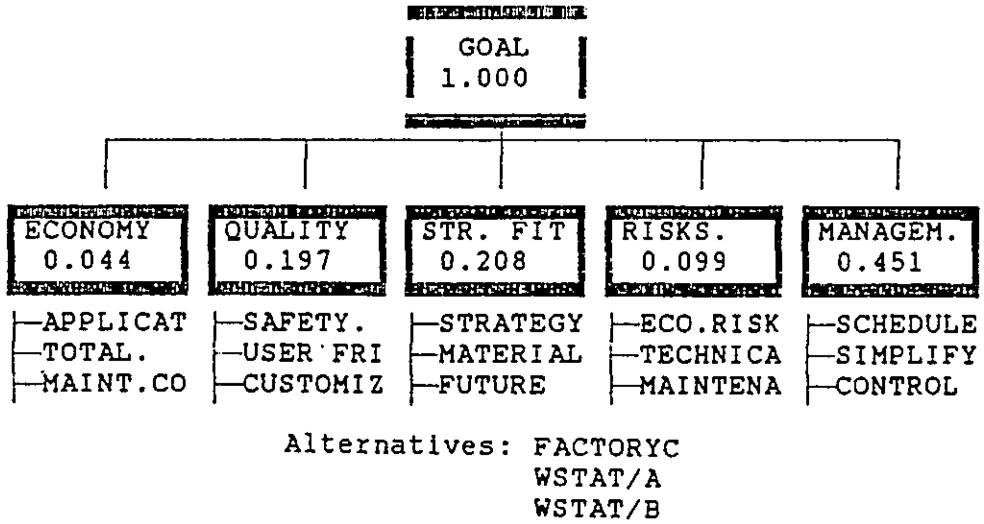


Fig.4 The information network and CIM-applications

The basic infrastructure and the main tool selections have been made already some years ago for the whole CIM system but the realization of applications takes place step by step. When a new application is considered the real need as well as the different possibilities to carry out the development project are considered. Fig 5 shows a AHP-model to compare three different ways to carry out a CIM-software project. The team was comprised of the development manager, the information technology manager and three application engineers. For this decision process only one team meeting was needed, because the problem was rather simple and the team was homogenious of its knowledge. There was not as much need for clarifying discussions as in the previous cases, where the teams were not so homogenious.

BEST WAY TO CARRY OUT A SOFTWARE PROJECT



APPLICAT --- APPLICATION COSTS.
CONTROL --- POSSIBILITIES TO CONTROL DEVELOPMENT WORK.
CONTROLL --- POSSIBILITIES TO CONTROLL DEVELOPMENT WORK.
CUSTOMIZ --- POSSIBILITIES TO CUSTOMIZE.
ECO.RISK --- ECONOMICAL RISKS.
ECONOMY --- ECONOMICAL POINT OF VIEW.
FACTORYC --- APPLICATION WILL RUN IN THE FACTORY COMPUTER.
FUTURE --- AVAILABILITY IN FUTURE.
MAINT.CO --- MAINTENANCE COSTS.
MAINTENA --- MAINTENANCE RISKS.
MANAGEM. --- PROJECT MANAGEMENT.
MATERIAL --- COMPATIBILITY TO MATERAL MANAGEMENT SYSTEM.
QUALITY --- QUALITY .
RISKS. --- RISKS.
SAFETY. --- WORKING SAFETY.
SCHEDULE --- SCHEDULE MANAGEMENT.
SIMPLIFY --- SYSTEM SIMPLIFYING.
STR. FIT --- FITNESS TO THE SOFTWARE STRATEGY OF FACTORY.
STRATEGY --- DIRECT COMPATIBILTY.
TECHNICA --- TECHNICAL RISKS.
TOTAL. --- TOTAL SYSTEM COSTS.
USER FRI --- USER FRIENDLY.
WSTAT/A --- WORKSTATTION, EXTERNAL DEVELOPMENT.
WSTAT/B --- WORKSTATION , IN-HOUSE DEVELOPMENT.

Fig.5 The AHP-model for the case 3

4. Requirements for and benefits of using Expert Choice in the Cases

Based on the experiences gained by these cases, it can be stated that at least the following requirements have to be fullfilled to have a successful decision process:

* Participants have to understand the basic AHP working principle.
* Participants have to be familiar with the factors within the problem.
* There has to be a commonly agreed agenda for a systematic process.
* The decision situation is real; there are several alternatives and several criterias and subgoals.

The Analytic Hierarchy Process is a straight forward method and perhaps that is why there were no big difficulties to get people to understand the idea. All the three examples described were handling very concrete problems and the decision making team had no difficulties to understand and discuss the goals, subgoals, criterias and alternatives. So, the two first requirements were fullfilled .
The third requirement, to have a commonly agreed agenda for the process, was not in the first cases fullfilled. The old custom to try to solve the problem at once is rooted very deep into people's mind. It takes time to learn to discuss about all the factors affecting the decision and to change the point of view during the process. But once the participants learn to stucturize the decision process, and it is the AHP that helps a lot in this, the whole team work gets a fruifull grounding, upon which the decisions can be built.
The last requirement, to have a real decision situation, is just a checking point whether to start a process or not. If the problem is very simple or if there is one superior allternative, it is only wasting time to build decision models. Expert Choice, like other software, is just an effective tool and should not be used only for its own sake.

The benefits from using AHP in these cases were more indirect . Of course the direct benefit, to find the best solution for a problem, can not be ignored. Especially in the third case, the CIM project, the choice where the team ended up was not in the beginning considered to have any chances. The indirect benefits from Expert Choice were:

* Decision process was faster than a "manually driven" process, when a certain reliability level is striven for.
* Process will be documented automatically.
* The opinions will be stored for later reviewing needs.
* Computer graphics helps to visualize ratios.
* Process can be controlled and projected easily.
* The quality level of team work rises.
* Overall reliability increases.

In summary the experiences were so good for every team member, that it is easy to take this software tool and AHP into use whenever it is needed.