MANAGEMENT DECISION SUPPORT AND THE NEW PRODUCT DEVELOPMENT PROCESS

by

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ABSTRACT

This thesis describes one approach to the new product development process for automobiles and then abstracts from this process in order to define a management decision support system to aid in decision making related to new product development.

Part 1 of this thesis involves a discussion of the New Product Development (NPD) Process. Part 2, develops guidelines for a management information system that will serve as an advisor to management during the New Product Development process.

In describing the New Product Development Process, divisional and corporate responsibilities is identified, and functional participation is discussed. Abstracting from the decision and information channels with the organization, a system and software architecture for the proposed management decision support system is derived. The management decision support system makes use of two information technologies, namely, multimedia and artificial intelligence. The applicability of these two technologies to the new product development process is discussed in detail.

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the responsibility of the real world.

Now, I am good and ready.
Thesis Objectives

The goal of this thesis is twofold. The first goal is to describe the process by which a new product (in this case a new car) is brought to market and to concentrate on the decision making process involved. The second goal is to abstract from this decision process and to define an architecture for a management decision support system to decision making related to new product development.

Part 1 of this thesis describes the New Product Development (NPD) Process, while Part 2 develops guidelines for an information system that will serve as an advisor to management during this development process. Obviously, Part 2 of this thesis will abstract from Part 1.

In describing the New Product Development Process, divisional and corporate responsibilities will be identified and functional participation will be discussed. Abstracting from the decision and information channels with the organization, a system and software architecture for the proposed management decision support system will be derived. The management decision support system will make use of two information technologies, namely, multimedia and artificial intelligence. The applicability of these two technologies to the new product development process will be discussed.
PART 1. NEW PRODUCT DEVELOPMENT PROCESS
1.0. Introduction

1.1. New Product Development at General Motors

The process of New Product Development (NPD) at General Motors Corporation (GM) takes place over several years and involves the participation of several functions, including engineering, manufacturing, marketing and sales and finance. NPD takes an average of four to five years from the moment an idea or concept is born until the product is launched.

It would be an understatement to describe the NPD process for automobiles as complicated. Until recently, there was no formal methodology for NPD at GM's divisions although a rudimentary one has existed at the corporate level for seven years. In 1987, GM divisions adopted a methodology called the "Four Stage Process" (4SP), which breaks down the development process into four roughly equal time segments demarcated by critical decision events. 4SP enables marketing, engineering and manufacturing to work together to build a new product\(^1\).

1.2. The Four Stage Process: An Overview

The 4 Stages of the new product development process are:

- **Stage 1: Technology and Concept Development**

At this initial stage, ideas for new products are conceived and tested on customers to determine the ones with the greatest potential for success. Several customer surveys aimed at developing a detailed concept of a new product are conducted. Concurrent with the idea generation and refinement process, technologies and strategies that can translate customer needs to product characteristics are being investigated and developed. To win approval for any product concept, clay and fibreglass models have to be built.

\(^1\) The sales organization has not as yet been integrated into 4PP.
• **Stage 2: Product & Process Development and Prototype Validation**

Once the new product concept has been refined and approved as a result of rigorous testing, it enters the next stage where a prototype has to be built for approval from the corporation. During this stage, initial preparations to manufacture the product are commenced.

• **Stage 3: Process Validation and Product Confirmation**

Once the prototype has been approved, the new product program is in full swing. At this stage, efforts are underway to bring the new product to market. Advertising and product launch strategies are being designed, while production facilities are preparing to commence production. The initial pilot automobiles are produced towards the end of this stage.

• **Stage 4: Production and Continuous Improvement**

The start of this stage is signalled by the launch of the automobile. As the name suggests, this stage involves tracking the market performance of the automobile and effecting minor changes to make the car more desirable to customers. Customer satisfaction data and buying behavior data are collected. Ultimately, the information gathered during this stage will be used to develop the next generation of automobiles. In other words, Stage 4 of one product blends seamlessly into Stage 1 of the next development cycle.

1.2.1. **Process Objectives**

The Four Stage Process is the outcome of the need to achieve a methodical reduction in lead times for new product development, to make more effective use of resources, and to develop products that provide customer value and satisfaction.

GM and its numerous divisions needed a 'common language' of new product development. Corporate and the divisions traditionally had conflicting perspectives and objectives in
developing new products. The 4SP is an attempt to develop a common language so that both corporate and the divisions can work towards mutually beneficial goals.

The nature of the automobile industry changed dramatically in the 1980's with new and improved competition. Customers have a lot more power now. GM realized that it needed to be increasingly more customer focused. To be really effective this customer focus had to be incorporated into the NPD process. 4SP is an attempt to use customer wants and needs to direct the new product development.

Without a company wide framework for NPD there was substantial duplication of work among various divisions and also among divisions and corporate. Sometimes several critical steps of the development process would either be ignored or be performed incorrectly or inadequately. The 4SP provides clear guidelines for NPD and allocates responsibilities. It also sets out development milestones which enables corporate to control and coordinate the development effort, since funding is tied to achieving the milestones. The 4SP also helps corporate to plan budgets.

One of the major problems with NPD at GM has been the transition from development to execution. By defining four stages in the development process and establishing clear goals, objectives and milestones for each stage, 4SP attempts to ensure quality execution.

1.2.2. Timing of the Four Stage Process

The NPD process can take as long as 7 to 10 years from the very first stages of development. 4SP accounts for the last 4 to 5 years. Stage 1 is the most critical stage, while Stage 4 blends into the Stage 1 of a subsequent development cycle.
Stage 1 ends when the concept for a new car is approved. Approval requires clay and fibreglass models in order to demonstrate the product concept and demands a clear demonstration of sales potential for the proposed product. Approval sets in motion the activities of Stage 2 which are aimed at developing a prototype vehicle and winning final approval for the product program. Once the final approval is granted, Stage 3 activities get underway culminating with the production of a pilot vehicle and product launch.

A Process of Continuous Improvement

Although the 4SP accounts for only 4 to 5 years of the NPD cycle, in reality, new product generation is a continuous and longer term endeavor. Both corporate and the individual divisions are constantly scanning the market for opportunities and examining existing product lines for redundancies. Product programs are reviewed regularly from financial and strategic standpoints. Both Corporate and Divisional Marketing study customer satisfaction and buying behavior on a periodic basis. 4SP provides a clearly defined framework for the latter part of the NPD process.

1.2.3. Participants in the Four Stage Process

The main participants in the 4SP are corporate and divisional market research teams, marketing and sales, design and engineering, manufacturing and finance. The Divisional General Manager and Comptroller are key decision makers at the divisional level, while the Chairman of the Board is the key decision maker at the corporate level. Several business teams, both at the corporate and the divisional levels, are involved in decision making during NPD. Exhibit 1 summarizes the main participants in the 4SP and identifies primary information flows between them.
EXHIBIT 1. PRIMARY INFORMATION FLOWS BETWEEN 4PP PARTICIPANTS
Market Research

The corporate research arm is called Market Research and Planning (MRP). MRP is a part of a Corporate Staff Organization called Marketing and Production Planning Staff (MPPS) (see Exhibit 2 for organizational structure of MPPS). Together with divisional market research teams, MPPS is responsible for gathering and analyzing data that will streamline the NPD process and make it more efficient and effective. MPPS and the divisions conduct research clinics, or customer surveys, at every stage of the 4SP to test and validate product concepts and to help forecast future product sales.

Design and Engineering

Design teams are constantly experimenting with new car concepts and styles and hold regular exhibitions of their work. During the 4SP design teams work closely with the divisions to develop clay and fibreglass models of products based on information gathered by the research teams.

Production (Platforms)

Production teams are responsible for hand-building prototype of the car and for developing a manufacturing strategy. Platforms have a considerably different perspective on the new product process than the divisions. Platforms are very sensitive to styling issues (divisions are not) since they affect the choice of tools and equipment. Divisions, on the other hand, are very aware of market segment effects while the platforms are relatively independent of segment and industry dynamics.

Sales

The sales organization is not involved during the early stages of the 4SP. In the later stages of 4SP some sales participation is secured but the new product is "handed off" to sales
during the final phase of Stage 3. The sales organization at GM is more or less an independent entity with a culture that is very different from the rest of the organization.

Finance
Finance teams review the financial performance of divisions periodically on a short-term (5 year window) and a long-term (ten year window) basis. In the short-term, divisional spending targets, profit contributions, sales volumes, competition, and program evaluations (divisions are forced to rank their product programs) are reviewed. Program rankings are used to identify product redundancies and new product opportunities.

The Marketing Line Manager and The Product Line Manager
The guardians of a new product concept are the Marketing Line Manager (MLM) and the Product Line Manager (PLM). The MLM works closely with divisional market research in the early stages of Stage 1 while developing a business case to convince the division and corporate of the viability of the new product. In Stage 1 the marketing-engineering involvement is roughly in the ratio 90%-10%. During Stage 2, the PLM gets more involved as the development of the product and process evolves. Both line managers spend an equal amount of time at the design studios with the design teams. In Stage 2 the marketing-engineering involvement is roughly 10%-90%. In Stage 3, both line managers are equally involved, coordinating and cooperating on every significant action.

1.2.4. The Initial Response to 4SP
Since 4SP is a new discipline at most divisions, the effects of the process will not be known at least until model year 1993. The initial verdict has however been positive. It has taken time for the divisions to buy into the 4SP philosophy. Extensive training is required to familiarize managers with procedures. Articulating or making sense of the 4SP is still a
difficult task. As more and more people buy into the discipline, there is the realization that 4SP makes it easier to communicate and coordinate with other functions and corporate.

4SP has proved most useful in imposing a much needed discipline on the NPD process. It has brought marketing, engineering and production together and has opened lines of communication between these functions. In short the 4SP has served as a communications tool for interdisciplinary cooperation.

For example, with 4SP, it has become easier to communicate customer needs to engineering. With data gathered from customer surveys, the marketing function can develop a strong case for changing a product. Engineering staff recognizes the validity of the data and are now more receptive to the change than before.

4SP has also improved communication between marketing and production. Marketing wants to be responsive to customer needs while production wants to minimize the number of changes to a product. 4SP enables marketing to identify customer needs right up front so few changes have to made at later stages of the process.

1.2.5. What's Next?

The NPD process can be streamlined with the help of two technologies, multimedia and artificial intelligence. There are a number of other computer based technologies as well as modelling techniques that have the power to make the NPD process more effective. It must be stressed, however, that although these new technologies present wonderful new opportunities for improving the process of new product development, "attitudinal" changes, such as the organizational acceptance of a scientific forecasting tool, are by far the more
challenging. Part 2 of this thesis will be limited to addressing the impact of new technology on the NPD Process.
PART II  MANAGEMENT DECISION SUPPORT
2.0. Integrated Information System for New Product Development: An Overview

This part of the thesis will address the potential impact of information technology on the New Product Development (NPD) Process. To set the stage for the application of Information Technology (IT) to NPD, it is important to start with a framework. Prof. Glen Urban, at the MIT Sloan School of Management, has proposed a conceptual framework for an integrated NPD system (see Exhibit 3). The main components of this system are an "Information Acceleration" module, a consumer behavior modelling module, and a Management Decision Support module or Knowledge Based System (KBS) that advises management during the development of marketing, production, R&D, sales, and financial strategies.

Information Technology can be applied with great impact at both the front end (information acceleration module) and the back end (KBS for management decision support) of the integrated NPD system. The rest of Part 2 will examine the "information acceleration module" and "the manager's decision support module (i.e. KBS)" in greater detail. Multimedia technology and its applicability to the NPD Process will be discussed in the section on information acceleration. Finally, a framework for a KBS, that transforms raw mathematical model output and other information into a format usable by managers, will be defined.

2.1. Information Acceleration

Information Acceleration is the concept of making multiple sources of product information (such as product brochures, TV and print advertising, simulated retail store visits, and word of mouth encounters with product users) available to prospective customers at one place (e.g. a personal computer) in an inexpensive and timely fashion. By providing multiple
EXHIBIT 3. CONCEPTUAL FRAMEWORK FOR AN INTEGRATED NEW PRODUCT DEVELOPMENT SYSTEM

Information Sources
- Marketer Produced
- Retail (Store) Visits
- Interpersonal
- Neutral

Business Plan
- Product Design
- Production Capacity
- Marketing Plan
- Financial Planning

Information Acceleration
- New Product Simulation
- Search Environment Simulation
- Information Availability
- Search Enablement

Consumer Behavior Model
- Individual Choice
- Diffusion of Innovation
- Utility Parameters
- Response Functions
- Categorization
- Positioning
- Segmentation

Knowledge Based System and Management Interface
- Aggregate Presentation
- Consultant Report
- Simulation Forecasts
- Decisions: R&D/Production/Marketing
sources of information conveniently, at one location, the search process for the prospective customer is accelerated.

Also, information about the product may be provided to prospective customers while still under development; the somewhat sequential process of new product conceptualization, development and market awareness are compressed (or accelerated) within a smaller time frame. The new technology that enables the "acceleration of information" to prospective customers is called Multimedia\(^2\).

Another perspective on information acceleration is the accelerated flow of market information to the new product developer, through sophisticated consumer studies and advanced modelling and data analysis techniques. The net results of information acceleration to the customer and back to the organization, are:

- A reduction in the development time for a new product
- A more informed and educated buyer

As a prospective customer searches for information on the computer, his or her search process is tracked by the computer. Additional geo-, demo-, and psycho-graphic information are collected through questions at relevant points during the search process. Advanced techniques convert tracking data and answers to questions, into models that describe consumer behavior in general (e.g. a multivariate utility model of information sources)\(^3\).

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2 Multimedia technology will be discussed in the following sections.

3 For detail on modelling techniques and for an in depth study of the modelling of consumer behavior please refer the forthcoming Doctoral thesis of Bruce Weinberg at the MIT Sloan School of Management, 1990.
EXHIBIT 4 SCHEMATIC OF A KBS FOR MANAGEMENT DECISION SUPPORT

INPUT
- GM Vehicles
- Competition Vehicles
- Vehicle Attribute Details
- Range of Feasible Vehicle Packages
- Customer Groups
- Vehicle

KNOWLEDGE BASED SYSTEM FOR DECISION SUPPORT

OUTPUT
- Vehicle Sales
- Optimal Product Package
- Target Customer Groups
2.2. A Knowledge Based System to aid in New Product Development

Some of the consumer behavior models may be quite advanced, requiring in depth knowledge of modelling techniques to interpret the results. To be useful to managers while making strategic and tactical decisions, these models have to be interpreted and analyzed in light of economic trends, competitor strategies etc.

The Knowledge Based System (KBS) takes in clinic data (tracking data and answers to questions) along with other relevant market, competitor and product information, uses "expert' knowledge to analyze this data and provides managers with 'advice' on issues such as vehicle sales, product package, target groups etc. (see Exhibit 4). The resulting "consultant report" impacts decisions on product design, production capacity, marketing plan and financial goals. The KBS serves as a decision support system for management during the NPD Process (it is not meant to supersede the manager during the process).

2.3. The Information Acceleration Module

As mentioned in the previous section, Information Acceleration is availability of multiple sources of product information to prospective customers in an inexpensive and timely fashion. By providing several sources of information conveniently, at one location, the prospective customer's search process is accelerated. To accomplish the presentation of multiple information sources, conveniently and at a single location, the information acceleration module makes use of a new computer based technology, popularly known as multimedia\(^4\).

\(^4\) The information acceleration module has been under development for just under two years. For a complete review of the advanced technical capabilities of multimedia please refer the Master's thesis of John Prescott Halstead at the MIT Sloan School of Management, 1990, titled "A Technology Strategy for on-going Development of the Information
EXHIBIT 5 SCHEMATIC OF TYPICAL MULTIMEDIA SYSTEM

LASER DISK

LASER DISK PLAYER -> GRAPHICS PROCESSOR -> TV SCREEN OR COMPUTER TERMINAL

PERSONAL COMPUTER

INPUT DEVICE
2.3.1. **What is Multimedia?**

Multimedia is a new computer-based technology that enables mixing of text, numbers, graphics, animation, audio, and full-motion video on TV or on computer screens. Multimedia provides a more realistic "viewing" experience, combining the massive computational power of the computer with the expressive power of pictures and video.

People learn by absorbing information from many sources, and learn best from experience. Experiences are made up of many different stimuli - visual (film, video, simulations and animations), auditory (voice and music), and textual (words and numbers). Multimedia blends these stimuli into one coherent environment (the personal computer for example) and presents a multi-sensory learning experience that is both powerful and effective.

One version of a multimedia system is shown in Exhibit 5. The typical components are:

- a Central Processing Unit (CPU)
- a video disk player
- one or more video disks (the information on the disks defines the use of the system)
- a computer or TV screen
- a special graphics processor
- special multimedia software which drives the hardware

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5 There are several radically different types of multimedia systems under development. For an excellent summary of the technological directions of multimedia I recommend, "Multimedia moves in and computer giants map their strategies", by Jack Shandle, in Electronics, February 1990, p. 48-71.
2.3.2. Applicability of Multimedia to the NPD Process

The expressive and computational power of multimedia can be harnessed by the New Product Development Process, to make the process more effective and efficient. Some of the uses of multimedia technology in the NPD Process are outlined below.

- **Acceleration of New Product Information to the Customer**

Multimedia brings a variety of information sources to a single desktop. This ability is particularly useful to a prospective new car buyer, who has to spend time and money to visit dealerships, study consumer reports, gather word of mouth (WOM) impressions, and keep an eye out for advertising information.

Multimedia can make these varied and multisensory data available at a single personal computer. Prospective customers can peruse (the preferred term is 'navigate') the available information (which includes a simulated showroom visit, complete with a salesperson in attendance to answer questions at the customer's behest) at their own pace and convenience, at all times in control of the sequence of search.

The concept of "information acceleration using multimedia" is just as valid for products that already exist in the market. It presents an opportunity to provide more detailed product information to the customer. And it serves as a tool to get information about customer wants and needs back to the product developer.

The value of unbiased and complete information on a product (be it an existing product or one that is still in the development cycle) to prospective customers is readily apparent. Multimedia can make this product information readily available in near realistic detail.
• Understanding the Customer's Buying Process and Information Needs

Another significant advantage of making information available on a computer and allowing prospective customers to navigate freely through the information, is the ability to track and document the customer buying and decision process in detail. As the prospective buyer navigates through the information available on the multimedia system, a background tracking procedure documents the search process.

Information gleaned from a study of the buying process can provide managers (of the organization that develops the product) detailed market information and can help them plan merchandising tactics for the product just prior to product introduction. For example, the importance of each information source can be learned from tracking the use of a multimedia system (it may be discovered that word of mouth generates the greatest impact followed by showroom visits, consumer reports, and television advertisements). Another use of tracking data is its usefulness in training the sales force; knowledge of the most probable questions asked off salesmen at the showroom, the progress of the prospective customer through the showroom etc., can be used to train dealers and salespeople.

The potential use of consumer buying behavior data is unlimited. For example, assume that a study finds that on average, a potential new car buyer views 2 TV advertisements, reads one consumer report or product brochure, visits a showroom twice and spends half an hour each time, and solicits product advice from at least 2 informed sources (excluding a salesperson). Assume that the study finds that the first showroom visit occurs early on in the buying process while a second visit to the same dealership is usually the final one and that the buyer behaves very differently on each of these visits.
This knowledge is useful to the marketing line manager while planning training programs for the dealers and salespeople. Dealers should be trained to approach customers differently, depending on whether it is their first or second visit to the showroom. Knowledge of the different information needs of customers during first and second visits, can enable dealers to tailor their approach to customer needs.

- **Sales Forecasting for New Products**

  The effect of the various information sources on the consideration set for prospective buyers can be readily measured using the tracking facility of the computer as well as with questions before and after the subject's use of an information source. By calibrating the effect of information sources to the sales of existing cars, a model for the projected sales of a new product can be derived (the effect of information sources for the new product can then be determined using a multimedia information acceleration system).

- **Rapid Product Concept Prototyping and Understanding Customer Needs**

  Computer imaging and simulation technology allows rapid prototyping of ideas. Multimedia technology takes prototyping several steps further with its facility to animate graphics, and add voice and text to fill in suitable blanks.

  New product concepts can be prototyped rapidly using wireframe modelling techniques and can then be presented to target markets to enable early and rapid feedback. By animating wireframe models, and using multimedia technology to enable the prospective buyer to "walk" around the car as in a real showroom, a new car concept can be presented in realistic
detail. The "walkaround" is simulated by allowing the prospective buyer to use a 'mouse' or 'joy stick' to control the direction of travel.

There are several benefits to this rapid and easy prototyping. For example, 'advanced' design styles can be simulated and presented to customers far in advance of the clay or fibreglass models, and for far less expense. Several design styles may be presented to determine market preferences.

Clay and fibreglass models of new products during Stage 1 can be complemented or enhanced, as required. Information acceleration of product information, using multimedia, during Stage 3 of the NPD cycle can dramatically reduce the expense and time required to conduct diversion or volume potential clinics.

A number of product concepts can be prototyped quickly, at minimum additional expense and time. Multiple concepts can be tested very early on in the process of NPD. All this prototyping and modelling can be done as early as Stage 1 while Voice of Customer (VOC) information is being collected. The potential impact of this ability to prototype concepts rapidly and inexpensively is to reduce the length of the NPD process and to make it more efficient and effective.

The information acceleration system is another 'vehicle' (or tool) for gathering Voice of Customer information. Information acceleration using multimedia, provides an entirely new and different window on the Quality, Function and Deployment (QFD) process.

\[\text{\textsuperscript{6}}\] Drive simulators may be used to provide a realistic experience of key drive characteristics, such as cornering, and can enhance the prospective buyer's perception of reality.

Combined with the ability to track prospective customer reactions as they navigate through information about the new product concept, prototyping provides a new product developer with valuable market and customer information at the very initial stages of the development process.

Such information could prove invaluable to the developer and the customer. The developer makes products that the market demands, and the market benefits by having its demands answered. By having market information early on in the development process, the developer has the opportunity to dramatically reduce the development time for the product.

- **Rapid Advertising Concept Prototyping**

Apart from the design of the new product, multimedia technology can be applied to the design of the advertising campaign. A set of ad concepts, in animated story board form (in full color, with audio and text) can be tested on a target group. By tracking the target segment's likes and dislikes one can identify the concept with the greatest potential impact\(^8\). By matching demographic and psychographic profiles of the subjects with tracking data, tactics for an ad campaign can be planned.

**A Note of Caution**

It must be stressed that multimedia is not a panacea for all the problems inherent to the process of new product development. It is one way to ease the difficulty of conveying the product concept to the customer. It may simplify the communication of the product concept

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\(^8\) For example, the computer can track the time that participants spend viewing ads or the frequency with which the concepts are reviewed.
to the customer on one hand yet complicate the relatively efficient product development systems already in place.

The organizational implications of the introduction of a tool such as the 'multimedia information accelerator' must not be underestimated. To ease the integration of the information acceleration system into existing NPD processes, a modular implementation schedule is necessary. The validity of the information acceleration concept must be demonstrated at Stage 3 of the NPD cycle before tackling the more ambitious tasks during Stage 1.

2.4. Management Decision Support System for NPD

Ideally, a management decision support system will take in clinic and other research data (including tracking data and answers to questions from the information acceleration module) along with relevant market, competitor and product information, and use "expert' knowledge to analyze this data and provide managers with "advice" on issues such as vehicle sales, product package, target groups etc. (see Exhibit 4).

The resulting summary of key decisions (or consultant report) will impact product design, production capacity, marketing plan and financial goals etc. The heart of the decision support system is the Knowledge Based System (KBS). The KBS will serve as an "advisor" during the NPD Process and is not meant to supersede the manager during the development process.

There are three major levels in the management decision support system for NPD:

1. The system architecture (the macro level or data level)
2. The software architecture (the intermediate level or software level)
EXHIBIT 6 SYSTEM ARCHITECTURE FOR NEW PRODUCT DEVELOPMENT INFORMATION SYSTEM

EXHIBIT 7 SOFTWARE ARCHITECTURE

APPLICATION INDEPENDENT MODULE

USER INTERFACE
- HELP
- GRAPHICS
- EXPLANATION FACILITY

ERROR HANDLER

PRIMARY LEVEL
- GENERAL RULES (General Principles of New Product Development)

SECONDARY LEVEL
- ANALYTICAL ENGINE

APPLICATION DEPENDENT MODULE

BASIC LEVEL
- AUTOMOBILE DATABASE
  - STRATEGIC OBJECTIVES
  - STRATEGIC CONSTRAINTS
  - AUTOMOBILE SPECIFICATIONS
  - DECISION RULES
- CASE BASE
  - FILTER
- OPTIONS BOARD
- STATUS BOARD

TERTIARY LEVEL
- NUMBER CRUNCHER

3. The user interface (the user level)

The system architecture is a definition of the components of the entire system (it is a macro perspective). The software architecture is a definition of the software components and the nature of information that the software operates on. The final perspective is the manager's perspective. His or her interaction with the information system involves the definition of the user interface. The system architecture for the MDS\textsuperscript{9} is shown in Exhibit 6, while a software architecture is presented in Exhibit 7.

The three perspectives of an information system can be clarified using the example of a manufacturing plant. The system architecture is analogous to the plant layout, while the software architecture is analogous to the different machines and materials within the plant. The user interface corresponds to the machine control systems.

2.4.1. System Architecture

The system architecture (see Exhibit 6) is a macro-view of the decision support system and it identifies the data components of the system. There are several modules in the system architecture that correspond one-to-one with GM organizational entities\textsuperscript{10}.

The main components of the system are:

\textsuperscript{9} The KBS system described here will draw heavily on the following two sources:

\textsuperscript{10} A modular approach to developing information systems has several benefits: Ease of conceptualization, Ease of updating, Step-by-step implementation, Ease of expansion etc.

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• the strategic base
• the functional base
• the product base
• the tool base.

The strategic base is includes long term goals and strategies of the corporation, divisions, platforms and competitor strategies in the context of the larger environment. The functional base is a storehouse of functional data broken down into several modules such as marketing and advertising, manufacturing, finance, design etc. The product base contains product specific data such as competitor product lines, product platforms, options etc. Finally, the design / tool base contains a variety of mathematical and conceptual models from forecasting and pricing tools to design tools. These tools and model help the organization to build its store of knowledge. Also integrated into the information network are the production information systems, providing on line production information.

2.4.2. Software Architecture

The software architecture describes the nature of the software system and the types of information that this software operates on. In this case it is essentially a Knowledge Based System (KBS)\(^1\), that takes data (say, data collected at research clinics), develops a model (say, a multivariate utility model of information sources) and then analyzes model results in the context of information that is a part of the system architecture. The transformation of raw data to management advice occurs by virtue of the "knowledge of NPD specialists" that is encoded as "rules" within the KBS.

\(^1\) KBS is the term currently used for AI based systems or expert systems.
The software architecture (see Exhibit 7) identifies two classes (or modules) of information: the Domain Independent Module (DIM) and the Domain Dependent Module (DDM)\textsuperscript{12}.

Within the DIM, the Primary Level contains general rules on NPD. The Secondary Level consists of procedures for analyzing data (e.g. tools to analyze consumer behavior models in the context of industry and market trends or decision / risk analysis tools)\textsuperscript{13}. The user interface is the gateway through which a manager will access information from the system. User interface components include sophisticated graphing functions, simulation capabilities, help and explanation facilities etc. An error handler prevents the system from being driven beyond its intended capabilities.

While the information contained in the DIM can conceivably be applied to almost any new product domain (from cameras to turbine disks), the DDM contains specific information (in this case automobiles). The level of specificity of the data in the DIM and DDM may be varied. For example, the DIM can correspond to the entire GM organization while the DDM can correspond to each of its divisions.

The two components of the DDM are the Basic Level and the Tertiary Level. The Tertiary Level is a set of models specific to the automobile development process (e.g. GM's proprietary forecasting techniques) that perform involved computations on large amounts of data.

\textsuperscript{12} It may be useful to return to the analogy of the manufacturing plant and think of the DIM as a general purpose machine and the DDM as a special purpose machine.

\textsuperscript{13} Cover Story, developed by Prof. John D.C. Little, is an example of a Secondary Level analytical engine.
The Basic Level is composed of the Application Base and the Case Base. Consider the following example to differentiate between the Primary and Basic Levels. At the Primary Level, a "rule" for concept approval prior to product development may be stated as follows: 

_For concept approval validate a product model._ At the Application Level, the same basic requirement is stated as follows: _For concept approval, validate a clay model and then build and validate interior and exterior fibreglass models._ Obviously, the Basic level contains greater detail. It also has more automobile specific information. The Application Base for a particular division of GM also includes that division's objectives, constraints (divisional regulations and resource limitations), product line characteristics, etc.

The Application Base contains rules and data about new car development. The Case Base is like a drawing-board on which the new product concept evolves. The Options Board keeps track of the options (design and process options) available at any given point in the NPD process while the Status Board updates the actual state of the product as it evolves. The Filter resolves conflicts (considers the different options in light of divisional and corporate goals, objectives, constraints etc.) to derive the product status.

2.4.3. **User Interface**

The user interface is the only element of the IS that the manager will come into direct contact with. Therefore the interface must be:

1. Easy to use
2. Convey managerial information adequately (through the use of graphs, simulations etc.)
3. Provide a logical explanation for any conclusions since the aim is to aid managers and not to supercede them¹⁴.
The output should be concise (2 to 3 pages at most), presenting data at an aggregate level. The manager may then choose to penetrate certain issues to a greater depth using the explanation function.

2.5. Two Implementation Details

Any information system should follow a strategy of modular implementation. A modular execution can serve result in several advantages. Conceptually, it serves to identify independent modules or components of the system. Operationally, it allows for validation of each module before work is begun on the next module; validation at every step also allows for organizational buy in into the system. It allows for ease of future updating; if the program or data needs to be updated only the relevant module need be changed.

- Progress from Stage 3 Support to Stage 1 Support

From an organizational standpoint, the management decision support system must first address the issues of Stage 3 before dealing with Stage 1 decisions. From a new product perspective, Stage 1 decision making is more critical to the success of the product than Stage 3 decision making. Using Stage 3 as a 'test bed' for the decision support system will serve to validate as well as enable the modular implementation of the system.

Similarly, it may be prudent to initially focus on product data and then with market data. Product data is easier to acquire, since it is in most part, intrinsic to the organization.

14 The explanation facility is an absolute necessity since very few managers will listen to a computer system, no matter how powerful a system it may be, without solid logical reasoning to back the advice.
Market data is fuzzier by nature and more difficult to gather.\textsuperscript{15}

\begin{flushright}
15 Data acquisition for expert systems may take up to 70\% of the total time and effort required to develop the complete system.
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CONCLUSION

A management support system for new product development must be sensitive to the wants and needs of the managers involved in the development process. The system must provide managers with sufficient and relevant information to make decisions and must be easily usable, understandable and verifiable.

An integrated new product system should contain data about the product and the market that normally resides only with individuals within the organization. By studying the current process of new product development we identify the key decision makers and the information that they use to make these decisions. The proposed system architecture for an integrated new product development system is based on the organizational structure of the developer. The expertise of key decision makers is to be encoded as rules. This expert knowledge will form the Knowledge Based System that serves as an advisor to management during the new product development process.

The two key technologies that have been identified in order to implement the proposed integrated new product development system are Multimedia and Artificial Intelligence. Mathematical modelling of consumer buying behavior and projected sales of new products are also key components of the integrated system.

Future work will concentrate on providing potential customers with a realistic and complete presentation on products that are still in the development cycle. Several new technologies, including drive simulators, virtual reality and CAD Animation are potential choices for new product presentation.\(^{16}\)

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\(^{16}\) For a review of future technological directions, please refer the Master's thesis of John Prescott Halstead at the MIT Sloan School of Management, 1990, titled "A Technology Strategy for on-going Development of the Information Acceleration Project".
Development of mathematical modelling techniques that interpret the data collected through the "information accelerator" is another area that will receive attention in the future\textsuperscript{17}.

Finally, to interpret and analyze the models in the context of market information, a Knowledge Based System must be designed based on the framework suggested in this thesis. The system must be designed with the input of managers involved in the new product development process in order that it may fully reflect their information wants and needs. To enable validation of the advisory system, the first target for implementation should be product-based and should concentrate on the decision period of a year prior to product launch.

\textsuperscript{17} A detailed discussion of modelling issues is a part of the forthcoming Doctoral thesis of Bruce D. Weinberg at the MIT Sloan School of Management, 1990.
BIBLIOGRAPHY


