Chapter 2

Theoretical Consideration

Throughout this chapter author will look at various sources of information available to, which provides author a useful thinking during the writing of this thesis as well as to become familiar with the general research area and to be able to focus at the core matter. First author will look at some of the relating theory that is of useful for this thesis, follow by a search and review on some of the relating literatures. Author will also look at the business and market trend of needs as approaching the next century enabling author to select the right management tools that of most suitable to the nature of the concerned company discussed in this case study.

2.1 Business Environment

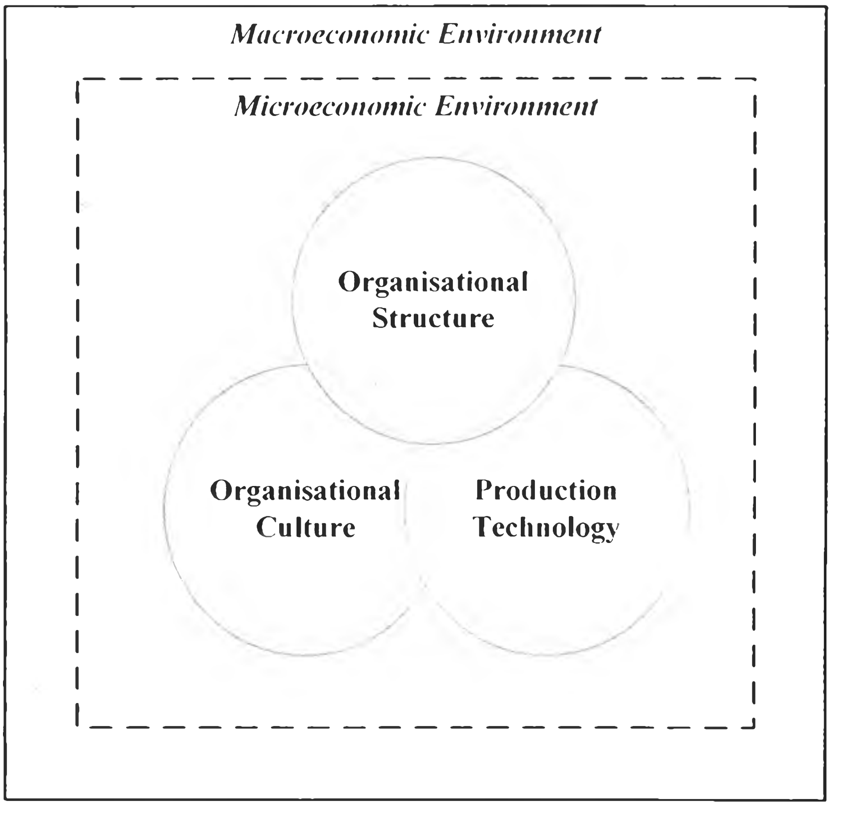

Figure 2.1: Business Environment

Source: Adapted from Pass C., *et al.* (1999, *Business and Macroeconomics*)

and Robins S. (2000, *Organizational Behavior*)

Pass C., *et al.* (1999: *Business and Macroeconomics*) suggested that business operates under two environments – the microeconomic environment and the macroeconomic environment – as illustrated in Figure 2.1. The fundamental of corporate success under Microeconomic environment is to sell products to meet and beat competitors in supplying products. While operating under Macroeconomic environment the company's fortunes is dependent on both the domestic and international economies.

A booming domestic and international economy typically provides efficient and competitive companies with added opportunities for expanding their sales and profits, but by contrast, a prolonged recession is likely to adversely affect the trading performance of even the strongest companies. It is therefore strategically important for the management to realize the nature of fluctuations in a business cycle. For this reason it is useful to look at the system as a whole in order to benefit all the relating parties creating a win-win situation.

2.1.1 Current Business Environment Trends

- Globalization, convergence, deregulation, and hence severer competition
- Information system continues to evolve with technological advances
- Increasing customer demands for greater variety and choice in product configuration
- Flexibility is being built into the design phase, and is expected in the manufacturing process.
- Shorter product life cycles, reducing time-to-market, and a focus on customer service

Figure 2.2: Trends in Business Environment towards the 21st century
Source: Adapted from Lu (2001, *WMG Supply Chain Management*)

As we head towards the 21st century with a widely expanded market and highly advanced manufacturing capability, Lu (2001, *WMG Supply Chain Management*) stated that both the growth opportunities and the need for technical competence are increasing dramatically, see Figure 2.2. As we are stand in the era of Information Technology, most the businesses are witnessing a sudden rise in the pressure of global competition and the impact of the information explosion over the last two decades. To help these businesses improve performance implementation of technological solutions are employed but bear in mind that the technology is made available to anyone who can financially afford solution as such and there is no exception to the competitors, hence, significant advantage comes from the focused application of this technology.

Robins S. (2000: *Organizational Behavior*) underlies that benefits of such improvement programs can be realized with harmonic of the three aspects of an organization – organizational structure, organizational culture, and production technology – as illustrated in Figure 2.1. Hence, for any company in a globalization world to survive and prosper, only being effective is not enough, but also efficiency is needed.

2.1.2 Current Product Demand Patterns

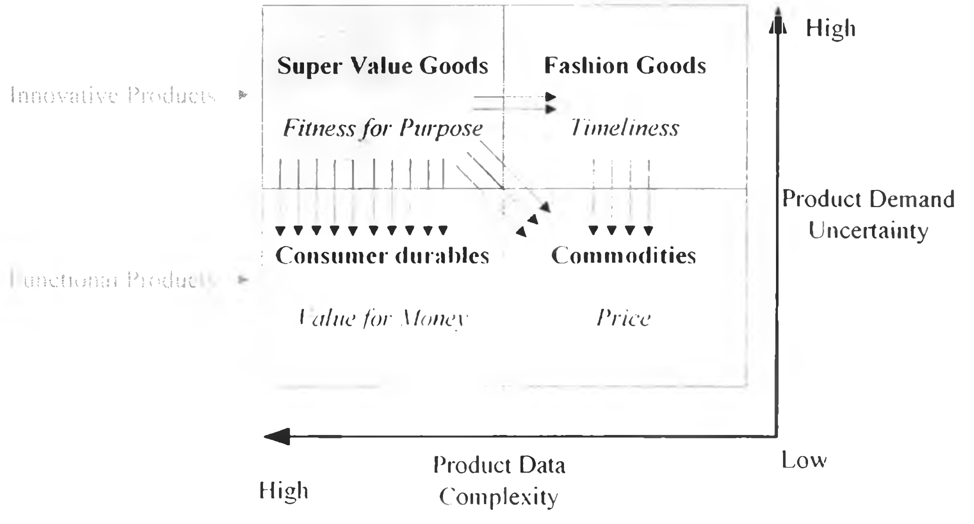

Figure 2.3: The Nature of Product Demand Patterns

Source: Adapted from Puttick J. (1994, *the future of manufacturing industry in the UK*)

Over the past two decades, management has witnessed a period of dynamic change in the history, in terms of technology advancement and globalization of market. Almost every business in any industry are going through some kind of restructuring in order to operate more efficiently ready for the competition across the industry and world. Therefore companies, especially in an innovative goods manufacturing sector, have to improve their internal processes rapidly in order to stay competitive and prosper.

To avoid low margin due to low enter-barrier in the manufacturing of functional products, many companies introduce innovations in fashion or technology to give customer variety of choices to customers, see Figure 2.3. Although innovation can enable a manufacturing company to achieve higher profit margins, the very newness of innovative products makes demand for them unpredictable. In addition, their life cycle is short because as imitators erode the competitive advantage that innovative product enjoy, companies are forced to introduce a steady steam of newer innovations. The shorter life cycles and the greater variety typical of these products further increase unpredictability. Therefore, current situation of many manufacturing companies has been coping with increasing customer expectation and tougher market requirements.

2.1.3 Key Elements of Competitive Performance

	Output	Price	Quality	Service	Choice
1960's	✓				
1970's	✓	✓			
1980's	✓	✓	✓		
1990's	✓	✓	✓	✓	
2000's	✓	✓	✓	✓	✓

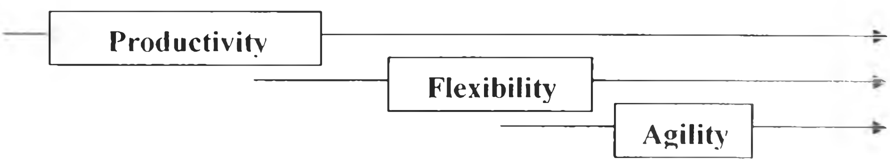

Figure 2.4: Winning Characteristics

Source: McGuffog (1999. *Principles of Value Chain Management and Electronic Commerce*)

As illustrated in Figure 2.4, the demand for new product escalated since the 1980, manufacturing companies were required to become increasingly flexible and responsive to modify existing products and processes or to develop new ones in order to meet ever-changing customer needs. Establishing the key elements of competitive performance is the first step in aligning the organization to beat the competition. Therefore, management should realize that producing a quality is not enough. Getting the products to customers when, where, how, and in the quantity that they want, in a cost-effective manner, constituted an entirely new type of challenge.

As a result of these new challenges, it implies that manufacturing companies should be involved in the management of their corporate resource more effective and efficient in order to become world-class in today's business environment.

2.2 Knowledge Management (KM)

2.2.1 The Need for Knowledge Management – as a Key to Future Growth

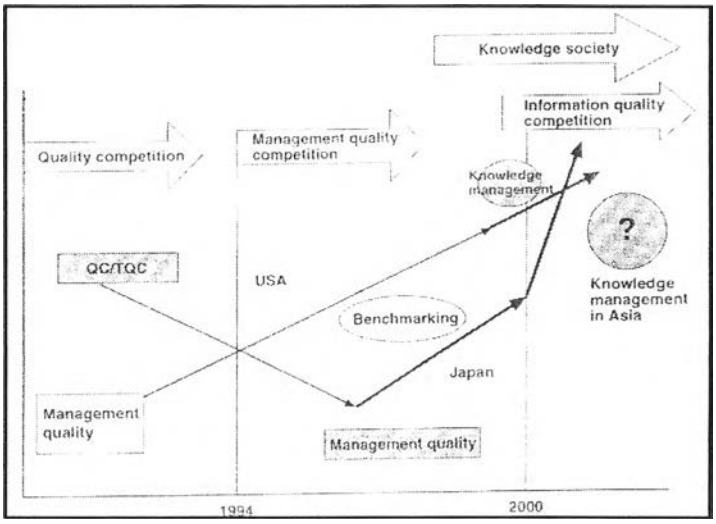

Figure 2.5: Comparison of the Use of Knowledge Management Tools in Japan and the USA
Source: Takanashi T. (1997, *Introduction to Knowledge Management: A Tool for Knowledge Creation*)

As shown in Figure 2.5, the efforts in trying to improve a business have been continuously evolved through time. For example, according to the Asian Productivity Organization or APO (2002, *Knowledge Management: a Key for Corporate Competitiveness*), in spite of the successful introduction of Quality Control (QC) and Total Quality Control (TQC), most top management were still lacking the confidence in making decisions. QC and TQC were no longer decisive management tools for higher productivity and competition in an ever-changing, uncertain global arena of the 21st Century. Afterward, Total Quality Management (TQM), Reengineering, and Benchmarking were highlighted during the 1980s and 1990s as new highly effective management tools to gain competitive position. Peter Drucker, a well known marketing guru, also mentioned in the year 2000 that:

"Knowledge Management is a key to future growth and the productivity can only be generated from knowledge, not from the mere improvement of production and processes."

– Drucker P.

Source: Asian Productivity Organization, APO (2002, *Knowledge Management: a Key for Corporate Competitiveness*)

2.2.2 Definitions of Knowledge Management

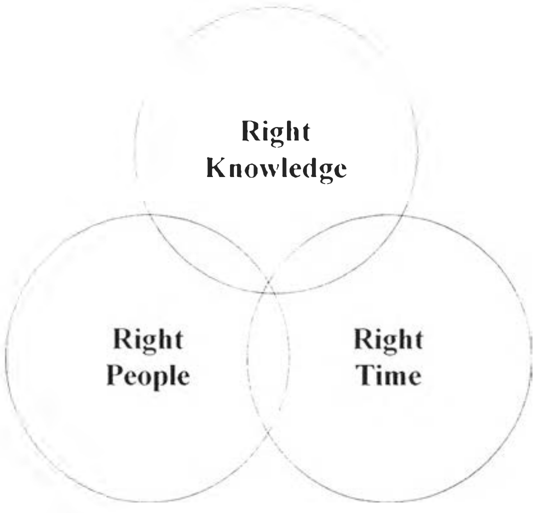

Figure 2.6: The Purpose of Knowledge Management

Based on the American Productivity & Quality Center or APQC (2000, http://www.apqc.org), Knowledge Management or KM can be defined as the broad process of locating, organizing, transferring, and using information within an organization. It can also be defined as the administration and structuring of an effective framework using a systematic approach that gets the right knowledge to the right people at the right time in order to achieve the goals and purpose of organizations, as illustrated in Figure 2.6. A systematic approach means taking steps to find, understand, analyze, share, and utilize knowledge that creates value. In simple terms, Knowledge Management is the exchange and sharing information for practical activities.

2.2.3 Distinction between Data, Information, Knowledge, and Wisdom

However, Kamala (2002, *A CLEVER Approach to Selecting a Knowledge Management Strategy*) argued that unlike KM, definitions of knowledge were much more elusive because there are various ways to classify knowledge with respect to its properties and organizational context. However, in order to facilitate the view of this particular thesis involving in the management of data, the definition of knowledge is based on that of Takanashi (1997, *Introduction to Knowledge Management: a Tool for Knowledge*

Creation), who distinguishes between data, information, knowledge, and wisdom as presented in Figure 2.7. He describes that knowledge can be data, simple facts, or figures; data is converted into information; information is converted into knowledge. This implies to the author that management should rely on data as a basis for wise business decisions.

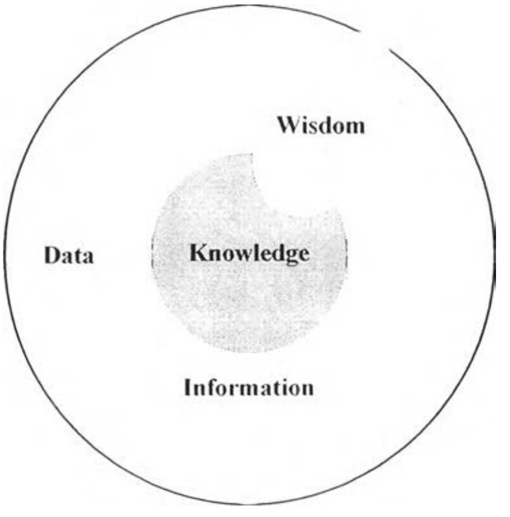

Figure 2.7: Relationship among Data, Information, Knowledge, and Wisdom
Source: Takanashi (1997. *Introduction to Knowledge Management: A Tool for Knowledge Creation*)

The underlying point is that in a current business world, where change and speed are key, intangible assets such as ideas for the development of new products and processes, well-trained workers, flexible organization, well-organized R&D activities, and knowledge about new market potentials will play a crucial role in coping with changing markets. This is where Knowledge Management and the resulted information systems come into play. Hence data is increasingly viewed as a key corporate resource, which must be utilized wisely within the organization and protected carefully against the competitors in order to further the aims of the business. For high engineering content manufacturer where productivity, flexibility, and agility are key competitive factors, product data plays the central role within there broad view of corporate data.

2.3 Standard Time Estimation

Based on Neible & Freivalds (1999, *Methods, Standards, and Work Design*) and Jiao & Tseng (1999, *A Pragmatic Approach to Product Costing Based on Standard Time Estimation*)

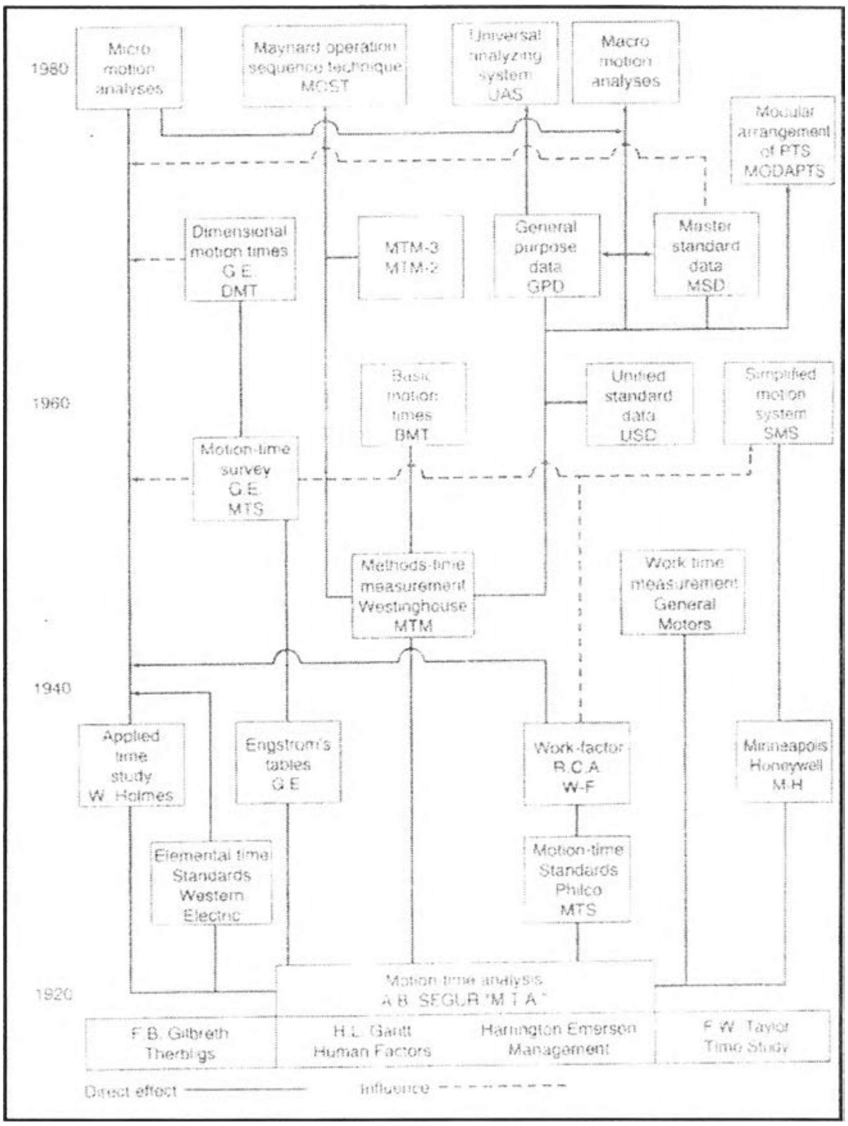

Figure 2.8: Family Tree of Predetermined Times

Source: Sellie (1992, *Predetermined Motion-Time Systems and the Development and Use of Standard Data*)

Illustrated in Figure 2.8, many years ago, Frederick W. Taylor visualized the development of standard times for basic divisions of work using a stopwatch. Today, the vast majority of standard times are developed by using standard data. Such standard time data are typically developed based on long historical production data of individual company. This section will review both methods and investigate why the latter is more popular today.

2.3.1 The Early Stopwatch Time-Study Method

The idea of standard time concept was first established by Frederick Winslow Taylor in 1911, also recognized as Taylor system or Taylorism. Taylorism was the approach of those days in search for the fastest worker or specialist. Taylor examined person's movements on the task, which he would then eliminate unnecessary movements and suggested new approach in which he would then time both approach in order to compare between the two. The best person at practice (specialized worker), whom called "first class person" would become the standard role model to which others should follow. Taylor advocated breaking up the work assignment into small divisions of effort known as "elements." Experts were to time these individually and use their collective values to determine the allowed time for the task.

Taylor's early presentations of his finding were received without enthusiasm, because many of the engineers interpreted his findings to be a new piece-rate system rather than a technique for analyzing work and improving methods. Both management and employees were sceptical of piece rates, because many standards were either typically based on the supervisor's guess or inflated by bosses to protect the performance of their departments.

2.3.2 Standard Time Data Method

Using such standards, an analyst can determine how long it should take the normal operator to perform the task required to produce the part. The application of standard time data is fundamentally an extension of the same process used to arrive at allowed time through a stopwatch time study, which is proven to be accurate and reliable. The principle of applying standard data is not new; many years ago, Frederick W. Taylor propose that each element time established be properly indexed so that it could be used to established standard times for future work. When speaking of standard data today, it refers to all the tabulated element standards, curves, alignment charts, and tables that allow the measurement of a specific job without the use of a timing device, such as a stopwatch.

Standard time data has three levels of refinement, which are: Motion; Element; and Task, where Motion take consider of very detailed time values of the fundamental motions of the operator for example REACH, MOVE, TURN, GRASP, POSITION, DISENGAGE and RELEASE [Maynard, 1997], while Element is a combination of motions to perform work assignments for example GET, PUT, GRAP, STEP and else, where as Task is the least refine of the three. Task is a combination of motions and elements to perform certain activities for example HANDLE TRANSPORT, SETP AND FOOT MOTIONS, and BEND AND ARISE. For this thesis, the author will concern on Task since it allows engineer to estimate standard time at faster pace and as it is currently employed in the case study.

The case study adopts the ABC concept (Activities-Based Costing) to identify the underlying activities that drive costs. These activities are then used as building blocks to construct the costs of a given process or work center. However, the drawback in ABC lies in how to determine the resource consumption in terms of number of cost drivers for each activity and the unit price of each activity with respect to a particular cost driver. Instead of dealing with these trivia, the case study determines resource consumption according to the estimated processing time for each activity timed by the unit price of standard time.

2.3.3 Benefits When Using Standard Time Data Method

The standard time estimation methods have been evolved to the use of predetermined time system (often referred to as a standard time data method), which represents a more rapid, consistent, and simple method compared to the use of timing device to each basic motion or element of work (often referred to as a stopwatch time-study method).

1) **More Consistent** – Work standards calculated from standard data are relatively consistent in that the tabulated elements result from many proven stopwatch time studies. Since the values are tabulated, it is only necessary to accumulate the required elements to establish a standard, and the various time study personnel within a given company should all arrive at identical performance standards for a given method.

Consistency therefore is assured for standards established by different analysts in a plant, as well as for the various standards computed by a given time study observer.

2) **More Rapid** – Standards on new work can usually be computed more quickly through standard data than by a stopwatch time study. This allows the establishment of standards for indirect labor operations which is usually impractical if stopwatch studies are required.

3) **Simpler** – Typically, one work measurement analyst can establish five rates per day using stopwatch methods. This compares to 25 rates per day using standard data. Also, standard data permit the establishment of time standards over a wide range of work. Not only is determination of a standard simplified, but also some sources of tension between labor and management are alleviated.

2.3.4 Concerns When Using Standard Time Data Method

The application of standard data is an exacting technique – it is as good as the people using them. The standard data itself must first be accurate before anyone who later will utilize it can estimate a consistent standard time. Plus, careful and thorough training in methods and shop practice are fundamental before analysts can accurately establish standard times using the standard data methods. Analyst must know and recognize the need for each element in the class of work. Supplementing this background, the analysts should be analytic, accurate, thorough, conscientious, and completely dependable.

When no job exists to time study, if properly applied, standard data permit the establishment of accurate time standards before the job is performed. This feature makes their use especially attractive for estimating the cost of new work, for cost quotes, and for subcontracting purpose. Both a process of estimating the final cost of a product at the design stage (often referred to as product costing) and a process of developing an efficient manufacturing at the production stage include the use of standard times.

2.4 Process Planning

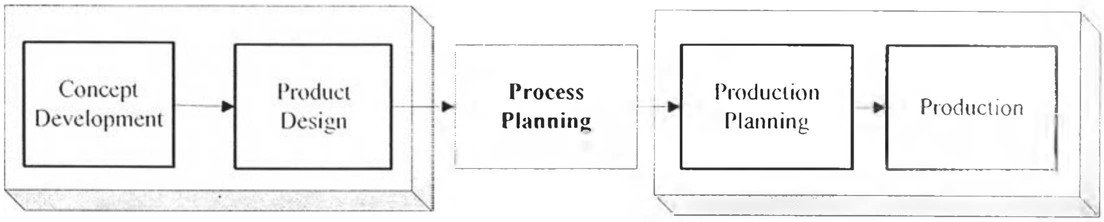

Figure 2.9: The Need of Process Planning to Link Design to Manufacturing

Source: Wang (1991: *Computer-Aided Process Planning*)

From Figure 2.9, in a product life cycle development, a process planning function follows the design function. The process plans and bill of materials are used for production planning. Production planning deals with the orderly operation of the production shop by efficient management of labor, machinery, and other resources in the production of parts. The focus of production planning is the efficient utilization of resources.

Once the product is designed, the work of the process planner probably has more impact on the cost and quality than any other activity of the enterprise. Process planning represents a link between the design and the manufacturing environment. The purpose of process planning is to determine the manufacturing process that will actually produce the product. The manufacturing engineer usually does it by relating the product design characteristics to specific manufacturing operations. Creation of a process plan is therefore important to orderly and efficient operation of a manufacturing enterprise. The process planning function defines the collection of all planning activities to convert a component design into a manufactured item. It includes:

1) Interpretation of component design,
2) Determination of production tolerances,
3) Selection of processes,
4) Selection of process operations and their sequence,
5) Selection of operation parameters,
6) Selection of tools and equipment,
7) Design of jigs and fixtures,

8) Machining program generation,

9) Selection of inspection devices,

10) And calculation of overall production times.

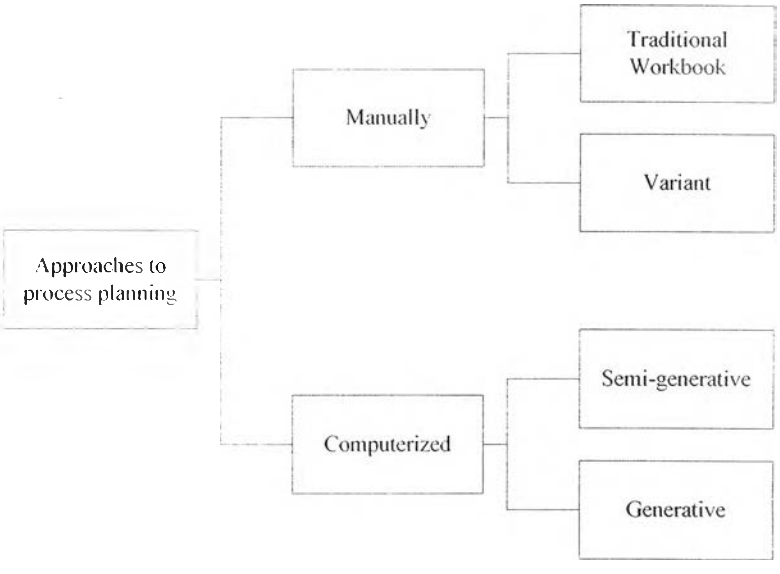

Figure 2.10: Different approaches of Process Planning

Source: Wang (1991: *Computer-Aided Process Planning*)

Currently, the rate of change of design is increasing, the need to satisfy customer requirements more quickly is increasing and manufacturing technology itself is subject to an increasing rate of change. This entire means that the existing skills of engineers must be used more productively to improve the agility of a manufacturing environment. Therefore, according to Wang (1991: *Computer-Aided Process Planning*), there are two approaches in developing a standard process plan, which are a variant approach and a generative approach. Many standard process plans do not exactly fit into this classification and combine both approaches, and they are referred to as semi-generative systems as shown in Figure 2.10.

2.4.1 Variant Process Planning Approach (VPP)

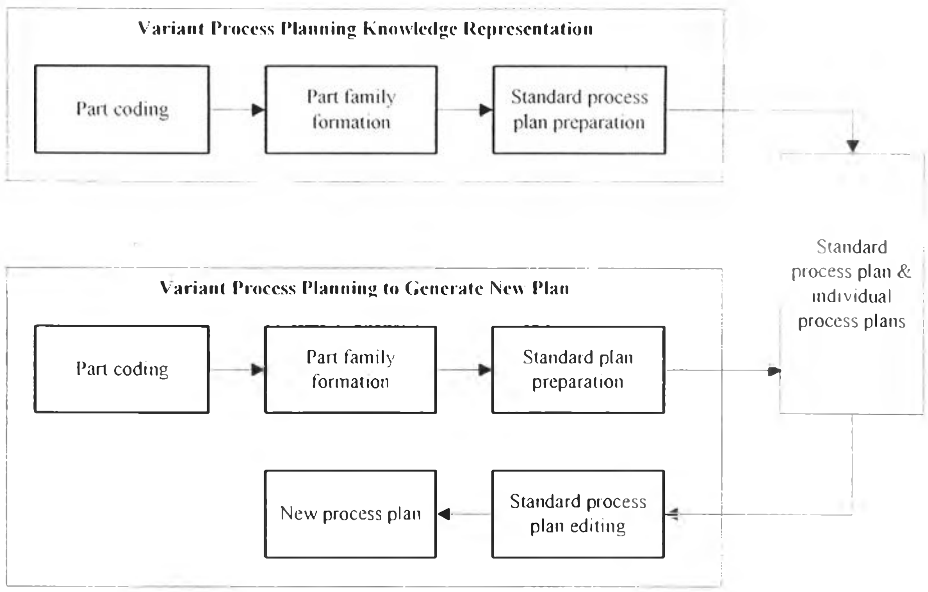

Figure 2.11: Variant Process Planning System

Source: Wang (1991: *Computer-Aided Process Planning*)

The variant approach is comparable to the manual approach where a process plan for a new component is created by retrieving an existing plan for a similar part and making the necessary modifications for the new part as shown in Figure 2.11.

Benefits of Variant Process Planning Approach

1) Clerical effort can be reduced and lead times improved
2) Standardized method of manufacture can be introduced through consistent and accurate process plans
3) The process planning logic can be captured and retained within the company
4) Makes it possible to integrate Design and Manufacturing function
5) Fast and accurate cost estimating capability enables better negotiating power with the suppliers
6) Fast and accurate bids for new projects may help against the competition

Limitations of Variant Process Planning Approach

1) Skilled process planner is required
2) Difficult to accommodate the various combinations geometry, size, material, etc., within the part coding and classification

2.4.2 The Generative Process Planning Approach (GPP)

In the generative approach, the process plans are generated by means of component geometry based reasoning, decision logic, formulae, and technology algorithms. Unlike the variant approach, no standard process plans are pre-defined or stored. Instead, the generative approach automatically generates a unique process plan from the part design information. This capability makes it highly desirable in implementing concurrent engineering.

Benefits of Generative Process Planning Approach

1) Some of the advantages same as variant process planning such as clerical manual activities are automated
2) It generates consistent standard process plan rapidly
3) New components can be planned easily since it is fully automatic and an up-to-date operation sheet is generated each time a part is ordered
4) It has potential for integrating with an automated manufacturing facility to provide for detailed control information

Limitations of Generative Process Planning Approach

1) It is a formidable task requiring a long term investment of time, manpower, and computer resources
2) Generative standard process planning is complex and a truly universal generative standard process planning system is difficult to develop

2.5 Product Data Management (PDM)

2.5.1 Business Need for Product Data Management

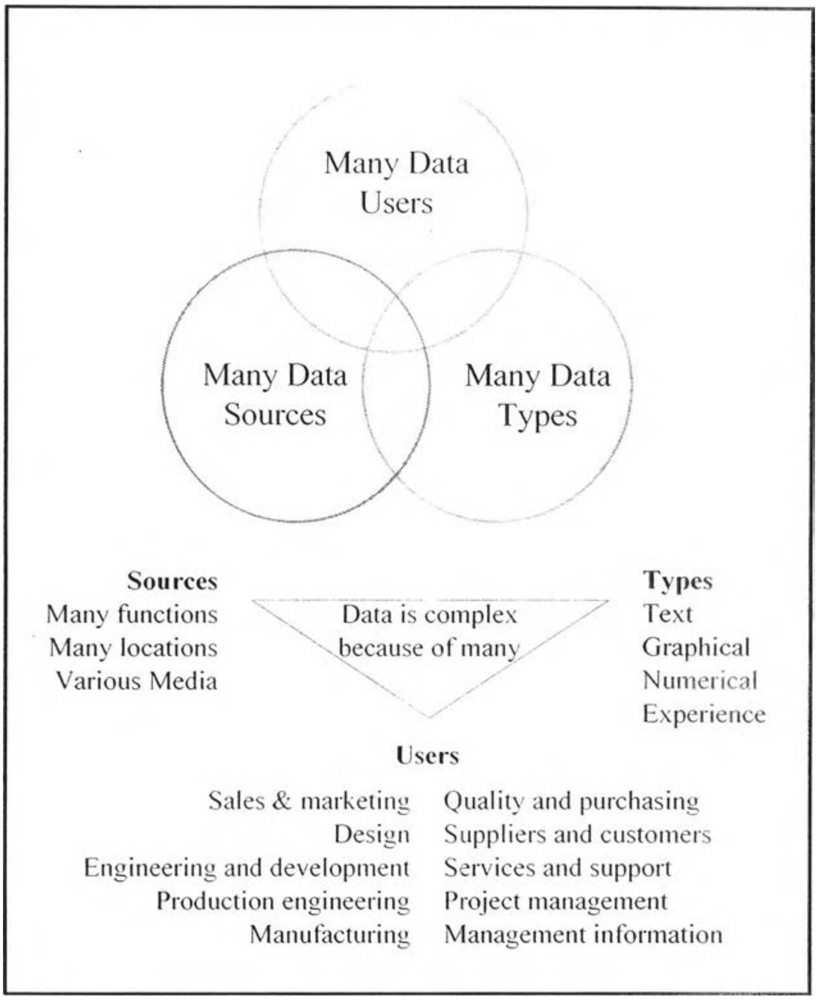

Figure 2.12: Causes of Corporate Data Complexity

Source: Adapted from McMahon C. & Brown J. (1998, *CADCAM – Principles, Practice, and Manufacturing Management*)

The development of computer-based applications to increase flexibility in design, engineering, and manufacturing has led to an explosion in the volume of product definition data. This has overwhelmed traditional manual systems. A compounding factor has been the storage of these data in a wide variety of locations often in different formats. The causes of product data complexity are summarized in Figure 2.12, as suggested by McMahon C. & Brown J. (1998, *CADCAM – Principles, Practice, and Manufacturing Management*).

Traditionally, complex manufacturing data have been required to co-ordinate mass production systems, and later provide more flexibility in manufacturing systems to meet specific customer requirements. This has now changed to an environment where each product requires significant customization in the design and configuration phase, while the manufacturing system is expected to cope with the variety of products on offer. Sackett J. & Bryan M. (1998, *Framework for the development of a product data management strategy*) illustrated in Figure 2.13 that in the days when just-in-time was king, inventory was the rocky bed on which the manufacturing companies could flounder, but now the physical rocks of inventory have been replaced by the virtual rock of product data.

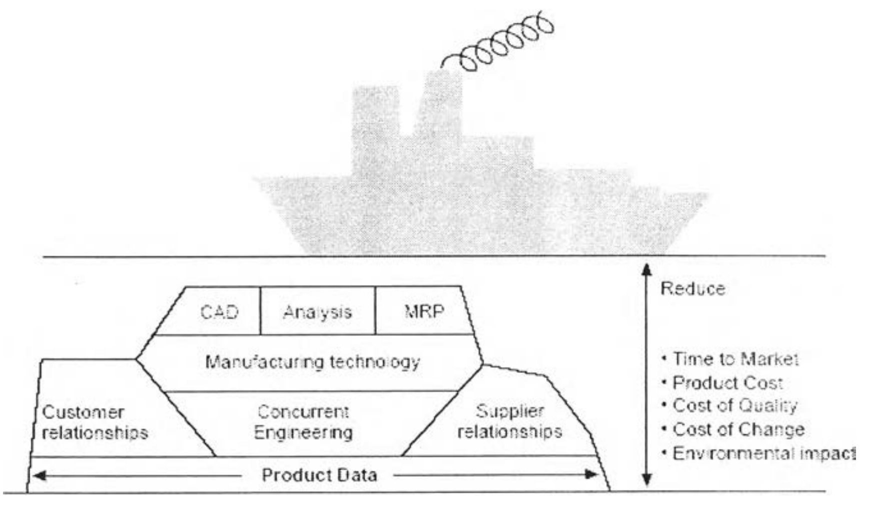

Figure 2.13: The Business Need for Product Data Management

Source: Sackett J. & Bryan M. (1998, *Framework for the development of a product data management strategy*)

The current key performance factors of the corporate are shorten time-to-market, reduce product costs, reduce environmental impact, improve product quality, and increase flexibility, which are being tackled by initiatives such as Concurrent Engineering, MRP, TQM, and the application of Computer Aided Design and Engineering. Product Data Management (PDM) systems can bring these data under control by assisting engineers and managers with the tasks of managing product definition data and the processes of creating it. Therefore, the management of product data is now one of the limiting factors to further improvements in business performance.

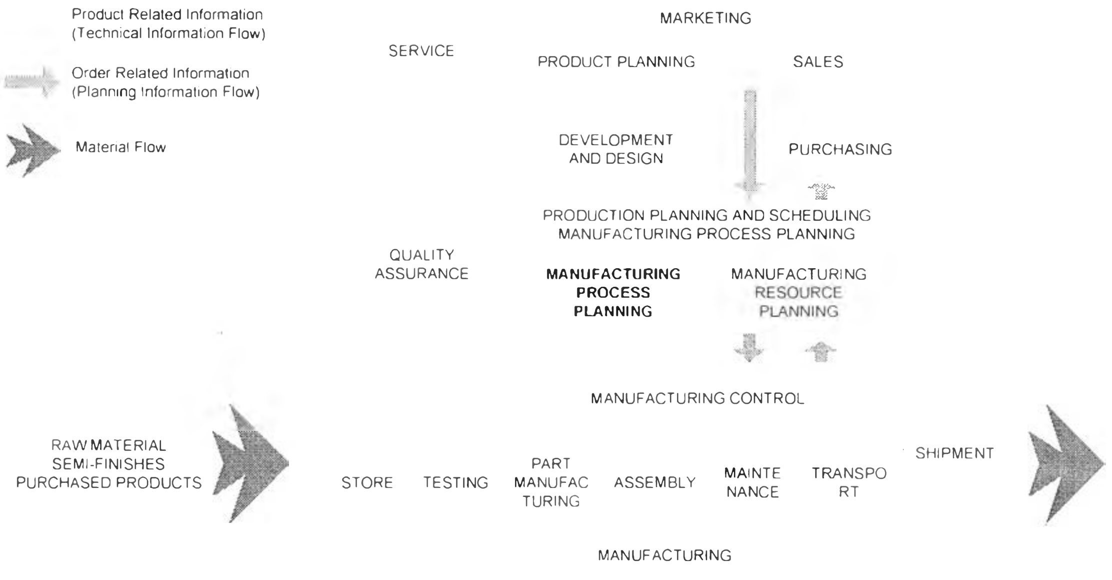

Figure 2.14: Two Types of Data in a Large Production System

Source: Foston L., *et al.* (1991, *Fundamental of Computer Integrated Manufacturing*)

PDM systems are an important tool for companies that create any kinds of products. PDM can have a dramatic and positive impact on time to market and product quality through improved development methods that are faster and produce fewer errors. According to CIMdata (1997, *Product Data Management: The Definition*), Product Data Management is a general extension of techniques commonly known as engineering data management (EDM), document management, product information management (PIM), technical data management (TDM), technical information management (TIM), image management, and other names. PDM provides a common term, encompassing all systems that are used to manage product definition information.

According to Foston L., *et al.* (1991, *Fundamental of Computer Integrated Manufacturing*), there are two types of data in a large production system as illustrated in Figure 2.15 – a product data (technical information flow) and an order data (planning information flow). In short, product data can be any information needed throughout a product's life. By providing data management and security, Product Data Management systems can ensure that users will get and share the most recent, approved information.

2.5.2 Benefits in Implementing a Product Data Management System

The benefits of implementing a PDM system range from organizational benefits of reduced time-to-market, reduced product cost, improved product quality, to direct benefits like reduced cost of photocopying, reduced costs of document storage, and reduced costs of engineering change. Based on Sackett J. & Bryan M. (1998, *Framework for the development of a product data management strategy*), the major benefit areas claimed for PDM are shown in Figure 2.15.

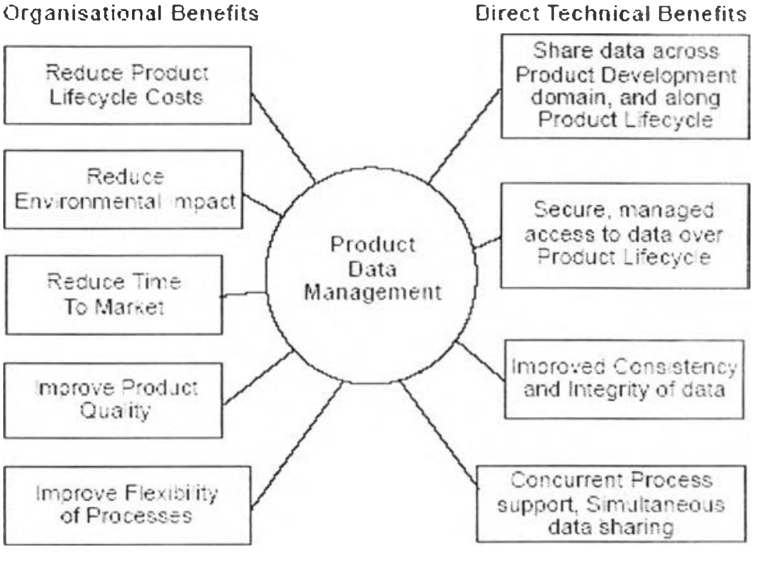

Figure 2.15: Business Benefits in Implementing a Product Data Management System

Source: Sackett J. & Bryan M. (1998, *Framework for the development of a PDM strategy*)

This implies that many of these benefits need to be specifically interpreted by individual companies to meet specific business requirements, but when implemented successfully PDM systems can deliver major benefits.

2.5.3 Difficulties in Implementing a Product Data Management System

However, according to Sackett J. & Bryan M. (1998, *Framework for the development of a product data management strategy*), some of the common difficulties experienced can be:

- developing a specification which is derived from the features and functionality available in commercial PDM solutions, when business requirements should determine the systems specification;
- knowing where to start, and what to do first. PDM can be seen as a large project requiring significant resource input over long timescales;
- the big-bang versus the work-group implementation path and the scalability of projects to reflect a full organization-wide implementation;
- escalating project scope, cost and vendor intervention, in the delivery of a functioning PDM implementation;
- maintaining interest and support for a project which may take a considerable length of time before expected and significant benefits are produced;
- focus on the implementation of PDM technology at the expense of other related issues;
- matching a PDM product to the size and scope of the project and;
- finding a solution within the available price/functionality range.

Hence, in order to implement Product Data Management successfully, these are important challenging issues that should be considered. Without developing a sound strategy first, implementing a Product Data Management system for the case study of this thesis could be a complex process, which can easily run out of control or end with an incomplete, under-performing system.

2.5.4 Success in Implementing a Product Data Management System

Sackett J. & Bryan M. (1998, *Framework for the development of a product data management strategy*) also suggested that many Product Data Management implementations have been less successful than anticipated when their cost has been measured against system functionality. The scope of many implementations is restricted to point data management issues; integration of segments of the design process; storage and access to data, on a local or global scale; and conformance to quality management standards. The diversity of environments in which Product Data Management has been implemented makes comparison and prediction of performance in a specific environment difficult.

The range of functionality offered in Product Data Management applications is expanding rapidly. However, the functionality of the system is determined by the user organization, and it is here that the success of systems must be measured. Success, measured by reduced design cycle time, product cost, and warranty claims, can be seen in many examples:

- 95 per cent reduction in the product change cycle, and annual savings of £1 million through re-engineering of the engineering change process.
- $3.5 million p.a. through PDM control of project databases.
- 80 per cent right first time design.
- New product introduction cut from 36 to 22 months.
- Reduce design to manufacture lead time from 20-22 days to five to seven days.
- Cost of quality reduced by 1 per cent of cost of sales.
- Inventory and work in progress reduced by 50 per cent.
- Material costs reduced 1.5 per cent as a result of reduced scrap.
- Rework labor costs reduced 4 per cent as a result of reduced errors.

Therefore, to build a successful Product Data Management system, organizations need to identify the primary focus of the implementation, and applicable/relevant technologies to realize achievable benefits.

2.5.5 Objectives of Product Data Management

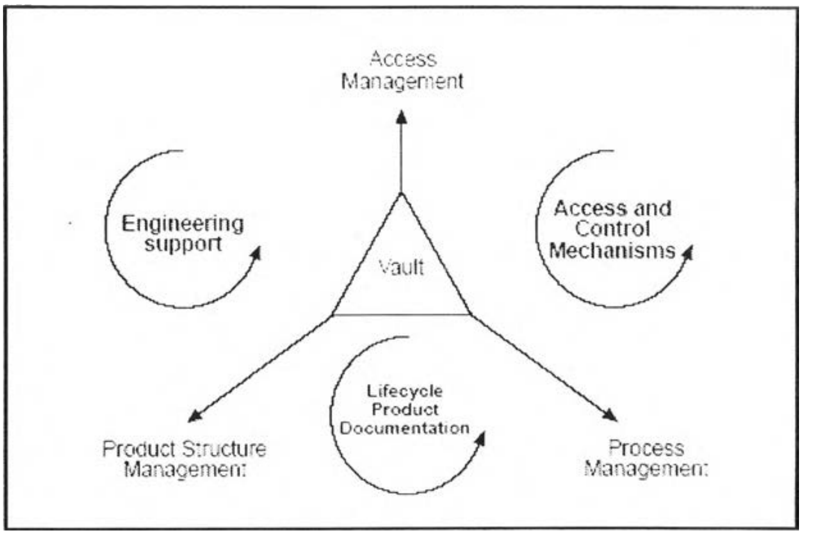

Figure 2.16: Functionality of Product Data Management

Source: Sackett J. & Bryan M. (1998, *Framework for the development of a PDM strategy*)

There have been many definitions of Product Data Management objectives, such as:

"The systematic planning, management, and control of all the engineering data required to adequately document a product from its inception, development, test, and manufacture, through to its ultimate demise"

–McIntosh K.

(1995, *Engineering Data Management: A Guide to Successful Implementation*)

"Organize, access and control product data, and manage the lifecycle of that data to meet business unit objectives"

– Brett, S.

(1994, *Take a Step Inside*)

"Systems to help engineers manage both data describing products and the process of developing products"

– *CIMdata*

(1997, Product Data Management: the Definition)

Sackett J. & Bryan M. (1998, *Framework for the development of a product data management strategy*) proposed that such definitions can be mapped to the PDM product capabilities as they demonstrated in Figure 2.16.

From Figure 2.16, Business requirements to be met by the PDM implementation are:

1) **Lifecycle product documentation** – The ability to manage product structures, the relationships between product data in an overall product design, and the management of the processes which make changes to this data.

2) **Access and control mechanisms** – A compromise in access management, the ability to retrieve and interpret product data; and process management, the movement of product data through the work processes of the product lifecycle.

3) **Engineering support** – Removing from the engineer the onerous tasks associated with the search, retrieval, and interpretation of product data, and the subsequent addition, update, or replacement of data residing in the product structure.

2.5.6 Functions and Features of Product Data Management

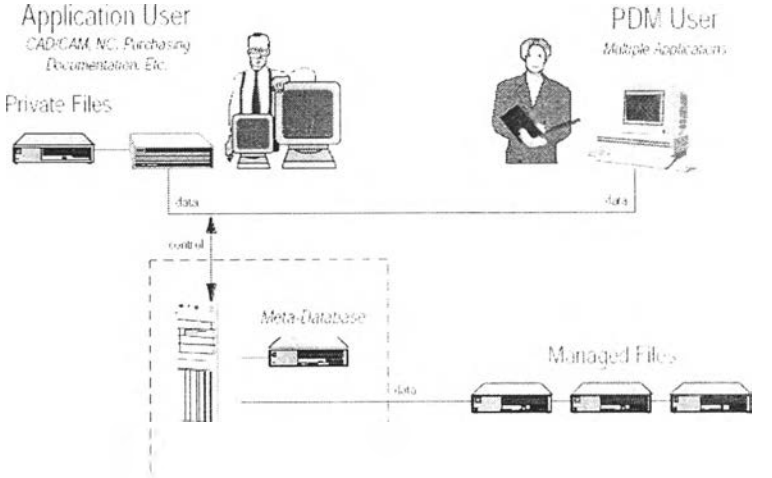

Figure 2.17: Functional View of a Product Data Management System

Source: CIMdata (1997, *Product Data Management: The Definition*)

CIMdata (1997, *Product Data Management: the Definition*) argued that, in a functional view as illustrated in Figure 2.17, Product Data Management systems are composed of:

- An electronic vault or data repository – The PDM vault stores product data and control information
- A set of user functions – User functions support data storage and retrieval
- A set of utility functions – Utility functions provide the PDM infrastructure

1) **An Electronic Vault** – An electronic vault is used as a repository to control all kinds of product information. The vault is a data store that contains some data within itself and controls other externally-generated data by managing access to it. Two types of data are stored:
   - Product data generated in various applications, such as specifications, CAD models, CAE data, maintenance records, and operating manuals
   - Meta-data, which is data about PDM-controlled information. Meta-data is stored in a PDM database and supports the functions performed by the PDM system

2) **A Set of User Functions** – User functions provide the user's interface to the PDM system's capabilities including data storage, retrieval, and management. Different types of users use different subsets of the user functions. These functions are divided into five categories:
   - Data Vault and Document Management
   - Workflow and Process Management
   - Product Structure Management
   - Classification
   - Program Management

3) **A Set of Utility Functions** – Utility functions provide support that facilitates the use of the system and provide support to the User Functions mentioned above. Utility functions interface with the operating environment and insulate its functions from the user. Tailoring permits systems to operate in conformance with the user's environment. Utility functions include:

- Communication and Notification
- Data Transport
- Data Translation
- Image Services
- System Administration

Product Data Management systems support database management system (DBMS), Object-Oriented Database Management System (OODBMS), and a network-based technology. The ultimate goal is the Product Data Management integration between OEMs and supplies, creating a virtual enterprise, and using synchronous online data sharing. Product Data Management can provide support for the activities of product teams and for techniques such as concurrent engineering, MRP, and TQM. These are important initiatives under knowledge management used to increase productivity, flexibility, and agility for today's business.

In this chapter, the basic concepts in Knowledge Management, Standard Time Estimation, Process Planning, and Product Data Management are reviewed. The key principle is that data is a corporate resource. Particularly in complex goods manufacturing with high engineering content where productivity, flexibility, and agility are key competitive factors, product data plays the central role within the broad view of corporate data. It is evidenced since 1945 that there has been a growing interest in the use of historical product technical information as a method to predetermine standard times prior to the actual production and without using a timing device. This implies that the large impact on standard time estimation can be made in the management of product data. In the next chapter, the author will further investigate this assumption through a case study.