

**INFORMATION TECHNOLOGY and INDUSTRY**  
(Strategic Issues and Opportunities)

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**Summary**

This report is intended to show the reader the way industry looks at information technology and how it deals with it. This relatively new technology must be regarded and utilized as an important, strategic cornerstone in all activities of an industrial enterprise. Strategy, use and quality of information technology will be discussed in three chapters. The benchmarking method will be elucidated in one of these chapters.

In chapters 5 and 6 a number of intrusive questions regarding the impact of information technology on running a business and the organization of an enterprise will be discussed. This could result in drastic organizational and even societal changes: downsizing, outsourcing and partnering.

In chapter seven a subject that has attracted great attention during the last couple of years will be treated: integration of computer-related activities and the integration of the enterprise. In the same chapter re-engineering and concurrent engineering will be discussed. These three subjects: integration, re-engineering and concurrent engineering have been combined into one chapter because of their inherent organization-related connections.

Chapter 8 will be devoted to customer service, probably the least discussed and researched part of the product's life cycle.

In a final chapter a number of important conclusions will be summarized point by point.

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## 1.0 Introduction

It is impossible to imagine where the industrial situation would be to-day in a world where information technology would not have any influence. To compare such a situation with to-day's reality challenges our imagination. In a way which it is as bizarre as trying to find an answer to the question of where in our body does our personality reside or how is it defined.

In the short period of some forty years information technology has changed our way of working, living, moving, entertaining, learning and thinking, and not always in the most positive sense. In many situations one can assume that this development has given the human being a better way of living and working and doing business. However, all that has happened at the expense of an enormous amount of changes, adaptations and costs. Since we never will be able to create a world as it would have looked without information technology, it is impossible to make a rationale judgement about the positive or negative aspects of this phenomenon. We are forced to accept the situation that has been created and we can only ask ourselves what we did wrong or where we were right or what we should have done differently in order to achieve an even better (or different) result.

Developments in information technology have led from enormous rooms containing immense cabinets with electrical and electronic equipment surrounded with long rows of magnetic tape readers and magnetic disk drives. Now we have devices which can perform many times faster and better than the early equipment, and can be held in the palm of our hands. It led from coordinated attacks on large amounts of data (cartography, nuclear experiments, meteorology) to the fascinating application of computer graphics, electronic mail and multi-media. And yet we are still not capable of predicting, in an orderly fashion, further future developments.

In all these tumultuous developments both industry and the academic world have done pioneering work. Industry has, as usual, been forced to do this in order to maintain or advance its competitive position and to improve its overall performance; the academic institutes got involved in this technology because it was new and it was necessary to provide this new engineering discipline and science with appropriate and fundamental theories and methodologies. In many application areas industry appeared to be ahead of academic research. This resulted in a situation where almost all new inventions could be credited to industrial research and development. After the initiating efforts of industry, the academic world improved and extended the industrial innovations and developments. This involved both the hardware and the software. It is remarkable that, however, not a single academic institute was involved in or rendered support to some of the most celebrated and most advanced consumer products of this century: the compact-disk and the laser disk. Yet, these were products that could not have been developed without the use of

information technology, and is based on a combination of advanced optics, electronics, mechanical engineering, high precision manufacturing and information processing techniques. We witnessed a similar situation of the relative absence of applied academic input in other areas where products are produced with the aid of information technology, and where the same technology is heavily incorporated in those products: telecommunication systems, optical systems, electronically controlled equipment, robots, (air) traffic control systems etc. However, the later improvements to these new technologies were often based on important theoretical and applied research studies carried out by a variety of universities and academic research institutes from different parts of the world.

Similarly the methods and techniques that enabled enterprises to improve their market position and competitive edge lacked a vigorous initial academic interest. Adaptation of internal organizational structures, educating their personnel, directing the management and control of a business enterprise, the application of computers and software and the way that non-strategic activities are being subcontracted (outsourced); these are all a direct or indirect effect of the changed industrial situation. Note, however, that in those situations the academic institutes have been successful in leading new research efforts and are attempting to place themselves more and more in the role of precursor or trendsetter. However, in these more business-oriented subjects, the academic world only became aware of them long after internal re-orientation forces within the businesses had been put into practice.

These forces arose from the changes in attitude and relationship of the customer vis-a-vis the manufacturer (supplier). Porter [1] identifies the following competing forces needed to be considered in any business strategy:

1. the bargaining power of the customers
2. the bargaining power of the suppliers
3. the current competitors
4. the threat of new entrants into the market
5. the threat of substitute products or services.

Porter's advice to the industry is: Utilize your possibilities in a very flexible way in order to conveniently enter a market, operate in that market and possibly, exit from it again. On the other hand a well-established firm has to create high obstacles to other companies in order to avoid any easy entrance into its market(s).

Most companies to-day are constantly besieged with demands from their internal divisions and departments for funds to enable them to implement their automation plans, plans that are intended to meet Porter's considerations.

Even under optimal economic conditions it would be foolhardy for a company to invest in all comers. Here an intelligent enterprise

has to separate the wheat from the chaff, and provide funds for only those projects that contribute positively to the company's profitability and productivity.

Many methods and techniques directly or indirectly related to information technology will contribute to that aim, and many firms and institutions have jumped enthusiastically on the bandwagon of the companies that introduced IT-related methods and techniques successfully.

The most important of these methods and techniques will be described in this report. Emphasis will be placed on the way specific industries or service-organizations have used these techniques, and how they managed to deal with Porter's five threats. That academic institutions were initially little involved in research into these emerging methods and techniques was because many companies in order to survive economically, had to shield off the attacks of established competitors and newcomers to their market segments. This situation is quite different for the majority of academic institutions. They have different objectives with respect to their research areas and are remote from the daily struggle for survival that companies have been in since the mid-eighties.

The subjects that will be discussed in this report and that are relevant to the importance of the use of information technology in a highly competitive market are the following:

- The strategic importance of IT for the manufacturing and service industries
- Advanced information systems (databases, artificial intelligence etc.)
- The Quality of information systems
- Benchmarking
- Downsizing and outsourcing
- Partnering
- Integration
- Re-engineering
- Concurrent engineering
- Customer service.

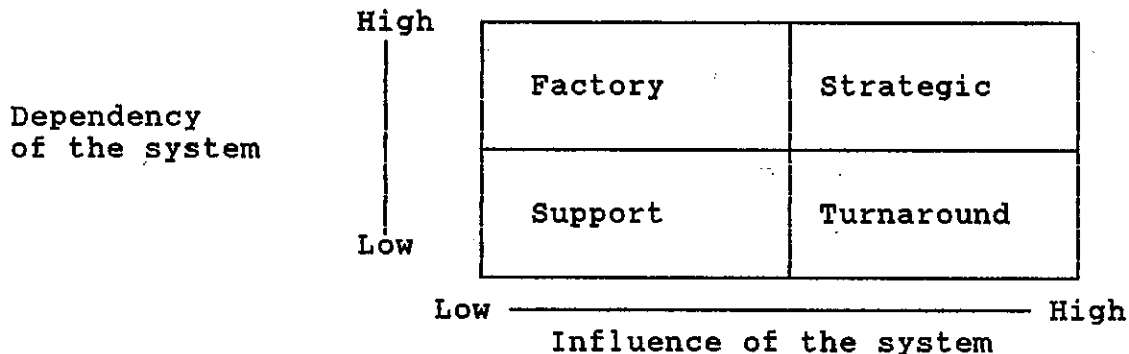
## 2.0 The Strategic importance of Information Technology (IT)

The greatest part of current developments in industrial processes and activities is the increasing application of information technology. Information technology also feeds industries that are going through a period of large organizational changes.

In a large number of firms where management was told that IT was the key to renewal, innovation and industrial successes, the introduction of IT did not yield the successes that one expected. In highly developed nations in several industrial areas there were enterprises that even lost their grip on their markets and lost their competitive edge. Without exception this can be blamed on the complete negligence of applying modern business strategies. In many situations senior management refrains from taking initiatives that could result in merging modern available technologies with business processes.

This report shows cases where information technology has been a key to success and/or survival. In all these situations members or a member of senior management who was conversant with technology and who was capable of judging the importance of IT correctly, joined forces with a knowledgeable technologist or team of technologists. These dynamic combinations had insight, experience and the knowledge of how information technology can be used strategically.

F. Warren McFarlan and James Cash developed a framework related to these strategic considerations. This framework assesses the strategic significance of a system to an organization.



This matrix-like function can help a company determine the classification of the company and determine the most appropriate way to manage the company's technological resources. The classification should be based on the answer to the question of whether those resources serve as a support function or whether they have a strategy determining role in the organization.

The figure is a two-dimensional representation of four different types of management environments:

1. Strategic forms (banks, movie-studio's) have a tight relationship to technology. They have an excruciating dependence

- on technology, and the systems that they develop or acquire are critical to their competitive success.
2. Turnaround firms (transportation, retail shops) don't have quite the dependence on technology as do strategic firms. Their current systems are not considered strategic yet, but the development of new ones are making them crucial to the competitiveness of the organization.
  3. In the manufacturing firms technology heavily supports their smooth operations. Technology is not seen as a major differentiator.
  4. In support-oriented enterprises (cleaning firms, plant installation firms, repair shops) technology is considered important and useful. It is not on the company's short list of necessities.

The many forms of technology related to business strategies require different sets of techniques. In using technology to support the mission and strategy of organizations a well-know technique is "strategy set transformation":

- \* Identify the set of strategies important for the organization. This consists of a firm's mission statement, its organizational objectives, the organizational strategy, and strategic organizational attributes.
- \* Identify stakeholder groups within the organization.
- \* Identify the operating objectives of the stakeholder groups and the constraints related to the development or acquisition of systems.
- \* Develop information strategies using these results.

This set of steps is quite elegant in its simplicity. Its use assures the organization of a proper match between technology and business.

To support these strategy-changes it is important to compose an information plan. Such a plan must be deduced from the business plan(s), and contains (generally) a list of the used and required technologies, methods and systems. It also describes the current situation and the required IT-related environment of the company. It analyses the current technology and systems, and contains an enumeration of the tasks and actions required to achieve the desired environment.

Many firms that drafted information plans used IBM's Process Quality Management (PQM) technique. This technique applies the concept of critical success factors. PQM is actually a combination of methodologies that many companies use independently, but IBM brought these techniques together and created a method that is used to-day by many companies.

PQM is initiated by gathering, preferably off-site, a knowledgeable staff team. The team's members should represent all facets of the project. The team leader must have a mix of skills closely attuned to the projected outcome of the project. For example, a

PQM-team charged with improving the productivity of a factory needs a team leader who is an expert in process control, even though the eventual solution to the process consist of an enhanced automation system.

The first task of the team is to draft the team's objectives. Vague objectives must be accompanied with more concrete sub-goals that can be formulated more directly, and can be achieved more readily. In a brainstorming session the team must enumerate all factors that could contribute to failure of the project. Here the team should formulate those factors in a very short period of time (not more than 10 minutes) without much discussion. They must be stated in sentences of a few words only.

Then the team has to identify critical success factors (CSF's), which contain specific tasks the team must perform to accomplish its objectives. A consensus on these CSF's is very important. The next step in the PQM-process is to make a list of all the tasks necessary to accomplish any specific CSF. The description of these tasks must be declarative. Every action has to be stated with a verb such as: study, measure, reduce, negotiate, eliminate.

This process results in a project chart and a graph that contains the priorities. The project chart will contain enumerations of all tasks and the degree to which the task can contribute to the goals of the project. This is done by comparing every task with the set of CSF's. A special column of the chart enables the team to assign grades (A through E) to the tasks. For example, A is excellent, D is bad, E is not currently performed, etc.

The priority graph will steer the mission to a successful and prioritized conclusion. The two axes in this graph are Quality, using the A through E gradings, and Priority, represented by the number of checks that each task received.

The final task of the team is to decide how to divide the priority graph into different zones representing the first priority, second priority and so on. The definition of the appropriate project(s) to pursue and push for a competitive technology follows the activities of the PQM-project. Then the need for a productive and high-quality development effort becomes extremely important.

The case for productivity will be discussed now. The quality of information systems is treated in a separate chapter.

Aspects crucial to the development, introduction and application of software and that receive insufficient attention are: productivity of the software experts and improvement in efficiency by using information technology.

High quality of software developers, programmers and systems people go hand in hand with the efficient introduction of automation systems. According to Yourdon there is a 25 to 1 differential between the best people and the worst people, and a 4 to 1 differential between the best teams and the worst teams. The best way to improve productivity and quality is just to improve the hiring practices of the personnel departments. A method used

by a number of firms is to have the candidate software experts work out a complex problem. The better people will solve it many times faster than the less qualified. This selection method is not used throughout our industries yet. The heads of personnel departments still prefer diploma's that say little about the quality and the persistence of the person.

Another factor that improves the productivity of the people are the ergonomic conditions of their working environment. People who are locked up in office landscapes and are forced to work in small and noisy cubicles with artificial lighting perform considerably less than those working in offices with adequate space and normal daylight.

Productivity will certainly be enhanced when IT-personnel have the opportunity to regularly improve their knowledge by following well-structured and high-quality training courses. They will be able to augment their current knowledge with newer methods and techniques as well as tools that are constantly being updated and improved..

Companies that will win the competitive battle of this decade are those that will leverage their investments in technology to create new possibilities. What is needed to make IT a productive contribution are good management, good technical staff, good estimators and testers, good tools and a good methodology.

A methodology represents the processes or steps that a technology unit goes through in order to successfully specify, develop and then implement a computer system. Many companies develop or introduce a system without using a sound methodology. The Software Engineering Institute, located in Pittsburgh PA, has made an in-depth study of this problem and has developed a framework that charts the maturity of IT in a company.

The framework consists of five steps:

1. The initial step. The IT-efforts take place on an ad hoc basis; there are few formal methods; the tools are informally applied to the process.
2. The repeatable step. The company has achieved a stable process with a repeatable level of statistical control.
3. The definition step. A foundation for major and continuing progress has been achieved.
4. The managed step. In this stage the company has gained substantial quality improvements and comprehensive process measurements have been introduced and are applied.
5. The optimized step. In this final stage of maturity major quality and quantity improvements have been achieved. The company will continue to work to further optimize its processes and enhance its performance.

The study of this institute revealed that 80% of the companies are still struggling somewhere between steps 1 and 2. This is because the user communities in these companies still don't know what they want and what they might expect from the available



technologies and tools. Many people still create their own methods, then look for the tools that will force them to apply those methods.

Summarizing, it is of extreme importance that modern companies first develop their IT-strategy and secondly select the systems that suit that strategy. At the same time they have to pay considerable attention to the productivity of their IT-staff (implementors, developers, analysts, system-managers) and make sure that the efficiency of the staff is supported by suitable and useful methods, techniques and tools.

### 3.0 The Industry and its use of Information Systems.

The term *competitive intelligence* is very much at the tip of the tongue in the economic circles of to-day. The term means that the competitive position of a company can be greatly improved by using systems with intellectual qualities that the human can not add to the operations of the company. Competitive intelligence is, however, just part of a larger view of the business world we live in. It is a subset of *business intelligence* and can be viewed as the radar of an enterprise. As with radar, the business environment has to be constantly scanned to avoid danger and to seize opportunities. Business intelligence can be seen as the other half of strategic planning (see chapter 2). One has to view the business intelligence as the cohesion of all activities with which the company monitors the competitors, the changes in the political situations, the behaviour of the customers and even affairs that concern our natural environment. Everything that happens in the ever changing world where a company operates influences the long-term aspects of such a company. Competitive intelligence transcends the boundaries of an industry and, if used correctly, provides the organization with an immediate advantage.

The methods and/or systems that can be captured under the term "competitive intelligence" are:

- \* Executive Information Systems (EIS);
- \* Corporate Data Bases;
- \* Benchmarking
- \* Strategic tools;
- \* Artificial Intelligence.

In the next paragraphs we will discuss these systems, methods or techniques and in a few cases examples of successful and useful applications of these subjects will be presented.

#### 3.1 Executive Information Systems (EIS).

Executive Information Systems are important tools that can be used immediately to make information available in such a form that it can be used more effectively, especially for the managerial levels of a company. The purpose of an EIS is:

- to reduce the amount of data with which a manager is daily bombarded;
- to increase the relevance, the timeliness and the usefulness of the information that is brought to the attention of managers;
- to draw the attention of management and management teams to critical success factors;
- to monitor the progress of decisions that were made and to monitor the actions that were a result of those decisions;
- to intensify and improve communication with others;

- to take immediate notice of warning signals such as the actions that are considered or taken by the competition; demands or requirements that are formulated by the customers; the preparation or passing of laws that may influence the way a company conducts its business etc.

### 3.2 Corporate Data Bases

While Executive Information Systems provide a baseline for analyzing the business' intelligence, there will come a moment when software tools will be required to sift through collected data and uncover relationships that can be turned into profit.

In choosing an architecture for the company's corporate database, standards are important, and should be funded as well as supported by management. This process must not overshadow the more important issue of being able to navigate effectively through the data contained in the database. Standard database query languages easily retrieve information - but only the user knows specifically what she or he is looking for. One must use a more heavy-duty tool in case the request for information is vague.

A more difficult class of information that one must deal with is what can be termed as uncertain or fuzzy information. Upon analyzing a large database, it is possible to discover patterns, rules and unexpected relationships between data items that were previously unknown and unrealized. This is what can be considered the hidden treasure in corporate databases.

This constitutes an intriguing possibility and a challenge. However, it is a challenge on which only a few companies are embarking. This is unfortunate, since companies would certainly benefit from discovering some interesting correlations between, for example, sales data and customer financial data. The following practical situation will serve as an example.

#### 3.2.1. The New York Stock Exchange (NYSE)

The regulating department of the New-York Stock Exchange is charged with ensuring that the brokerage firms that are members of the NYSE are financially sound. This is accomplished by requiring that these firms file huge amounts of financial data which financial analysts of the regulatory department of the NYSE then review.

The most important tool for this purpose is a program that is called EDR (Exception Disposition Report). This report is produced by comparing the data filed by the brokerage firm with a set of statistical algorithms such as: "If the firm's excess capital is greater than 25 percent of its profits then flag an exception". These exceptions, formulated in the form of rules, were developed by the financial analysts by comparing and reviewing one information item against another. The rules, called EDR's, were coded statements concerning the relationships between financial data items.

The financial analysts met regularly to improve the rules of the system. There was the constant danger that these rules could be wrong resulting in incorrect relationships. This was because these rules were composed manually.

A greater problem was the absence of certain rules. A potentially dangerous financial situation would never be discovered in case of missing rules. The product would be considerably better if the rules could be deduced automatically. This alarming situation has been remedied with the introduction of expert systems (see also paragraph 3.5.).

### *3.2.3 IntelligenceWare and IXL*

The market leader in these corporate databases is IntelligenceWare, a company that markets IXL (Introduction of Extremely Large databases). IXL is a unique system that analyses very large databases and discovers patterns, rules and often unexpected relationships. IXL uses statistical methods and self-learning techniques that generate simple rules. A very interesting case was discovered recently using IXL. The University of Southern-California conducted an investigation in lead poisoning. Analysis of the gathered information led to the discovery that a relation existed between the gender of a person and the level of lead in the blood that could result in damaging a kidney. This relationship was unknown and possibly catastrophic.

Meanwhile many firms started to explore this form of intelligent information processing using corporate databases. The fact that little is known about their efforts is understandable in this stage of the application.

### *3.3 Benchmarking*

An increasing number of companies discovered the usefulness of starting activities where they gather information concerning the intelligence and the position with respect to technological situations and the lead of competing companies. It appears that it is not required for a company to have access to a mainframe computer for this activity. It is possible to do this with the aid of a personal computer. The technique of gathering the information of the competing industries is either called "Combustion Engineering" or "Benchmarking". We will use the latter term here. The objective of a benchmark activity is to analyze every separate competitor (or group of competitors) in terms of the strategies that they apply and their future developments. The most important difference between this technique and other methods is the direct participation of top management. It is not just a team of knowledgeable people that carries out this investigation and the analysis of the collected information. High ranked managerial functionaries are involved as well. They contribute in the analysis process and are crucial in deducing the strategies of the competitors in a logical way.

Benchmarking consists of five steps required to be able to perform a sound and useful analysis. The five steps are the following:

Step 1: Initiating meeting. When the company that will be analyzed is selected, an initiating meeting is held. This meeting has to be attended by the relevant managerial staff as well as the CEO of the company. This group has to be complemented with the companies experts who are capable of making the various information sources accessible to the rest of the meeting. These information sources consist of information and documents that are internally available and those that can be obtained from external sources. A plan is made at this meeting. This plan contains further actions that will result in obtaining even more information. The plan will also formulate the way the total amount of available information about the competitor has to be analyzed.

Step 2: Information-exchange meeting. At this meeting every person will be allotted a certain amount of time in which he or she will have to present the information gathered by him or her to the others. The team will then perform a strength-weakness-analysis. This will be done for all the collected information. This analysis addresses two questions: "Is the competitor stronger or weaker than our company?" and "Has the investigated area of interest a potential that may influence our customers?".

Step 3: Analysis of costs. When the meeting feels that all areas of interest have been sufficiently well defined and isolated a comparative cost-analysis has to be carried out. First of all a division of the costs of the company's own product has to be carried out. These costs involve labour costs, manufacturing costs, costs related to goods, materials and services that have to be purchased, distribution costs, and costs related to the commercial activities and accounting. Next the costs of the competitor are compared with the cost figures of the company that carries out the benchmark. These costs are classified on a scale with four components: considerably higher, somewhat higher, somewhat lower, and considerably lower. This can be worked out in detail. It is also possible to establish a certain percentage between "somewhat" and "considerably", for instance 10%. It is now possible to calculate or assess the total costs of the competitor for a specific product by attaching weights to all these cost factors.

Step 4: Motivation of the competitor. This is undoubtedly the most difficult and least tangible aspect of the benchmarking process. The team has to analyze the motivation of the competitor. This can be done by determining how the competitor measures their successes and to assess what are their objectives and strategies. During this part of the investigation a senior manager and his or her staff has to collect a considerable amount of information on this subject. Using on-line databases informa-

tion can be obtained from: advertising material, brochures, annual reports, press releases etc. One should also obtain information from former employees of the competitor. This concerns (especially) information about the strength of the marketing department, analyses of the investments, the supplier(s), the customer, the production strategies etc. One should be able to deduce the motivation of the competitor from this information.

Step 5: Composing the total image. Further analysis of the collected data makes it possible to get an impression of the strong and the weak points and areas of the competitor. These points relate to the competitor's cost structures, his objectives and strategies. The team can now begin to develop an insight in specific areas and develop an understanding about possible next steps that will be taken by the competitor. The team can show, for example, that the competitor is stronger in his direct sales, has created a more profitable position in terms of his labour costs and is in the process of moving up from a pure regional operating company to one that will be more active on a national or international level.

When a company can carry out sufficiently large amounts of benchmarks, it will be able to adapt its own strategies to challenge the competition successfully and to even take a lead. The use of proper methods and tools offered by the information technology in collecting, analyzing and synthesizing the relevant information is indispensable in a benchmark activity.

#### *3.4, The use of strategic tools.*

The apparently smooth evolution from handling data to processing information has been characterized by great improvements in the way information technology is currently being utilized and in the availability of appropriate tools and methods. The advent of fourth-generation languages, vastly improved application programs to which a certain amount of intelligence has been added, advanced communication means and the heavy reduction in hardware costs characterizes this evolution. Human productivity also increased due to the aforementioned developments. At the same time companies introduced new methods that assisted them in searching databases that contained massive amounts of information faster and more efficiently. Currently the management of companies can choose from a wealth of methods that permits management to retrieve the most relevant information almost immediately. Some of these methods will be described shortly.

The monitoring method provides the user with data on an exception basis. This can be variance reporting, where the system only produces exceptions based on a programmatic review of the data. Examples are: the review of credit card payments where only those accounts are displayed where the payment was not received or the payment into the account of the card holder is below the minimal allowable amount.

The advent of a fourth-generation language, a tool that enables

the end-user to access corporate databases with an easy to use syntax, has thrust the interrogative method of system tailoring to the forefront. This method takes the many occasions into account when the user cannot identify the information required to handle day-to-day, ad hoc analyses in complex decision-making situations. In these cases, all of the information elements need to be resident in a database that is constantly accessible.

A model-oriented approach consists of a series of methodologies. Human resources or facilities departments are appropriate candidates for descriptive models. These are, for example, organization charts or floor plans. A normative representation of information is well suited for budgeting problems when the goal is to provide the best answer for a given problem. Economic models are a good target for methodologies that have the ability to handle uncertain data. Operations management functionaries often apply game theories to those problems where it is required to find the best solution in spite of a profound lack of information. An example of a problem where this type of strategy would be used is a competitive marketing system where information about the competition is scarce or unknown.

Information technology is more than just software. Slowly companies have started to realize that the value of information has been augmented by improvements in computer hardware and communication technologies. The dominating position of mainframe computers of the sixties and seventies has been replaced by small equipment (personal computers) that can be used locally and can be used as workstations by linking them to powerful networks. Thus the PC can use the complete potential of large computers remotely. With the introduction of distributed architectures (as in client/server concepts) the term "information system" is no longer one that is only applicable to the hardware of the eighties. With the advent of distributed concepts, extremely fast and reliable communication means and powerful information processing capabilities, industry should at last be able to embrace Information Technology completely and unconditionally.

### *3.5. The application of Artificial Intelligence (AI).*

Industrial enterprises have begun to explore and use the specific area of information technology known as Artificial Intelligence (AI). The most important application of AI is the use of "intelligent robots", programmable machines equipped with vision and touch-sensitive devices. The second important applications are those of expert systems. In this report we will limit our discussion of AI to the application of expert systems.

#### *3.5.1. Expert systems.*

During the last five years more than 80% of all industries making the list of the "Fortune 500" have investigated and/or introduced expert systems and methods used to capture human expertise.

Expert systems are said to be able to copy the knowledge and the reasoning skills of the company's experts. It will permit the users to interact with expert systems and add the knowledge of the "tapped" experts to their own knowledge and capabilities. This will enhance their productivity. It underlines the power and possibilities of information technology.

The essence of an expert system consists of the knowledge which is stored into the knowledge base of this system. The first hurdle to be taken is to discover "expertise" and formalize it. Expertise is not necessarily associated with a smartness. Expertise is not so much the function of intelligence of a person but more the way that person has accumulated experience and uses that experience skilfully. It is the experience that one wants to formalize, formulate and store in the knowledge bases of expert systems. Experts have a solid and deep-rooted knowledge of a specific subject. If they are confronted with a problem they will be able to immediately create a clear view of the problem in the context of the situation that problem manifests itself. Inexperienced employees or employees who lack the ability to use their knowledge properly will often find themselves in a situation where they can not see the trees through the forest. The most interesting difference between the expert and the inexperienced employee is probably the fact that the expert is much more capable of organizing his or her knowledge and applying it. The expert learns to recognize certain patterns that are, as it were, burnt into her or his memory. A new problem exhibits quite often certain features and characteristics that resemble previous problems in certain instances, and are different from those that are stored in the expert's memory in other instances. The expert makes associations with his or her earlier experiences, identifies the differences and makes decisions about solving the new problem almost immediately.

The first generation expert systems could only handle superficial knowledge. This is knowledge collected during interviews with experts. The second generation expert systems is strongly supported by research in psychology and the neurosciences; research that has been carried out at a wide range of different universities. The conducted research helped developers of expert systems to obtain a better understanding of the way knowledge and experience are stored in the memory of experts. This research led to tangible and practical results, especially in the use of neural networks. These will be discussed in a later paragraph.

### *3.5.2. Some practical examples.*

*3.5.2.1. E.I. du Pont Nemours & Company* became aware of the strategic value of this technology in 1985. The Company allowed the personnel who showed interest in expert systems to make themselves familiar with this technology and create their own expert systems. Now Du Pont uses more than 600 expert systems. What is even more important is that the company has saved between



1985 and the present more than \$ 150. million by using the expert technology. The enterprise has expanded its share in the market and was able to enter new markets. That was demonstrated with the expert system "Packaging Advisor". This system has been successfully used in the design of rigid plastic food containers. It helped Du Pont to break into the very competitive barrier resin market.

*3.5.2.2. Digital Equipment Corporation* has installed more than 50 expert systems. The company states that it has saved about \$ 200. million with the use of this technology. The most well-known of DEC's expert systems is XCON, a system that automatically generates the technical specifications of a customer-oriented computer. A human technical author will undoubtedly make many more errors than XCON when specifying a computer, especially since DEC's computers contain between 2000 through 8000 parts. DEC became a serious competitor to IBM in the early eighties with this system.

### *3.5.3. From expert systems to neural networks.*

Neural networks simulate a network consisting of hundreds of interlinked units that work in parallel. Messages are transmitted between the nodes (the neurons) of a neural network with enormous speeds. The neuron's function in such a network is to receive messages and to respond to these messages almost immediately. This resembles the conventional ways that networks operate. Neural networks are actually programs that differ largely with the existing programs. First of all, neural networks can recognize low-quality input. This enables the neural networks to process incomplete data. Handwritten documents are an example of the application of a neural network. Several financial institutions use neural networks to recognize signatures. These signatures may be badly written. Even signatures of people who don't write their signatures in exactly the same way each time can be recognized.

A completely different application of neural networks is a PC-oriented neural network that predicts the value of stocks, gold and foreign currencies. The value of those stocks, gold and currencies are stored in a knowledge bank. These data have been collected over a 40-year period with 10-day intervals. When the net is switched on it searches for input patterns that will result in a specific output stream - in this case a decrease or increase of the value of the item that is being investigated. The larger the amount of stored information, the greater the accuracy of the prediction. That can be readily understood since the neural network copies the way in which the human being learns and it simulates the way our brains operate. If our memory contains many examples that lead to a certain result, then they can find a normative answer to received data. Our brains will anticipate the answer, even if the received data is irregular and incomplete.

#### 3.5.4. Requirements that have to be met.

To-day there are many examples that show how AI-systems contribute to a company's strength compared to that of their competitors who neglected to take advantage of this technology. However, before acquiring, developing or implementing an AI-system a number of important aspects have to be considered and certain measures have to be taken.

1. All management levels have to be convinced of the usefulness and the need for an AI-system. They must support this activity without reserve.
2. Adequate training in AI-systems is very important. An expert system should not be regarded as another conventional system.
3. Potential systems have to be evaluated and reviewed by the pool of future users and the technical staff that will be charged with implementing or developing the system. Not all of the company's problems can be solved with the aid of AI-systems.
4. Don't use more than three professionals in the development of a system unless the company has enough experience in this type of technology. Differences in opinion among the professionals often lead to delays and errors.
5. The problem that has been selected to be solved with the aid of an AI-system has to be defined formally. The resulting system should not come as a complete surprise to the future users and to management.
6. Intelligence and automation systems can be enhanced with more than one solution that Artificial Intelligence has to offer. A well-formulated decision based on solid fundamentals and principles will help in making the right choice for the specific AI-technique that can be used.
7. In case an AI-system is developed, one should always start with the construction of a prototype system first.
8. The three most important activities to be carried out when developing and implementing an AI-system are: testing, testing and testing. The assumption that expert systems and neural networks can not be tested is a fable.

#### 4.0 Quality of Information Systems.

This chapter is a natural continuation of the previous two chapters. Attention will be devoted to the quality of acquired, developed or otherwise implemented systems and their associated use. The quality of the products a company produces is not being discussed here. Orientation will only be focused on software quality.

However, the quality aspect of software is tightly connected to all aspects of a company. It is about the quality of its products, the productivity of its employees etc. It is part of the culture of the company; how it develops, implements and uses its technology. It has been proven that caring for quality on a short term basis leads to an increased productivity in the long term. Quality is still neglected in situations where a company tries to implement (or deliver) systems before or exactly on the due date. Despite timing constraints or other pressures, one must continue to make serious attempts to enhance the quality of the output. That means that measures have to be taken to assure the quality of every implemented or used system. In assessing the quality use can be made of an enumeration of a large number of aspects that relate to the size, structure and functionality of a software system. These can all be measured and can considerably improve the software as well as the information content generated with the aid of software. Table 2 can be viewed as containing a fast evaluation of the achieved quality of software.

1) Number of lines of code
2) Pages of documentation
3) Number and size of the tests to be carried out
4) Summary of the functions
5) Number of variables
6) Number of decision trees
7) Module count
8) Depth of nesting
9) Number of required changes
10) Number of detected errors
11) Number of changed lines of code
12) Time used to design, code and test
13) Defect discovery rate in each phase of the development
14) Development costs
15) Number of external interfaces
16) Used tools
17) Reusability percentage
18) Variances in the planning of the development
19) Staff years experience of the team
20) Years of experience with the used language(s)
21) MAPS per person
22) Ratio of support personnel to development personnel
23) Ratio of time not spend on the project to project time

Table 1: Metrics Productivity/Quality

1) How easy is it to use?	1	2	3	4	5
2) How secure is it?	1	2	3	4	5
3) How is its level of confidence?	1	2	3	4	5
4) How easy is it to upgrade?	1	2	3	4	5
5) How well does it conform to requirements?	1	2	3	4	5
6) How easy is it to change?	1	2	3	4	5
7) How portable is it?	1	2	3	4	5
8) How easy is it to locate a problem and to resolve it?	1	2	3	4	5
9) Is the response time fast enough?	1	2	3	4	5
10) How easy is it to educate staff?	1	2	3	4	5
11) Is it simple to test?	1	2	3	4	5
12) Is the software efficient in terms of the computer capacity	1	2	3	4	5
13) Easy to couple with other systems?	1	2	3	4	5
14) Does the system utilize the minimum storage possible?	1	2	3	4	5
15) Is the system self-descriptive?	1	2	3	4	5
16) Is the software modular?	1	2	3	4	5
17) Is there a program for continuous Quality awareness for all employees?	1	2	3	4	5
18) Is the quality of the supplier checked regularly?	1	2	3	4	5
19) Is there a quality department?	1	2	3	4	5
20) Is this the correct system to be developed, implemented or used?	1	2	3	4	5

Circle the applicable number next to each measure. Add total score.  
1=positive; 5=negative

Table 2: Quality factors. Rating these factors and totalling the score provides a way to measure the overall quality of a software project.

A good example of an enterprise where quality and productivity are best tracked is Hewlett Packard (HP); a company that produces electronic systems and equipment. This firm has implemented a Total Quality Control (TQC). TQC is defined by the fundamental principles that

- 1) all business activities can be scrutinized in terms of the involved processes, and that
- 2) metrics can be assigned to each process to evaluate its effectiveness.

This TQC approach places software quality and assessment high on the list of software development tasks. When projects are initially defined, the knowledge about the project to be automated is evaluated and the project team will define the metrics that are to be used to measure the automation process. When HP

decided to base the company's future on a new type of computer architecture they realized that the reliability of the equipment and the software would be a critical issue. The development of the operating system would turn out to be one of the largest development efforts in the history of HP. It was also an effort in which more than one division was involved. HP concluded that going over the budget by 50% and getting a product out on time reduces the eventual profits with approximately 4%. However, staying within budget and getting the product to market five months late reduces the profits with 60 to 70%.

HP was one of the first companies that introduced a System Software certification program to ensure measurable, consistent, high-quality software through the definition of metrics, goal setting, collecting and analyzing data, and certifying products before releasing them.

The results were impressive. Errors were detected and corrected early in the development stages. Those were stages where the costs involved in finding and correcting those errors were still relatively low. This all resulted in lower overall costs and a higher productivity of the departments and employees involved. At the same time it increased the quality of the products that were shipped to HP's customers.

This is one example of what a company can achieve with the appropriate use of development methods and sound information technology practices. Unfortunately this example has not yet lead to an overall higher interest in the HP approach at the majority of other companies and institutes.

Obtaining the ISO-9000<sup>2</sup> certificate is often viewed as a way to improve quality. However, the HP example shows that achieving quality requires enormous effort, much more than the effort involved in obtaining the ISO-9000 certificate. Those are limited to the definition and composition of procedures. This is complemented by teaching the staff and the firms' employees how to answer questions during the formal audits that are being conducted by ISO-9000 auditors. The answers to those questions are known and can easily be learned by heart.

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<sup>2</sup> It must be noted that the ISO-9000 certificate is based on the ISO-9001 standard. Companies that are serious in their quality efforts should at least aim for complying with the ISO-9004 standard. Even better is to try to obtain the Baldrige or Demming award.

## 5.0 Downsizing and outsourcing.

The term downsizing has different meanings for different people. It means making the hierarchy of a company flatter if it is viewed from the perspective of the human being. This phenomenon manifested itself more clearly after the collapse of the stock market of 1987, especially since that event was followed by a deep economic recession. Even during the recovery that started in late 1991 the trend of companies to continue this downsizing process continued. That was because the higher management of enterprises realized that this process resulted in a number of noticeable advantages and a higher efficiency of the company at large. Downsizing of a company made it necessary to conduct a thorough analysis of the kind of functions that have to be carried out within the company itself, the core functions, and tasks that can better be performed by outside specialized forms. That led to an increase in the sub-contracting of certain activities. A new term for this long practised activity had to be found and the industrial society started to use the term "outsourcing". (Note that the verb "outsource" is non-existent in the English language, whereas "subcontract" is). Many companies made extensive use of so-called "service bureau's" long before this term became popular. Its practice is as old as the phenomenon of corporate computer centers. In the era that preceded the cheap personal computers most of the information processing activities were carried out on mainframe computers. This was often a costly affair and was extremely difficult to calculate the profitability of the operations that were performed on these types of computers. Companies that did not have the financial means and/or the technical capabilities to perform certain automation tasks in-house started to buy time and services from a firm that could offer these services to a large variety of customers. Many of these service bureaus even started to specialize their operations and focused on certain branches of industrial activities. These services also included the choice of a wide range of application programs for the customers.

Downsizing and outsourcing did not stop when the economic situation improved in 1992. On the contrary, tens of thousands of highly skilled specialists lost their jobs almost overnight. The human tragedy that went hand in hand with the many downsizing operations created an enormous amount of human sufferings, something that would certainly have attracted more attention in the sixties and the early seventies. The author mentions this aspect since each of the success stories about downsizing and outsourcing ignore this human aspect completely. The impact on the quality of life of these "redundant" specialists and technicians is much more serious than is generally known. This becomes more evident by the large percentage of suicides, divorces and violent outbursts within the "protected circle" of the family of those technically high-skilled, well educated ex-employees of downsized companies.