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MASTER OF FINE ARTS

The CAID Information System

By

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I would like to express my gratitude to a number of people for making this work possible.

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1. Introduction

1. 1 Background

Design may be described as an activity whose purpose is to transform a statement of requirements for a new product into a detailed description of that product. Since both the input into and the output from the design is information, it is not surprising that information technology has had, and will have a considerable influence of design methods. [1]

The swift exploration of modern technologies forces the environment of product development into experiencing more structural change than ever before. The main idea of new kinds of production environment is to shorten the product development time by using accurate communication of information. To accomplish this, new product development methods, such as concurrent engineering and lean production, have been devised.

The importance of information technology to modern industrial design is increasing generally with the changes of the production environment. Accordingly, the need to use a computer in industrial design is increasing.

In the industrial design process of modern product development, the use of computers has increased. This use does not represent a change of a method but a change of a tool.

Many accurate 3D modeling and rendering programs have been invented and now they are the main stream of computer aided industrial design (CAID) programs. These programs have nice features, modules and functions, but they provide linear work flow and therefore; can not control much information about product development.

To assist and lead the whole new product development process with accurate use of information and faultless design, a computer aided industrial design information system is needed in place of linear processing CAID pro-

1 Dr George Rzevski, "Impact of information technology on design methods." *Design Theory and Practice.* The Design Council (1984) : 47 52.

grams.

Industrial design is the first and most important stage of a product development process. Therefore, it is important to develop an appropriate design method which fits modern product development environment.

1. 2 Objectives

The main objective of this thesis is to determine the feasibility of an information system in industrial design and to develop a computer aided industrial design program as a CAID information system which can help an industrial designer during the design process while avoiding mistakes. This system may shorten the whole product development time in the modern product development process and improve the design quality.

The following research objectives are pursued:

1. Study of information systems and exploring the possibility of developing information systems in industrial design.

2. Understanding a modern product development environment as a basis of industrial design in the information technology aspect.

3. Investigation of industrial design methodologies.

Based on the above research, a practical CAID information system is proposed as a computer integrated industrial design system.

1. 3 Scope

The scope of this thesis is limited to factors about a computer aided industrial design Information system which can solve problems that arise from estrangement between industrial design and information technology.

This study regards an industrial design process as an information circulation process. It considers an Information system as a means to enhance information management.

The application of the CAID Information system proposed in this thesis is limited to the stages of the industrial design process from concept development to design documentation. This is being limited to strengthen the quality of the study, and focus on the core part of industrial design.

The research will concentrate on the following areas :

Product design process and information technology

Knowledge based Information systems and industrial design

This will help to provide an understanding of the theory of Information systems and to reveal the potential of industrial design Information systems.

CAID and concurrent engineering environment (CE)

The important modern environment factors for industrial design are CAID and CE. An understanding of this environment is critical to the study.

1. 4 Method

The following research step was executed:

Step 1 : Broad investigation of Information systems, data base systems, the computer science theory , computer programming languages, the content of CAM/CIM, and the relationship between

CAID and industrial design methodologies.

Step 2 : Determination of the CAID Information system's structure and the required parameters that the CAID Information system will respond to.

Step 3 : Obtaining and making the knowledge based on data base system.

Step 4 : Selection and studying of a specific programming language

Step 5 : Making the user interface

Step 6 : Applying the prototype Information system to the design of a selected product.

Step 7 : Evaluation of the effectiveness of the CAID Information system as a tool for an industrial designer.

2. Product Design and Information Technology

2. 1 Design Process

2. 1. 1 Characteristics of Design Process

Design has become one of those words having a wide range of meaning that we can't be really certain as to what it means.
Some definitions and descriptions of design appear below.

- Finding the right physical components of a physical structure. (Alexander,1963)
- A goal-directed problem solving activity. (Archer, 1965)
The optimum solution to the sum of the true needs of a particular set of circumstances. (Matchett, 1968) [2]

- Design is a prescriptive activity. (Lawson, 1980) [3]
The core of designing is reasoning for function to form. (Roozenburg, 1995) [4]

Like these many definitions, the design process can also be executed in many different ways. It is impossible to find a general model which can be applied for every design process because of its diversity.

Giving an exact definition of design process and understanding the meaning of the process are very difficult. A designer only knows the composition of design process. Generally a design process consists of analysis, synthesis and evaluation.

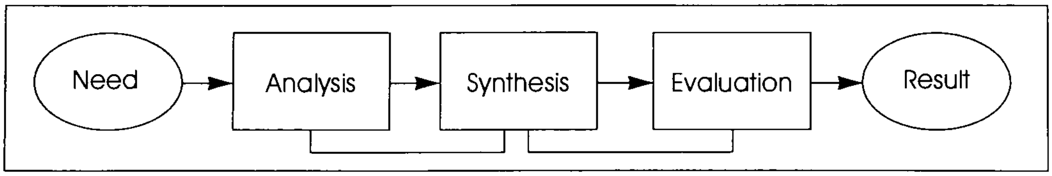

Figure 1. General Design Process

2 J. Christopher Jones, *Design Methods* (New York : Wiley-interscience, 1970), 3.
3 Bryan Lawson, *How Designers Think* (London : The Architectural Press, 1980), 90.
4 N. F. M. Roozenburg and J. Eekels, *Product Design: Fundamentals and Methods* (New York : John Wiley & Sons, 1995), 83.

Bryan Lawson's analysis of design process is that design problems defy comprehensive description and because they often have an inexhaustible number of solutions the design process cannot have finite and identifiable end. The designer's job is never really done, and he can always try to do better. [5]

The reason why design process has lots of models and there is no general procedure is that the word design has been used in so many fields like industrial design, fashion design, engineering design, architecture and so on. The product design which analysis and synthesis stage are executed by visualization method is included in general design process, but also has its own characteristics.

> Product design is the process of devising and laying down the plans that are needed for the manufacturing of a product. It is a goal-directed thinking process by which problems are analyzed, objectives are defined and adjusted, proposals for solutions are developed and the quality of those solutions is accessed. In an industrial company the design of a new product is not an isolated activity. It is part of a more comprehensive process called 'Product development'. Product development is the development of a new business activity around a new product. Product design, therefore, demands a multidisciplinary approach. Which disciplines have to contribute largely depends on the characteristics of the product to be developed, but engineering, industrial design, ergonomics, marketing and innovation management are nearly always involved. [6]

Since mass production is the major premise of industrial design, the industrial design process has lots of related fields and departments and also has many restrictions. To solve these problems, industrial design process consists of repeated analysis, synthesis and evaluation circles.

2. 1. 2 Model of Design Process

Design process is diverse depending on the object, but generally it takes the cycle of analysis, synthesis and evaluation. The contents of this cycle are: first,

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5 Bryan Lawson, *How Designers Think* , Op. cit., 88.

6 N. F. M. Roozenburg and J. Eekels, *Product Design: Fundamentals and Methods* , Op, cit., 3-4.

divide the design problem into smaller parts: second, synthesize the parts with new methodology: third, attempt to give a new arrangement to those parts and finally, evaluate the result. This method is similar to ordinary problem solving process.

Though there are basic analysis, synthesis and evaluation cycles which most design processes would follow, many design theorists have their own design processes which are different from each other. Each different design process can be well established by its own situation. Nigel Cross classifies design processes into descriptive models and prescriptive models,[7] While Roozenburg and Eekels divide design processes into problem-solving types, phases of the product design process types and the phases of the product development process types. [8]

1) Problem-solving type [9]

In problem-solving steps can be distinguished which form a cycle that plays a part in each phase of the product design and product development process. The empirical cycle is the basic model for problem-solving. Adjusting this cycle to the process of solving design problems leads to a basic design cycle. This cycle is the most fundamental model of the design process.

This type is fundamentally a trial-and-error process. Solutions are provisionally chosen and tried out, after which the effects are evaluated and corrective measures taken.

A second important characteristic is that solutions are usually not tried out in reality, but in the imagination. Problem solving is not a primitive, unconscious form of trial and error in which a randomly chosen action is tried out directly, but conscious and purposeful trying in the form of a thought process.

The third important characteristic is the spiral-like development of the problem and the solution. To solve a problem, one generally passes through the cycle many times. The results of the evaluation of the previous cycle are the

7 Nigel Cross, *Engineering Design Methods* (New York : John Wiley & Sons, 1989), 19-31.
8 N. F. M. Roozenburg and J. Eekels, *Product Design: Fundamentals and Methods* , Op, cit., 84- 111.
9 Ibid., 84-87

input data for the new cycle.

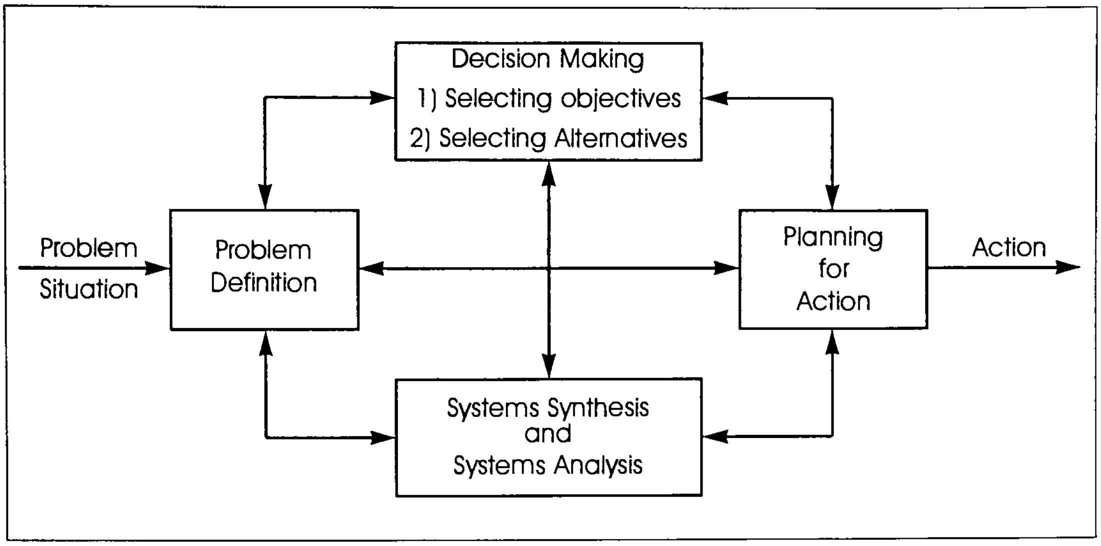

Figure 2. Problem-solving model

Source : Arthur D. Hall, *A Methodology For System Engineering* (New York : D. Van Nostrand Co., 1962), 89.

2) The Phase of the Product Design Process [10]

This model is described as a process in which the design of a product is worked out on different levels of abstraction. These levels correspond to various forms which a design in the making can be represented, such as the function structure, the principal solution and the preliminary design. Such representations of not yet completely worked out product design stand in a means-end relationships one to another, upon which the phase models of the design process are founded.

Examples of this approach are the models of French, Pahl and Beitz, and the VDI(Verein Dectscher Ingenieure). Among the most widely adapted versions of the phase model are those of French and of Pahl and Beitz.

Phase models are based on the idea that a design in the making can exist in three different ways.

As a function structure

10 Ibid., 93-110

- As a solution principle
- As an embodied design

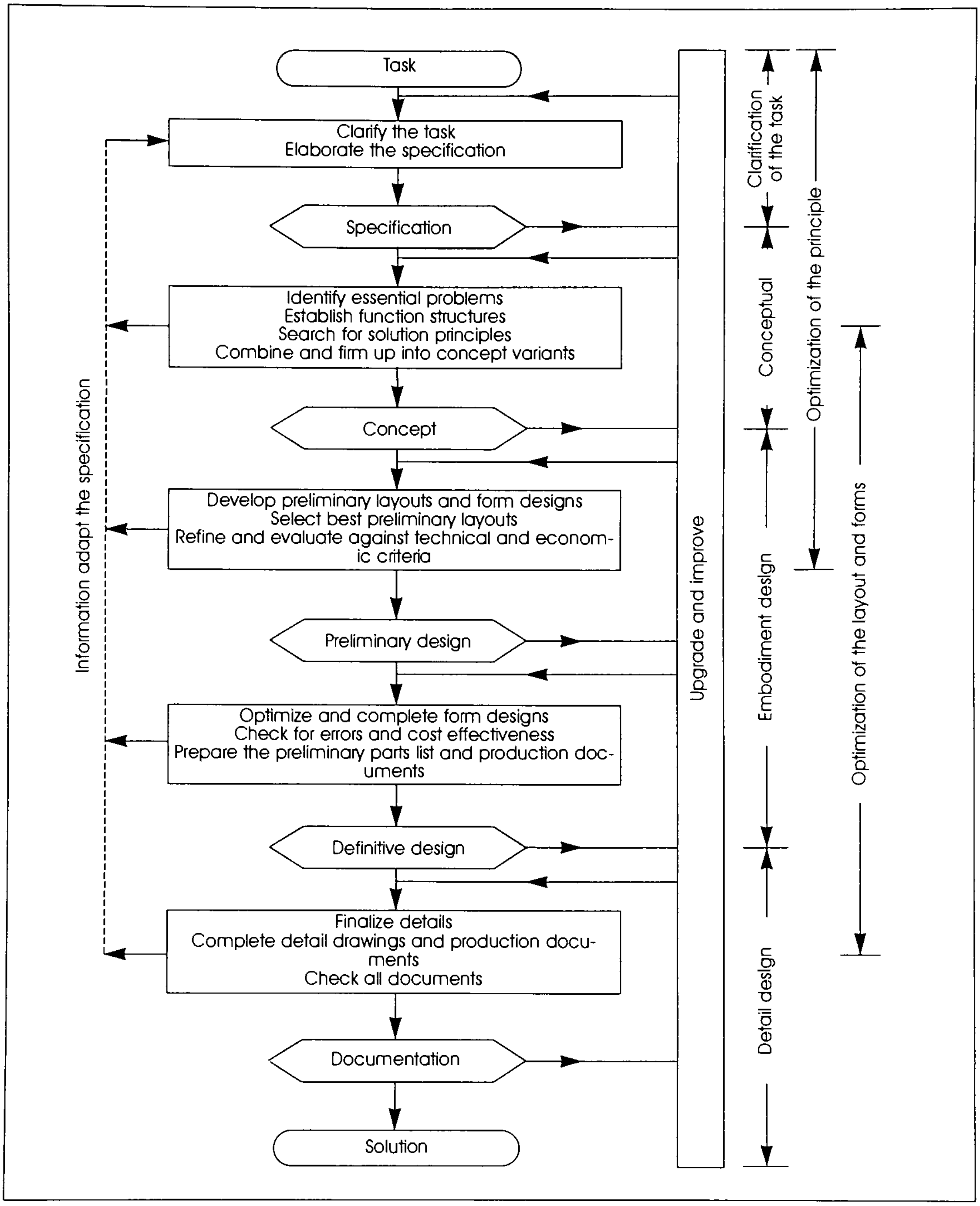

Figure 3. The phases of the design process according to Pahl and Beitz

Source : N. F. M. Roozenburg and J. Eekels, *Product Design: Fundamentals and Methods* (New York : John Wiley & Sons, 1995), 104.

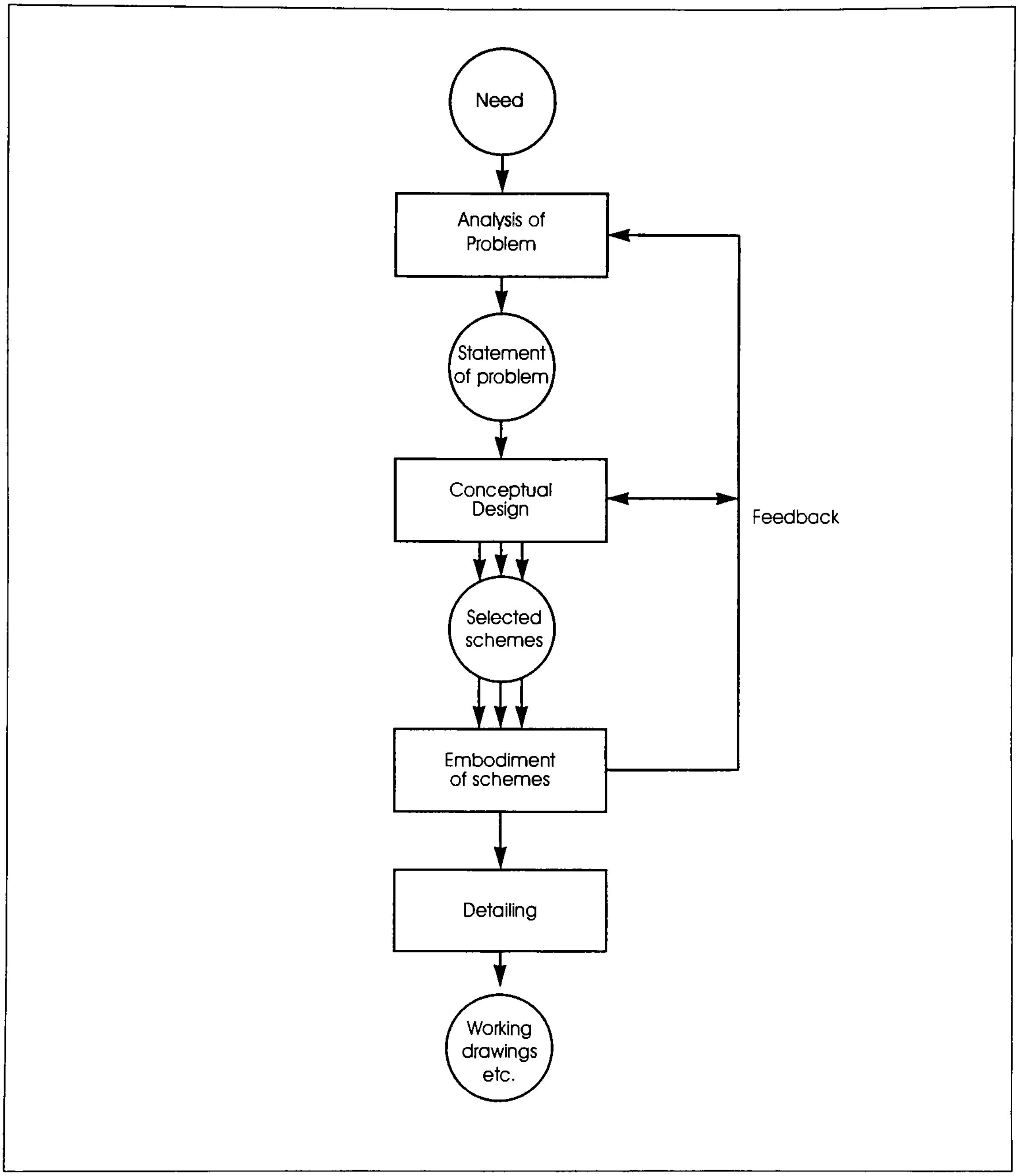

Figure 4. The phases of the design process according to French

Source : M. J. French, *Conceptual Design for Engineers* (London: The Design Council, 1985), 2.

3) The Phase of the Product Development Process [11]

This comprises activities of the product design process, as well as of product development and the development of the marketing plan. The domain of this model is not only the design of a new product, but the design of the plan for a new business activity as a whole. In these models the interaction between the various aspects of product development comes to the fore. They offer something to hold on to in product design, but are also very important in managing product development projects. The product development program of L. Bruce Archer is given as a typical example.

	STAGE
STRATEGIC PLANNING	1 Policy formulation 1. establish strategic objectives 2. Lay down outline timetables, overall budgets and guide lines for inno -vation
RESEARCH (production-oriented only: concurrent market-oriented, material-oriented, plant-oriented and pure or applied research would follow different patterns)	2 Preliminary research 1. Select an invention, discovery, scientific principle, product idea or technological base 2. identify an area of need, marketing opening, consumer appetite, product deficiency or value base 3. establish the existing state of the art (library and market research) 4. prepare outline performance specification (a verbal prescription for a proposed product-specification) 5. identify probable critical problem areas 3. Feasibility study 1. establish technical feasibility (basic calculation) 2. establish financial viability (economic analysis) 3. resolve critical problems in principle (inventions) 4. propose outline overall solutions (sketch designs 1) 5. estimate work content of phases 4 and 5 and probability of a suc cessful outcome (risk analysis) [Out of ten product ideas emerging from stage 3 . . .]
DESIGN	4. Design development 1. expand and quality performance specification (specification 2) 2. develop detailed design (design 2) 3. predict technical performance and product costs 4. prepare design documentation 5. design technical evaluation experiments and user trials 5. Prototype development 1. construct prototypes, mock-ups (prototype 1) 2. conduct bench experiments with prototypes 3. evaluate technical performance 4. conduct user trials with prototypes (trial 1) [. . .Perhaps three go to prototype stage . . .]

11 Ibid., 111-114

	5. evaluate performance in use 6. trading study 1. re-appraise market potential in light of trials 2. re-appraise costing 3. appraise marketing/production problem 4. revise basic objectives (strategic planning) and development budget 5. revise performance specification	
DEVELOPMENT	7. production development 1. develop a production design (design 3) 2. execute production design documentation 3. design technical, user and market trials 4. construct pre-production prototypes (prototype 2) 5. conduct technical, user and market field tests (trials 2) 6. appraise trials results and modify design 8. Production planning 1. prepare marketing plans 2. prepare production plans 3. design packaging, promotional material, instruction manuals 4. design jigs and tools	. . . and one survives for production development
MANUFACTURING MARKETING START-UP	9. Tooling and market preparation 1. construct jigs and tools 2. construct trial batch of products off tools (prototype 3) 3. test trial batch (trials 3) 4. produce marketing materials and print 5. install marketing machinery 6. install production control machinery	
PRODUCTION	10. Production and sale 1. initiate marketing effort 2. commence production and sale 3. collect market, user, repair and maintenance feedback 4. make recommendations for second generation designs (stages 2 to 4) 5. make recommendations for research (stages 1 and 2)	

Figure 5. A characteristic program for product development (Archer's model)

Source : N. F. M. Roozenburg and J. Eekels, *Product Design: Fundamentals and Methods* (New York : John Wiley & Sons, 1995), 113.

These three types of models portray different dimensions of design products, but these models do not oppose, rather supplement one another.

2. 2 Information Technology

2. 2. 1 Meaning of Information

The question 'What is information?' may appear to be basic. Nevertheless, it has generated many answers in the information research community. Let's consider a few definitions.

Information is recorded experience that can or shall be used in decision making. (Churchman, 1979) [12]

The distinction between data and information is simple. Information is associated data, that is to say, data items which have been processed in some way so that we can identify each item by associating it with other items. (Grindley, 1975) [13]

Information is digested data. The same data can be processed in a variety of different ways to produce different pieces of information which are useful in different circumstances. (Martin, 1981) [14]

Information is data that has been processed and is meaningful to a user. 15

Since information and meaningful data are processed , it dictates that some data has to be collected and transmitted, than processed and stored. To be meaningful to users, the information must be retrieved and distributed to them.

2. 2. 2 Utility of Information

Roman R. Andrus suggested that form, time, place, and possession utilities are useful concepts for understanding information value besides accuracy and use of information.

The meanings of four utilities follows:

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12 Janice Burn and Eveline Caldwell, *Management of Information Systems Technology* (New York : Van Nostrand Reinhold, 1990), 14.

13 Ibid., 14.

14 Ibid., 14.

15 Niv Ahituv, Seev Neumann, and H. Norton Riley, *Principles of Information Systems for Management* (Dubuque : Business and Educational Technologies, 1994), 2.

Form utility - As the form of information more closely matches the requirements of the decision making, its value(or utility) increases.

Time utility If decisions are to be based on information, the information must be available before the decision is made. Availability when needed(time utility) is expensive component of information value.

Place utility (Physical accessibility) Place of availability is a determinant of the value and usage of information. many of the developments in display hardware and on-line terminals are designed to maximize place utility, as well as time utility of information

Possession utility (Organizational location) Control of information is an important facilitator or inhibitor of managerial performance. The possession of information strongly dictates its value.[16]

2. 2. 3 Information Systems

1) Definition of information systems

Information is data that has been processed. A system is a set of components that operate together to achieve a common purpose. With these two basic definitions, we can proceed to a definition of an information system. An information system is the arterial system of an organization. It provides decision makers with facts and forecasts, and it conveys policies and instructions to operating organizational levels.

All information systems activities within an organization and the structure of the information system unit emanate firm relevant strategies and policies adopted by general management. Information system is an organization within an organization.[17]

2) Subsystems of information system

Subsystems of information system are divided into five categories. They are the accounting system, management information system, decision support system, office automation system, and expert system. Each subsystem can pro-

16 Roman R. Andrus, "Approaches to Information Evaluation." *MSU Business Topics* (Summer 1971) :42-43.

17 Niv Ahituv, Seev Neumann, and H. Norton Riley, *Principles of Information Systems for Management* ,Op. cit., 2.

vide information to be used in quality management.[18]

- Accounting information system : The accounting information system performs the firm's accounting applications. These applications are characterized by a high volume of data processing. Data processing consists of four major tasks - data gathering, data manipulation, data storage and documentation. [19]

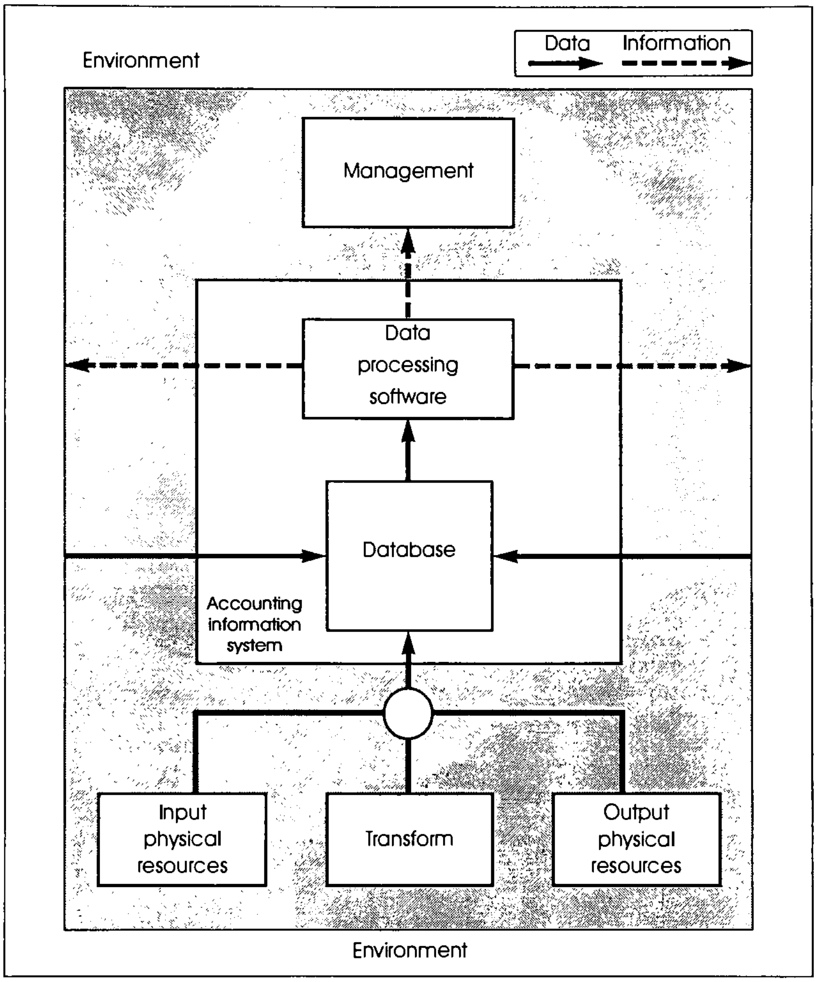


Figure 6. An Accounting Information System Model

Source : Raymond McLeod, *Management Information Systems* (New Jersey : Prentice-Hall, 1995), 359.

18 Raymond McLeod, *Management of Information Systems : a study of computer-based information systems* (New Jersey : Prentice-Hall, 1995), 103-104.
19 Ibid., 358.

- Management information system : The purpose of the management information system (MIS) is to meet the general information needs of all the managers in the firm or in some organizational subunit of the firm. Subunits can be based on functional areas or management levels. All functional information systems can be viewed as a system of input subsystems, database, and output subsystems. [20]

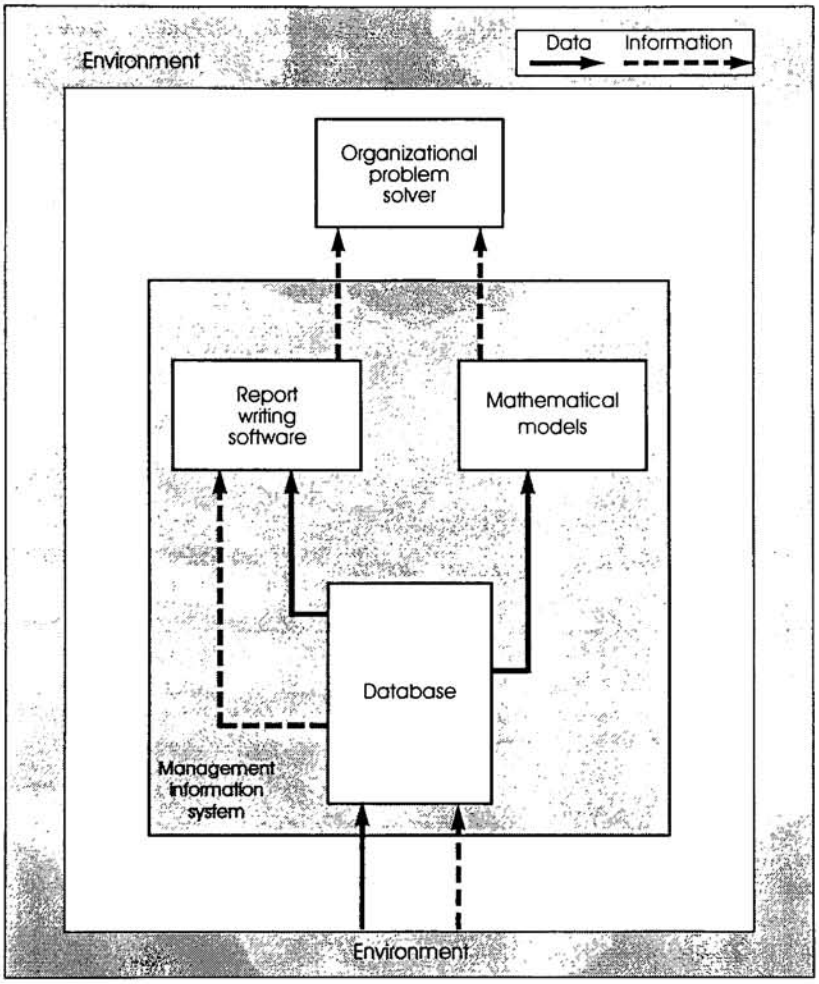


Figure 7. A MIS System Model

Source : Raymond McLeod, *Management Information Systems : a study of computer-based information systems* (New Jersey : Prentice-Hall, 1995), 384.

20 Ibid., 382.

- Decision support system : The decision support system provides problem-solving information as a communications capability in solving semistructured problems. The information is produced in the form of periodic and special reports, and outputs from mathematical models and expert systems. The communications are used when a group of managers engage in problem solving. 21

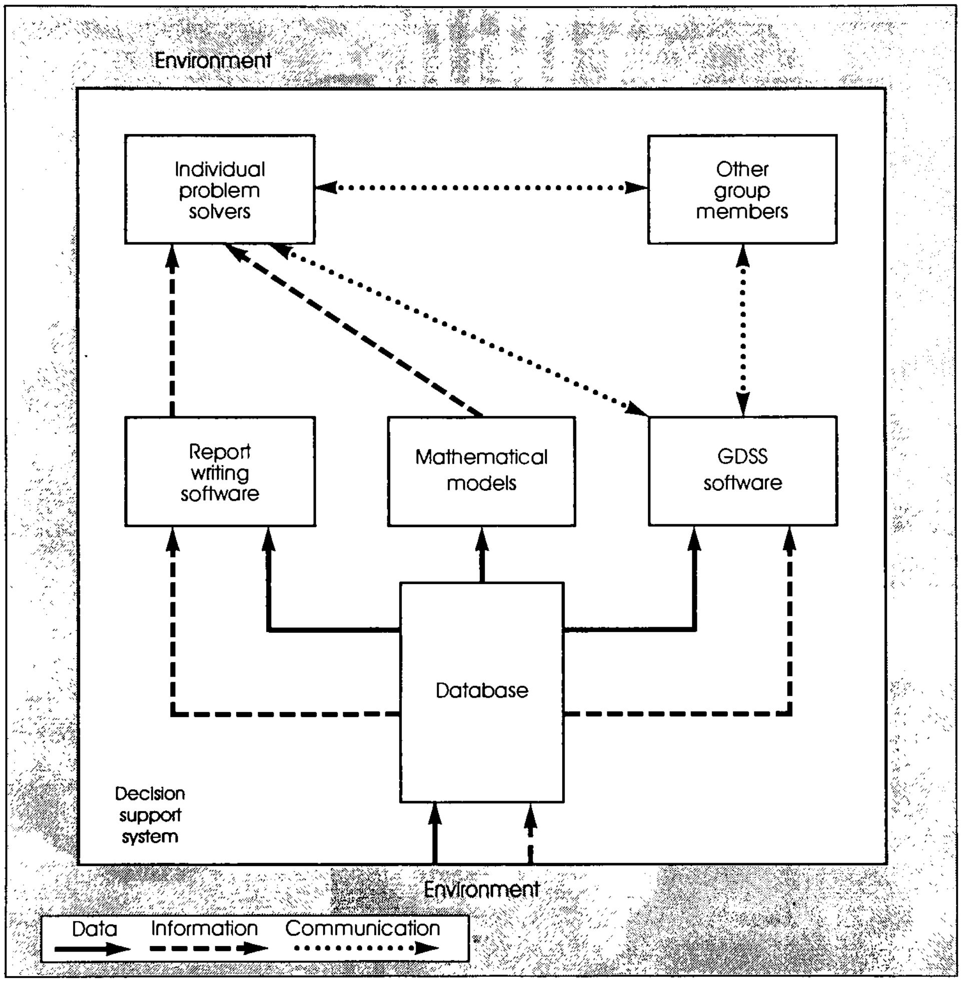


Figure 8. A Decision Support System Model

Source : Raymond McLeod, *Management Information Systems* (New Jersey : Prentice-Hall, 1995), 413.

21 Ibid., 408.

- Office automation system : The office automation system (OA) provides a communication capability for persons within the firm, enabling them to communicate among themselves and with suppliers and customers in the firm's environment. These communications enable groups with quality responsibilities, such as committees and project teams; to coordinate their efforts. Word processing, electronic mail, voice mail, and facsimile transmissions meet their needs well. Other OA applications, such as video and audio conferencing, are excellent for communicating information among groups that are scattered around the world. [22]

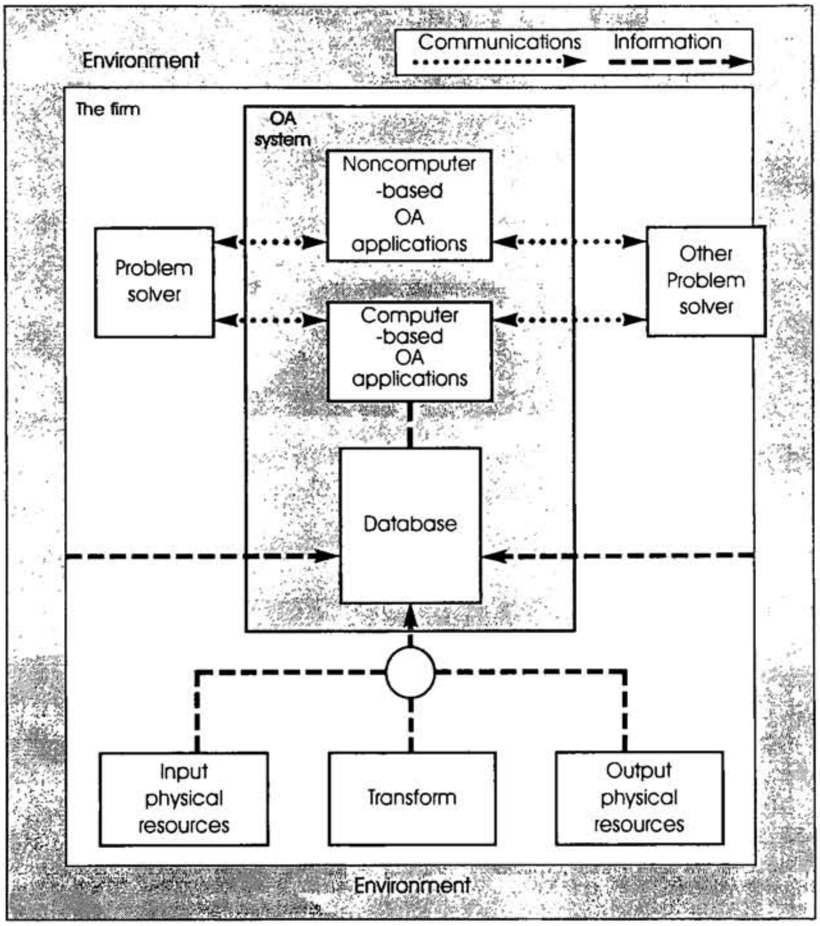


Figure 9. An Office Automation System Model

Source : Raymond McLeod, *Management Information Systems* (New Jersey : Prentice-Hall, 1995), 438.

22 Ibid., 104.

Expert system : The expert system is attracting the greatest attention from computer scientists and information specialists. Unlike the decision support system, an expert system has the potential to extend a manager's problem-solving ability beyond his or her normal capabilities.

An expert system consists of four parts : user interface, knowledge base, inference engine and development engine.

Expert systems offer advantages both to the using firms and managers, but they have significant limitations. Continued research such as that involving neural networks is expected to extend the capabilities of future expert system. 23

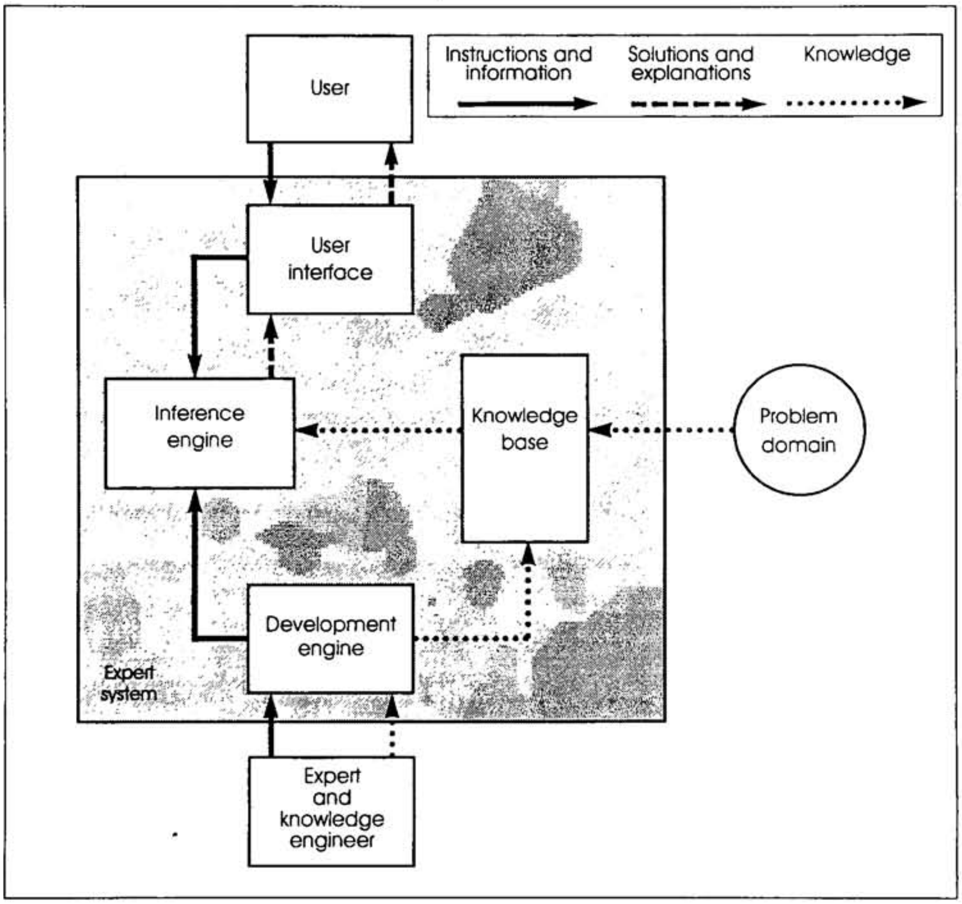


Figure 10. An Expert System Model

Source : Raymond McLeod, *Management Information Systems* (New Jersey : Prentice-Hall, 1995), 463.

23 Ibid., 460.

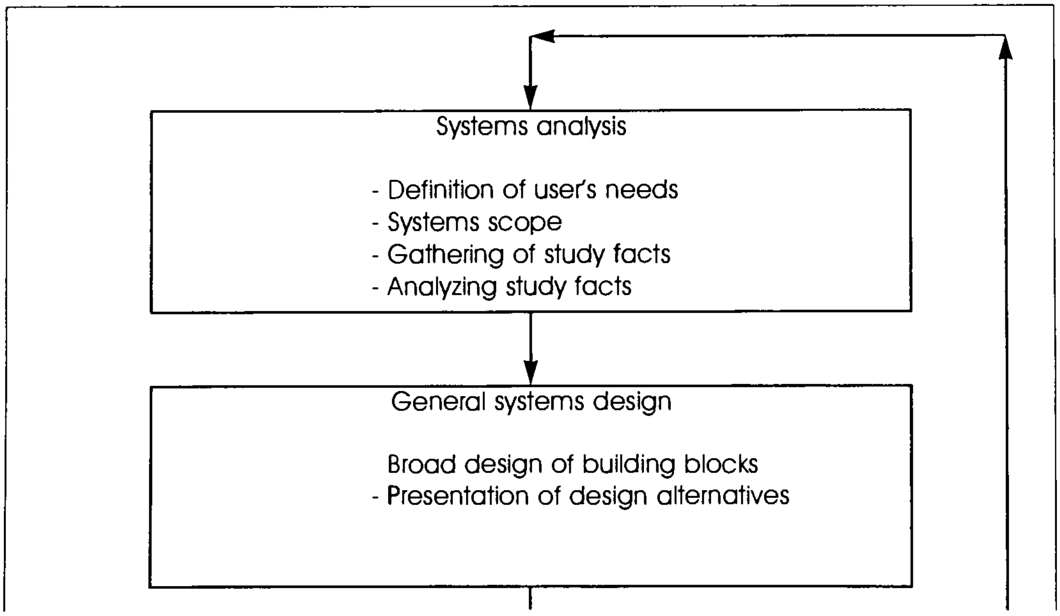
2. 2. 4 Information Systems Development Methodology [24]

The systems development methodology is what systems analysts follow in doing their work. The systems analyst prepares design specifications that are given to technicians, such as programmers, ergonomists, forms designers, and communication specialists. The systems analyst will coordinate all these specialists' tasks for final implementation of the total system.

1) Major phases of the Systems Development Methodology

The major phases of the systems development methodology are systems analysis, general systems design, systems evaluation, detailed systems design, and systems implementation. The major activities or tasks are included within each phase. The first four phases are directed toward providing specific values for the building blocks. The last phase deals with making the building block operational.

The systems development methodology is a step-by-step progression from very general to the very specific. The major goal of the systems development methodology is to reduce false starts, undue recycling, reworks and dead ends.



24 John Burch and Gary Grudnitski, *Information Systems : Theory and Practice* (New York : John Wiley & Sons, 1989), 54-57.

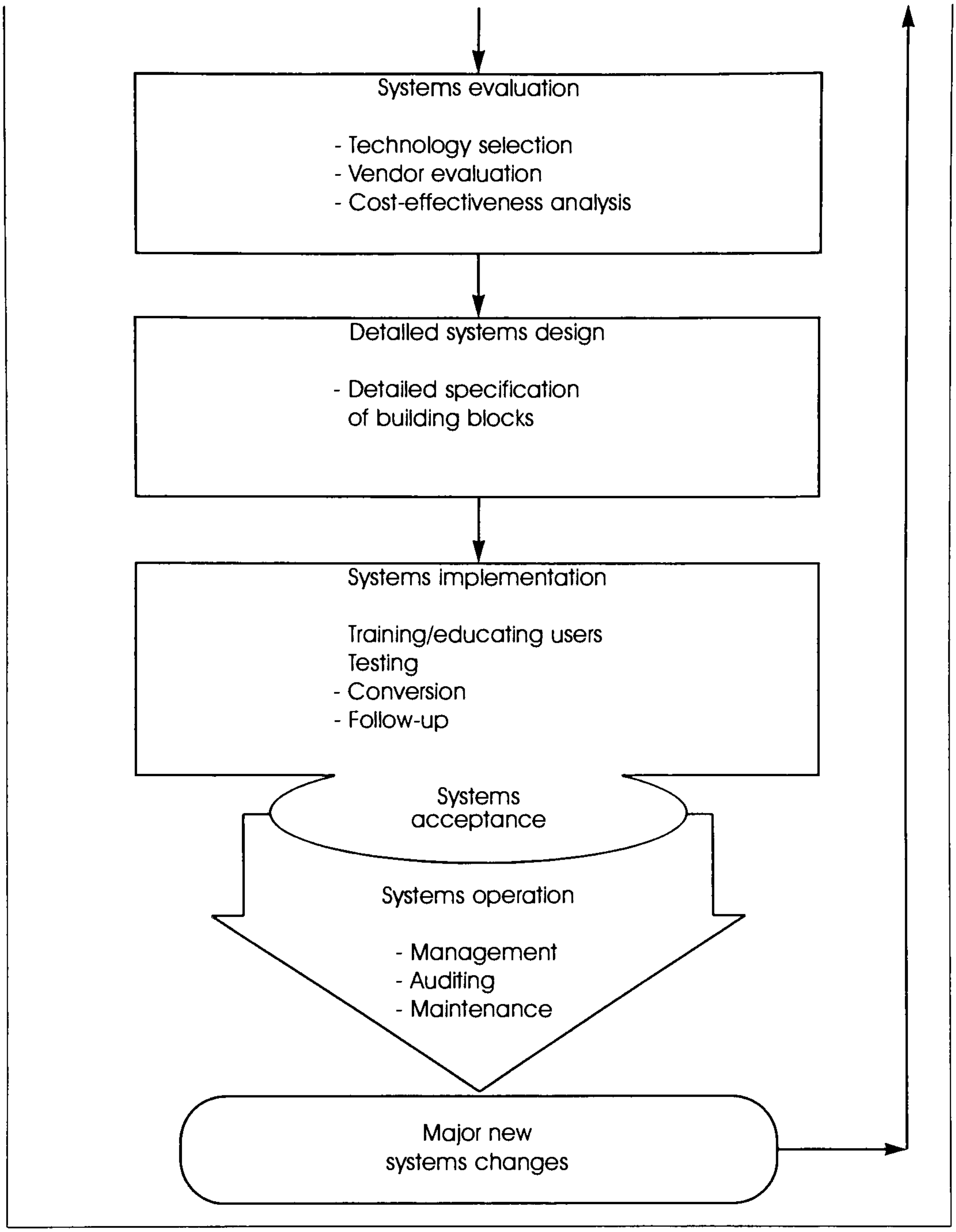


Figure 11. The Systems Development Methodology

Source : John Burch and Gary Grudnitski, *Information Systems : Theory and Practice* (New York : John Wiley & Sons, 1989), 55.

2) Definition of the systems development methodology

Systems analysis phase : Systems analysts assist users in identifying what information is needed. A number of interviews are conducted and questions are asked. After much interviewing, observing and sampling, systems analysts begin to put together many study facts for further analysis.

General systems design phase : Design is the process of translating requirements defined during analysis into several design alternatives for users' consideration. It also entails ferreting out all the design forces to see how they will impact on and influence different design.

Systems evaluation phase : This phase entails the selection of the technology that will support the other building blocks, the evaluation of this technology and the vendors who supply it, and a complete cost-effectiveness analysis of each proposed systems design alternative to determine the one with the best effectiveness-to-cost ratio.

Detailed system design phase : Before this work is started, analysts want to make sure that all parties have reached a final consensus as to the system they want implemented. Here, every building block is given precise and detailed definition.

- Systems implementation phase : This is the training and educating of users, testing and conversion to make the system operational. Here is where all development and design work comes to a climax.

2. 3 Design Information

2. 3. 1 Meaning of Design Information

In design process, information conversion usually occurs. In each phase of design process, a designer converts design information from a former phase into his or her new design concept or improved design information. The general meaning of design information is that which helps the designer to solve a design problem.

The role of information in design is well documented. It has been shown that it is central to the design activity, being the processing agent that is used to break down the problem as it is explored in both breadth and depth. It is information both general and specific that is collected, repatterned and blended together as mental imagery to synthesis solution. [25]

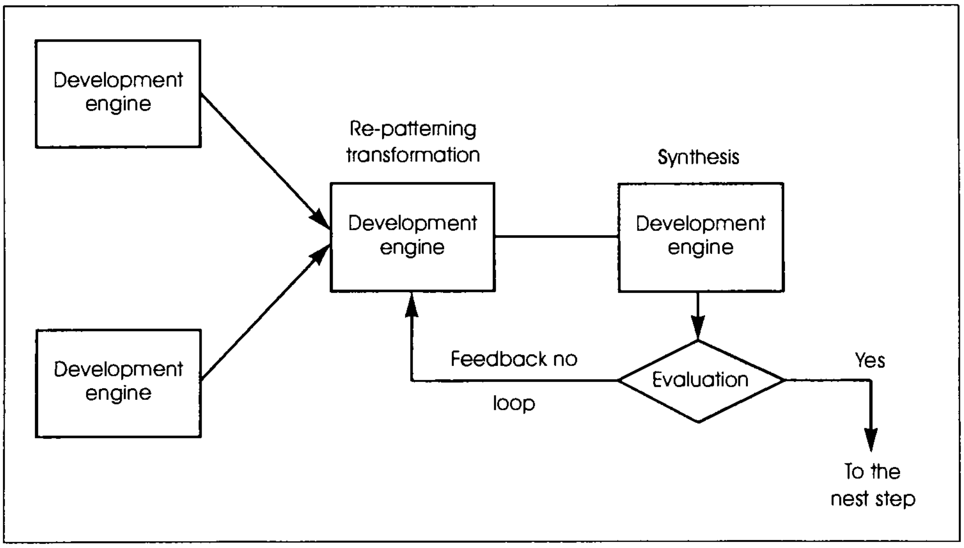


Figure 12. The central role of information in design activity

Source : H.Gill, *A Descriptive and Operational Model for Design: Design Theory and Practice* (London : The Design Council, 1984), 132.

25 H.Gill,"A Descriptive and Operational Model for Design", *Design Theory and Practice* (London : The Design Council, 1984), 132.

The information brought to bear on the problem will be both general and specific. General information covers aspects that are common to all design. Specific information covers that which is relevant to that particular type of design.

Design process starts by seeking information to break down the problem so as to achieve a better understanding of it and to reduce uncertainty as to its essential nature. Indeed, information has been defined as that which reduces uncertainty and design as decision-making in the face of uncertainty with high penalty for error. From this it can be seen that design with a vested interest in the reduction of uncertainty is keenly interested in the quality of information both as it relates to understanding the problem and as it is embodied in decisions about solutions.

2. 3. 2 Classification of design information

According to H. Gill, design information can be classified into HARD information, SOFT information, NECESSARY information and DISPENSABLE information.[26] This classification is informal but is suggested in order to encourage the designer to be discerning and not to treat all information in the same way.

HARD information is verifiable, well documented, and has been checked by several sources. It includes principles, laws, quantities, standards, contracts, data on existing designs, test data, drawings and other graphic material.

SOFT information is not usually verifiable, maybe transient, and mostly qualitative. It includes opinions, market surveys, recommendations, ideals and projection of future possibilities.

NECESSARY information can include either or both HARD and SOFT information and, as the name implies, is considered essential.

DISPENSABLE information implies the opposite to the above but this would not be evident when the problem was first explored and the information was originally assembled.

26 Ibid., 134.

According to C. M. Crawford, The attribute of a product can be divided into features, functions and benefit and these attributes have linear relationship. [27]

Typology of Attribute Analysis Techniques		
Features	Functions	Benefits
Dimensions Aesthetic characteristics Components Source ingredients Manufacturing process Materials Services Performance Price Structures Trade marks etc.	Functions are rarely used and often are treated as features or benefits, depending on the case	Uses Sensory enjoyment Economic gains Saving, such as time and effort Nonmaterial Well-being, such as health. etc.

Figure 13. The Typology of Attribute Analysis Techniques
Source : C. M. Crawford, *New Product Management* (Boston : IRWIN, 1991), 119.

In this CAID information system, five major design information factors will be used as basic information classification.

Dimensional factor : essential characteristics and shape of a product.
(e.g.) Size, Length, Height, Width, and Volume

Functional factor : Basic factors of a product to do specific function.
(e.g.) Functions, Durability, and Maintenance

- Aesthetic factor : Subjective factors of a product.
(e.g.) Shape, Color and Style

Market factor : Consumer market environment information.
(e.g.) Consumer trend, Market competition

Manufacturing factor : Information about product manufacturing.

27 C. M. Crawford, *New Product Management* (Boston : IRWIN, 1991), 117-120.7

(ex) Schedule, Material, Fabrication and Technology

2. 4 Possibility of Industrial Design Information System

Design may be described as an activity whose purpose is to transform a statement of requirements for a new product into a detailed description of that product. Since both the input into and the output from the design is information, information technology has had , and will have a considerable influence on design methods.

2. 4. 1 Possible uses of information technology in design [28]

1) Storage and retrieval of design data

Manual storage and retrieval of design data is a very time consuming and ineffective activity. The usual practice is to limit the range of data source that are consulted, which in turn may lead to the uniformity of products and to the neglect of new effective components, materials, methods, processes or tools.

It is a technology which is feasible to increase considerably the effectiveness of this activity by storing all design data in a computer database and providing a fast access to every item whenever repaired and in the format which is the most suitable for the situation at hand.

2) Generation of tentative design solutions

Many improvements about design process are possible by using information technology, including the following.

The quality of the visual feedback to designers may be considerably improved by the use of interactive color graphics terminals.

- Machines are very effective at rapid checking of tentative solutions for mutual compatibility and consistency. This further improves preliminary error

28 G. Rzevski, "Impact of information technology on design methods." *Design and information technology* (London : The Design Council, 1984), 48-49.

elimination.

Rapid retrieval and display of previous designs as well as relevant guidelines from the database may stimulate the designer when his inspiration is about to disappear.

3) Elimination of errors

The idea of entering a tentative configuration, layout and shape of a future product into a computer and then using its considerable data processing capabilities is for the purpose of :

predicting various aspects of product performance by simulation or mathematical analysis.

modifying the product model with a view to eliminating observed errors.

comparing all aspects of the product with different tentative solutions until the best solution emerges.

4) Communication links with other functions.

Design is a constituent activity of a complex process of planning, marketing, purchasing, storing, manufacturing, testing, installing and maintenance of products.

The two major tasks of information technology follow.

Providing aids for collecting, storing, processing, retrieving, distributing and utilizing information needed for each constituent activity of design process.

Providing the means for communication of information between the various constituent activities.

2. 4. 2 Ideal design information system

An ideal design information system must have the following facilities.

- A design database where all design information is stored and is easily accessible to designers.

Ergonomically designed interfaces, which enable designers to enter and output all required information and to control effectively all data processing activities.
A set of programs, which generate tentative solutions and/or carry out error elimination activities under overall control of designers.
Communication links with information systems for manufacturing, testing, purchasing, marketing, installation, maintenance, management, etc. [29]

29 Ibid., 50.

3. Computer Aided Design

Computer technology has made the greatest impact on design methods. Computer aided industrial design(CAID), a design carried out interactively by designers and computers, is now a well established discipline. The possibility of computer application in industrial design is unlimited.

The computer system can help an industrial designer during the visualization and prototype modeling stage of the industrial design process. Because of the computers, the proposed industrial design can be evaluated, modified and revised many times before production begins. A design database system and an expert system can also help the conclusion of an industrial design process.

3. 1 Definition of CAD

The concept of CAD was proposed by Coons of MIT in the 1960s.[30]
It envisioned human operators using interfaces to work with computers, with both sides playing a complementary role in implementing production engineering. Specifically, design encompasses both logical and intuitive perspectives. Logical problems are consigned to high speed computer processing, intuitive problems are illogical and defy the capacity of computers, and are thus consigned to the judgement of human operators. The goal of CAD is the creation of a numerical model prior to the production of a physical prototype, with the greatest merit of this approach being that such numerical models may be developed and represented in a rich range of media.

3. 1. 1 Objective of CAD

The objective of CAD is to apply computers to both modeling and communication of designs. There have been two different approaches which are often used together.

30 Tomohiro Ohira, *Computer Designics* (Tokyo : Graphic-sha, 1995), 7.

- at a basic level, to use computers to automate or assist in such tasks as the production of drawings or diagrams and the generation of lists of parts in a design.
- at a more advanced level, to provide new techniques which give the designer enhanced facilities to assist in the design process. [31]

Computer aided design should involve the development of a central design description on which all applications in design and manufacturing should feed. This implies that computer-based techniques form the analysis and simulation of the design, and for the generation of manufacturing instructions, should be closely integrated with the techniques for modeling the form and structure of the design. In addition, a central design description forms an excellent basis for the concurrent development of all aspects of a design in simultaneous engineering activities.

In principle, CAD should be applied throughout the design process, but in practice its impact on the early stages, where very imprecise representations such as sketches are used extensively, has been limited. It must also be stressed that CAD should help the designer in the more creative parts of design, such as the generation of possible design solutions, or in those aspects that involve complex reasoning about the design.

3. 1. 2 CAD System Architecture

CAD systems can be thought of as comprising

hardware : the computer and associated peripheral equipment
software : the computer programs running on the hardware
data : the data structure created and manipulated by the software
- human knowledge and activities.

CAD systems are combinations of computer programs and computing hardware. The software normally comprises a number of different elements of functions that process the data stored in the database in different ways. These

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31 Chris McMahon and Jimmie Browne, *CADCAM : From principles to practice* (Reading : Addison-Wesley, 1995), 13.

include elements for :

model definition : for example, to add geometric elements to a model of the form of a component.

- model manipulation : to move, copy, delete, edit or otherwise modify elements in the design model.
- picture generation : to generate images of the design model on a computer screen.

user interaction : to handle commands input by the user and to present output to user about the operation of the system.

database management : for the management of the files that make up the database.

application : these elements of the software do not modify the design model, but use it to generate information for evaluation, analysis of manufacturing.

utilities : a term for parts of the software that do not directly affect the

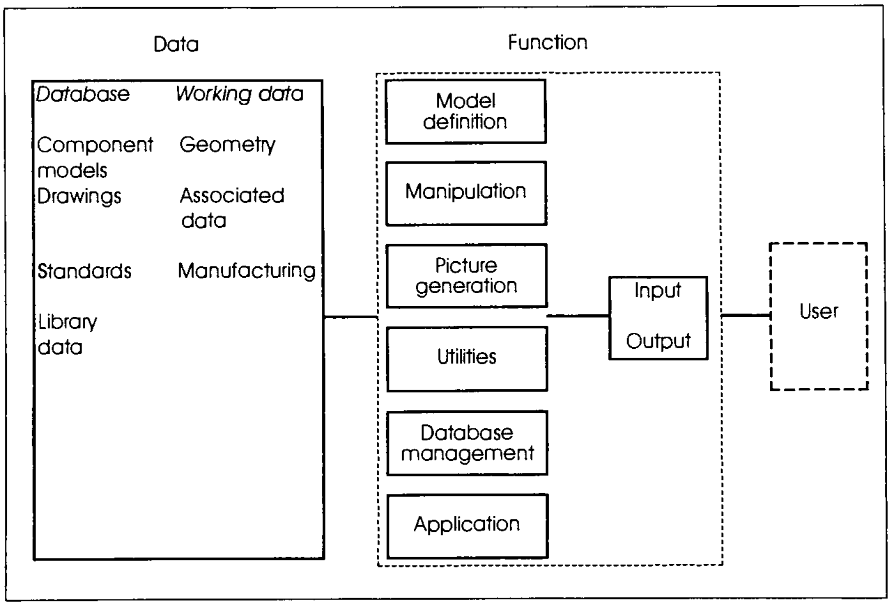

Figure 14. The architecture of a computer-aided design system
Source : Chris McMahon and Jimmie Browne, *CADCAM : From principles to practice* (Reading : Addison-Wesley, 1995), 15.

design model, but modify the operation of the system in someway. [32]

3. 1. 3 Benefits of CAD

The use of current CAD system has brought to the manufacturing industry some considerable benefits. The major benefits are :

reduction in design lead time
- improve quality of products
reduction of design costs
reduction of manufacturing costs
improved design planning and control
improved job satisfaction
improved company image [33]

Integrating CAD with computer-aided fabrication and construction not only saves time and money by eliminating the intermediate step of drawing production, it also redefines the relationship between designing and producing.

Since CAD/CAM can significantly shorten the production cycle, it may allow designers to experiment in prototype with forms, materials, and processes before committing to final decisions. It bridges the gap between designing and producing that opened up when designers began to make drawings.[34]

3. 2 Present and Future of CAD

3. 2. 1 Present

CAD is now so extensively applied that in some companies most design work is done by using CAD systems. Despite this success, there is a widespread view that CAD is not yet adequate as an aid to the designer in generating a design. CAD is considered to concentrate rather too much on providing means of representating the final form of the design, whereas designers also need a continual stream of advice and information to assist in decision making.[35] For exam-

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32 Ibid., 14-15.
33 Dr George Rzevski, "Impact of information technology on design methods." *Design Theory and Practice*. The Design Council (1984) : 51.
34 William J Mitchell and Malcolm McCullough, *Digital Design Media* (New York : Van Nostrand Reinhold,1995), 440.
35 Chris McMahon and Jimmie Browne, *CADCAM : From principles to practice* (Reading : Addison-Wesley, 1995), 216.

ple, a CAD system might allow a finite element model to be developed for the analysis of a design, but it would give no advice on what element type is to be use in a particular circumstance or on how to model a certain loading condition; it might allow manufacturing instructions to be derived from the design geometry, but it is unlikely to be able to advise the designer whether a certain shape is capable of being economically cast or forged.

3. 2. 2 Future

The tasks of CAD systems of the future are to represent a wider variety of a designer's properties, in terms that are familiar to engineers, and to handle those aspects of engineering practice, and of a company's organization and equipment, that influence design. The way in which it is hoped to achieve this is to bring ideas and techniques from research into artificial intelligence and information systems. and also to search for higher-level methods for modeling of the design representation.

Recently, a study on CAD systems that may be appropriate in the future has been done. A current theme in this field is the concept of integrated systems, which provide many different computational approaches to assist the designer, and allow the product itself and the production plant, design process and application to be modeled. The integrating technologies in such systems will be CAD modeling, AI, information systems and databases, and the product models will underpinned by new ways of describing products.

The prediction of William J. Mitchell about future CAD systems and environment follows:

> As the technology continues to develop, digital models will play increasingly central roles in practical design process. They will be handled by sophisticated editing and management software, and they will receive inputs from various conditions of designers, consultants, intelligent software agents, and information extracted from online databases. They will produce input to visualization systems, drawing and report generators, wide range of analysis and criticism software, rapid prototyping systems, and CAD/CAM facilities. And, though integration of

computer-aided design systems with advanced telecommunications capabilities, they will effectively support the work of geographically distributed virtual design organizations working in virtual design studio.[36]

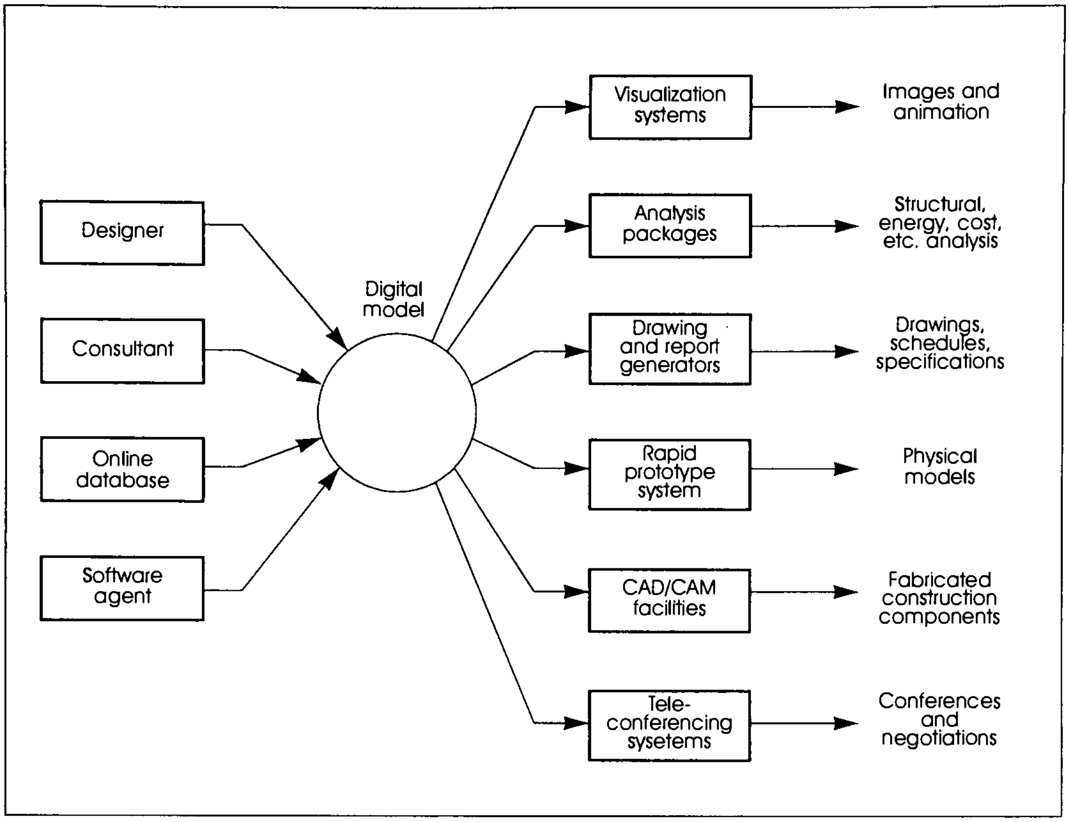


Figure 15. The Integrating Role of the Digital Model
Source : William J Mitchell and Malcolm McCullough, *Digital Design Media* (New York, Van Nostrand Reinhold,1995), 465.

36 William J Mitchell and Malcolm McCullough, *Digital Design Media* (New York : Van Nostrand Reinhold,1995), 464.

4. Prototype of CAID Information System

4. 1 Synopsis of CAID Information System

4. 1. 1 Concept

1) Goal of CAID information system development

The main objects of CAID information system are to shorten industrial design process by providing necessary and important information to industrial designer promptly, and to improve overall industrial design quality by decrease the possibility of design error occurrence. Furthermore, in new kinds of product environment like concurrent engineering, this program will help industrial design departments to share information with other related departments to execute overall product development process efficiently.

2) Premise

The most important and basic precondition for CAID information system development is the central database system, which can be shared with other product development departments like marketing, engineering and manufacturing departments. This database system should contain all kinds of information for the whole product development process and should be perused by related departments easily. In order to maintain this huge database system, there should be an independent database system manager in all departments. Each department also needs to have its own database system manager.

The secondly import precondition is the network system, which links all product development related departments. The central database system which is used by the CAID information system is shared by the Network. In this prototype of the CAID information system, all related departments exchange their information through LAN (Local Area Network) with a server.

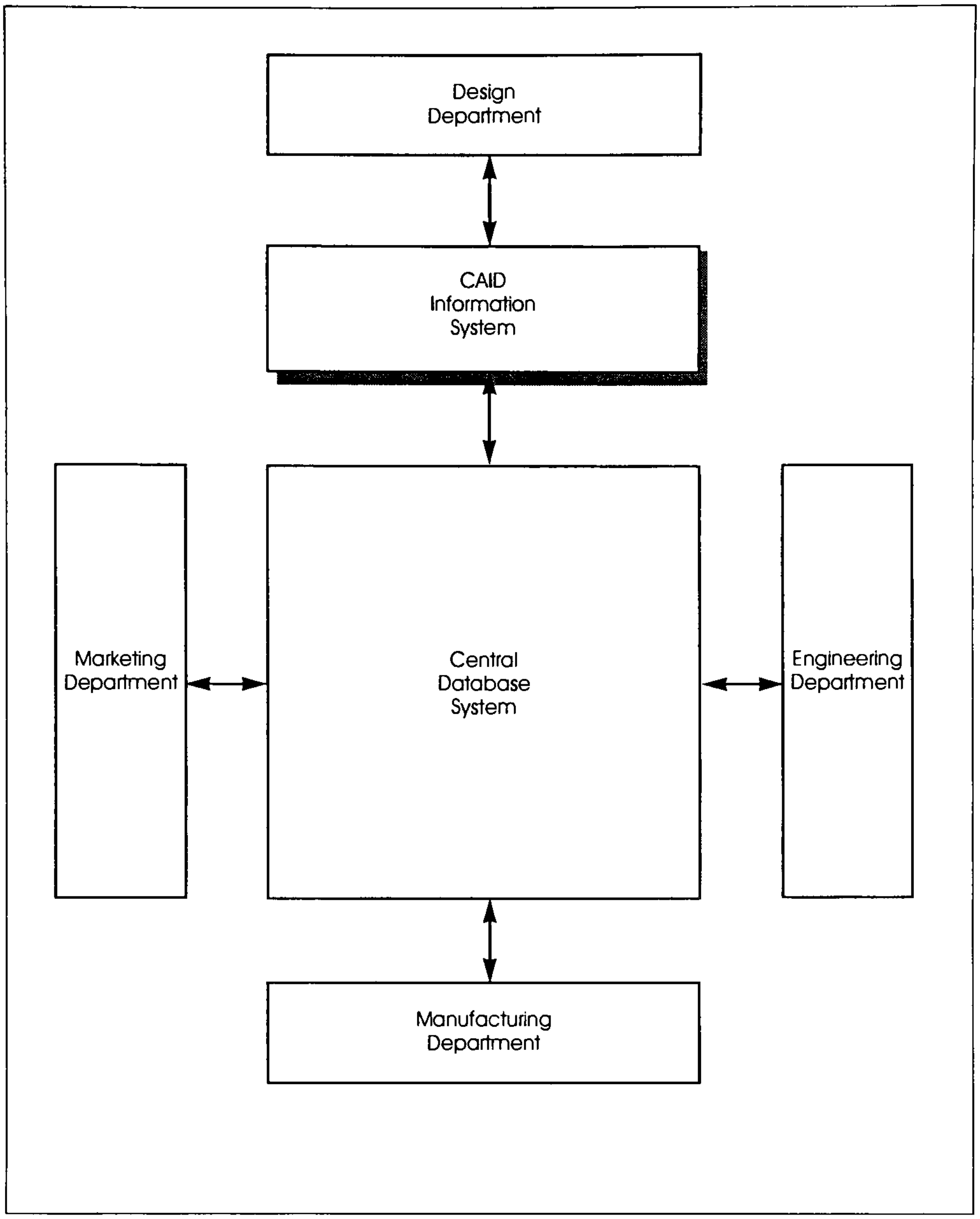


Figure 16. The Conceptuol Diogrom of CAID Informotion System

4. 1. 2 System development environment

The basic operating system of this CAID information development is the Microsoft Windows NT 4.0, and the main program language is the Microsoft Visual basic 4.0. The Microsoft Access is used as the main database engine. The main 3D solid modeler is the Trispective1.0, and the MicroStation 95 is used as an auxiliary 3D modeler. For the surface modeling and rendering, Alias/Wavefront 7.0 is mainly used.

4. 1. 3 Characteristics of the CAID information system

The characteristics of the CAID information system are as follows.

The main program menu is divided by Assist and Analysis, and these sub menus are subdivided into various fractions to provide needed information at each design development process.

- All information is classified by design project, and each design project has its own specific information.

In order to aid easy information grasp, visual data is positively used.

- To prevent errors which usually occur during design process, an industrial designer can easily examine design requirements at each design stage with this program.

Marketing, engineering and manufacturing information are also provided, and this information is easily checked at any design stage.

4. 2 Components and structure of the CAID Information System

4. 2. 1 Components

The basic components of the CAID information system are project, information, database and 3D modeling program.

1) Project

Almost all industrial design works are done by project base. On the basis of this fact, all design related information in the CAID information system is classified by project base. The CAID information system is a means to classify information systematically to help each product development to easily share that information.

2) Information

Much information is needed during product development process. The classification of information used in the CAID information system is as follows:

Physical attribute	Technical attribute	Aesthetic attribute	Marketing attribute
Width Height Depth Volume	Technology Trend Paten Productivity Material	Color trend Styling trend Product trend Idea sketch Rendering Shape	Consumer report Market define Life style Position map Schedule Concept

3) Database system

In a medium size company, marketing, design, engineering and manufacturing departments are the product development related departments. During product development process, each department usually make, use and removes its own information.

Overall product development process is getting shorter, and the key to success in this kind of product development environment is to make a database system which helps a company to collect and distribute all information from the product development process. The prerequisite of the CAID information system is the database system, which should be used by all related departments. All information from each department is collected by its own database manager and sent to the central database system. The central database system manager will classify the information by content and type. This information will be used in the CAID information system to help successful product development.

4) 3D modeler

For a physical attribute check of a design project which is the main characteristics of the CAID information system, a 3D modeler is an essential component of this program. There are two kinds of 3D modelers among computer 3D modeling applications. They are a solid modeler and a surface modeler.

The solid modeler can more easily calculate and generate physical attributes like dimension and volume of a 3D model than a surface modeler. Because of this reason, a solid modeler is selected as a main 3D modeler in the CAID information system. In order to wed the solid modeler to the CAID information system, the modeler should support OLE(Object Linking and Embedding) and DDE(Dynamic Data Exchange) function of the Visual Basic 4.0, and the Trispective1.0 of 3D/Eye is selected as a main 3D solid modeler because of its superior support for the OLE and DDE.

4. 2. 2 System Structure

The industrial design process consists of market research, concept establishment, idea sketching, modeling, modeling evaluation, rendering, rendering evaluation, mechanical drawing, mock-up making and final mechanical drawing. The application of the CAID information system in each industrial design stage is displayed in Figure 17.

The main role of the CAID information system in the whole product development process is applying the central database system in the industrial design department. Through each product development, related departments use the same central database system, but each department has its own need and usage of the central database system. The CAID information system is the program for the industrial design department, and the other departments may need their own information control program to use the central database more efficiently.

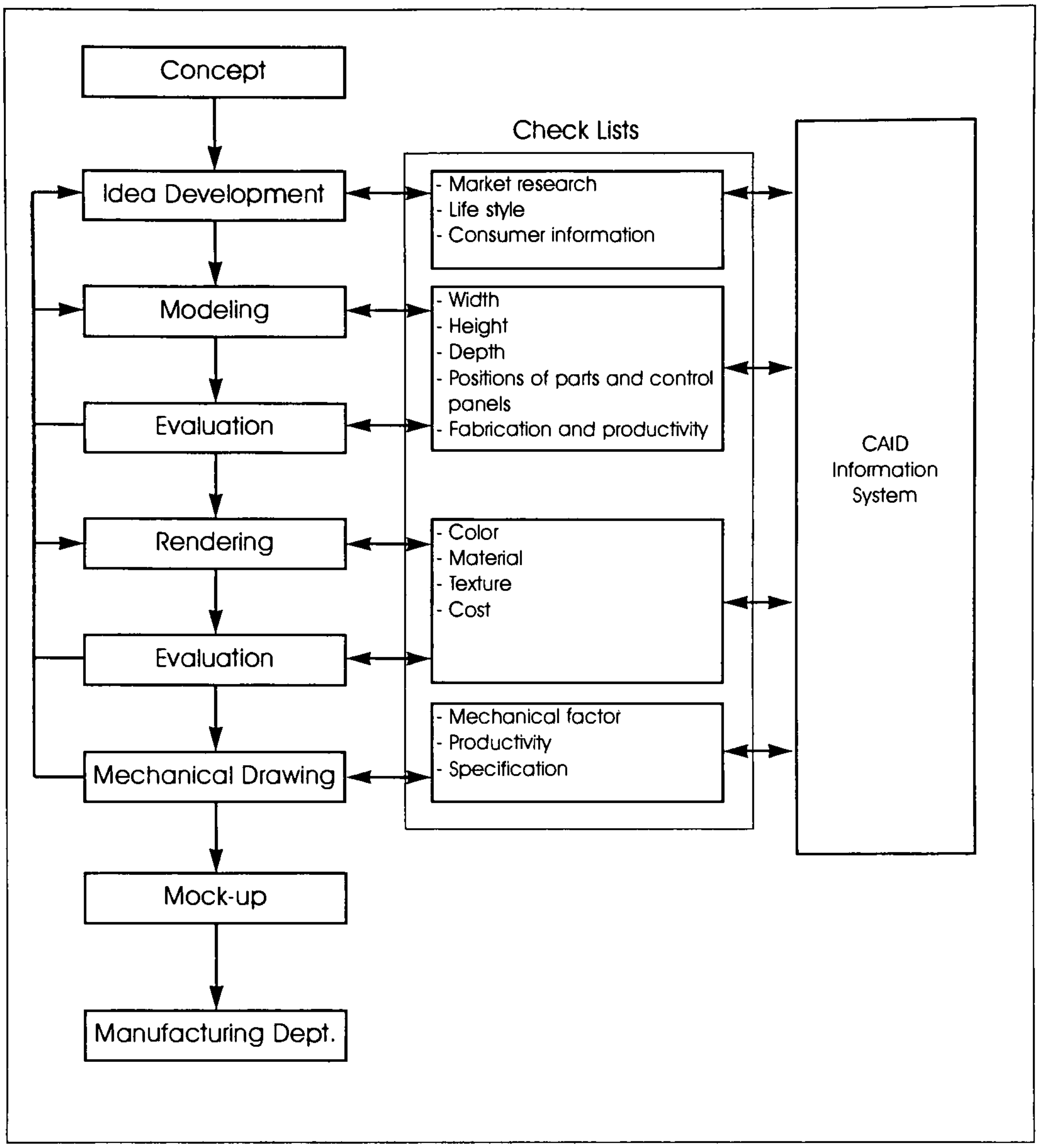
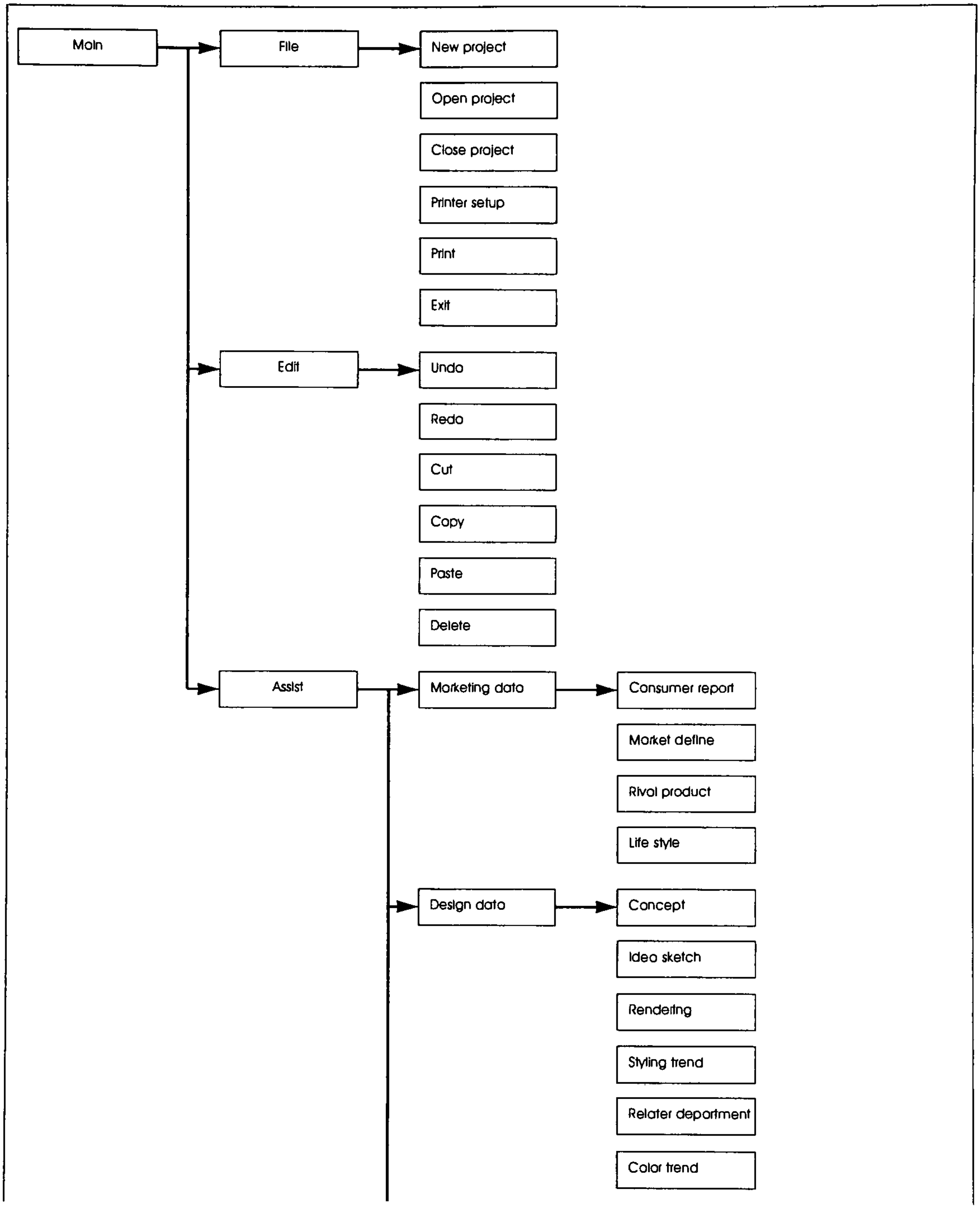
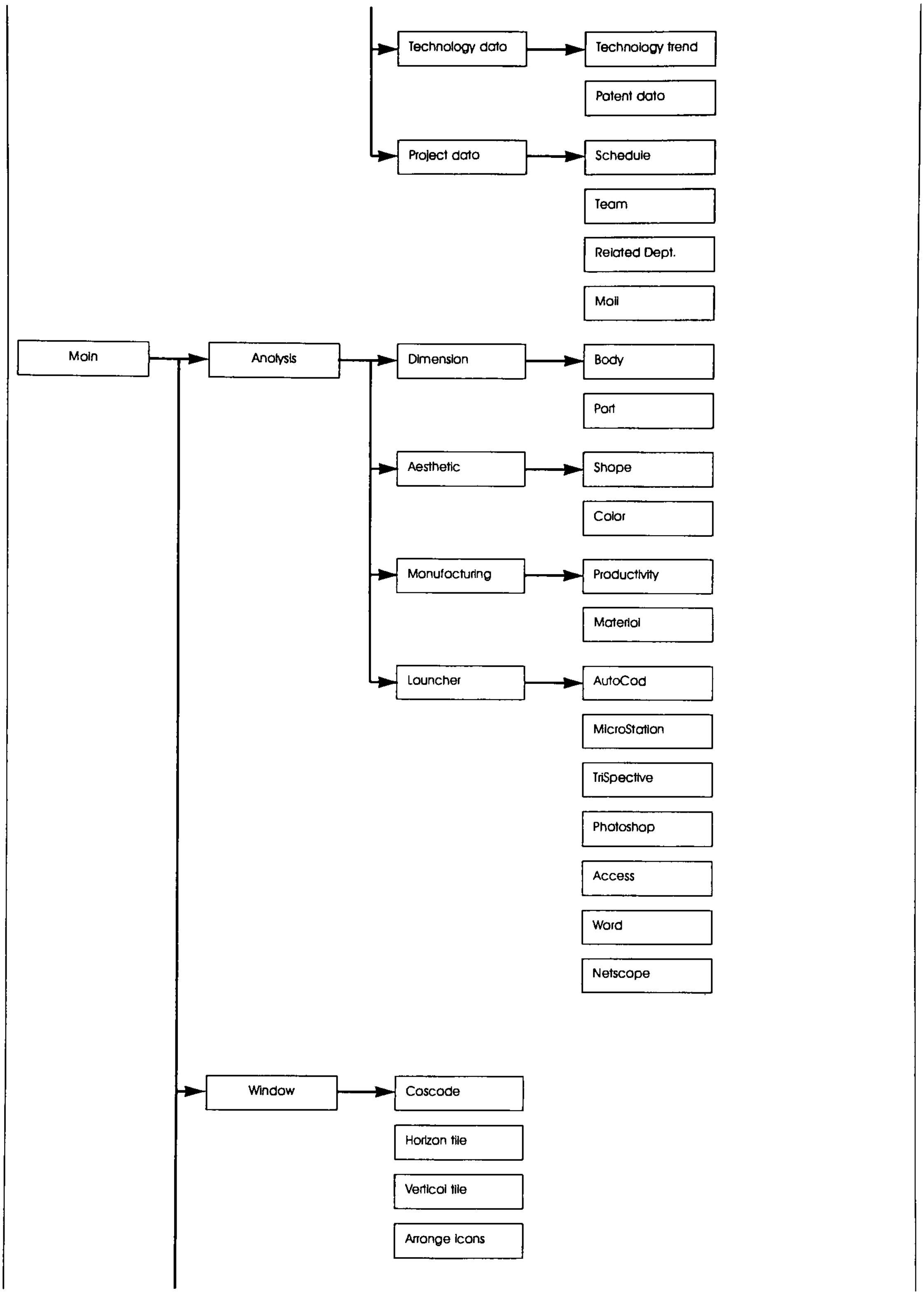


Figure 17. The Application of the CAID Information System in Each Industrial Design Stage

1) Menu tree

The CAID information system mainly consists of Assist and Analysis. The detailed menu tree diagram follows.




Technology data
Technology trend
Patent data
Project data
Schedule
Team
Related Dept.
Mail
Main
Analysis
Dimension
Body
Part
Aesthetic
Shape
Color
Manufacturing
Productivity
Material
Launcher
AutoCad
MicroStation
TriSpective
Photoshop
Access
Word
Netscope
Window
Cascade
Horizon tile
Vertical tile
Arrange icons

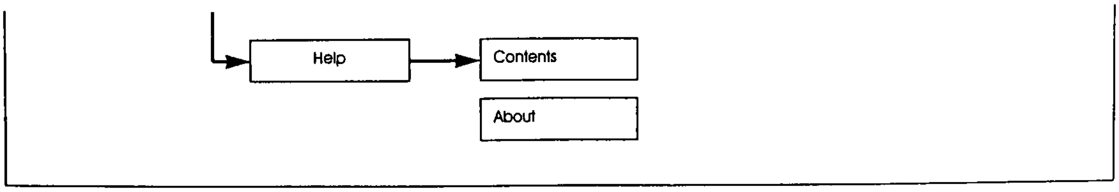


Figure 18. The Menu Tree of the CAID Information System

4. 3 Application

To test and confirm the operation and efficiency of the CAID information system, a portable DVD player is selected as a design project. The supposition of this project is that this is not a design project of a small industrial design company but a design project of large scale electric consumer product company which has marketing, industrial design, engineering and manufacturing departments.

All product development related departments are linked with imaginary network to share the central database system.

In order for the reader to understand the CAD information system more easily, the menus of the program are explained in order.

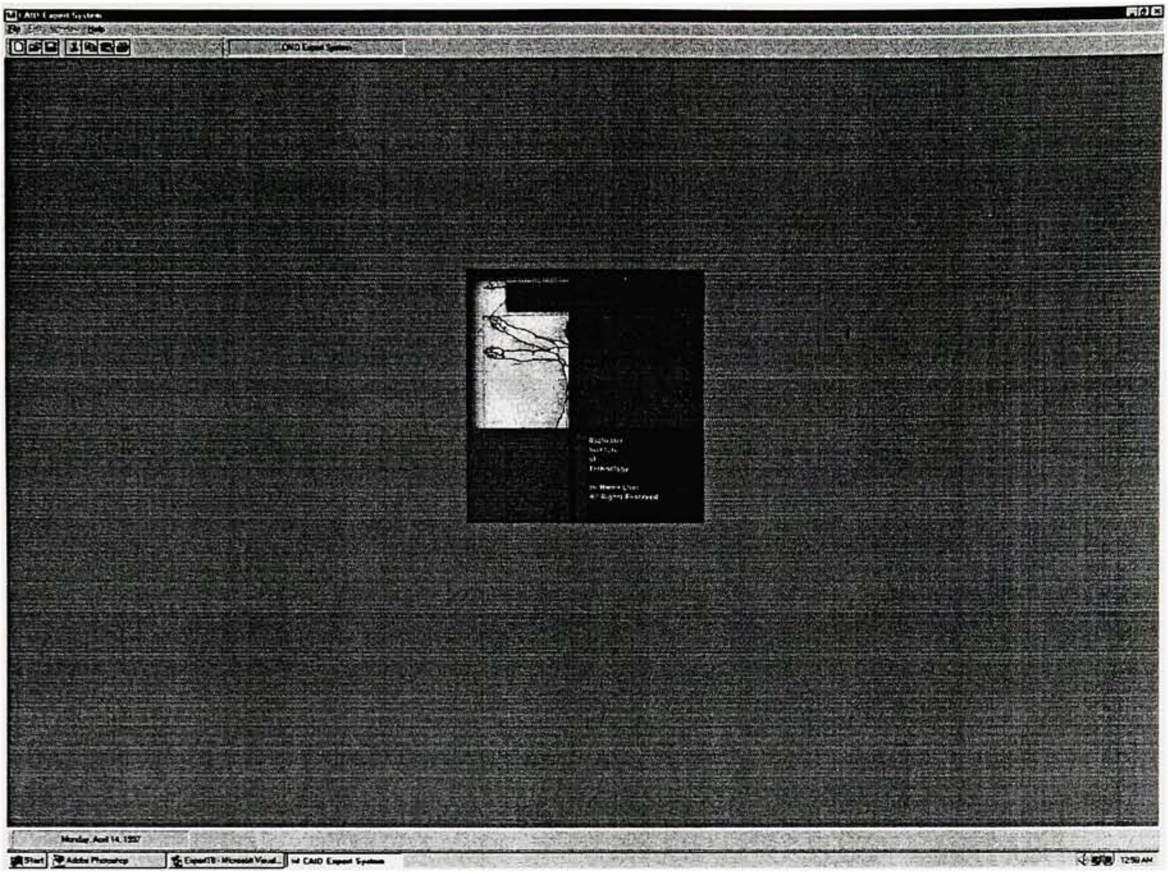


Figure 19. The Start Window

4. 3 .1 Work flow

Start window

After double clicking on the CAID information system's icon, the *start window* will be displayed. In this window, you can execute the *File* menu and *Help* menu. The *File* menu has its own submenu which opens, saves and closes a design project file. The *Help* menu provides some brief information about the CAID information system.

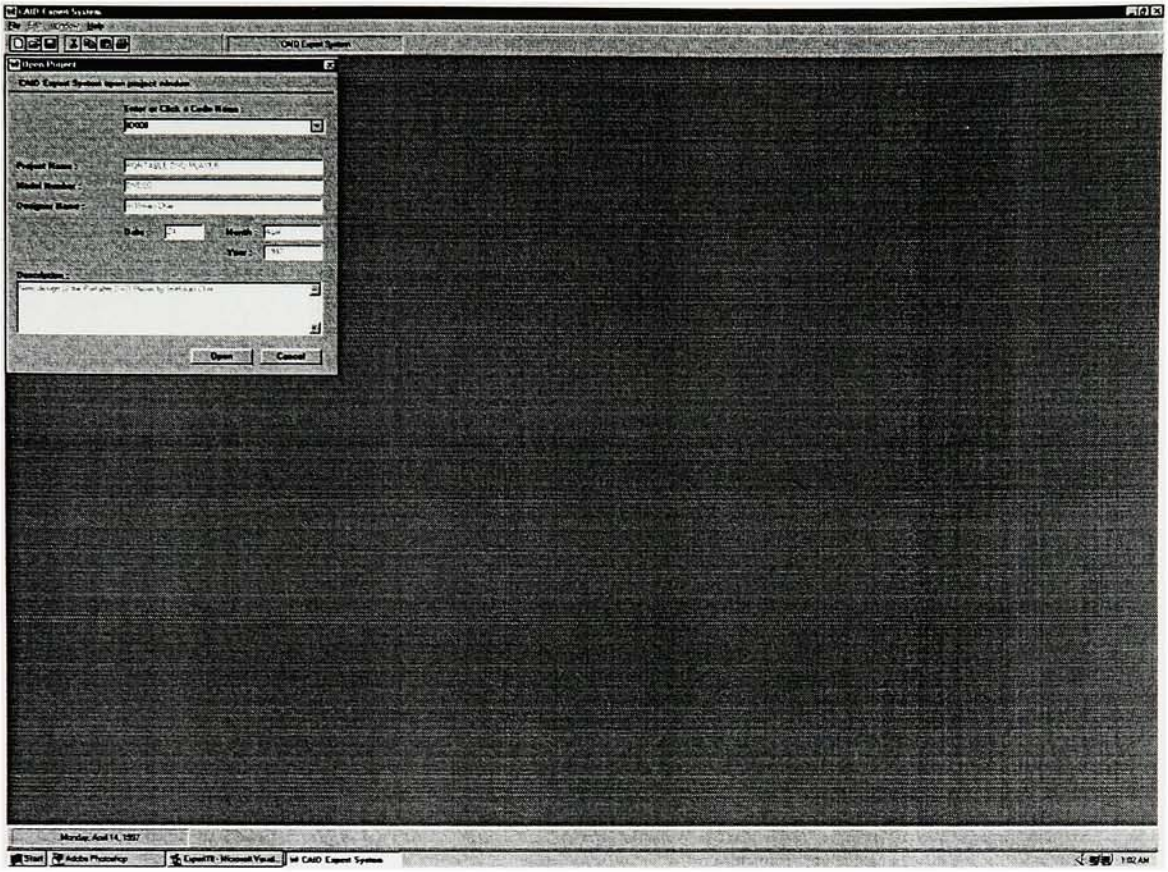


Figure 20. The Open Project Menu

Open project

If you click the *open project* menu, which is the submenu of the *File* menu, the *Open project window* will appear. In order to open a specific design file, you can type or select the project code name. After selecting a project code name, some brief information about the project such as project name, model number, designer name and description will be displayed.

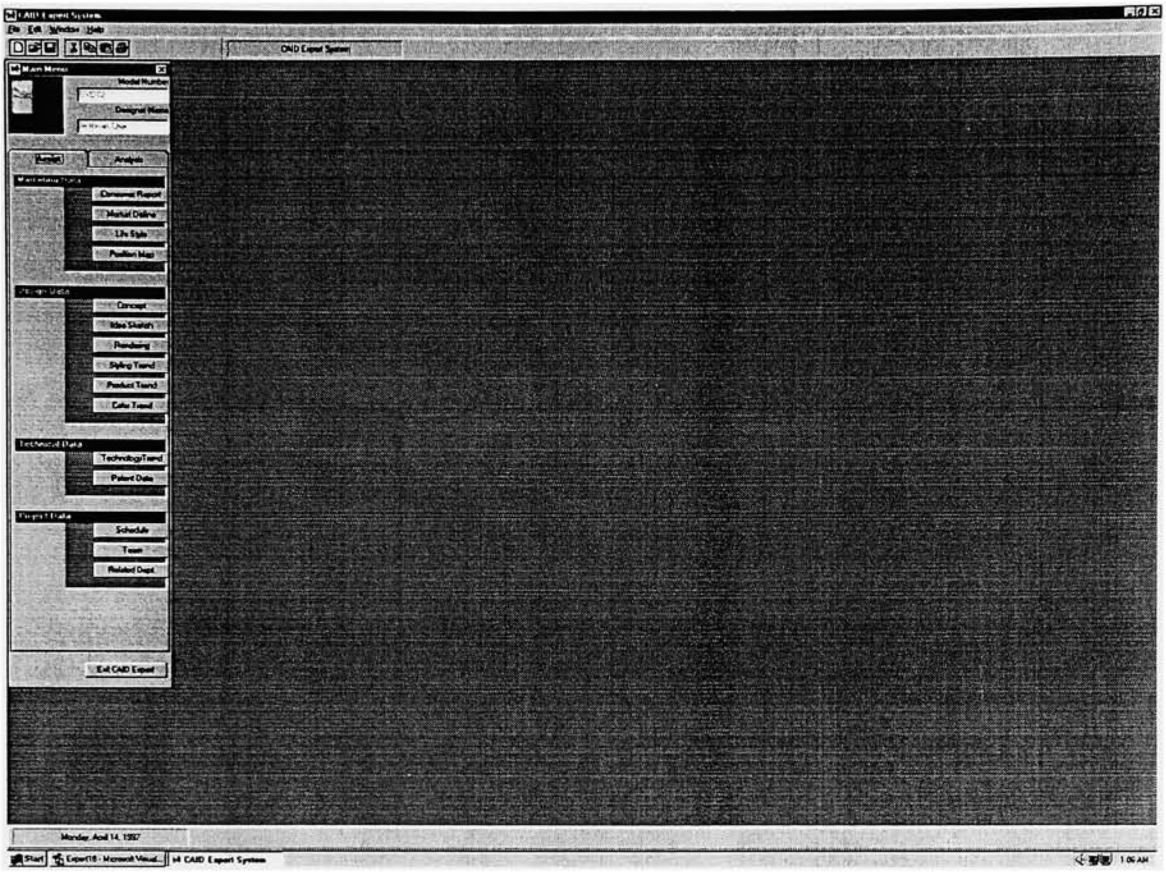


Figure 21. The Main Menu

Main menu

The *main* menu window follows the *open project* menu. The main menu contains of all the CAID information system functions that are required in the whole design process. Because of the large number of tools available, the main menu is broken down into the *Assist* menu and *Analysis* menu which help you find tools quickly.

The *Assist* menu consists of *marketing data, design data, technical data* and *project data* menus. Each menu of the *Assist* menu also has its own submenu.

The structure of *Analysis* is almost same as the *Assist* menu. The *Analysis* menu contains *dimension, aesthetic, manufacturing* and *launcher*.

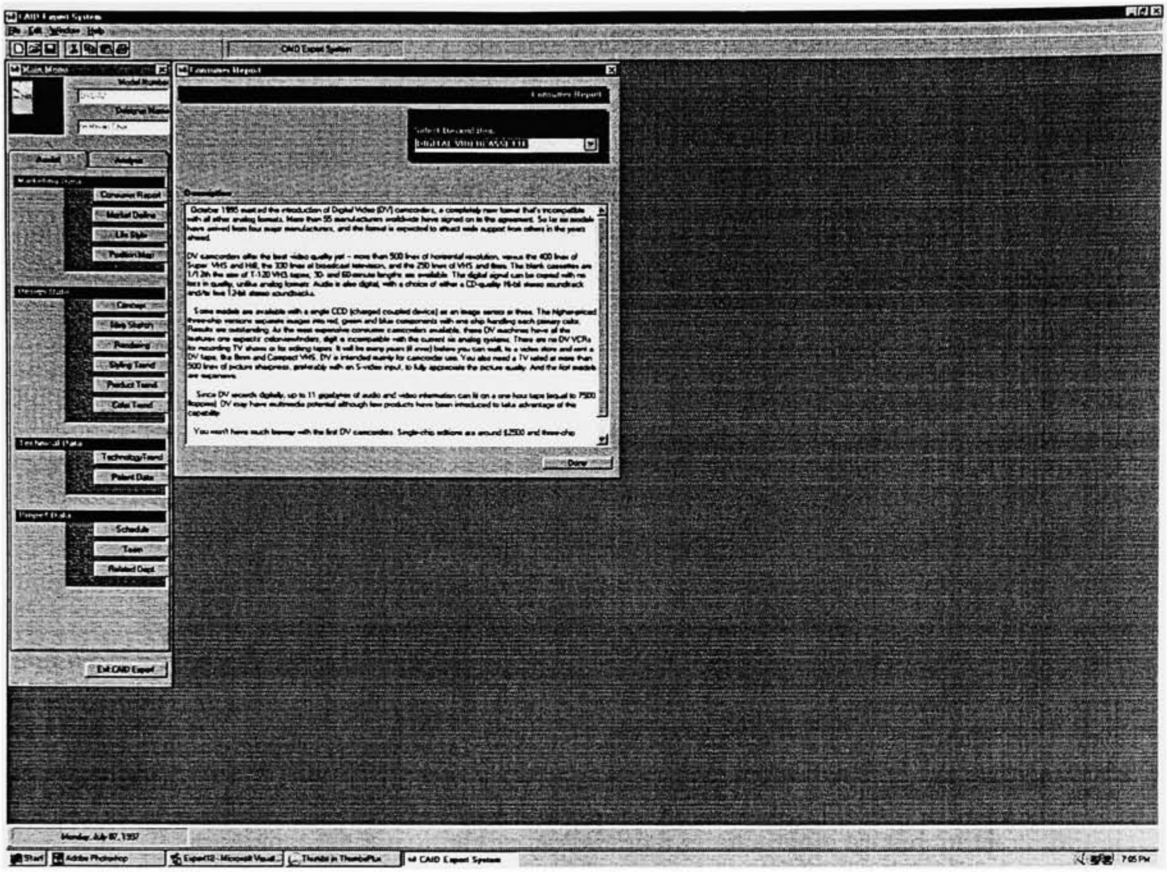


Figure 22. The Marketing Data Menu

1) Marketing data

The *Marketing data* menu contains *consumer report, market define, life style* and *position map*. The purpose of the *Marketing data* is to provide marketing related information about current design project.

Consumer report

If you select *consumer report* menu which is one of the *marketing data* menu's submenu, the *consumer report* window will be displayed. In this window, you can click any item you want to examine. With the *consumer report* menu, an industrial designer easily obtains some important consumer reports and grasps market environment about current project.

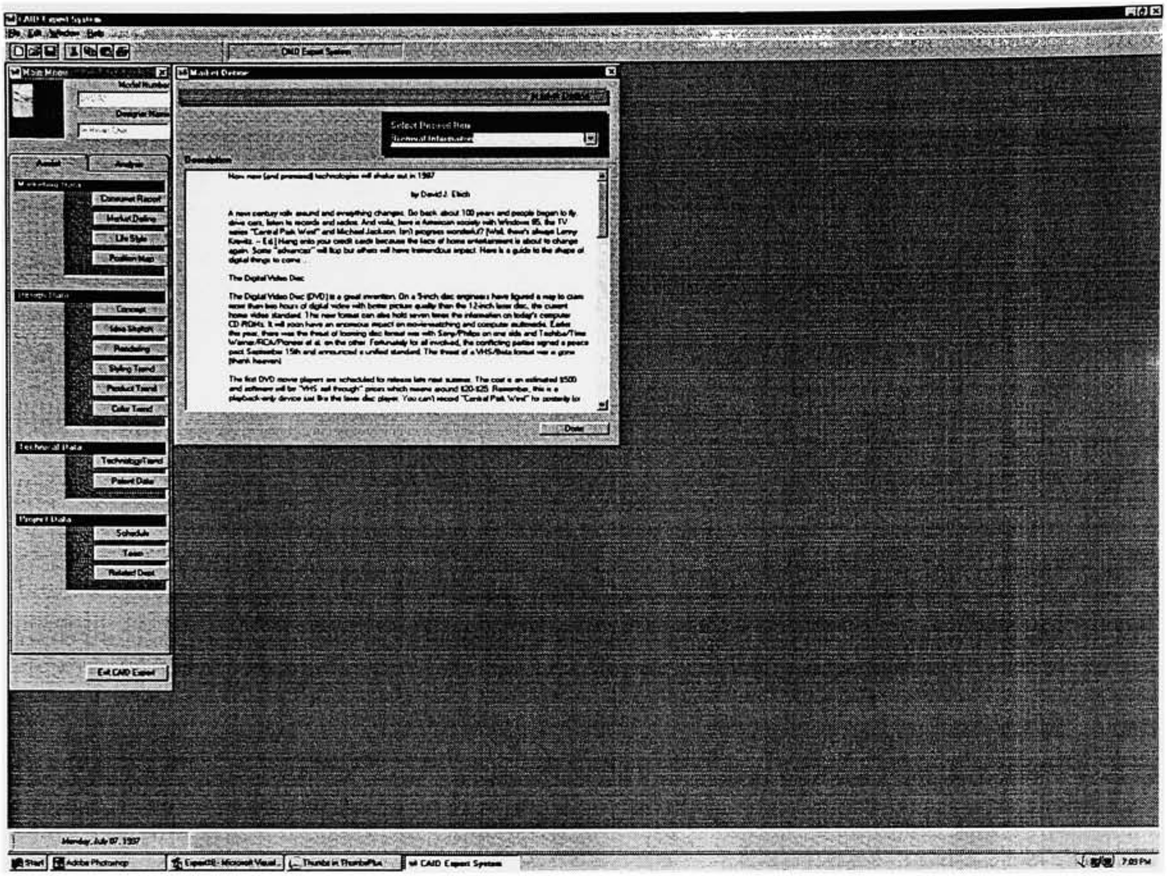


Figure 23. The Market Define Menu

Market define

The *Market define* menu provides past and future information about current design product market environments and trends. In this menu, an industrial designer can get a brief view of the current product market situation and use this information to design a better product.

The user interface of the *market define* menu is almost the same as the *consumer report* menu.

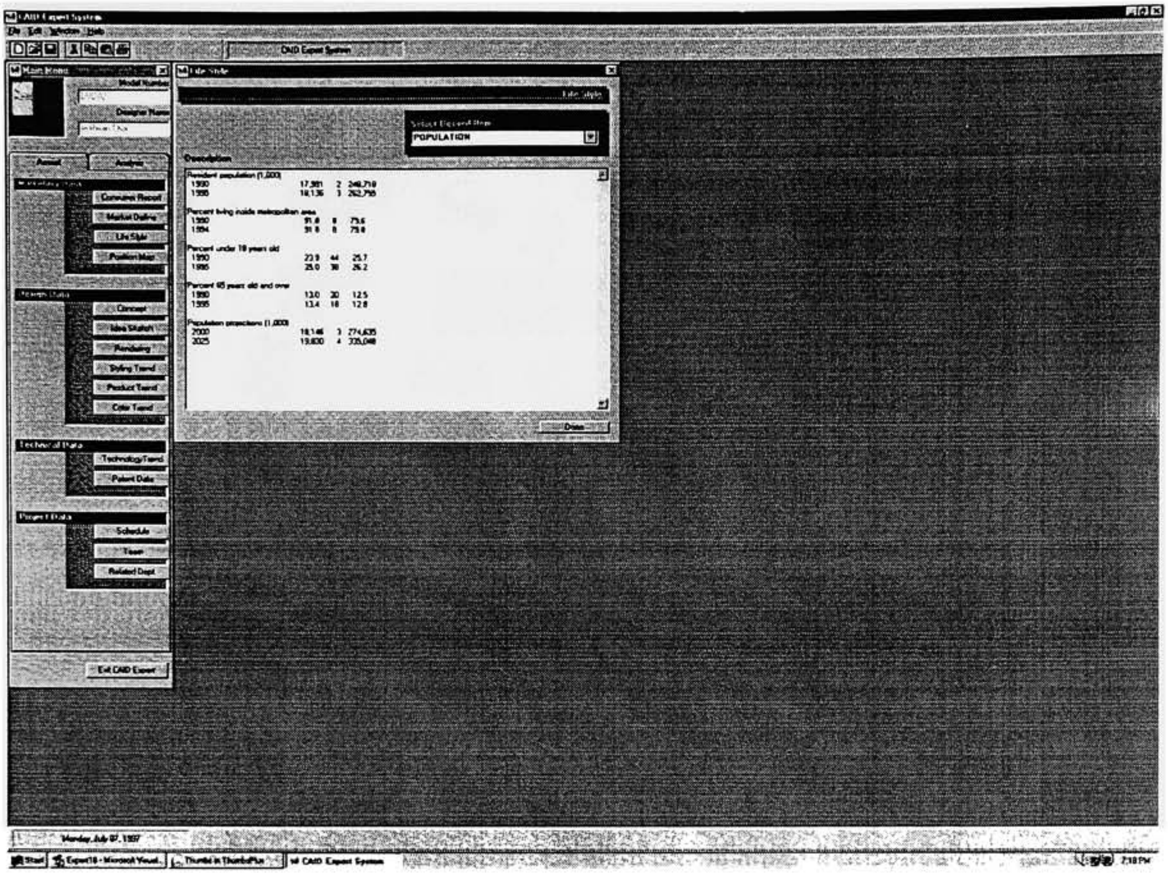


Figure 24. The Life Style Menu

Life style

The *Life style* menu has information about overall consumer life style related data. Information provided from this menu is about population, education, income, consumption, retail track, public aid and poverty, labor force, vital statistics and health.

The use of the *life style* menu is the same as the *consumer report* menu.

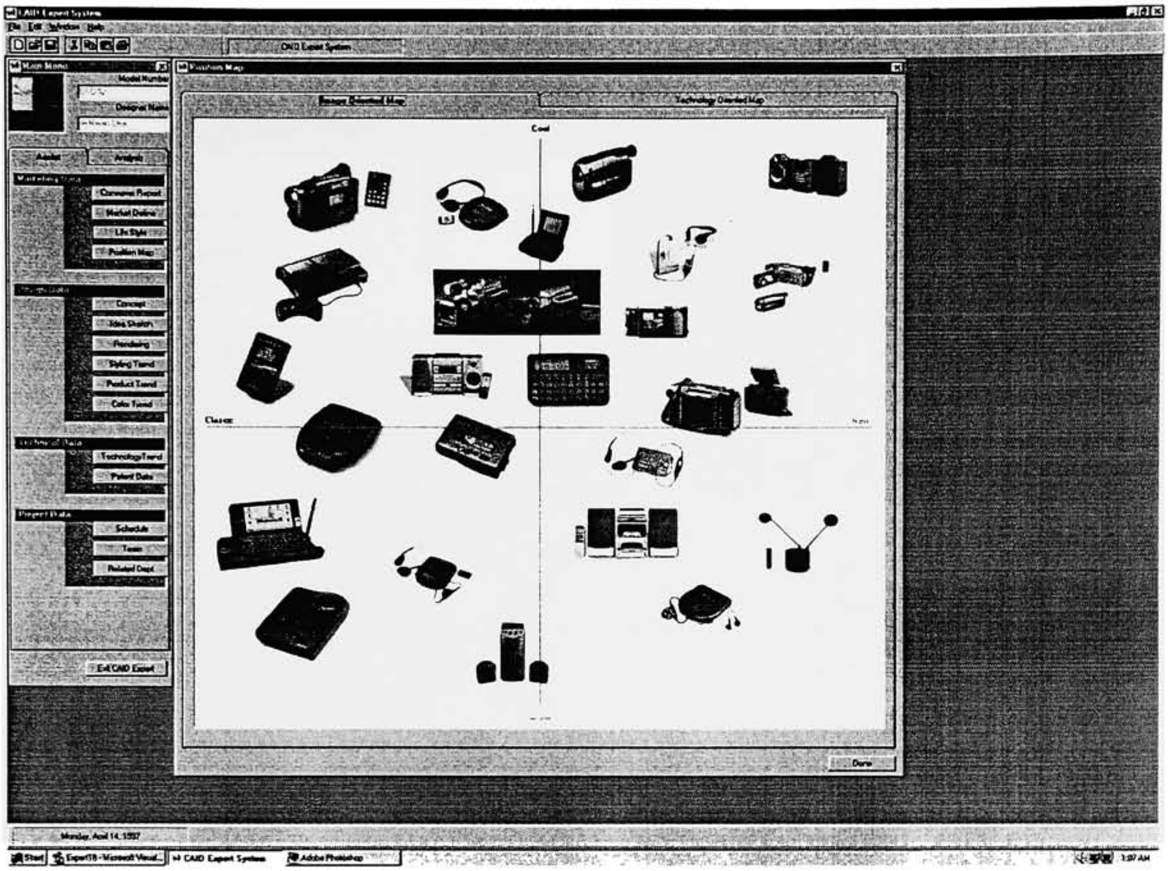


Figure 25. The Position Map Menu

Position map

This is the last submenu of the *marketing data* menu. The *position map* option provides a collection of the current project in the market.

This map consists of two kinds of map. One is an image oriented map and the other is a technology oriented map. Industrial designers in a specific team can share the image of their design target through this map.

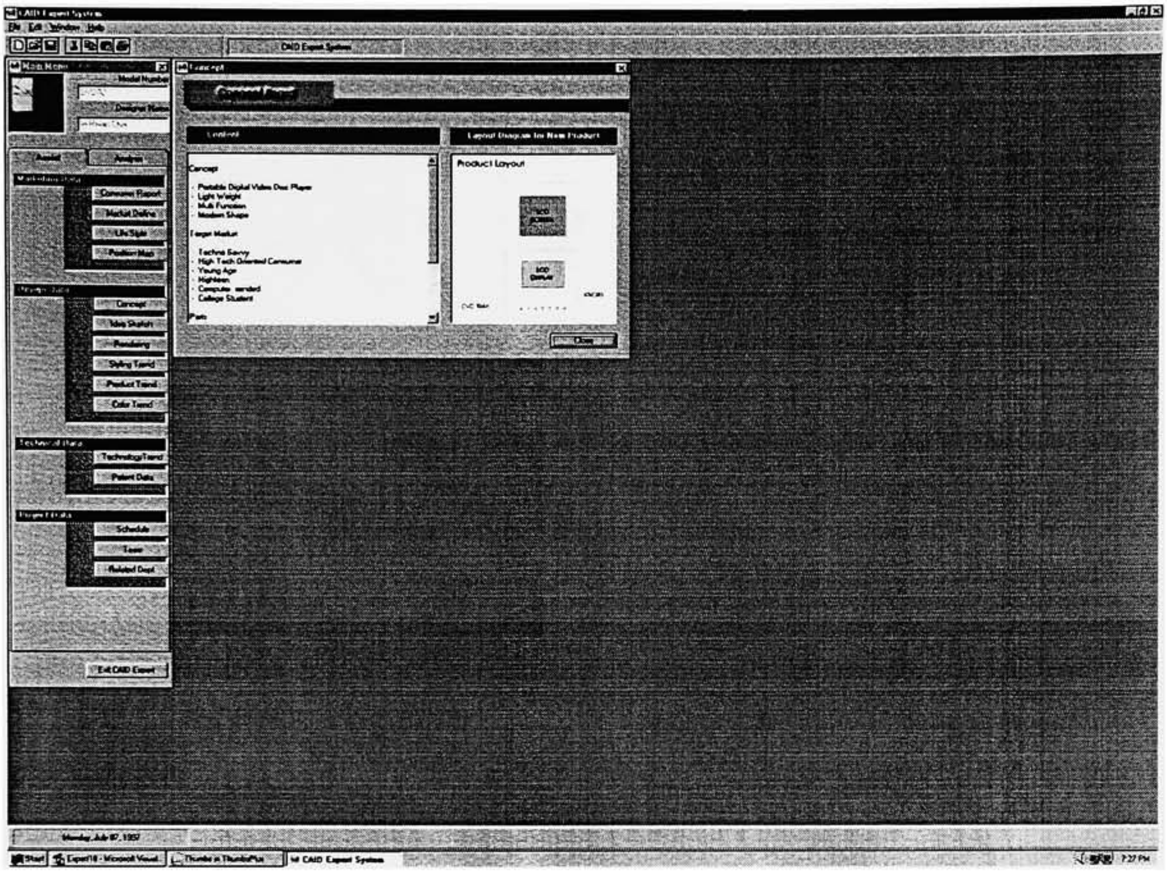


Figure 26. The Concept Menu

2) Design data

The submenus of the *design data* menu are *concept, idea sketch, rendering, styling trend, product trend* and *color trend*. These menus provide an industrial designer with emotional and visual design reference data which is related to the current project and also other design projects.

Concept

The *Concept* menu includes the basic specifications and objectives of the current design project. This stage is the starting point of the industrial design process and also one of the most important steps of the whole industrial design process.

An industrial designer obtains overall product specifications and the conceptual product layout of a current project.

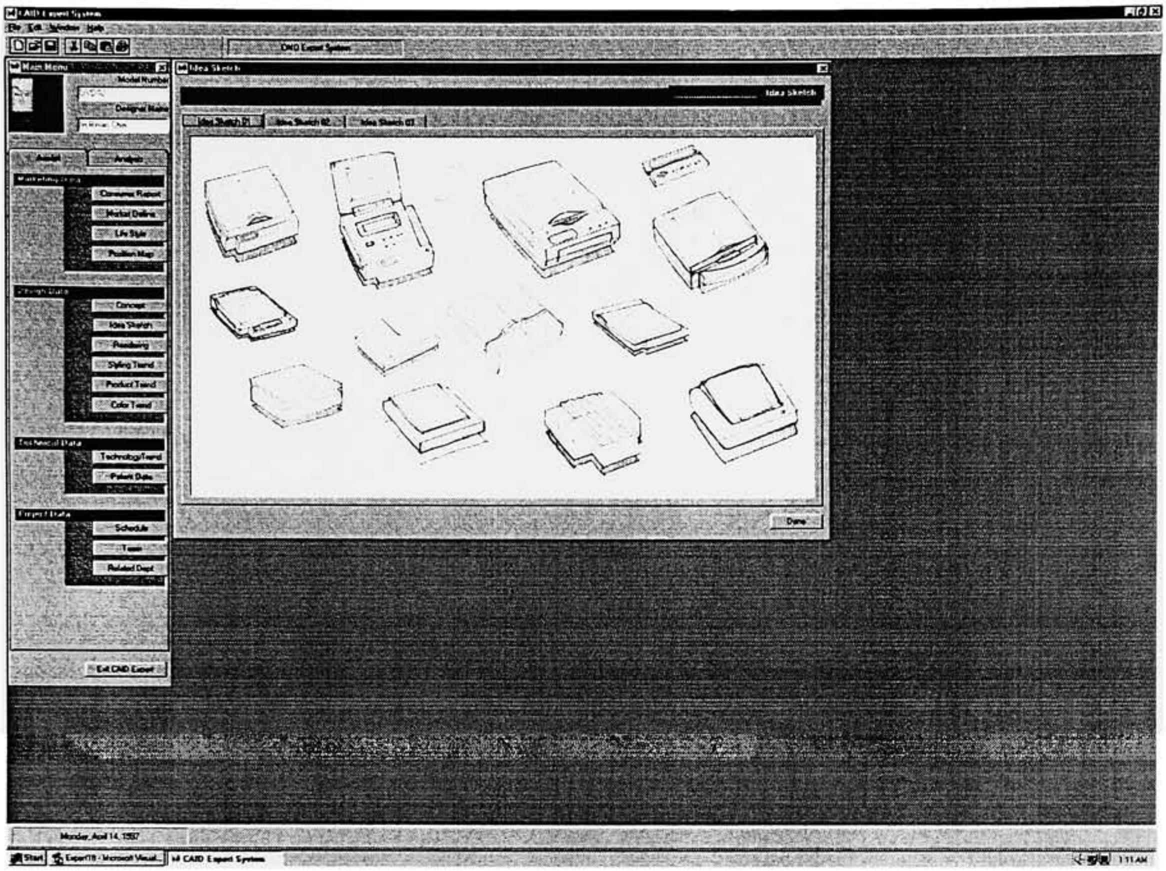


Figure 27 The Idea Sketch Menu

Idea sketch

During the design process, an industrial designer does a great deal of idea sketch work. Those idea sketches are classified into shapes and provided to an industrial designer as a reference through this menu.

You can browse this image by clicking tabs.

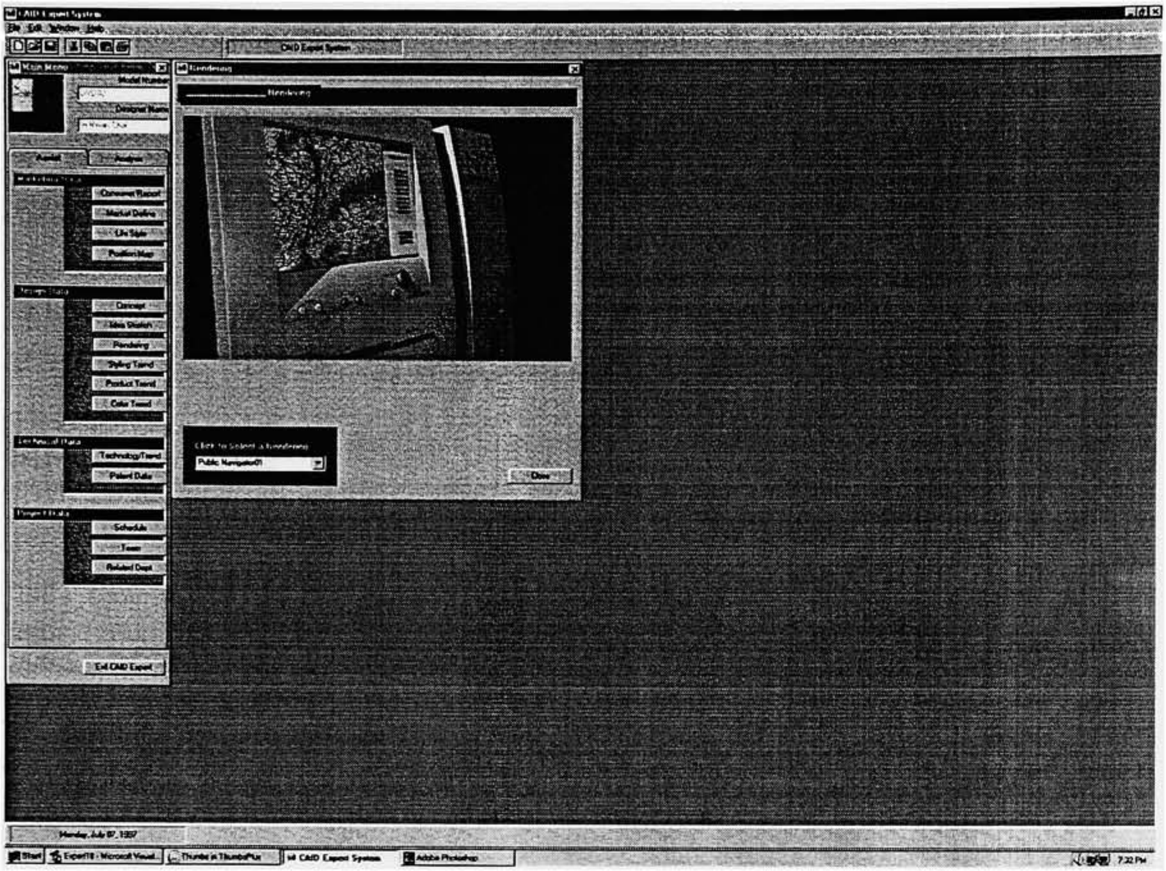


Figure 28. The Rendering Menu

Rendering

The *rendering* menu includes some rendering images from past design projects. This image oriented menu helps an industrial designer to find the direction of the current design project rendering.

Mainly, the *rendering* menu has computer generated rendering images, but through a scanner, some traditional renderings which used to be done by marker or pastel can be included.

If you select a projected name by mouse, then the rendering of that project will be displayed.

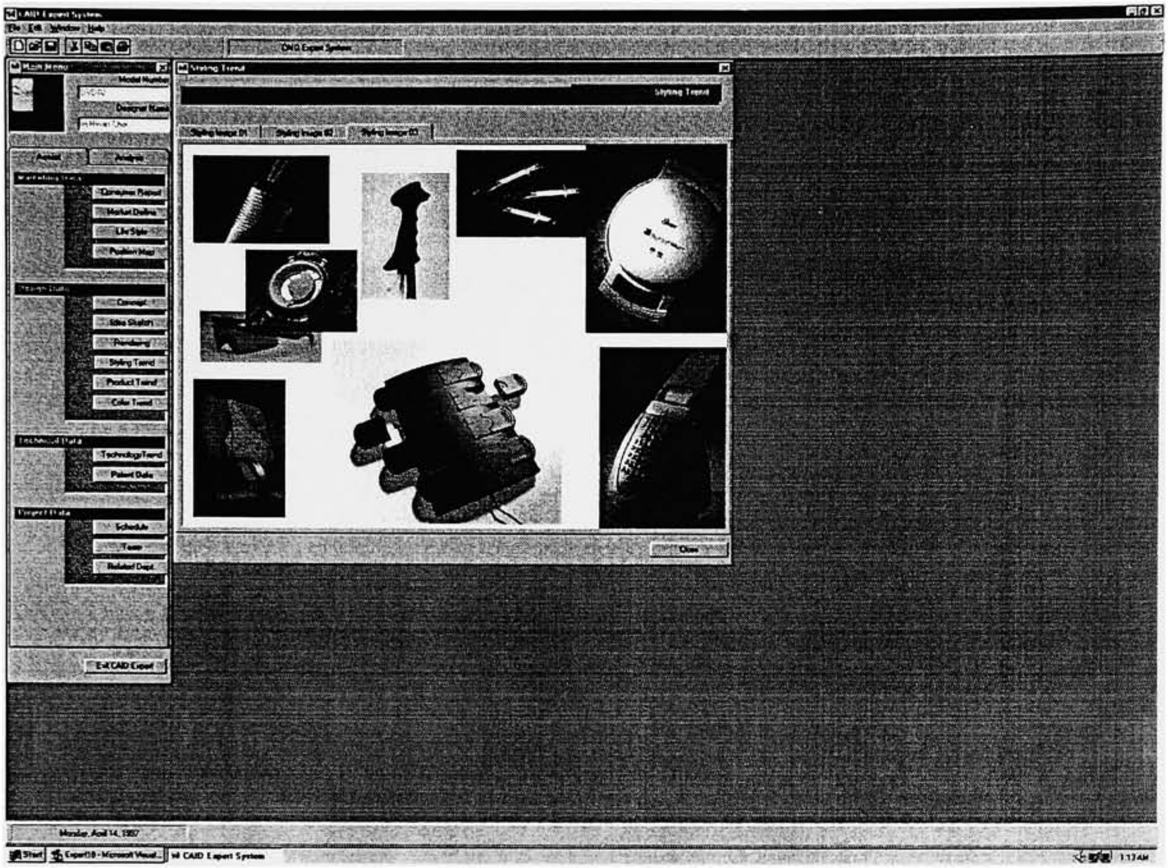


Figure 29. The Styling Trend Menu

Styling trend

The creation of unique and suitable shapes which match current design concepts is an important task of an industrial design project. The *styling trend* menu includes a collection of contemporary industrial design shape images to help an industrial designer. An industrial designer can grasp the current design styling trend with this menu.

The user interface of this is the same as the *idea sketch* menu.

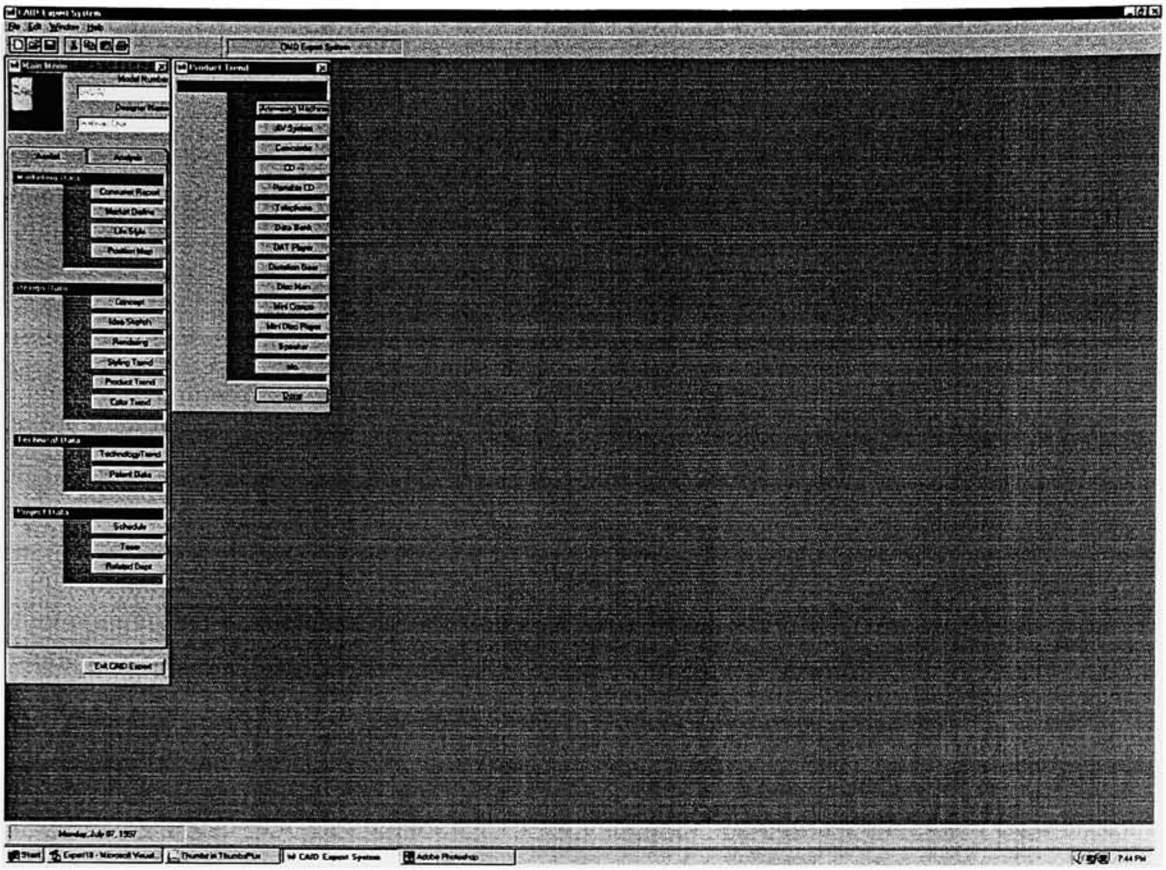


Figure 30. The Product Trend Menu 01

Product trend

The understanding of current product and rival product trends is important for an industrial designer in order to define the objectives of the current design project. With this understanding, an industrial designer can make a unique and better product than other rival products.

The *product trend* menu provides images and information about current consumer product trends. It has its own submenu. You can view the contents of any product trend sub menu by clicking the submenu item.

The flow of the product trend menu is as follows.

If you click the *product menu*, then the submenu will pop up.

The submenu contains each product category button.

In this menu you can select any product category item.

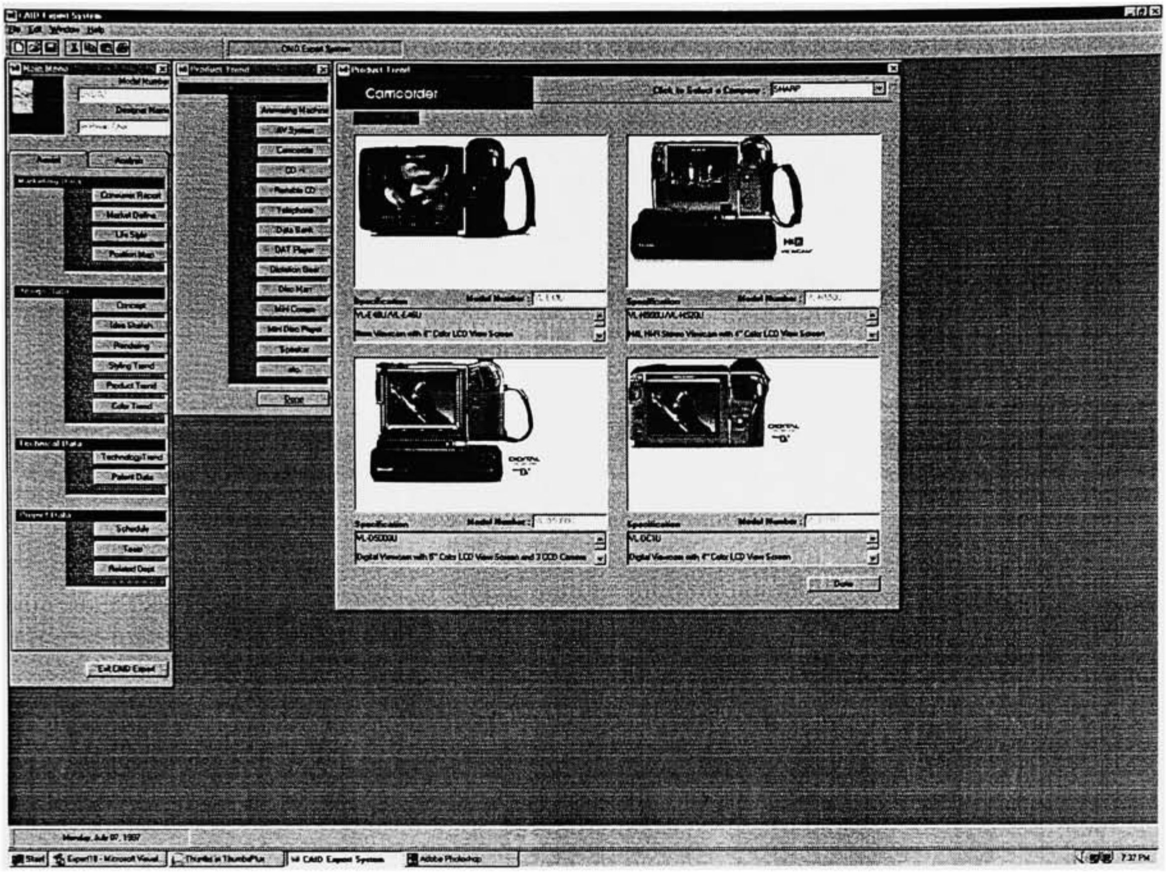


Figure 31. The Product Trend Menu 02

After clicking a product category menu, the product image window will be displayed.

This image window contains images and text data which is classified by company name.

You can select any company, and the product image of that company will be displayed.

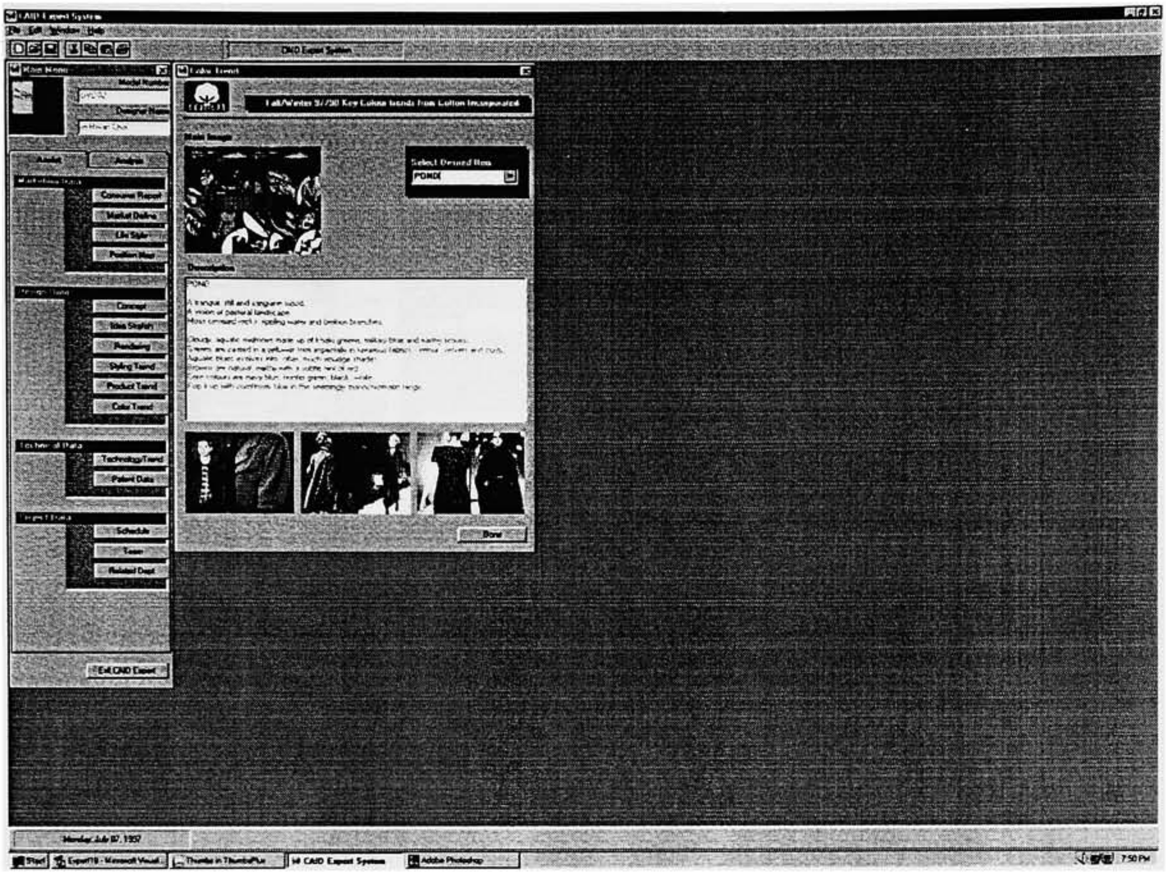


Figure 32. The Color Trend Menu

Color trend

Selection of an appropriate color for a product is an important task for an industrial designer.

The *color trend* menu includes some color information about future color trends to help one choose a suitable product color.

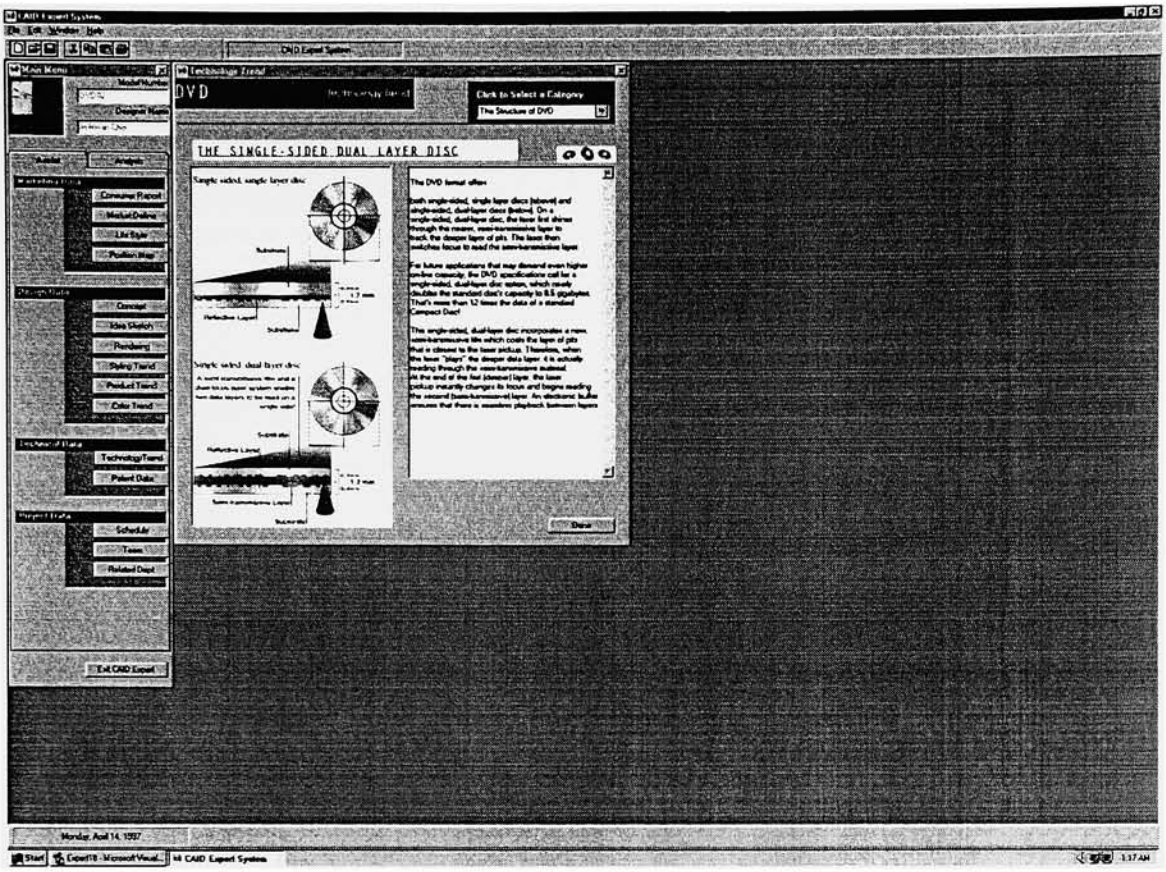


Figure 33. The Technical Data Menu

3) Technical data

The *technical data* menu includes technical information and patent information about the current design project. For a good design result, the understanding and use of the technical trend of a product is essential.

Technical trend

The *technical trend* menu provides an industrial designer with overall technical trends and direction of current design projects. The information provided from this menu contains the origin, history and structure of technology about a product.

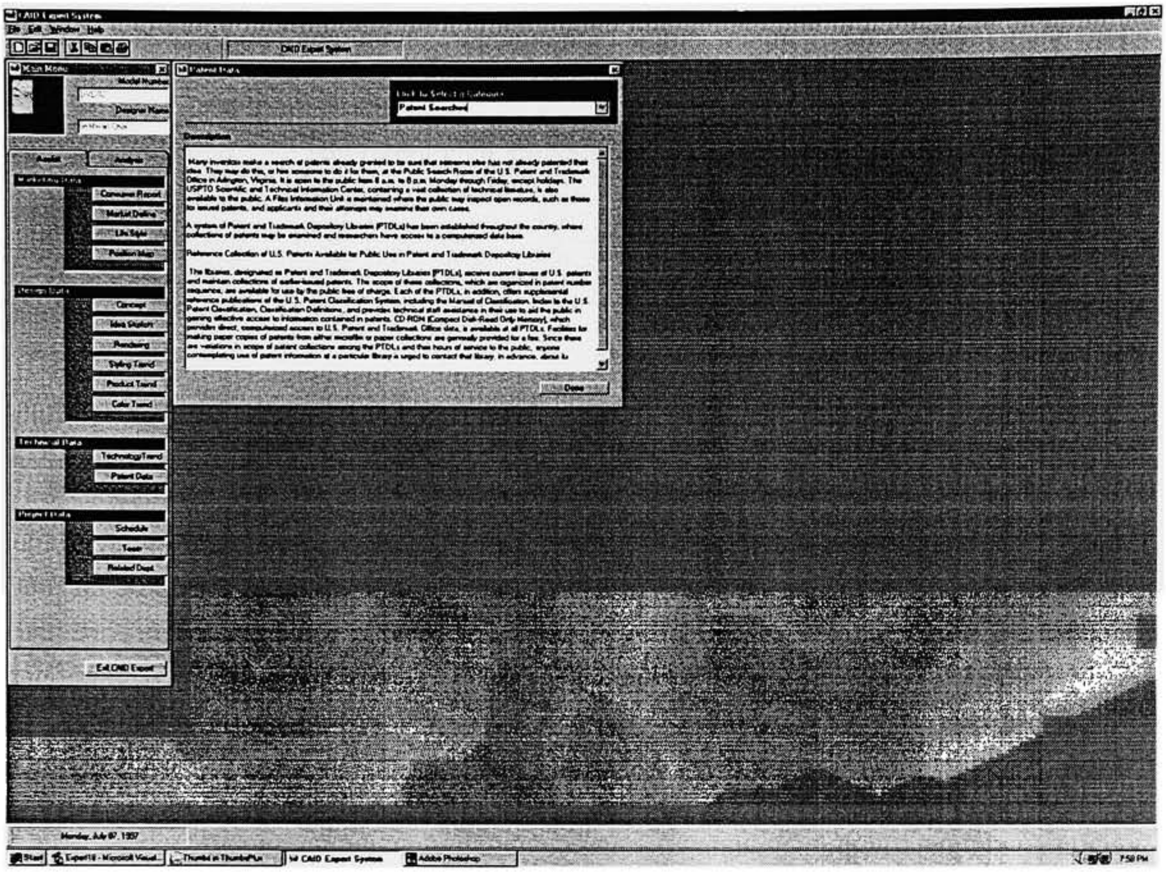


Figure 34. The Patent Data Menu

Patent data

The *patent data* has patent information of current project related products and other products.

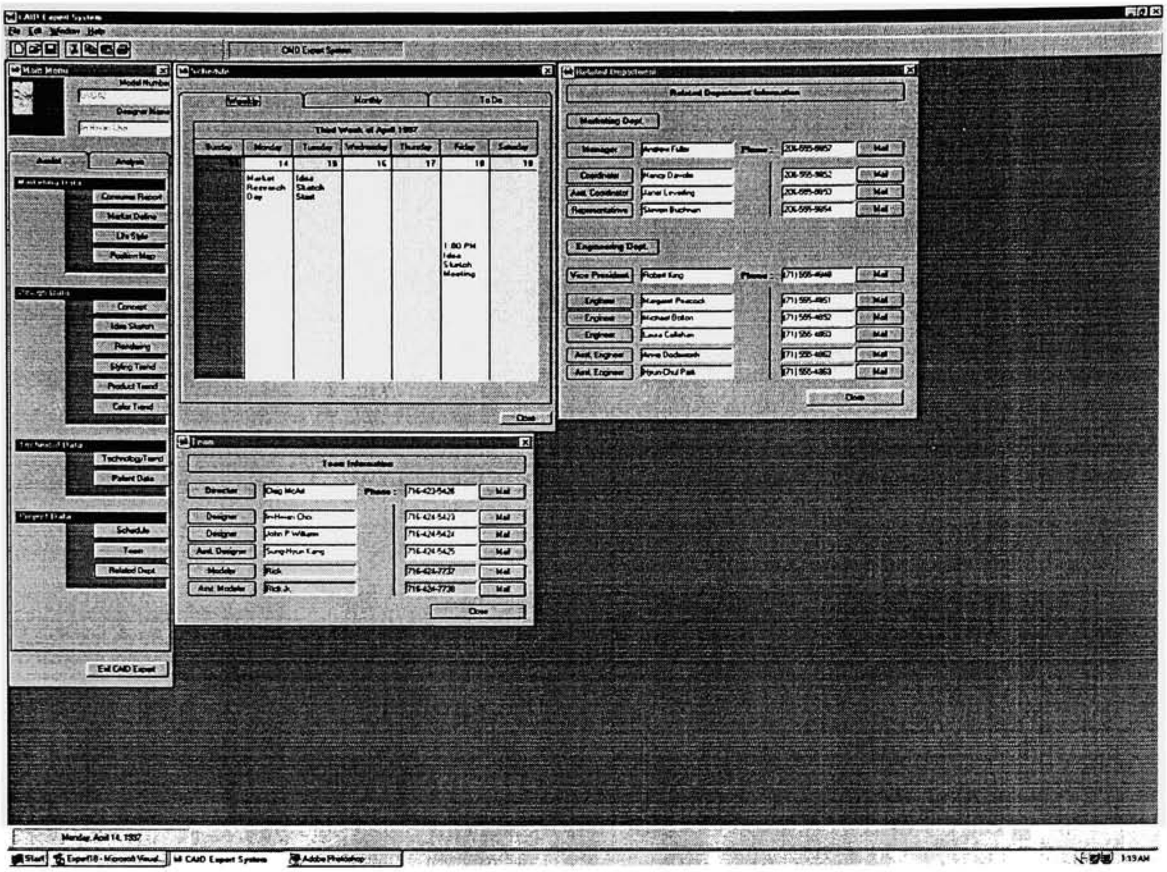


Figure 35. The Project Data Menu

4) Project data

During the product development phase, keeping the design schedule is an important factor for the industrial design team.

The *project data* menu consists of information about the design team, design schedule and related departments. With this menu, an industrial designer can communicate with other related department members and check the design schedule.

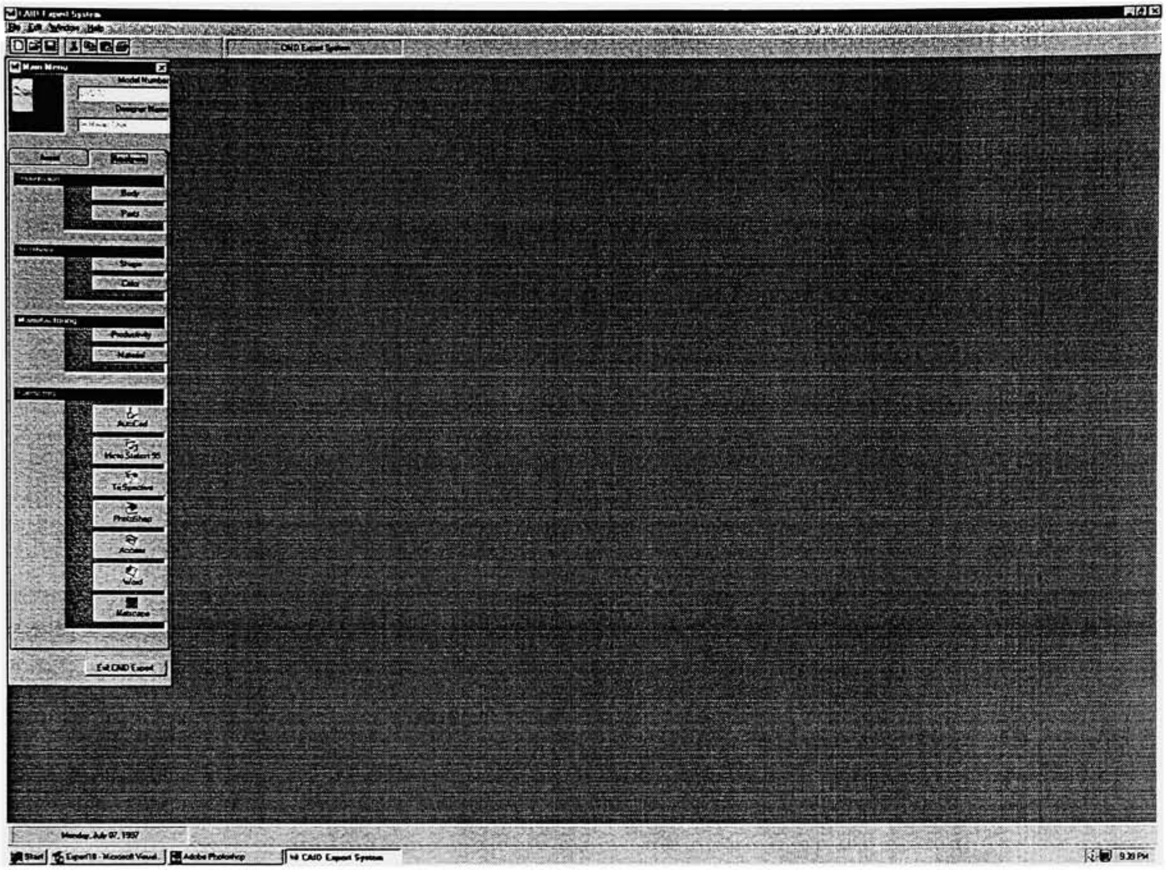


Figure 36. The Dimension Menu 01

5) Dimension

The *dimension* menu is included in the *Analysis* menu, which is one of the two major menus of the CAID information system main menu. With this menu, an industrial designer can check the physical attributes of parts of the current design project.

The main solid modeler of the dimension menu is the TriSpective 1.0 of 3D/EYE, inc..

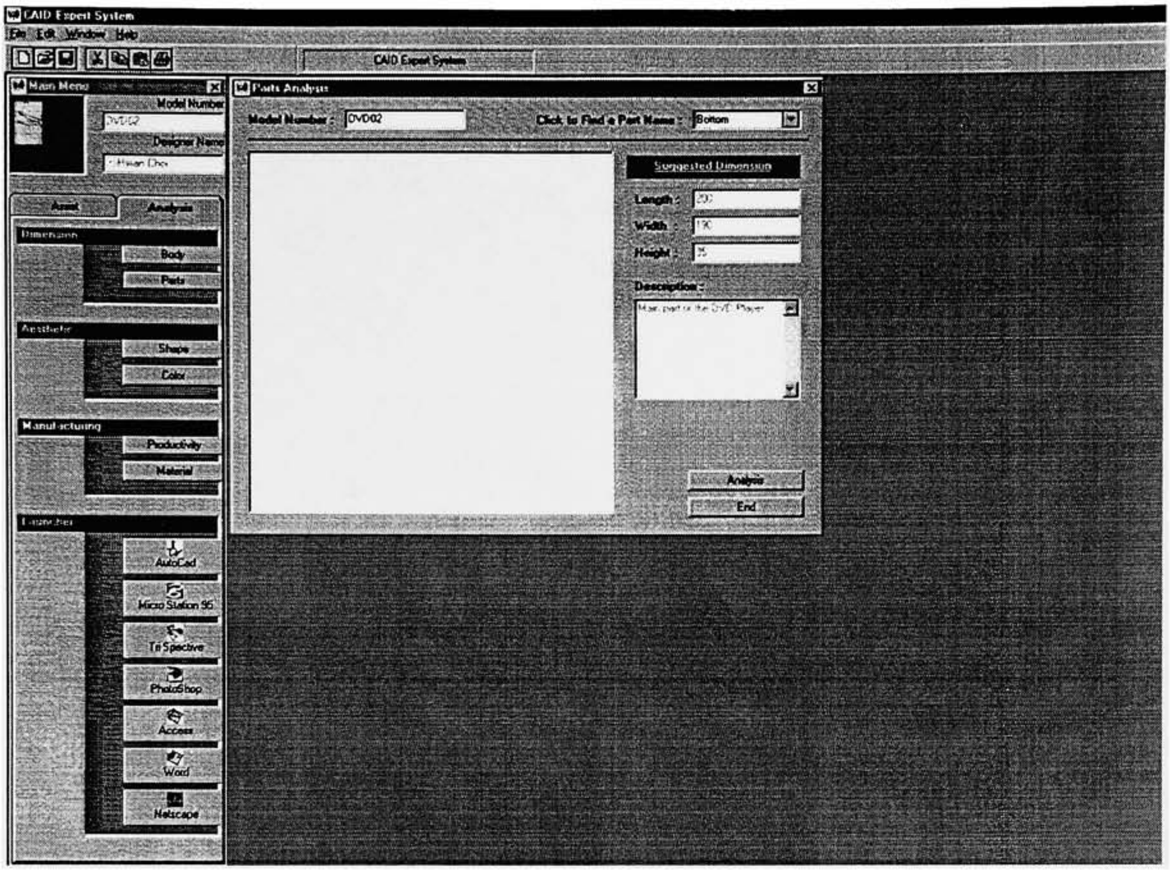


Figure 37 The Dimension Menu 02

The following is the sample process of physical attribute analysis of the portable DVD player's bottom part.

First, click the *part* button of dimension menu.

In *part analysis* window, select *bottom* part.

As a result, the suggested dimensions of the bottom part is being displayed in the *parts analysis* window.

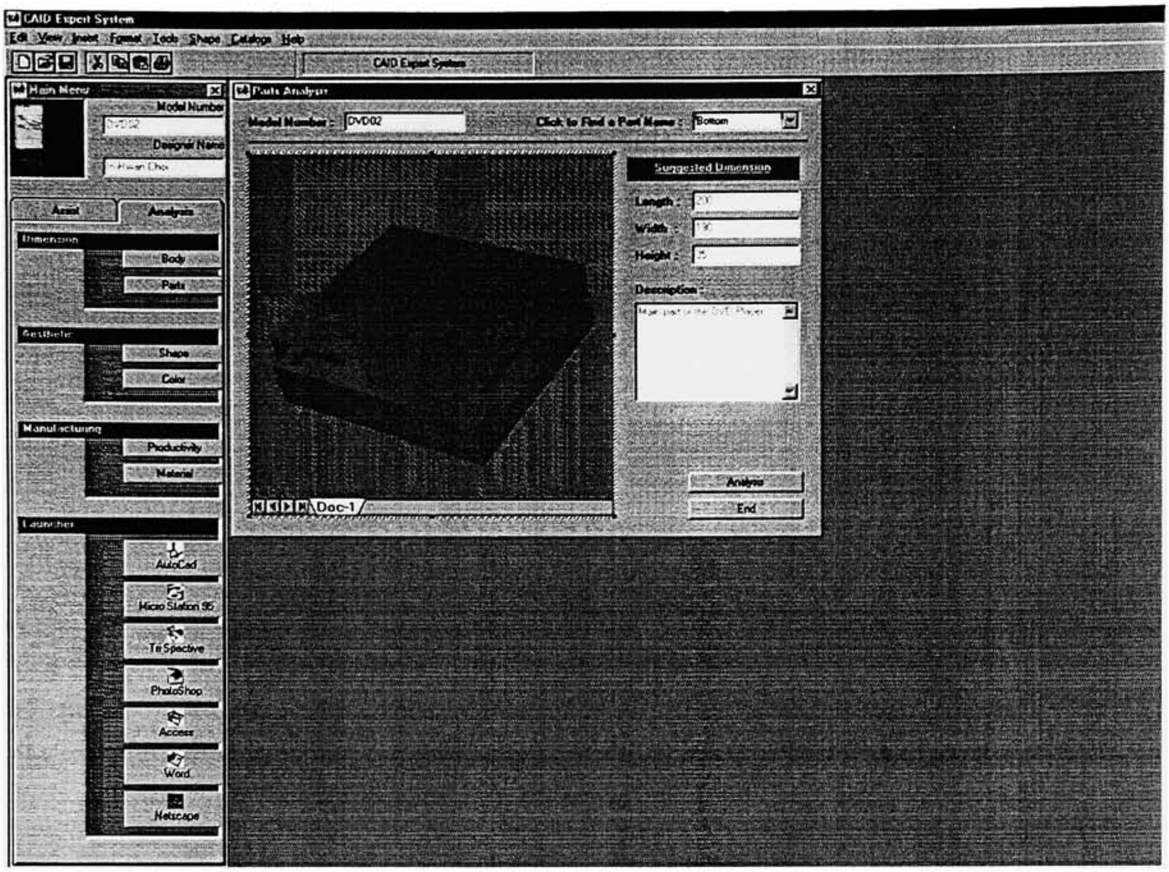


Figure 38. The Dimension Menu 03

Click the *analysis* buttons of the *parts analysis* window: Then the solid model of bottom part will be displayed. Now, the TriSpective is linked to the CAID information system through the OLE function of the Visual basic.

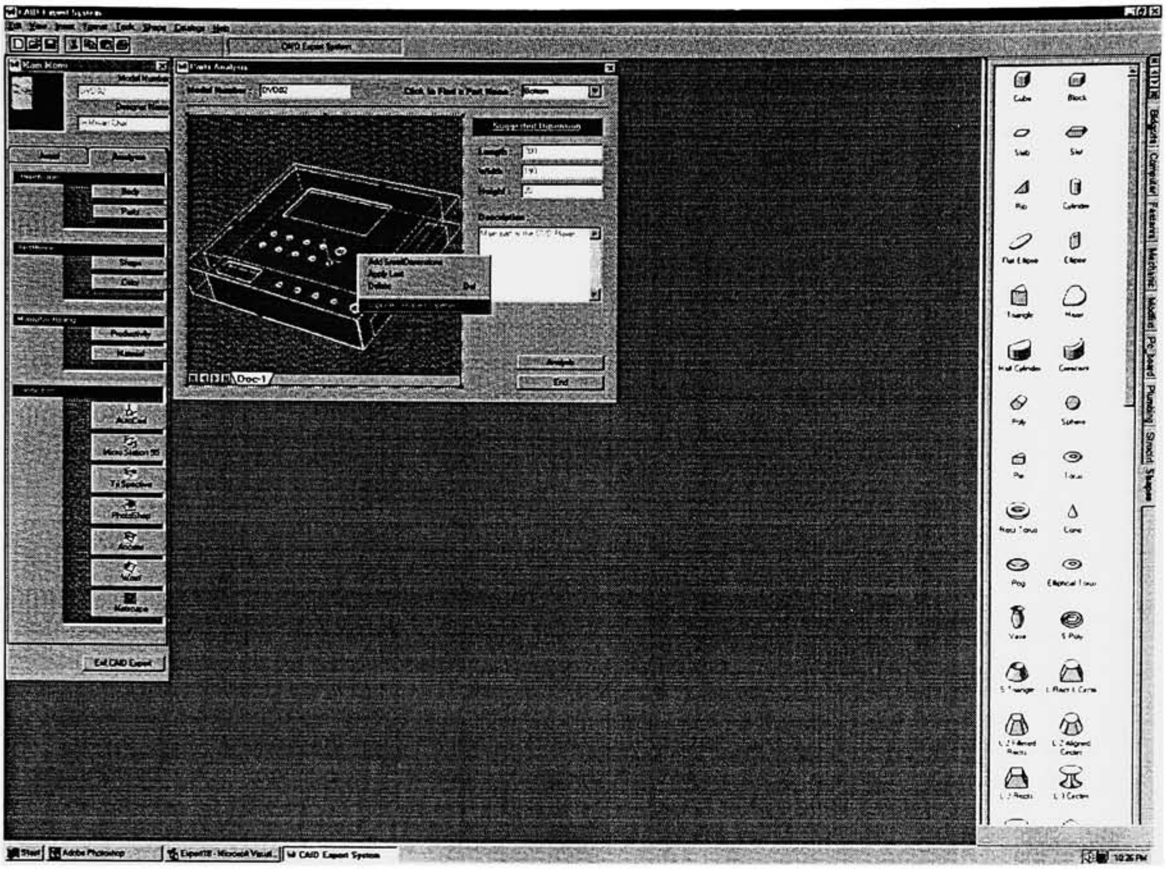


Figure 39. The Dimension Menu 04

Click the solid model of bottom part to display the submenu for physical attribute analysis.

Click *shape property* to make the shape properties window appear.

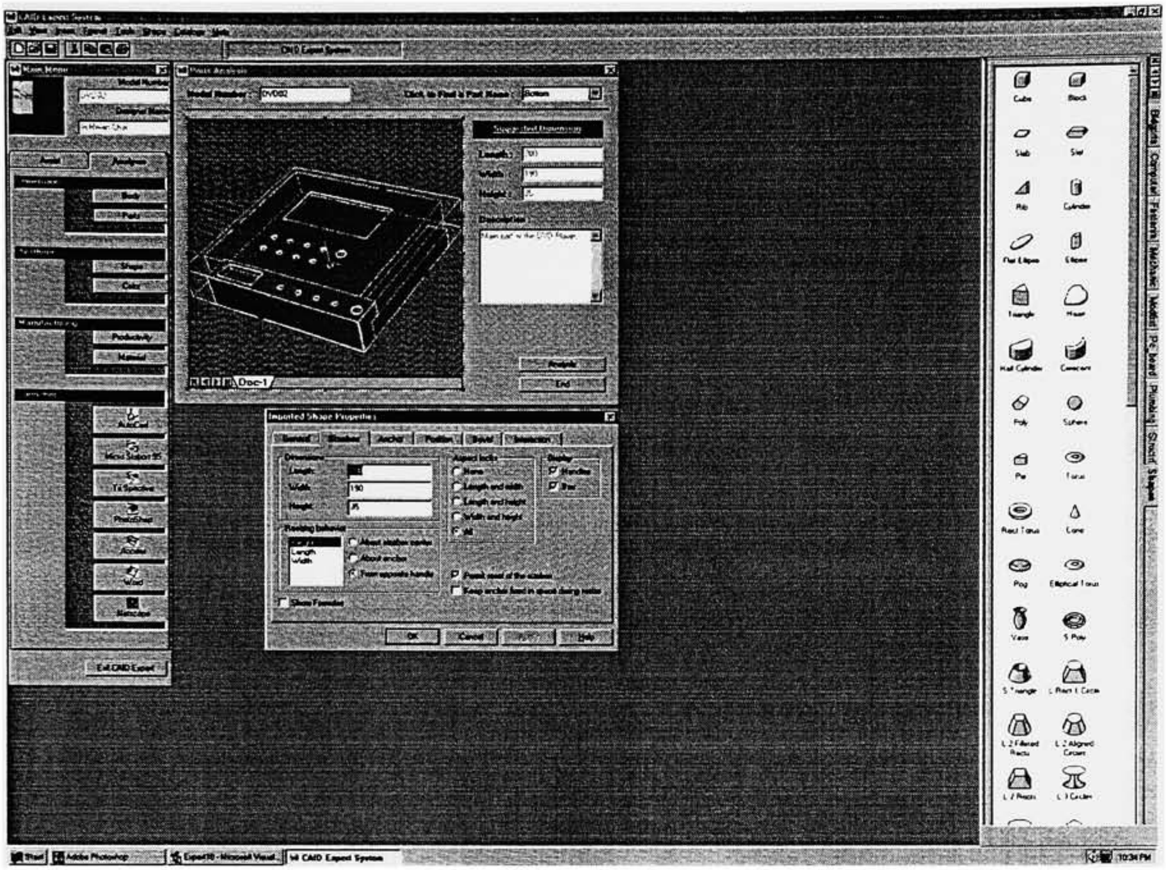


Figure 40. The Dimension Menu 05

In the *shape properties* window, click *size box* and the real dimension of the solid model of bottom part will be displayed. With these dimensions, an industrial designer can compare the real dimensions with suggested dimensions from the engineering department.

If there is an error, then type the right dimension. As a result, the shape of the solid model will be changed automatically.

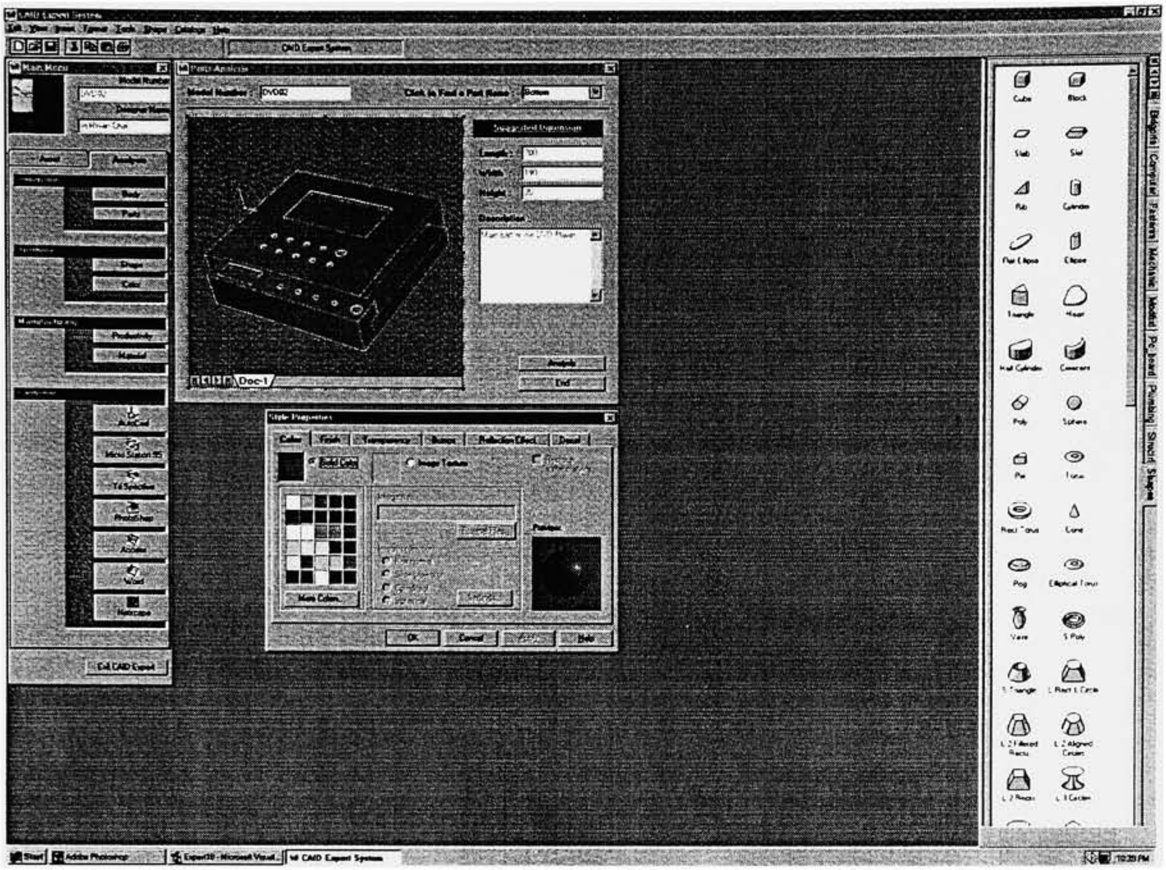


Figure 41. The Dimension Menu 06

An industrial designer can make an analysis of other physical attributes such as volume, mass, texture and color of the current design project with this menu.

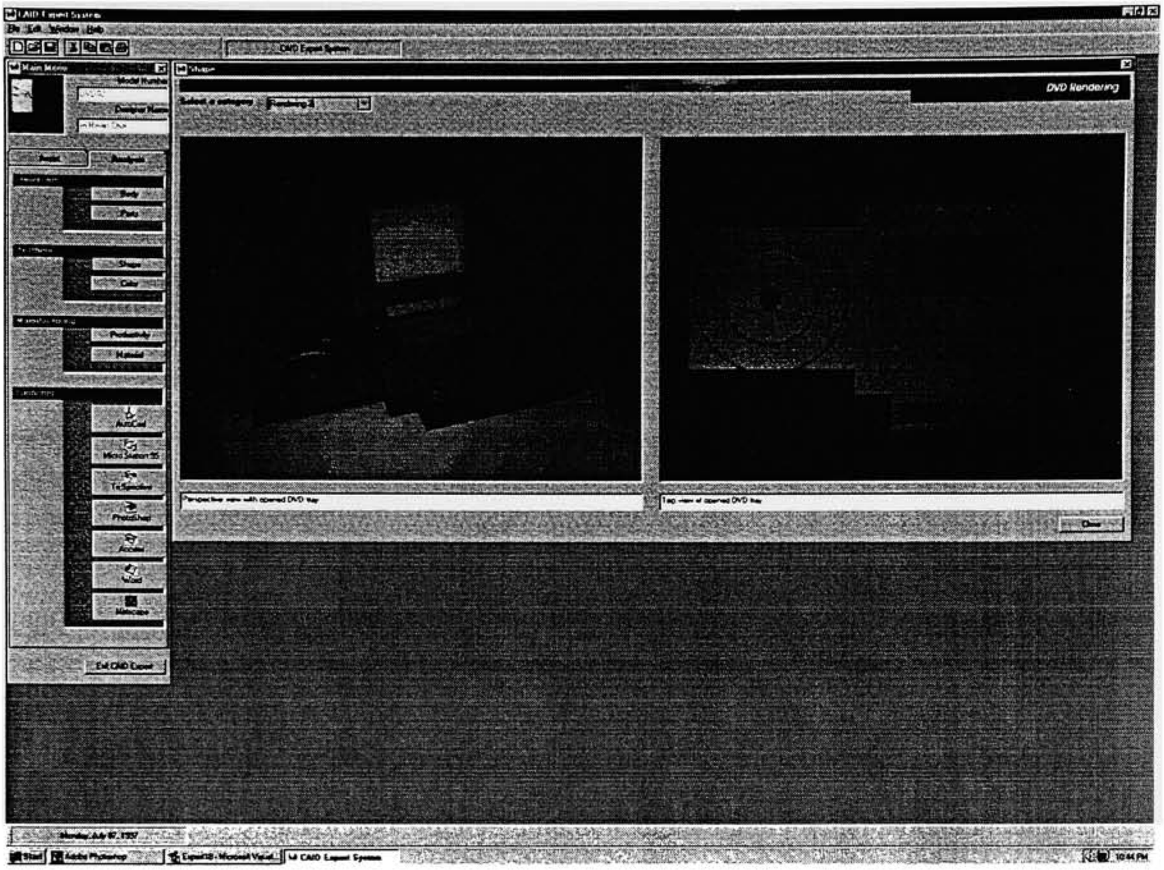


Figure 42. The Aesthetic Menu

6) Aesthetic

This menu is for aesthetic evaluation of a product design. The *shape* menu and the *color* menu are the core parts of the *aesthetic* menu.

Shape

The *shape check* menu consists of a collection of rendering files. It provides several shape check windows which contain files of current renderings and product descriptions of the current project.

With this menu, an industrial designer examines aesthetic attributes of the current design project.

Figure 43. The Color Menu

Color

The *color check* menu contains color related information. It contains suggested color and rendering images of the current project. Comparing color information from the *color trend* submenu of design data menu with the color of this rendering image is possible in this menu.

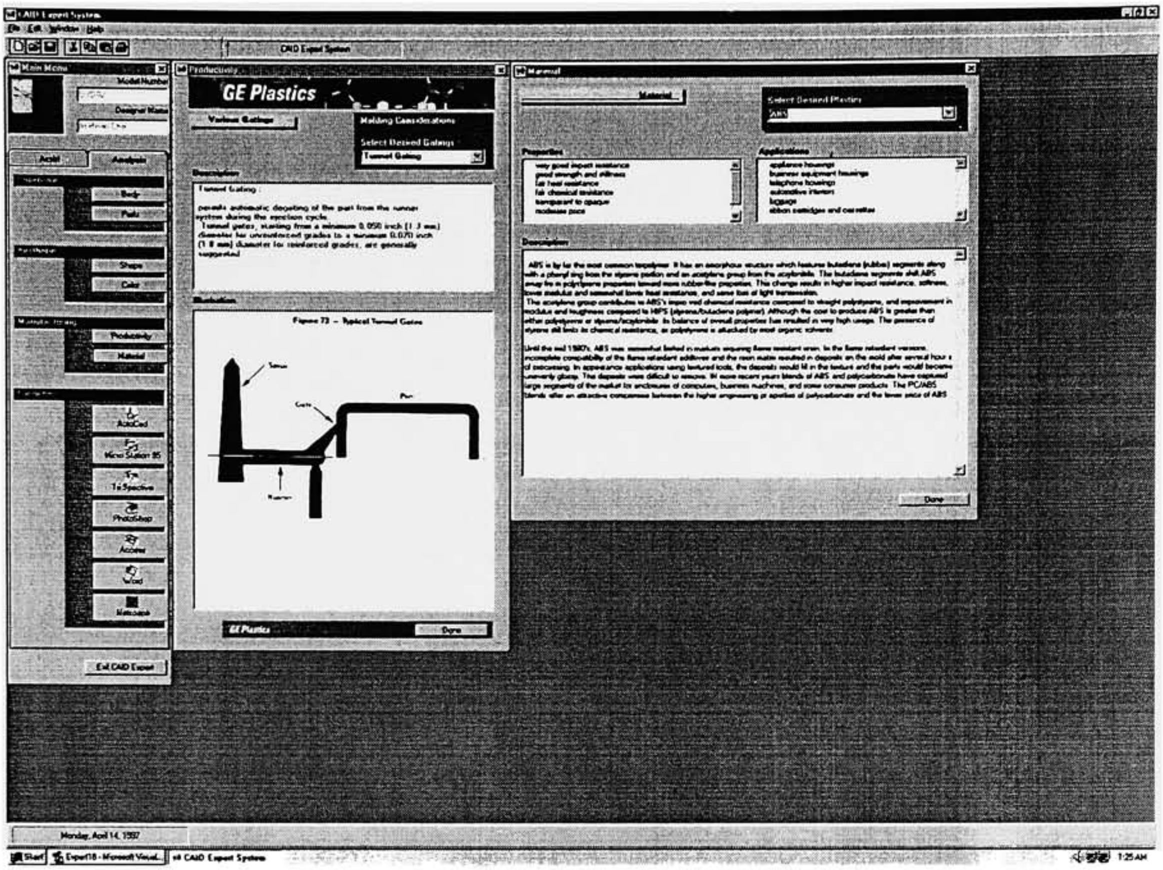


Figure 44. The Manufacturing Menu

7) Manufacturing

The *manufacturing* menu consists of the *productivity* menu and the *material* menu. In order to make a good product, the productivity of a design result is an important factor of the product design.

The productivity menu provides information about various plastic injection molding considerations and techniques.

The material menu has plastic material related information such as properties and applications of a design project.

Through this menu, a designer easily checks manufacturing related attributes of a design project.

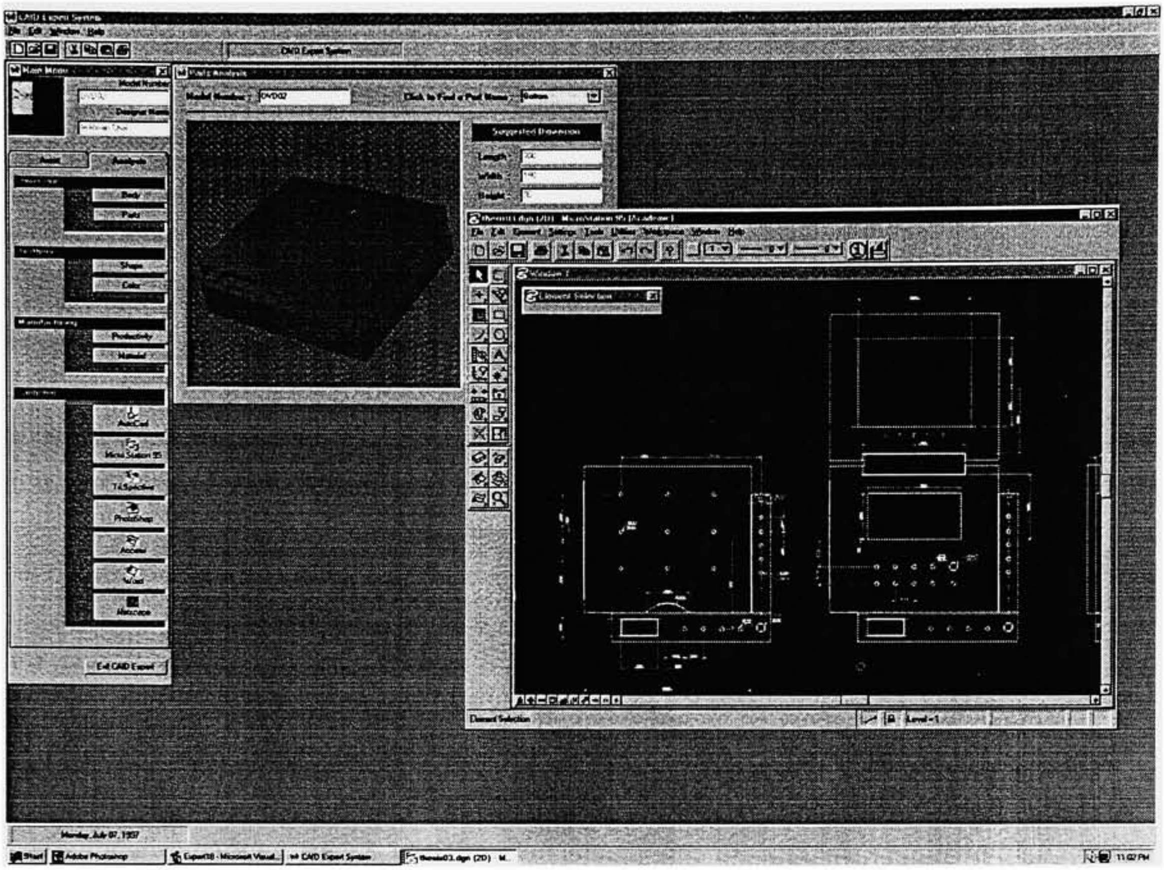


Figure 45. The Launcher Menu

8) Launcher

The *launcher* menu has the ability of running other application programs in the CAID information system.

The example shows that the MicroStation 95 is being used to check the detailed dimensions of the bottom part of the portable DVD player.

5. Conclusion and Future Task

5. 1 Conclusion

The rapid development of information technology and computer science which includes wide area communication such as internet, provides an important motive for changing the product development process toward the 21st century. Now, the development of computer hardware technology allows PCs to do the hard tasks which had been done by workstation grade computers. Moreover, the keen competition in the international product market among product manufacturers forces the emergence of new objectives of the product development process. These objectives include improvement of product quality, low cost, and shortened product development process.

The most important initiative to achieve these objectives is concurrent engineering. The main concept of concurrent engineering is parallel and simultaneous product development, which is contrary to traditional serial product development. Many major product companies already use the concurrent engineering method successfully.

The essential foundation for this kind of new product development process is a computer network system which is based on computer and information technology to enable information exchange and communication among product development related departments in a company.

We infer, then, from newly developed methods for product development, the need and usefulness of the CAID information system for industrial design will be increased. With the CAID information system, an industrial design department can manage and use information during the product development process easily, and share information with other related product development departments.

Furthermore, an industrial design department can be assimilated with the new product development initiatives such as concurrent engineering, and lead the overall product development process.

5. 1. 1 Results

The results from the CAID information system study follow.

Collecting and using information from each phase of the industrial design process is important, and a suitable information control system will play an important role in the whole industrial design process. Because of the rapid development of information technology and computer science, the need for the CAID information system to lead the change of the industrial design process in the newly developing product environment has increased.

The processing capability of desktop PCs is being improved rapidly. If a company uses appropriate network technologies such as WAN(Wide Area Network), PCs in the company can easily be connected to some workstations which are partly used in each product development department. An information control program like the CAID information system, which provides useful and important information to the industrial design department during the product development process, can be development based on this kind of network. The CAID information system will play a main role as an information provider and communicator among product development departments, and bring benefits such as shortened product development time and improved product quality to the company.

- The CAID information system will shorten time consuming work processes during the industrial design process and give more time for an industrial designer to do more creative work. Appropriate information providing, and the design error check function of the CAID information system, will improve the overall design quality.

5. 1 Future task

The CAID information system study has been done on an IBM compatible PC with Windows NT 4.0. For a wider application area and a network environment which includes Mac and Unix based computer systems, a study of those kinds of operating system will be needed.

The criterion of the CAID information system study is a medium size product manufacturing company which has its own design, marketing, engineering and manufacturing departments. As a result, the scope of information which was generated , analyzed and processed during this study also has that size limitation. To enlarge the application area of the CAID information system, it will be necessary to study the vast range of information which is necessary during product development process. A systemati analysis, classification of design information and a rational method of storing and sorting technique will be the main next tasks of this study.

The CAID information system has a physical dimension check function for the current design project. For a more efficient industrial design information system, there is a need to study and include expert system theory which can help a designer in the decision making phase.

The evolution of computer science and information technology will continue and the product development process will change more rapidly. In this rapidly changing environment, there will be an increasing need for a computer program which can help an industrial designer to improve design quality and shorten the overall product development process. To take advantage of the newly developed technology for use in the industrial design process, each industrial designer should continually study these kinds of new technologies.

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