AN INFORMATION SYSTEMS APPLICATIONS STRATEGY FOR A MANUFACTURING ENTERPRISE

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by

Andrew Charles Lyons

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CHAPTER ONE

INTRODUCTION

PURPOSE OF THIS CHAPTER

The purpose of this Chapter is to introduce the research area, define the research problem, and specify the research aims and objectives. The approach for addressing the research issues and satisfying the objectives is also presented, together with a practical and initial justification for the research topic.

1.1 - INTRODUCTION

Manufacturing organisations have for a long time realised the importance of marshalling and effectively managing four of their prime resources, namely, men, materials, money and machines to ensure the success of their businesses. In recent years academics, consultants and the more enlightened in manufacturing industry have recognised the existence of the fifth prime resource, information, and begun to actively advocate its value, and use it as an additional lever to achieve business success [48].

The recognition of information as a valuable business asset is only a recent revelation. Information has been said to be "the lifeblood of any organisation" [139], "the foundation upon which sound management is built" [70] and the provider of "raw material for problem solving and controlling other resources" [27]. Information permeates every aspect of business operations; it is used by every employee in every organisation everyday. Yet it is ironic that its ubiquity and obvious value hasn't, until recently, led to information being considered to be anything more than trivial. It has been the poor relation in the family of business resources.

A major factor in the emergence and acceptance of information as a critical resource is the dramatic recent developments in information technology (IT), for example, personal computers, databases, knowledge-based systems and office automation [18]. Combined with their reductions in cost, these technologies have presented manufacturing organisations with new opportunities. Hollingum [70] suggests two other reasons. The first is the now widespread availability of high quality machine tools, assembly machines, robots and other advanced production machines to all competitors in domestic and international markets has meant that such processing technologies can no longer be relied on as a significant source of competitive advantage. The second reason lies in the changing market pressures facing manufacturing organisations. The focal point of competition has shifted from product cost to one in which companies must consider cost as well as a much wider range of pressures such as:

- customer service, in terms of reliable delivery and short lead time, which increases the pressure on planning and control of operations,

- markets expect a much wider product range, requiring manufacturing flexibility,

- the acceleration of technology increases the pressure to get new products into the marketplace quickly.

Each of the above challenges can be tackled through the use of information and the development of effective information systems (IS), a claim supported by Vollmann et al [151], who, in their examination of the 1986 North American action programmes argue that many of the required initiatives, for example, leadtime reduction, manufacturing systems integration and production control, are directly attributable to

IS quality.

1.2 - DATA OR INFORMATION, SYSTEMS OR TECHNOLOGY?

The emergence of the 'information area' has led to many confusions. One of the most common is caused by the inconsistent use of terminology. Many terms have quite different meanings in different contexts and to different people. The following terms are fundamental, were used throughout the research and appear frequently throughout this thesis:

- data
- information
- information technology (IT)
- information system (IS)

The definitions of these terms are often ambiguous, and 'information' and 'data', and 'IT' and 'IS' are often used interchangeably. It is useful (at this early stage) to define, and delineate between, them.

Data and information are related but represent different things. Data are the building blocks or raw materials from which information is obtained. On its own data does not provide the necessary stimulus to initiate an action or make a decision. First, it needs to be evaluated or interpreted. This process converts the data into usable information. Information, on the other hand, is essentially an accretion of data that have been manipulated in some way in order to be useful to a user. Information has an explicit meaning; its value lies in its ability to be used for effective decision making whereas data are simply facts from which information, or knowledge (meaning), may be elicited.

It is also important to note that data and information are context dependent. Avison and Fitzgerald [4] cite a typical example of this distinction where "a line manager analyses the departmental figures and presents the results to the planning department. For the line manager the results are an interpretation of events and are therefore information rather than data. For the central planners, these figures are the raw input for their own analysis, not yet interpreted, and are therefore data rather than information".

IT can be defined as the hardware and software that is used to manipulate data. Although computers are a central component of IT, Scott Morton [138] points out that IT consists of much more, and at least the following:

- computers,
- telecommunications,
- white collar productivity tools i.e. office automation and clerical support,
- blue collar productivity tools i.e. robotics and related factory automation.

IS and IT are fundamentally different. (IT is a subset of IS.) IT, if used effectively, is potentially an important part of IS, but only a part. IS will often have many manual (or clerical) aspects.

IS help organisations process and manage information by facilitating information flow. An IS consists of a collection of rules, procedures, technology and people designed to serve a particular business need by gathering, processing, storing and disseminating data and information. The aim is to provide relevant information of the required quality, that is, at the right time, at the appropriate level of detail and format, and accurate and accessible enough for the users of that information [4]. The following are examples of IS:

- A forecasting system is an IS. The system is used to generate forecasts of demand at regular intervals over a period of time. Historical sales data must be routinely collected, and the actual computations used to make the forecast can be done by way of a computerised algorithm. A forecasting IS drives production, capacity, and scheduling systems and serves as input to financial, marketing and personnel planning systems [66].

- An inventory management system is an IS. The raw data of the system include holding, ordering, set-up and unit costs, inventory transactions and capital costs. The system will provide statements and analyses of inventory levels, when to order and how much to order.

- A payroll system is an IS for administering employees' pay. Input data to the system include rates of pay of employees, hours worked, overtime and deductions such as tax, national insurance and pension and union contributions. The system outputs would include payslips and analysis reports.

1.3 - THE VALUE OF THE INFORMATION RESOURCE

Manufacturers are faced with fiercely competitive environments and an ever increasing pressure to balance the conflicting demands of low cost and low volume production with high product quality and high variety [95, 97, 110]. It is widely acknowledged that IT impacts the strategic options open to companies and effective and innovative utilisation enhances a company's ability to successfully compete and meet these demands [139].

Findings by Scott Morton [139] from a six year research programme carried out by leading MIT academics and their industrial partners indicated that:

- IT is enabling fundamental changes in the way work is done,

- IT is enabling the integration of business functions at all levels within and between organisations,

- IT is causing shifts in the competitive climate in many industries,
- IT presents new strategic opportunities for organisations that reassess their missions and operations.

Indeed, since the '80s and the rapid advances in the capabilities of IT combined with substantial reductions in its cost, the use of IT has spread like a flesh-eating bug, and academics, consultants and practitioners alike have been extolling the potential (competitive) advantages that could be leveraged by IT, and have deluged publishers and swamped the literature with claims of potential step changes in competitive performance, theories and methodologies for effective IT development and implementation, analytical frameworks, and exemplars of best practice [12, 21, 44, 71, 96, 107, 122, 126, 142, 143].

Clearly, IT has emerged from a supporting role used to automate functions such as payroll and stock control to become a major contributor to the competitiveness of many companies [129]. However, the ability to transform performance must be kept in perspective. The literature is littered with promises of IT that are difficult to uphold. An example is Porter and Millar's [126] suggestion that IT is affecting competition in three vital ways:

- it changes industry structure and, in so doing, alters the rules of competition;
- it creates advantages by giving companies new ways to out-perform their rivals, and
- it sponsors whole new businesses, often from within a company's existing operations.

These are ambitious aspirations, and their meanings are vague and ambiguous. Similar, if more sustainable, claims have been cited by Parsons [122] who identified a range of impacts IT can have at three different levels: industry, firm and strategy, and Earl [42] who generalised that IT can be applied strategically in a least four different ways:

- to gain competitive advantages,
- to improve productivity and performance,
- to enable new ways of managing and organising, and
- to develop new businesses.

These claims can often romanticise the real benefits of IT, which are as an effective subset of IS that significantly contribute to business objectives. Strategic advantage (from IS) can only be assured through the alignment of IS development with business objectives.

There are two related points that can be elicited from the literature:

- there is rarely a distinction made between information, IT and IS in terms of strategic or operational value obtained from the information resource,

- most of the literature focuses on companies in what King et al [88] call the 'information business' i.e. commercial database companies, banks, insurance companies, travel agents, airlines; there is a dearth of empirical evidence concerning the merits of the value of the information resource in manufacturing industry.

Examining the first point; since it has been established that information, IT and IS are quite different, each should be considered separately when attempting to identify strategic uses of information resources. This is rarely done. Most of the literature dismisses information and IS, and concentrates solely on IT. Clearly, as suggested by King at al [88], when considering strategic use of information resources, IT will usually be thought of first as it is easier to visualise. King et al [88] suggest that intangible information "is likely to be pushed into the background when, in fact, it may have the greater potential to produce benefits". Toyota's use of paper and visual kanban systems to control daily variations of production as described by Zenzaburo Katayama, assistant manager of Toyota's TQC Promotion Department and cited by Cole [27] illustrate the benefit of simple, usable IS. The use of computers for the fine tuning of the production schedules instead of kanban would probably require more than twenty times the existing computing capacity, and even then "no computer programme can predict the fluctuations in automobile production" [27]. Research by Kehoe et al [82] has also shown that, in many circumstances, a wholly manual IS can be just as effective in satisfying business objectives as a wholly or partially computerised system. So, it is important to distinguish between the three in order to systematically analyse the appropriateness of information resources to any particular business situation; a computerised solution should not be assumed.

Regarding the second point; whereas the IT exploits of service sector companies are well documented [50, 129, 140] there is substantially less empirical evidence of manufacturing companies obtaining the same gains. Companies such as Ford [58], Toyota [116], Buick [140], Perkins [10], Hitachi [72] and Nissan [72] have certainly achieved business objectives through IS, and for some, absence of certain technologies would render them 'businessless', actual evidence is rare and in most cases anecdotal.

Manufacturing industry may not be in the 'information business' and primarily adds value through materials processing, but business objectives are achieved through the management of the overall business and meeting the needs of the marketplace. IS have an important role to play. Manufacturers do recognise the potential advantages that can be gained from IS, but many lack the methodology to ensure success.

1.4 - PROBLEM DEFINITION

Although the significance of the information resource as an integral part of business is being recognised and manufacturing systems are increasingly looked on as IS rather than simply places for 'bashing metal' [119], the ability to gain control over information and use it productively to support and achieve business ambition is less well understood [99] and even less well applied [139].

Whereas the management of the other resources is planned centrally and strategically and generally well undertaken, the planning and coordination of the information resource is often approached in ad hoc fashion [102].

Referring to previous work by Mackulak, Gupta et al [61] argued that in most cases the planning that occurs in organisations is that which relates to cashflow, profitability, and product mix decisions. Personnel planning is another activity that quite rightly is rarely forgotten. The planning for IS development, however, is often ignored. Historically, there has been an absence of real strategic thinking about IS [147]. IS have been developed according to the discrete functional needs of the individual business areas within the organisation [14]. The resulting ad hoc, or piecemeal, development of IS is often characterised by

- escalating IS related costs, with a majority of time spent on maintenance,
- a growing backlog of project requests,
- missed project completion deadlines,
- duplicated data entry,
- incompatible IS,
- obsolescence of hardware and software,
- dissatisfied users,
- underused IS,
- sub-optimisation and waste [70, 99].

Hollingum [70] cites the piecemeal approach as the reason for the failure of many MRP systems, which often grew as a result of each new problem as it arose, and Tricker [147] sees the danger in random piecemeal developments as being lack of coordination, little standardisation, loss of scale economies, no integration of data flows, 'reinvention of the wheel' in different departments and sub-optimisation as separate units take decisions which are beneficial to the achievement of their own shorter-term goals and detrimental to the organisation as a whole.

The problem has been exacerbated by the wide availability and advances in IT which, for the sake of owning state-of-the-art, has often led companies into rash and expensive purchases devoid of careful analysis and alignment with business requirements. IT itself is not a guarantor of business success, or an effector of business objectives. IT is a tool. The purposes to which that tool is used determine whether the company benefits [34, 139]. As Tricker [147] points out "the choices (of IT) should reflect the needs of the business, not the desirability of technology", and Earl [44] comments "strategic advantage obtained potentially (from IT) is all 'hype' unless properly executed". If the potential of IT is to be realised, it has to be focused on the true needs of the business.

The solution is to approach investment in IT, development of IS and the management of the information resource with at least the same amount of rigour as any other capital expenditure [1]. IS projects must be treated as important, strategic decisions "just like the decision to expand, to invest in a new piece of equipment, or to enter a new market" [23]; far too many development projects start at the detailed, insular analysis stages.

The way to avoid the piecemeal approach (to IS development), obtain full value from IT expenditure and think strategically about information is to match IS development to business needs. This can only be guaranteed through the formulation of a structured IS strategy.

Escalating IS related costs, a growing backlog of project requests, missed project completion deadlines (sic) are the symptoms of poor 'information' practice, the lack of a coherent IS strategy tailored to business needs is often the disease!

1.5 - THE NEED FOR AN INFORMATION SYSTEMS STRATEGY

Several surveys aiming to elicit key IS issues have been conducted in recent years [22, 39, 41, 65, 67]. These have generally been conducted by academic researchers, canvassing the opinions of IS and senior executives. An examination of these studies reveals that strategic planning and using IS (often quoted solely as IT) for competitive advantage have consistently appeared as the top two critical issues.

Synthesising these two requirements constitutes the key need for the formulation of an IS strategy: to align systems development with business strategy. There are several other reasons why an IS strategy is necessary. Each reason can be classified into one of the following categories:

- strategic alignment considerations
- resource commitment considerations
- technical considerations

Strategic alignment considerations encompass the need to avoid the piecemeal approach to IS development, to trace IS development and implementation to business objectives, to involve top management in IS investment decisions, to identify opportunities for strategic use of IS and to ensure IS development is consistent with the company's direction and the plan for other company departments. 'Strategic considerations' is the most important category and has the widest remit. Management must consider how IS impact upon the entire operations of the business so that IS can be strategically justified and guaranteed to contribute to business success. According to a report carried out by the Institute of Internal Auditors Research Foundation and Price-Waterhouse, the most important management challenge of the 1990s is to integrate IS development with business strategy [69]. " 'Systems that are not linked to organisational strategy will not satisfy business or user requirements' says the report" [69].

The shortage of finances and skilled personnel, and the pressure to obtain a satisfactory ROI also necessitates a careful IS strategy [108]. IS can be one of the most costly of the many investment decisions for a company, and IS demands must be weighed against the many others for limited resources [140]. Without an IS strategy, conflicts will occur over the allocation of staff time and the priorities given to projects [88]. Resource considerations also include the need to ensure the satisfaction and involvement of IS users in the development of IS, so strategic and resource considerations together ensure a shared vision of user and senior staff.

Technical considerations necessitating an IS strategy include the need to integrate diversified technologies, ensure the compatibility of hardware and software and to take advantages of rapid changes in technology. An article in *Computing* [149] eloquently describes the situation as one in which "most users have to live with an uncoordinated IT wardrobe where the latest fashion item rests alongside the technological equivalent of the kipper tie". The synergies that can be obtained from integrating modern ITs and the avoidance of a pot pourri of incompatible hardware and software can be better served from a 'total company', top-down development of IS. An IS strategy can provide this view. Technical considerations also include the need to harness the expertise of IS staff in IS development; so all three considerations provide an IS strategy with user, IS and senior staff participation.

1.6 -RESEARCH AIMS & OBJECTIVES

This research project is based on the contention that in order to derive sustainable and complete value from the information resource, an IS strategy is necessary. Two supporting beliefs are that a structured methodology is the most appropriate delivery instrument for such a strategy and that significant work remains to be done to provide approaches and techniques for IS strategy development suitable for the manufacturing domain.

In order to investigate these hypotheses, three research objectives were established:

1. To identify and formulate the components of a successful approach to IS strategy development and implementation in manufacturing industry.

2. To formulate a methodology for IS strategy development appropriate for manufacturing industry.

3. To validate the methodology through rigorous application.

It is important to distinguish between an IS applications strategy, upon which this research is based, and an IS delivery strategy. An IS applications strategy is a ranked portfolio of requirements specifications for IS development projects that support business objectives and are elicited from an examination and evaluation of internal and external business variables. It is business-focused and does not include IS design.

An applications strategy is a 'curtain raiser' to a delivery strategy and is an essential prerequisite to proper delivery strategy formulation. A delivery strategy does incorporate IS design, and so includes the appropriate technological infrastructure, screen formats and other features pertaining to the design of an IS. It is technology rather than business-focused. The two levels of strategy are naturally related; but the main thrust of this research has been into IS applications strategy concerns.

1.7 - RESEARCH APPROACH

The research approach adopted incorporated both pure and applied elements in order to ensure both its theoretical and industrial validity. The pure elements consisted of reviewing and evaluating the existing theoretical and empirical literature, and the applied elements consisted of case studies in a range of manufacturing organisations. An outline of the research approach is depicted in Figure 1.

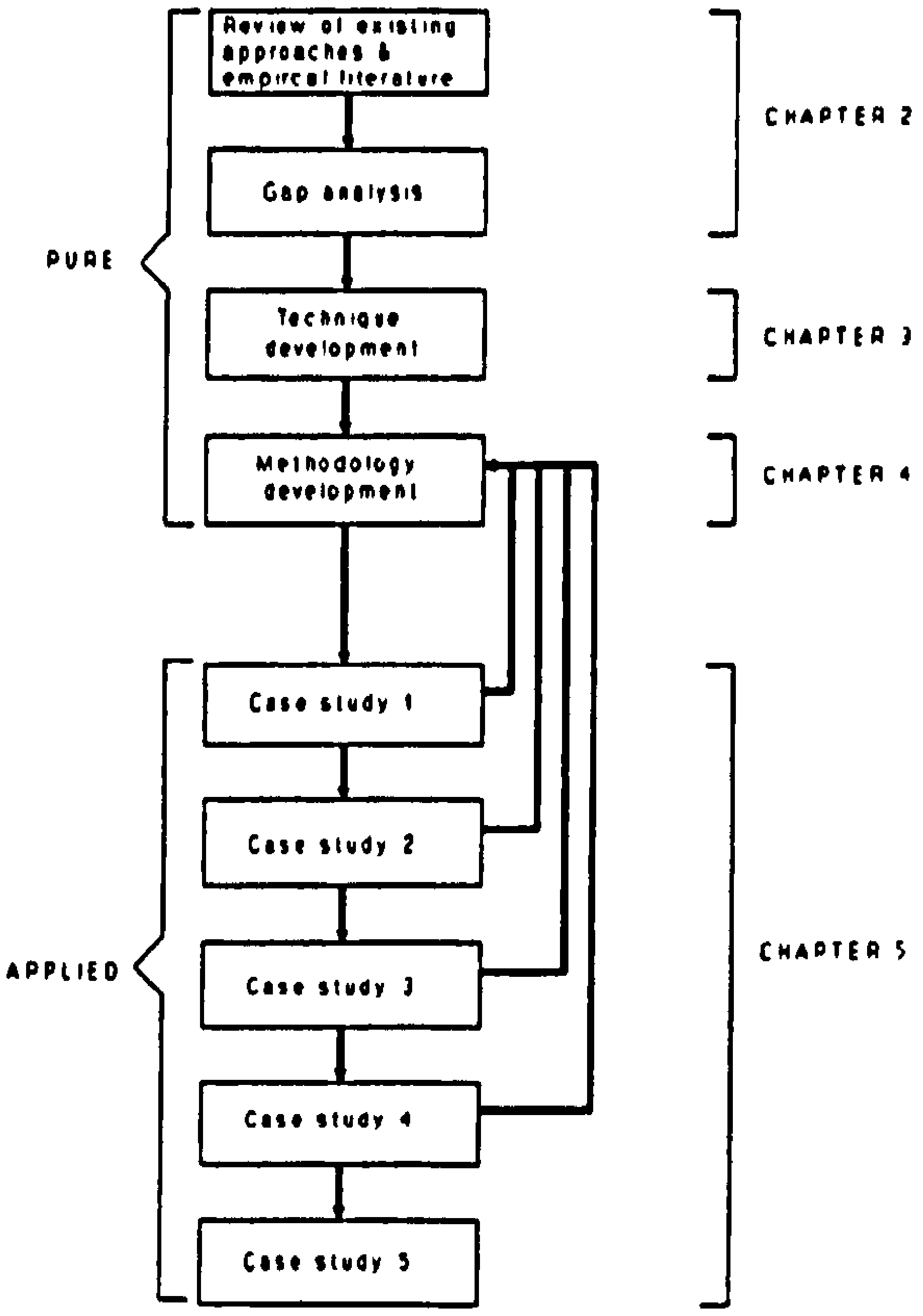

FIGURE 1 - Research Approach

The pure research elements began with a thorough review of existing literature in order to establish state-of-the-art IS strategy development and implementation. Gaps and inconsistencies that were evident in the state-of-the-art were identified and a set of techniques to fill these inadequacies was developed. The last pure research element was to formulate a methodology based on these techniques. The applied elements of the research involved applying and refining the developed methodology in five manufacturing business units.

Although the focus of study is overtly manufacturing industry in both the pure and applied elements of the work, an area which has always been less fashionable than the service sector in terms of information-based research; empirical work, experiences and theories pertaining to service sector industries have been plundered in order to provide a true and complete picture of state-of-the-art approaches to IS strategy development and application.

CHAPTER TWO

LITERATURE REVIEW

PURPOSE OF THIS CHAPTER

The purpose of this Chapter is to present a review and summary of IS strategy formulation policies and practices identified and deliberated upon in the literature. It is intended to be *descriptive* rather than openly *evaluative*. The succeeding two chapters provide a more detailed investigation and a thorough evaluation of many of the policies and practices presented here.

2.1 - INTRODUCTION

An IS strategy is a ranked portfolio of IS development projects that help an organisation achieve its business objectives. The process of formulating such a strategy is far from new. Earl [42] cites King [89], and McLean and Soden [109] as the earliest advocates of strategic planning for IS. However, real attempts to align IS development with business ambition were comparatively rare until the mid 1980s when IS strategy emerged as a priority concern for senior managers, and the focus of managerial attention shifted from predominantly resource considerations in IS development to all three 'categories of need': strategic, technical and resource considerations. Simultaneously, a semantic shift has taken place and 'strategic information systems planning', 'IS strategy' and 'strategic planning for information systems' studies have replaced what were previously called 'systems reviews' and 'systems audits'.

With the growth in knowledge concerning IS planning, publications detailing the topic have primarily dealt with:

- the strategic role of IS,
- the need for IS strategies,
- measuring the value of IS and justifying investment, and
- IS planning approaches.

A description of these concerns, and an overview of major research on each, forms the basis for the remainder of the Chapter.

2.2 - THE STRATEGIC ROLE OF IS

The ability of effective IS to contribute to competitive performance by facilitating strategic objectives is irrefutable. Vollmann et al [151], for example, cite that with high quality information rather than relying on high levels of physical inventory to avoid coordination decisions, decisions can be based on data about inventory. Such sentiments are shared by many other authors including Tricker [147] who commented that "computer-based systems and organisational strategy are inevitably entwined"; Scott Morton [139] who, based on the results of a major research exercise provided multiple evidence of the ability of IT to facilitate a step change in providing strategic opportunities; A.T. Kearney [1] who point out that "companies should recognise the significant swing away from the view of IT as solely a productivity enhancer, to IT as a powerful aid in the management of the overall business"; Lei and Sobol [95] who cite several examples of firms that "successfully utilise IS as a competitive weapon to manage inventories, control costs and respond faster to customer needs" and in particular they note that IS are at the forefront of many firm's efforts to use time as a competitive weapon; Watts [153] who pointed out that IS strategy can proactively influence and help define business strategy; and Parsons [122], who lauds the ability of IT to "support, reinforce, or enlarge a business strategy".

Brady et al [21] found many instances where IT generated some form of competitive advantage, but found this advantage to be unsustainable. King et al [88] also raise the issue of sustainability. They argue that the strategic use of IT is where IT helps in the achievement of a key objective and provides sustainable competitive advantage. Brady et al [21] claim that few companies have done this, yet remark that in order to do so companies have "to build their systems through continuing incremental innovations in order to maintain competitive advantage".

Several authors have generalised about the way IT can be applied strategically. Earl [44], for example, considers four approaches to the strategic application of IT:

- to gain competitive advantage,
- to improve productivity and performance,
- to facilitate new ways of managing and organising, and
- to develop new businesses;

Porter and Millar [126] suggest that IT is affecting competition in three ways:

- changing industry structure,
- creating competitive advantage,
- sponsoring whole new businesses; and

Mead [110] claims that IT can offer strategic advantage in six ways:

- fundamentally altering the structure of cost and value-added in the business and by changing the basis of competition,
- raising the barriers to entry by other competitors,
- augmenting or enhancing the product with services, on which the customer learns to rely,
- 'locking-in' customers,
- facilitating the exploitation of information from one area of the business to another,
- pre-empting and blocking competitors.

To realise the full potential of IS, close attention to the integration of business functions is essential [61]. IS planning facilitates integration. However, integration in manufacturing has tended to be realised at a technical rather than an overall business level [96]. Effective planning for IS development can facilitate integration and bring about the synergistic benefits associated with integration at an overall business level, that is, ensure IS development is both meted out across business functions and aligned with business strategy. Such findings were corroborated by Scott Morton [139], and Gupta et al [61], who, following the analysis of 269 manufacturing organisations found that integrating business functions achieved significantly higher levels of strategic benefits.

In order for IS benefits to be strategic, an IS needs to be instrumental in helping achieve a strategic objective, that is, an objective that enhances the competitive performance of a business. A.T. Kearney [1] pointed out that the emphasis of benefit has changed as productivity has become less of an IT issue and increasing importance has been attached to the management of the overall business and to addressing the needs of the marketplace. They also generalised that the potential benefits of IT can be looked at from two perspectives, internal or external - either reducing costs or increasing revenues.

Figure 2.1 shows the benefits attributed to IT from A.T.Kearney's [1] 1990 survey of IT practice in over 400 UK companies.

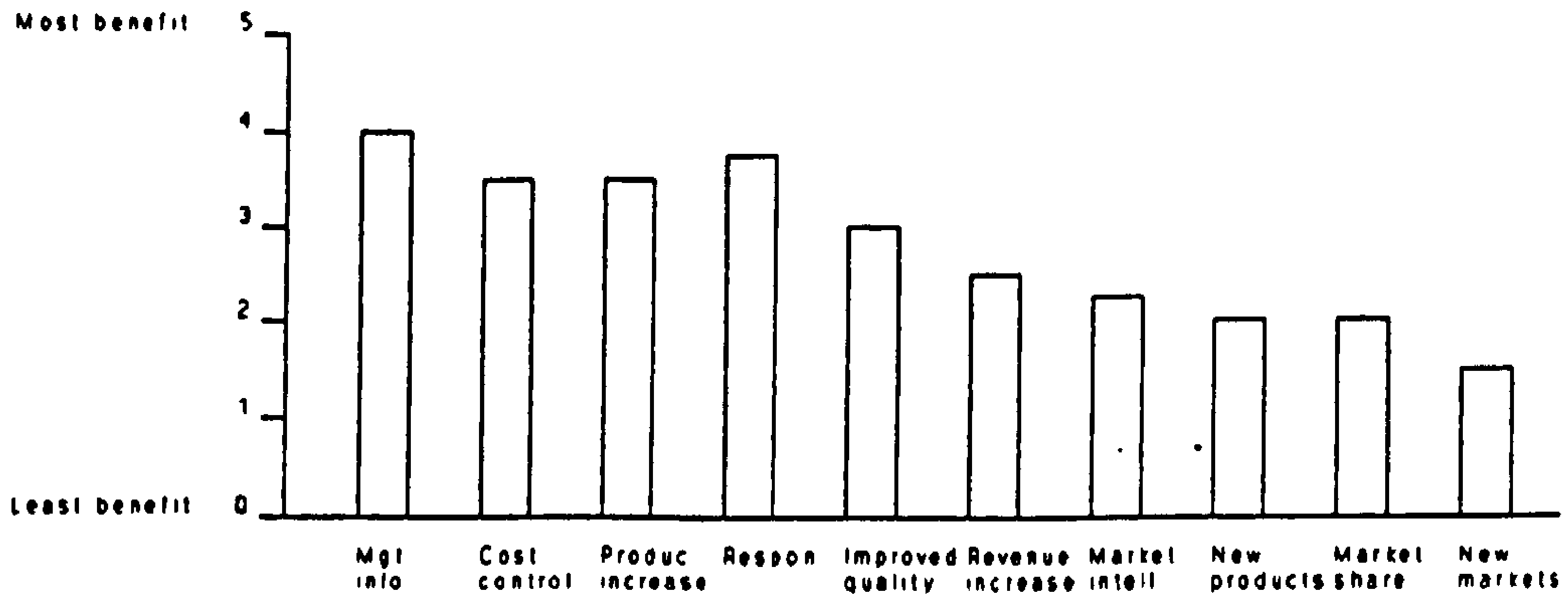

FIGURE 2.1 - IT benefits (A.T. Kearney [1])

Cresap et al [28], suggested that from a general management perspective, the most important benefits of IS planning were the following:

- business programmes are assured of needed IS support;
- scarce IS resources are allocated wisely;
- general management becomes informed and involved concerning IS activities.

Baets [5] suggests that a number of spin-off advantages could be as important as a strategic IS planning study itself:

- the overall corporate strategy can be defined, adapted or improved if currently inadequate or even non-existing;

- communication can be improved between different functions and between different hierarchical layers;
- a number of company cultural values based on shared understanding and vision of the company are likely to be developed and will help facilitate the management of change necessary to implement the strategy;
- an inventory of knowledge will result and additional knowledge will have been created about the company.

2.3 - THE NEED FOR IS STRATEGIES

McFarlan et al [108] reported that rapid changes in technology, scarcity of skilled people and other corporate resources, the trend toward integrated systems, and the importance of IS to corporate goals make planning necessary in the IS field. Earl [43] offers another four-fold view of the pressures to plan:

- the ability of IT to alter the basis of competition by changing the nature of the market sector;
- the pursuit of competitive advantage;
- the alignment of IT with business needs;
- a means of revamping the IT function.

Galliers [52] found from a survey of 209 organisations a prioritised set of reasons for undertaking IT strategy studies. They were:

- matching IS to business needs;

- coordinating IS developments;

- resource considerations (accountability, justification, return on investment);

- need to prioritise IS development (increased demand, limited resources);

- need for effective IS / past IS failures.

Overwhelmingly, the ability to integrate strategic concerns into IS development, and the ability to use IS as a strategic effector dominate the literature on the need to plan. Bansal [7], for example, claims that JIT, zero defects and product design strategies are putting exorbitant pressures on business information loops. Lederer and Gardiner [92] wrote that "strategic information planning gives information managers the opportunity to identify broad initiatives, specific applications, and critical technologies to help their organisations carry out their current business strategy more successfully". An article in *Computer Weekly* in March, 1992 [69], reported that "the most important management challenge of the 1990s is to integrate the planning, design and implementation of complex application systems with the strategy of the organisation". An article in *Manufacturing Systems* in August 1990 [19], reported that although the business objectives of a company may be clear, the means to translate these into reality is not, and intimated that an integrated IT strategy can provide such means.

Examining the consequences of being without an IS strategy also appears to emphasise its strategic influence. The *Computer Weekly* [69] article for instance, reported that "without a closely linked organisational strategy, the foundation of the (IS) applications will be based on a dubious set of requirements, and achieving cost effectiveness will be difficult". King et al [88] found that lack of appropriate planning to be the 'number 1' inhibitor in preventing a company's efforts to utilise information or IT for strategic purposes, and A.T. Kearney [1] discovered that without a business and operations strategy foundation, IT is likely to fail.

There are several other pressures to plan. A significant imperative is economics. Systems development represent a considerable annual spend in manufacturing businesses, and expenditure is increasing [70, 102, 147]. Consequently, inappropriate investment can be very costly. In 1992, it was claimed that UK companies are wasting £4bn of the £10bn a year they spend on IT [69].

Forza and Filippini [51] intimate that effective IS planning is needed for world class manufacturing. They comment that "IS should be taken into serious consideration in the implementation of world class manufacturing policies". Hollingum [70] even wrote that "an information strategy for many companies .... may be the singlemost important guarantee of their future profitability and even viability".

McFarlan et al [108] regarded rapid changes in technology and the need to integrate IS as reasons for IS planning justification. Parsons [122] is supportive of such claims, and comments that "IT has dramatically altered the structure of markets in a number of industries", and Gupta et al [61] noted that the "IS function will need to enhance its data communication capabilities and resources and develop a portfolio of systems that enhances integration". Breuer et al [23] note that because of the hundreds of IT applications marketed "it is critical for companies to develop a rational plan to identify true needs for IT, select the right technology to fulfil these needs, and carry out IT projects successfully". Karababas and Cather [80] regard the main reason behind the rarity of integrated systems as the lack of a company-wide, strategic approach to IT.

IS are clearly at the core of business processes, and such recognition has been acknowledged in a number of surveys that have emphasised the need for IS planning. Doukidis et al [45] in a survey of 29 Greek companies (mostly manufacturers) found that 'identifying opportunities for the strategic use of IS' and 'aligning IS strategy with business strategy' as the top two ratings of IS management issues. Brady et al [22] described a recent IT survey conducted by Price Waterhouse that revealed that integrating IT with corporate strategy as the major issue facing IT managers. Brancheau and Wetherbe [44] in a major survey found 'improving strategic planning' and 'using IS for competitive advantage' to be ranked first and second in importance of the most critical issues facing IS executives in the future.

2.4 - MEASURING THE VALUE OF IS & JUSTIFYING INVESTMENT

The fact that it is inappropriate to consider a piecemeal approach to IS development, and similarly inappropriate to consider a piecemeal approach to IS expenditure and justification is a tautology. One implies the other. Williamson [154] illustrates this point by suggesting that the real benefits from a CADCAM system far exceed those associated solely with drawing office productivity. The inference is that much of the benefit is non-quantifiable. Intangible gains such as the ability to respond to market changes and customer requirements, and the abilities to shorten task times, improve product quality, enrich tasks and improve job satisfaction are common with IS development.

In 1983, Parsons [122] pointed out that "senior executives increasingly feel that businesses should receive more benefit from technology, but few are able to articulate the impact IT has or should have on their businesses". It would appear that the situation had not improved by 1986, when Mead [110] noted that "many strategic applications of IT are difficult to justify on traditional cost-benefit grounds alone". In 1988, Ward [152] suggested that "tomorrow's technology is being sacrificed on the altar of yesterday's financial techniques", yet offered a solution by suggesting that "a structured measurement technique must be applied, but it should reflect and attempt to evaluate all benefits likely to accrue". By 1990, the problem appeared to have worsened when A.T. Kearney [1], found that nearly 40% of all companies (manufacturing and service) were finding it harder to make IT investment decisions compared to five years earlier with the major constraints to IT investment being benefit credibility, cost justification and top management support. More recently, it has been a similar story: in 1991, for example, MacDonald [101] noted that with a few exceptions, the justification of IT was based on operational savings rather than strategic considerations; in 1992, Doukidis et al [39] found that the evaluation of IS remained a difficult issue; and later that year, an article in *Management Consultancy* [85] conceded that "in today's tough economic climate, IT directors have to provide bullet-proof business cases for investments".

IS have important strategic significance. Many companies can testify to this claim. Yet, it would appear that measuring the value of IS, and justifying IS investment is unstructured at best and remains the bane of IS stakeholders. Davenport [34] cites a classic case of an IS project rejection because there was no obvious financial justification just better business performance. The traditional methods of investment justification look only at quantifiable cost/benefits and therefore cannot account for, or justify the strong emphasis placed on competitive advantage [61] and intangible gains. Mead [110] noted that "strategic applications result in implementation only when the more qualitative strategic advantages are made explicit and compelling to top management". He [110] also outlined the overall flow of a successful justification (see Figure 2.2).

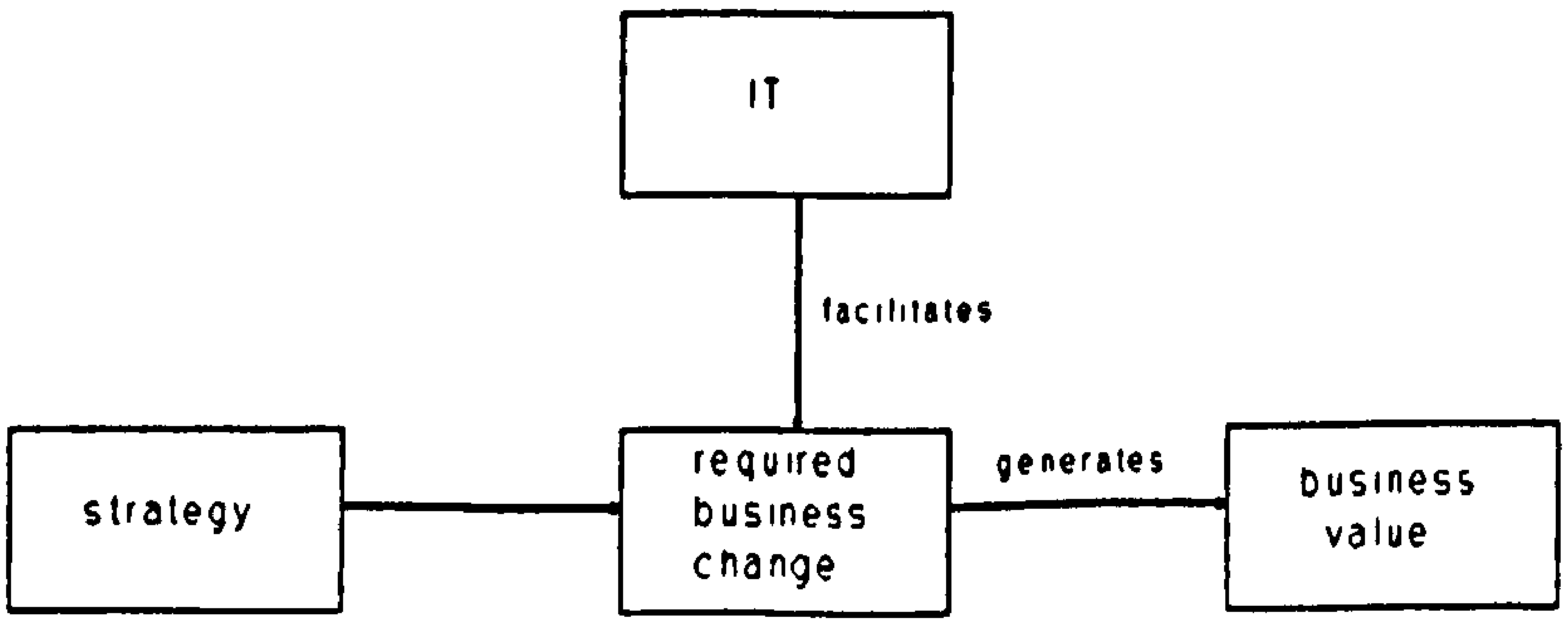

FIGURE 2.2 - IT justification (Mead [110])

Breuer et al [23] argue that companies must see IT as an investment, which if properly carried out will provide benefits that more than offset the expenses. A.T. Kearney [1] warned of the difficulty of assessing the benefits of proposed IT projects, which often results in companies finding it harder to justify expenditure due to lack of credibility in the alleged benefits. As a consequence, Reich and Huff [129] have conceded that managers have to use intuition to justify investment, and also warned that "research to date has provided little in the way of generaliseable, reliable results".

2.5 - IS PLANNING APPROACHES

Many approaches are available for carrying out IS strategy formulation studies. These include Business Systems Planning (BSP) [73, 74, 93], Critical Success Factor (CSF) approaches [20, 131, 132], Strategic Value Analysis [30, 31], Customer Resource Life Cycle (CRLC) [76], Value Chain Analysis [126], Lucht's methodology [99], Information Engineering (IE) [104, 105], Tetrarch [120], Method/1 [2, 92], Tozer's methodology [145], CASE*Method [118], Navigator [47], PC Prism [75], and Strategic Planner [91]. As well as these approaches, many companies will customise an existing methodology or develop their own 'in-house' approach [52]. Galliers [52] found from an investigation of IS planning practice in the UK and Australia, that the choice of approach tends either to be imposed - by policy or by the person responsible for IS planning - or to evolve in some way through company experience or discussion.

Independent evaluative and empirical analyses and research of the approaches appear to be rare. Lederer and Sethi [94] overviewed BSP and IE, and provided a basic comparative analysis of BSP, IE, Method/1, the CSF approach, CRLC, and Value Chain Analysis. They also collated a series of problem statements relating to strategic IS planning studies, and conducted a causal analysis of these problems. With a variety of colleagues Albert L. Lederer has published several such review articles. Lederer and Putnam [93] described and provided some evaluation of BSP, and Lederer and Gardiner [92] described and provided case study evidence of Method/1. Hares and Royle [63] described and provided examples of elements of CSFs, SVA and Value Chain Analysis, and Martin [103] provided an overview of CSFs and BSP. Earl [42] summarised Value Chain Analysis, and the CSF approach, and illustrated suitable contexts in which each could be applied. He also provided a brief insight into Business Systems Planning. Earl [42] concluded that:

- a contingency theory is required in order to prescribe which methodologies are effective in what situations and over time;

- techniques embodied in the various methodologies need both further development and more rigorous appraisal.

Lederer and Gardiner [92] wrote "for years, improved strategic information planning has been one of the most serious challenges facing IS managers"; yet within the topic, there appears to be a paucity of techniques, regardless of the number of methodologies. It would appear that the project manager has one of two choices: a costly bill from a consultant, or a series of general rubrics. Given the number of approaches, there appear to be few unique, differentiable techniques. It would appear that the available methodologies can be likened to onions whose 'layers' of project management, top-down analysis and bottom-up implementation can be peeled away until you reach the two essentials: a statement of business ambition and cluster analysis. Cluster analysis is perhaps the most commonly used technique. It is a relational analysis for re-configuring a matrix-based business model into related data classes. The results of such an analysis assist in determining:

- which users, locations, and/or business units share information and for what potential there is for developing common systems across functional and/or organisational boundaries;

- how data files should be designed/managed to best support the long-term systems development effort [99].

IS planning approaches are described and evaluated in detail in Chapter Three in order to attempt to identify successful methods, and distil best practice; planning techniques are described and evaluated in Chapter Four in order to identify, and where necessary define, the optimal make-up of a planning approach.

CHAPTER THREE

APPROACHES TO STRATEGICALLY PLANNING INFORMATION SYSTEMS DEVELOPMENT

PURPOSE OF THIS CHAPTER

In this Chapter, existing approaches and techniques for IS strategy formulation are comprehensively reviewed, and empirical evidence of strategic IS applications* is examined. Existing IS strategy formulation approaches are broad and often cover all aspects of a business operation, and so the review of approaches is necessarily detailed. Each approach is summarised and rigorously evaluated. Based on this critique, an attempt is made to elicit the most effective techniques and methods of analysis, and a set of criteria for successful IS strategy development and implementation is proposed.

3.1 - INTRODUCTION

Strategic plans for IS are designed to nullify the chances of IS being implemented in an ad hoc fashion. An uncoordinated, function-by-function approach can lead to inefficiency and sub-optimisation. In order to avoid the problems associated with such a fragmented approach, and address the issues that make IS strategy formulation a necessity, the need for strategic planning as an essential first step in the IS

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* It is important to realise that in the literature, writers will often refer to strategic IS but mean strategic MIS (Ramaswami et al [128] for example), in other words, IS that are concerned with supporting strategic decision making rather than IS that actually impact upon business objectives.

development life cycle must be recognised, and a formal planning process to identify and quantify the key IS needs and priorities of a business should be adopted. Thus a mechanism for identifying opportunities, prioritising applications and translating strategic objectives into specific IS development plans in support of those objectives can be obtained.

Earl [42] has posited that there are two ways of providing such a mechanism:

- Frameworks for analysis

- Strategy formulation methodologies

This classification provides the basis for reviewing state-of-the-art approaches and techniques for IS strategy formulation.

3.2 - FRAMEWORKS FOR ANALYSIS

Earl [42] classifies 'frameworks for analysis' into 3 categories:

- awareness frameworks
- opportunities frameworks, and
- positioning frameworks.

This is a suitable taxonomy and effectively encompasses all published frameworks related to integrating strategic concerns into IS development.

3.2.1 - Awareness Frameworks

Awareness frameworks are used to generate awareness and appreciation (particularly by senior management) of IT as a strategic effector. Parsons [122] developed one such framework. He proposed a very simple "three-level framework to help senior managers assess the current and potential impact of IT on their businesses" that was developed from the results of a two-year study of more than a dozen companies (see Figure 3.1).

Industry Level

IT changes an industry's:
- Products & Services
- Markets
- Production Economics

Firm Level

IT affects key competitive forces:
- Buyers
- Suppliers
- Substitution
- New Entrants
- Rivalry

Strategy Level

IT affects a firm's strategy:
- Low-Cost Leadership
- Product Differentiation
- Concentration on Market or Product Niche

FIGURE 3.1 - Parsons' three-level impact framework [122]

The framework conceptualises and generalises the way IT may impact the competitive environment and business strategies of firms. It purports to enable managers to target IT resources on the firm's most important areas.

At the 'industry level', Parsons describes how IT may impact the fundamental nature of an industry's products and services specifically by reducing the time between an idea for a new product and its production and distribution; IT affects markets, particularly in the financial industries through electronically-based banking and funds transfer; and production economics through economies of scale.

At the 'firm level', Parsons [122] uses Porter's [124] five generic, competitive forces i.e. 'the buyers', 'the suppliers', 'the substitutes', 'the new entrants' and 'the rivals' to show how IT can change competitive forces within a particular industry. Each force may potentially be used as a lever to gain competitive advantage.

At the 'strategy level', Parsons [122] again relies on Porter's [124] work to advocate the use of IT in effectively implementing one or more generic strategies:

"- overall cost leadership on an industry-wide basis;
- differentiation of products and services on an industry-wide basis;
- concentration on a particular market or product niche".

The framework is far too simplistic to be of any practical utility in identifying areas ripe for exploitation. Although it does promote 'awareness' of common and broad areas where IT may potentially provide benefit, and as Earl [42] points out may prove "valuable in the classroom", its basic generality means it can only meaningfully be used for 'bluesky' hypothesis or as an aid to a brainstorming session. It does, however, draw attention to the need to align IT investment to business strategy and to the multi-level impacts IT can provide. At an industry level, it would appear IT has a more profound impact in the financial and distribution sectors rather than the manufacturing sector. Seemingly it is at the 'firm' and 'strategy' levels that are likely to be more fruitful for IT exploitation in manufacturing organisations. However, this does imply that strategy has to be defined in Porter-like terms, and this in itself is a restriction [42].

Another 'awareness' type framework was proposed by Benjamin et al [12] who developed a "framework for exploring strategic opportunities". Again the framework is very simple (see Figure 3.2) and seeks to address two significant questions:

- Can technology make a significant change in the way business is done to gain a competitive advantage?

- Should companies concentrate on using IT to improve their impact in the marketplace? Otherwise, should companies centre their efforts on internal improvements in the way activities are currently carried out?

	Competitive Marketplace	**Internal Operations**
Significant Structural Change	Gannett - USA TODAY Merrill Lynch General Electric	Digital Equipment
Traditional Products & Processes	American Hospital Supply Bank of America Toyota	Xerox United Airlines

FIGURE 3.2 - Strategic opportunities framework (Benjamin et al [12])

The first question is a 'shot to nothing'. Managers have nothing to lose in assessing whether "huge competitive leaps" can be facilitated by IT, is the gist of the authors' thinking.

The second question is meant to place emphasis on the "two ways in which any business can be made substantially better: (1) improving the organisation's impact in the marketplace, (2) improving key internal operations, thereby lowering costs or improving services" [12].

Together, the questions suggest a four-cell 'strategic opportunities matrix', as in Figure 3.2. The authors "believe it presents a simple, but powerful way of thinking about strategic use of IT". A number of companies were assigned to cells in the matrix.

The framework could feasibly be used to generate awareness of the potential advantages of IT, but like Parsons' 'impact framework' is too simplistic to be of real practical utility and to answer the questions posed by this research.

Lei and Sobol [95] developed another awareness framework that "attempts to capture the relationship between technological change and market fragmentation in the linkage of CIM (computer-integrated manufacturing) and IS activities". A modified version of the framework biased in favour of the description of IS activities is shown in Figure 3.3.

The framework highlights opportunities for CIM and IS tasks to complement one another. This is done via the context of what the authors consider to be two significant factors: technological change and market fragmentation. Technological change has meant that "the manufacturing and information-based skills required to compete in any fast-changing industry have multiplied greatly" [95], high product variety has become a dominant basis of competition and this, in turn, has led to demands for IS to facilitate fast response to the requirements of suppliers and customers. Coupled with the increasing fragmentation of markets, the pace of technological change has led to a greater need to produce increasingly complex products in small lot sizes.

The framework compares the degree of market fragmentation facing a company with the level of technological change facing the company's products.

Cell 1 companies tend to manufacture durable products such as construction equipment, home appliances, light machine tools, and farm equipment. In order to achieve just-in-time (JIT) inventory cost reduction, several companies in this cell have developed strong supply chain IS to support the key market requirements of low-cost procurement of materials, flexible production systems and economies of scale. Process yield and high quality (because of high standardisation) are other critical success factors (CSFs) and, as such, areas for IS attention.

Market fragmentation	*Low*	**Cell 1** *Simple goods* *Large lots* IS links up vendors for JIT delivery. *Examples*: farm equipment, home appliances	**Cell 3** *Complex goods* *Large lots* IS becomes the basis for strategic alliances & CAD/CAM networks. *Examples*: cars, engines, plastics, VCRs
	High	**Cell 2** *Simple goods* *Small lots* IS becomes a lever to store ideas, designs & innovations to be used system-wide. *Examples*: health products, food products	**Cell 4** *Complex goods* *Small lots* IS serves as a database for innovations & to track emerging market niches. *Examples*: biotechnology, specialised machine tools
		Low	*High*
		Technological change	

FIGURE 3.3 - Organising IS tasks for building competitive advantage (Lei & Sobol [95])

Companies in cell 2 tend to be food processors, manufacturers of consumer non-durables, and other related products. IS concerns generally support the production of small lot sizes, with insightful use of databases often proving to be the focal point of IS strategy.

Cell 3 companies are often in the car, consumer electronics, telecommunications and commercial aircraft industries. Owing to the large size of consumer markets and their homogeneity, production occurs in large lot sizes. Companies in this cell often use the IS linkage to customers and suppliers as a competitive weapon. Fast technological change demands a high turnover of new product designs and this imposes two critical demands on IS: (1) IS networks allow the company to integrate their design and production activities with suppliers to provide a division-of-labour across subcontractors, (2) IS networks are essential for integrating internal activities such as marketing, production and design. Computer-aided design (CAD), computer-aided manufacture (CAM) and computer-aided process planning (CAPP) are often utilised in cell 3 type companies.

Companies in cell 4 compete in a highly changing and competitive environment typical of a mix of industries. Concurrent integration of design, manufacturing and marketing and technologies such as flexible manufacturing systems (FMS), automated storage and retrieval systems, CAPP and CAD/CAM are necessary to out-design and out-produce competitors. IS are a critical competitive weapon that are required to maintain the company's market position.

Although the key purpose of the framework is to promote the idea of integrating CIM and IS viewpoints, with the more complex the goods and the smaller the lot size the greater the need to reduce the gap between both sets of tasks, the framework is a useful rule-of-thumb for highlighting the differing roles and advantages that are obtained from IS in different industries. The framework, without intention, underlines the need for an effective strategy in order to guarantee the focused use of IS and provide the business benefits suggested. It could clearly be used as a starting point to a more rigorous strategic IS study, and as an initial guideline for revealing IS opportunities in four broadly-based industry types.

3.2.2 - Opportunities Frameworks

Opportunities frameworks are more detailed than awareness frameworks. Rather than generating a broad understanding of the potential strategic impact of IT, opportunities frameworks attempt to identify specific opportunities in specific business areas for strategic application of IS.

Porter and Millar's [126] 'value chain' is the archetypal opportunities framework. Based on Porter's previous work on competitive advantage [124], Porter & Millar's framework is much respected, and quoted as an effective instrument for identifying strategic IT opportunities by a number of authors [2, 23, 26, 101, 121, 140]. It is used as part of a strategic IS planning methodology [2, 120], has been said to have formed the basis for business process re-design [101], and referred to as "the most recent phase in the evolution of strategic planning" [43].

The 'value chain' (see Figure 3.4) "divides a company's activities into the technologically and economically distinct activities it performs to do business" (value activities) [126].

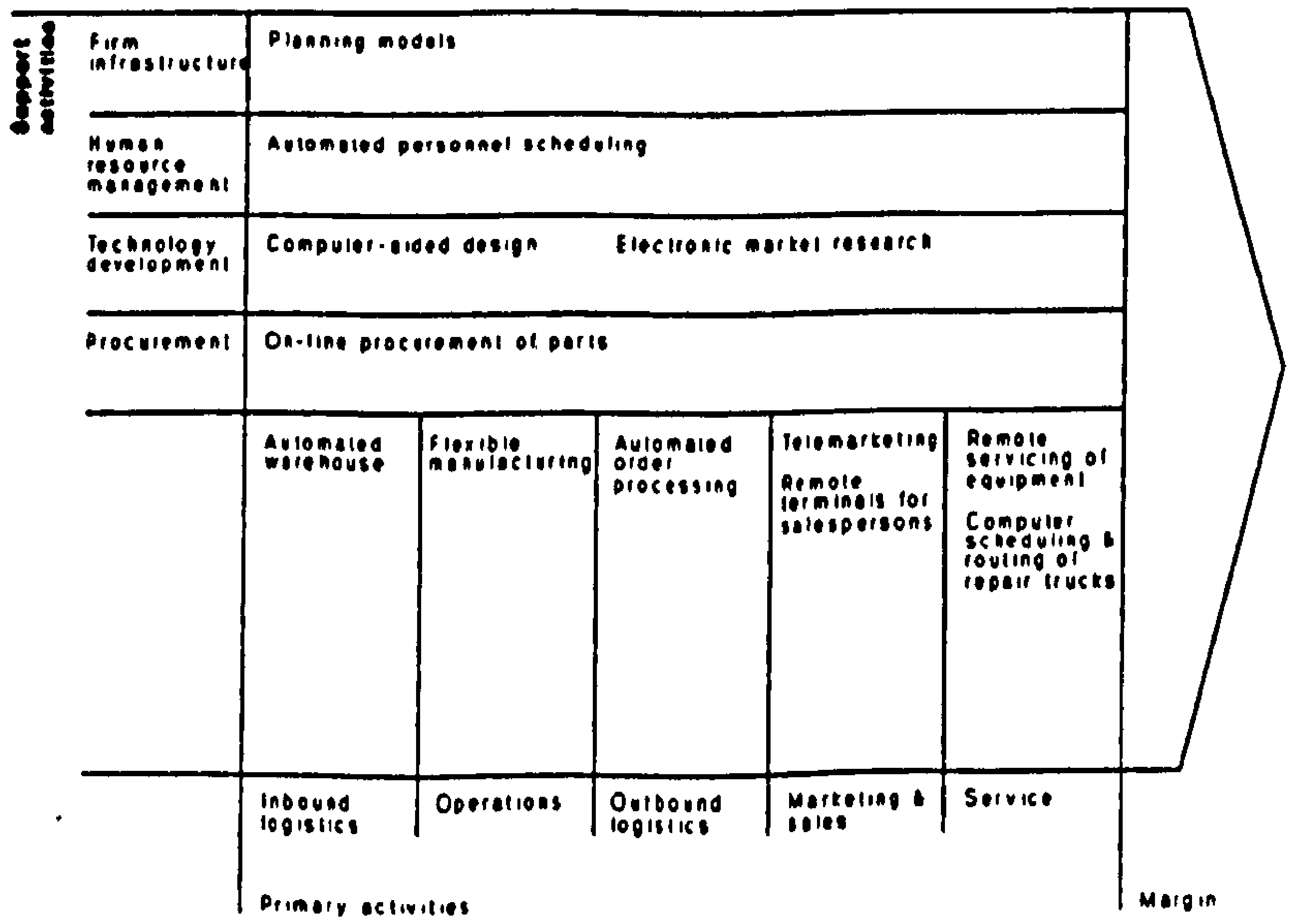

FIGURE 3.4 - IT permeates the value chain (Porter and Millar [126])

The value a business creates must exceed the cost of performing the value activities if the business is to be profitable. Value activities are performed by nine generic business functions, five 'primary' covering order receipt through to delivery activities, and four 'support' covering the associated infrastructure and management activities required to support the primary functions. The activities are connected by a system of linkages. Linkages (between activities) as well as the activities themselves need to be optimised in order to achieve competitive advantage. IT is an important lever that can potentially be 'pulled' to improve each activity and linkage. Porter and Millar [126] suggest that the value chain can be used to guide analysis and define areas for IT exploitation.

Extolling the virtues of 'value chain analysis' has become a pastime for IS strategists. The principle itself: examining the relationships between business activities in an attempt to discover IT improvement opportunities, is sound and commendable. However, the framework lacks prescription and detail. It is a carte blanche and leaves too much to the imagination for it to be used as a sole instrument for formulating IT investment priorities.

The problem is not caused by the authors but by the disciples of competitive analysis eager to empathise and find an explicit use for Porter's work. It is they who have turned the value chain into a sacred cow. Indeed, if offered by authors[**] of lesser repute, it would probably have long been forgotten, unearthed only by 'trawling' research students.

Although very difficult to apply in its existing form, the value chain could indeed be useful. It could help articulate thinking and provide a very broad guideline as to where strategic IT opportunities lie. It should, however, be put into perspective: analysed on its own, the value chain certainly does not provide an IS strategy, and

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[**] Michael Porter is a major authority on competitive advantage and competitive strategy

only with great difficulty would it produce a definable set of IS opportunities. It could, however, trigger further analysis, and if used in conjunction with other techniques, or as part of a structured methodology it could prove to be beneficial.

Another opportunities framework was developed by Ives and Learmonth [76]. Called the 'customer resource life cycle (CRLC) model', it purports "to determine not only when opportunities exist for strategic applications, but also what specific applications should be developed".

The model is described through a series of examples focusing on the customer-supplier relationship. It consists of thirteen stages as depicted in Figure 3.5.

Extended model	**Description**
Establish requirements	To determine how much of a resource is required.
Specify	To determine a resource's attributes.
Select source	To determine where customers will buy a resource.
Order	To order a quantity of a resource from the supplier.
Authorise and pay for	To transfer funds or extend credit.
Acquire	To take possession of a resource.
Test and accept	To ensure that a resource meets specifications.
Integrate	To add to an existing inventory.
Monitor	To control access and use of a resource.
Upgrade	To upgrade a resource if conditions change.
Maintain	To repair a resource, if necessary.
Transfer or dispose	To move, return, or dispose of inventory as necessary.
Account for	To monitor where and how much is spent on a resource.

FIGURE 3.5 - Thirteen-stage resource life-cycle (Ives & Learmonth [76])

Each stage can potentially act as a focal point for improving customer service through the analysis and proposition of supplier-developed strategic IS.

The CRLC model operates at a lower level of detail than Porter and Millar's [126] 'value chain'. However, it lacks adequate explanation and, as such, would be difficult to apply outside the context of the examples provided. The examples themselves are nearly all distribution, service and finance-based. Taking these two points together, the CRLC model or any similar concept requires specific IS opportunities to be articulated across the whole range of business operations to be of real use as an IS analysis tool in a manufacturing environment.

3.2.3 - Positioning Frameworks

"Positioning frameworks have been developed to help executives assess the strategic importance of IT for their business with a view to understanding how the IS function should be managed" [42]. McFarlan et al's [108] 'strategic grid' (see Figure 3.6) is a well known example of a 'positioning framework'.

		Strategic impact of application development portfolio	
		Low	High
Strategic impact of existing operating systems	Low	*Support*	*Turnaround*
	High	*Factory*	*Strategic*

FIGURE 3.6 - Strategic grid (McFarlan et al [108])

The grid represents four different IS environments. Each is identified by a different metaphor: 'strategic', 'turnaround', 'factory' and 'support', with each metaphor representing the relative importance of IS contribution towards business activities.

IS activities represent an area of critical strategic importance in companies in 'strategic' situations. Companies in 'turnaround' situations are less dependent on existing operational IS to achieve either short or long-term objectives, but new applications under development are vital for the company's strategic objectives. 'Factory' companies are heavily dependent on IS for effective operations but applications development portfolios are unlikely to affect the company's ability to compete. In a 'support' situation, IS play a distinctly supporting role with neither applications portfolios nor existing IS operations fundamental to the company's strategic success.

The most useful application of the 'strategic grid' is to characterise the different positions of various business units within an organisation.

Porter and Millar's [126] 'information intensity matrix' is a second example of a positioning framework. The matrix (see Figure 3.7) uses the differences in the role and intensity of information to distinguish between various industries.

The matrix is an arrangement of four cells, each cell representing a relationship between the value chain, or processes, and the product. The greater the information content in either of these elements, the greater the importance of IT. The banking and newspaper industries have a high information content in both product and process, and so are positioned in the 'high-high' quadrant of the matrix. Oil refining has a high information content in its process but a relatively low level in the product. Cement has both a low level of information content in the product and the processes and so is positioned in the 'low-low' quadrant of the matrix.

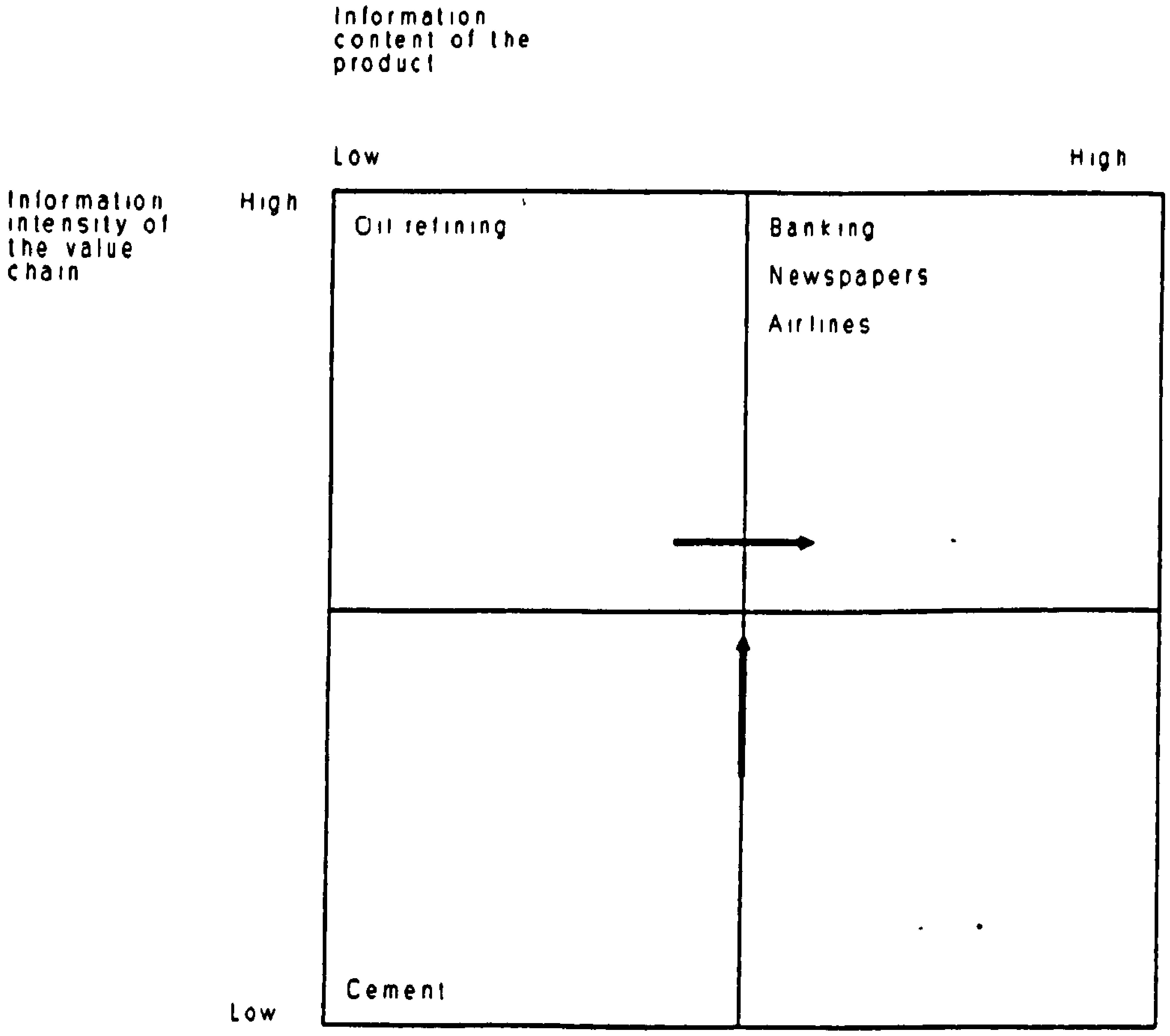


FIGURE 3.7 - Porter & Millar's 'information intensity matrix' [126]

Like McFarlan et al's [108] 'strategic grid', the 'information intensity matrix' is useful as an industrial configuration tool, and as Silk [140] suggests, as an aid to identifying very broadly where information is important in what an enterprise does. However, the matrix is not evaluative, and reveals very little about managing the information resource.

Earl [42] recommended the use of positioning frameworks to determine how to manage IT appropriately and strategically, and commented that future positioning frameworks should seek to assess not only the strategic importance of IT but also factors such as organisation structure, management style, dominant technology and business environment. In order to begin to address these needs, Earl [42] developed a framework that "seeks to indicate a preferred mode of IT strategic planning according to the IT strategic context in which the firm or business unit is placed".

This framework is depicted in Figure 3.8.

Strategic context	**Characteristic**	**IT strategic planning**
IT is the means of delivering goods and services in the sector	Computer-based transaction systems underpin business operations	Infrastructure-led
Business strategies increasingly depend on IT for their implementation	Business and functional strategies require a major automation, information, communications capability and are made possible by these technologies	Business-driven
IT potentially provides new strategic opportunities	Specific applications or technologies are exploited for developing business and changing way of managing	Mixed

FIGURE 3.8 - Earl's modes of IT strategic planning [42]

The first row of the framework indicates that in companies where IT is the means of delivering goods and services, such as banking, IT strategic planning should focus investment on efficient and integrated technological infrastructure. IT strategic planning should be business-driven in companies that depend on IT for the implementation of business strategies as indicated in the second row. The last row concerns companies where IT potentially provides new strategic opportunities and a mixed IT strategic planning approach is recommended.

3.2.4 - Frameworks for Analysis - A Critique

The frameworks described above have been developed by recognised authorities in the field of strategic IS and are recognised approaches for incorporating strategic concerns into the IS development process, for identifying appropriate business areas for IS investment, for identifying strategic and operational IS improvement opportunities, and for enhancing the status of IS within organisations. Most of the frameworks are conceptual and descriptive rather than practical and prescriptive. Earl [42] describes them*** as "maps and rubrics" rather than "practical offering tools". Indeed, most frameworks are long on rhetoric and short on application. When confronted with the result of such an analysis, even the most easily pleased of industrialists is likely to be disappointed by its banality and sheer obviousness. The four-cell matrix is a recurring theme, and although simplicity is a virtue lacking in many approaches to IS strategy formulation (see Section 3.3 - Strategy Formulation Methodologies), the production of such a simple framework, no matter how perceptive the underlying analysis, is likely to be treated as trivial.

Earl [42] is the only author to have made a concerted attempt to categorise IS frameworks, and examine and assess the "theoretical validity and practical utility" of a range of frameworks. Several other authors have eulogised about 'frameworks for analysis'. Ives and Learmonth [76], for instance, describe and offer opinion on McFarlan and McKenney's [108] 'strategic grid', Parsons' [122] 'impact framework' and Benjamin et al's [12] 'strategic opportunities framework'; and Silk [140], Breuer et al [23] and MacDonald [101] describe and comment upon the use of Porter and Millar's [126] 'value chain' and/or 'information intensity matrix'. However, in general, evaluative comment is rare and few attempts have been made to improve upon the existing framework-set.

*** Earl's analysis did not cover Porter & Millar's 'information intensity matrix' [17], nor the work of Silk [140], and Lei & Sobol [95].

Using an IS framework to help articulate what IS can do for a business, identify where IS opportunities lie or reveal how to exploit opportunities is a very useful concept and enticing proposition. Thus the simplicity of the existing frameworks belies the importance of their function. There are also a number of deficiencies with the existing set. Existing awareness frameworks are too basic and general to practically articulate what is possible. Wide applicability is necessary from a single framework but such frameworks still need to maintain a level of integrity and detail that is conducive to real application. Both Parsons' [122] and Benjamin et al's [12] frameworks incorporate basic industrial classifications. A more sophisticated and useful classification is used by Lei and Sobol [95], yet richer and more varied descriptions of the actual exemplar IS applications are needed. Lei and Sobol's [95] framework should also be commended for using IS rather than IT as its basis for analysis.

Existing positioning frameworks are equally, and in this case quite appropriately, simplistic and general, yet lack depth of analysis. McFarlan et al's [47] 'strategic grid', Porter and Millar's [126] 'information intensity matrix' and even Earl's [42] 'modes of IT planning' framework state the obvious. A wider and more revealing remit is required from any future developments.

Opportunities frameworks are potentially the most valuable of the three sets. Having the ability to match an inventory of IS applications with specific application areas is a key element of any approach to strategic IS development. This is the only type of framework from those currently available that could be considered to be a potential mechanism for formulating IS strategies. However, there is an exaggerated respect for the value chain, and the CRLC is difficult to comprehend. Without acknowledgement of business objectives or explicit and detailed guidelines and templates for application, neither can realistically identify or prioritise opportunities for IS investment.

In short, frameworks are potentially valuable tools for dealing with awareness of

strategic] ; framework (a
practical ı that support the
execution on serious about
the value rameworks lack
prescripti ı be said of the
present s(strategic IS area.

3.3 - STRATEGY FORMULATION METHODOLOGIES

IS strategy formulation is a vital activity, requiring perceptive analysis and discerning techniques. It is by no means a simple task. Mintzberg [114] wrote that "there is perhaps no process in organisations that is more demanding of human cognition than strategy formulation". Frameworks lack prescription and substance, are subject to misinterpretation and, as such, are unsuitable as lone strategy formulation instruments.

A methodology is generally a better proposition for ensuring the strategic and focused application of IS. A methodology is "an ordered set of techniques and supporting procedures with a resultant set of integrated deliverables and supporting documentation" [63]. Methodologies are generally prescriptive and multi-faceted. Evans [48] reported that a good methodology should consist of a set of guidelines which contains:

- lists of tasks to be carried out, from which an appropriate selection can be made to tackle the job in hand;
- a structure (which may be prescriptive) which links the tasks together;
- techniques which will ensure accurate and meaningful deliverables from the tasks.

Several authors have promoted the need for an IS strategy formulation methodology [48, 92, 103]. In particular, Lederer and Gardiner [92] suggested that in order for managers to better understand IS strategy formulation, it is necessary to examine it within the context of a specific methodology, and Lederer and Putnam [93] posited that the best way to avoid the problems associated with the traditional approach to developing IS is to adopt a formal systems planning methodology. Referring to strategic IS planning, Evans [48] suggested that a methodology provides significant gains in productivity by:

- reducing a potentially very large exercise to manageable timescales through strict application of the task list;
- managing the analysis and techniques of business functions, departments and data through a coherent structured approach.

A number of IS strategy formulation methodologies exist. Each one is a multi-step process. A very simple classification of these existing methodologies and a numbering system indicating relative publication chronology is depicted in Figure 3.9.

Individual consultancy approaches	**Company consultancy approaches**
2. Critical Success Factor (CSF) approach [20, 131, 132] 6. Lucht's method [99] 8. Tozer's method [145]	1. Business Systems Planning [73, 74] 3. Information Engineering [104, 105] 4. SVA [30, 31] 5 Tetrarch [120] 7. Method/1 [2] 9. CASE*Method [118]

FIGURE 3.9 - IS strategy formulation methodologies

Organisations will often purport to use their own unstructured approach to procuring IT and developing IS. Most of these approaches typically begin at a low, functional level of detail, for which techniques such as process modelling using data flow diagrams (DFDs), data modelling using entity relationship diagrams (ERDs) and decomposition diagrams using structure charts are widely used and well developed. Quite often, they have pre-determined and pre-formulated technology solutions and the objective of the analysis becomes a search for a suitable problem to match this solution. However, the lack of effective mechanisms for linking IS development with business strategy is the key failing of such approaches. In short, they are not strategy formulation approaches at all, but the very opposite - narrow, ad hoc specifications for IS development in particular functional areas. Methodologies such as Structured Systems Analysis and Design Method (SSADM) [40], Structured Analysis and Design Technique (SADT) [135] and Jackson Systems Development (JSD) [78] have been developed to specifically address such issues and formulate such specifications. Galliers [52] suggests that a significant proportion of the approaches adopted might be described as either reactive (i.e. they are little more than an attempt to match the supply of IS and technology with demand) or informal (i.e. they are ad hoc in nature with little real pattern and unclear objectives). Although these organisations might achieve their strategic goals without a detailed planning methodology, they may be missing the opportunity to do even better [93].

Occasionally, organisations develop their own strategy formulation methodology internally. More often they select and customise an existing one, or carry out their planning study with consultants from the vendor of the methodology [92].

Lederer and Gardiner [92] represent the IS strategy formulation process as an input-process-output function (see Figure 3.10), where a strategic planning methodology converts, amongst other things, business plans and technology trends inputs into the strategic information plan of proposed applications output. The plan ultimately affects the success of the organisation, which in turn becomes an input to future planning activities.

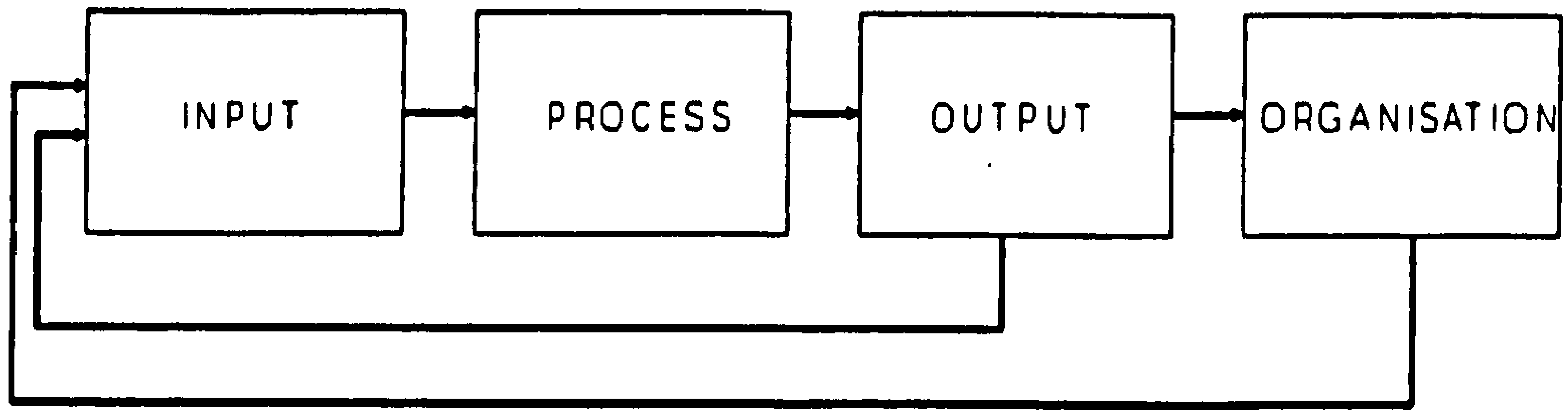


FIGURE 3.10 - IS strategy formulation as an input-process-output function (Lederer and Gardiner [92])

In this section, a chronological synopsis of each of the existing methodologies and a discussion of their relative strengths and weaknesses is offered.

3.3.1 - Business Systems Planning

IBM's Business Systems Planning (BSP) approach is a comprehensive strategy formulation methodology. It was the earliest developed systems planning methodology; first made available to IBM customers in 1970 [93]. There have since been a number of revisions to the methodology. The methodology was developed as a consequence of IBM's own mistakes in implementing large IS [93]. IBM defines BSP as a structured approach to assist an organisation in establishing an IS plan to satisfy its short and long-term information requirements. Other objectives include:

- impartially determining IS priorities,
- planning long-lived IS based on enduring business processes,
- managing systems resources to support business goals,
- assigning systems resources to high-return projects,
- improving user department and IS department relations, and
- improving understanding of the need to plan IS [93].

BSP is based on three fundamental tenets:

1. Establishment of a business-wide perspective
2. Top-down analysis, bottom-up implementation
3. Systems and data independence

The BSP approach emphasises the importance of a general management vantage point for systems planning [73, 74]. A wide-scope perspective forms one of the major distinctions between IS strategy formulation approaches and the more traditional IS requirements specification approaches. This principle, in itself, therefore, is certainly not unique. Business objectives are global, not localised; so, by virtue of the very nature of IS planning, a wide perspective is necessary to cater for the influences of these objectives. However, addressing IS development from a total rather than a functional viewpoint was original and particularly novel when BSP was developed.

BSP promotes a top-down analysis of a business for planning the development of IS, followed by bottom-up IS design and implementation. In order to conduct a top-down analysis of the business, the team carrying out the study first attains a knowledge of business objectives and the problems faced by the business in meeting these objectives. This is followed by identification, or definition if necessary, of the processes performed by the business to enable it to meet its objectives. Identification of the information and related broad classes of data required to support these processes completes the analysis. These key elements and their relationship are shown in Figure 3.11.

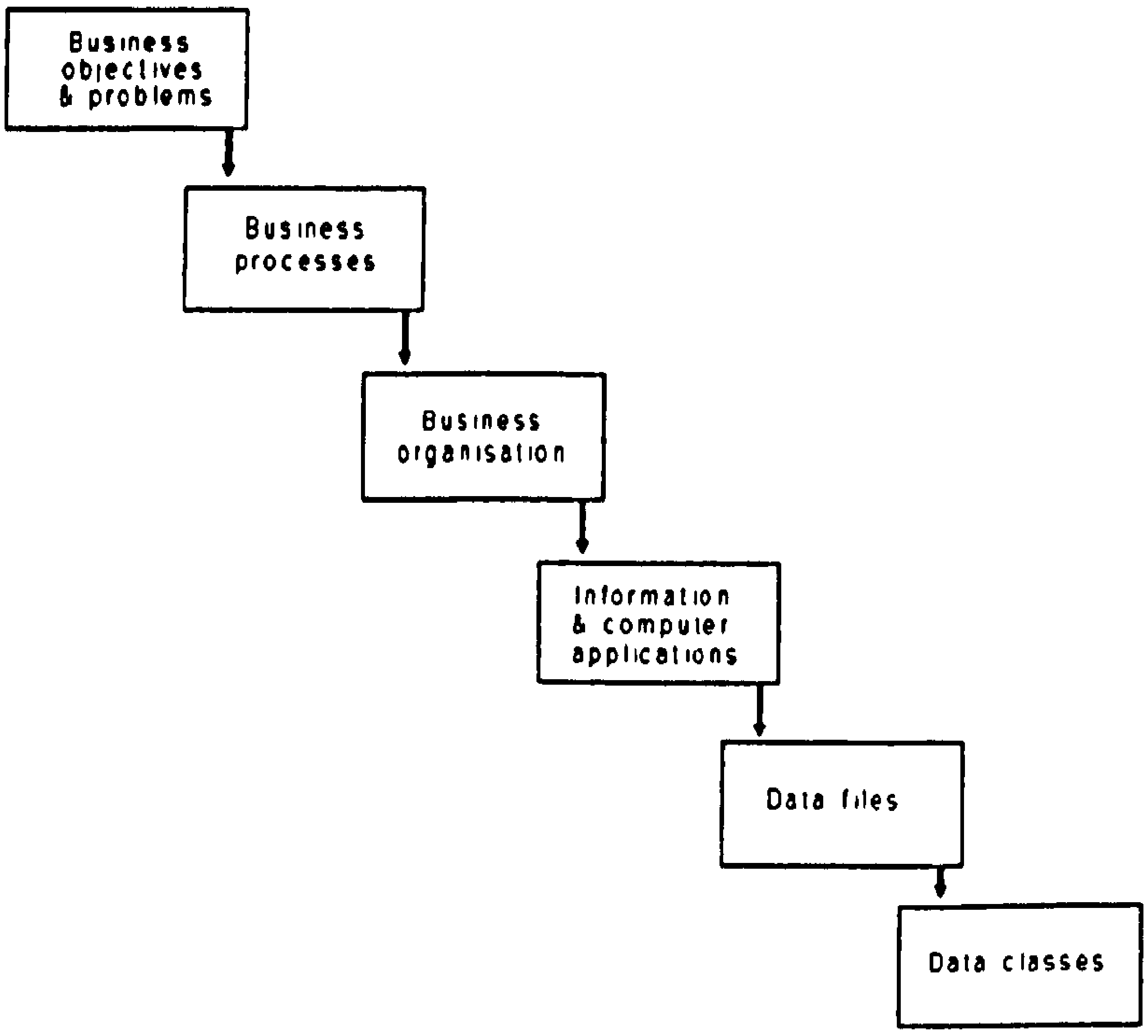


FIGURE 3.11 - Elements in top-down analysis [74]

The BSP approach becomes bottom-up oriented during the follow-on design and implementation of specific IS. In the bottom-up analysis, each of the elements, apart from two, in the top-down analysis, are again analysed, designed and/or implemented. The first exception is the exclusion of the business organisation; instead, the data provided by a designed IS network is related directly to the business processes. The network of IS is built around the business processes essential to achieving business objectives. The second exception is the data files, which are replaced in IS design by a data base [73]. These key elements and their relationship are shown in Figure 3.12.

The third plank upon which BSP is based is to define IS so that data is independent of the organisational structure of the business. Systems designed to support specific organisation structures often become obsolete and must be re-designed when the organisation changes [74].

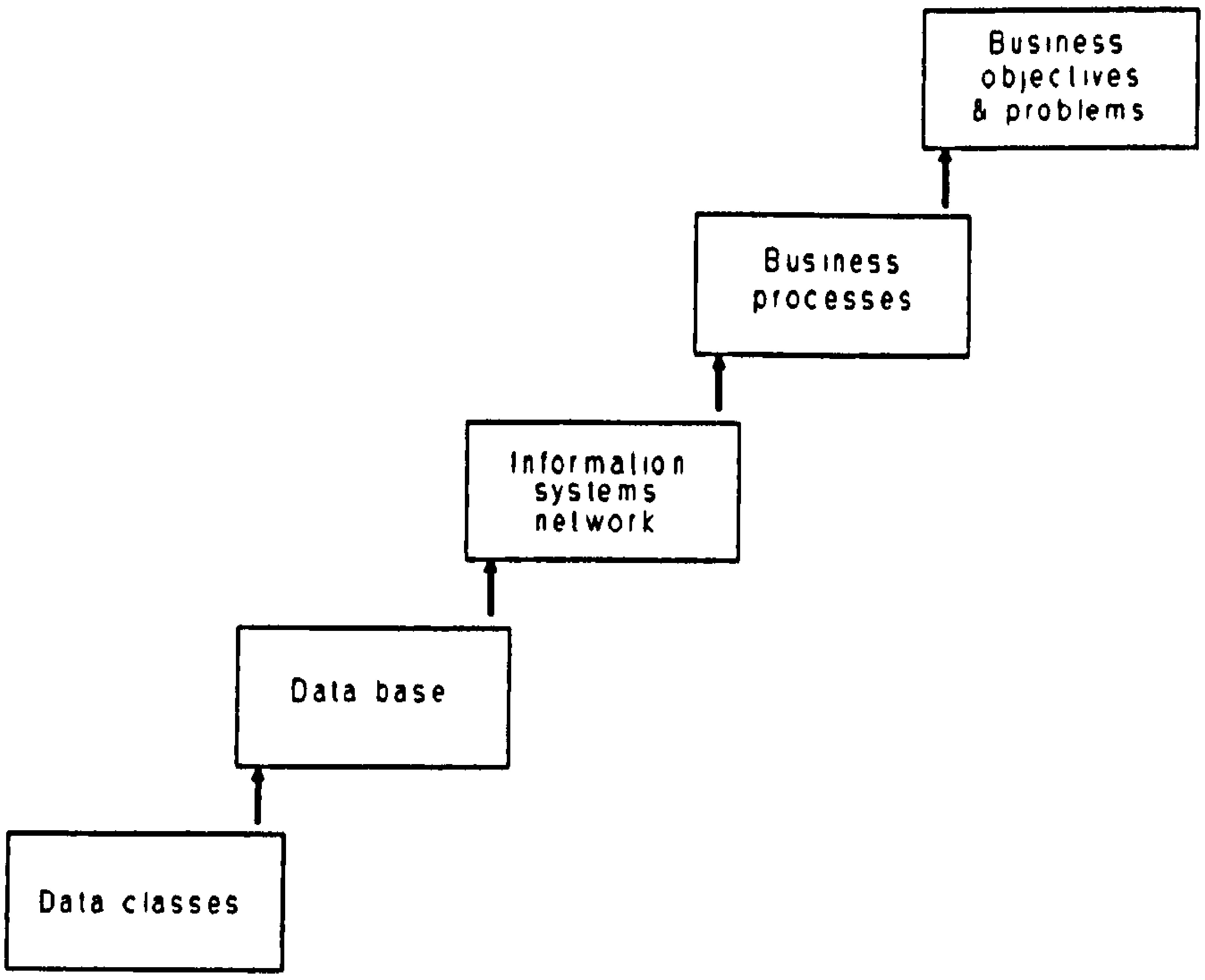


FIGURE 3.12 - Elements in bottom-up analysis [74]

On the other hand, desirable organisational changes may be prevented from taking place because of the rigidity of certain systems. BSP advocates that, where possible, systems should be defined to be independent of specific organisation structure. This principle implies that the business processes, or "the fundamental and non-changing areas around which a business is based" [74], are the foundation upon which a BSP study should be based. Proper identification, and definition of these processes is the key to achieving organisational independence [73, 74].

BSP addresses the first two phases (Identification and Definition) of IBM's concept of the systems development life-cycle. The following list illustrates how these two phases fit into the overall cycle:

Phase 1 - Identification of Requirements
Phase 2 - Definition of Requirements
Phase 3 - General Design
Phase 4 - Detailed Design
Phase 5 - Development and Test

Phase 6 - Installation

Phase 7 - Operation

The total business 'disturbance' caused by a BSP study necessitates executive sponsorship and approval of the study process. An executive sponsor is assigned to oversee the BSP study. After which, a study team is selected to carry out the Identification Phase. The team should comprise a team leader with broad experience of the business and the respect of top management, a manager or senior systems analyst from the IS department and an undefined number of other team members with particular skills and knowledge of the business being studied. IBM BSP consultants assist the team in undertaking the methodology.

In carrying out the Identification Phase, the team is expected to: .

- develop an overall understanding of the business;
- understand how IS currently supports the business;
- identify a gross network of IS that will support the business;
- identify the first or most needed subsystems to be implemented within the network;
- develop an action plan for the Definition Phase [73].

Four major activities are performed to meet the objectives of the Identification Phase. These activities and their key tasks are listed in Figure 3.13.

The 'action plan' and the 'study team orientation' ensure that 'who does what and when' is properly defined, interview lists are compiled, and adequate exposure and knowledge of the BSP mechanisms, techniques and implications are obtained by each of those administering, involved or in any way affected by the study. Both of these tasks should be completed as soon as executive commitment to the BSP study has been gained. The 'announcement to executives' is a formal recognition of the level of executive involvement in BSP. This usually comprises a letter emphasising the support that top management has given to the study. The letter is distributed to all managers who control the major functions to be analysed.

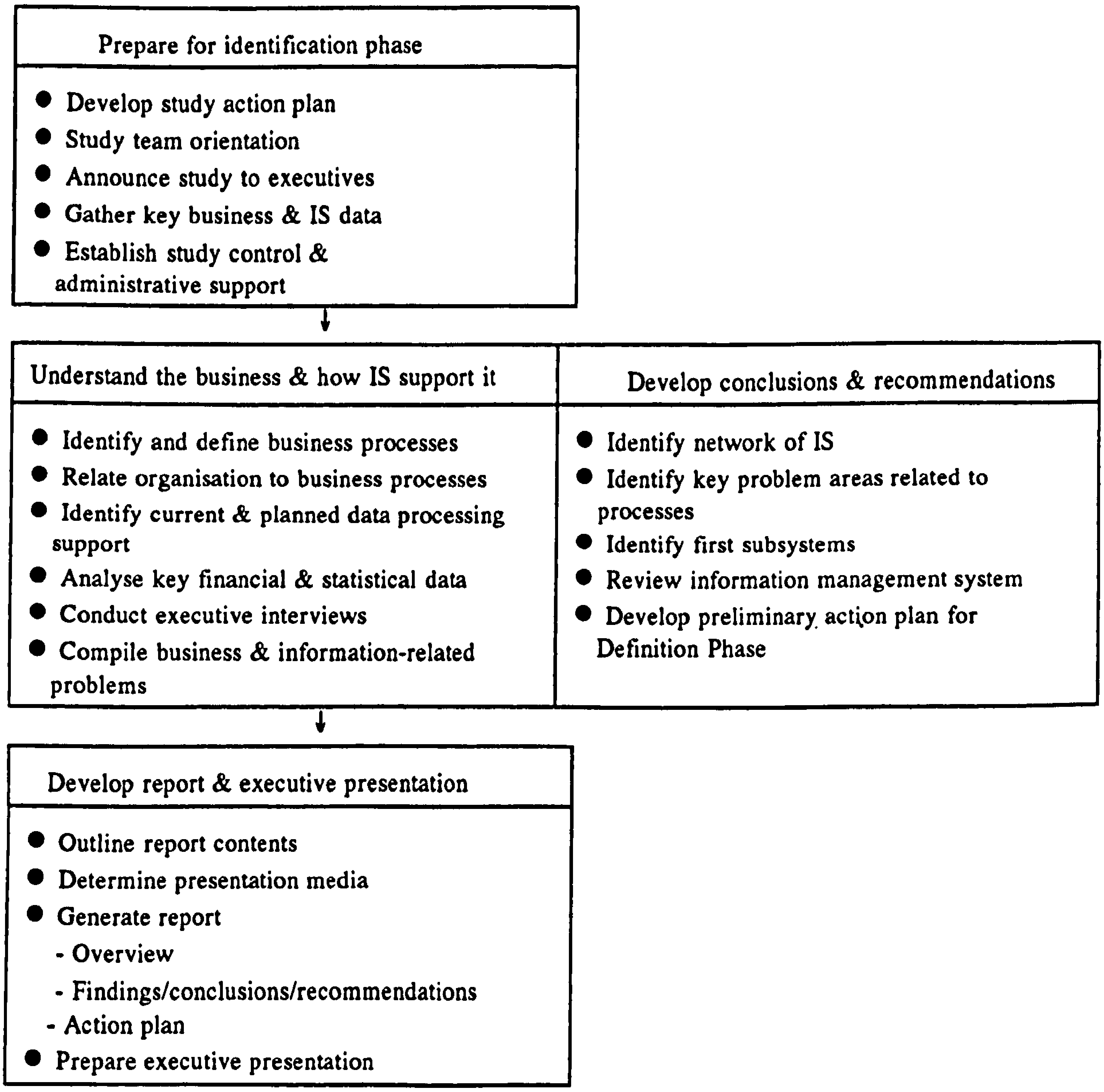


FIGURE 3.13 - BSP Identification Phase activities (IBM [74])

Preliminary data gathering is carried out by the team and presented in summary form to each team member. This presentation helps team members understand business direction, products, markets and how IS currently support the business. This understanding is from a general rather than functional management perspective.

The second major BSP activity is for the study team to understand the business and how IS currently support the business. The first task, defining business processes, involves identifying "the essential decisions and activities required to manage and administer the resources and operations of a business" [74]. Proper identification of these business processes is critical to subsequent tasks, so failure to do so will reflect in all later stages of the methodology. BSP provides guidelines to help business process identification. For example, when defining business processes, team members are advised to ignore the existing organisation structure so as not to align business processes with a possible transient entity. Examples of business processes are marketing, manufacturing and distribution. Each process includes several sub-processes; for example, manufacturing includes production scheduling, expediting and vendor selection.

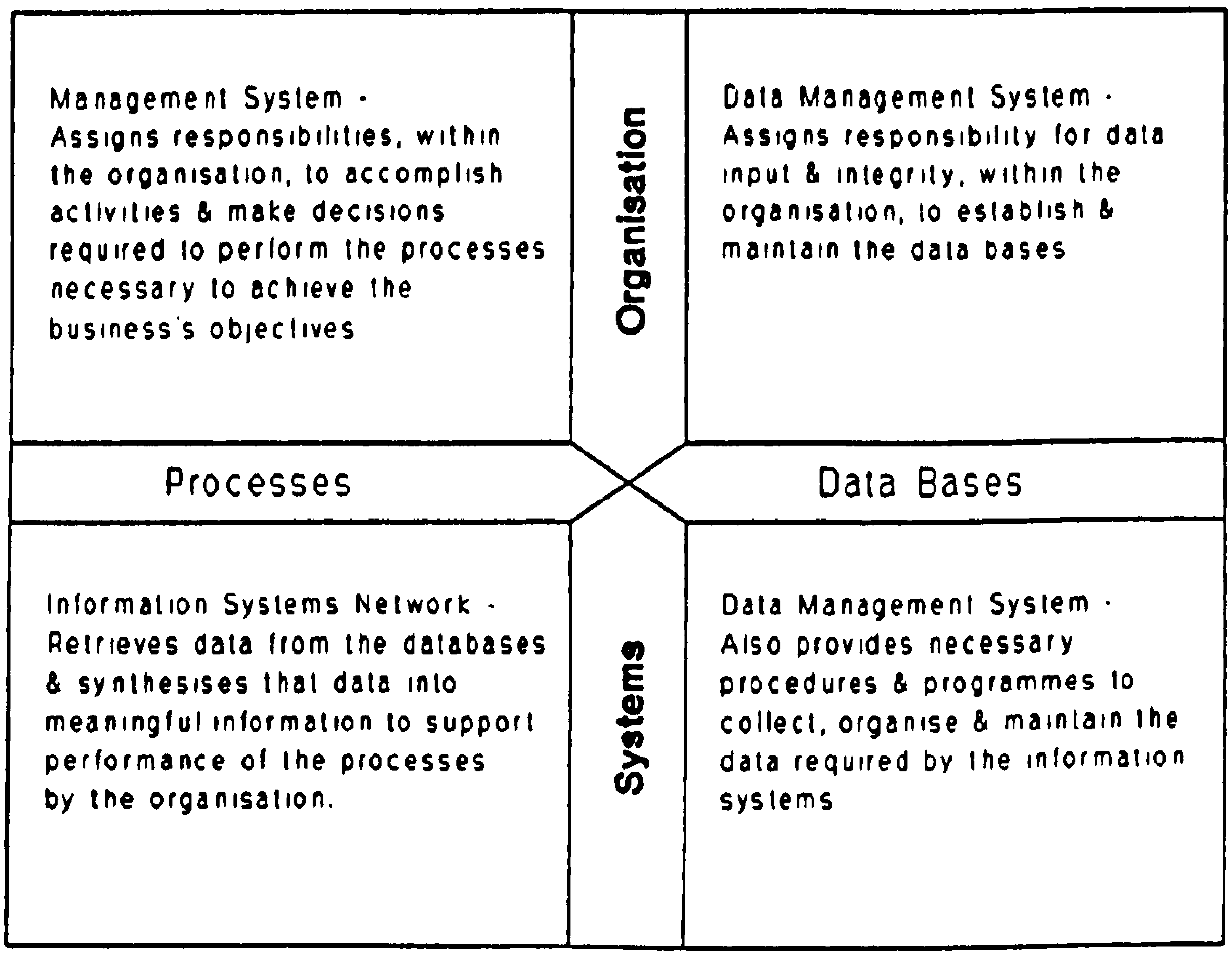
Once the processes have been defined, a matrix (organisation-to-process) is constructed to represent the relationship between these processes and the organisational entities that perform them. There is no set number of organisational units. Numbers depend purely on the size and complexity of the organisation. The degree of involvement of each organisational unit to the processes is represented by the following code:

⊗ - major responsibility and decision maker
x - major involvement in the process
/ - some involvement in the process

The matrix helps:

- identify key individuals to be interviewed
- determine questions to be asked of the individuals responsible for processes
- helps analyse needed IS that support the processes

The organisation-to-process matrix provides the first quadrant of a four-quadrant matrix relating organisational entities (and people), processes, IS, and data bases required by the business. This overall relationship is depicted in Figure 3.14.



Management System - Assigns responsibilities, within the organisation, to accomplish activities & make decisions required to perform the processes necessary to achieve the business's objectives

Data Management System - Assigns responsibility for data input & integrity, within the organisation, to establish & maintain the data bases

Information Systems Network - Retrieves data from the databases & synthesises that data into meaningful information to support performance of the processes by the organisation.

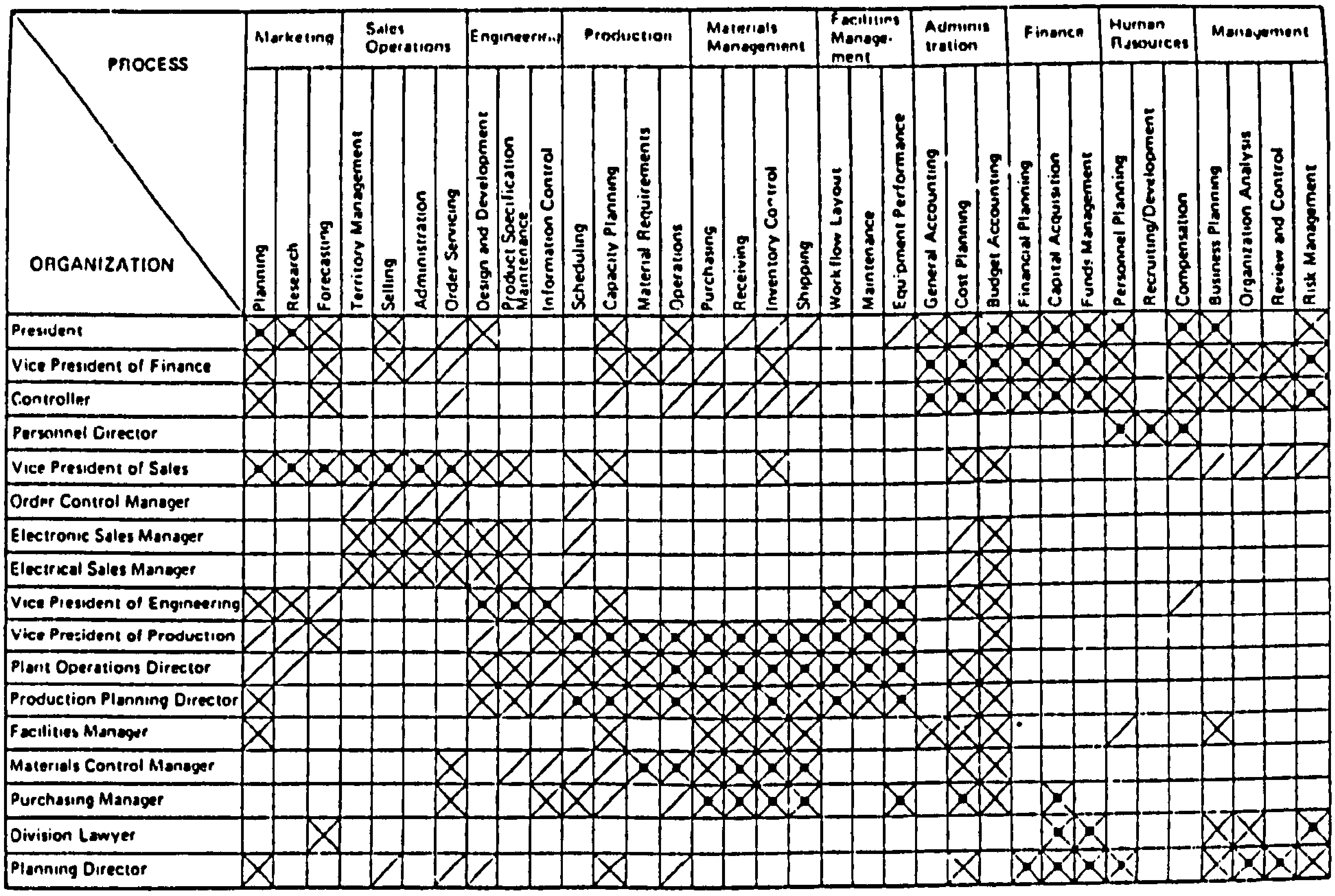
Data Management System - Also provides necessary procedures & programmes to collect, organise & maintain the data required by the information systems

FIGURE 3.14 - BSP interrelationship of management system to data management system and information system (IBM [74])

The relationship between current and planned data processing support and business processes is examined via a systems-to-process matrix and represented by the second quadrant (counter-clockwise) of the matrix shown in Figure 3.14. IBM [73] point out that the establishment of a direct relationship may be difficult as most systems and applications were (and still are) developed by, and for, individual organisational units. A letter code is used to indicate the status of an application:

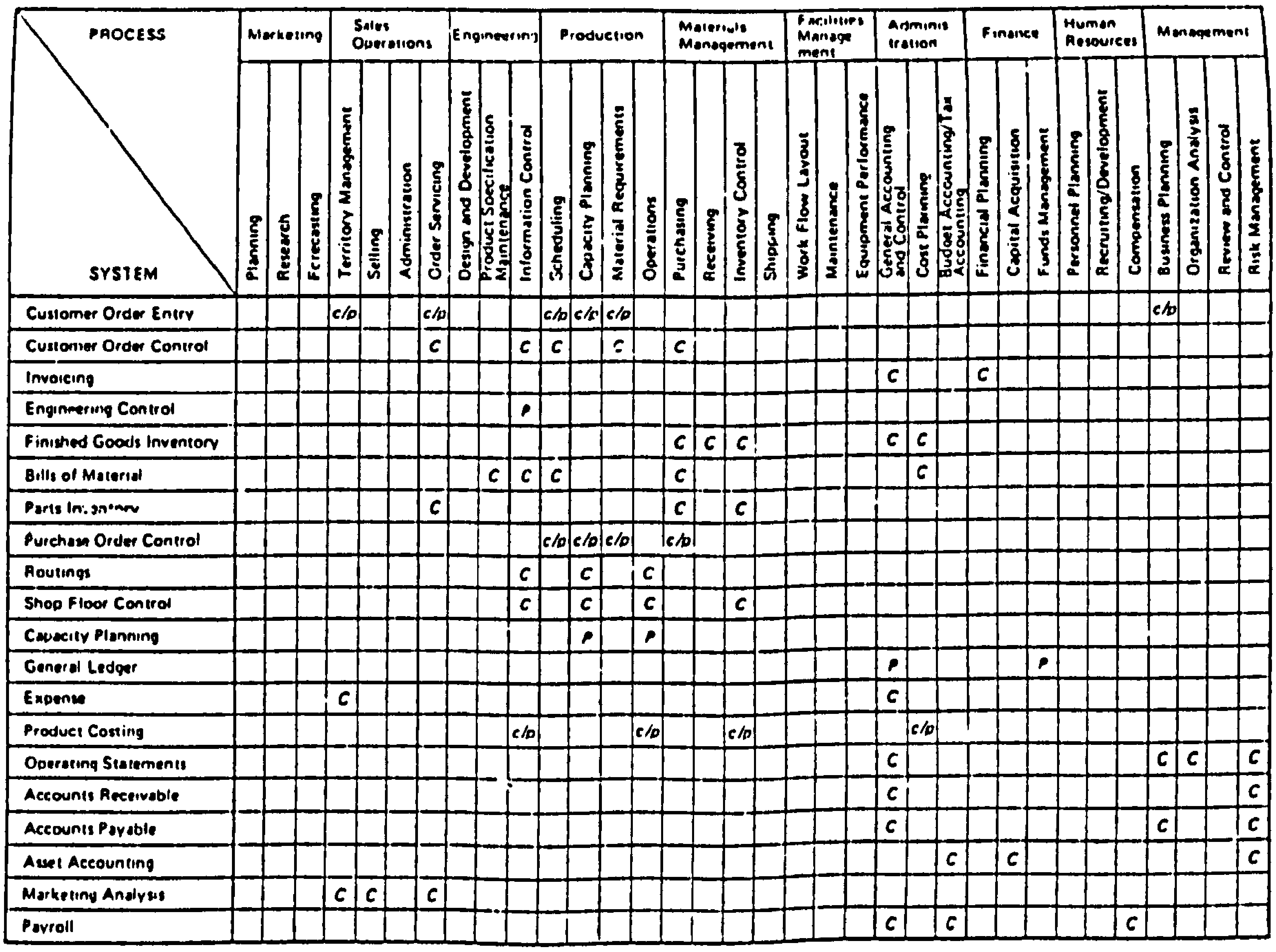
c - currently supporting a process
p - planned to support a process
c/p - system currently in place; another system planned to enhance or replace it.

The remaining two quadrants of the four-segment matrix define the relationships between systems and the data files or classes used or planned to be used to support those systems, and between the data classes and the organisation, or the people responsible for the information in each class. IBM emphasise that the using the matrices provides an excellent mechanism for easing business understanding. A related example of the four quadrants of the matrix is shown in Figures 3.15 (a), (b), (c) and (d).



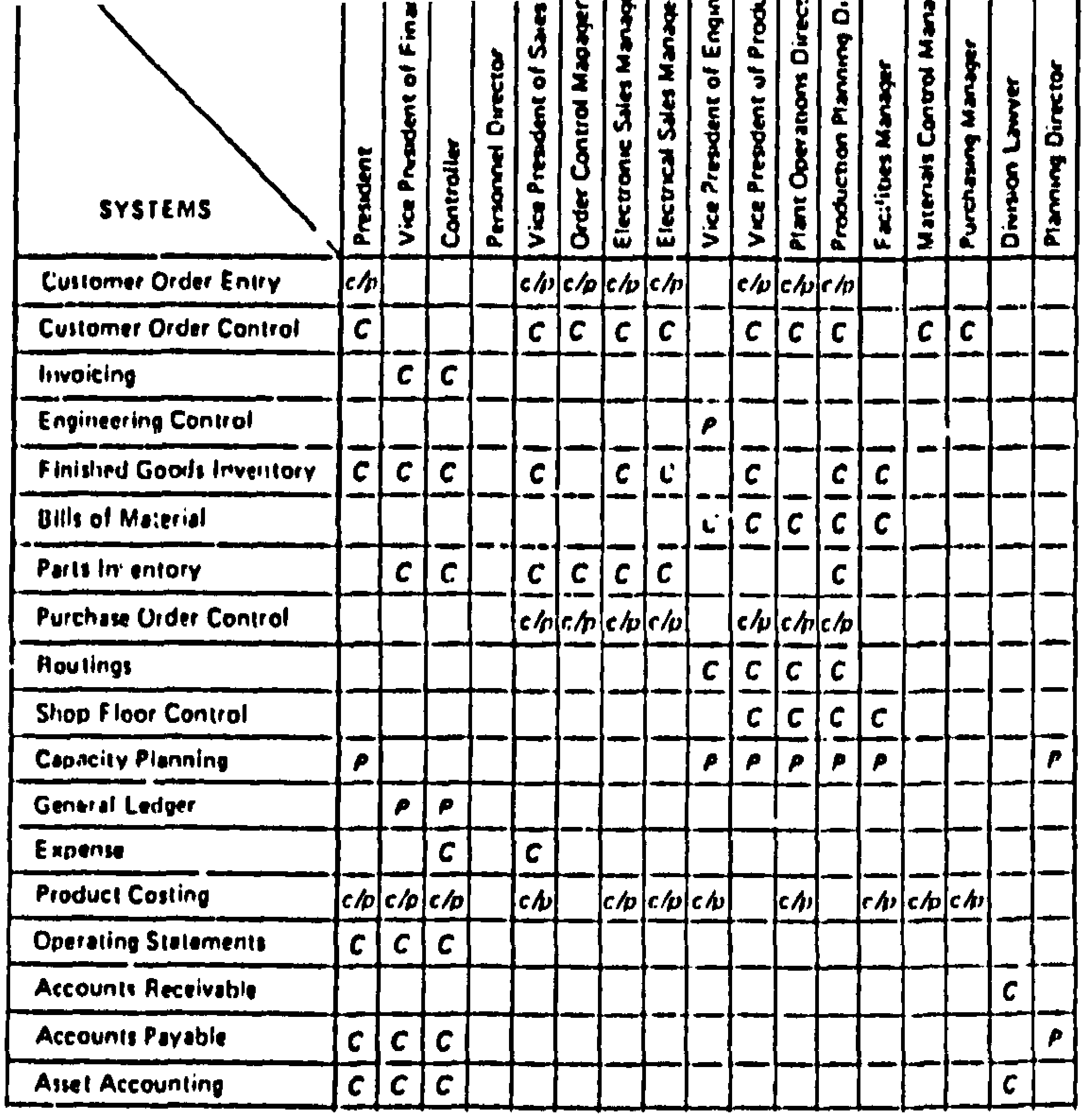
PROCESS	Marketing			Sales Operations				Engineering			Production				Materials Management				Facilities Management			Administration			Finance			Human Resources			Management			
ORGANIZATION	Planning	Research	Forecasting	Territory Management	Selling	Administration	Order Servicing	Design and Development	Product Specification Maintenance	Information Control	Scheduling	Capacity Planning	Material Requirements	Operations	Purchasing	Receiving	Inventory Control	Shipping	Workflow Layout	Maintenance	Equipment Performance	General Accounting	Cost Planning	Budget Accounting	Financial Planning	Capital Acquisition	Funds Management	Personnel Planning	Recruiting/Development	Compensation	Business Planning	Organization Analysis	Review and Control	Risk Management
President	⊗	⊗	X		X		/	X				X		X		/	/	/			/	X	⊗	⊗	⊗	⊗	⊗	⊗		⊗	⊗			X
Vice President of Finance	X		X		X	/	/					X	X	/	/		X					⊗	⊗	⊗	⊗	⊗	⊗	X		X	X	X	X	⊗
Controller	X		X				/					/		/	/	/	/	/				⊗	⊗	⊗	⊗	⊗	⊗	X		X	X	X	X	⊗
Personnel Director																												⊗	⊗	⊗				
Vice President of Sales	⊗	⊗	⊗	⊗	⊗	⊗	⊗	X	X		\	X					X						X	X						/	/	/	/	/
Order Control Manager				/	/	/	/				/																							
Electronic Sales Manager				X	X	X	X	X	X		/												/	X										
Electrical Sales Manager				X	X	X	X	X	X		/												/	X										
Vice President of Engineering	X	X	/					⊗	⊗	⊗		X							⊗	⊗	⊗		X	X						/				
Vice President of Production	/	/	X					/	/	X	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗			X										
Plant Operations Director	/	/						X	X	/	X	X	X	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗		X	X										
Production Planning Director	X							X	X	/	⊗	⊗	X	⊗	X	X	⊗	X	⊗	X	⊗		X	X										
Facilities Manager	X											X			X	X	X	X				X	X	X				/			X			
Materials Control Manager							X		/	/	/	/	⊗	⊗	X	⊗	⊗	⊗					X	X										
Purchasing Manager							X			X	X	/		/	⊗	⊗	⊗	⊗			⊗		⊗	X		⊗								
Division Lawyer			X																							⊗	⊗				X	X		⊗
Planning Director	X				/		/	/				X		/									X		⊗	⊗	⊗	⊗			X	⊗	⊗	X

FIGURE 3.15(a) - Process/organisation matrix (IBM [73])



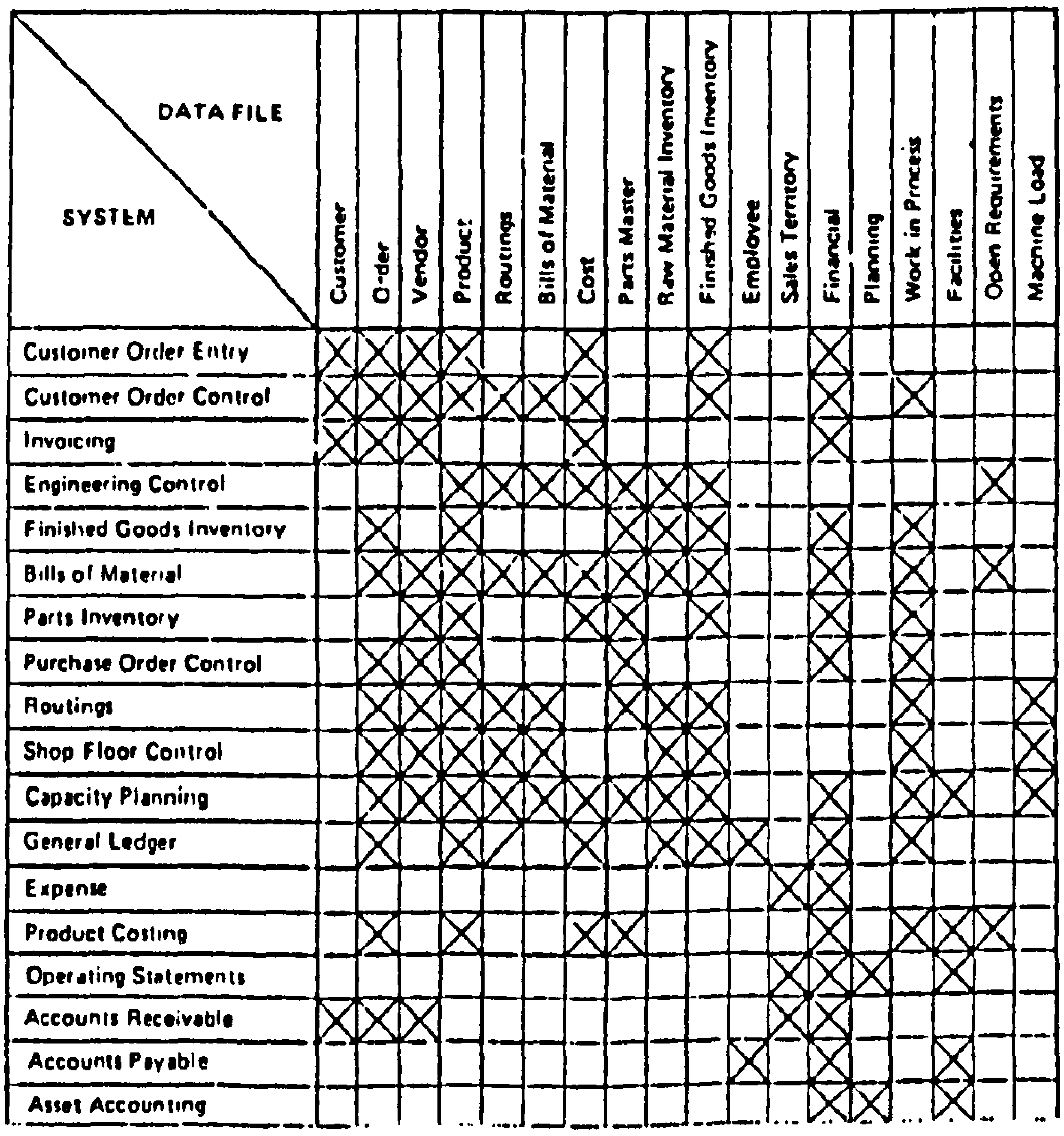
PROCESS	Marketing			Sales Operations				Engineering			Production				Materials Management				Facilities Management			Administration			Finance			Human Resources			Management			
SYSTEM	Planning	Research	Forecasting	Territory Management	Selling	Administration	Order Servicing	Design and Development	Product Specification Maintenance	Information Control	Scheduling	Capacity Planning	Material Requirements	Operations	Purchasing	Receiving	Inventory Control	Shipping	Work Flow Layout	Maintenance	Equipment Performance	General Accounting and Control	Cost Planning	Budget Accounting/Tax Accounting	Financial Planning	Capital Acquisition	Funds Management	Personnel Planning	Recruiting/Development	Compensation	Business Planning	Organization Analysis	Review and Control	Risk Management
Customer Order Entry				c/p			c/p				c/p	c/p	c/p																		c/p			
Customer Order Control							c			c	c		c		c																			
Invoicing																						c			c									
Engineering Control										p																								
Finished Goods Inventory															c	c	c					c	c											
Bills of Material									c	c	c				c								c											
Parts Inventory							c								c		c																	
Purchase Order Control											c/p	c/p	c/p		c/p																			
Routings										c		c		c																				
Shop Floor Control										c		c		c			c																	
Capacity Planning												p		p																				
General Ledger																						p					p							
Expense				c																		c												
Product Costing										c/p				c/p			c/p						c/p											
Operating Statements																						c									c	c		c
Accounts Receivable																						c												c
Accounts Payable																						c									c			c
Asset Accounting																								c		c								c
Marketing Analysis				c	c		c																											
Payroll																						c		c						c				

FIGURE 3.15(b) - Process/system matrix (IBM [73])



SYSTEMS	President	Vice President of Fina	Controller	Personnel Director	Vice President of Sales	Order Control Manager	Electronic Sales Manag	Electrical Sales Manage	Vice President of Engi	Vice President of Produ	Plant Operations Direc	Production Planning D	Facilities Manager	Materials Control Mana	Purchasing Manager	Division Lawyer	Planning Director
Customer Order Entry	c/p				c/p	c/p	c/p	c/p		c/p	c/p	c/p					
Customer Order Control	C				C	C	C	C		C	C	C		C	C		
Invoicing		C	C														
Engineering Control									P								
Finished Goods Inventory	C	C	C		C		C	C		C		C	C				
Bills of Material									C	C	C	C	C				
Parts Inventory		C	C		C	C	C	C				C					
Purchase Order Control					c/p	c/p	c/p	c/p		c/p	c/p	c/p					
Routings									C	C	C	C					
Shop Floor Control										C	C	C	C				
Capacity Planning	P								P	P	P	P	P				P
General Ledger		P	P														
Expense			C		C												
Product Costing	c/p	c/p	c/p		c/p		c/p	c/p	c/p		c/p		c/p	c/p	c/p		
Operating Statements	C	C	C														
Accounts Receivable																C	
Accounts Payable	C	C	C														P
Asset Accounting	C	C	C													C	

FIGURE 3.15(c) - Organisation/system matrix (IBM [73])



SYSTEM / DATA FILE	Customer	Order	Vendor	Product	Routings	Bills of Material	Cost	Parts Master	Raw Material Inventory	Finished Goods Inventory	Employee	Sales Territory	Financial	Planning	Work in Process	Facilities	Open Requirements	Machine Load
Customer Order Entry	X	X	X	X			X			X			X					
Customer Order Control	X	X	X	X	X	X	X			X			X		X			
Invoicing	X	X	X				X						X					
Engineering Control				X	X	X	X	X	X	X							X	
Finished Goods Inventory		X		X				X	X	X			X		X			
Bills of Material		X	X	X	X	X	X	X	X	X			X		X		X	
Parts Inventory			X	X			X	X		X			X		X			
Purchase Order Control		X	X	X				X					X		X			
Routings		X	X	X	X	X		X	X	X					X			X
Shop Floor Control		X	X	X	X	X			X	X					X			X
Capacity Planning		X	X	X	X	X	X	X	X	X			X		X	X		X
General Ledger		X		X	/		X		X	X	X		X		X			
Expense												X	X					
Product Costing		X		X			X	X					X		X	X	X	
Operating Statements												X	X	X		X		
Accounts Receivable	X	X	X									X	X					
Accounts Payable											X		X			X		
Asset Accounting													X	X		X		

FIGURE 3.15(d) - System/data file matrix (IBM[73])

IBM [73, 74] point out that the matrices provide an overview of the current and planned IS support for the business, but do not indicate the degree of support and the value of such support to each of the processes. The intention is that this information should be obtained from executive interviews regarding problems with current systems support and additional needs for information. These interviews help prioritise IS enhancements.

Priorities for identifying the first subsystems to be developed rest on the judgement of the study team leader and team members. Executive interviews are the primary source of information for determining the business problems and management's need for overcoming the problems. These interviews and their subsequent analysis are the most time-consuming aspects of the Identification Phase. (Key financial and statistical data, obtained as part of the original orientation package also help in the problem identification process by helping the team understand how resources are currently committed by examining investments, inventory, personnel, equipment, etc [74]).

Common questions for executives relate to responsibilities, objectives, methods for determining resource allocation effectiveness, anticipated changes, information satisfaction and needs emphasising the additional costs that may be incurred from inaccurate and untimely information, and the value of any additional information desired. Business and information-related problems are documented using a chart similar to the one shown in Figure 3.16.

Organisation	Problem Example	Impact	Need/ Recommendation	Value/Benefit
Business affairs	The annual financial report requires weeks to compile from the manually maintained general ledger.	The production of this report requires attention of highly paid accountants when financial data for this report could be produced by a properly designed financial system.	Design a general ledger system that would automatically provide the financial reports.	Financial reporting can be done more easily, quickly, and with less clerical effort.
Business office	Monthly historical budget information cannot be provided to departments and offices using current manual methods.	Departmental management must manually maintain this information.	The financial system should incorporate this capability.	Provision of a better fiscal tool for departmental manager. Reduction of need for clerical effort in departments.

FIGURE 3.16 - BSP sample problems, needs, and value statements chart [74]

Similar or related problems identified through the charts are combined to form a method of weighting areas for development.

After documenting and charting the information gathered from interviews, the study team undertakes the last major activity of the Identification Phase and develops its formal conclusions and recommendations relative to the following issues.

- Identifying a network of IS - the network should be a logical set of systems and data bases related to the decision and activity areas of the processes and sub-processes. It is a "visual description of the strategic long-range objective of the IS plan" [74]. IBM advocate the use of a simple set of generic business activities to help in the network's construction. These activities are common to most businesses:

  - demand (customer interface functions),
  - supply (supplier interface functions),
  - requirements (operations functions),
  - administration, and
  - management.

  After the construction of the network, its major problems and information needs are addressed.

- Identifying key problem areas related to business processes - problem areas that are directly related to business processes and sub-processes are grouped together. These problem areas are then expressed in terms of information deficiencies. A matrix of processes versus information deficiencies helps in assigning priorities to problem areas. The study team should attempt to weight the problems in relationship to the total business.

- Selecting the first, most-needed subsystems - priorities are determined by considering:

- return on investment (implementation cost, financial return, cost/benefit ratio);
- impact (number of people affected, qualitative effect, effect on accomplishing overall objectives);
- success (degree of business acceptance, probability of implementation, length of implementation, risk, resources available);
- demand (value of existing systems, relationship with other systems, political overtones, need).

Processes and sub-processes can be analysed as 'first-subsystem candidates' by ranking each of the four categories above on a 1-10 scale.

- Reviewing IS management capabilities - the development of integrated, business-wide data base systems may force a change in the direction of the existing IS organisation and management. Requirements for change should be identified and recommendations made.

The Identification Phase concludes with a 'consensus report' developed by the study team. The report articulates the most significant findings, conclusions and recommendations identified. These are also presented to top management.

The Definition Phase is initiated after the top management's full understanding and approval of the recommendations developed during the Identification Phase. Its primary objective is to develop a plan for the design, development and implementation of the IS network based upon data base concepts. The plan is biased towards the development of the first subsystems as recommended in the Identification Phase, but also serves as a guideline for implementation of the other IS in the network.

The Definition Phase involves six major activities:

1. Preparation

2. Interviews
3. Definition of IS network
4. Definition of first subsystems
5. Definition of IS development controls
6. Preparation of documentation

'Preparation' tasks involve study team selection and orientation, education of the team and development of an action plan. To ensure continuity, at least one of the Definition team members should also have been a member of the Identification Phase team. The team should be made up of business, IS and technical-oriented personnel. A review of the Identification Phase report is the first task carried out by each team member. The next task is to develop the action plan for the Definition Phase. The action plan contains the following:

- a study announcement plan to inform managers about the study and forewarn interviewees of required interview sessions;
- a work plan to specify what is to be done, by whom, and when;
- a financial plan indicating likely expenditure in terms of resources required for the study;
- a study review plan indicating review times for milestone and objective achievement.

'Interviews' is the next major activity. As a general rule, two levels of management below the Identification Phase interviewees are targeted for interview. Users of the first subsystems to be implemented are interviewed first. Key decisions made by the functions' major problem areas and the degree of user satisfaction with current IS support are determined. Questions are generally more detailed than those in the Identification Phase.

Defining the major systems of the IS network, and how they interrelate is the next activity. This activity builds upon the groundwork laid in the Identification Phase.

The network is developed by charting business processes, data classes, and systems groups, and showing clusters of systems that use certain data types to support processes. Data bases required to support the IS network are then defined. In this way, the processes and users that can share data are identified, and the potential for common systems across organisational entities is determined. Figure 3.17 indicates an example of the 'cluster analysis' process.

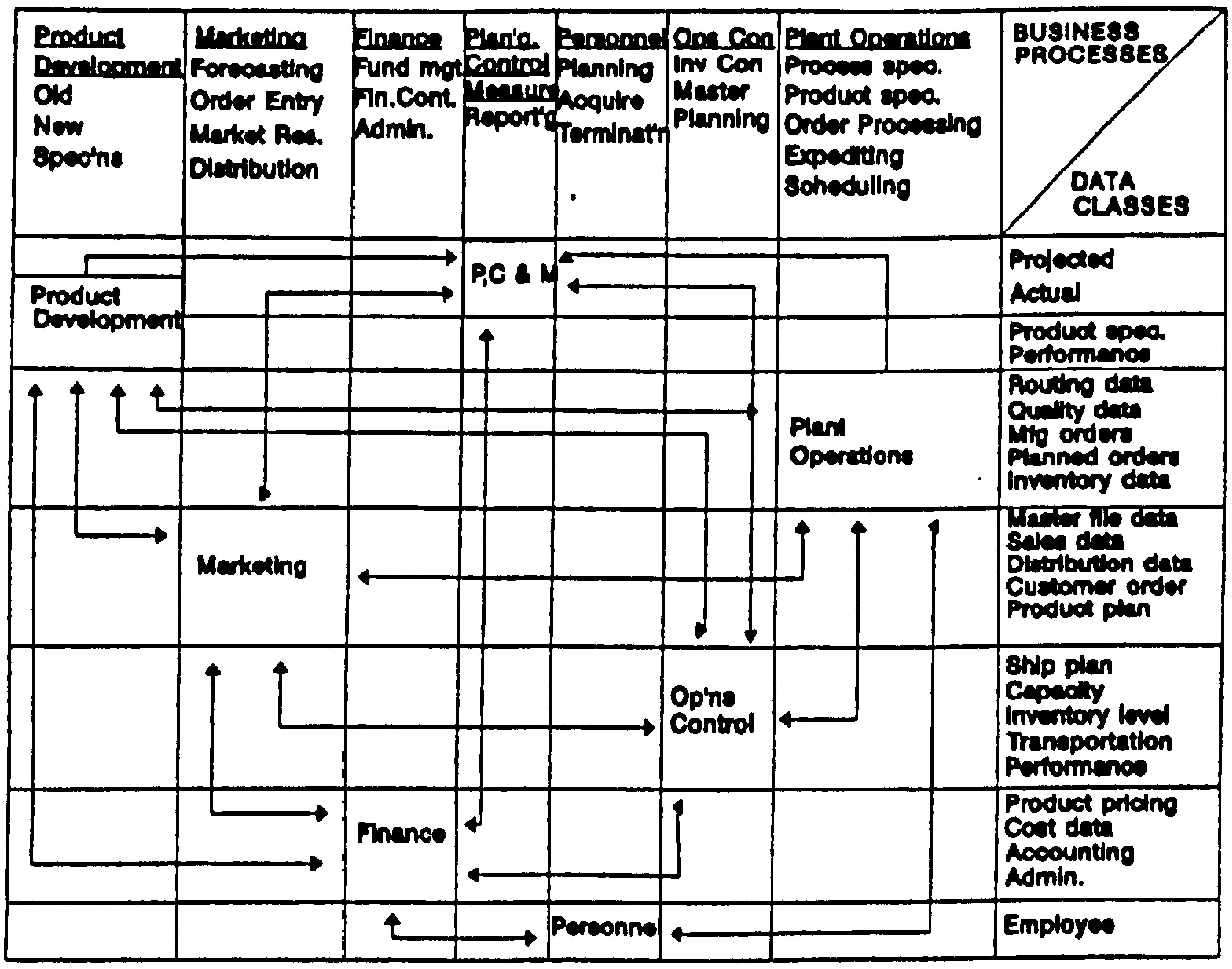


FIGURE 3.17 - BSP 'clustered' IS network (IBM [74])

Cluster analysis is again used in the next technique to define the first subsystems. The sub-processes and data bases that compose the sub-systems are described and the relationships between these sub-processes and data bases are determined. Flowcharts are used to augment the subsystem description. Estimates of resource requirements including equipment must also be considered for the first subsystems.

Deficiencies in IS development controls are addressed in the fifth Definition Phase activity. This includes a rigorous review of the adequacy of the existing organisation structure to support the IS network, the extent to which revisions can be made to the

IS plan, the establishment of standards for data base administration and structure, and the control and measurement of network implementation. This latter activity includes the establishment of controls for allocating funds, phase reviews and auditing.

The final activity of the BSP methodology is to prepare the Definition Phase documentation. The documentation should consist of an executive summary outlining the major findings, conclusions and recommendations and divided into IS network and IS management sub-sections; a definition phase report substantiating all major statements about the identified business shortcomings; a proposed action plan outlining the objectives, strategies, actions, schedule dates and responsibilities for achievement of the study recommendations; and an IS plan summarising the BSP findings, conclusions, and recommendations.

After 24 years since its inception and first application, one could be forgiven for assuming that BSP would nowadays be regarded as a methodology dinosaur. This is not the case. BSP has provided a solid foundation for the IS strategy formulation arena. Many modern consultancy approaches are BSP-like (c.f. Sections 3.3.5 - Method/1, 3.3.6 - Tetrarch, 3.3.7 - CASE*Method). In particular, the matrices and cluster analysis techniques have proved to be particularly resilient and provided the cornerstone for several IS approaches (sic).

BSP has a number of strengths and weaknesses. Lederer and Putnam [93] suggest that the major strength is its ability to involve top management in the study. The fact that BSP is a consultancy approach necessitates top management involvement in order to sanction the 'buying' of the methodology. However, the involvement of the highest-level decision makers is a recurring success factor in IS strategy formulation approaches [103]; without executive approval and commitment to IS planning, any approach is almost certain to fail. An approach that demands the involvement of top management, like BSP, is therefore, more likely to succeed.

Lederer and Putnam [93] also point out that BSP is highly structured and well documented providing "cookbook-like instructions for carrying out the study, along with educational courses and consulting services". The high quality of published documentation could feasibly mean that a company could apply a BSP-like study without the help of BSP consultants. However, the resource and project management implications of BSP are considerable, and without the added dimension of suggestions and ideas learned from other studies, implementation of the full process would be further complicated and inhibited. That is not to say that certain 'keystone' techniques can't be applied in isolation, outside of the BSP context.

Furthermore, BSP's fundamental principles:

- business-wide perspective,
- top-down analysis, bottom-up implementation, and
- systems and data independence,

although simple, are ideologically sound and provide a framework for any approach to IS strategy formulation.

Lederer and Putnam [93] cite the most common criticism of BSP as being the difficulty in implementing the results. This is not unusual in IS planning approaches. An IS strategy, or plan, is often the result of a long and resource-intensive process, but in itself, it provides no significant business change. It is only after implementation that business benefit is realised. The design and implementation of IS must be given the same consideration as planning. In addition, the specificity of an IS specification often determines the ease with which it can be translated into appropriate code or aligned with an 'off-the-shelf' package. The more exact the specification, the easier the translation. Standard specification formats can also assist this process.

As with all strategy formulation approaches, success is dependent upon the skills and experience of the study team. In particular, the charting and clustering techniques used in BSP require considerable expertise. Furthermore, IS project priority development with BSP is relatively unstructured requiring the study team to aggregate large quantities of data and yet still be able to separate the "forest from the trees" [131]. This in itself is another weakness of the methodology. The identification of unambiguous, specific priorities for IS development is fundamental to effective IS planning. The development of techniques that ensure specific priority identification is particularly important. The inclusion of prioritisation criteria to form composite techniques can ensure greater prioritisation integrity.

An obvious 'turn-off' of the BSP methodology is the length of time a study takes. Typically, the development and implementation of an IS network takes several years. Although IS strategy formulation is a comprehensive, total-business activity, a 'quick-slice' approach focusing on real, value-added activities would ensure more extensive adoption. Furthermore, BSP promotes IS revolution rather than evolution, thus, elongating the IS development life-cycle. The methodology assumes a computerised network of data bases as the solution to all IS problems, and this results in a total redo of all existing and planned systems that do not conform to this scenario. It should be noted that BSP involves considerable data collection (many of the project management and administrative activities were omitted from the methodology description), and, as such is very expensive in terms of time and manpower.

3.3.2 - The Critical Success Factor (CSF) Approach

The CSF approach is perhaps the best known and most widely practised methodology. It is a structured procedure for identifying the CSFs needed to achieve organisational goals and deriving the IS applications needed to achieve or support the CSFs. It was first proposed by Rockart [131] to help chief executives define their significant information needs. Rockart's [131] approach was developed from a 'success factor' concept originally suggested by Daniel [33].

Rockart [131] defined CSFs as "the limited number of areas in which results, if they are satisfactory will ensure successful competitive performance for the organisation". He developed the approach as a method for providing relevant information to top management. Rockart advocated that the CSF approach should be undertaken by way of two or three separate sets of interviews. In the first, the executives' goals are recorded and their underlying CSFs and related information needs are identified. The second, and third if necessary, are used to review and sharpen up the results of the first and obtain final agreement on CSF measures. Goals represent the end points that an organisation hopes to reach. CSFs are the areas in which good performance is necessary to ensure attainment of those goals [131]. The performance in each of these areas should be continually monitored to ensure 'things go right' [131]. An outline of the relationship between the key elements of the CSF approach is shown in Figure 3.18.

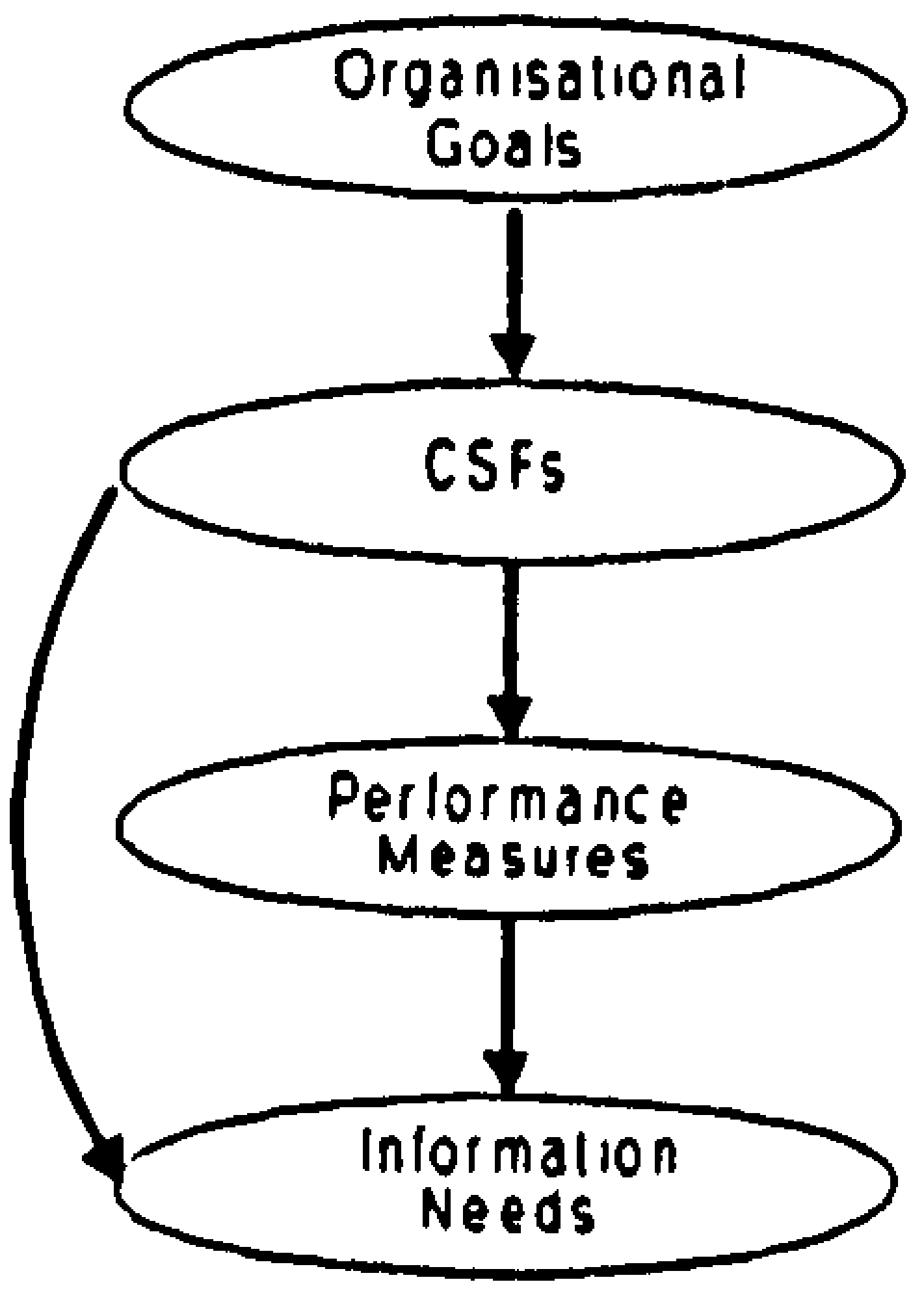


FIGURE 3.18 - Outline of CSF elements

Rockart [131] identified four prime sources of CSFs:

- structure of the particular industry
- competitive strategy, industry position, and geographic location
- environmental factors
- temporal factors significant for the success of an organisation for a particular period of time.

Similar organisations can have quite different CSFs by virtue of geography, competitive strategy and/or a host of other factors. Rockart [131] emphasises that it is important for executives to clearly define at any point in time exactly those factors that are critical to the success of his particular organisation over the planning period. Rockart and Crescenzi [132] used the CSF technique as part of a methodology aimed at engaging top management in IS development. The technique is used to agree on the most critical business functions and thus enable IS needs in these critical areas to be defined.

Boynton and Zmud [20] developed the CSF concept further. They found that the approach is particularly effective in supporting strategic IS planning by identifying the IS requirements needed to support or deliver the CSFs. They also found that the approach can help in eliciting the enthusiasm and involvement of senior management in IS concerns and in facilitating a structured, top-down business analysis. Mead [110] pointed out that the CSF process also identifies areas where knowledge is insufficient or where current plans and strategies are unrealistic.

It is apparent that, with proper application, the CSF methodology certainly helps determine where management, and therefore IS, attention should be focused [20, 131]. The critical questions to address, however, are

- in what circumstances are CSFs best used?
- how is the approach best applied?
- is the approach reproducible/replicable in different companies?
- what are the strengths and weaknesses of using a CSF analysis to formulate IS strategy?

Unlike other methodologies, empirical CSF analysis has been widely undertaken and documented (see Section 3.3.10) and answers to each of these questions are evident.

It appears that the technique is appropriate for identifying links between corporate strategic efforts and related IS concerns rather than detailed information requirements analysis [20, 42], and, as such, is useful as a front-end planning technique for pinpointing areas of concern rather than as an aid to detailed requirements specification generation. Other observers have pointed out that it works best where there is an available business strategy or where strategic analyses have been done beforehand [42].

The method is best applied in conjunction with high rather than low or junior-level managers [20]. High-level managers better appreciate the need to devolve strategic concerns throughout a business, and consequently, strong endorsement of the CSF application as a means of identifying important areas that need attention is common amongst these managers [20]. Rockart [131] suggested a series of senior managerial interviews to capture a manager's key concerns and for developing appropriate measures for those concerns. Boynton and Zmud [20] recommended the use of an experienced analyst with a total business perspective conduct such interviews.

Several authors recommend a review process once an initial set of CSFs have been identified [110, 131]. In addition, a decompositional approach is particularly useful. Identifying those activities that must be done well for an organisation to succeed and attempting to link information functions directly to those activities is a difficult process. Identifying one, or even better, two levels of supporting sub-activities enhances prescription, structure and detail. A direct link between strategic and IS concerns is eminently more feasible and of greater integrity via the use of a formal, decompositional approach (see Figure 3.19).

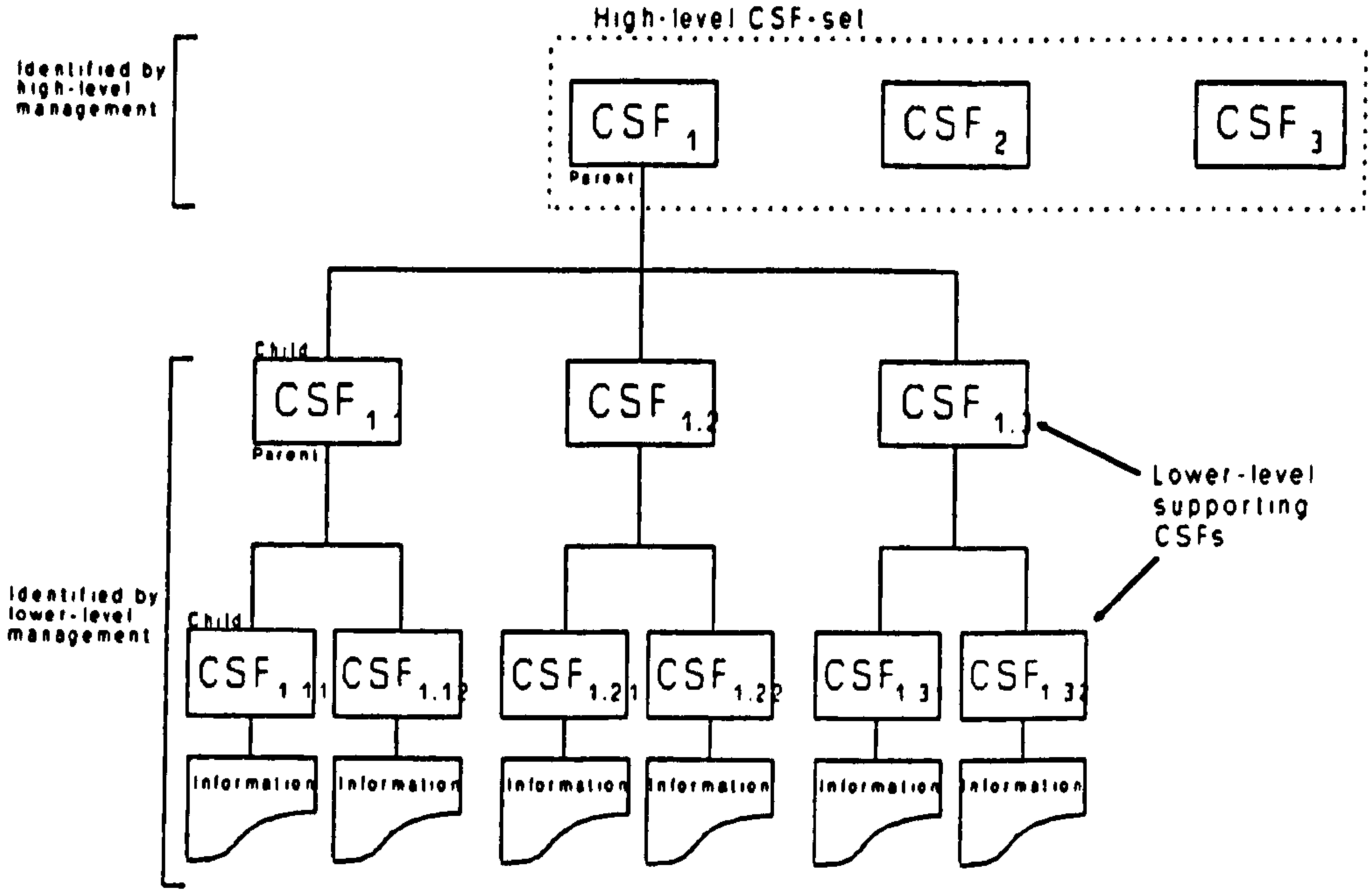


FIGURE 3.19 - Decompositional CSF approach

Although high-level managers are well qualified for defining the highest-level CSFs, as endorsed by Rockart [131] and Boynton and Zmud [20], with a decompositional approach, lower-level managers are more suitably equipped to identify the CSFs of related sub-activities and should be interviewed and called upon in order to identify these related CSFs. Not all CSFs will be easily decomposed, but, as a general rule, a high-level CSF identified by a senior manager should have a number of critical supporting activities that need to be performed well to satisfy it. These activities, in turn, will require other sub-activities to be performed equally well if they are to be achieved. Several analyses undertaken by Lyons [83] and illustrated in Chapter 6 (Case Study Compendium) support these assertions.

Boynton and Zmud [20] suggested that a major weakness of the CSF approach was that it is difficult for certain managers to ascertain their information needs using only CSFs. It is indeed true to say that some managers will have difficulty in relating a CSF explicitly to an information need. However, the process is made much simpler by decomposing the CSF into lower levels of detail and identifying the information needs of these lower-level activities. The process may still not be straightforward.

The very nature of certain CSFs obviates the need for information. Some are simply not easily supported by information. For example, Rockart [131] identifies four CSFs in the automotive industry. Of these, 'vehicle styling' is one which has a particularly narrow focus and is relatively difficult to explicitly relate to information, whereas, 'manufacturing cost control' has a considerably broader focus and is particularly easy to relate to information. Figures 3.20 and 3.21 show a conceptual and partial decomposition of these two high-level CSFs to illustrate the point.

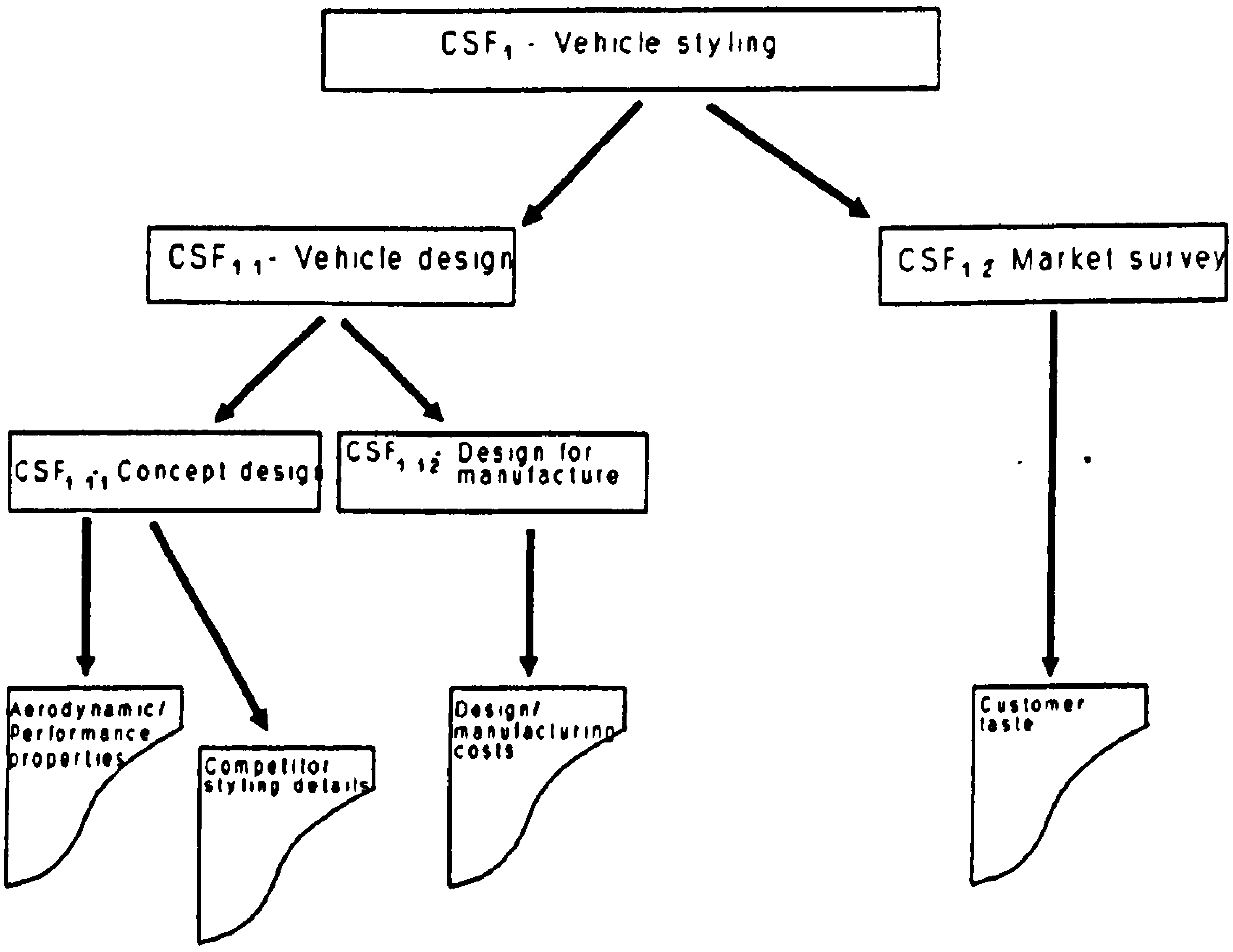


FIGURE 3.20 - Vehicle styling CSF decomposition

Decomposing the CSFs ensures a rigorous analysis and a comprehensive list of related information needs. Although the CSF concept is simple, without the intermediate levels of analysis, the relationship between the highest-level CSFs and information needs is abstract, difficult to comprehend and prone to omissions.

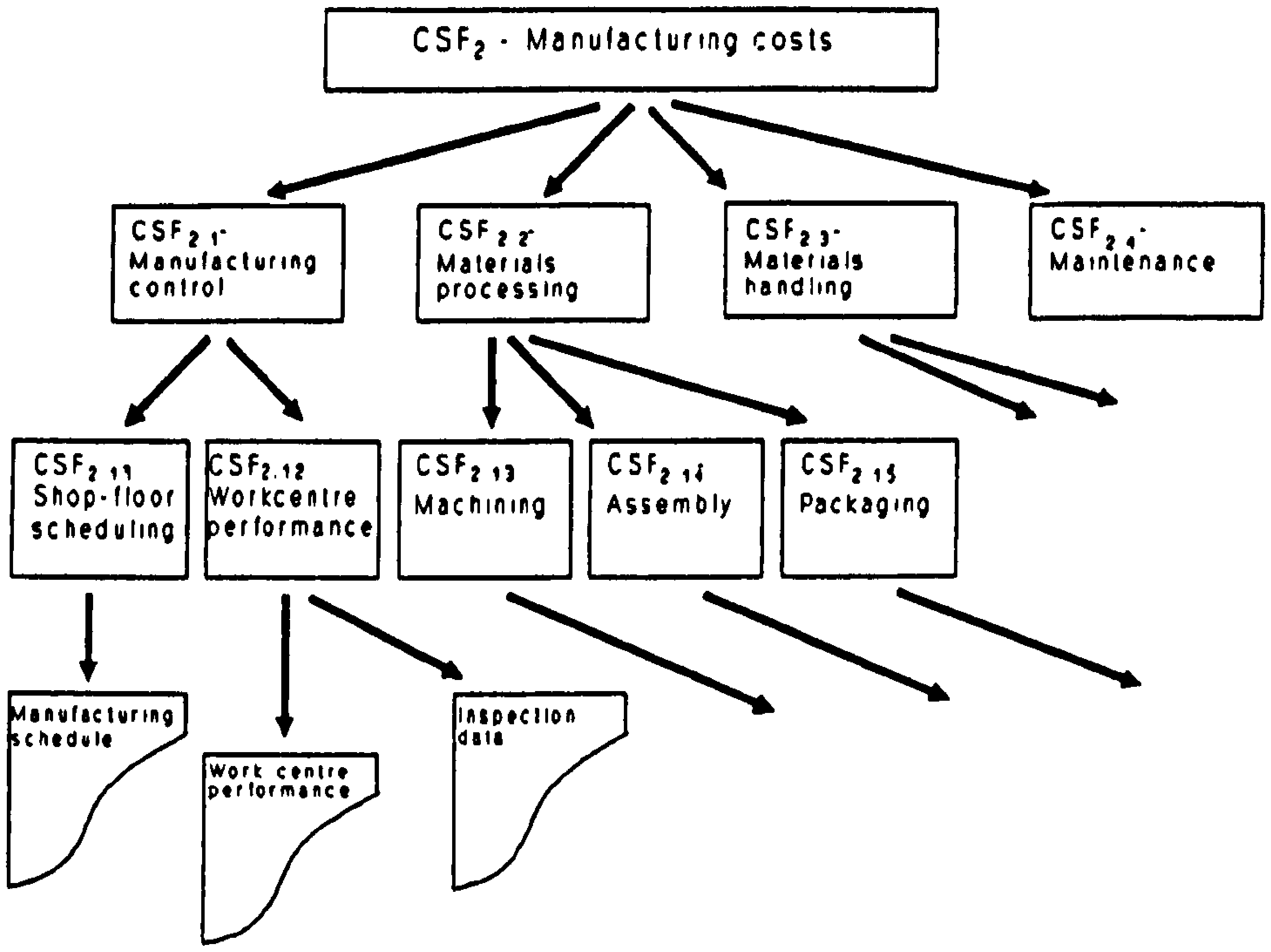


FIGURE 3.21 - Manufacturing cost control CSF decomposition

Porter & Millar's [126] 'information intensity matrix' represented in Figure 3.7 can be used to prescribe the relative ease with which information needs can be identified from CSFs. A company in the 'high-high' quadrant of the matrix with a high information content in both its products and processes will tend to have CSFs that are likely to have supporting IS concerns. Conversely, companies in the 'low-low' quadrant of the matrix are likely to have few CSFs with directly related IS concerns. There will always be exceptions to the rule, but in general, managers in companies in the 'information business' will find CSFs easier to relate to information needs.

The CSF approach has a number of strengths in terms of its suitability as an IS strategy formulation methodology. It is simple to understand and easy to apply in a short period of time without requiring a large commitment of organisational resources. It promotes top-down analysis, and helps focus attention on areas critical for business success and so fulfils a fundamental objective of IS strategy: aligning IS development with organisational goals. It also helps ensure that these critical areas are monitored, and forces the development of measures in these areas. The approach places emphasis on the need to tailor management planning and control systems to a company's strategic objectives and recognises that different managers have different information needs. Although the CSF approach has primarily been developed to define the information needs of chief executives and for formulating IS plans by Rockart [131] and Boynton and Zmud [20] respectively, another strength of the concept is that it can also assist in focusing management attention on key areas to serve other objectives. Scott Morton [8] points out that the success of the CSF methodology in the IS domain has been overshadowed by its use as a mechanism to get managers to think through what are the critical dimensions of their jobs to which they must pay undivided attention.

An obvious weakness of the CSF approach is its uni-dimensional focus. Although ensuring congruence between organisational goals and related business areas is a vital ingredient in any approach to IS strategy formulation, a meal is not made from bread alone. The approach is devoid of several concepts that to even an untutored analyst would appear glaringly obvious. Firstly, although 'flexibly' structured in its strategic alignment mechanism as described by Rockart [131] and Boynton and Zmud [20], it is lacking an appropriate mechanism for measuring 'critical area' performance. Although performance measurement is emphasised, the specific process for doing so has been left undefined by both Rockart [131] and Boynton and Zmud [20]. For defining chief executive information needs, the problem is not significant. The executive is interested in performance, and provided measures are developed, a report describing performance will satisfy the executives' needs. However, when specifically used for IS planning the CSF approach needs to incorporate suitable information-related performance measures. Identifying critical 'operational' information needs as opposed to 'monitoring' information needs is very important, but of no use unless the effectiveness of this information is ascertained. Are users' needs being satisfied? Are alternative ways of operating being explored? Are strategic requirements being served? These questions will not be answered unless guidelines and measures are developed for them to be addressed.

Secondly, the CSF approach lacks a mechanism for prioritising 'critical areas'. Unless the highest-level CSFs are weighted, the analyst has no way of assessing the relative importance of the identified information needs, and, as such, no way of prioritising development applications. Again this is only a problem which arises when using CSFs for IS planning; for defining executive information needs, the relative performance of each area will determine problem severity.

Boynton and Zmud [20] suggested that the conceptual nature of CSFs made it difficult for managers to directly relate CSFs to information needs. This is a weakness, but one that can often be overcome, as has been illustrated, by decomposing high-level CSFs into lower levels of detail. The integrity of the process can be enhanced if accompanied by a set of questions to help managers and staff responsible for the lower-level CSFs identify information needs.

Figures 3.20 and 3.21 illustrate another weakness of the CSF approach: the expansive remit that each CSF can potentially cater for. Where possible, CSFs should serve a narrow band of issues. The 'manufacturing costs' CSF illustrated in Figure 3.21, impinges upon an almost infinite number of business functions, whereas, 'vehicle styling' illustrated in Figure 3.20 affects only a small number of functions and, as such, better identifies specific areas 'ripe for development'. A wide focus for CSFs undermines the approach. 'Manufacturing costs' is an appropriate and generic CSF for the automotive industry, but each organisation within that industry, at any time, will have their own unique cost 'hot spots', and such areas should be used as the high-level CSFs. The use of verbs to express the intention of the CSFs and measures to specify the goal of the CSF considerably enhance the 'narrowing' process. For example, a 'manufacturing costs' CSF could conceivably be replaced by several CSFs such as 'reduce manufacturing costs in the PCB assembly area by 25% in the next year'.

3.3.3 - Information Engineering (IE)

IE is a comprehensive life-cycle methodology incorporating not only planning and analysis but also design and construction of IS. Martin [104] defines IE as:

"the application of an interlocking set of formal techniques for the planning, analysis, design, and construction of IS on an enterprise-wide basis or across a major sector of the enterprise".

It was developed primarily by Martin and Finkelstein [105], although Avison and Fitzgerald [4] point out that several other authors have added their own techniques and concepts to those proposed in the initial version. However, IE primarily remained the property of its most quoted proponent, James Martin, through his consultancy company, James Martin Associates (JMA), until recently, when its rights were purchased by Texas Instruments [144].

IE is based predominantly on data analysis rather than functional analysis claiming the stability of data to be greater than that of functions or processes as the reason for such a standpoint. The methodology is automated. Indeed, James Martin has been quoted as saying that the automation of the IE process is 'the biggest single revolution in the history of computing' [4].

IE is top-down and consists of four phases within which there are seven stages. Only the first two phases are reviewed in this discussion. Figure 3.22 depicts the phases and stages of the complete methodology.

The first phase, 'Information strategy planning' consists of a number of steps carried out by user management and IS staff, although Martin [104] emphasises the importance of involving top management in the study. It typically takes between three and twelve months to complete in most enterprises [104]. Six months is used as a reasonable target in a medium-sized enterprise. Its objectives are to:

- investigate how better use of technology can enable an enterprise to gain competitive advantage;
- establish goals for the enterprise and CSFs;
- use CSF analysis for steering the enterprise to enable it to better achieve its goals;
- determine what information can enable management to perform its work better;
- prioritise the building of IS in terms of their overall effect on the bottom line;
- create an overview model of the enterprise, its processes, and information;
- subdivide the overview model into business areas ready for business area analysis;
- determine which business area to analyse first;
- enable top management to view its enterprise in terms of goals, functions, information, CSFs, and organisation structure [104].

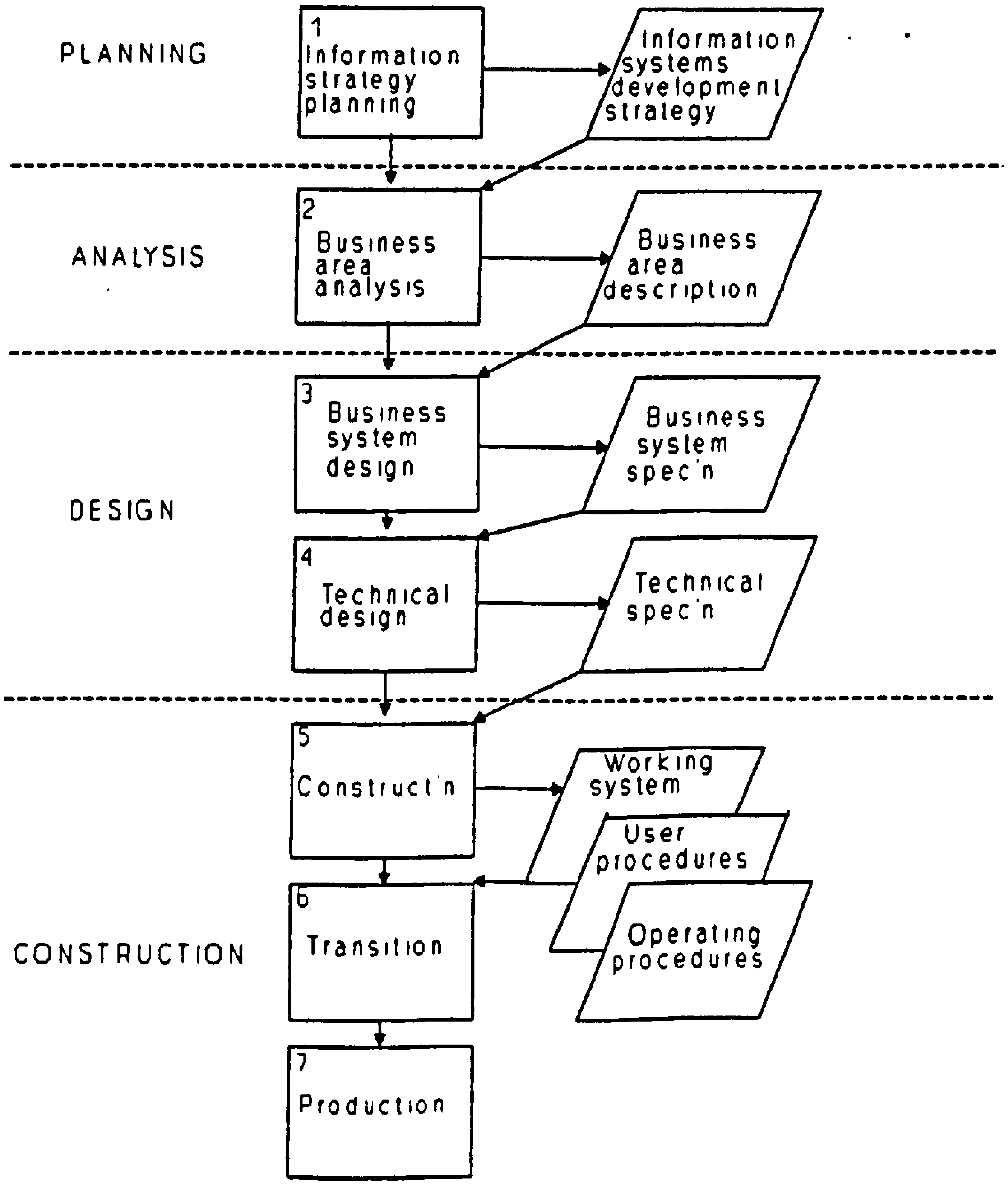


FIGURE 3.22 - Stage framework of the IE methodology (Avison & Fitzgerald [4])

The steps used in IE are flexible and may vary from one enterprise to another. A list of typical steps in the 'Information strategy planning' phase of the methodology classified according to business and technical orientation is depicted in Figure 3.23.

Business-Oriented

- Computerise the organisation chart of the enterprise.
- Identify the organisation's goals, targets, and strategies.
- Examine technological trends and how they might be used by the enterprise to create new opportunities or competitive advantages.
- Determine CSFs for the enterprise and break these down into CSFs throughout the organisation chart.
- Interview key executives to determine problems, opportunities, and information needs.
- Record all of the above in a computerised planning and analysis tool.

Technology-Oriented

- Develop an enterprise model showing the basic functions of the enterprise on a function decomposition diagram.
- Develop an overview entity model.
- Analyse the functions and entities with a matrix tool and determine business areas.
- Analyse current systems.
- Set priorities for IS development

FIGURE 3.23 - Steps in IE information strategy planning

The business-oriented steps, in general, relate to top management activities and business ambition; the technology-oriented steps relate to IS modelling, and technical infrastructure.

The first step is to create a computerised version of the organisation chart and store it in the 'encyclopaedia'. The encyclopaedia is used as a repository of knowledge about the enterprise. It is a knowledge base used not only to store information but also to check its accuracy and validity.

A function decomposition chart is constructed next. Typical business functions include business planning, finance, product planning, sales, distribution and accounting. Each business function is sub-divided into a set of processes. Unlike the continuous nature of a function, a process relates to a specific act. Processes usually begin with verbs and have a definable beginning and ending point. Examples include:

- create purchase requisition;
- select supplier;
- follow up order;
- prepare information for accounts payable;
- analyse supplier performance.

A simple matrix is used to match business functions against personnel.

An entity model is constructed by, firstly, identifying the highest-level overview of data, such as

- customers;
- orders;
- products;
- parts;
- materials;
- employees.

For each data subject, entity types are then identified. For example, 'customers' may have entity types 'customer', 'address' and 'contact'. The relationships between entities are modelled using entity relationship diagrams (ERDs) (see Chapter 4). A matrix, as in BSP, is constructed to show the relationships between entities, functions, organisational units and locations. This is done automatically by computer.

In the next step, the goals of the enterprise are analysed. Each goal should be broken down into lower-level goals that apply to lower-level departments. Goals can be found from a variety of documents, such as:

- business plans,
- information technology plans,
- annual reports,
- executive reports.

These documents should be searched before interviews with management are conducted to elicit their statements of goals. Problems associated with achieving goals should also be identified, as should possible solutions to problems. Both goals and problems are given a criticality rating on a scale of 1 to 5. Goals and problems are related in the encyclopaedia with systems and entities. Matrices are used to define relationships.

Next, CSFs for the enterprise as a whole are determined. Like business goals, these are also decomposed into lower-levels of detail. The use of consultants to identify CSFs is recommended. CSFs are said to help in two ways. First, they help focus on those activities that are most important, and, second, they help executives think through their information needs.

A set of business and management opportunities that result from technological change is developed next. This may initially be put together from a brainstorming session. Priorities for opportunities are ranked on a five-point scale. They are consolidated by interviews with appropriate managers. A business proposal for each opportunity is developed indicating its advantages, risks and costs.

Cluster analysis, as in BSP, is carried out to show what functions and data naturally fit together. Such groupings form the basis for analysis areas, which are examined in more detail in 'business area analysis'. Setting priorities for which business area should be analysed first is done with respect to the following:

- the business urgency for automating that area, or rebuilding its current systems;
- the potential impact on the goals of the enterprise as determined in the information planning study,
- the strategy or competitive impact of new systems;
- the current management priorities;
- the potential for automation of the business area;
- the cost, difficulty, or inadequacy of maintenance of current systems;
- the project staff availability and expertise.

In phase 2 of the methodology, 'Business area analysis', business areas identified in the information strategy plan are treated individually and a detailed data and function analysis is performed. Maximum involvement of end users is recommended at this stage [4].

A typical 'business area analysis' takes from three to six months [104]. A fully normalised data model is developed for each analysed area. (The mechanics of data modelling and the concept of normalisation are discussed in Chapter 4.) Martin [104] recommends that 'business area analysis' should be independent of current systems, citing that old systems often constrain an enterprise to use inefficient procedures with batch processing, dumb terminals, unnecessary key punching, redundancy, too much paperwork, and the bureaucracy that goes with paperwork. Martin [104] suggests that "entirely different procedures may be designed if there can be a personal computer on every knowledge worker's desk, on-line to databases anywhere in the enterprise".

Martin [104] attributes the following characteristics to 'business area analysis':

- It is conducted separately for each business area.
- It creates a detailed data model for the business area.
- It creates a detailed process model and links it to the data model.
- The results are recorded and maintained in the encyclopaedia.
- It requires intensive user involvement.
- It remains independent of technology.
- It remains independent of current systems and procedures.
- It often causes a rethinking of systems and procedures.
- It identifies areas for systems design.

The tasks in 'business area analysis' are centred around the production of four different types of diagrams:

- data model diagram based on the ERD constructed in information strategy planning;
- process decomposition diagram showing the decomposition of business processes throughout the business area;
- process dependency diagram showing the data flows from one process to another;
- process/data matrix, mapping the processes against normalised data, showing which processes create, read, update, or delete the records.

IE has many of the same strengths and weaknesses as IBM's BSP. It is comprehensive and likely to result in powerful and efficient IS supported by top management if carried out effectively. However, success is dependent on study team skills and the ability of the team to choose and use the techniques appropriately. Prioritising specific business areas with IE is a difficult process requiring intuition as well as technique. The exact nature of several of the techniques is less overt than in BSP. Their prescription and application, although eloquently eulogised about, are not described in 'cook-book-like', user-friendly detail (in the literature reviewed). (This is only to be expected with a consultancy approach.) Like BSP, IE is expensive in terms of time and manpower, and the magnitude of the total task should not be underestimated. Because multiple business area analyses are undertaken, it may take two to three years to construct the necessary IE models. This is before a great part of actual system design. By the time such analyses have taken place, the original requirements specification for the first business area studied may have changed. Martin [104] advocates that as much of the complete IE methodology as possible should be implemented. This means the methodology is also expensive in terms of computerised hardware and software. Data logging, and business and data modelling often require sophisticated computer hardware and software such as computer-aided software engineering (CASE) tools.

Also like BSP, IE promotes 'information revolution'. A basic tenet of IE is that 'old' systems are inefficient and restrictive, and that a network of integrated computerised data bases is the solution to all IS problems. It was intimated in Chapter 1 that such a pre-formulated solution is not always appropriate. IE is most appropriate for a large organisation committed to such a long-term data base strategy. It may not be so appropriate in a manufacturing small or medium-sized enterprise (SME) looking to cheaply and quickly align its IS development strategy with business ambition and market influences (or which wants to simply identify high-impact applications).

3.3.4 - Strategic Value Analysis (SVA)

SVA [30, 31] was developed by Robert M. Curtice and colleagues at Arthur D. Little consultancy company. SVA was developed to offer a fresh approach to systems planning [30]. Its key objective is the provision of a modern systems planning methodology to link IS to business strategies directly and quantifiably [31]. It attempts to address the requirements for a modern methodology by incorporating the following issues in its application and structure:

- independence of organisation structure,
- relationship to strategic business objectives,
- priority setting beyond return on investment (ROI), and

- the establishment of a flexible systems framework.

The methodology consists of ten steps, as outlined in the chart in Figure 3.24.

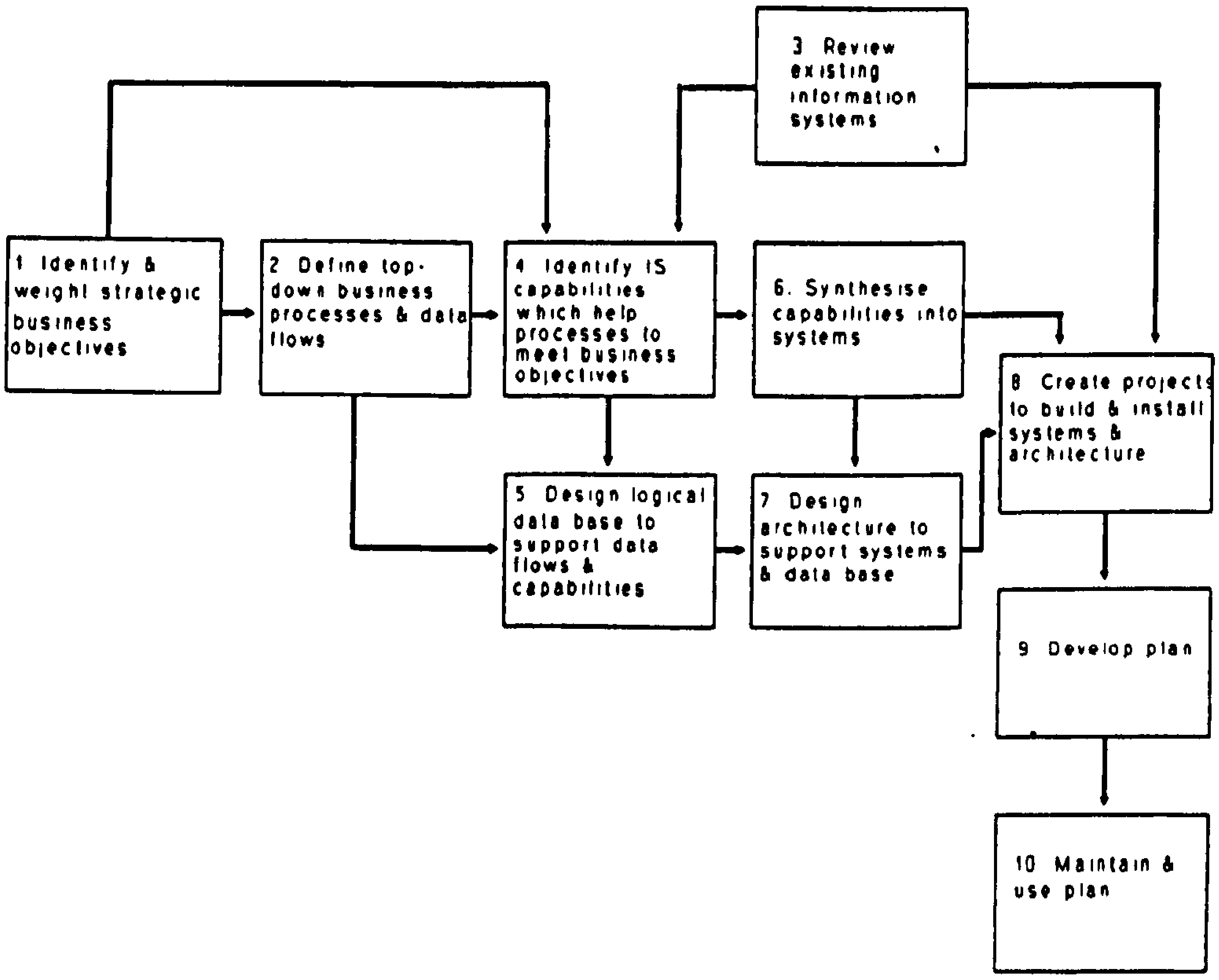


FIGURE 3.24 - Overview of SVA methodology (Curtice [31])

A 'taskforce' is selected to carry out the methodology. The taskforce make-up ranges from 6-15 persons, all of whom should be open to change, have suitable business experience and an overall company viewpoint, working from one-quarter to three-quarters of their time ranging from 2-5 months. The first step for the taskforce is to review existing strategic business objectives, or, if necessary, formulate a set of new objectives. This is done from a review of written documents, and from discussions with corporate planning representatives and senior management. Business objectives are ranked and assigned a percentage factor. The percentages of all objectives must total 100, so the significance of each one is relative to any other one.

The next step in the methodology involves modelling the business from a top-down perspective using data flow diagrams (DFDs). (Examples of DFDs can be seen in the

Reference Model in Appendix A.) The emphasis is on the 'to be' rather than the 'as is' situation as anticipated improvements identified by the taskforce are incorporated in the DFD model. SVA also breaks down the identified business objectives into lower levels of detail. A set of sub-objectives that support the higher level objectives are identified at each level of the DFD model. Subobjectives are also assigned a percentage factor; their sum totalling 100 percent. Figure 3.25 depicts the concept of functional decomposition along with decomposition of business objectives.

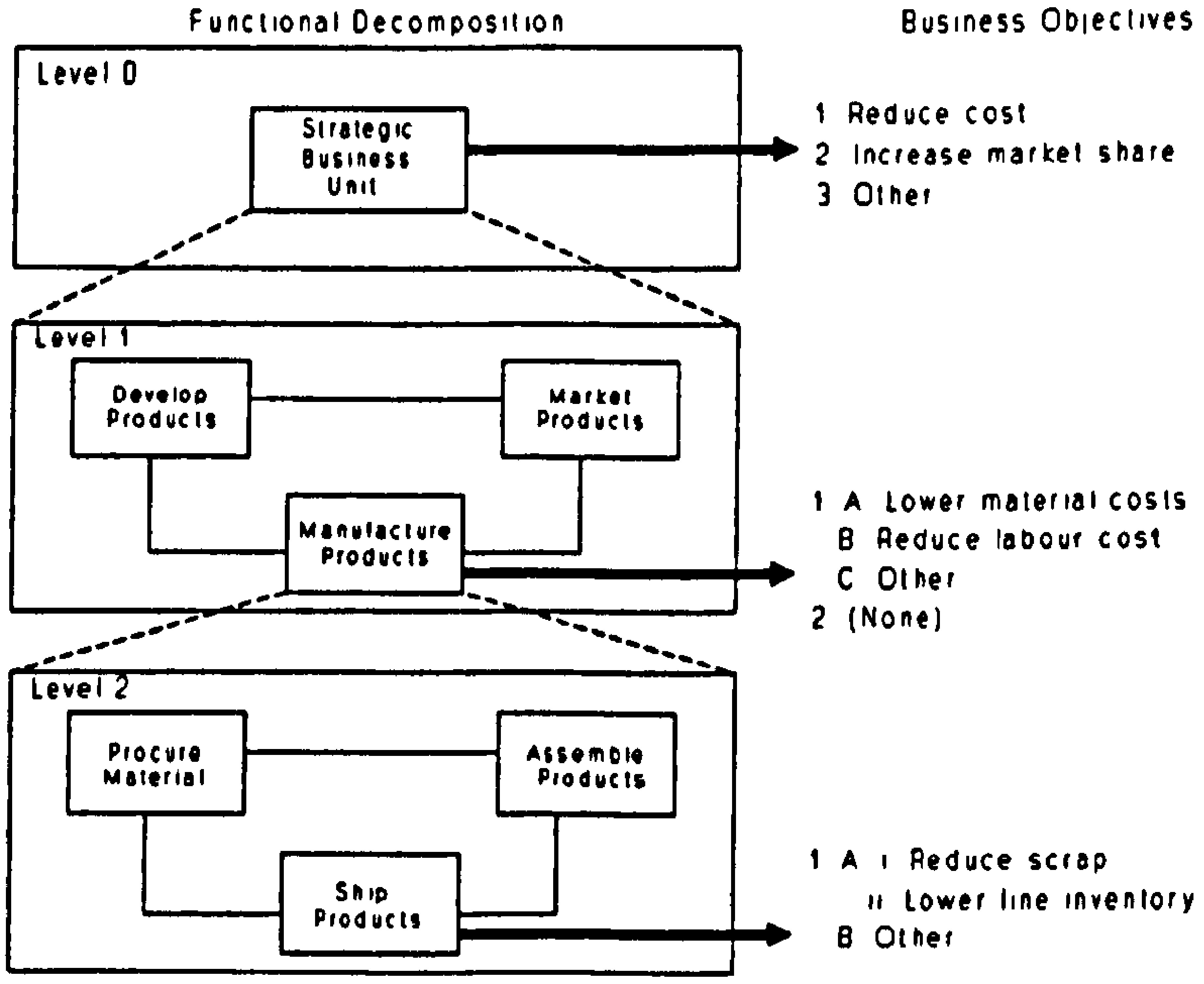


FIGURE 3.25 - Functional and objectives decomposition (Curtice [31])

At level 0, objectives correspond to the corporate strategic business objectives. Lower-level objectives are stated in terms of support for the objectives of superior processes. Curtice [31] purports that objectives decomposition is a powerful technique for forcing the examination of objectives at each function of the business and in increasing levels of detail, and also brings to light ongoing programmes and projects that are not in support of business objectives. The IS planning case studies described in Chapter 6 (Case Study Compendium) support this view.

Construction and orientation of DFDs is dependent on the viewpoint of the analyst concerned, although understanding should be common amongst analysts. Aware of this characteristic, Curtice [30] emphasises the need to document processes, data flows and objectives with clarity and consistency. He points out that although DFDs may have been developed by a group, individual taskforce members will have different interpretations of the processes and data flows involved, so entities should be carefully defined.

Step 3 in SVA involves a review of existing IS support. This consists of an analysis of existing hardware and software, personnel, and other resources currently available. Other perspectives included in the assessment are:

- plans and measurements,
- systems development technologies employed,
- budgets, and
- security.

The objective of this review is to ensure that the implementation that emerges from the planning study is realistic in terms of the organisation's ability to carry it out.

The objective of step 4 is to identify IS capabilities that can help achieve the business objectives. Capabilities to support the lowest-level subobjectives are sought. Those that satisfy such objectives will automatically and correspondingly support the highest-level business objectives owing to the integrity of the decomposition process. An IS capability (or a subobjective) can support more than one higher-level objective. Curtice [30], describing an SVA case study in a manufacturer of pumps and hydraulic components identified a computer-aided product design IS capability that supported 'speed up design processing', and 'reduce design costs' objectives.

A weight ranging from 1-5 is assigned to each capability signifying its effectiveness to achieve its objective. The more effective the capability, the higher the weight. A 'score' is then calculated for each capability from the product of its effectiveness weight and the weight of each of the higher-level objectives leading back to the strategic objective. Any one capability can contribute to more than one objective, and, as such, scores are aggregated. The following example taken from the hydropower case study illustrates this process.

A group technology capability supported three separate level 1 objectives:

(1) reduce design lead time; assigned a percentage factor of 35,
(2) enable short manufacturing time; assigned a percentage factor of 20,
(3) reduce other design time; assigned a percentage factor of 15.

Group technology effectiveness weights assigned to these objectives were 5, 5 and 4 respectively, and the highest-level strategic objective *improve customer response* was assigned a weight of 45. Thus, the group technology capability received an overall score of 14,850 calculated from the sum of (5 x 35 x 45), (5 x 20 x 45) and (4 x 15 x 45).

The logical data base to support the 'to be' data flows and suggested capabilities is designed in step 5. The data base is intended to act as a framework that ensures IS integration yet is flexible enough to allow a phased evolution of systems development and enhancement. In designing the data base, a data model of the business is constructed providing a second framework (in addition to the DFD model) for IS development. The model represents the data relationships between business entities ('things of interest') and is a standard and commonly applied precursor to the implementation of a computerised data base. The process has been described and documented by a number of authors [40, 135].

Identified capabilities are 'synthesised' into systems in step 6. This is not a simple process. Curtice [30] points out that "It requires an understanding of both the application subject and the technology. Sometimes systems need to be described that are not merely combinations of identified capabilities, but are required elements of a broader facility...... Putting the right components together can drastically affect the overall logical and physical architecture of the resulting set of systems." Planned systems should be agreed by the planning taskforce and carefully described. Such descriptions must contain references to the individual capabilities that they are intended to satisfy. The 'score' assigned to a capability provides an indicator of how each planned system contributes to the overall strategic objectives. A simple SVA system description is shown in Figure 3.26.

System Name: Computer-Aided Design System

Description:
A computer-aided design system for Hydropower would allow engineers to develop the initial design concepts and overall geometry of new and modified pumps on a CRT screen. Support for engineering analysis of the design would be required.

System Acquisition Strategy:
Purchase of turnkey hardware/software package

Major System Features:

- Three-dimensional solid modelling
- Integration with bill-of-material database
- Automated drafting support
- Finite element modelling
- Deformation and thermal stress analysis

Capabilities Supplied: (Score)
Automated graphics (2,700)
Computer-aided design (11,850)
Computer-aided engineering (2,400)

(14,550)
Estimated Cost:
3-year installation with 12 workstations $310,000

FIGURE 3.26 - SVA sample system description (Curtice [30])

Scores enable systems to be assigned usually to one of three priority classes (high, medium or low). More classes are considered if more than 20 systems are identified. Figure 3.27 depicts an example of systems classified by priority.

Priority	System	Score
High	Computer-aided design (new)	19,650
	Shop floor control (enhance)	18,000
	Group technology (new)	16,500
	Vendor data base	Prerequiste
Medium	Vendor rating and tracking (enhance)	12,200
	Office automation (new)	11,450
	Automated process planning (new)	11,300
Low	Quality analysis (new)	8,200
	Robotics (new)	7,600
	Automated test (enhance)	7,150
	Accounts receivable (enhance)	6,250

FIGURE 3.27 - SVA classification of system by priority (Curtice [30])

In step 7, the architecture to meet the needs of the systems and data base is specified, and caters for hardware and software selection, interconnections and storage of data.

In step 8, specific projects to implement the required IS changes are developed. Timescales and resources required for implementation are estimated. As a general guideline, a planning horizon ranging from 36 to 60 months is estimated for project implementations. Each project should have specific objectives and well-defined deliverables. In the case of a software package-selection project, Curtice [30] suggests that suitable deliverables might be:

- a set of selection criteria,
- analysis of candidate packages versus criteria,
- recommended package and reasons,
- proposed installation schedule and cost.

Alternatives to the management, and sequencing of these projects are evaluated in step 9 and a final recommended plan is presented to management. The last task, step 10, is the ongoing activity to adhere to and use the plan.

Very little has been written about the SVA methodology in the IS planning literature. It has been omitted from the major analyses of IS planning approaches by Lederer and Sethi [94], and Galliers [52]. This is surprising and can only be explained by a lack of willingness by the authors to disseminate the methodology, for it has a number of strengths that would undoubtedly appeal to potential adopters. Firstly, it is well established that a technique for modelling business operations is essential for effective planning [86]. BSP and its 'clone' methodologies use a matrix as their model. SVA use diagrammatic structured analysis. The main reasons for developing a model are to understand the operation of the existing business IS and to provide a foundation from which IS changes can be made and communicated. By definition, a pictorial analysis does this better than a tabulated analysis. Diagrams are very appealing to users and management [4]. A total IS is usually a complicated 'animal' and a table or matrix concentrates the complexity. A set of DFDs, however, spreads complexity. Each DFD, in itself, is simple to understand thus making comprehension of the total IS simpler. DFDs , or a similar structured analysis technique provide other benefits. They are hierarchical, and so facilitate and encourage top-down analysis of business activities, they are readily understood and communicated, they require little skill to construct, many systems analysts are familiar with them, many IS departments use them as a standard, and they are functionally rather than organisationally driven. On the other hand, a matrix model, similar to Figure 3.14, is more difficult to comprehend, provides little actual information and does not help the planning concepts of organisational independence and top-down analysis.

A second major appeal of SVA is its inherent intention to prioritise and rank specific IS development projects. Although company management are unlikely to fully support any technique that obviates the need for good judgement and intuition, IS strategy formulation, by definition, should, through the use of appropriate techniques, leave very little to intuition. The effectiveness of any approach has to be measured by its ability to consistently hit the right 'hot spots'. Provided the correct concepts and techniques are considered, a methodology that does this is the best. Because of the biases and poor judgement inherent in people, management should strive for a suitable methodology that produces specific results that they have confidence in. In using quantitative data, SVA produces such specific results.

SVA is also lean on time and resource commitments compared to other 'total company study' methodologies, is suitable for application in manufacturing environments (evidenced by Curtice's [30] case study) and easily understood. It also forces the inclusion, and therefore search, of IS capabilities.

However, SVA has its faults. For example, it does not define the levels at which functional and objectives decomposition finishes and IS capabilities analysis begins. This seems purely to be left to the discretion of the analyst. This in turn could undermine the scoring process. Because a percentage factor is assigned to each level of decomposition, the more levels the greater the weight. This appears unnecessary. More levels of decomposition does not mean that that particular 'strand of analysis' is more important.

The IS capabilities analysis is undoubtedly a difficult process requiring diverse and detailed knowledge of IT solutions to specific business problems. Individuals within the taskforce will have their own preconceived ideas about systems and IS capabilities, and their own biases and agendas. Not pandering to the 'loudest voice' would be critical for the selection of suitable capabilities.

Another weakness of SVA is that it has no formal mechanism for identifying IS weaknesses. The systems review in step 3 of the methodology is unstructured. In order to identify areas for development, it is necessary to evaluate how effectively existing IS are satisfying business objectives. Step 3 of SVA tackles IS resource support rather than strategic or operational support.

3.3.5 - Method/1

Method/1 is Andersen Consulting's life-cycle systems development methodology. Its four phases are depicted in Figure 3.28.

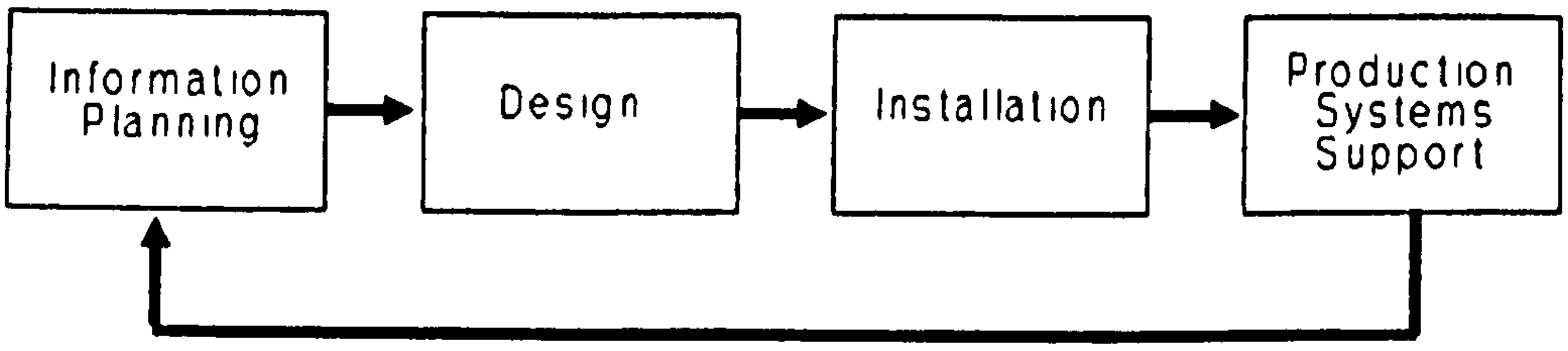


FIGURE 3.28 - Method/1 outline (Andersen Consulting [2])

This review of Method/1 is based on Andersen's Method/1 [2] documentation and a description of the methodology based on Method/1 1987 documentation carried out by Lederer and Gardiner [92]. Only the first phase of the methodology, 'information planning' is reviewed. It has five main objectives:

- to define the information needs of an organisation's business functions;
- to identify new opportunities for using information to achieve competitive advantage;
- to define information technology requirements to satisfy an organisation's strategic objectives;
- to define the data, application, technology and organisational requirements for supporting business objectives and functions;
- to define the activities required to implement an IT strategy [2].

The work segments of 'information planning' are shown in Figure 3.29.

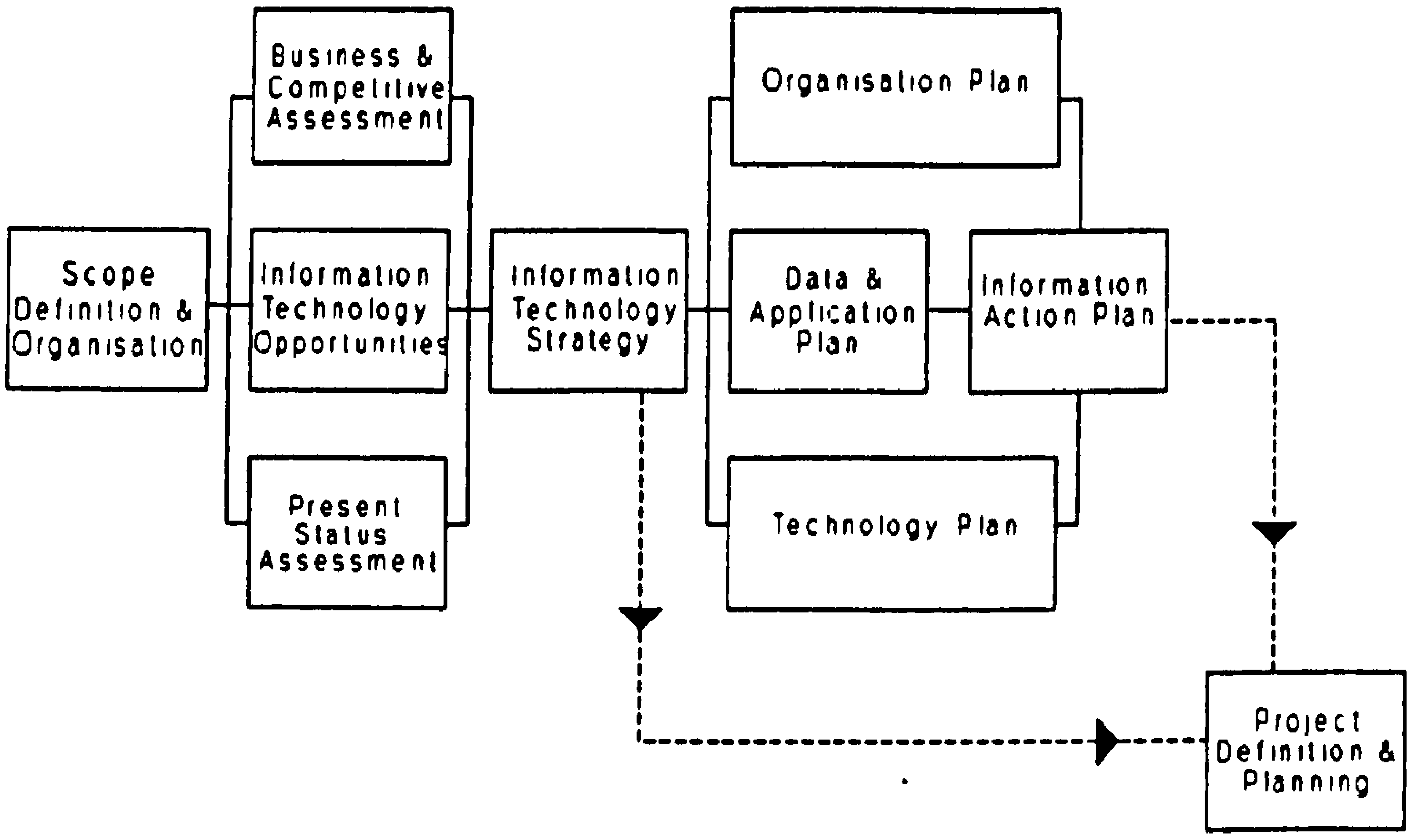


FIGURE 3.29 - Method/1 'Information planning' work segments (Andersen Consulting [2])

The first work segment involves determining key planning issues, defining the project scope and approach, organising the project team, and obtaining commitment from top management. Method/1 documentation [2] purports that one of the methodology's greatest benefits is its flexibility. Customisation, omissions, or additions to any of the tasks can occur. Key planning issues are devised uniquely for each organisation. The project team identifies the necessary focus and direction of the study according to management's concerns, goals and expectations of the planning process. These direction-setting issues define the scope, as well as the emphasis for systems planning. After the scope has been defined, a project team with the appropriate diet of skills and experience is finalised. Training, an orientation session, and a work plan are formulated for each team member. The last activity of the first work segment is to obtain management commitment to the planning process. This is a crucial task. Method/1 recommends the earliest possible involvement of senior management in the planning project to ensure that the plan is effective and represents the goals of the organisation.

A 'business and competitive assessment' is conducted in the second segment of the methodology. This is carried out concurrently with the next two segments, 'information technology opportunities' and 'present status assessment'. The team reviews strategic documents, organisational strengths and weaknesses, and elicits the views of senior managers so that the organisation's business objectives and competitive environment can be established. Such an analysis is vital to any IS planning process for dictating the IS implications of business ambition and the competitive environment. To further enhance business understanding, the team also examines the organisation's products, and its operations and structure, and using analytical tools such as value chain analysis strengths and weaknesses in critical business areas are identified. Porter's [126] five forces analysis is also carried out by looking at major buyers and suppliers, substitute products and/or services, the threat of new entrants, and existing competitors. Next, based on its understanding of business strategies, and strengths and weaknesses, the team identify and search for IT opportunities for supporting the strategies, consolidating the strengths and shoring up the weaknesses [92]. Method/1 uses Porter and Millar's [126] suggestion that organisations can gain competitive advantage from information in three major ways:

- alter industry structure,
- improve present business,
- create new business opportunities.

No technique is offered for aiding the identification of information opportunities, instead "creative thinking on the part of the project team" [2] is required.

'Present status assessment' involves the following key activities:

- documenting existing information and systems;
- assessing the effectiveness of information services;
- reviewing functional operations;
- assessing current operations, technology, and capacity; and

- evaluating the IT position of the competition.

The project team familiarise themselves with existing IS and current plans for IS development in order to evaluate how well existing and planned systems support strategic direction identified in the previous work segment. Existing IS, and proposed development and maintenance projects are inventoried and summarised by functional area. A review of the IS organisation is carried out by analysing the quality and cost of its service, its staffing level, the skills of its members, its management practices, policies, procedures, and ability to support existing and potential IS [92]. Users' needs are also identified to determine their level of satisfaction with existing IS. This helps reveal potential applications and problem areas, and existing capabilities with which the users are unfamiliar, and the potential for improved or more sophisticated systems. Next, existing hardware, software, and communication strategies and plans are inventoried, and investigated to assess their effectiveness in supporting information and systems requirements. Lastly, current IS capabilities are contrasted against industry trends and those of competitors' organisations.

In the fourth work segment, 'IT opportunities', the project team "analyses IT trends in support of the competitor and peer analyses performed in the 'business and competitive assessment' and 'present status assessment' segments" [2]. The use of technology within the organisation's own industry and in related industries is studied. The results of this 'opportunities analysis' are then combined with the findings from the two previous work segments to determine each functional area's information needs. These needs are synthesised into overall organisational information requirements based on business strategies, processes and functions. Finally, areas where IS might best be used are targeted and prioritised based on a top management assessment of quantifiable benefits (such as cost reductions) and non-quantifiable benefits (such as support of business strategies). Special note is made of short-term opportunities which should be pursued immediately or at the end of the next work segment [92].

'IT opportunities' identified in work segment 4 form the foundation for the definition of 'IT strategies' in the next work segment. In this activity, technology alternatives are evaluated and the required IS architecture, and data, technology and organisation structure changes are identified to determine high-level IT strategies. Expected changes to management practices, personnel, information requirements, hardware, software and competitive position brought about by the proposed strategies are also assessed, and their economic impact determined. The project team presents the IT strategies (and their associated broad migration plans) to management for approval.

The 'data and application plan' is a detailed breakdown of the IT strategies formulated in the previous work segment (number 5). Information needs are translated into data entities and the interrelationships between data entities are identified and represented by way of a data model. Specifications for applications are designed, and requirements for data management, security and training are identified. Application systems may be defined as groups of related application system functions using the following broad guidelines:

- data accessed by each system and how it is used;
- relation to major business event or function;
- organisational responsibility;
- processing frequency;
- security requirements.

Tools and procedures suitable for project development and maintenance such as CASE tools and application packages are evaluated. Finally, the team assesses the costs and benefits, and the resources and actions needed to put the plan into place. Actions are prioritised using the results of the cost/benefit analysis and their risks are identified.

The 'organisation plan' segment deals with developing a 'change management approach' and a 'human resources plan' that will enable the new strategies to succeed and new technology to be 'absorbed' into the organisation. Issues throughout the organisation that can prevent and facilitate adoption are analysed [92]. This is primarily done through an examination of the IS organisation's planning and control activities and functional area practices. The team develops an approach for implementing organisational change and overcoming any barriers that may prevent change. The lack of participation, communication, and education are seen as the keys to the failure of a change management programme [92]. Any mismatch between the skills needed by the change management programme and those identified through the 'present status assessment' (work segment 3) are rectified through the development of a human resources plan. Hence, the organisation plan may indicate the need for education, training and recruitment.

The 'technology plan' work segment involves identifying the hardware, software, databases and communications required to support the data and application plan. Alternatives for meeting these technical requirements are evaluated, and once agreed upon, the required technical components are recommended. The formal technology plan, which includes policies and specifications, and covers appropriate hardware and software, and training expenditure to implement the chosen technical components is formulated.

The pen-ultimate work segment, formulating the 'information action plan', involves:

- developing a migration plan;
- preparing an information action plan; and
- approving and initiating the information action plan.

The migration plan is a strategy for moving to the new information processing environment. The project team reviews the data, application, technology and organisation plans, groups them into projects and sequences their implementation. Next, all of the previous work is synthesised into an information action plan. This plan includes:

- a summary of the organisation's IT strategy;
- a summary of actions in the data and application, organisation, and technology plans;
- the migration plan;
- the costs and benefits in light of project relationships;
- a description of the process for annually updating the action plan;
- an appendix of reference materials [92].

The information action plan is reviewed by the team and presented to management for approval, after which, it is implemented and monitored.

The final work segment of the 'information planning' phase of Method/1 is 'project definition and planning' .This segment results in a model for beginning the implementation process with an individual project [92]. The team prepares a plan for carrying out the project, establishes a new team for doing so and defines its intended results. An initial conceptual system design is also prepared. The project definition requirements and conceptual design are presented to management for approval and authorisation to complete the development and implementation of the project [92].

Method/1 is rigorous. Its IS planning component is comprehensive, and if carried out effectively, and perhaps most importantly, by an experienced team, it would undoubtedly produce desirable results. It is also strongly supported by Andersen's CASE tool - Foundation. However, although very strong in project management and task integrity, Method/1 appears to be weak in actual 'pinpointing' technique. All IS planning methodologies require 'packaging' to orientate and drive the planning study, however, inherent in them must also be an ideological base and a core set of techniques to support and implement the ideology. A technique, or set of techniques, coupled with managerial judgement, to irrevocably pinpoint areas for IS development is essential. Although Method/1 does home in on critical areas and formulates development projects in these areas, the focus is stumbled upon after a pot-pourri of different and undirected interview activities, broad technique application and intuitive 'gut feel' rather than perceptive use of specific techniques.

Laudably, Method/1 assumes one of three approaches to applications development:

- custom systems,
- packaged systems,
- iterative development,

and so is more flexible in its delivery solution than IE. It also emphasises the importance of integrating new systems development technologies into existing and planned for information architectures and thoroughly documents the appropriate tasks for doing so.

However, original technique is ostensibly lacking in key work segments. The identification of IT opportunities is the methodology's crux for developing IT strategies, yet, the Method/1 documentation quite openly, offers no discerning 'opportunities' technique. A cynic might point out that the planning phase of Method/1 is a synthesis of others' techniques, heavily influenced by the work of Porter [124, 125] and Porter and Millar [126], and so no opportunities technique is offered as one is yet to be published by anybody else.

Other points worthy of note are that the mechanics of data modelling for Method/1 are vague, and as is often the case with IS planning, the methodology is expensive, and time and resource intensive. To its credit, Method/1 is a flexible 'pick and mix' methodology, and in any given situation, it is pointed out [2] that only a portion of the methodology is likely to be carried out, thus eliminating needless repetition.

3.3.6 - Tetrarch

Tetrarch is the software workbench supporting PA Consulting's proprietary strategic

IS planning methodology [120]. PA's approach to IS strategy formulation is undertaken in five stages as depicted in Figure 3.30.

Stage	Objectives
1. Initial business review	Interpret the ambition of the business & identify key issues to be addressed through IT.
2. Identify IS opportunities	Appraise the current situation & seek creative opportunities for exploitation of IT in pursuit of business strategy.
3. Prioritise opportunities	Determine the ideal system & data architectures to support the identified opportunities in terms of their contribution to business objectives.
4. Evaluate strategic options	Develop practical scenarios for implementing the key systems opportunities & evaluate these in terms of economics, risks and achievability.
5. Refine and document the strategy	Select, refine & document the preferred scenario and plan its detailed implementation.

FIGURE 3.30 - Stages of Tetrarch (PA Consulting Group [120])

Stage 1 of the methodology ensures that those issues which are of greatest importance to the future of the business are recognised and addressed. Top management interviews are carried out to examine:

- the company mission,
- the marketplace,
- industry trends,
- competitive position,
- business objectives,
- installed technology,
- CSFs.

This information helps to identify the right people for the study team and can be recorded within the Tetrarch workbench for subsequent analysis.

Stage 2 of the methodology seeks to identify strategic IT opportunities in areas where IS activities have been identified as deficient or under-performing from an appraisal of the existing IS situation. The appraisal typically involves:

- development of a high-level model of business functions based on an analysis of the value chain,
- development of a high-level information model,
- evaluation of existing systems to establish their effectiveness,
- analysis of business performance and operational bottlenecks.

Tetrarch enables a hierarchical business model (HBM) to be constructed providing a pictorial representation of the business processes. PA purport that "the structure of the HBM relates directly to the 'value chain' of the business and can accommodate cross references to product, organisation and information aspects of the business" [120]. Information models depicting the flow and interchange of information between business functions are constructed based upon entity-relationship modelling. Figure 3.31 depicts the structure of the HBM.

In selected key value-adding areas of the business, the functions and information models are analysed in more detail, and together with a product/business life-cycle analysis and creative workshop sessions with top management, broad opportunities for improving profitability, competitiveness, customer service and management practices are identified. Together with an understanding of trends in IT in similar industries, the need for creativity in identifying opportunities is once again emphasised. The magnitude of the task is made apparent as PA point out that the wish-list of IS derived in this way may number one hundred or more.

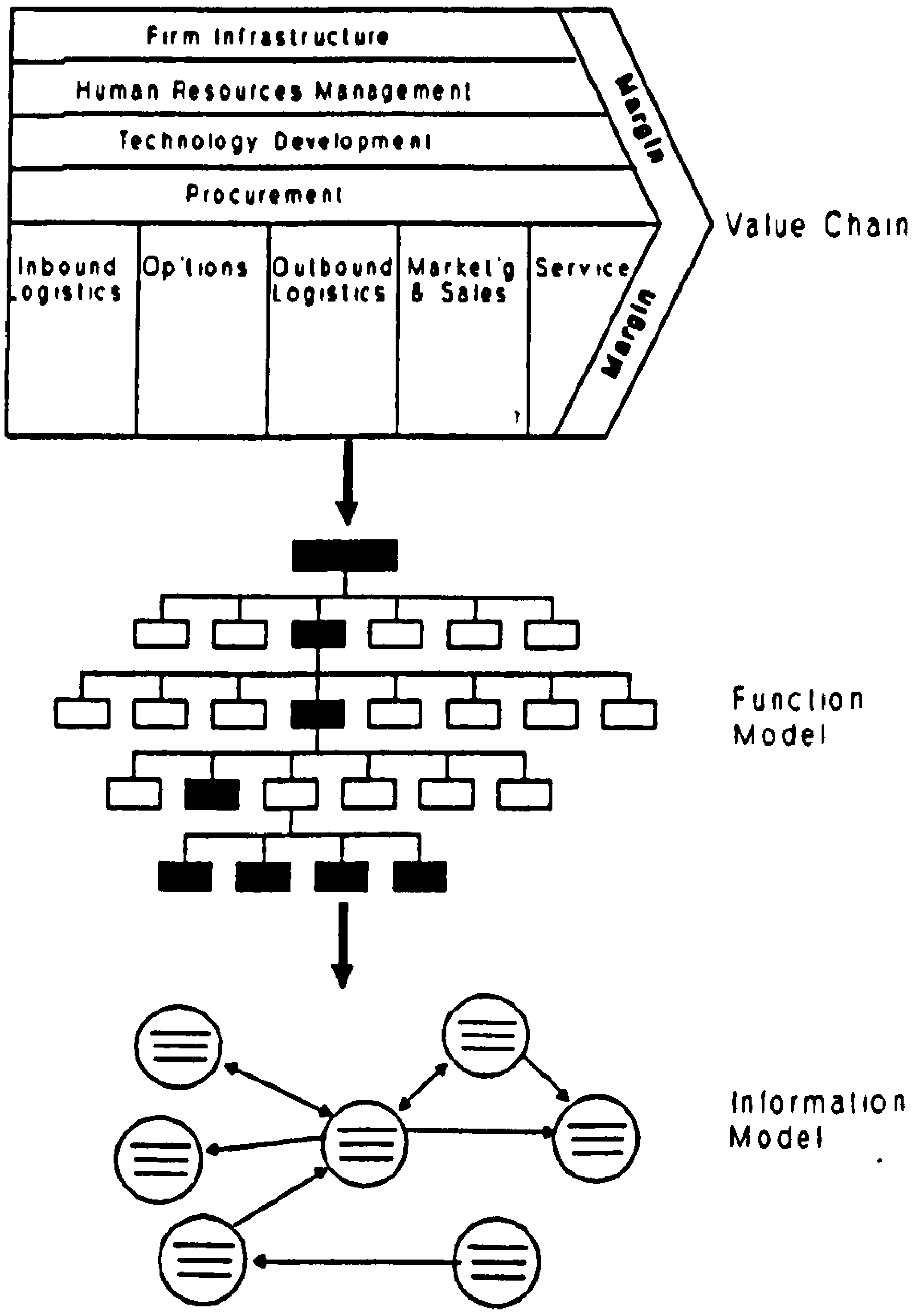


FIGURE 3.31 - Structure of the HBM (PA Consulting [120])

In stage 3, the IS opportunities are prioritised. Business priorities, available resources and opportunities for data sharing and rationalisation are considered in the prioritisation process. A matrix analysis facility within Tetrarch also enables the relationships between organisation units, identified business entities and functions, and IS opportunities to be defined and analysed. In this way, IS opportunities can be cross-referenced to any other object defined via Tetrarch, key relationships can be highlighted and decisions made regarding:

- system and data distribution,
- integration of systems,
- technical priorities.

"This typically results in a much smaller number of integrated systems initiatives as the backbone of the systems strategy" [120]. Each initiative is prioritised with respect to:

- contribution to business objectives,
- business return,
- practicality,
- cost-benefit (net present value) calculation,
- intangible benefits (undefined in the available documentation).

In stage 4, key issues for implementing the IS initiatives are considered and practical scenarios for doing so are evaluated. The type of issues analysed are as follows:

- IT budget,
- centralised versus decentralised processing,
- hardware supplier policy,
- environmental software policy (operating systems, DBMS).

Various scenarios combining the above issues and demonstrating their implications can be analysed via Tetrarch using the HBM and information model to reflect scenario characteristics. Estimates of expected man-months and elapsed time for design, programming and implementation of each prospective computer system (application packages or custom-written) are made. Manpower costs are assessed, and measures for people, technology and system complexity to quantify the risk associated with each system are calculated. In this way, comparisons between the various development options can be made.

The objective of the final stage of the methodology is to gain management approval of the preferred strategy and commitment to its implementation. This requires:

- selection of the preferred strategy from the options put forward in the form of strategy scenarios,

- refinement and documentation of the strategy,
- planning the strategy implementation,
- adoption and publication of the strategy.

The methodology's main benefits are purported to be:

- confidence that IS investment is strategically focused;
- potential for economies of scale and vendor leverage through an understanding of the whole picture;
- corporate initiatives as standards, data sharing and systems integration;
- a clear blueprint of the ideal, which can be adjusted with changing ambitions and market environment.

The above description of PA's methodology is based purely on a management overview document [120]. Access to methodologies is often restricted to such summaries and consequently only a flavour of the full methodology and its software support have been obtained. However, the overview is detailed enough to understand the tenets upon which the methodology is based and descriptive enough to appreciate the thrust and rigour of the analysis, and mechanics of the techniques.

The methodology is potentially very powerful. The Tetrarch functionality, although clearly displaying typical CASE tool and spreadsheet characteristics, is novel. The ability to support all aspects of strategic IS planning in one tool is time and resource efficient, particularly as most other approaches necessitate the use of several different software application packages and resource expense is a trait of most methodologies.

The concept of relating value-adding activities to business functions and subsequently data entities, provided current business ambition is properly determined and considered, is essential for effective IS strategy formulation. PA purport that Tetrarch has facilities for carrying out such an analysis. Whether this is done with any real 'intelligence', that is, can the software actually locate specific entities, via the value chain and a function model, that relate to business objectives, or does Tetrarch simply cross reference related objects? The former would be highly desirable, although the latter is more likely. Details of the mechanics of the process are not present in the overview documentation. However, acknowledgement of the importance of the concept and its inclusion in the methodology is positive in itself, as an attempt to structure the prioritisation process is clearly made.

Tetrarch's ability to automate relationship modelling (a process similar to BSP's cluster analysis) to help IS priority identification is also desirable. It quickens an otherwise slow and laborious process and increases its integrity. Although one or two tasks appear poorly supported by appropriate techniques, for example the actual process of identifying IS opportunities and the establishment of existing systems effectiveness both require substantial judgement and intuition, most tasks are incisive and structured, obviating the need for excessive personal judgement. In particular, project evaluation with the methodology is a rigorous and quantifiable process and reduces the number of prospective development initiatives.

Overall, the methodology is leaner than most of the previously reviewed methodologies, that is, each task within each stage has a specific rationale and focuses on value-adding activities, its purpose is plainly visible and it can readily be related to IS planning objectives. There is seemingly little project management 'packaging' and ancillary activities.

3.3.7 - CASE*Method

CASE*Method is Oracle's IS development life-cycle methodology [118]. It has a number of fundamental principles upon which it is based, which are emphasised throughout the approach to applying the methodology [118]. They are:

- top-down analysis;

- heavy user involvement;
- organisational independence;
- technology independence.

Although computer assistance is not essential for carrying out the methodology, the use of CASE tools is recommended for many of the complex and error-prone tasks. Consistency checking and procedural integrity is handled particularly well by CASE tools.

The stages of the complete CASE*Method methodology are depicted in Figure 3.32.

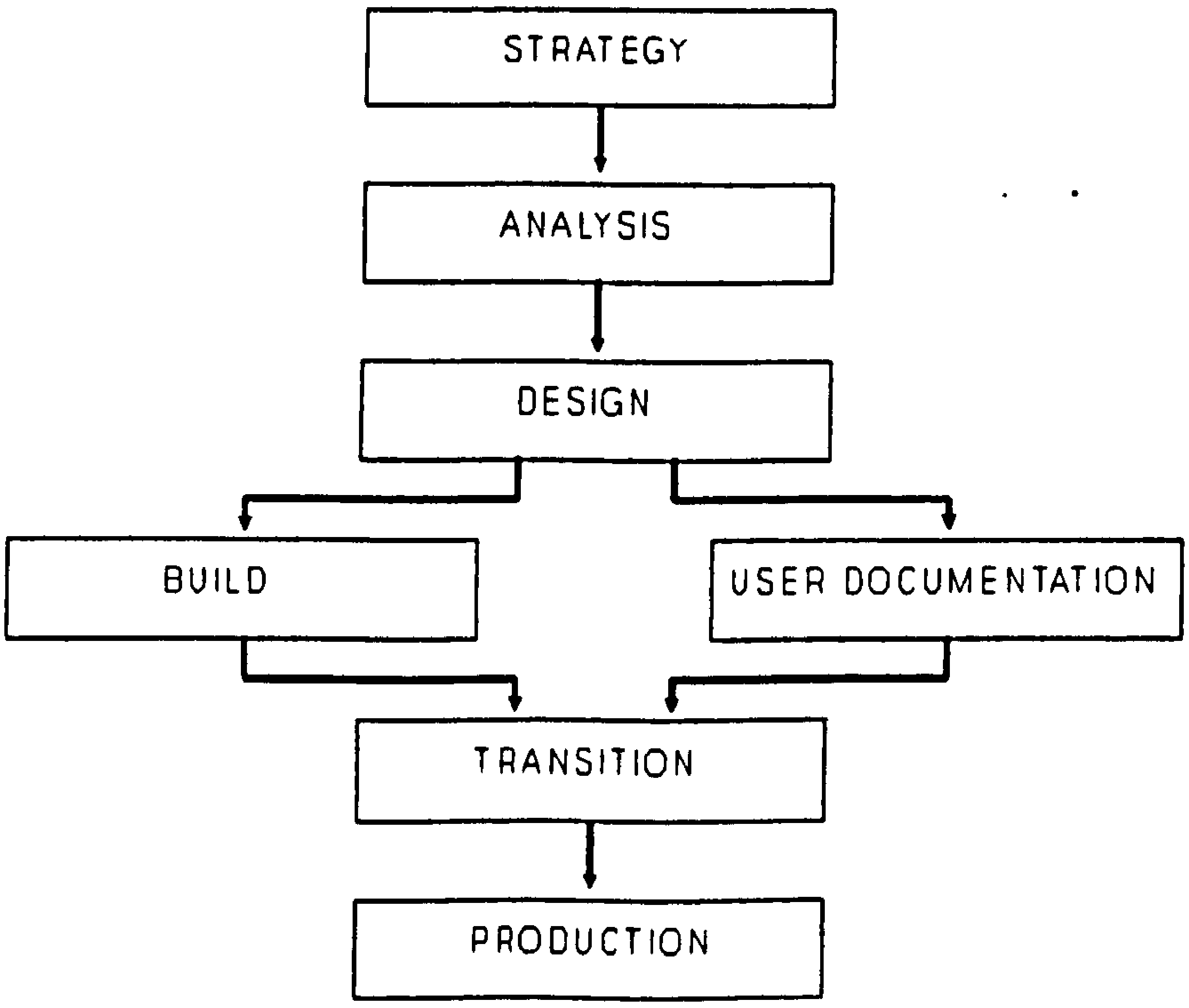


FIGURE 3.32 - Stages of CASE*Method (Oracle [118])

Only the strategy and analysis stages are reviewed. "The objective of the strategy stage is to produce, with user management, a set of business models, a set of recommendations and an agreed plan for IS development, which will serve the organisation's current and future needs, while taking account of organisational, financial and technical constraints" [118]. A framework outlining the main elements of the methodology is depicted in Figure 3.33.

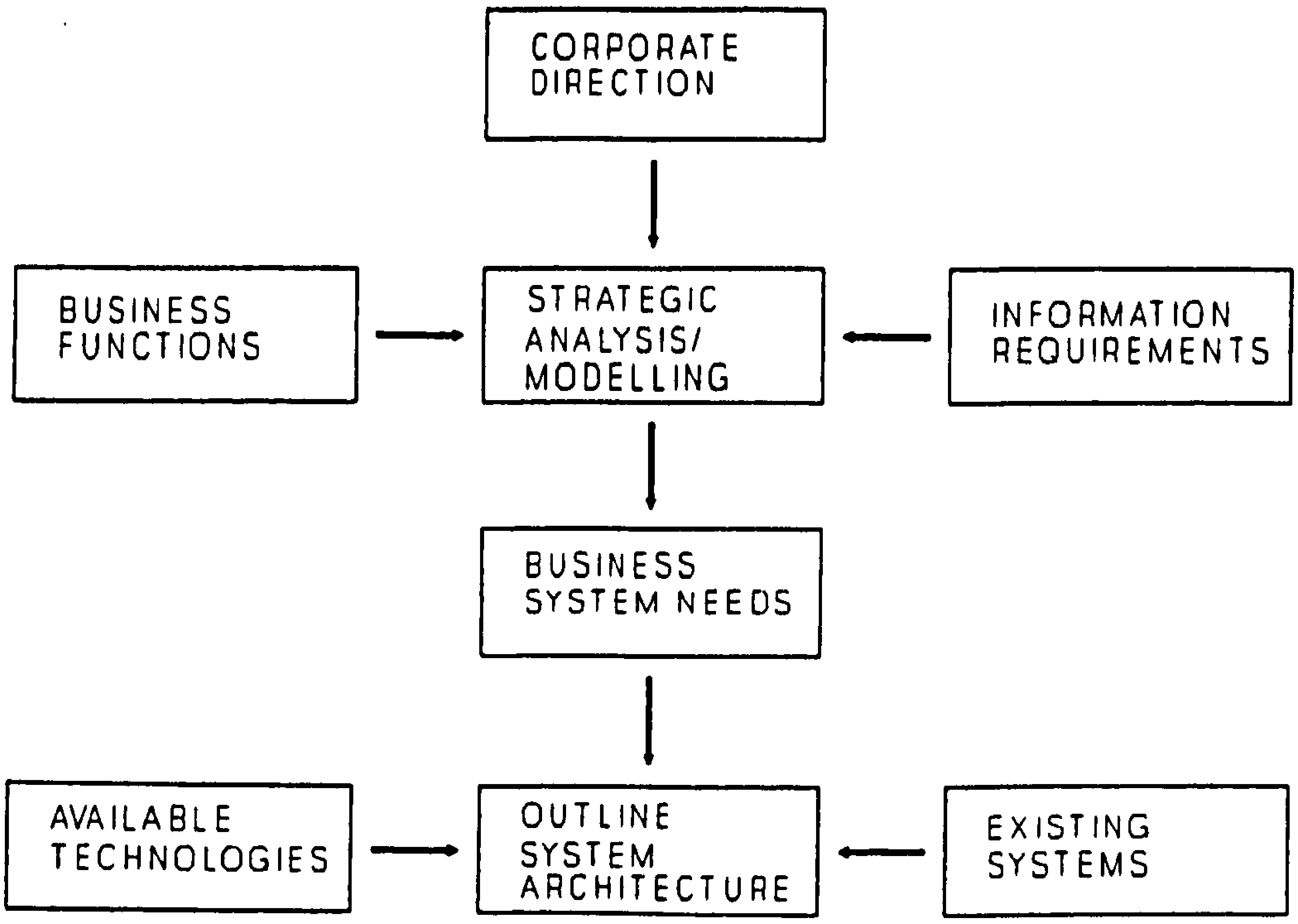


FIGURE 3.33 - Evolving a strategy with CASE*Method (Oracle [118])

The approach is claimed to be methodical rather than mechanistic, that is, the discipline of a step-by-step approach is combined with the flexibility to retrace the steps at any time to correct misunderstandings, and to investigate alternative means of achieving the methodology's objectives [118].

Tasks comprising the strategy stage are listed in Figure 3.34.

S10 - Project administration and management
S20 - Scope the study and agree Terms of Reference
S30 - Plan a strategy study
S40 - Briefings, interviews and other information gathering
S50 - Model the business
S60 - Prepare for feedback session
S70 - Conduct feedback session
S80 - Consolidate results of feedback session
S90 - Complete documentation of the business model
S100 - Evolve information systems architecture and make other recommendations
S110 - Determine forward system development plan
S120 - Prepare verbal report
S130 - Report to senior management
S140 - Prepare and deliver written report

FIGURE 3.34 - CASE*Method strategy stage tasks (Oracle [118])

Project administration and management is an ongoing task carried on throughout the stage. It consists of typical administrative activities performed by the study team such as progress reporting and activity scheduling to ensure the integrity of tasks and monitor the quality of task deliverables.

The scope of the study is determined in the next task. A total company view is not explicitly recommended, but a wide enough area to make the study meaningful must be reviewed. Scope definition enables an appropriate judgement to be made on timescales. A terms of reference for the study is also defined in this task. This entails defining and agreeing project objectives, constraints and deliverables. The number of interviews are estimated and staffing requirements and responsibilities established.

The third task, 'plan a strategy study', encompasses preparation for the study such as background reading, briefing sessions and interview scheduling. An initial view of critical areas for investigation is identified.

In task 40, interviews are carried out and summarised. After the project team has consolidated the interview notes, an initial business model and a rough 'function hierarchy' and entity relationship diagram are constructed.

In the next task, business direction in terms of business objectives, aims, priorities, strengths, weaknesses, opportunities and threats, and CSFs is identified. A consolidated model of the business (function model in terms of a function hierarchy and entity model in the form of an entity relationship diagram) building on the initial and rough model from the previous task is constructed, and checks are performed that each element of business direction is supported by business functions and information needs. Functions, entities and information needs are cross-checked and their interrelationships shown using the cluster analysis technique as described and reviewed in the BSP methodology.

In the next three tasks, a 'feedback session' is prepared for and conducted and the results of it consolidated. In the sessions, the models are presented for criticism and amendment, if necessary, to a group of eight to ten participants. The task results in a consensus agreement of the results obtained to date. Task 90 ensures that the documentation of the 'business model' is complete and in a form that allows it to be used.

Task 100 uses the information obtained and the developed models to formulate a system architecture. A number of activities precede the architecture formulation. First, business needs and their priorities, and any logical dependencies are identified. Next, application areas from the function model are selected. The future applicability of existing systems is examined and co-existence and transition issues are investigated. The volume and frequency of information transfer is established. In the next activity, potential useable hardware and software are identified. Alternative solutions for each application area are identified. Reports for feasible solutions are written and fully costed. Technically or economically unfeasible solutions are rejected or deferred. The system architecture is reviewed with reference to the feasible solutions.

In task 110, the recommendations produced in the form of a system architecture are translated into a costed plan for systems development. Each application area is subdivided into segments of both dependent and independent work. The resources required to complete each activity are estimated and an activity schedule is produced. The combined development plan and recommended system architecture comprise the strategy: the intended result of the first stage.

The final three tasks of the strategy stage are geared up to obtaining management approval to the strategy for systems development. In task 120, a verbal report of the strategy is prepared. The strategy is presented in the next task. In the final task, 140, the management approved strategy is documented. The main body of the report is typically between thirty and sixty pages in length.

The analysis stage of the methodology "takes and verifies the findings from the strategy stage and expands these into sufficient detail to ensure business accuracy, feasibility and a sound foundation for design within the scope of the organisation and bearing in mind existing systems" [80]. Analysis tasks are listed in Figure 3.35.

A10 - Project administration and management
A20 - Plan detailed analysis
A30 - Review standards, constraints and potential design issues
A40 - Investigate detailed requirement
A50 - Review findings against Terms of Reference to confirm approach
A60 - Provide detailed specification
A70 - Provide initial transition strategy
A80 - Define audit/control needs
A90 - Define back-up/recovery requirements
A100 - Perform outline sizing and predict performance
A110 - Review results of detailed analysis
A120 - Obtain stage-end commitment

FIGURE 3.35 - CASE*Method analysis tasks (Oracle [118])

Task 10 is equivalent to task 10 of the strategy stage and covers reporting, quality assurance and administrative activities. In task 20, the approach, structure and timescale for the analysis stage are decided upon. An analysis stage terms of reference is also written and interviews are scheduled.

In task 30, a series of decisions relating to standards, constraints and potential design issues are made. Firstly, standards required for documentation and naming conventions are determined, likely acceptance criteria for the system are then determined and finally, a high-level review of factors that potentially will affect the design stage:

- preferred technologies,
- user performance expectations,
- technical constraints (for example, current or preferred hardware, database management systems),
- organisational concerns.

Detailed requirements are investigated in task 40. The objectives of the investigation are to extend and cross-check the entity relationship diagram and function hierarchy developed in the strategy stage.

Interviews are conducted with users and/or IS personnel and to aid the model development process. A function/entity matrix is constructed to aid the entity and function cross-checking. Those functions where complexity, dependency or usage require attention are identified. Function dependency, state transition and data flow diagrams are drawn, and function logic (English-like language for defining functions) and potential design issues are defined.

The feasibility of the current direction and/or opportunities are reviewed in the next task incorporating the results of task 40. Possible changes include scope, technical alternatives and development method, each of which must be agreed upon before proceeding onto the next task.

A detailed specification is the outcome of the next task. This includes a check that all required entities have been included in the analysis, a specification of business functions to the required level by way of a definition of function dependencies (one function's relationship to another), data usages and function logic and a draft definition of standards, for forms, reports, menus, user documentation and any other form of user interface.

An initial transition strategy is produced in task 70. Transition elements include a delivery and acceptance plan containing notes on what could be delivered and its preferred implementation mode; a training plan outlining organisational and procedural changes and preferred training methods and requirements; a data take-on plan outlining data sources and ownership; a cut-over plan describing the procedures for changeover to the new system; an installation plan outlining required hardware and software and a schedule for implementation; and critical factors containing details of key people and resources essential for a smooth transition.

Audit and control requirements are defined in task 80. This covers system security access, any necessary legal requirements and an evaluation of potential significant error handling. Requirements for back-up, recovery and storage of information are defined in task 90. In the final three tasks, 100, 110, and 120, data base size is estimated and likely system performance predicted, the results of the analysis stage are reviewed to ensure model and procedural completion and consistency, and an analysis report or presentation is produced and commitment to proceed obtained, respectively.

CASE*Method is a comprehensive and detailed methodology. For each task, the methodology documentation provides a description of the activities necessary to carry out the task, and lists of task inputs, outcomes, time estimates, resources, techniques and tools. The methodology is verbose in its comment and description even to the admonishment to "make every effort to ensure good grammar, correct spelling and a high-level of readability" and to "look for concern in the eyes of the users". This level of detail aids prescription and so prevents potential ambiguities and errors in application but is perhaps a little pedantic and condescending. Curiously a similar level of rigour is absent from several of the most critical tasks within the methodology.

CASE*Method is BSP-like; based on several of the same concepts, for example, top-down analysis and organisational independence, and utilises several of the same techniques, for example, cluster analysis. Like BSP, if wielded appropriately, it would provide an effective IS development plan and requirements specifications.

The methodology places great value upon project management and is replete with reporting and feedback tasks and activities. These often appear disproportionate to the number of pinpointing and actual analysis activities. For example, the 'feedback session' of the strategy stage is allocated four whole tasks (two sevenths of the complete stage in terms of number of tasks), yet a vital element in order to evolve an information architecture and make recommendations such as identifying possible technologies like packages, hardware and software is given only one activity within a single task (task S100, activity 40). In a similar fashion, preparing and delivering a report of the systems development plan to senior management is allocated three complete tasks. This is not to say feedback sessions and reporting activities are unimportant, but the impression given is one in which project management is considered above business and IS analysis. The methodology does appear to be short on the appropriate techniques to conduct such an analysis. Although techniques such as CSF analysis and SWOT analysis help focus on key issues, they are limited. Unambiguously identifying areas for IS development is not easily achieved using CASE*Method.

CASE*Method is clearly a 'hungry' methodology. It is expensive to apply in terms of time and resources, and requires the use of a CASE tool for effective application. However, by virtue of its Oracle ownership, it is certain to be supported by top management, and this is laudable (and hopefully cost effective). Also, to its credit, it advocates flexibility in application. Like IE, it is continually evolving, taking account of the latest advances in the field. It is more appropriate in a large organisation than in an SME (small or medium-sized enterprise).

3.3.8 - Lucht's Methodology

Lee H. Lucht of Jostens Inc. [99] describes the primary objectives of the planning phase of the systems development life-cycle as being to:

1. Provide a formal, objective method for management to identify the business's short and long-range IS needs and priorities.

2. Determine the data/systems architectures and develop cost-effective strategies for implementing individual projects that will eventually lead to cohesive, integrated systems that have a long life.

3. Maximise the effectiveness and productivity of the information management resources.

4. Increase executive confidence that the systems development effort will support both the strategic and tactical plans of the business.

5. Identify data as a resource that needs to be planned, managed, and controlled in order to be used effectively by everyone in the organisation.

6. Improve the relationship between the IS staff and users by providing systems that are more responsive to user requirements and priorities.

He offers a generic systems planning methodology to achieve these objectives. The methodology is an attempt to present a broad systems planning framework that can be applied in almost any business setting simply by using the building-block approach (deciding which components are applicable and which are not). The framework is shown in Figure 3.36.

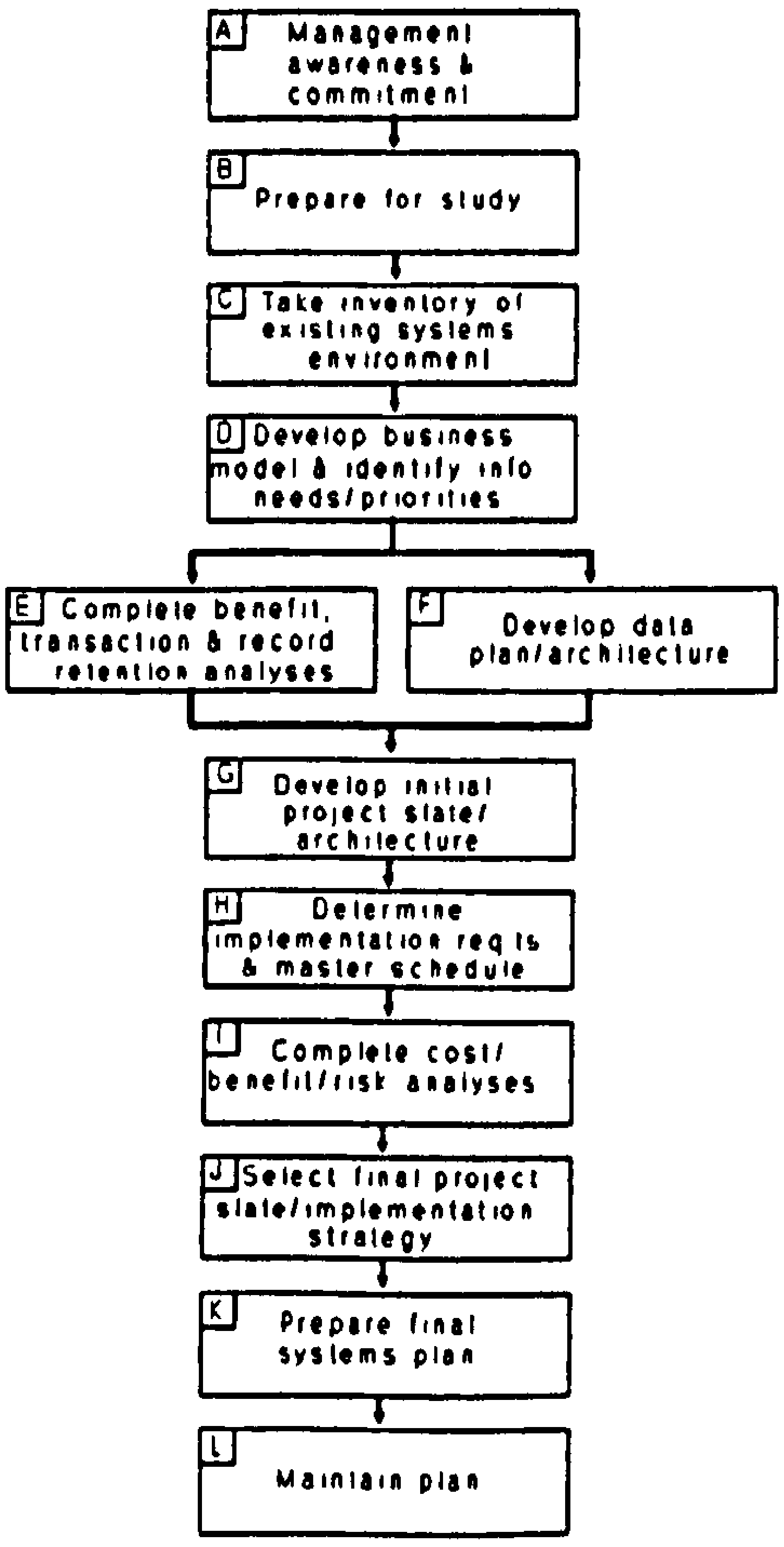


FIGURE 3.36 - Outline of Lucht's generic systems planning framework [99]

The questions addressed during the planning process are:

- Where are we now?
- Where do we want to go?
- Why do we want to get there?
- How are we going to get there?
- When will we get there?
- What will it cost?
- What will be the net impact on the business once we get there?

In the first stage, management awareness and commitment is gained through a series of systems planning awareness sessions for all key managers. After the sessions, managers are required to express their commitment to the planning effort both verbally and in writing. Involvement of top managers is regarded as being fundamental to the quality of the end product. Active and objective ongoing commitment is required in all aspects of the study until it is completed. It is recommended that a multi-functional IS steering committee should also be formed to "provide overall direction, guidance, and support throughout the planning process, and to install a control mechanism to ensure that all key final output objectives are met within schedule" [99].

The next stage, 'prepare for study' has four primary objectives:

- select study team,
- determine scope of study,
- develop master completion schedule,
- prepare orientation package.

It is recommended that the team should be composed of both user and IS members who can objectively analyse the existing systems and procedures. Three or four permanent members should be the normal size of the study team. In certain areas, the expertise of other staff may be required, and temporary team members may be used. A team member with previous systems planning experience and a broad business background is designated as the 'torchbearer'. Assurances by top management are made that team members will be allocated time for completing the study and will have opportunity to become trained in the methodology prior to its commencement.

The scope of the study is large, and could be an entire company, a factory or a single division. The decision to decide the scope of the study appears to be somewhat arbitrary. Simple guidelines are offered and advice is given. For instance, it is recommended that the boundaries of the planning process do not become too large, and, in a large decentralised company, it is best to tackle one division at a time. Experience and expertise gained in the first division can then aid the planning process in the others. A master completion schedule in the form of a simple Gantt chart is prepared and distributed by the study team. It shows the required planning stages and their respective completion dates. Assignment of study team members to specific stages and tasks is also done at this point. It is estimated that a feasible systems plan takes between three and eight months depending on business size, complexity and study team skills.

Next, an orientation package tailored to each functional area or participant influenced by the study is prepared by the team. The package should contain:

- an interview guide
- a summary of previous management interviews, if applicable,
- an initial draft business model,
- examples of potential IS requirements.

The packages should be distributed to the interviewees prior to the actual interviews, thus, allowing themselves the necessary time to prepare.

In stage C, a comprehensive inventory and assessment of existing systems is made. Its purpose is to address the 'Where are we now?' question. The inventory accounts for hardware, applications software, data management systems, programming languages, data communications network, economics, age, technological level, flexibility for change or growth, data architecture, file structures and so on.

'Where do we want to go?' is addressed in the next stage. "This is done by asking the users to translate their business objectives into needs and priorities" [99], and consists of the following activities:

- schedule user interviews,

- review previous interview summaries, if applicable,
- obtain business perspective,
- review business objectives and CSFs,
- refine and expand the initial business model,
- identify IS requirements and priorities, and
- summarise input and obtain verification.

After interviews have been scheduled and previous ones reviewed, the organisation's strategic position and goals are examined in order to obtain an overall business perspective. This includes identification of plans relating to business growth, diversification of products and services, acquisitions and mergers, and broad changes in operating policy, and precedes a review of business objectives and organisational CSFs. In the next activity, the initial business model is refined and expanded. The model evolves as depicted in Figure 3.37.

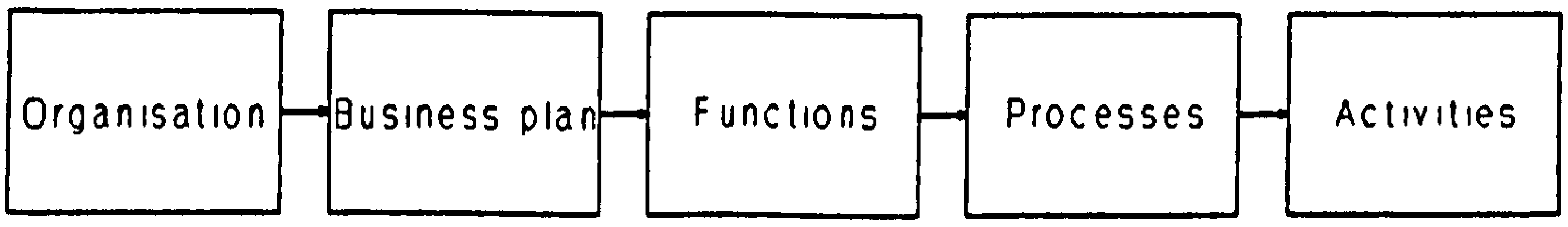


FIGURE 3.37 - Evolution of business model (Lucht [99])

A business model is constructed from a tabulated hierarchy of business functions and processes together with the information required to support them. Lucht [99] defines a business function "as the highest-level summary of logically related actions that must take place to perpetuate the business" and a process as the "ongoing set of related activities that support one of an organisation's functions". When completed, the business model is used as a basis for:

- assisting users to identify their IS needs, priorities and benefits,
- developing the data plan/architecture,

- developing the systems plan/architecture,
- providing a reference from which a transaction analysis can be completed.

Users are asked to translate business objectives and CSFs into IS needs and priorities in the next task. To aid this somewhat difficult process, it is suggested that "pertinent examples of various information technology capabilities be demonstrated and communicated to them by the study team during the interview process in order to facilitate this 'needs' identification process" [99]. The importance of each need is compared to the quality of the existing systems support. Lucht [99] tentatively suggests that this process can be done numerically by comparing the 'importance' of each request, against a number of performance criteria such as 'cost to deliver' , 'relevancy' and 'timeliness'. After each interview, the notes are summarised, and each summary is sent back to the users for verification.

In stage E, benefit, transaction, and record retention analyses are performed. The 'Why do we want to get there?' question is addressed in the benefit analysis. The task seeks to identify the benefits obtained from implementing the various IS requests. Where appropriate, users are asked to identify and quantify the benefits associated with their chosen IS requests. Guidelines and worksheets (see Figure 3.38) are used to facilitate the benefit (both quantitative and qualitative) identification process.

A transaction and record retention analysis is conducted in order to determine transaction activity levels and record retention needs.

Areas of Potential Benefits	Annual Revenue or Expenses	Estimated Improvement		Projects					
		%	$	1	2	3	4	5	etc
• Direct labour & fringes • Indirect labour & fringes • Overtime Premium • Purchased materials & supplies • Purchased services • Freight • Phone • Bad-debt write-off • Inventory carrying cost • Receivables carrying cost • Increased sales (translated into contribution)									
Totals									

FIGURE 3.38 - Benefit analysis worksheet

A high-level data plan and architecture is developed in stage F. The stage begins to address the 'How do we get there?' question. The cluster analysis technique as described in section 3.3.1 is used to group related data into subject data bases or data classes. During the cluster analysis process, Lucht [99] posits that a manufacturing company will typically identify 20 to 60 subject data bases, dependent upon the size and complexity of the business. After clustering, the architecture itself is prepared and represented in the form of a matrix as shown in Figure 3.14. The architecture is used to help determine:

- which users, locations, and/or business units share information and what potential there is for developing common systems across functional and/or organisational boundaries;
- how data files should be designed/managed to best support the long-term systems development effort (e.g., subject data base or application data base);
- the IS implementation and geographic processing architectures;

- the compatibility of packaged application software data file structures with the desired file structures.

Addressing the 'How do we get there?' question is continued in stage G. The stage has two objectives:

- identify logical IS projects and develop the implementation architecture;
- develop the geographic processing architecture.

In order to achieve the first objective, a review of the business model, the data architecture and the IS requirements is carried out. This involves, first, formulating broad projects by grouping together sets of related processes in need of computer-based support. A design and implementation horizon of a year or less is used as a rule of thumb to determine project size. Projects estimated to take longer than this are broken down into smaller units. Data files required to support each project are identified and recorded, and dependent and independent activities are identified in order to develop the implementation architecture. It is at this point that the geographic processing architecture is decided upon, and the decision is made as to whether the IS environment should be centralised, decentralised, distributed or a combination. A cost/benefit/risk analysis is carried out to aid this process. Lucht [34] suggests that, at this point, it is useful to prepare an initial project 'slate' to be presented to the IS steering committee for prioritisation purposes. This reduces the number of IS requests to a manageable size.

The remainder of the 'How are we going to get there?' question and the 'When are we going to get there?' and 'How much will it cost?' questions are addressed in stage H. The activities involved in the stage are as follows:

- determine application software development strategy and associated costs/risks;
- determine hardware/data communications requirements and associated costs risks;
- determine other design/implementation requirements and associated costs/risks;

- prepare systems implementation master schedule;
- determine organisational needs and associated costs;
- prepare consolidated project cost schedule.

Firstly, the decision as to whether new or enhanced software should be developed in-house or purchased from outside is made. Development, implementation and maintenance costs/risks associated with each project are identified for both the 'make' and 'buy' options. Next, hardware and data communications requirements are determined. Data communications are often an integral part of the hardware and software strategies. Cost, lead times and risks associated with all feasible equipment options are evaluated. Prospective master schedules are prepared to analyse various implementation timetables, after which the business implications and costs of the alternative strategies and implementation plans are determined. This results in the development of an organisational plan outlining two or three systems development/schedule/staffing options for presentation to the IS steering committee. The last step of this stage is to prepare a consolidated project cost schedule by aggregating the costs associated with each project.

The primary purpose of stage I is to address the 'What will be the net impact of the business?' question. A cost/benefit/risk analysis is conducted for each option. Lucht [99] emphasises the need to 'time-phase' the estimated costs and benefits associated with each project over its expected useful life as negative cash flows are often expected in the early years of major projects. Risks associated with each project are also determined.

Stage J involves selecting the final project slate and implementation strategy. This is based on the consensus opinion of the IS steering committee and involves a rigorous comparison of all projects and implementation options.

In the last two stages, a final systems plan is prepared by summarising and compiling the key outputs from each of the previous stages, and procedures and mechanisms established to ensure that the plan will be reviewed and updated periodically.

Lucht [99] provides a very succinct, lucid and honest description of his methodology. The flow of activities is logical and follows a clear pattern, 'user-friendly' proformas are provided for applying techniques and achieving task objectives, and the methodology is not overburdened with project management and what has already been described as ancillary packaging activities. This results in an approach that is relatively simple to apply with meagre resources and in a relatively short space of time when compared to some of the other methodologies. Furthermore, the methodology has several original and differentiating features in the issues it addresses and areas of analysis it focuses upon. Firstly, the very important issue of effectively integrating and ensuring the compatibility of old and new systems is structured and catered for in a detailed yet concise fashion. Costs, benefits and risks of project requests are rigorously considered, and hardware, software and data communications options are appropriately and contextually evaluated. However, it is noted that key analyses, as in most of the methodologies, are subjective or consensus-based rather than objective or technique-based. For instance, the opportunities analysis and project prioritisation are both developed through weight of opinion. This reinforces the notion of the apparent shortage of dedicated IS strategy formulation techniques.

3.3.9 - Tozer's Methodology

Ed Tozer is an independent consultant. His methodology was developed and refined over a number of years through extensive use in planning projects [145]. The methodology requires a number of managerial pre-requisites:

- the existence of a business plan, and a will among senior management to make it clearly visible to and well understood by all levels of management;
- a willingness on the part of senior management to commit energy and resources to defining and implementing the IS plan;

- a broad appreciation of general trends in IS use and expenditure; "management need to have thought through how these trends relate to their own organisation's industry sector and its competitive position" [145].

The purpose of the methodology is to produce for an organisation quickly an IS plan which reflects the business information needs, and operational support needs and priorities, and which forms a basis for subsequent evolution. There are four main phases to the methodology:

1. Determination of business information needs
2. Developing architectures for applications and data
3. Setting key priorities and groupings
4. Migration planning and presentation of the results.

Figure 3.39 illustrates the overall structure of the approach.

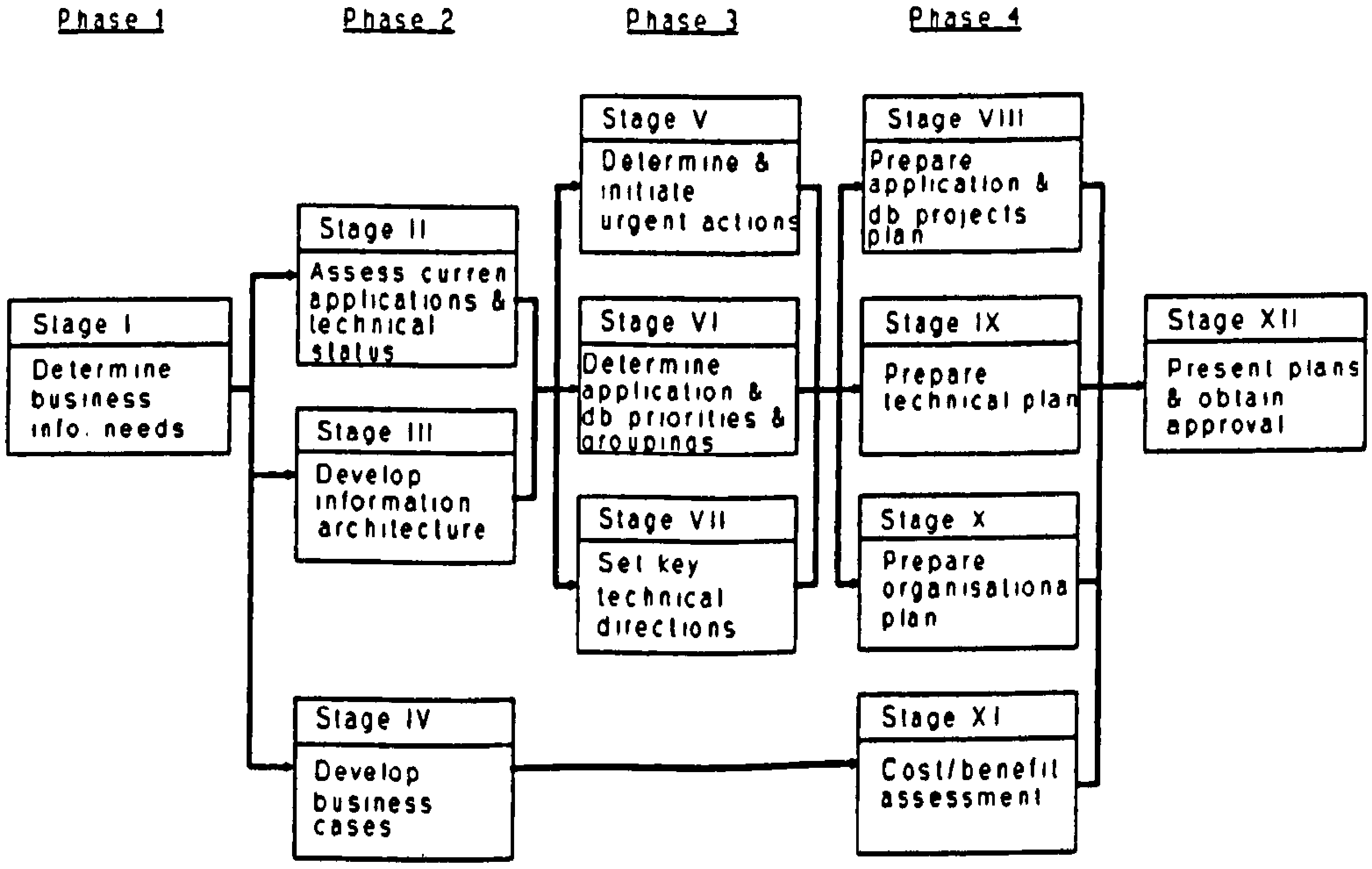


FIGURE 3.39 - The stages of Tozer's methodology (Tozer [145])

In phase 1, business plans and priorities, and the functional and organisational structure of the enterprise are analysed by way of a series of top-down interviews with management. Information elicited from the interviews follow the business planning elements shown in Figure 3.40.

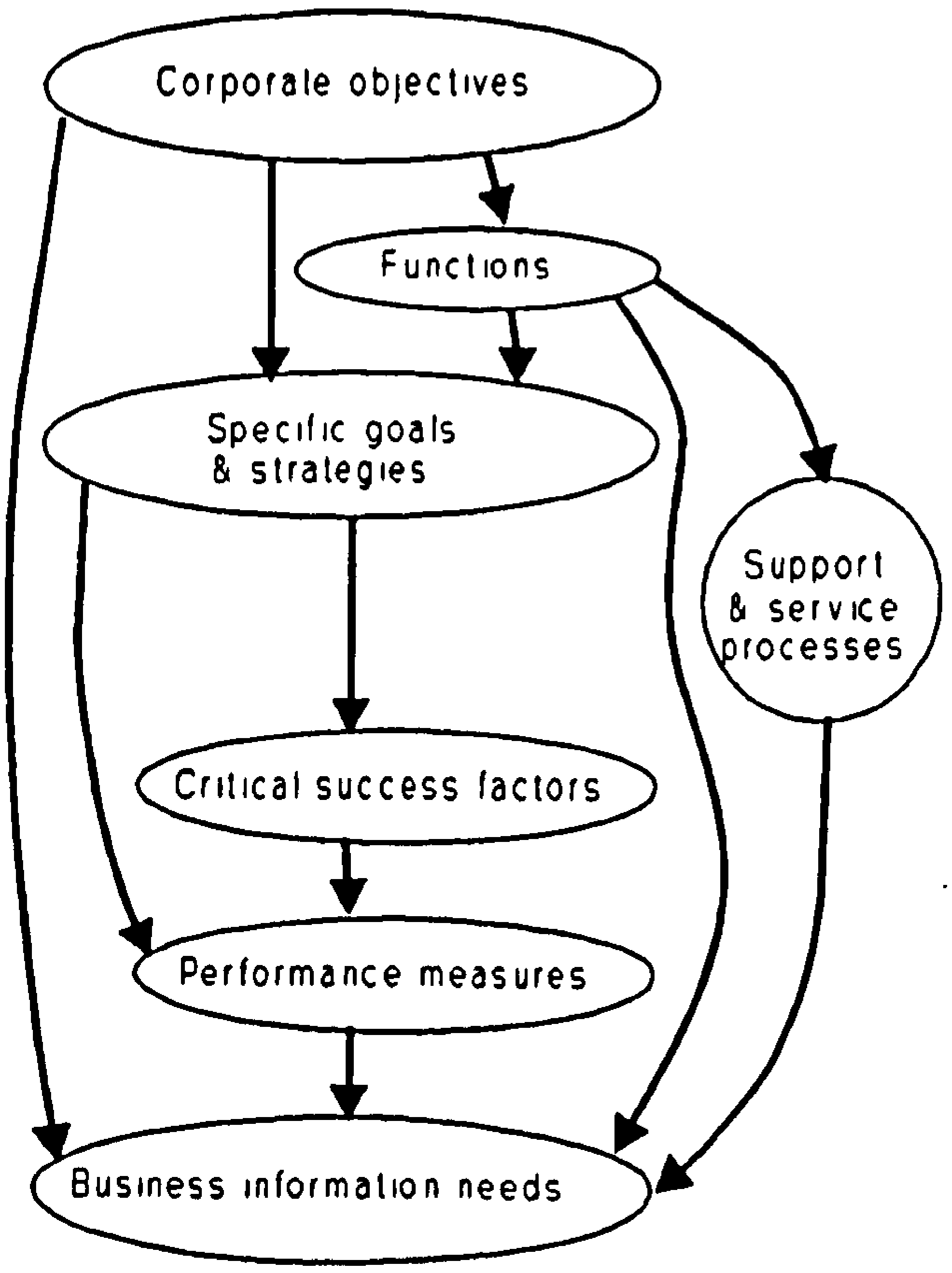


FIGURE 3.40 - Business planning elements (Tozer [145])

At the lowest level of the "management by objectives" hierarchy, prioritised business information needs, which are directly related to the needs for running the business, and which can be used to drive the plan for IS are defined. An extract of a statement of business information needs is shown in Figure 3.41. Priorities for information needs are agreed through a series of working interviews with the managers interviewed. These form preliminary priorities for IS areas.

Information need	*Source priority (H/M/L)*	*System implications*
Capability for extensive analysis of, & modelling based on marketing database e.g. - to explore potential impact of new products under range of circumstances - risk evaluation of new ventures eg modelling of potential market share & profitability of alternative product & promotion strategies	M	Needs new marketing database development, & enhanced end-user facilities & support. High potential for use of interactive modelling tools.
Market & consumer opinion research & surveys - concerning purchasing preferences - concerning image & product markets	M	Much external input.
Competitor information - prices, market share - tracking of activities	M/H	
Analysis of demand trends, related to pricing, promotional & competitive activity	H	Needs far better information on shipments & external factors.
Fuller & more accurate analysis of all elements of manufacturing & distribution costs	VH	Needs integrated, uniform treatment of all costs, coding categories.
Analysis of supplier performance, relating quality, returns & timeliness of delivery	H	
Accurate, up-to-date costs for all stages in the distribution chain	H	Need compatible coding structures & information flows from all sites.

FIGURE 3.41 - An extract of a statement of business information needs (Tozer [145])

Preparatory information for phase 2 of the methodology is also collected. This includes an inventory of all current systems, databases, files, IS staff resource, skill and experience levels and all computer communications hardware and software.

Three stages, running approximately in parallel make up phase 2. Firstly, a full assessment is made of:.

- current computer and communications hardware and systems software,
- current applications including development projects,
- all systems development and technical staff resources.

In each case, the collection of information is followed by an assessment of strengths and weaknesses made in relation to the business needs and priorities identified in phase 1. Specifically, assessment is made in terms of:

- needs met,
- user satisfaction,
- operational stability and integrity,
- enhancement potential.

An ideal set of applications, regardless of historical constraints or cost/benefit considerations is represented by way of a map. The map is in the form of a simple block diagram.

Secondly, a preliminary definition of the information architectures needed to support business needs is made. At this early stage, the definition is "coarse" and "conceptual". The architecture forms the basis for drawing up a plan for how the different elements of the systems and files or databases should fit together. Structured modelling techniques are used to represent the information architectures. No single technique is offered, but a range of options is provided, i.e.

- data analysis (entity modelling),
- functional analysis,
- data flow,
- dependency analysis,
- affinity analysis.

Thirdly, an 'idealised' set of business applications is identified for each natural group of information needs. A 'business case' is developed for each application.

The objective of phase 3 is to turn the conceptual applications and databases into real systems and databases and group them into suitable implementation projects.

Technical strategies are also considered at this point. This is done with reference to:

- near versus longer-term options,
- risk analysis and control,
- keeping the total number of technical components to a minimum.

Tozer [145] defines a number of technical environments which can be used as a good 'starting-point':

- central operational batch processing based on a shared integrated database,
- central operational on-line access/update of the same main operational database,
- central MIS and end-user computing,
- general purpose local DP support for single users and small groups,
- office administration support and automation.

It is also emphasised that advances in technical directions should be monitored. These include:

- computer hardware power trends,
- artificial intelligence-based developments,
- developments in rapid development and 'fourth generation' languages,
- data in networks - microcomputer and distributed database.

In phase 4, the physical placement of computers and file is determined. This is done so as to optimise:

- computer hardware costs,
- data communications costs,
- provision of robustness and resilience,
- provision of future flexibility.

The following information is collected:

- the business location(s) of the user(s);
- volumes of messages and data entities;
- what data is used, and with whom it is shared;
- where data is shared, how up-to-date must the view be.

It should thus be possible to determine whether for particular applications, it is most appropriate to provide:

- a shared central service,
- departmental facilities, with local sharing,
- dispersed personal computers,
- some combination of the above.

Tozer [145] emphasises the importance of an effective IS organisational'and manpower resource plan. The objectives and requirements for key changes in IS organisation include the following:

- rapid and clear identification of end-user versus IS division responsibilities,
- effective allocation of roles for rapid and effective support and development,
- maximum devolvement of responsibility to end-users for creation and maintenance of business data'
- identification of the need for intervention by IS professional when applications of high complexity or strategic significance are proposed.

A business case is developed for each potential project. This is done by the responsible user, and concerns at least the following:

- business benefits,
- avoidance costs - what it will cost to survive without the system,

- alternatives considered.

It is also essential to show that all major risks have been considered, and that there are ways of recognising and controlling them. The last step is for the business case to be presented to "fund allocators".

By his own admission, Tozer's methodology is not radically new or different. It, instead, follows a familiar trend of synthesising selected existing techniques into a workable whole. The methodology as a technique 'toolkit' is armed with most of the IS strategy formulation techniques discussed in each of the previous methodology descriptions. These include both data and function modelling and the use of cluster analysis matrices for determination of subject data areas and natural application groupings.

The methodology has some familiar strengths and weaknesses. It involves top managers, users and IS staff actively in the study. It provides a rigorous analysis of business ambition and direction, and detailed checklists and questionnaires for ease of application. Furthermore, it provides a pictorial representation of information architectures and a detailed analysis of potential technical components and options to form part of the architecture.

However, the methodology demands revolution rather than evolution of IS, and its lack of prescription and apparent choice of technique it gives the prospective user, over-complicates its application leaving much to the intuition of the responsible consultant.

3.3.10 - Strategy Formulation Methodologies - Summary and Critique

An attempt has been made to cover all of the IS strategy formulation methodologies developed for which suitable and sufficient documentation has been published and is freely available. This is difficult as every methodology is a consultative approach, and for issues of confidentiality, specific details of application are difficult to unearth. As such, the review is not completely exhaustive. In particular, Ernst & Young's Navigator [47], Index Technology's PC Prism [75] and LBMS's Strategic Planner [91] have been omitted due to a lack of adequate available information. However, despite the number of methodologies in active use, very few are uniquely differentiated; very few of the ideas are original and most of the techniques are 'well trodden'. Indeed, originality is not something most of the methodology 'owners' have been concerned about. Most of the approaches are made up of 'borrowed' techniques woven into new frameworks and vehicles for application. The bottles are different but the wine is often the same. Figure 3.42 categorises the reviewed methodologies into those that have provided new techniques and fresh insight into the strategy formulation area ('innovators') and those that have merely provided alternative mechanisms for applying existing knowledge ('followers').

Innovators	*Followers*
• Business Systems Planning [73] • Critical Success Factor approach [131] • Strategic Value Analysis [30] • Lucht's methodology [99]	• Information Engineering [105] • Tetrarch [120] • Method/1 [2] • Tozer's methodology [145] • CASE*Method [118]

FIGURE 3.42 - Innovation in IS strategy formulation methodologies

The lack of heterogeneity and pluralism in the methodologies is further evidenced by the main 'planks' upon which the methodologies are based. These key concepts and techniques have been tabulated in Figure 3.43.

Methodology	Key Concepts	Key Techniques
BSP	• Business-wide perspective • Top-down analysis, bottom-up implementation • Independence of organisation structure	• Cluster analysis
CSF	• Top-down linkage between strategic thrusts & related IS concerns	• CSF analysis
IE (Planning & Analysis Segments)	• Business area prioritisation & segmentation • Data analysis	• CSF analysis • Entity relationship diagrams
SVA	• Independence of organisation structure • Functional analysis	• Opportunities/capabilities analysis • Objectives decomposition • Data flow diagrams
Tetrarch	• Functional analysis • Data analysis	• Opportunities analysis • Value chain analysis • Entity relationship diagrams
Lucht	• Top-down analysis	• CSF analysis • Cluster analysis
Method/1 (Information Planning Segment)	• Top-down analysis • Data analysis • Technology planning	• Opportunities analysis • Value chain analysis
Tozer	• Functional analysis • Data analysis • Technology planning	• Information needs analysis • Cluster analysis
CASE*Method	• Top-down analysis • Heavy user involvement • Independence of organisation structure • Technology independence • Use of CASE tools	• Cluster analysis • CSF analysis • Entity relationship diagrams

FIGURE 3.43 - Methodology 'planks'

The concepts are the fundamental tenets upon which the methodologies are based; the techniques are the key mechanisms for developing and delivering the IS strategy. The table illustrates how a small number of concepts and techniques, regularly repeated, form the backbone of methodology application. The word 'technique' is used in the broadest sense, for example, Method/1's 'opportunities analysis' is little more than a request for creativity on the part of the study team. However, it is integral to IS strategy formulation in a Method/1 application.

The methodology review in sections 3.3.1 to 3.3.9 represents a comprehensive description and analysis of each of the most commonly quoted and discussed IS strategy formulation methodologies, plus several more obscure approaches. It is more detailed in its breadth of analysis, that is, in the number and the aspects of the methodologies covered, than any other review. Coupled with the propensity of the methodologies to incorporate a limited number of heterogeneous concepts and techniques - no more than the number of methodologies - the rigour of the review has ensured a full and complete analysis of existing strategic IS practice, and rendered the inclusion of 'more of the same' consultancy methodologies needless.

The value judgements attributed to each methodology in sections 3.3.1 to 3.3.9 are based upon objective analysis singularly for each methodology and collectively based upon progressive knowledge gained from a review of each of the methodologies, from the observations of others, and, most importantly, from objective empirical analysis of others, and actual application of the key techniques constituting the methodologies.

Objective empirical evidence of any of the approaches is rare. Documented applications in manufacturing environments are very rare. Galliers [52] pointed out that most of the literature on IS planning and the identification of strategic information has been of the nature of

- an explication of a particular approach based on personal experience,
- a comparison of approaches.

The situation has not changed much since his observation. The majority of research in the area is conceptual and anecdotal often embracing only basic generalities of the strategic IS issue and only aspects of strategy formulation. Furthermore, most studies relate to the service sector, mainly financial [5, 108, 128], health [130] and travel

[50] organisations. Most of the widely quoted best-practice exemplars such as Merrill Lynch [12, 43, 132], American Airlines [43] and Thomson Holidays [43] are also non-manufacturing based. Only American Hospital Supply [12, 43, 94] regularly features as an example of a manufacturer that has gained competitive advantage from IS.

The literature is mainly descriptive rather than evaluative with very few authors actually addressing the replicability of approaches, the circumstances in which an approach is best applied, the mechanics of application, success criteria, and the comparative strengths and weaknesses of different approaches. Most importantly, the literature is practically devoid of suggestions of what makes some organisation's IS implementations better and more successful than others [1].

Although normative research is of immense value for aiding the formulation of IS strategies, the reality of IS planning needs to replace the rhetoric in a greater proportion of the research undertaken [43]. This has seldom been attempted. Chan and Huff [25] attribute this to the problems of measurement, difficulties in obtaining data and the dynamic nature of the strategy formulation phenomenon. Figure 3.44 illustrates the extent of empirical investigation for each of the methodologies reviewed.

One of the more comprehensive empirical analyses was conducted by Tricker [147] who described the process of systems planning in seven types of organisation. Although he did not comment on the quality of the planning process or the results produced, his reporting and collation of the issues raises some fundamental concerns.

Method	Applications	Comments
BSP	• Mitchell [115] reported a BSP study carried out in Northern Gas.	• A key result of the study was "a data/systems architecture which expressed business processes and business entities in terms of DP applications and databases and the relationship between them".
	• Black & Jarvis [15] reported on a case study in the Coats Patens Group (thread manufacturers) in Italy.	• A number of priority areas for application were identified. Although it was found that detailed, prioritised systems requirements were produced, the degree of definition of the databases resulting from cluster analysis was thought to be weak. The study was considered to be "a long project that consumed much management time to produce results of a sometimes marginal nature".
		• Detailed examples of task deliverables in methodology documentation.
CSF	• 2 case studies by Boynton & Zmud [20].	• Methodology provided an excellent vehicle to identify the firm's future information infrastructure. Proved difficult to formulate specific management information needs. Managers had difficulty manipulating conceptual CSFs to define concrete information needs.
	• 1 case study by Rockart & Crescenzi [132] of a steel company.	• A 3-phase process; identifying CSFs, developing systems priorities and creating prototypes and implementing actual systems found 3 phases not enough. A number of 'behind-the-scenes' steps were found to be necessary. 3 systems (information data base for marketing support, a pilot system for inventory management and an improved production scheduling system) successfully up & running as a result of the process. A number of significant business advantages incurred as a direct result of each system.
IE	• Mitchell [115] reported on a study carried out by Northern Gas.	• Only Business Area Analysis had been conducted at time of print. IE was found to be flexible and meaningful. It was also identified that different emphases could be placed on the use of different techniques (i.e. function v. entity analysis) depending on the requirements of the project. Report was generally one of work in progress and not a completed study.
SVA	• Fictional, self-reported case study by Curtice [30] of a pump and hydraulic component manufacturer.	• Typical, uncomplicated case study. Very useful as an aid for understanding the application of the methodology. Most noticeable that an integral part of the methodology - the identification of IS capabilities - are very broad and general. For example, a key capability was identified as the use of group technology (GT), another was the use of FMS and robots. Project identification is also very broad, for example, robotics and office automation.
	• Fictional, self-reported case study by Curtice [31] of the First Regional Bank.	• An attempt to provide a wide-ranging yet uncomplicated study. Again very broad IS capabilities and project identification.

Tetrarch	• No published case studies.	• Awareness of an application where the methodology was considered to be 'useful'.
Lucht	• No published case studies.	• Some examples of tasks provided in methodology documentation.
Method/1	• No published case studies.	• Some examples of tasks provided in methodology documentation. • Lederer & Gardiner [58] comment on the results of undisclosed, empirical analyses, for example, a pharmaceutical company that, as a direct result of the methodology, provided sales reps with personal computers linked to central corporate systems to enable them to retrieve product and customer info.
Tozer	• Fictional, self-reported case study by Tozer [145] of a manufacturer of toys and games.	• Useful as an aid for understanding the application of the methodology.
CASE* Method	• No published case studies.	• --

FIGURE 3.44 - Published case studies

His first reported case study was that of a large US manufacturing company organised into 20 separate divisions and with an annual turnover of $1bn in capitally intensive engineering products. An annual strategic review is carried out with each business unit submitting its plans. The company is convinced that a successful plan is "driven by the responsible line managers who set the priorities, not by the MIS staff" and by the "integration of systems planning with corporate planning". The systems plan is essentially a coordination of users' needs into an efficient and effective set of systems.

In the second study, that of a centralised service company, the importance of the strategic potential of IS is clearly recognised, and a key enabler of an effective systems plan was deemed to be a board level executive to be responsible for MIS, thus ensuring that the strategic implications and opportunities for systems development were recognised.

The next study was that of a large multi-national corporation (MNC), part of the automotive industry operating with a series of geographically separated production facilities which are co-ordinated centrally. An annual IS strategy is developed from a long-range IS strategic plan. Company policy is for line executives to "take the lead and establish priorities". Such an approach is considered to engender "a sense of ownership of IS projects at the top level". Consistency with corporate strategy is again considered to be of the utmost importance.

The fourth study was that of an aircraft manufacturer. The head of IS in the company advocates a five-stage approach to the development of a systems plan:

- Base the IS plans on business reality.
- Establish the broad purpose for systems development from the top management perspective.
- Identify the core information areas in the business.
- Keep referring back from IS plans to the business reality.
- Give system developments an orientation that is company-wide.

As before, in developing IS strategies, responsible and experienced managers take the lead, not the computer technologists. The use of an independent viewpoint from external consultants is also considered valuable.

Minimal detail is provided for case study 5, the European operations of a large MNC, suffice it to say that the company recognises the strategic potential of IS.

Systems planning in a global corporation was described in the next study. The company advocates the use of a formal approach to systems planning and the overall co-ordination of functional processes to achieve company goals. The approach is governed by goal setting and direction by top management, and the recognition of IS as a key facilitator of change. Systems development is governed by ROI criteria in a manner similar to any other capital investment.

In the final study, that of a UK manufacturer with a separate systems company, a team-based approach is used for systems planning. The systems company is selffunding, uses ROI criteria and its corporate plans are built into the parent company's plans.

Notable of other empirical work is that carried out by Gooding [58], and Hunt and Targett [72].

Gooding [58] described systems planning in the Ford Motor Company. The *Systems Business Plan* is structured in two parts:

- a demand section embracing users' demands, and
- a supply section, which acts as a review of enabling technologies.

The process actively involves both user and senior management and is integrated with the *Corporate Business Plan.*

Targett and Hunt [72], although not reporting on the precise mechanics of strategy formulation, decribed IT practice and strategies in a number of Japanese industries. Included were Hitachi Europe Ltd. (HEL), JVC (UK) Ltd., and Nissan Motor Manufacturing (UK) Ltd. Planning IT at HEL involves reacting to staff suggestions and ideas, inter-function consultation, and through a system of consensus decision making. Targett and Hunt [72] reported that most IT-related decisions involved a financial analysis. JVC (UK) Ltd. adopts a similar consensus-based approach to managing and planning IT. Performance monitoring and feedback after a system implementation are significant inputs to future IS planning. IS planning in Nissan (UK) Ltd. follows a specific methodology which results in an input to the company's capital budget for a five-year period. Post-implementation reports are an important part of the process.

Scott Morton [139] proposes several appropriate reasons for the need for empirical research. Firstly, he suggests that the concept that IT can be exploited for strategic advantage needs verification. This raises further issues related to the nature of strategic advantage, how it has actually been derived and whether there are any common principles, directions, or patterns. He also points out that most of the strategic IS methodologies whilst seeming to be grounded in common sense and analytical logic, need validation, as they are but tentative or experimental approaches. In short, the ability of a technique or methodology to consistently produce desired results needs to be validated, and this can only be achieved through rigorous and wide-ranging application. The value or need for a new perspective cannot be assessed without proper empirical analysis.

Case study documentation was one of the key contributors to the evaluative comment attributed to each of the reviewed methodologies in sections 3.3.1 to 3.3.9. A summary of the main strengths and weaknesses of the approaches, as discussed in these sections is outlined in Figure 3.45.

3.4 - REQUIREMENTS OF AN EFFECTIVE APPROACH TO IS STRATEGY FORMULATION IN MANUFACTURING - SUCCESS CRITERIA

Having discussed the weaknesses and failings of existing approaches to IS planning, it is important to elucidate those factors that ensure success. There is no exact recipe for success, but there are several critical features that clearly increase the chances of an approach succeeding. These features are present in varying degrees of detail and sophistication in each of the approaches analysed and relate to either the structure of the approach or the process of applying it. These IS strategy formulation 'success criteria' help determine, at least to a certain extent, the relative success of an approach and serve as a framework to assist planning projects in a manufacturing environment.

Method	Strengths	Weaknesses
BSP	● Established ● Necessitates top management involvement ● Highly structured ● Well documented ● Ideologically sound	● Long process ● Resource intensive ● Considerable data collection ● High level of skill & expertise required ● Unstructured project priority formulation ● Promotion of IS revolution
CSF	● Simple to understand & apply ● Resource efficient ● Focuses attention on areas critical for business success	● Uni-dimensional ● Lacks priortising mechanism ● Difficult to relate to information needs without decompositional approach ● Expansive remit
IE	● Established ● Comprehensive	● High level of skill & expertise required ● Intuitive ● 'Unfriendly' documentation ● Long process ● Resource intensive ● Promotion of IS revolution
SVA	● Use of diagrammatic structuredanalysis ● Ability to prioritise specific IS development projects ● Use of quantitative analysis ● Time & resource efficient ● Easily understood	● Decomposition ambiguity ● Unstructured systems review ● Broad, general & potentially ambiguous IS capabilities & projects
Lucht	● Simple to understand & apply ● User-friendly documentation ● Time & resource efficient ● Technical awareness	● Subjective techniques
Tetrarch	● Sophisticated automated support ● Time & resource efficient ● Structured, incisive techniques	● Some intuition required ● Certain tasks unsupported by appropriate techniques
Method/1	● Rigorous & comprehensive ● Supported by a dedicated CASE tool ● Detailed project management & task integrity ● Flexibility of approach	● Weak in 'pinpointing' techniques ● Intuitive ● Inadequately supported by appropriate techniques ● Long process ● Resource intensive
Tozer	● Top management, user & IS staff active involvement ● Rigorous analysis ● Detailed questionnaires & checklists ● Technical awareness ● Diagrammatic	● 'Revolutionary' ● Lack of prescription ● Intuitive
CASE* Method	● Comprehensive, detailed documentation ● Flexible approach	● Lack of appropriate techniques ● Lack of clear prioritisation mechanism ● Long process ● Resource intensive ● Unclear focus

FIGURE 3.45 - Strengths and Weaknesses Summary

They have resulted from a search (theoretical and applied) of those factors that consistently proved to be, or were considered to be robust and successful in

- helping achieve business objectives through IS development,
- making the process of strategy formulation lucid and easily applicable,
- producing effective systems, and
- avoiding ad hoc and sub-optimal investment decisions.

A strategy formulation process needs to address each of the success criteria to maximise its chances of success. Failure to do so will result in a loss of precision and reliability of the process. The criteria have been compounded within the following:

- *Structured, top-down methodology*
- *Top management commitment and involvement*
- *Establishment of a business-wide perspective*
- *Integration with the overall business planning process*
- *Independence of organisation structure*
- *Formal user involvement*
- *An examination of IS opportunities*
- *Improvement-oriented*
- *A flexible and integrated information architecture*
- *A reference framework*
- *An approach that yields specific and dependable results*

3.4.1 - Structured, Top-Down Methodology

Formulating an IS strategy necessitates the analysis of numerous business functions and activities, the evaluation of diverse IS requirements and the appeasement of cantankerous stakeholders. It is a complicated, time-consuming and resource-intensive task. McFarlan et al [108] appropriately used the words "planned clutter" to describe IS strategy. The difficulty of managing and organising such a task should not be underestimated. Frameworks are generally too simplistic, superficial and rudimentary. On the other hand, the use of a structured methodology enables the planning process to be carried out with integrity and precision, and in such a manner as to segment the whole task into manageable elements. A methodology also facilitates both time and resource efficiency. Several authors have explicitly emphasised the need for a methodology in order to provide a formal approach to managing the information resource and carrying out the planning process [48, 92, 103].

Contrary to this, it should be pointed out that Silk [140] advocates the use of frameworks rather than methodologies for formulating IT strategy. His argument for a non-prescriptive approach is to say that ".... the 'tools' ..... will provide a spark for most people". However, a lack of direction is precisely what is not needed in a field littered with unproven theorems, general rubrics, too much intellectualising and few prescriptive route maps.

A methodology should be top-down in its approach to business analysis. Activities should first be defined and analysed from a strategic level and the subsequent analysis should cascade down to increasing levels of detail. This ultimately promotes *fit* between IS modules and subsystems and encourages synergy. Top-down analysis has been actively promoted by IBM [73], Martin [103], Williamson [154], Fairbairn [49] and Lucht [99].

3.4.2 - Top Management Commitment and Involvement

The need for the commitment, monitoring, and to some extent, active involvement of top-level managers in capital-intensive projects has become something of an industrial cliché. However, the commitment of the highest-level decision makers in a manufacturing concern to an adopted IS planning approach is undoubtedly essential for success. Only those people directly involved in establishing business direction can guarantee that the IS planning process is in complete harmony with the business planning process. Only a top-level manager can ensure that adequate time and resources are committed to systems development. Recognition of this key issue has not been lost in the literature. Lucht [99] pointed out that "obtaining ongoing direction, involvement and support from senior management may be the most vital ingredient to success" (in systems planning). Karababas and Cather [80] rated senior management involvement and commitment as first and second in a ranking of integrated systems success factors. Breuer et al [23] identified a key planning issue for IT strategy as engaging senior management actively in IT projects, and reiterated Bawden and Blakeman's [9] claim that the success of an IT plan is very much dependent on the seniority of the people involved in the planning process. A.T. Kearney [1], in a survey of 400 companies (approximately 58% manufacturers) found management support to be the most significant factor for success with IT projects, and commented that successful companies maintain accountability for IT at a higher level in the organisation than unsuccessful ones. Hickey [68] found the role of corporate champion to be very important in successfully developing strategic systems. Reich and Huff [129], in a survey of 11 companies, reported that the strong support of the CEO was an important factor in the success of strategic systems. Rockart and Crescenzi's [132] approach to CSF analysis is geared up to the "highly desirable" objective of engaging top management with IS "in organisations of every size". Martin [103] emphasises the need for top management involvement in IS planning and regards it as being essential for success. Galliers [52] in a survey of 209 companies found that commitment and involvement of senior management were overwhelmingly the most important success factors in IT strategy planning, and in a survey of IS planning practice in 334 companies, Cresap et al [28] (approximately 50% of which were in manufacturing industry) found companies to be more successful in IS planning when their business planning processes have the following characteristics:

- management commitment to planning,
- wide distribution of the business plan,

- perception of the business plan is realistic,
- use of the business plan to monitor performance.

Other advocates include Mead [110], Feeny [50] and Baets [5].

In 1977, McLean and Soden [109] reported that in many corporations MIS planning was done with little involvement from top management. However, since then the situation has improved. A.T. Kearney [1] found that top management were generally not regarded as a 'barrier' to successful IT usage. This indicates the current willingness of top-level decision makers to become involved in IS planning projects. Gradually, managers are accepting that information is a valuable business resource, and have begun to consider investment in IS alongside investments in other areas of business activity.

3.4.3 - Establishment of a Business-Wide Perspective

The analysis of a wide scope of business operations distinguishes the IS planning process from the more traditional data processing-oriented studies. In searching for appropriate applications for systems development, any business activity that potentially impacts business objectives needs to be included in the analysis. Martin [103] regards corporate-wide planning as vital, and Bansal [7] considers a holistic approach essential for proper definition of priorities. IBM [73] advocate that the process should span organisational boundaries, not solely addressing the information needs of a single area of the business - manufacturing, marketing, distribution etc. but taking the perspective level of general management - corporation, group, division - where multiple functional areas are involved. This is a sensible proposition. There is every chance of omitting a business activity that is potentially of significant strategic influence when a focus narrower than a general management perspective is chosen.

3.4.4 - Integration with the Overall Business Planning Process

In order to ensure congruence between systems development and business ambition - a fundamental tenet of any planning approach - the IS planning process has to be aligned with the business planning process. Practitioners and academics alike are in complete agreement with such a perspective. The need for such a concept is obvious, but the existing tool-set is lacking a single, reliable mechanism for ensuring proper alignment.

In industries where information processing is a significant contributor to core business activities such as banking, insurance and publishing, the relationship between systems and business plans is explicit and generally well established. Curtice [30] observed that in such industries, senior management is keenly aware of the potential impact of IS as a competitive weapon to achieve strategic business objectives, and, in some cases, actually change the industry basis of competition. In manufacturing industry, however, the relationship is often more subtle, but unquestionably still evident. In Tricker's [147] review of systems planning in seven different company types, one, a large US manufacturing company is convinced that a major factor in the development of a successful systems plan is the "integration of systems planning with corporate planning"; in another, a manufacturer in the automotive industry, consistency with corporate strategy was considered to be of the foremost importance; and for a third, an aircraft manufacturer, a key step in the planning process was to "establish the broad purpose for systems development from the top management perspective".

A significant finding of the A.T. Kearney [1] (sic) study was that successful companies are more likely to have fully interdependent business and IT plans than unsuccessful ones. Much has been written about the relationship between business and systems plans. Robertson and Cowley [130] reported that a sound business plan is the foundation for IS/IT planning. Earl [43] talks about "putting the business into IS" in order to match IS investment with business needs. Lucht [99] suggests that the systems planning process should be an integral part of the short and long-term business planning process in order to assure harmony with the strategic and tactical plans of the business. Cresap et al's [28] survey (sic) of successful planning, found that any technique used to forge linkage between business planning and IS planning was the most important determinant of success, and found lack of knowledge of the business's direction and requirements was cited most frequently as the leading problem in IS planning. De Brabander and Thiers [35] suggest that the ultimate goals of an organisation should be the focus of attention in IS development. Parsons [122] argues very strongly that "IT applications should be consistent with a firms' strategy". Benjamin et al [12] and Kantrow [79] argue persuasively for senior managers to have an entrepreneurial attitude and view new technology as a central part of business thinking. Tozer [145] regards the alignment of the IS development approach to business plans and priorities as essential in providing a basis for determining which systems should be developed. Brady et al [21] from an investigation of strategic IT issues in six organisations reported that both IT and non-IT executives argued that alignment of the IT strategy and business objectives is fundamental if IT is to play more than merely a passive support role in the organisation. He quotes Angell and Smithson [3] to support his argument - "companies without a coherent policy linking technological development to corporate goals, tend to surrender responsibility for IT to technocrats, who may indulge their fascination for irrelevant technology without considering the wider needs of the organisation".

However, just because business strategy and IS requirements are defined, it does not mean the two are aligned. Earl [43] observed that "... most business have found their business strategies inadequate - too vague, immature, uncertain, or general - as a foundation for IS strategy". Sohal et al [141] observed that the matching of business objectives to systems is often intuitive and superficial. Baets [5] reported that the general acceptance that one of the key factors for successful IS planning and implementation is the close linkage of the IS strategy with business strategy, but counters that, in practice, this linkage is not yet well established. Gelders [55] discovered a lack of consistency between business strategy and company improvement programmes, and Bhattacharya et al [13], from a survey of the literature on manufacturing strategy, concluded that the linkage between manufacturing strategy and infrastructural decision areas or operating systems and policies has been inadequately researched.

3.4.5 - Independence of Organisation Structure

Many organisations are in a continual process of change. IS should be defined flexibly to allow for such change. Organisation structure is perhaps the aspect of organisations most vulnerable and prone to change. IS requirements must allow for this, and be modelled and defined in as generic a manner as possible; function requirements should define what is done, not how or by whom [118].

A bedrock of the BSP methodology is that IS should be defined to be independent of organisation structure. IBM [73] point out that when systems are designed to support specific organisation structures (and people), they often become obsolete and must be redone when the organisation changes. Conversely, an organisational change that is desirable or necessary may be prevented or restricted because of the rigidity of certain systems.

Besides IBM, the proponents of such a viewpoint include Oracle [118] and Curtice [30, 31].

3.4.6 - Formal User Involvement - Creating Partnership

Lyytinen [100] suggested that the key reason for IS failure stems from the lack of understanding about the individuals who will eventually use the system. The inclusion and articulation of users' requirements in the planning process ensures that the needs of those affected by an IS will be met and incorporated in any new or improved system. With such involvement, users and managers are much more likely to accept changes to current working practice. Lucht [99] posits that in order for people to accept new ideas and changes, they must either have had some part in their development or feel they will benefit from them personally. He suggests that key managers at all levels of the organisation should be asked to participate in the planning study.

A common thread in the systems planning studies reviewed by Tricker [147] was that successful plans "are driven by responsible line managers ..... who take the lead and establish priorities". Swift [142] suggests a partnership between business executives, managers and IT professionals to ensure "everyone is singing off the same hymn sheet" and prevent user managers from feeling "squeezed out" of systems development by senior executives and IT staff. Silk [140] extols the virtues of a similar information management partnership where the key players are top managers, middle managers and other users of IS, and IS professionals. He warns that "failure here is going to make it very difficult to achieve effective IS". Ruohonen [137], after rigorous research, concluded that the key stakeholder groups in the strategic IS planning process are top management, user management and IT/IS management. Grindley [60] suggests a similar team-based approach.

Breuer et al [23] define a key issue for IT strategy as the active participation of end users of IT and Baets [5] suggested that user involvement was of paramount importance. A major survey by A.T. Kearney [1] (sic) found close cooperation between the data processing department and eventual system users a significant factor for success with IT projects. Bullinger and Neimeier [24] found the utilisation of user 'know-how' to be a CSF. De Brabander and Thiers [35] suggest that user involvement is a crucial factor in successful IS development. They point out that 142 of the 250 participants of the *Founding Conference of the Society for MIS,* held at the University of Minnesota considered that factor as the most important for successful MIS-use. They also reported that Edstrom [46] was able to demonstrate that symptoms of ineffective communication between users and specialists are consistently related to user dissatisfaction with an IS. Tricker [147] appropriately sums up the argument for user involvement with his suggestion that "the user is king".

3.4.7 - An Examination of IS Opportunities

Identifying opportunities where IS can make a significant contribution to business ambition is an important success criterion. Curtice [30] commented that although it is erroneous to assume that information processing technology will prove to be useful in achieving any business objective, its pervasiveness means that it is worthwhile at least to ponder the possibilities.

'Pondering the possibilities' is the standard mechanism for forcing the examination of how IS (more usually regarded as IT) can contribute to strategic goals. There is a glaring lack of structure to the process. SVA [30], Tetrarch [120], Method/1 [2] and IE [105] all formally recognise the importance of IS opportunities analysis, but rely on experience and intuition on behalf of the analysts such as brainstorming sessions (IE), creative workshop sessions (Tetrarch) and requests for creativity and insight (SVA and Method/1) rather than structured and incisive techniques. The methodologies of Lucht [99] and Tozer [145] recognise the importance of opportunities analysis but address it less formally.

Porter and Millar's [126] value chain, although purportedly a technique for identifying IS opportunities, lacks prescription and is a mere checklist of typical business activities where IS can potentially act as a strategic effector. Similarly, Ives and Learmonth's [76] customer resource life cycle, although offering more prescription, lacks adequate explanation and is difficult to apply and elicit clear opportunities for IS improvement.

However, the apparent lack of a reliable technique has not prevented industrialists and academics alike enthusing about the value of opportunities analysis. Breuer et al [23] cite identifying IT opportunities by way of the value chain as a key planning issue for IT strategy. Robertson and Cowley [130] point out the valuable contribution IS/IT opportunities can make in the business planning and thus IS/IT planning process. Gooding [58] reports the successful use of an 'opportunities' leg in the IS plans produced by the Ford Motor Company. Earl [43] has suggested, as a result of his own research, that an innovative analysis of IT opportunities with high user involvement is of significant importance in the development of an effective IS development portfolio. Williamson [154] recognises that opportunities for improvement are an important consideration in his integrated planning methodology but offers no technique for doing so.

The unquestioned ability of IS to support strategic goals in manufacturing as evidenced by Tricker [147], Pyburn [127] and Hunt and Targett [72] means the analysis of IS improvement opportunities is essential and renders an approach without such an analysis inadequate. However, the existing tool-set is weak, and, particularly in the frameworks and methodologies discussed, lacks structure .

3.4.8 - Improvement-Oriented

Many IS planning approaches encourage the implementation of a totally new business IS (*revolution*) rather than one planned to evolve from current systems (*evolution*) [73, 103, 145]. However, the majority of IS in any manufacturing organisation will have been designed with good intentions, and such systems will often not require comprehensive overhaul in new or revised IS plans. Where possible, IS strategies should be improvement-oriented, and be concerned with incremental change and continuous adaptation to changing circumstances [150]. A significant analysis to substantiate this factor was made by Runge and Earl [136]. They found that many applications that provided competitive advantage were evolutionary 'add-ons' to existing systems Evolution is not short-termism, but pragmatism.

From the extreme of IS revolution, it is as equally important not to be too conservative in the approach adopted and develop, for instance, an automated system that imitates the previous paper system. Simplication and rationalisation of information flow patterns should occur prior to any attempt at new or improved automation.

3.4.9 - A Flexible and Integrated Information Architecture

IS plans need to provide flexible solutions to systems development. Plans are ongoing and subject to continual review. No plan should be 'carved in stone' or dedicated to an irreversible solution. Manufacturing is a dynamic, ever-changing environment. Systems solutions need to be easily 'updateable', 'open' and flexible enough to incorporate advances in technology and changes in business ambition and direction.

IS plans also need to promote integration and provide confidence that individual 'IS modules' fit and function properly in a coherent network [73]. Efficient systems should be simple and compatible, and be able to function together and share data. Analysts can very easily over-complicate information architectures. Bidgood and Jelley [14] point out that a major problem with the matrix modelling technique for developing information architectures is the sheer size of the analysis. They illustrate this point with an example - "... cross relating (say) 200 entities with 130 activities - not uncommon - produces a matrix of 26000 cells.... not only is considerable effort required but the level of detail is inappropriate for a strategic study".

Bidgood and Jelley [14] suggest that the problems commonly encountered with information architectures can be largely overcome by defining a concise and properly segmented strategic architecture and then, later, exploding individual application areas to greater levels of detail. Martin [86], similarly suggests top-down planning of data and the localised design of systems in many different user areas. Unnecessary detail in entity and activity identification and definition over-complicates and increases the inefficiency of the planning process. Bidgood and Jelley [14] suggest a key problem with the data modelling approach to developing information architectures is its proponents' pre-occupation with normalisation - ".... although important for database design purposes, at the strategic level it is irrelevant". Information architectures need to be simple and easy to understand whilst remaining integrated and flexible to change.

3.4.10 - A Reference Framework

A major obstacle in the development of an effective IS strategy is the detailed modelling and understanding of existing business practice that the strategy formulation process necessitates. This is often the most laborious and time-consuming task of the whole approach to strategy formulation. A mechanism for quickening the process without a loss of detail and integrity would increase efficiency and be a valuable addition to any IS planning tool-set. A reference framework of a generic manufacturing business unit can provide such a mechanism. Such a framework needs to encompass all aspects of the business, to a generic level of detail and articulation of information flow comparable with a typical information flow model/systems architecture constructed in the planning process. Manufacturing reference models with varying degrees of complexity and intention have been offered by Morgan [159], Yeomans etal [160] and the ESPRIT Consortium AMICE [161].

3.4.11 - An Approach that Yields Specific and Dependable Results

IS development constitutes a significant expenditure and proportion of available operating budget. Senior management need to be confident that the planned investment in IS is focused on those areas that contribute most to business objectives, and therefore, ensure the most effective return on the capital invested in IS. In order to ensure such a return, the choice of systems development project should be specific, not ambiguous. Success depends upon effectively prioritising such systems development projects. This is a difficult task; one tackled with little sophistication by the majority of the approaches used. Much is left to analysts' discretion, personal judgement and intuition. User managers are likely to treat such subjective analysis with suspicion. Managers like to see the stages of the process explicitly stated [123].

The integrity and effectiveness of the techniques applied as part of the methodology are vital. They should be simple, yet incisive, easy to apply, yet envelop the necessary criteria. Platts [123] noted that "managers were not predisposed to long periods of solitude grappling with complex tasks, they had a desire for simple techniques". Fairbairn [49] recommends the use of tools and techniques that present "a more friendly and understandable face to the user, while at the same time quickly getting on with the business of applying the fundamental principles and disciplines". Grindley [60] observed that although some managers clearly perceive the potential of IT, they must also feel good about what IT actually delivers. In order to do this, he suggests a focus on "friendly and simple solutions to the problems they (managers) own and recognise". Simple techniques lead to clear requirements definitions and solutions. A.T. Kearney [1] consider clarity of requirements definition as critical to successful IT implementation. Part of the problem is the volume of potential projects an IS planning approach might throw up. Many IS departments regularly face a backlog of several years worth of new systems and improvements projects. The planning process should cut a swathe through such a list. Techniques, in order to be successful need to unambiguously differentiate between development demands. However, Earl [83] ([59]) comments that in the face of unlimited opportunity and limited resources, the difficulties associated with agreeing priorities should not be underestimated. At present, there is a lack of comprehensible analytical mechanisms for establishing linkage between inter-dependent techniques and for consolidating the outcomes of the application of these techniques to focus on specific applications for development. Chan and Huff [25] point out that SISP researchers have tended to discuss IS strategic fit in qualitative terms only and have made few attempts to quantify fit. Given its business performance implications, it is critical that researchers improve their ability to measure the concept [7]. Referring to research of the concerns of IT directors in major companies, Grindley [60] concluded that a top concern was measuring the benefits of IT investment. A quantitative aspect to the IS planning process makes such measurement possible. Chan and Huff [25] consider such an analysis to be a "non-trivial challenge".

Success depends on the development of two sets of measures:

- measures that help identify specific areas for IS development by aggregating the results of technique application;
- measures that serve as indicators of improved business performance after IS development.

The former type of measure are of most interest to IS planners, the latter to top management. However, neither has been adequately developed. An article in the October issue of *Computing* [148] stated that ".... of the UK companies which could benefit from measurement techniques, only 10 to 15% are doing anything about it. The organisations embracing performance measurement in IT are the large companies, such as the Post Office, National Power and the major clearing banks". The first measure is essential for measuring existing systems effectiveness, strategic fit and thus for prioritising areas for IS development. The second measure is essential for evaluating the effectiveness of a change brought about by IS development.

3.4.12 - Empirical and Survey Evidence of Success Criteria

It is important that the success criteria articulated in sections 3.4.1 to 3.4.11 are not deemed to be rhetoric, 'cherry picked' to support a conveniently chosen, and perhaps random set of requirements. As such, Figure 3.46 illustrates empirical and survey evidence that support each criterion. The table shows how the success criteria are steeped in proven fact not supposition.

Success criterion	Evidenced by	Comments
Structured, top-down methodology	• Hunt & Targett [72] in a survey of IS strategies and practice in Japanese industry.	• Nissan (UK) Ltd. use a top-down methodology to link IS developments to future business growth.
Top management commitment & involvement	• A.T. Kearney [1] in a survey of 400 companies. • Reich & Huff [129] in a survey of 11 companies. • Galliers [52] in a survey of 209 companies. • Cresap et al [28] in a survey of IS planning practice in 334 companies. • King & Grover [87] in a survey of 84 SIM members. • Earl [45] in field studies in 21 companies.	• Identified as the most significant factor for success. • Support of CEO found to be an important factor in the success of strategic systems. • Found overwhelmingly to be the most important success factor in IT strategy planning. • Found companies to be more successful in IS planning with management commitment to the process. • Found strong organisational/top management support as a key facilitator in the strategic use of information resources. • Found top management involvement and support to be the two most important success factors in SISP.
Establishment of a business-wide perspective	• Hunt & Targett [72] in a survey of IT strategies and practice in Japanese industry.	• Identified the importance HEL attach to global systems and pan-European systems compatability. • JVC (UK) Ltd. develop systems on a pan-European basis.
Integration with the overall business planning process	• Tricker [147] in a large US manufacturing company. • Tricker [147] in an automotive manufacturer. • Tricker [147] in an aircraft manufacturer. • A.T. Kearney [1] survey. • Cresap et al [28] survey. • Hunt & Targett [72] survey.	• Company ensures a successful systems plan by integrating systems and business planning. • Consistency of corporate and systems plans considered to be of the foremost importance. • Top management perspective considered to be essential in the development of systems plans. • Identified that successful companies are more likely to have fully interdependent business and IT plans than unsuccessful ones. • Found that any technique used to forge linkage between business and IS planning as the most important determinat of success. • Found linking IT development with strategic objectives to be critical in HEL. • Nissan (UK) Ltd. found only to be interested in developing systems to satisfy business requirements than in IT itself.

Independence of organisation structure	-	-
Formal user involvement	• Tricker [147] in a number of studies. • A.T. Kearney [1] survey. • De Brabander & Thiers [35] in a survey of conference attendants. • Hunt & Targett [72] survey.	• Successful plans were found to be driven by responsible line managers. • Found relationship between data processing department and system users as a significant factor for success with IT projects. • User involvement most important factor for successful MIS-use. • Ideas and suggestions from staff were considered very important at HEL. • Nissan formally recognise user opinion in the IS develoipment process.
An examination of IS opportunities	• Gooding [58] in an analysis of the Ford Motor Company. • Hunt & Targett [72] survey.	• Considered opportunities analysis as a key factor in IS plan development. • JVC IS staff consider information about the latest IT technological developments to be a significant contributor to new IT systems.
Improvement-oriented	• Runge & Earl [136].	• Found many applications that provided competitive advantage were evolutionary.
A flexible & integrated information architecture	• Hunt and Targett [72] survey.	• Reportedon HEL's aversion to incompatible systems and communication and promotion of compatability.
Reference framework	• King & Grover [87] survey.	• Found "complexity of the concept" to be a key inhibitor to conducting a strategic IT study.
An approach that yields specific & dependable results	• A.T. Kearney [1] survey. • Platts [123] in a study in several companies. • Hunt & Targett [72] survey. • King & Grover [87] survey.	• Clarity of requirements definition critical to IT implementation. • Noted that managers had a desire for simple techniques. • Nissan use stringent selection criteria to prioritise viable projects. • Found "difficulty in assessing tangible contribution" to be a key inhibitor to conducting a strategic IT study.

FIGURE 3.46 - Empirical and survey evidence of success criteria

CHAPTER FOUR

METHODOLOGICAL FRAMEWORK - TECHNIQUE SELECTION & DEVELOPMENT

PURPOSE OF THIS CHAPTER

In the previous Chapter, the criteria for formulating an effective IS plan were defined. In any situation, IS strategy approaches were seen to require up to 11 different criteria. In this Chapter, these criteria are mapped onto a methodological framework, forming the foundation for a subsequent IS strategy formulation methodology. Techniques to satisfy the framework are introduced, evaluated and, where necessary, developed from afresh to produce an integrated approach to IS strategy formulation.

4.1 - INTRODUCTION

The *success criteria* were identified as:

- *Structured, top-down methodology*
- *Top management commitment and involvement*
- *Establishment of a business-wide perspective*
- *Integration with the overall business planning process*
- *Independence of organisation structure*
- *Formalised user involvement*

- *An examination of IS opportunities*
- *Improvement-oriented*
- *A flexible and integrated information architecture*
- *A reference framework*
- *An approach that yields specific and dependable results*

The 11 criteria are different, yet in some cases related. The intention of a methodological framework is to combine them into one single, coherent picture in order to provide a clearer understanding of the nature of successful IS planning.

Several existing methodologies and frameworks incorporate, quite successfully, several of these criteria, yet the review of current approaches shows that none incorporate all. In some organisations, dependent on previous planning experience, culture and individual circumstance, certain criteria will be more easily achieved than others. However, this does not detract from the fact that a tool-box methodology incorporating each criterion is quite an appropriate and enviable option for the IS and manufacturing communities.

4.2 - THE FRAMEWORK

The methodological framework is displayed in Figure 4.1. The framework suggests an approach driven by business ambition and implies the identification of business plans and goals and their subsequent projection onto the current IS position. The effectiveness of this position is, in turn, established and put forward for future project prioritisation. Improvement of this position in accordance with business ambition is examined via an exploration of IS opportunities. *Business ambition*, *systems effectiveness* and *IS opportunities* are evaluated by a methodology *filter*, the result of which is a series of individual, strategically-justified projects. The framework amalgamates successful IS planning criteria into five elements:

- understanding and depicting information architectures,
- an analysis of business plans and goals,
- establishing existing systems effectiveness,
- an investigation of IS improvement opportunities,
- business area analysis.

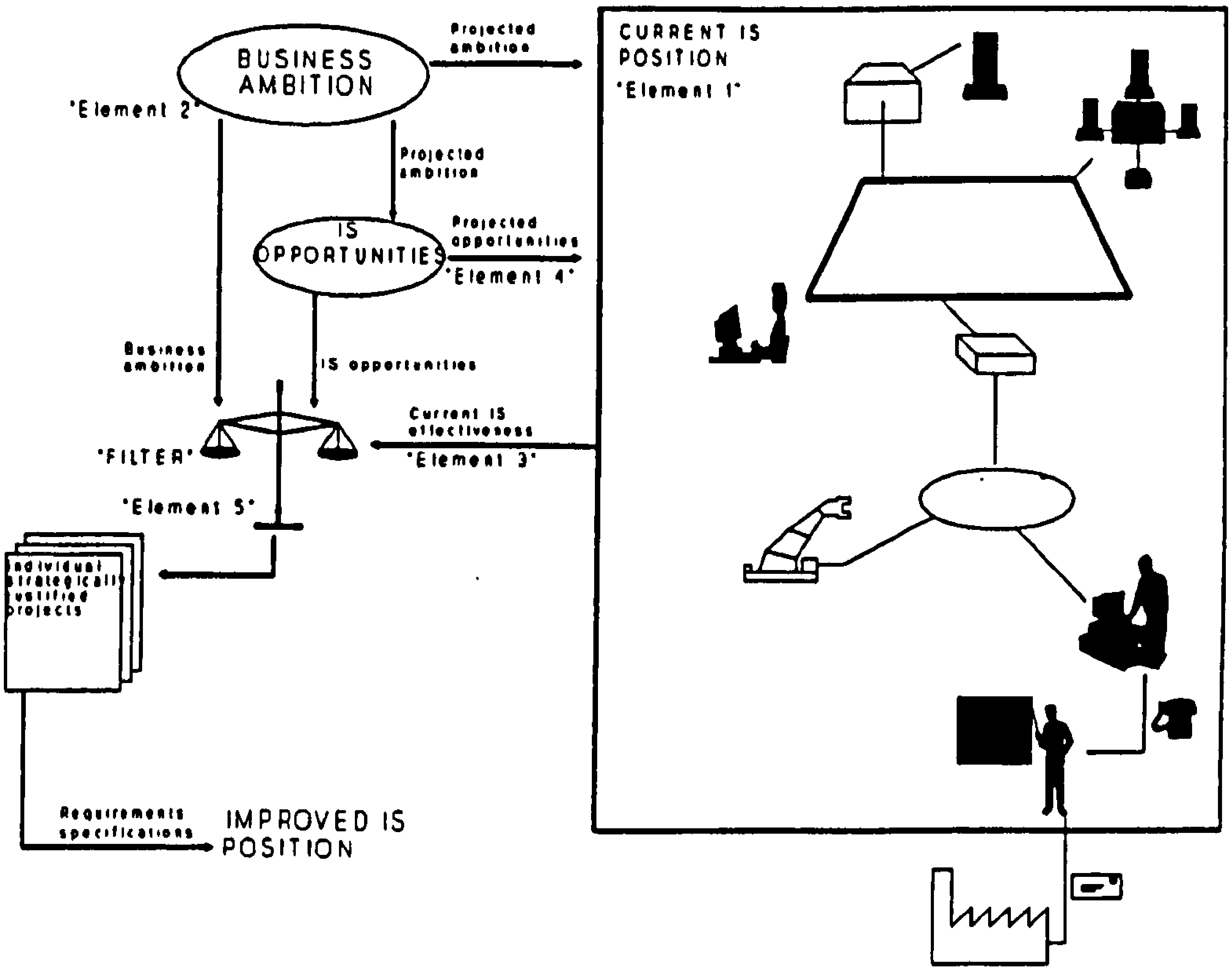


FIGURE 4.1 - Methodological framework

Figure 4.2 shows the fit between the major aspects of the framework and the identified success criteria.

The remainder of this Chapter is devoted to an examination of the five major aspects of the framework.

Aspect of methodological framework	**Incorporated methodology success criteria (*Support potential*)**
Information architecture (Element 1)	Structured, top-down approach Independence of organisation structure Reference framework Establishment of a business-wide perspective A flexible and integrated information architecture
Business plans & goals (Element 2)	Integration with the overall business planning process Top management commitment and involvement Improvement-oriented Approach that yield specific and dependable results
IS effectiveness (Element 3)	Formal user involvement Reference framework Approach that yields specific and dependable results
IS opportunities (Element 4)	An examination of IS opportunities Reference framework Improvement-oriented Approach that yields specific and dependable results
Business area analysis (Element 5)	Structured, top-down methodology Formal user involvement

FIGURE 4.2 - The fit between the methodological framework and methodology success criteria

4.3 - UNDERSTANDING & DEPICTING INFORMATION ARCHITECTURES (ELEMENT 1)

4.3.1 - Structured Systems Analysis and Representation Techniques

Existing techniques can be broadly classified into two categories; those that address process objects (*functional analysis*) and those that address data objects (*entity or data analysis*). Both functional and entity analysis are commonplace in data processing and systems development, more so than the concept of strategic IS planning, and are used in a variety of methodologies both within and outside the domain of IS strategy formulation.

4.3.2 - Function Modelling and Analysis

Functional analysis is based upon the analysis of business activities using functional decomposition, that is the structured break down of an activity or business problem into more manageable and investigable sub-activities. Such analysis stemmed from the perceived benefits of top-down, hierarchical programming used in software engineering [4]. Two techniques are widely used:

- Data flow diagrams (DFDs), and
- IDEF0.

Data flow diagramming was developed as part of structured analysis approaches proffered by Ross and Schomann [135] in their *Structured Analysis and Design Technique* (SADT), Gane and Sarson [53] in their STRADIS methodology, and in the work carried out by Yourdon and Constantine [157] and DeMarco [36]. Apart from their use in several other business area rather than business unit analysis methodologies, such as CORE [117], Multiview [155] and SSADM [40], DFDs are extensively used for business and information flow representation and analysis in the SVA methodology [30]. DFDs basically display the information flow patterns pertaining to a system. Only four constructs appear on a diagram:

- A *process* is a task carried out within the area of study, and is thus a receiver and generator of information. Each process is explicitly defined in order to avoid confusion with other business activities. This is usually achieved by assigning a descriptive name beginning with a verb to each process, for example, *Develop Product Design*, rather than use an organisational unit name such as *Engineering* [30]. Curtice [30] advocates the importance of being specific in process definition, and not hide anything under a generic label.

- A *data flow* represents a transfer of data between any of the DFD constructs.

Avison and Fitzgerald [4] report on two commonly used analogies as illustration; firstly, the liking of data flow to a pipeline down which parcels of data are sent, and secondly to a conveyor belt in a factory which takes data from one worker to another. Irrespective of analogy, it is important to realise that data flows encompass any type of communication, be it verbal, paper or electronic transfers, for example, meetings, telephone conversations, faxes, computerised reports and online transactions.

- An *external entity* is an activity (inside or outside the organisation) that is outside of the scope of the study but interacts with it, that is, it receives or generates information from or to at least one process within the study area.

- A *data store* (or logical file in Ross and Schomann [135] terminology) represents an area where data resides, that is, a file or a database.

DFDs are simple to construct. An inexperienced analyst can become quite expert in their construction in a relatively short space of time. The first step is to define the scope of the analysis. This is represented by a level 0 DFD with a single process, *Manage Business Unit* for example, and depicting the data flow interaction between that process and all external entities. The second step is to construct a level 1 DFD that depicts a set of processes that broadly compartmentalise the level 0 process. The data flow interactions between these processes, and between the processes and external entities are depicted. Next, a series of level 2 DFDs are constructed. Each diagram represents an explosion of a level 1 process, and depicts the level 1 sub-processes together with relevant data flows and external entities. This decomposition process can be continued for as many levels of detail as required.

It is usually the case that there is not one unique way to decompose the level 0 DFD, but a number of correct alternatives are possible depending on one's viewpoint and interpretation of the business [30]. There are several guidelines that can help in the construction of DFDs:

- the emphasis should be functional not organisational so correlating processes with organisational units must be avoided; an individual or department may be responsible for several processes or alternatively several departments may be responsible for a single process;

- data flows on a diagram must be accounted for on any lower-level diagrams;

- as a rule, three to five (and never more than seven) processes are best for one diagram; Ross [135] stated:

Everything worth saying
Anything worth saying something about
Must be expressed
In six or fewer pieces

The development of IDEF0 is attributed to the U.S. Air Force's *Computer-Aided Manufacturing* [134] programme. Like DFDs, IDEF0 is based on constructing a hierarchical set of diagrams that enable a system to be examined in both overview and detail by segmenting it into areas of manageable size. IDEF0 diagrams consist of only two constructs; rectangles to represent processes or activities, and arrowed lines to represent inputs and outputs to and from the processes, constraints (controls) imposed upon them and techniques and mechanisms to implement them. Figure 4.3 shows an example of a typical IDEF0 construction.

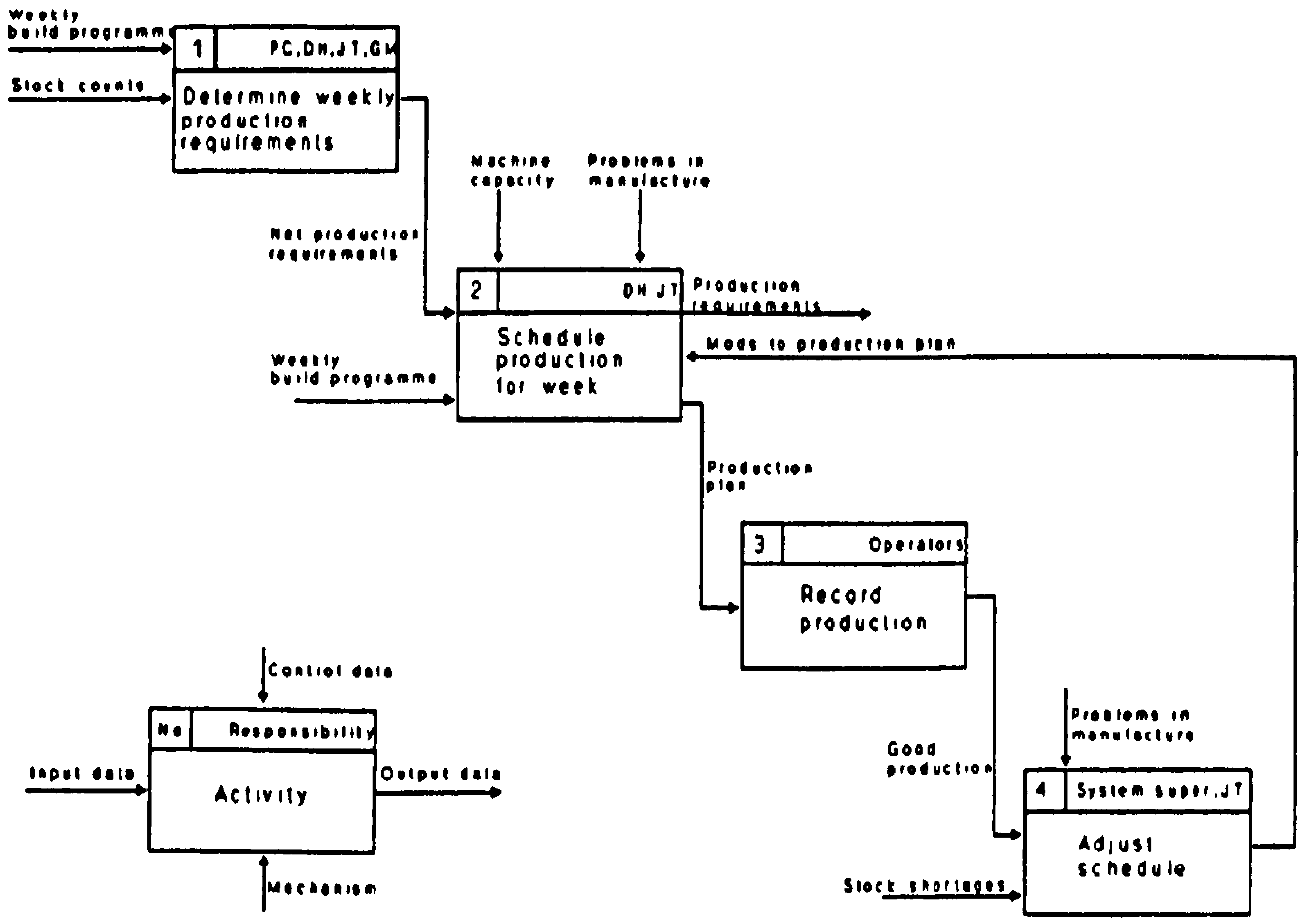


FIGURE 4.3 - IDEF0 example

The rules pertaining to the construction of DFDs also apply to IDEF0 analysis. However, the added complexity of including process controls often leads to misinterpretation, and ambiguity between the controls and data input.

4.3.3 - Entity Modelling and Analysis

The emphasis in functional analysis is on business activities or processes; in entity (data) analysis, emphasis is on data and understanding the relationships between data. Entity modelling was originally developed to provide discipline and structure to the process of database design. However, it is now perceived as a more general analysis technique [4] and its use does not necessarily precede the implementation of a database but may have the sole purpose of aiding the understanding of a complex system. Entity models are used in several strategy formulation methodologies (IE [105], Tetrarch [120], CASE*Method [118]) to represent systems architectures and facilitate the development of future architectures. An entity model defines a set of data elements (entities) within the area of study and the relationships between them. The scope for entity definition is wide. Entities are "things of interest" [4]. They are not data, but something about which data can be kept. Examples include an *order*, *engineer* and *customer*.

Entities have certain properties. They possess *entity occurrences* which are particular instances or examples of an entity. For example, North West Water is an occurrence of the entity *customer* for a supplier of water treatment products. Entities also possess attributes which are characteristics of the entity. For example, a customer entity will have attributes such as *reference number*, *name*, *contact person* etc. A simple yet typical example of the diagrammatic model resulting from an entity analysis is illustrated in Figure 4.4.

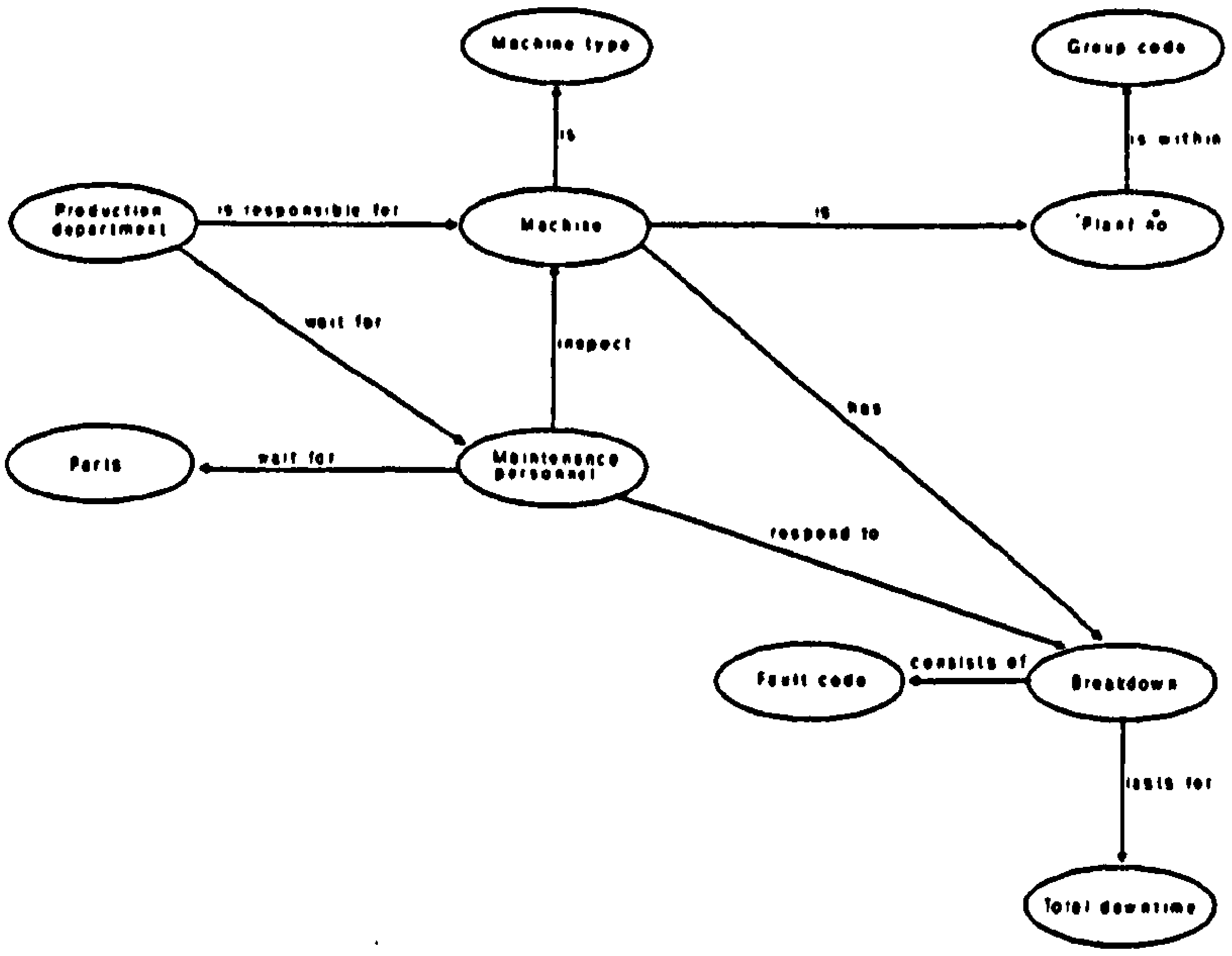


FIGURE 4.4 - Entity model

Relationships between entities (shown as ellipses) are represented by arrowed lines (different methods use different notation). Relationships may be one-to-one, one-to-many, or many-to-many depending on the association between entity occurrences.

Entity models are often subject to normalisation. This is a process of simplification by ensuring the relationships between data, and the data itself are readily understood and easily manipulated. The focus of attention in the process falls upon the unambiguous definition of a key attribute (unique identifier) for each entity, and the assurance that for any two dependent attributes, each one has no more than one value of the other associated with it.

The need for a reference model to support at least the planning stage of a strategy formulation methodology has been established. Morgan [159] working for the Department of Trade and Industry (DTI) offered a simple manufacturing reference model consisting of ten DFDs derived from a DTI survey of AMT standards. Besides an overview diagram illustrating typical information flows across an entire manufacturing system, the DFDs decsribe data flows within Sales, Purchasing, Production Control, Design Engineering, Industrial Engineering and Manufacturing activities. Decomposition is limited to an explosion of Design Engineering in three industry types: Electronic, Mechanical and Software Engineering. Although principally offered as an example to show how fragmented key company operations can be and how complicated data flows often are, and provided in a context promoting an open systems solution to integrated communication, the model does provide a coherent example of DFD construction and a logical segmentation of the main operations of a manufacturing business.

Over recent years, significant resources have been expended on developing CIMOSA (Computer Integrated Manufacturing Open Systems Architecture) [161, 162, 163, 164]. CIMOSA is an on-going project being undertaken by an ESPRIT consortium consisting of a number of major European companies and academic institutions. CIMOSA's key aim is to provide an open systems architecture for CIM, and provides the necessary toolbox to model an enterprise for the efficient operation of the information required to manage and sustain the business.

CIMOSA is generic. It provides a descriptive model for the representation of all aspects of a manufacturing enterprise inclusing all manufacturing, management and administrative processes. All aspects of the systems development life cycle are catered for and Requirements, Design and Implementation specifications and descriptions are represented. CIMOSA is based on four views: Function, Information, Resource and

Organisation and supports three levels of analysis: Enterprise, Partial and Particular. A set of generic building blocks based on a Requirements, Design and Implementation level of systems development is associated with each view [164].

Based on the ideal CIM implementation, integrated models are derived and optimised for a particular enterprise according to a common reference framework based on the elements described above. Although decompositional in its structure, such a wide-ranging set of constructs makes for a complicated model.

A CIMOSA evaluation report [164], concentrating solely on the Function view (the most applicable viewpoint for a systems planning reference model) identified several major weaknesses. These weaknesses are critical for the relative ease with which CIMOSA can be executed and adopted. Several of the weaknesses suggested were as follows:

- model development is subject to misuse as neither a modelling methodology nor modelling rules are defined;
- several concepts are inconsistently applied and not all concepts have enough stability for their application;
- the purpose of some of the constructs and their attributes are difficult to understand;
- the separation between levels of modelling is unclear;
- the linkage between the definition of the objectives and goals of the model and the modelling process appear tenuous;
- CIMOSA enforces the use of objectives and constraints in the details of the model but does not explain how they are used;

- application is difficult;

- no computer-based tool is available.

CIMOSA is overloaded with concepts and appears to be unnecessarily complicated. Examples would aid understanding particularly in order to distinguish between the different types of process offered (i.e. domain process, business process, enetrprise activity and enterprise function). Although CIMOSA does not pre-determine one particular modelling method but only an overall structure, the mechanics of the modelling process are virtually omitted. To its credit, the attempt to provide a coalition of views in a single model, and to cover both enterprise-wide and specific models, and implementation as well as requirements and design is ambitious and therefore bound to add complexity. However, CIMOSA is at present too cumbersome a technique to be of use or recommendation in a manufacturing planning approach with the goals or direction of this particular research.

4.3.4 - Technique Selection and Development

Functional decomposition using data flow analysis (or a derivative of it) and DFDs appear to be the most appropriate technique for modelling, understanding and communicating enterprise-wide information architectures necessary for an IS strategy study. Several authors have lauded the ability of DFDs to model business operations [54, 84], but only one, Curtice [30], in the context of IS strategy. Their appropriateness is valid for several important reasons:

- The approach is very easy to understand and apply by newcomers to data processing, which is essential if users are to be a driving force behind the study. Entity analysis, on the other hand, is more difficult to understand and apply. Proponents of entity analysis are often pre-occupied with normalisation, an activity that is unnecessary at the planning stage of systems development.

- It is easily 'automatable' through the use of Computer-Aided Software Engineering (CASE) tools.

- It is a top-down, hierarchical approach, which is critical for ease of understanding of information flows and business operations on an enterprise-wide basis. Entity modelling is basically non-hierarchical and thus more cumbersome in its representation of a business. A complete business unit is generally too large and ambitious an area for entity analysis.

- The approach is functionally driven, not organisationally driven.

- The detail can be controlled. Thus, in a functional area that is of considerable opportunity or necessity for improvement or where there is great potential for supporting strategic business objectives, the analysis may proceed to differing levels of decomposition.

The choice of DFDs over IDEF0 is attributable to two principal factors:

- IDEF0 has no formal mechanism for the representation of data stores and external entities, both of which are critical data constructs,

- tools for automating the process of DFD construction are more widely available than those for IDEF0.

Although IDEF0 has the seemingly added benefit of formal representation of mechanisms that facilitate processes and controls imposed upon them, these can often clutter the diagram, are misinterpreted, are subject to ambiguity, and such functionality can be readily incorporated into a DFD through an allied data dictionary or list of process descriptions.

Matrix modelling is the chosen technique of a number of methodologies to display information architectures. The concept of clustering applications can readily be achieved using DFDs and is not confined to a matrix-based analysis. However, cluster analysis is basically *flat* and non-hierarchical. The cells in a typical matrix can be vast, and thus render the technique unwieldy. Communication via matrices is also more difficult than a structured diagrammatic technique.

If DFDs are the chosen architectural technique, not only are they required to map an existing business situation but also provide the vehicle for constructing the reference model. Such a model was developed and is described and represented in Appendix A. The model, apart from having its origins in the basic structure provided by Morgan [159], is a refinement of process models developed in a number of manufacturing enterprise modelling studies, several of which are described later in this Chapter and in more detail in Chapter Six. CIMOSA, in its present form, is unsuitable as a user-defined manufacturing reference framework for an IS planning study. Other models such as ISO-OSI [159], IGES [159] and STEP [159] are focused on data exchange formats and media and are thus inappropriate.

4.3.5 - Exploratory Study

A case study of the data flow analysis technique was undertaken at company A (see Chapter 6 for company description). The objectives of the study were first to take inventory of existing computerised systems, and, second, to describe business processes and data flows as they existed, and thus test the effectiveness of the data flow technique. A third, implicit objective was to identify potential improvements to this *information architecture* and opportunities for data flow rationalisation, and procedural improvements.

Major computerised systems within the company are indicated in Figure 4.5.

Application	System
Capacity planning	Ingres database
Material planning	Impcon MRP module
Product design	Mcdonnell Douglas Unigraphics system
Scheduling and production control	Bull MSM system

FIGURE 4.5 - Inventory of major computerised systems

Figures 4.6 and 4.7 illustrate two examples of the DFDs constructed.

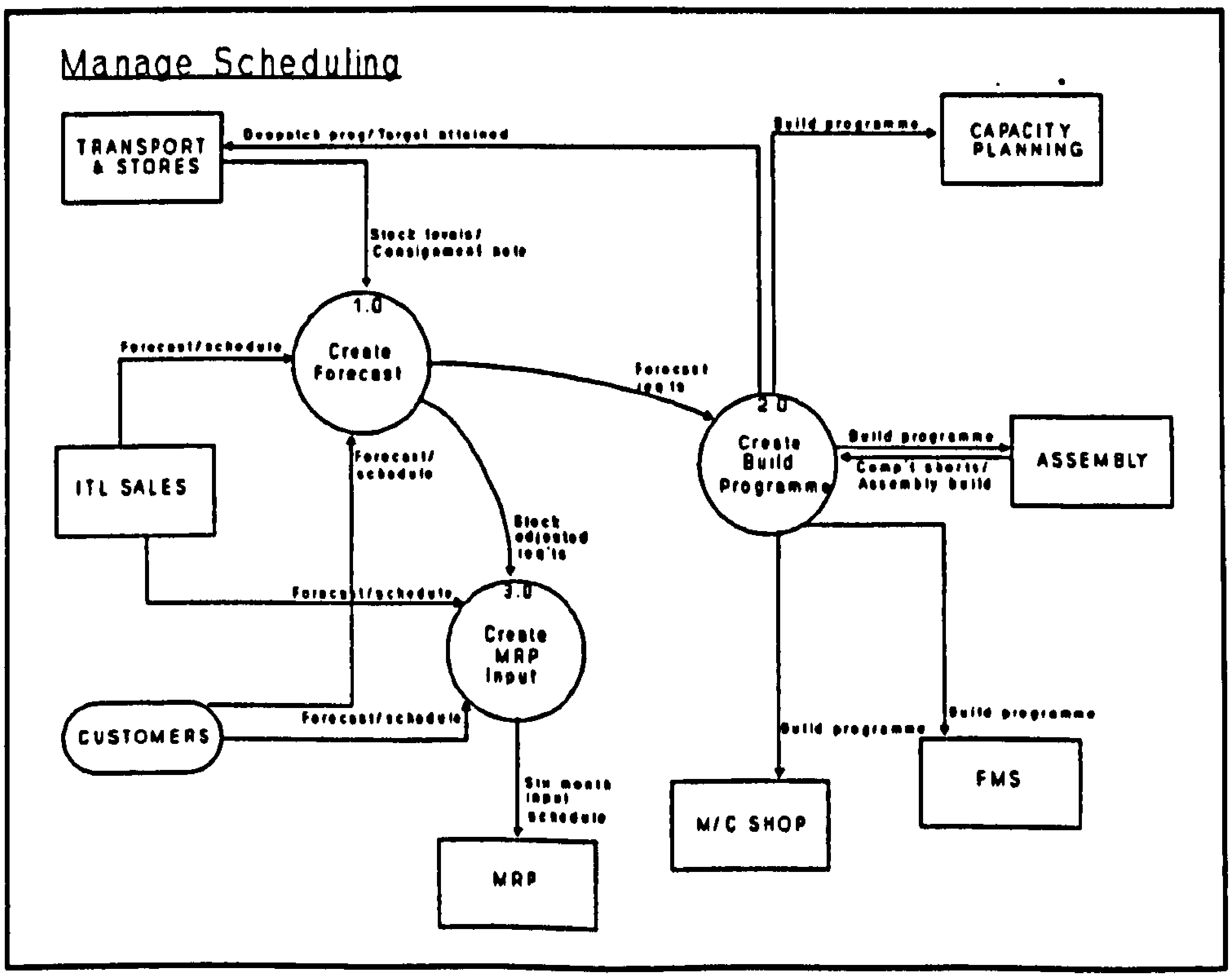


FIGURE 4.6 - *Manage Scheduling* DFD

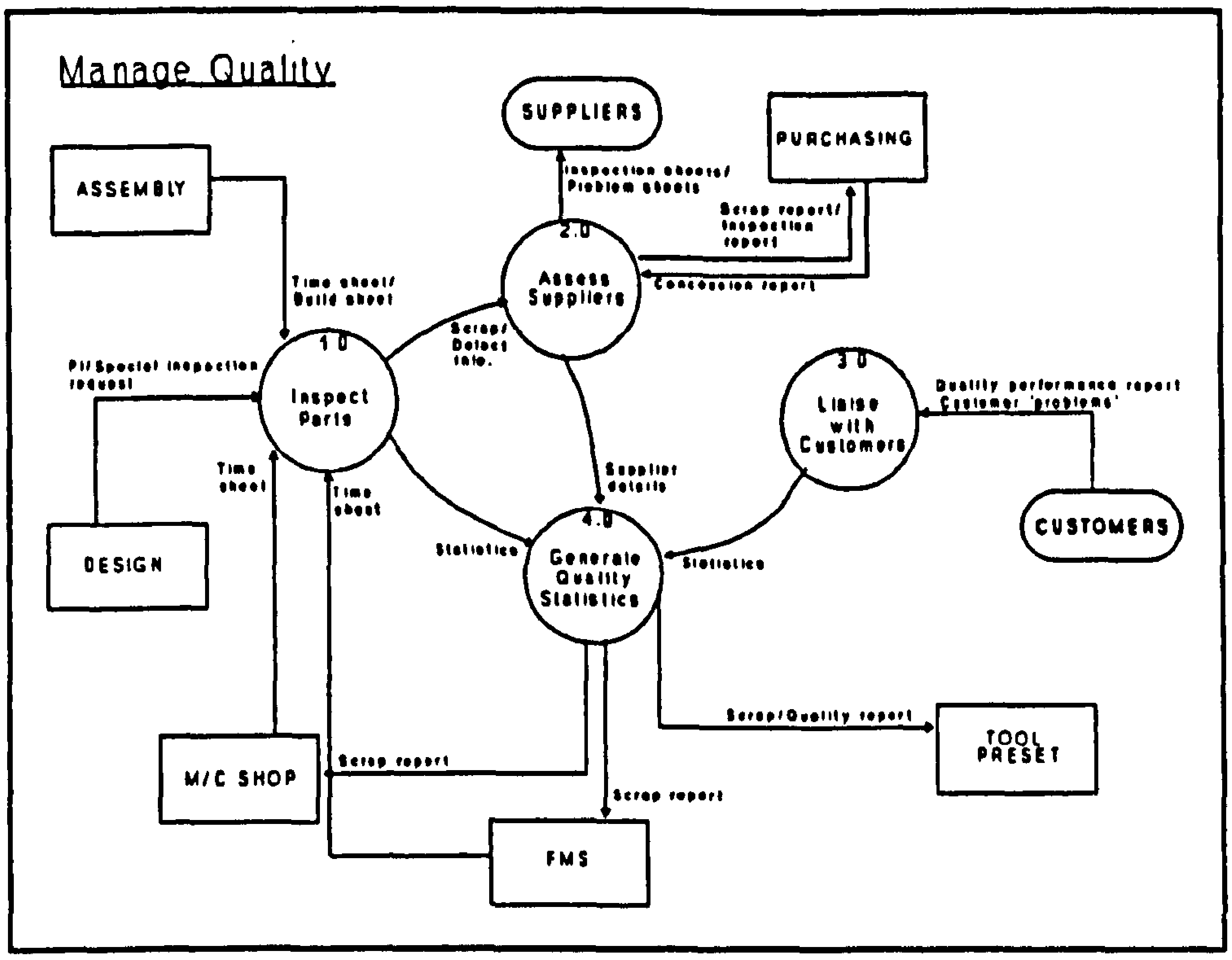


FIGURE 4.7 - *Manage Quality* DFD

The DFD data was obtained from interviews with key user managers and the DFDs were constructed using a CASE tool. A number of problems and clear improvement opportunities were discovered purely from constructing the diagrams:

- no procedure existed for prioritising machine faults,
- Unigraphics CAM modules were not used,
- *local stock data* of the MSMS was infrequently updated,
- the issue of *shift work requests* (SWRs) was slow and inaccurate,
- *Product improvement proposal* (PIP) change description was inadequate.

Experience gained and lessons learnt from this exploratory study and test of the technique included the following:

- The use of a CASE tool and associated data dictionary is not an essential pre-requisite for use of data flow analysis. A simple graphics package and tables for entity descriptions is sufficient for definition of the information architecture.
- Standard questionnaires are a valuable aid in eliciting the information required to

properly construct the diagrams.

- DFDs are equally as effective in functionally as opposed to organisationally modelling homogeneous systems from the same vendor, heterogeneous systems from different vendors and both manual and computerised IS.
- DFDs are readily understood by users and technical staff alike.

4.4 - AN ANALYSIS OF BUSINESS PLANS & GOALS (ELEMENT 2)

4.4.1 - Technique Development

Echoing Sohal et al [141], the matching of business objectives to systems development is often intuitive and superficial. However, such alignment is vital if systems are to contribute to real business improvement. Hollingum [70] pointed out that many senior executives assume that business objectives are obvious, so they do not realise the need to provide a clear statement to the next level of management responsible for the individual functions within the company. This will often lead to functional areas working in isolation from, and even in opposition to overall business objectives.

In order for business objectives to be related to a business area and ultimately be aligned with the development of a specific IS application, they need to be formulated in a manner that facilitates their marrying with business areas and information flow. This is difficult if business objectives are implicit, conceptual or general, and if an attempt is made to directly relate them to an explicit, narrowly-defined IS operating at a much lower decision level than that of the objectives definition process. Business objectives need to be specific, unlike Porter's [124] generic strategy models, independent of each other, and, where possible, should be prioritised and supported by appropriate performance measures. Hollingum [70] points out that any objective to achieve market share is admirable, but does not provide any direction to the functions within the business. Hollingum [70] argues that if an objective is to rapidly introduce new products, which product ranges, and what lead times are being sought must be stated explicitly; if objectives are to be achieved using short lead times, the market lead time requirements must be stated; if low costs, specific cost targets and sensitive product ranges must be identified.

If broken down into lower-level objectives the alignment process can be administered with the integrity required as 'cascading' objectives can be deployed to a low level of business operation and information flow. The technique of decomposing business activities into lower-levels of detail using, for example DFDs, lends itself, and can be similarly applied, to business objectives. Each DFD level is an aggregation of activities and decisions, and, as such, naturally have objectives associated with the processes within each level. These objectives can be decomposed in exactly the same fashion as DFD processes and provide further support for using functional decomposition as the method of generating information architectures. Objectives for a process at one level should support objectives at higher or lower levels. Only Curtice [30] has suggested that such a process is appropriate in the development of an IS strategy. How such decompositional analysis can be applied to the CSF method has already been suggested and described in Chapter 3. Objectives decomposition can be achieved in exactly the same fashion. At the lowest level of abstraction information flow patterns and business information needs allied to the highest level strategic goals can be identified. The technique is not particularly unconventional, but as a basic truism, it has largely been ignored.

The identification of business objectives needs to be done at board level and thus involves the highest-level decision makers in the drivers of the study. Lower-level objectives are defined by lower-level user managers, thus gaining their involvement in the study both in terms of defining their own study drivers and in supporting overall business objectives. Any approach must ensure that the activities at the different levels are closely related.

4.4.2 - Exploratory Study

A study of objectives decomposition was undertaken at company A. Figure 4.8 illustrates the results.

Priority	Strategic Objective (related to level 1 of DFD model)	Related sub-objective (of level 2 DFD processes)	Related sub-objective (of level 3 DFD processes)
1	Reduce manufacturing lead-time.	• Reduce machine downtime. • Improve MRP performance.	• Introduce preventive maintenance & improved procedures. • Improve base disciplines, i.e. BOM accuracy.
2	Reduce lead time on new product introduction.	• Eliminate unnecessary re-design.	• Develop Design/ Manufacturing Engineering task force (simultaneous engineering).
3	Reduce costs.	• Operate with reduced inventory.	• Introduce JIT supply. • Operate with consignment stocks.
4	Improve quality as seen by customer.	• Review material supply base & sourcing policies.	• Introduce vendor rating.

FIGURE 4.8 - Objectives decomposition

Strategic objectives were identified from interviews with company directors; their sub-objectives from interviews with those persons responsible for business functions (that is, actual information processes as defined by the DFDs as opposed to organisational units, defined, perhaps, by an organisation chart). A major problem with identified objectives was their generality. A more tailored approach geared specifically to IS strategy formulation was identified as requiring the following 'failsafe' additions to the objectives definition process:

- ranking and weighting (quantification) of strategic objectives to reflect business importance,
- the use of a coding system to indicate the level and position of objectives,
- formulation of a series of questionnaires and anticipated responses to ensure a deep understanding of business ambition and competitive position.

4.5 - ESTABLISHING EXISTING SYSTEMS EFFECTIVENESS (ELEMENT 3)

4.5.1 - Existing Definition and Measures of IS Effectiveness

Measuring the effectiveness of IS requires considerable attention as the topic regularly appears among the 'hot spots' in major surveys of issues requiring attention from the IS community [44]. It is an area where many IS strategy formulation approaches are deficient. Most randomly use subjective opinions. Miller [112], for instance, outlines an approach where systems effectiveness was subjectively estimated by the participants of the study team.

Improving existing systems or implementing new ones is pointless unless the changes benefit the company, or, more specifically, are congruent with company objectives. Thus, IS effectiveness only has meaning to the extent that IS contribute to business effectiveness. However, both IS and business effectiveness are difficult to measure, regardless of the current glut of research into business strategy and performance measurement [17, 55, 133]. This lack of metrics is reinforced by Dickson and Wetherbe [38] who suggest that the most common way to evaluate the MIS function is to listen to the "screams in the hallways".

There have been several attempts to define and measure IS effectiveness. Miller [112] placed these into four general categories: economic benefits, process outcomes, IS usage and user perceptions. However, there is considerable overlap between the first two categories and Miller has failed to include the prescriptions of IS staff and the use of software metrics. So, an alternative taxonomy would be:

- economic benefits of process outcomes,
- IS usage,
- DP perceptions,
- software metrics,
- user perceptions.

Traditional cost-benefit analyses have attempted to identify financial benefits gained from IS. Miller [112] reported on Crowston and Treacy's [29] review of several such studies which produced no definitive results. Swift [142] found that in his capacity as a Hoskyns IT consultant a lot of his clients did a *cost versus benefits* justification rather than *benefits versus costs*, that is, if a new system were to cost £20,000, how could enough benefit be obtained to equal £20,001? This simply confirms the impracticality of strict cost-benefit analysis related to process outcomes. The technique is clearly impractical because of the non-financial and often intangible benefits of IS.

When financial benefits cannot be successfully measured, the extent to which an IS is used has been suggested as an alternative for evaluating IS effectiveness. Miller [112] identified several studies that show positive correlation between system usage and value-related criteria [98, 146]. However, such a uni-dimensional approach is unreliable due to issues such as mandatory versus discretionary use, 'working smarter not just harder', and appropriate reductions in information usage with experience [111]. Miller [112] reported on this construct's difficulty of use, and Kaufmann and Weill [81] regard IS usage as a poor predictor of performance.

The use of the perceptions of DP staff (IS professionals) to establish systems effectiveness has no formal technique. However, the opinion of technical experts responsible for hardware and software administration, maintenance and, of course, strategy development cannot be excluded from any IS effectiveness study. Soliciting the ideas and opinions of IS staff is the most common method of justifying investment and measuring IS effectiveness. Brancheau and Wetherbe [22] suggested that the IS professional is often unable to establish and quantify the value of information. Such an approach would be unsuitable as a sole instrument for establishing effectiveness, but could be used objectively with perhaps at least one other of the reviewed techniques.

Measures and metrics have been used for some time within software engineering.

They have been used to predict and control both manpower and cost, verify correctness and completeness, and measure the attributes of understandability, performance and expandability. Examples include McCabe's Cyclomatic Number [106] to measure complexity, Halstead's Equation [62] for error prediction and the COCOMO model [90] to assist in cost prediction.

Whilst these measures are recognised to be useful for determining software development quality, they are heavily reliant on highly detailed information, which is unlikely to be available at the strategy formulation stage. In addition, this class of metric is of little use within manufacturing, due to their scope being too narrow and detailed.

Several studies [8, 77] have begun to regard user attitudes and perceptions as a surrogate measure for IS effectiveness. Without formulating specific techniques, other authors have supported the notion of using user attitudes to identify IS competence. Ghosh et al [56], for example, commented that the basic benefits to a production system such as accuracy of information processing or data transmittal are more realistically estimated than the more uncontrollable strategic factors such as financial position, competitive position or sales increases, and Tricker [147] commented that in order to appreciate information in its totality the meaning a user actually derives from the source data must be analysed.

Practical measures whether tangible or intangible appropriate to IS need to relate to the basic elements of information flow. Miller [112] concluded that metrics and measures related to user perceptions of their IS, offer a conceptually sound and pragmatic basis for defining and measuring IS effectiveness and advised that "the *user attitude* construct may indeed be equivalent to the *IS effectiveness* construct". However, Miller [112] observed that, in practice, the user attitude metric in IS is poorly developed. Certainly no attempt has been made to develop such a technique for aiding the IS strategy formulation process (although Lucht [99] does suggest and outline a procedure for using characteristics of information to identify system weaknesses). Indeed, establishing systems effectiveness in strategy formulation approaches is a 'technique desert'. However, identifying strengths and weaknesses of IS is crucial to proper systems development. Such a view is inexorably linked to aligning business ambition with business areas and ultimately identifying business information needs. Potentially, a measure of *user information satisfaction* is the most valuable and, if quantified, the most incisive approach to establishing effectiveness of IS performance as it embodies the need to involve end users in systems development. Critical in the development of an appropriate instrument is its ability to be quantified. Without a quantitative analysis the technique is conceptually no better than cost/benefit analysis.

4.5.2 - Measuring User Information Satisfaction

The umbrella term *user information satisfaction (UIS)* coined by Ives et al [77] is now widely adopted as describing techniques and methods, based on user perceptions to establish systems effectiveness. Their common-sense definition and description of UIS is "the extent to which users believe the information systems available to them meets their information requirements".

A number of instruments purporting to measure UIS have been devised but the usefulness of such instruments in IS strategy formulation approaches has yet to be exploited. Miller [112] identified twelve such instruments noting the wide variety in the number and range of items included. However, of these, only four appear to have been empirically applied with any rigour in a manufacturing organisation. They are:

- Bailey and Pearson (BP) [6],
- Ives, Olson and Baroudi (IOB) [77],
- Baroudi and Orlikowski (BO) [8],
- Miller and Doyle (MD) [113].

Miller [112] identified the factors assessed by each of these instruments. This is illustrated in Figure 4.9.

Factor	BP	IOB	BO	MD
Schedule of products & services	*			
Language for interaction with system	*			
Format of output				
Documentation of systems & procedures	*			
Error recovery for corrections and reruns	*			
Response turnaround time (online/batch)	*			
Integration of systems across functional areas	*			
Organisational position of the DP function	*			
Organisational competition with the DP function				
Expectations regarding IS products/services	*			
Job effects - changes due to computer systems	*			
Charge-back method of payment for services	*			
Vendor support	*			
Priorities determination (fairness)	*			
Volume of output				
Reliability of output information	*	*		
Precision of output information	*	*		
Relationship with the DP staff	*	*		
Users' feeling of participation	*	*	*	
Users' understanding of systems	*	*	*	
Processing of change requests				
Completeness of output contents	*	*	*	
Accuracy of output information	*	*	*	*
Relevancy of products/services provided	*	*	*	*
Time required for new development	*	*	*	*
Attitude of DP staff	*	*	*	*
Communications with DP staff				*
Degree of training in user proficiency	*	*	*	*
Currency of output information	*	*	*	*
Convenience of access to computer systems	*	*	*	*
Flexibility of systems	*	*	*	*
Timeliness of output information	*	*	*	*
Users' feeling of control/influence				*
Users' confidence in systems	*	*	*	*
Means of interface with DP function	*	*		*
Perceived utility/cost effectiveness	*	*		*
Technical competence of DP staff	*	*		*
Security of data				*
Senior management involvement	*	*		*
Hardware & system downtime	*	*		*
Technical sophistication of new systems	*	*		*
Quality of systems analysts	*			*
User-oriented systems analysts	*			*
IS support for users in preparing IS proposals				*
Increased IS effort on creating new systems	*			*
Responsiveness to changing user needs	*			*
IS strategic planning & resource allocation	*			*
Use of IS steering committee				*
Priorities reflecting organisational objectives				*
IS providing competitive advantage				*
Integration of office communications & IS				*
Direct user access to data & models				*
Quick & flexible access to computer data				*
Models to analyse business alternatives				
Data analysis to support decision making				*

FIGURE 4.9 - Items included in UIS instruments (Miller [112])

Whereas these instruments have proved their worth in situations where the ultimate goal has been to determine systems effectiveness, as tools within a strategy management exercise they are unmanageable and a number of issues need to be resolved:

- scant regard has been given to the time taken to carry out such an exercise; where establishing systems effectiveness is one of several related activities, and milestones have been set, the exercise must be undertaken in as short a time as possible;

- a particular objective of the IS exercise is to *pinpoint* areas and applications for systems development - in order for this to be effective, the approach should yield specific results;

- although results produced by these instruments are graded and in some cases numeric, there is no collation of factor assessment to provide indicators of functional or system performance - systems are evaluated purely on the merit of each factor;

- Tricker [147] points out that the ability to monitor (IS) efficiency at the technical level, using such measures as downtime, volumes of data processed and access time should not be confused with the measurement of effectiveness of the IS as a whole. In other words, efficiency of the equipment does not, in itself mean that it is being used to good purpose. Reich and Huff [129] observed that people rarely ask for an IS to solve their problems, but they do complain about the lack of information quality, timeliness and availability.

In order to resolve these issues and provide a UIS instrument capable of assessing systems effectiveness, and dove-tailing with complementary strategic IS management techniques, the following research initiatives were proposed:

- Provide an instrument that balances the *relevance* of information with a synthesis of IS effectiveness factors (this is based on the premise that the value of information is related to the relative importance of decisions or actions pertaining to that information, and these decisions or actions are impaired by poor systems effectiveness). Information only has value if it allows management to use it effectively in the operation of the business. Therefore, information must be considered not only in terms of its content but also in terms of its quality, that is, its presentation, accuracy, timeliness and completeness [70].

- A taxonomy of factors related to user-managers, IS professionals and a global information performance metric should be employed (this is based on Melone's [111] discussion of the complexity of the *attitude metric* and his conclusion that user satisfaction alone is not sufficient to capture the full meaning of IS effectiveness).

- Provide an instrument that is numeric, yields specific and dependable results and therefore is unambiguous in its treatment of user attitudes.

- Provide an instrument that is independent of computer-based systems so that information processing activities within business functions and information items can be assessed - existing UIS instruments are not applicable business-wide as they are geared solely to computer-based systems.

4.5.3 - Factor Determination and Exploratory Study

Referring to Figure 4.9, the following was noted:

- there is considerable overlap and repetition between a number of the factors, for example, *precision of output information* and *accuracy of output information* - this is principally caused by instrument jargon;

- several qualitative factors are better solely addressed by user-managers, for example, *attitude of DP staff* and *format of output*, several technical factors by IS professionals, for example, *security of data* and *priorities determination*, and several by a combination of the two, for example, *documentation of systems and procedures*;

- several factors can be eliminated as they are either ineffectual, for example, *user-oriented systems analysts*, or bring no perceived benefit to an IS strategy methodology, for example *language of interaction with system.*

From these observations, Figure 4.10 was produced.

Users	IS Professionals	Both
Format of information Volume of information Reliability of information Completeness of information Accuracy of information Relevance of information Currency of information Accessibility of information Timeliness of information	Error recovery for corrections & reruns Organisational position of the DP function Vendor support Priorities determination (fairness) Perceived utility/cost effectiveness Security of data Senior management involvement Hardware & system downtime Technical sophistication of new systems Quality & technical competence of systems analysts & DP staff IS strategic planning & resource allocation Use of IS steering committee Priorities reflecting organisational objectives IS providing competitive advantage	Documentation of systems & procedures Response/turnaround time (online/batch) Integration of systems across functional areas Job effects - changes due to computer systems Communication & relationship with DP staff Users' feeling of participation/influence Users' understanding of systems Attitude of DP staff Degree of training in user proficiency Users' confidence in systems Responsiveness to changing user needs

FIGURE 4.10 - Stakeholders of UIS factors

An exploratory study, using a modified version of the Delphi [57] technique, based on the factors in Figure 4.8, was commissioned at company A. The purpose of the study was threefold:

1) Formulate a series of questions and scales centred around these factors aimed at

both user-managers to assess information effectiveness and IS professionals to assess effectiveness of systems support (*Objective 1*).

2) Formulate a specific technique that is capable of establishing information item effectiveness by way of a numeric information effectiveness indicator compromising the *relevance* of information with a weighted consideration of the qualitative aspects of information (*Objective 2*).

3) Use the techniques to establish systems effectiveness at the company and use the results obtained to prioritise systems development (*Objective 3*).

To achieve Objective 1, a *technical effectiveness questionnaire* outlined in Figure 4.11 (and Appendix C section 1) was developed. The questionnaire is a development of those used by Tozer [145] and Oracle [118]. Part of it is aimed at users, part at systems staff, and part both. It is designed so that three or four key users, the head of IT, and two or three other systems professionals should be asked to participate. The quality scales are used on a Likert-type basis, where each factor is assigned a point on a 1 (ineffective) to 10 (effective) scale.

To achieve Objective 2, an examination of information attributes was necessary. It is apparent that certain information attributes are of more value than others, for example, for a given piece of information, it would generally be more desirable for the information to be *timely* than *formatted* correctly. This is not to say that *format* can be disregarded, but it would be generally unwise to perfect *format* at the expense of *timeliness*.

1) Effectiveness of systems support (systems professional view)

Questionnaire

- *What IT systems & applications software are currently owned/used? (hardware/software, languages, packages, suppliers, peripherals, storage devices etc)*
- *What is the function of each of these systems?*
- *If applicable, how are these system connected?*
- *Are users aware of all the features provided by the systems?*
- *Which systems are subject to misuse? How?*
- *What systems consistently underperform?*
- *What plans are there for further computerisation?*
- *Are users satisfied with the speed & effectiveness of response to requests for enhancements?*
- *Do any of the existing computer systems suffer from: a) user rejection? b) user irritation? c) slow operation? d) excessive errors? e) excessive maintenance f) poor vendor support g)*
- *Does the company have an IS or IT strategy? What approach was used to generate it?*
- *What further systems developments have been planned? (reasons for development, description, date for release, development strategy, development resource/cost, identified benefits, effects on other systems/user departments.)*

Quality Scales (1 to 10)

- *Vendor support*
- *Priorities determination (fairness)*
- *Security of data*
- *Senior management involvement*
- *Hardware & system downtime*
- *Technical sophistication of new systems*
- *Quality & technical competence of DP staff*
- *Documentation of systems & procedures*
- *Response/turnaround time*
- *Communication between users & systems staff*
- *Users' feeling of participation/influence*
- *Users' understanding of systems*
- *Degree of training in user proficiency*
- *Responsiveness to changing user needs*

2) Effectiveness of systems support (user view)

Questionnaire

- *How do you rate your information support services within the company? What are the main strengths and weaknesses of information services?*

Quality Scales (1 to 10)

- *Documentation of systems & procedures*
- *Response/turnaround time*
- *Communication between users & systems staff*
- *Users' feeling of participation/influence*
- *Users' understanding of systems*
- *Degree of training in user proficiency*
- *Responsiveness to changing user needs*

FIGURE 4.11 - Technical effectiveness questionnaire and quality scales

A sample of 24 key users were asked to rate the relative importance of those factors or information attributes that were considered to be solely attributable to users (see

Figure 4.10), i.e.

- format of information,
- volume of information,
- reliability of information,
- completeness of information,
- accuracy of information,
- currency of information,
- accessibility of information, and
- timeliness of information.

Each user was asked to sequence the attributes in order of importance, where *a* represents the most important, and *h* the least. Figure 4.12 represents the results obtained.

The user managers (from company A) responsible for the results of Figure 4.12 are shown in Figure 4.13.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Format	e	e	e	h	e	g	g	h	d	e	c	e	d	d	f	e	e	c	e	e	f	e	e	e
Volume	g	g	h	g	g	h	h	g	h	h	g	h	h	g	h	h	h	d	h	h	g	h	h	h
Reliability	h	h	g	e	h	e	f	f	f	g	d	f	f	h	g	g	g	g	g	g	e	b	f	f
Completeness	d	c	c	f	d	d	d	e	e	d	f	c	e	c	e	d	d	b	d	c	d	c	d	d
Accuracy	b	a	b	b	b	c	b	c	a	a	b	b	a	b	a	b	b	a	b	b	a	a	c	b
Currency	f	f	f	d	f	f	e	d	g	f	e	g	g	f	d	f	f	h	f	f	h	d	g	g
Accessibility	c	d	d	c	c	a	c	b	c	c	h	d	c	c	c	c	c	f	c	d	c	g	b	c
Timeliness	a	b	a	a	a	b	a	a	b	b	a	a	b	a	b	a	a	e	a	a	b	f	a	a

FIGURE 4.12 - User perceptions of attribute importance

1. Sales & Marketing Manager	2. Inventory Controller
3. Quality Manager	4. Teaching Company Associate
5. Teaching Company Associate	6. Tooling Engineer
7. Transport & Stores Manager	8. FMS Manager
9. Financial Controller	10. Machine Shop Manager
11. Manufacturing Manager	12. Teaching Company Associate
13. Materials Manager	14. Purchasing & Supply Manager
15. Manufacturing Engineer	16. Manufacturing Costs & Data Manager
17. Systems Manager	18. Stores Controller
19. Expediter,	20. Manufacturing Engineer
21. Plant Manager	22. Designer
23. CAD Manager	24. Assembly Manager

FIGURE 4.13 - Users surveyed

The results provide a mechanism for establishing an average weight for each attribute. Figure 4.14 shows the number of times each attribute was assigned the relative grades of importance (*a* to *h*).

	Form.	Vol.	Reliab.	Complete.	Accuracy	Currency	Accessib.	Timeliness
a	0	0	0	0	8	0	1	15
b	0	0	1	1	13	0	2	7
c	2	0	0	6	3	0	14	0
d	3	1	1	11	0	4	4	0
e	13	0	3	4	0	2	0	1
f	2	0	7	2	0	11	1	1
g	2	8	8	0	0	5	1	0
h	2	15	4	0	0	2	1	0

FIGURE 4.14 - Importance statistics

As the time required to carry out any strategic IS study should be kept to a minimum, it would be impractical to use all 8 of the attributes listed above in a systems effectiveness study. For ease of calculation, it is beneficial for the sum of ratios of the relative weights of the attributes to be equal to 100. Therefore, the number of attributes used should be a factor of 100, that is the number to be used would be 1, 2, 4 or 5. 5 is the optimum, therefore, the three attributes with the least perceived importance should be eliminated.

Examining the sum of each attribute from the most to the fifth most important rating, that is *a* to *e*, provided the following results:

$\Sigma^{ae} Format = 18$

$\Sigma^{ae} Volume = 1$

$\Sigma^{ae} Reliability = 5$

$\Sigma^{ae} Completeness = 22$

$\Sigma^{ae} Accuracy = 24$

$\Sigma^{ae} Currency = 6$

$\Sigma^{ae} Accessibility = 21$

$\Sigma^{ae} Timeliness = 22$

Therefore, *volume*, *reliability* and *currency* were discarded. To identify the relative perceived importance of the remaining attributes, those users that listed *format*, *completeness*, *accuracy*, *accessibility* and *timeliness* as the five most important attributes were targeted for a follow-up analysis. In this case, the users were asked to assign 100 points amongst the attributes reflecting their relative importance. Figure 4.15 shows the results obtained.

																$\bar{x}$
Format	5	5	5	5	8	5	7	10	10	5	5	5	5	10	5	5
Completeness	10	15	5	10	7	10	15	5	5	10	15	10	15	15	10	10
Accuracy	30	40	35	35	50	40	30	35	25	30	30	30	35	20	30	30
Accessibility	15	10	10	15	10	15	8	15	15	15	15	15	10	25	15	15
Timeliness	40	30	45	35	25	30	40	35	45	40	35	40	35	30	40	40
	1	2	3	5	9	10	12	13	14	16	17	19	20	23	24	

FIGURE 4.15 - Relative importance of attributes

Empirical evidence for a UIS instrument has been obtained. *Relevance* of information could be compromised with a weighted contribution of five information attributes, namely, *timeliness*, *accuracy*, *accessibility*, *completeness* and *format* with value ratios of 40/30/15/10/5 (8/6/3/2/1) respectively.

Hence, for any given information item, the analyst would ask the *user* the questions defined in *Objective 1* relating to *timeliness*, *accuracy*, *accessibility*, *completeness* and *format* supported by the appropriate *quality scales* to determine the effectiveness of the item and articulate this via a numeric effectiveness indicator.

For example, consider an information item, say, a *purchasing request*. The users of that item, say, a *purchasing manager*, would be asked the following:

- What is the relevance of the purchasing request in terms of the objectives of the purchasing function? (Objectives must be devolved from the identified highest-level strategic objectives.)
- How timely is the request?
- How accurate is the request?
- How accessible is the request?
- How complete is the request?
- How well formatted is the request?

In order to achieve Objective 3, information flow throughout the company was investigated. Raw data was represented in the form of a series of *information matrices*. Several such matrices are depicted in Figure 4.16.

Capacity Planning

Information requirements v. information attributes	Rel	Tim	Acc	Acs	Com	For
Weekly build programme (Scheduling)	10	10	8	10	10	8
BOM - machined parts (MRP)	10	10	8	10	10	10
Smv's (Ind Eng)	10	8	10	10	10	6
Changes to routings (Ind Eng)	10	2	10	6	10	2
Smv's (M/C Shop)	10	8	10	10	10	6
Changes to routings (M/C Shop)	10	2	10	6	10	2
Planned utilisation (M/C Shop)	10	10	10	10	10	10
Actual utilisation (M/C Shop)	10	10	10	10	10	10
Available hours (M/C Shop)	10	10	10	10	10	10

Change Control

Information requirements v. information attributes	Rel	Tim	Acc	Acs	Com	For
PIP (Design)	10	4	8	10	10	10
PI/NI (Design)	6	8	10	10	4	10

Design

Information requirements v. information attributes	Rel	Tim	Acc	Acs	Com	For
Application sheet - new (Cust)	10	10	8	10	8	10
Application sheet - old (Cust)	10	4	8	10	8	10
Test report (Cust)	10	6	10	8	8	8
PIP (Cust)	10	6	8	10	6	8
PIP (ITL Sales)	10	6	8	10	6	8
Application sheet (ITL Sales)	10	10	8	10	6	10

FIGURE 4.16 - Example information matrices

The raw data captured in the information matrices was then manipulated to incorporate the weight of each attribute and the sum of the latter five attributes was subtracted from the *relevance* rating (expressed as a percentage) to provide a *variance* for each information item. Where more than one item from any single business function was present, the result from this area was averaged. Thus the variances represent information flow effectiveness between any two business functions. The result is a series of *function matrices*. The corresponding function matrices to the information matrices in Figure 4.16 are depicted in Figure 4.17.

Capacity Planning

Functional requirements v. weighted information attributes	Rel (%)	Tim	Acc	Acs	Com	For	Fn Tot (%)	Var (%)
Scheduling	100	40	24	15	10	4	93	7
MRP	100	40	24	15	10	5	94	6
Ind Eng	100	20	30	12	10	2	74	26
M/C Shop	100	32	30	14	10	4	90	10

Change Control

Functional requirements v. weighted information attributes	Rel (%)	Tim	Acc	Acs	Com	For	Fn Tot (%)	Var (%)
Design	80	24	27	15	7	5	78	2

Design

Functional requirements v. weighted information attributes	Rel (%)	Tim	Acc	Acs	Com	For	Fn Tot (%)	Var (%)
Cust	100	26	26	14	8	4	22	78
ITL Sales	100	32	24	15	6	4	19	81

FIGURE 4.17 - Example function matrices

Several lessons were learnt from the study. Firstly, the definition of business functions had to be carefully considered. The temptation to regard what would normally be considered organisational units as functions has to be avoided. Thus, in the sample of examples chosen above, *Capacity Planning* and *Change Control* are viable business functions. However, *Design* is not, it is a department. At the time of the study the Reference Model was not developed. This would have avoided such a choice. The fact that a single manager may be responsible for a department which includes several business functions or that any single business function may require the involvement of several managers further complicates the process of function definition and further justifies the need for a reference model.

A related observation was ambiguity over the origin of information. Identification of information transfer from function to function does not necessarily locate its origin. For a company-wide study, the originators of problem data items would be identified. However, for a study where the boundary of analysis is less than company-wide, a more careful analysis is required.

Secondly, the reliability and validity of the *Information Quality Analysis (IQA)* instrument as a surrogate measure for IS effectiveness had been tested. The following points were noted:

- The instrument elements (that is, the information attributes) are plausible and valid indicators of IS effectiveness. The quality of a decision is dependent on the quality of the information on which it is based. The scores act as an information quality audit, and enable an appropriate action plan to be formulated.

- With IQA, intangibles such as relevance and timeliness of information can be rated alongside more traditional methods such as rate of return. Many authors ignore such intangibles. Project selection is thus based on a richer diet of criteria. Ghosh et al [56] point out that in the justification of manufacturing (and, thus information) systems, a comparative analysis of all appropriate procedures regardless of the perceived level of sophistication must be carried out. IQA does this.

- IQA cannot be said to be completely reliable. It was administered a second time to several of the users who participated in the exploratory study. On the second occasion, the technique did not always yield the same result. The discrepancy was not great (~ ±5%) yet it was a discrepancy. Consequently, IQA operates with a tolerance (±5) for the *information quality variances (IQVs)* it produces.

- IQA quantifies opinion in a formal and structured manner.

- There is a clear need for empirical guidelines to manage user involvement. IQA provides such guidelines.

- It is not possible to fully understand a process without being able to measure it. IQA enables the process of information flow management to be measured, and therefore, better understood.

- The overall effectiveness of a company-wide IS is not the sum of its individual parts but the product of its interactions. IQA is based on functional interfaces, thus forces the examination of, and provides an indication of the effectiveness of information flow interactions.

4.6 - AN INVESTIGATION OF IS IMPROVEMENT OPPORTUNITIES (ELEMENT 4)

Any approach to IS planning demands a *treasure hunt* for IS improvement opportunities. The sophistication and reliability of instruments to conduct such an analysis are naive and ineffective. Much is left to intuition and luck (sic). However, it is arguably the most difficult aspect of IS strategy formulation. Runge and Earl [136] have previously commented on the difficulty of opportunities analysis. Breuer at al [23] commented that in the past it was relatively simple to figure out where IT would be useful and where it would not be useful as the capabilities were limited to certain data processing applications. Now, IT has limitless uses and capabilities in manufacturing industry and adoption decisions are much more difficult [23].

Earl et al [43] recommend an approach where users take the lead in finding opportunities for the use of IT. Breuer et al [23] agree with such a view, but temper it with the notion that users need to understand "the capabilities and limitations of IT, and, what is more important, they have to embed in their everyday thinking the idea that IT is a tool, which can provide substantial benefits for themselves and for their clients". Users are clearly in an ideal position to comment on potential improvements to the operation of the IS with which they are associated. However, lateral and innovative thought, experience, and astute intuitive judgement (the recommendation of most of the strategy formulation frameworks and methodologies) are rare. Users need a framework to help them articulate their thoughts and identify genuine improvement opportunities; a framework that is demand rather than supply-driven.

After the application of each of the case studies described in Chapter 6, such a framework was developed. (See Appendix B for complete framework and Figure 4.18 for an overview.)

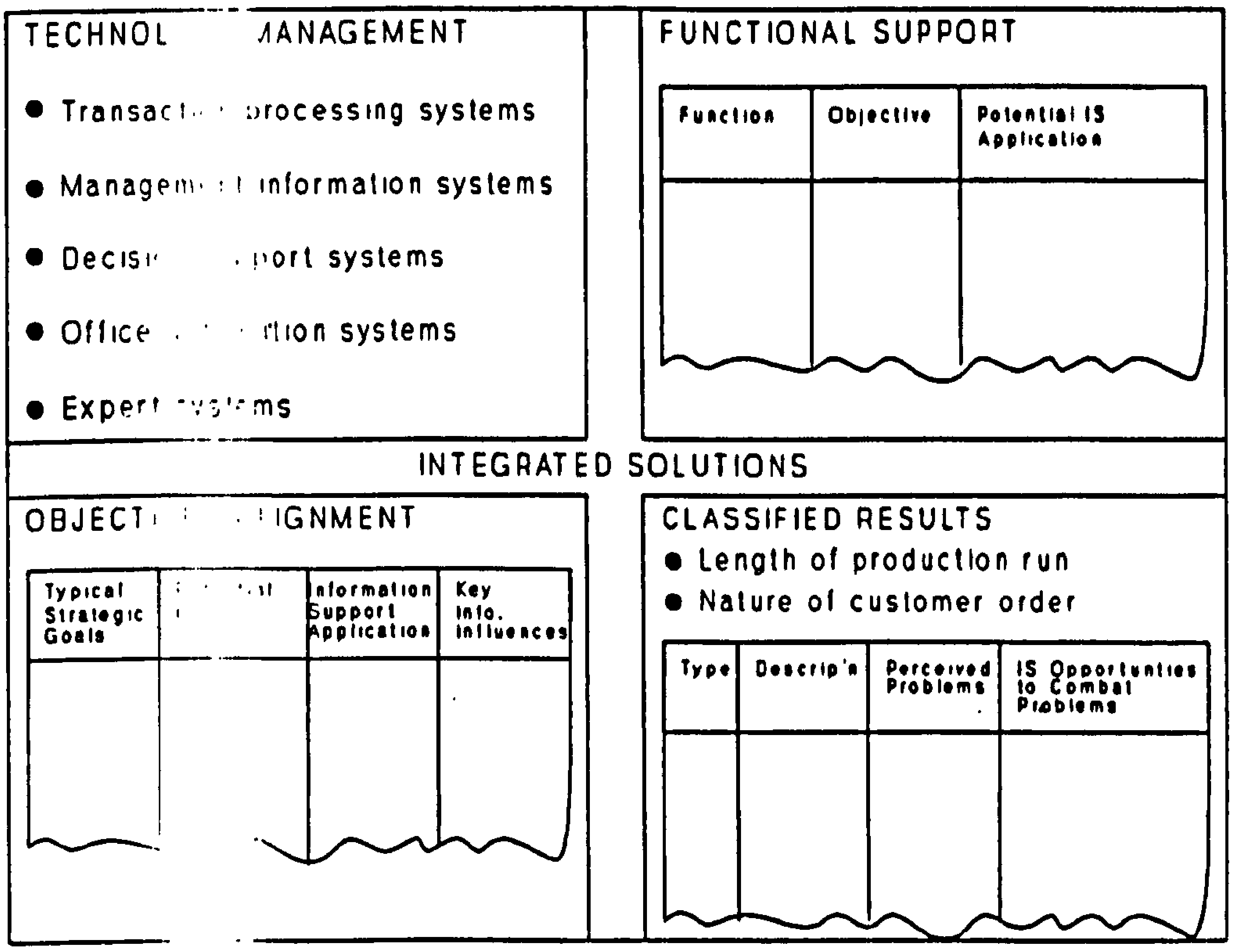


FIGURE 4.18 - Opportunities Framework

The *Opportunities Framework* is segmented into five sections or sub-frameworks. Each is a contextual advisory system for aiding the identification of suitable manufacturing information support applications. The sub-frameworks are entitled as follows:

- *Technology Management,*
- *Functional Support,*
- *Objectives Alignment,*
- *Classified Results* and
- *Integrated Solutions.*

The Technology Management sub-framework provides an overview of the five types of IS found in manufacturing industry, that is:

- transaction processing systems,
- management information systems,
- decision support systems,
- office automation systems, and
- expert systems.

The Functional Support sub-framework is an overview of IS' impact on manufacturing business functions. It is represented in the form of a table consisting of each identified business function, each function's typical objectives, and potential IS applications to support the objectives. The list of applications is far from exhaustive, but is intended to provide potential 'solution seekers' with a direction and an indication of commonly used IS, techniques and technologies that can improve business function performance.

The Objectives Alignment sub-framework is designed to identify CSFs, information support applications and information flows that support typical strategic goals. Having established the ambition of a manufacturing enterprise, this section makes it possible to identify potential IS applications to support that ambition*.

The fourth sub-framework, Classified Results, aids the identification of IS opportunities to combat typical problems in different types of manufacturer. The typology is bi-dimensional based upon length of a production run, and nature of a customer order.

The final sub-framework, Integrated Solutions, is an attempt to relate IS to a specific rather than a general situation by mixing several of the variables analysed in previous sub-frameworks.

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* Only through an effective IS strategy could such business benefits be guaranteed.

4.7 - PRIORITIES IDENTIFICATION "FILTER" & BUSINESS AREA ANALYSIS (ELEMENT 5)

4.7.1 - Technique Development

The theory behind project identification and prioritisation is based on Ghosh et al's [56] three stages of problem solving. They are the principles of decomposition, comparative judgements and synthesis of priorities. Decomposition is an analysis of the business that is divergent. This enables a clear view of overall IS requirements to be established. Comparative judgements, on the other hand, is a convergent analysis, evaluating and selecting between alternatives, and prioritising areas and applications for further investigation. The intention is to analyse the impacts of changes at the lowest levels on the overall direction of the business. Synthesis of priorities is the fashioning of IS improvement requirements into manageable project units suitable for detailed business area analysis. The result of this stage is a requirements specification document that establishes the functional rather than the technical aspects of improved IS that will support the ambition of the business[*].

Comparative judgements are traditionally made using discounted cash flow and payback methods of investment appraisal. However, such approaches are not conducive to the long-term and often intangible gains of modern IS [156]. Practitioners and theorists have generally put all the burden of investment justification on the budgetary process [7]. Curtice [30] bucked this trend by including the relationship to business objectives and IS capabilities in the SVA approach to project prioritisation. Silk [140], on the other hand, advocates that managers should approve projects on a subjective basis: "they recognise that quantifying all the benefits is unrealistic, but they have no methodical alternative, they, therefore approve the project as an intuitive act of faith".

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[*] Note, the objective is to provide an IS applications rather than an IS delivery strategy.

Ideally an approach is required that allocates resources to areas with the most strategic potential by considering IS opportunities, IS effectiveness and business objectives in its filtering mechanism to project selection. The challenge, therefore, is to establish a sort of *correlation coefficient* which could describe and analyse fit between the trilogy of key framework elements: business objectives, IS effectiveness and IS opportunities with the same precision and discipline that traditional correlation analysis handles a mathematical problem. Numerical analysis facilitates a specific, unambiguous solution. Acts of faith should be avoided. Conventional qualitative aspects of a business need to be manipulated so that they can be quantitatively measured. Changes need to be quantified in terms of observable parameters. IQVs do this for IS effectiveness; for business objectives, each strategic goal is assigned a numeric priority reflecting its importance. The underlying functional objectives and business information needs related to those goals are assigned the same priority. Similarly, a numeric rating can be assigned to each IS improvement opportunity reflecting its ability to support functional objectives. The product of these three ratings (subsequently called the *methodology metric*) can provide the means for evaluating areas for detailed investigation. The metric has to be tempered with at least estimated development cost of the improvement opportunities, tolerances of the ratings, solution of immediate problems, ease of implementation, and speed of implementation.

Project areas can be synthesised by clustering ratings for similar areas. Typically, IQVs are for functional interfaces, so there is at least two IQVs for each interface. Thus, clustering is concerned with at least two metrics. Having decided upon a specific application project, a lower-level and more detailed information architecture is required. This can be developed and expanded from the company-wide DFD architecture. A data model is also appropriate at this level. This lower-level architecture provides the basis for investigating and thoroughly understanding the business area. In formulating an effective requirements specification, also required are:

- a detailed definition of user requirements,
- identification of problems and problem causes,
- a specification of improvement requirements,
- an evaluation of possible courses of action.

Techniques to satisfy these requirements are generally well developed, much more so than the planning elements of the strategy formulation process. However, it is important that descriptive and evaluative analyses conducted at both the business unit and business area levels are consistent, so it is appropriate to use similar techniques, for example, evaluating low-level data quality using *data quality analysis* (IQA for data items).

4.7.2 - Exploratory Study

The highest-priority application area for business area analysis was identified as the interface and affiliated areas between and within the Machine Shop and Maintenance functions. The strategic objective this application area was related to was to *reduce the manufacturing cycle time.* This objective was (subsequently) assigned a weight of 30 and was supported by several identified sub-objectives throughout the company, one of which was to reduce machine downtime from an average of 12% to 6%. In turn, this objective (CSF) was supported by two lower-level sub-objectives:

- to improve the effectiveness of the fault notification procedure,
- to introduce planned maintenance to all machining centres.

Key information flows pertaining to these lowest-level objectives concerned the receipt of fault notification and machine utilisation details by Maintenance from the Machine Shop Function. The IQV for this information = 47. From the Machine Shop to Maintenance functions, pertinent information concerned completed fault notifications and repair estimate details. The IQVs for these information items were both 80.

Although at the time of the company A exploratory study, an opportunities framework had yet to be established, chances to improve the existing situation could still be identified in a similar manner to that of other planning methodologies, that is, by *pondering the possibilities*, through user interviews, by being creative and through common sense. A computerised maintenance management system was considered a valid IS improvement opportunity, as such a system would support both of the lowest-level CSFs and improve the effectiveness of the relevant information flows. The capability was assigned a 5 rating (on a 1 to 5 scale).

The product of the three ratings, for Machine Shop to Maintenance, = 30 x 47 x 5 = 7050, and for Maintenance to Machine Shop = 30 x 80 x 5 = 12000 provided an indication of the impact associated with implementing a maintenance management system or making an equivalent improvement.

The detailed analysis of the Maintenance/Production area firstly involved an overview of the functions concerned in terms of functional responsibilities, personnel, current practice, performance measures and pertinent IQA results. The detail of the study began with the construction of two separate models

1) Normative Model

2) Empirical Model

Both models consisted of the same three techniques (functional, entity and action modelling) applied to two different scenarios. In the Normative Model, the information processing activities, events and information flows which were perceived or supposed to occur in the day to day running of the Machine Shop and Maintenance Functions are represented. In the Empirical Model, it is the activities which actually do happen that are shown. The Normative Model is by no means an ideal model but one for which there is a facility to transmit the information depicted and undertake the actions and processes that are represented. Both these Models were constructed and the discrepancies between the two identified.

Functional modelling uses data flow diagrams (DFDs) to represent both the Normative and Empirical Models. High-level diagrams had been constructed for both the Machine Shop and Maintenance Functions in the overview information architecture. For this study both of these two DFDs were merged to form a Context and System diagram for the combined Machine Shop and Maintenance subsystem.

The Context Diagram depicted the boundary between the merged Machine Shop / Maintenance subsystem under analysis and the environment in which that subsystem operates. In other words, what is within its scope and what is outside it, was defined. Data flows in the Context Diagram showed the movement of information between the subsystem and its environment. Some flows showed information that the subsystem needed to do its work, other flows show information that the subsystem produced. The Context Diagram consisted of a single process that represented the entire Machine Shop and Maintenance subsystem. Lower levels of the DFD set showed the inner workings of the Context Process in gradually increasing levels of detail.

The System Diagram depicted the major functions that are performed by Maintenance and the Machine Shop. The requirements of the subsystem were used to identify its major functions; then each major function was shown as a process on the diagram. To fulfil the Machine Shop and Maintenance requirements, seven major functions were identified:

- make to schedule,
- maintain machinery,
- procure plant inventory,
- adjust schedule,
- monitor stock levels,
- examine manufacturing processes.

Each of these became a process on the System Diagram of both Models. Each data flow that appeared on the Context Diagram was also represented on the System Diagram. Interfacial flows that have undergone IQA were emphasised. An explosion path from the Context Diagram Process to the System Diagram was established, and similarly, explosion paths from several of the processes on the System Diagram to DFDs that depicted the processes in more detail were also established.

Processes on the System Diagram represented major tasks performed by both the Maintenance and Machine Shop Functions. At this high level, processes are complex and involve subsidiary operations. Process 2.0, 'Maintain Machinery', for example, takes a maintenance request form ('SWR') and does everything necessary to remedy the fault for which the form was initiated. This processing included many steps, from allocating work to determining which spares were required. This process was exploded to its own DFD that depicted these steps as lower-level processes. When a process is exploded to the new DFD, the data flows that enter and leave the parent process are carried down to the exploded diagram. These carried-down flows connect to separate process objects on the new diagram. This 'explosion activity' was carried out on all the processes pertinent to both the M/C Shop and Maintenance Functions until a level of abstraction that comprehensively describes the activities of both Functions had been represented.

Three processes (1.0, 2.0 and 3.0) on the System Diagram were exploded to lower-level DFDs. Several of the processes on these lower-level DFDs were in turn exploded to DFDs at an even greater level of detail. Figures 4.19 and 4.20 depict an equivalent normative and empirical example of a level 1 DFD.

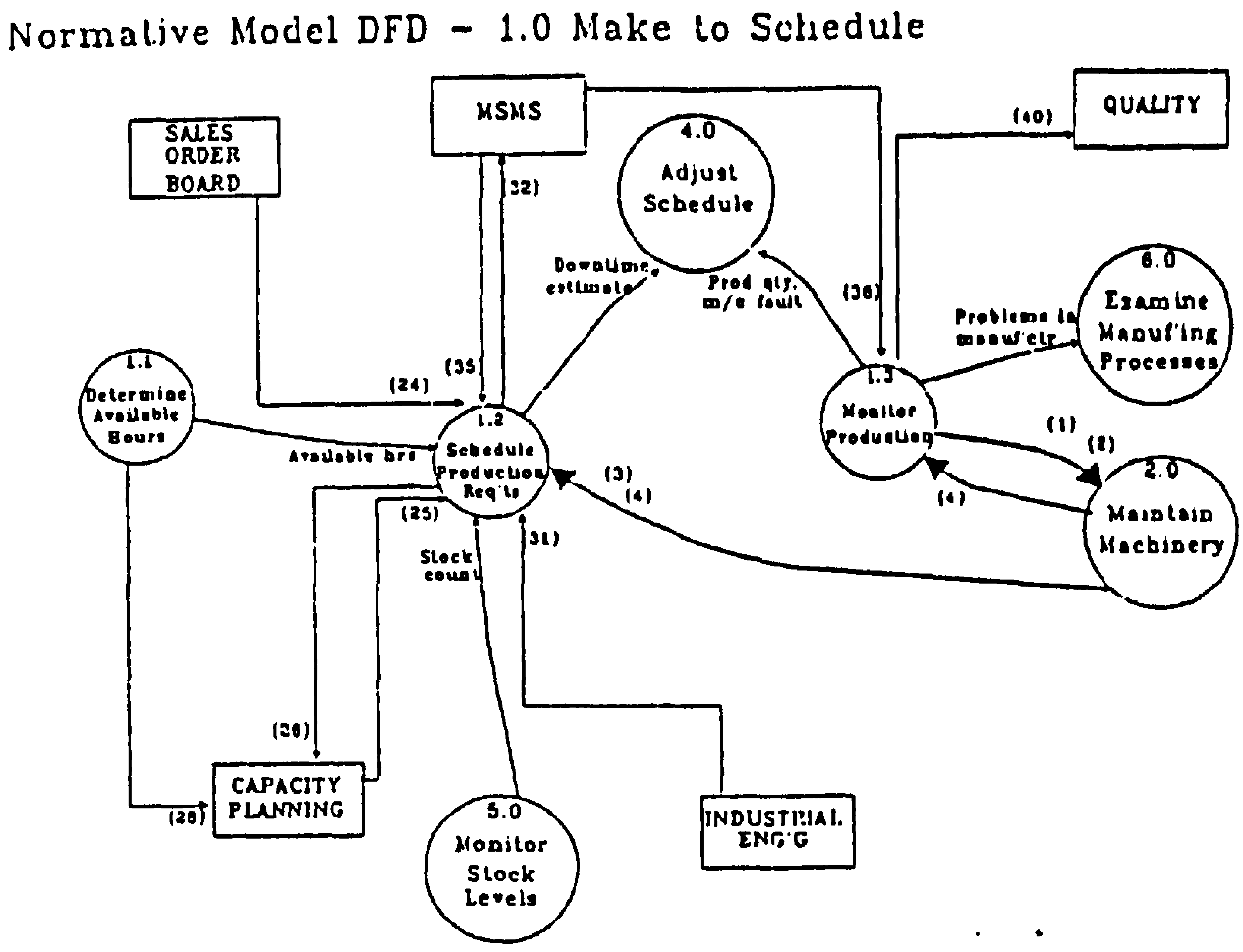

FIGURE 4.19 - Normative DFD example

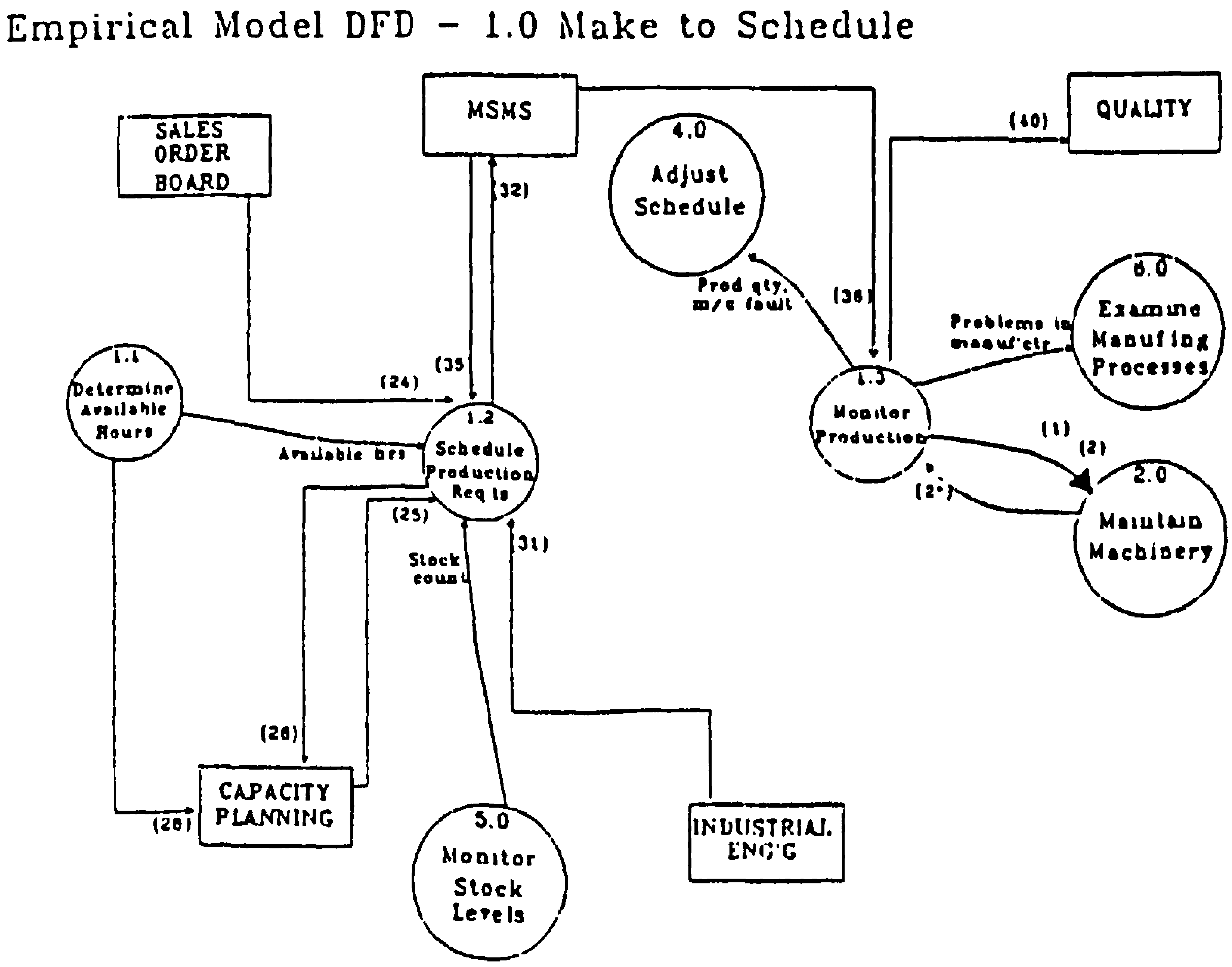

FIGURE 4.20 - Empirical DFD example

The type of entity modelling technique used, in both the Normative and Empirical Models, was entity relationship diagramming (ERD) as already described. Although the ERD could represent the Machine Shop / Maintenance subsystem as a whole, it was adapted so that only a particular part of the subsystem was modelled. This enabled an analysis to be undetaken that was uncomplicated and selective. Each entity was represented diagrammatically by an ellipse. Relationships between the entities were shown by arrowed lines between the ellipses with a diamond depicting the relationship.

In creating the ERD, the aim was to define entities that enabled the subsystem to be realistically described. Such entities as 'SWR', 'Maintenance Fitter' and 'Parts' were appropriate because thay were quantifiable, whereas 'Monitor Stock' and 'Repair Fault' were not appropriate because they expresssed actions that were related to what the subsystem did, and not things of interest involved in those actions. An entity occurrence is a particular instance of an entity which can be uniquely identified. For example, 'Minganti 3' would be an occurrence of the entity 'M/C'. An attribute is a descriptive value associated with an entity. It is a property of an entity. The attributes associated with the entity 'M/C' are 'Plant no.', 'Group code', 'Group description' and 'Plant type'. The values of a set of attributes distinguish one entity occurrence from another. An entity is uniquely identified by one or more of its attributes - the key attribute(s) shown by '*'s'. The relationships in the ERD's represent an association between two of the entities. Relationships arise because of:

- association, for example Machine Shop Operator 'operates' M/C,
- structure, for example Fault 'has' Repair Estimate.

The degree of the relationship is defined in the ERD. This could be one-to-one, one-to-many or many-to-many. A one-to-one relationship is represented graphically by a single arrow on the line between the entities. One-to-many and many-to-one relationships are shown by double-headed arrows on the 'many' part of the relationship. A dashed line represents an optional relationship. For example, the relationship 'M/C has Fault' is optional as it represents a possible not a mandatory activity. The Normative and Empirical ERDs can be seen in Figures 4.21 and 4.22 respectively.

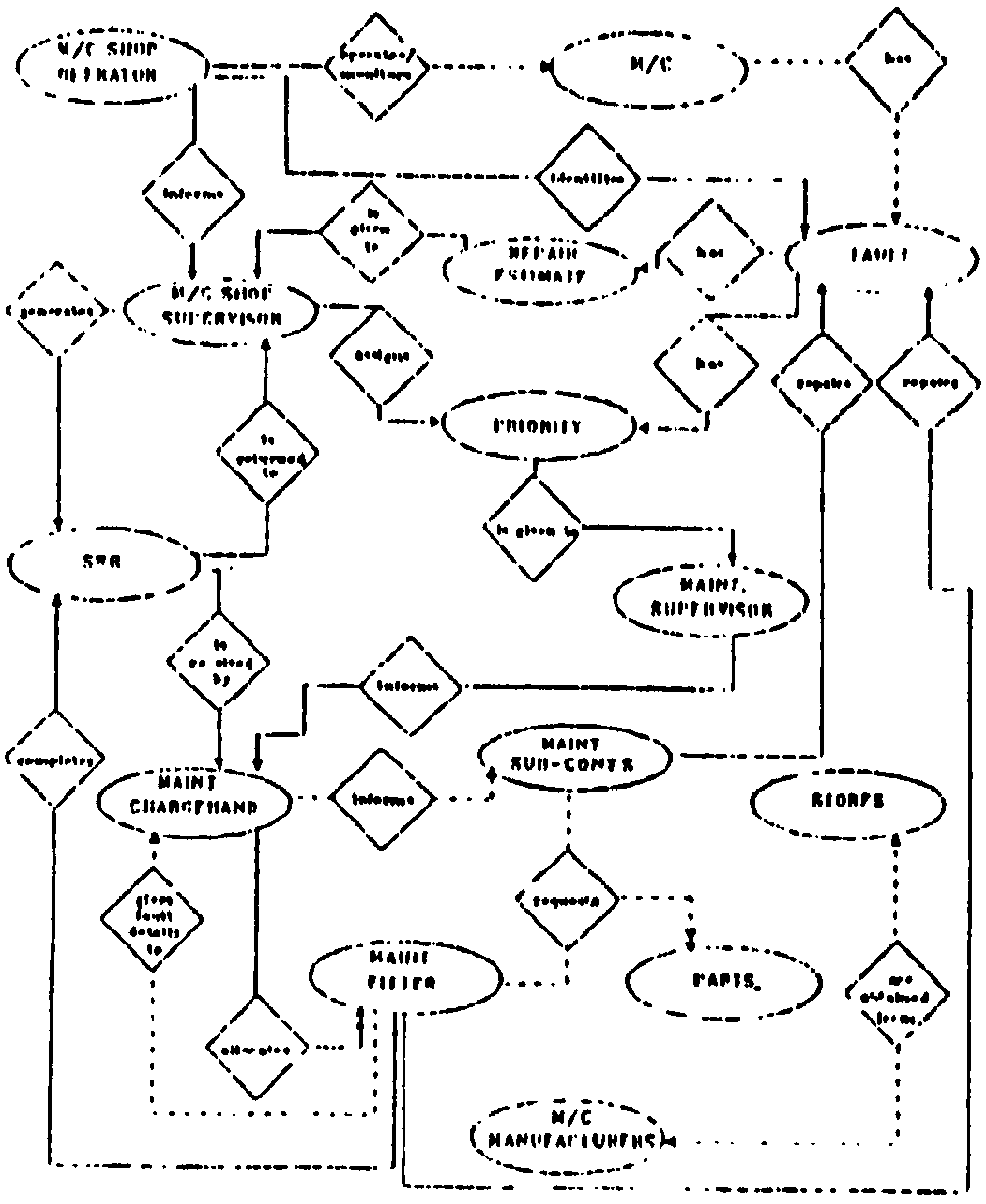

FIGURE 4.21 - Normative ERD

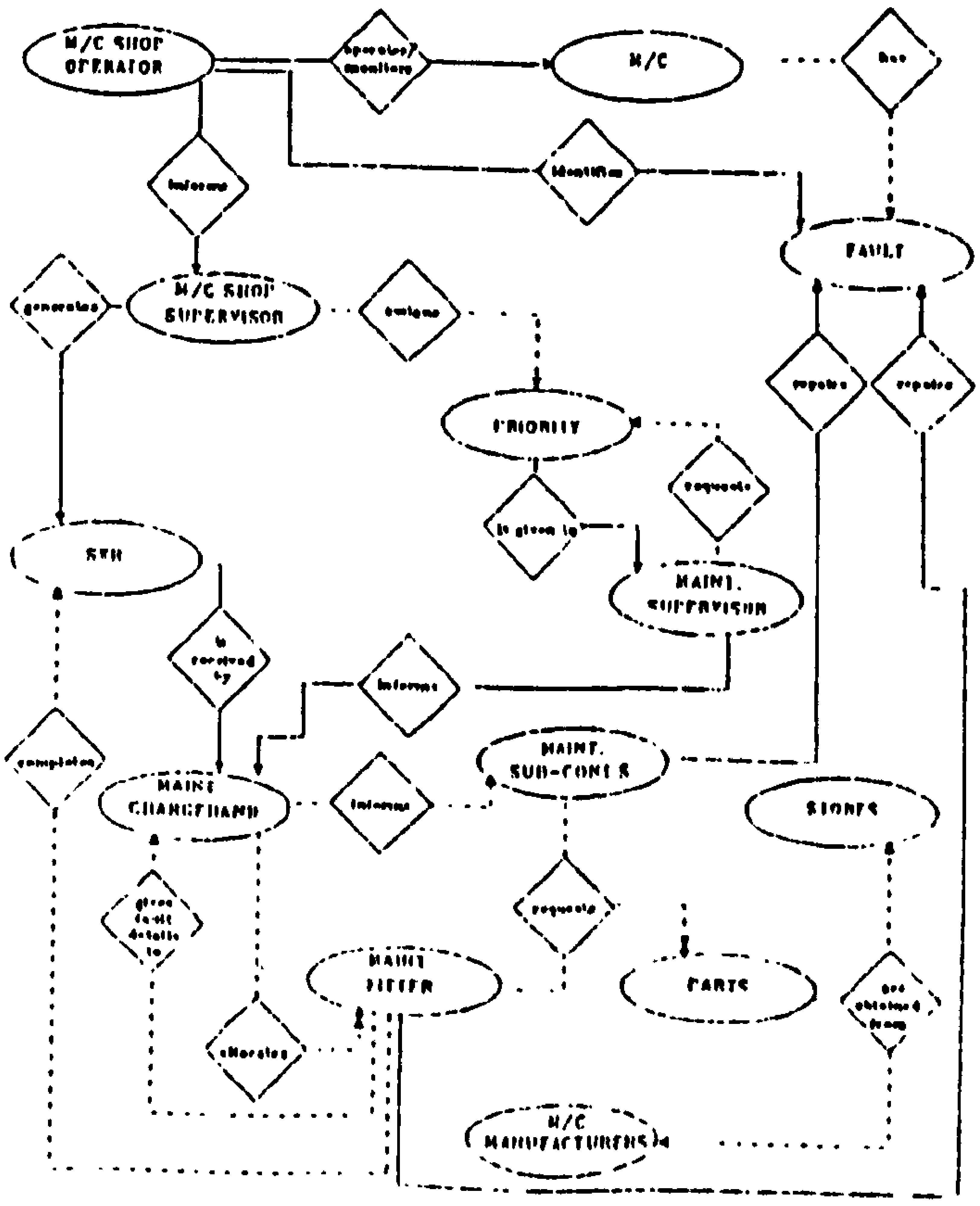

FIGURE 4.22 - Empirical ERD

The final modelling technique used was Action Diagramming. As with entity modelling, only a specific part of the susbsystem is modelled in the action diagram. This avoids unnecessary over-complications and enables the most relevant area of the subsytem to be emphasised and focused upon. It is the notion of timing and the relative sequence of activities that is unique to the action diagram.

The basic construct of an action diagram is a bracket which surrounds a group of actions. The actions within the bracket are performed in linear sequence. The brackets are nested to indicate hierarchical structure. If there is more than one dash in the bracket, this indicates that the parts in question are mutually exclusive. The execution of a loop is indicated by a double dash at the top of the bracket and a thicker than normal line for the bracket. An arrow is used to indicate an escape from a bracket completely as with the case with 'sub-contracted maintenance work'. Figures 4.23 and 4.24 show the normative and empirical action diagrams.

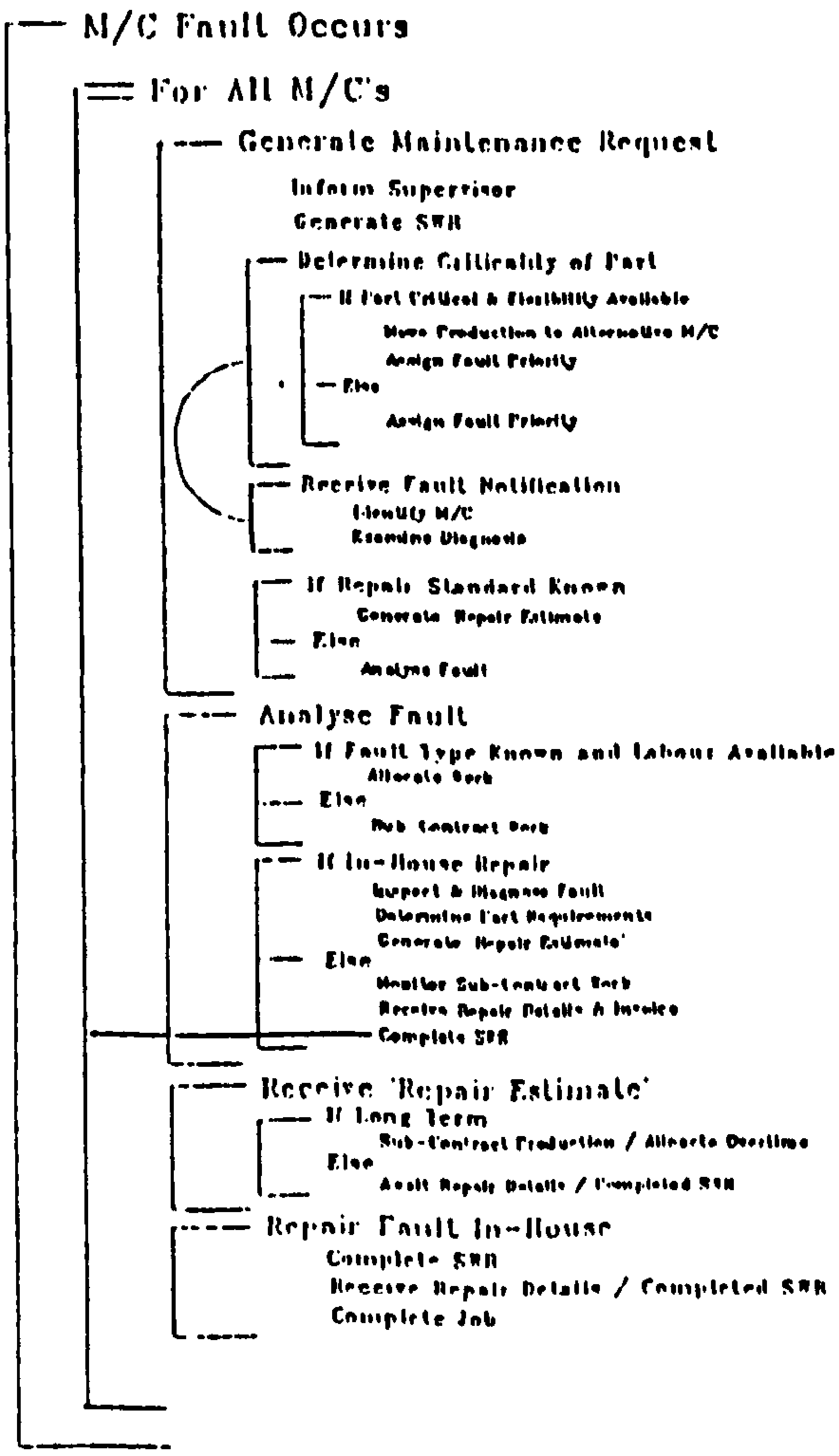

FIGURE 4.23 - Normative action diagram

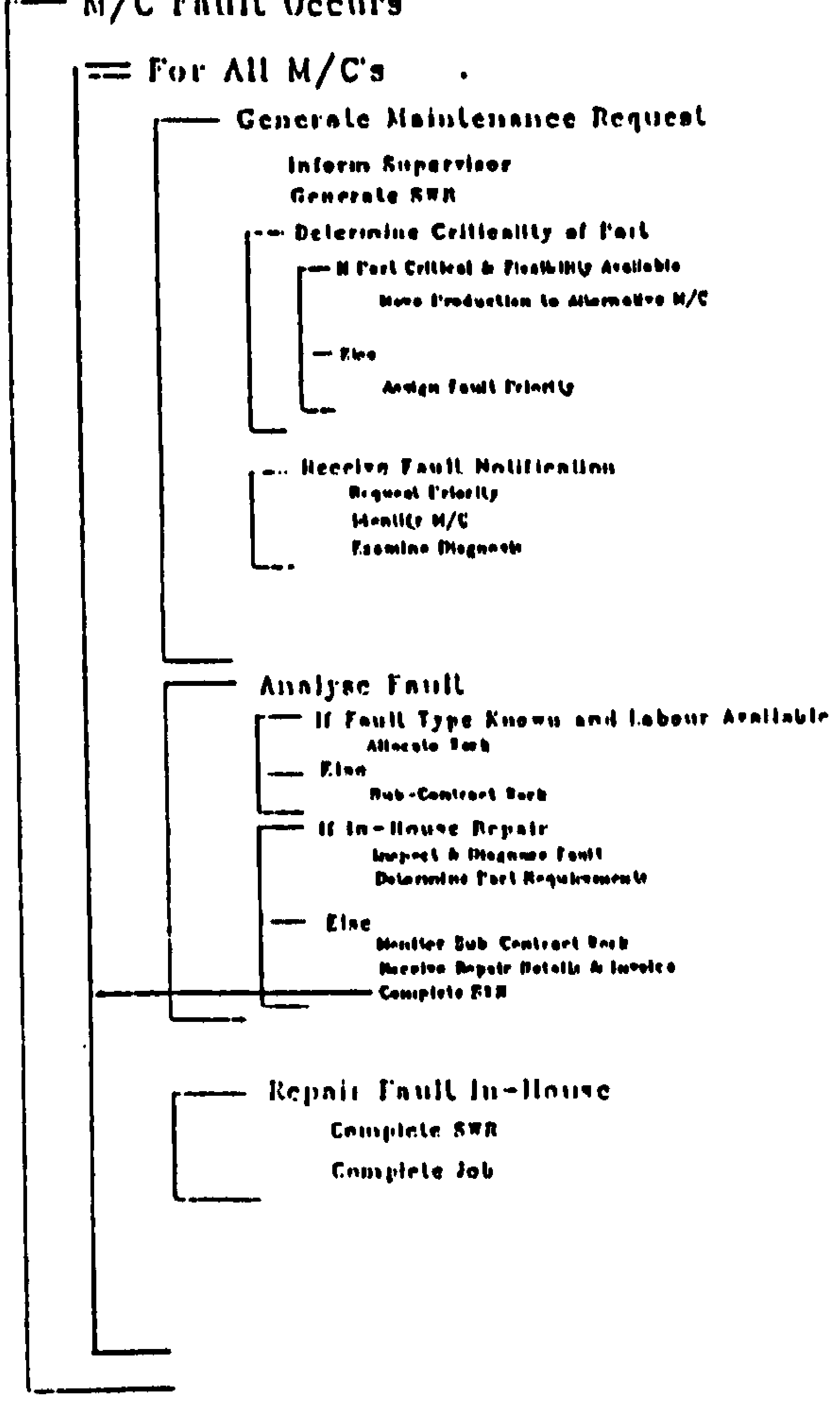

FIGURE 4.24 - Empirical action diagram

The three modelling techniques together gave a realistic and sufficiently detailed picture of the Machine Shop / Maintenance subsystem so that both the Normative and Empirical Models could be effectively described and understood. Each provides an enhancement to the picture that neither one nor a combination of any two was able.

The functional modelling technique, DFDs, represented the Machine Shop / Maintenance subsystem in considerable detail. From the DFDs, it was possible to examine the subsystem both in overview and at a detailed level whilst maintaining the links and interfaces between the different levels. The DFDs enabled a comprehensive understanding of the information and information processing activities to be obtained.

The entity modelling technique, ERDs, depicted the same portion of both models to a superficial level of detail. This enabled the most relevant part of the analysis area, i.e the actual Machine Shop / Maintenance interface, to be focused upon and emphasised, and in doing so enabled the complexities and idiosyncrasies of the interface to be more readily understood. The ERD enhanced the understanding of the relevant data and data structures and, if required, has the capability to act as the first 'stepping stone' for graduation to a database model.

The Action Diagrams provided a means of identifying the relative sequence of events and activities. Neither of the other techniques provided this 'timing' aspect. The Action Diagrams, like the ERDs, focused primarily on the activities involved in the interchange of information between the Machine Shop and Maintenance Functions.

The main discrepancies between the Normative and Empirical Models and hence the main differences between what is perceived to happen (or a facility exists for these activities to happen) as opposed to what actually did happen have been described in Figures 4.25 and 4.26.

NORMATIVE	EMPIRICAL	Identified by...
'Repair estimate' provided by Maint. for M/C Shop.	A repair estimate is very rarely provided.	DFDs, ERDs & Action Diagrams
Notification by Maint. repair complete - 'completed SWR' returned to M/C Shop.	M/C Shop Supervisor or Operator enquires about repair status - 'completed SWR' not returned.	DFDs, ERDs & Action Diagrams
Clear 'priority' assigned to fault.	Maint ask for clear 'fault priority'	DFDs, ERDs & Action Diagrams

FIGURE 4.25 - Major discrepancies

NORMATIVE	EMPIRICAL	Identified by...
Consignment Stock Index maintained.	Stock Index not kept up to date.	DFDs
'SWR' completed for subcontracted work.	SWR not completed.	DFDs
C'hand allocates all repair work.	Fitters often choose own jobs.	DFDs & ERDs
'Determine criticality of part' & 'examine fault diagnosis' occur simultaneously.	Activities are sequential.	Action Diagrams
Work is started immediately after a priority has been assigned.	Fitters not always available.	DFDs & Action Diagrams
No parts delays.	Frequent parts delays.	DFDs & Action Diagrams

FIGURE 4.26 - Other discrepancies

It was very rarely that a 'repair estimate' was provided by the Maintenance department for the Machine Shop. The possible implications of this were:

- the Machine Shop could not provide an accurate 'downtime estimate' with which to adjust the existing production schedule,
- there is indecision as to whether to wait for the fault to be repaired or to alter the existing schedule and move production to an alternative machine (if possible),
- sub-contracted work or overtime would be allocated even though the repair may have taken a short/finite time,
- the Machine Shop would wait for the repair to be started, before taking alternative action, only to find that the repair took an excessively long/indefinite time to complete,
- the manufacturing cycle time was increased.

'Completed SWRs' were not returned to the Machine Shop. The possible implications that arose from this were:

- the Machine Shop Supervisors continually had to enquire about the repair status of a fault,
- machines were operational but the Machine Shop Supervisors were unaware that they were,
- the Machine Shop had no record of the repair work that had been done,
- machining and labour time was wasted,
- increased downtime,
- manufacturing cycle time was increased.

The implications that arose from the Machine Shop failing to give Maintenance a clear 'fault priority' were:

- multiple priorities were generated,
- the Maintenance supervisor continually had to enquire about the current overriding

priority,

- essential repair, machining and labour time were wasted,
- downtime was increased,
- labour was allocated to sub-priority faults,
- sub-contracted work or overtime would be allocated to remedy the situation,
- manufacturing cycle time was increased.

The next analysis activity involved the detailed examination of the information problems and inadequacies of the Empirical Model. Information content and information transfer procedures were examined. Two techniques were used:

1) Data Quality Analysis (DQA)
2) Cause and Effect Analysis

DQA involves the analysis of the quality (adherence to requirements) of data items. As with Information Quality Analysis, IQA, this is done with reference to the quality of the content and transfer procedure of data, via the analysis of a number of attributes.

The information transferred between the Machine Shop and Maintenance Functions, the quality of which had been analysed in the IQA exploratory study was decomposed into its individual data items. The data items that constituted the 'SWR' generated by the Machine Shop and Assembly areas were:

- job no.,
- date,
- time request raised,
- time request completed,
- dept.,
- plant,
- equip,

- fault,
- supervisor signature.

The 'fault priority' was already in its most basic level of detail and could not be decomposed any further.

A Data Matrix, similar to an Information Matrix in IQA, was then constructed as shown below. (The 'fault priority' has been assigned the same attribute ratings as in IQA.) The Data Matrix depicts the data input items to Maintenance that were assigned by an interviewee in the Maintenance department. (The interviewee had previously been 'walked through' the attribute definitions and the attribute rating system.)

From the Data Matrix (Figure 4.27), a resultant Interface Matrix (Figure 4.28) was constructed:

- the Relevance values from the Data Matrix were expressed as percentages and assumed to represent the Minimum Required Level of Data Quality (DQ),

- the remaining attribute values are shown as a weighted contribution (ratio 8:6:3:2:1) to the overall Function Total percentage; this effectively means that the attributes have maximum values of 40, 30, 15, 10 and 5 respectively - the Function Total is assumed to represent the Actual Level of DQ,

- the differences between the Relevance and Function Total percentages represent a Data Quality Variance (DQV) or an indication of the 'strength' of a data item.

Attributes v Data	Rel	Tim	Acc	Acs	Com	For
Fault priority	5	3	2	2	2	2
Job no.	1	3	5	3	5	5
Date	4	3	4	3	5	5
Time req't raised	4	3	4	3	4	4
Time completed	1	0	0	0	0	0
Dept.	5	3	4	3	4	5
Plant	5	3	4	3	4	5
Equip.	5	3	3	3	4	4
Fault	5	3	3	3	2	3
Signature	4	3	3	3	5	5

FIGURE 4.27 - Data matrix

Data	Rel (%)	Tot (%)	Var (%)
Fault priority	100	48	52
Fault	100	58	42
Equip.	100	63	37
Plant	100	70	30
Dept.	100	70	30
Time completed	20	0	20
Time req't raised	80	69	11
Signature	80	66	14
Date	80	72	8
Job no.	20	78	-58

FIGURE 4.28 - Interface matrix

The results of the DQA indicated that considerable improvement is required in two data items:

- 'fault priority',
- 'fault'.

This was indicated by their Variances, namely '52' and '42' for 'fault priority' and 'fault' respectively. Improvement is also clearly needed in three other data items - 'equip.', 'plant' and 'dept.'. For each of these, particular emphasis must be placed on 'accuracy' and 'comprehensiveness'. In order to understand the reasons for the poor information/data quality for the Machine Shop / Maintenance interface, a Cause and Effect analysis was carried out. The results have been represented in the two 'Fishbone Diagrams' shown in Figures 4.29 and 4.30. The categories of 'cause', representing the quality of information content and interchange mechanisms and procedures are the attributes used in both Information and Data Quality Analysis (IQA/DQA), namely, timeliness, accuracy, accessibility, comprehensiveness and format. The 'causes' are applicable to the Variances obtained from both IQA and DQA.

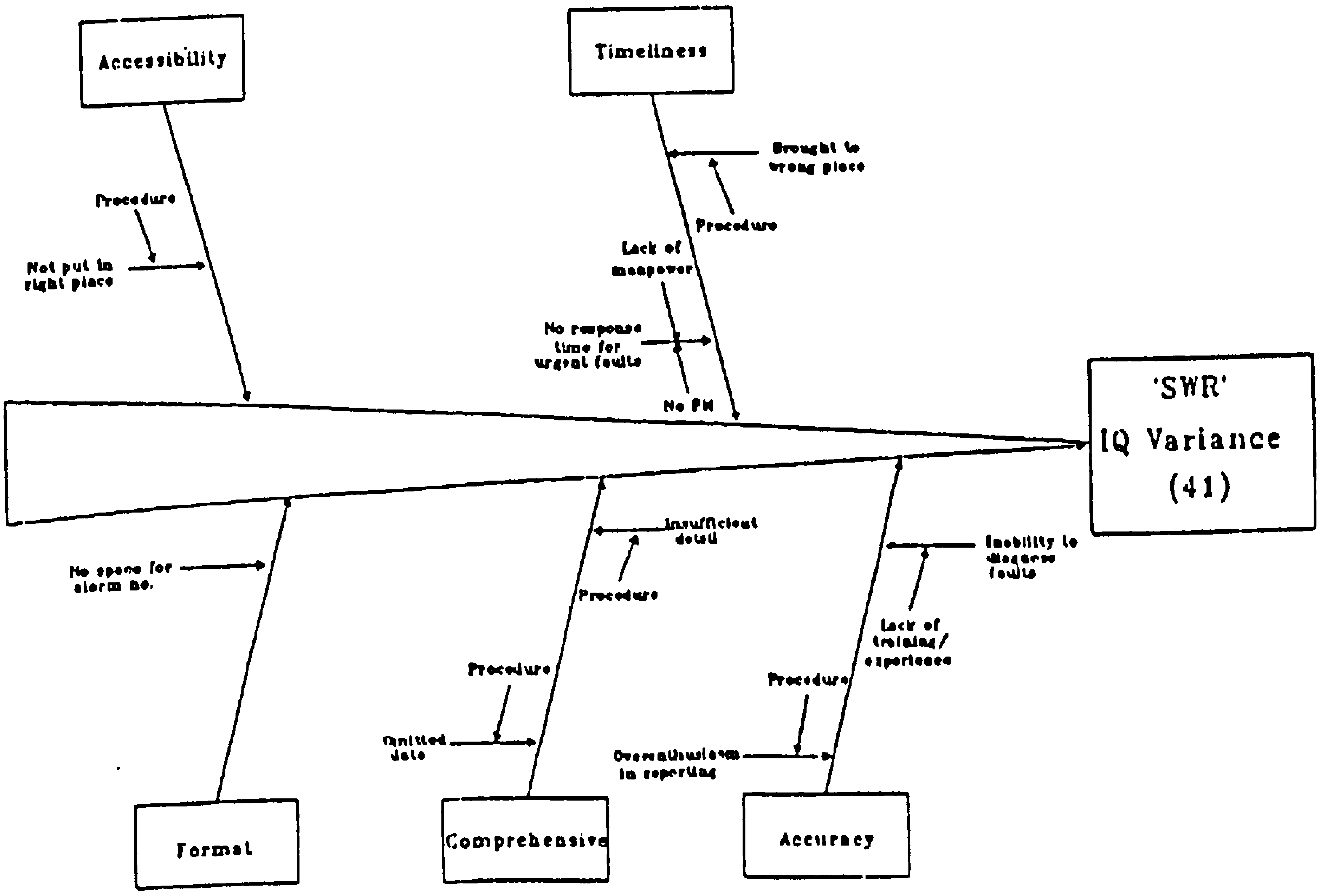

FIGURE 4.29 - 'SWR' fishbone diagram

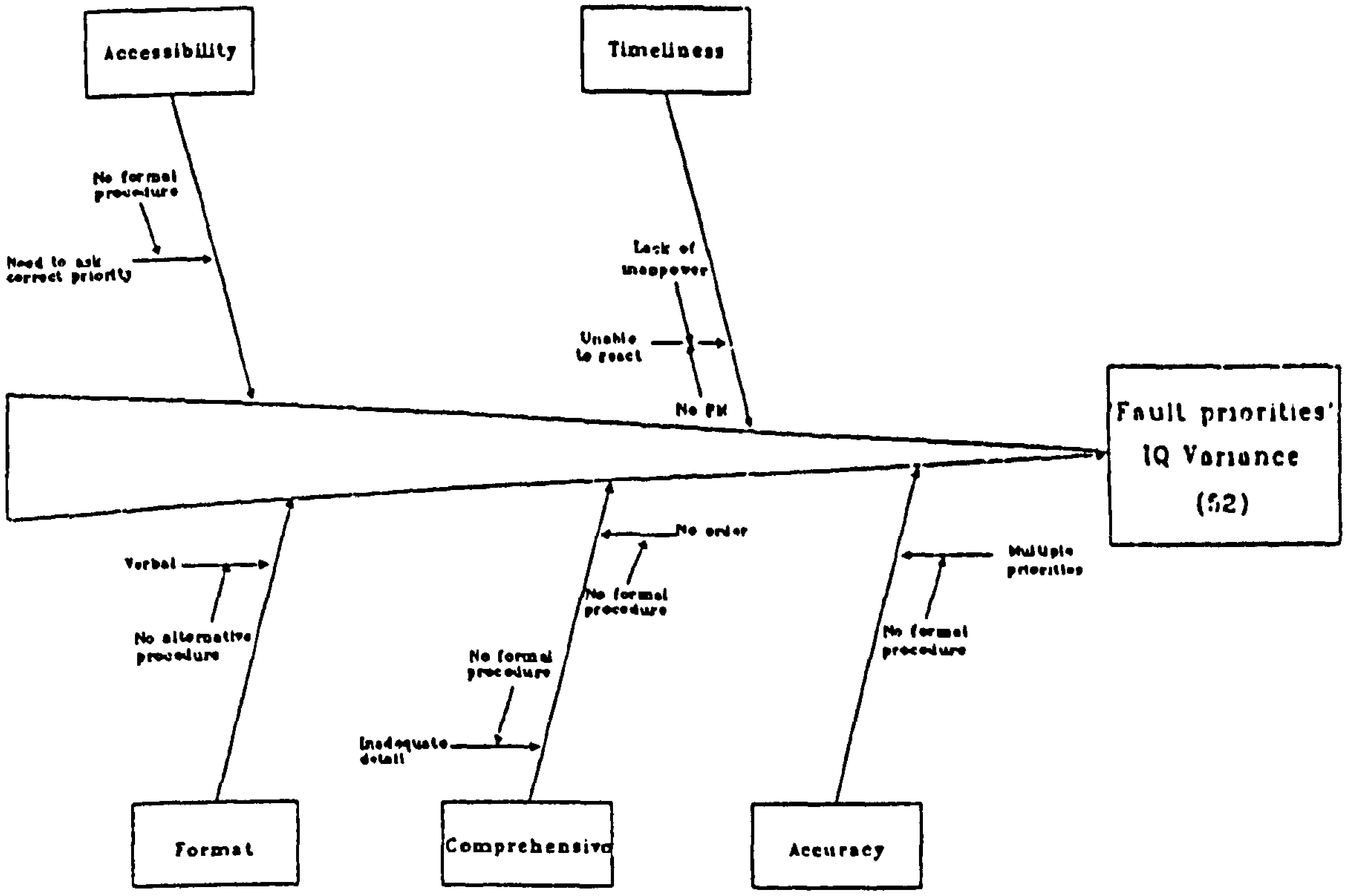

FIGURE 4.30 - 'Fault priorities' fishbone diagram

The main causes of the Maintenance department not supplying the Machine Shop with 'repair estimates' and 'completed SWRs' and consequently the IQV for Maintenance to Machine Shop being shown to be 80 was found to be an unwillingness of Maintenance personnel to commit themselves to a repair time and a disregard for, or ignorance of the usefulness of completed requests (for the Machine Shop) respectively. The high Variances incurred have further far-reaching 'effects' or implications on the business, namely:

- increased downtime,
- increased manufacturing cycle time.

If the number of errors/defects was to be reduced it made sense to tackle the categories making the greatest contribution to the problem. DQA highlighted the most important and major data problems via the analysis of data attributes and characteristics. The Cause and Effect Analysis identified the principal reasons for those problems. The main data items that needed to significantly improve their quality levels and the particular data attributes that need to facilitate that improvement were noted.

For the 'SWR', of the many causes and sub-causes of the high Variances, the main ones which needed to be tackled were:

- lack of a formalised procedure for generating the requests,
- inability to diagnose faults,
- no response time for urgent breakdowns.

For the 'fault priority' the main causes to be tackled were:

- no time to react,
- verbal,
- ambiguous.

The maximum involvement of end users is considered of paramount importance when altering or improving any system. Determining user requirements would help to assure that the needs of those affected by the system will be incorporated and met in an improved system. Consequently, an analysis of the requirements of the recipients and users of the information interchanged between the Machine Shop and Maintenance Functions was undertaken.

The results of the findings have been represented in Figures 4.31 to 4.34. Requirements have only been tabulated when a clear improvement in one of the attributes is needed. Each of the identified requirements has been assigned to one of six categories; five of which are the information attributes which have been used before and one to represent a requirement which cannot be assigned to any of the attributes. (The requirements are the interpretation of the views obtained from interviews with M/C Shop and Maintenance personnel.)

Timeliness	Immediate response after fault is identified
Accuracy	Location and fault diagnosis most critical
Accessibility	Readily available and instant response
Comprehensive	Location is critical and Alarm no. to be quoted
Format	Space for alarm no. is required
Other	Reliable

FIGURE 4.31 - Maintenance requirements (*maintenance request form*)

Timeliness	With 'maintenance request if possible, otherwise, as soon after 'maintenance request' has been generated
Accuracy	Clear & unambiguous
Accessibility	Readily available - with maintenance request if possible
Comprehensive	
Format	Written or graphical as well as verbal back-up
Other	Reliable

FIGURE 4.32 - Maintenance requirements (*Fault priority*)

Timeliness	As soon as 'maintenance request' has been generated, otherwise, as soon afterwards
Accuracy	Realistic
Accessibility	
Comprehensive	
Format	Written
Other	Approximations better than no estimate at all

FIGURE 4.33 - Machine Shop requirements (*repair estimate*)

Timeliness	Immediately after repair is complete
Accuracy	
Accessibility	Returned to 'completed repair rack'
Comprehensive	
Format	
Other	Reliable

FIGURE 4.34 - Machine Shop requirements (*Notification repair completed*)

It was established that each of the four information items interchanged between the Machine Shop and Maintenance Functions as shown in the Normative Model, namely; 'SWR', 'fault priority', 'repair estimate' and 'completed SWR' or the equivalent of these, were essential to the well being of both Maintenance and the Machine Shop and to the business as a whole. The importance of the interchange of these information items or their equivalent must be emphasised and adhered to. No other specific information items were required for this interface. As a consequence of this, because the information interchanged between the two areas had to remain essentially the same, so must value - any improvement comes in the reduction of costs and lead-times in generating and processing this information.

The following actions were identified as representing the potential scope for improvement in the quality of the data content and transfer mechanisms of the information items constituting the interfaces between the Machine Shop and Maintenance Functions.

Firstly, the maintenance request notification; this is a notification by the Machine Shop for Maintenance of a machine fault/breakdown.

- Change the existing name, i.e 'shift work request' ('SWR') to 'maintenance request form' ('MRF'). This is a much simpler name for the 'maintenance request' document and avoids any ambiguity with other documents.

- Change the format so that a specific section is provided on the document for the 'alarm no.'. By having this section, it is more than likely that the machine 'fault code'/ 'alarm no.' will be noted and entered into the space provided, thus increasing the accuracy of the fault diagnosis.

- Undertake a 'fault diagnosis' Machine Shop operator training programme. A programme of this kind identifying specific, repetitive faults and the way these faults manifest themselves would enable operators to diagnose machine problems with a greater degree of accuracy.

Systems requirements must simultaneously consider cost and benefits of proposed, improved system implementations. The optimum system would not usually supply all useful information since some information costs more than it is worth. There will always remain unfulfilled information requirements that cost more to satisfy than they contribute in benefits. This notion has been represented in the IQ curve in Figure 4.35.

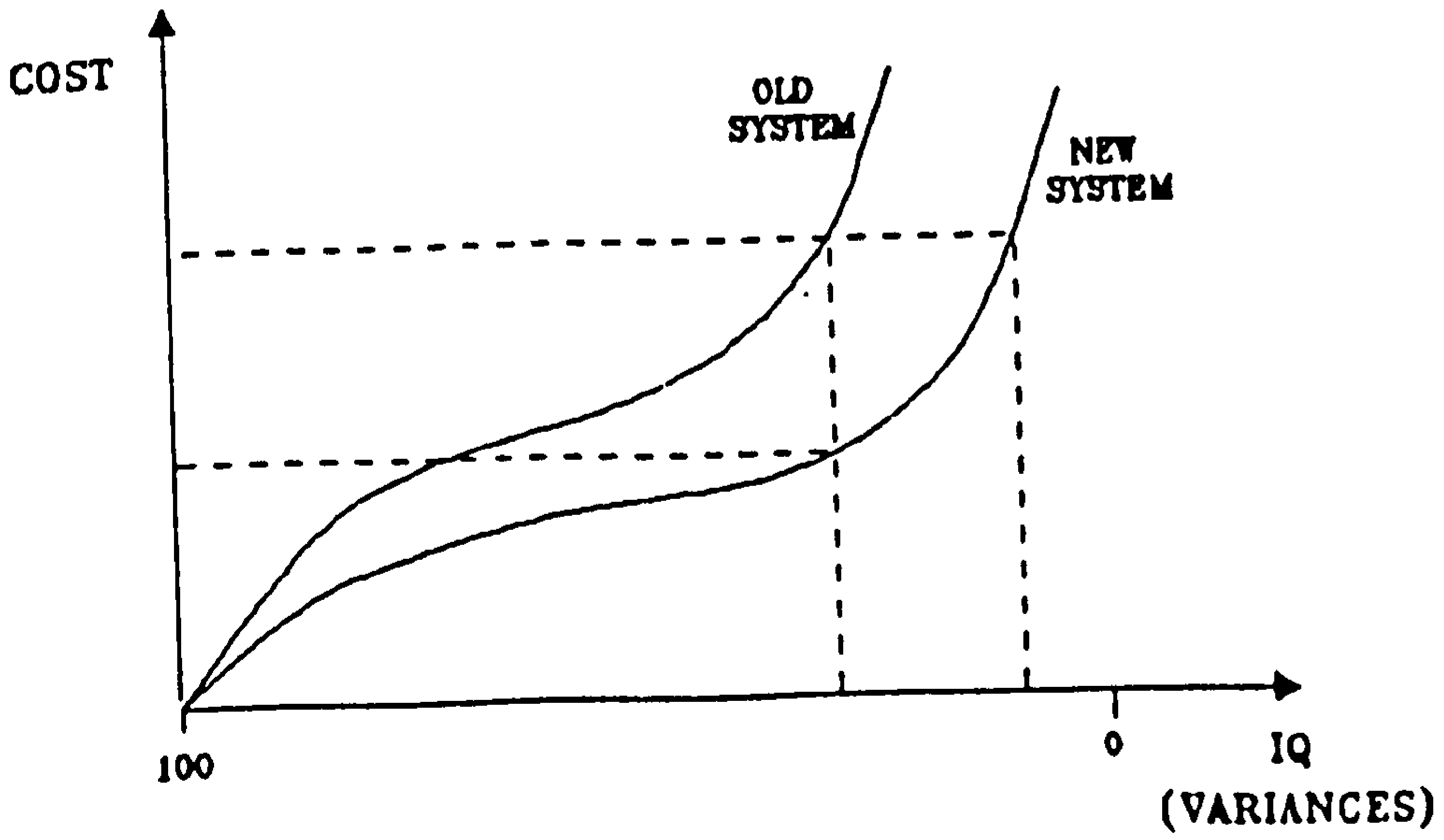

FIGURE 4.35 - IQ curve

The cost of a professional, operator training programme would not justify the benefits obtained from it at the current level of sophistication of the Machine Shop and Maintenance Functions. A more cost effective solution was a simple, 'fault diagnosis' Machine Shop training programme conducted by the companny's own Maintenance department. Emphasis would be placed on the most frequently occurring faults.

- Change the format so that the 'fault priority' is provided with the 'MRF'. (See 'Notification of Fault Priority')

- A formal, written procedure should be drawn up, by the Maintenance department, for generating 'MRFs'. Emphasis should be placed on fault diagnosis accuracy, 'over-enthusiasm' in diagnosing faults, machine location accuracy and comprehensiveness, and the exact location of where to despatch the form. Adherence to this procedure would ensure that several of the problems, outlined in the 'Cause and Effect Analysis' affiliated with the existing 'SWRs' would be resolved.

- 'Move' onto the MSMS as soon as possible. The immediate notification, for Maintenance, of a machine fault would significantly reduce the usual 'MRF' delay time. This is particularly important for urgent breakdowns. The MSMS would increase Maintenance response time and reduce the chances of operator errors. (The MSMS also had the added bonus of its ability to generate suitable reports; cell downtimes, machine downtimes etc. These are particularly useful for performance analysis.) However, using the 'maintenance' facility on the MSMS does not detract from the fact that an effective manual system for generating 'MRFs' would still have to be in place. There was no intention for either FMSs or the Assembly area to interface with the MSMS in the immediate future - so the manual 'MRF' system would still have to be in place to support the machines within these areas as well as acting as back up if the MSMS was ever to fail. The MSMS 'maintenance facility' would primarily be used for Maintenance Fitters to log on and off when commencing and completing work so that an efficient and accurate way of calculating downtime and immediate notification of a machine fault and the fault repair can be obtained and transferred to the relevant people. The MSMS did not have the facility to shown 'fault priorities' and so on, i.e. it is not a Maintenance Management System and should not be regarded as such.

Secondly, the notification of a fault priority; this is a notification, by the Machine Shop for Maintenance, of the relative priority or urgency of a fault repair.

- Introduce a 'two-tier' fault priority system. (The basic intention is to create a formalised procedure for allocating 'fault priorities'.) The first part of this system would be to have a visual/written 'fault priority' display incorporated into the layout of the existing 'awaiting maintenance rack/bench'. This primary priority would be based upon the following machine criteria:

  - flexibility, i.e. the ability of a machine to transfer its usual production load to another machine,
  - utilisation, i.e. required weekly run time,
  - recent fault history,
  - any other possible additional criterion, for example proximity to final product (JBA), value of parts made (Solon FMS) .

- The second part of this 'two-tier' system would be to assign a secondary priority, for each fault, on the 'MRF'. This priority would be a 'descriptive effect' of the fault. For example, possible 'effects' in decreasing order of importance could be: safety, stopping other area, stopped production, and reduced output. This would provide a 'back-up' if there was any uncertainty or ambiguity arising from the 'priority matrix'.

- If there was still any uncertainty about the current 'fault priority', the M/C Shop Manager would be asked and required to allocate a priority.

In the case of the 'repair estimate'; this is an estimate, given to the M/C Shop, of the time taken to repair a fault.

- The 'repair estimate' should primarily be based on repair standards and standard working practices. A 'standards' file should be generated and maintained. This file would provide the means for evaluating 'repair estimates'.

- Introduce a separate 'repair estimate' document, with a similar format to the 'blank' in Figure 4.36.

Estimated Downtime

Job no. .....
Area / Cell .... M/C / Equip ....
The above m/c will be ready by: .... ('Firm')
.... ('Approx.)
.... ('Possible')
Signature ....

FIGURE 4.36 - Estimated downtime (blank form)

This document would be generated by the Maintenance Chargehand (or other) once the fault had been identified and its 'repair estimate' identified from the 'standards' file. It would be deposited into a 'repair estimate' section of the 'rack/bench'. The 'estimate' would be classified into one of three categories dependent on the 'quality' of the particular 'standard' for that fault. This would act as a compromise to Maintenance not wanting 'to commit themselves to estimating downtime'. Commitment to maintaining and adhering to the 'standards' file would ensure that its 'quality' would increase and result in more accurate and reliable estimates. With increased 'standards quality', subjective estimates made by Maintenance Staff, by virtue of past experience and knowledge of the situation, would gradually diminish. An accurate estimate of downtime must also take into consideration the availability of the necessary parts required to repair a fault, and so effective stock control procedures must also be in place.

- The above mentioned 'repair estimate' procedure would require a certain amount of management commitment to ensure that it was successful and adhered to. The importance of generating a realistic estimate for production planning would have to be realised and stressed to Maintenance personnel.

For a notification by Maintenance that a fault has been repaired.

- Using the 'maintenance logging on and off facility' on the MSMS would, in the main, resolve the problems currently associated with the Machine Shop not being specifically notified of completed maintenance work. However, as has already been stated, for at least the immediate future a 'paper' system would still have to be used and be effective.

- One copy of the 'completed MRF' must always be returned to the 'maintenance rack'. This should be accompanied by verbal notification that a fault has been repaired. The implications of not notfying the M/C Shop Staff of this information should be stressed and fed to the Maintenance personnel. Management commitment is essential.

Usually it is not cost effective or wise to design the ultimate system in the first improvement effort. Ideally, several improvements should be designed and implemented simultaneously. At a later date, and once the transition period of the implementations is over, these improvements should be built upon to enhance further the existing level of sophistication and synergy.

An outline of the potential to build on the first-level of improvement that has been suggested would be the following:

1) Introduction of a 'plant database', accessible to both the Maintenance and M/C

Shop departments. Databases are powerful tools for accessing information. The type of information which would be stored and have to be maintained on the database would be:

- 'standards file' i.e. computerising the manual file that has already been mentioned. The Machine Shop would also have access to this 'file' so they would be able to evaluate their own 'repair estimates'.
- 'plant items and equipment file' - comprehensive list of all maintainable items.
- comprehensive 'fault history' file. ('Repair estimates' and 'fault priorities' would be totally dependable.)

2) Introduction of effective planning and control procedures and the incorporation of these activities into the database.

3) Introduction of effective stores and materials control and the incorporation of these activities into the database.

4) Explore the possibilities and potential scope for improvement that adopting and implementing a maintenance philosophy would bring, for example TPM, RCM.

Potential further improvements would be the introduction of a computerised maintenance managment information system (CMMIS) and a comprehensive preventive and predictive maintenance programme.

Improvements in information quality (IQ) and hence the effectiveness of the information interchange between the Machine Shop and Maintenance Functions provided an opportunity to realise potentially large cost savings by going some way to improving the existing level of plant utilisation.

These 'information improvements' provide reductions in material and labour delays, downtime, sub-contracted overload, overtime, sub-contracted maintenance, and manufacturing cycle time.

The requirements specification and the techniques used to generate it were well received by company management indicating that an appropriate procedure had been followed. A major part of the specification was implemented via a CMMIS. The identification of the Production to Maintenance area as the highest priority area for IS development, was validated by an independent, in-company total quality audit and analysis which came to the same conclusion and, subsequently, the Maintenance department has been expanded and re-organised.

CHAPTER FIVE

AN APPROACH TO INFORMATION SYSTEMS STRATEGY FORMULATION - THE IQ*Analyst* METHODOLOGY

PURPOSE OF THIS CHAPTER

This chapter details the approach to IS strategy formulation conceived to address the issues discussed in Chapter 3 and developed from the framework in Chapter 4.

5.1 - INTRODUCTION

To someone unaccustomed to systems development approaches, IQ*Analyst* may appear to be not a particularly unconventional methodology. However, in the world of IS planning, it is quite different. Firstly, it has been designed to minimise the amount of *black art* necessary for satisfactory results and effective IS, and maximise the amount of prescriptive analysis so that managers can explicitly see the mechanics of the process. This is not to say that there is no latitude for exercising experience and intuition, the methodology is wide-ranging and malleable, and is not so systematic to preclude good judgement and common sense, but the focus is on clear, open and incisive techniques and analysis derived from key planning successs criteria. IQ*Analyst* has thus primarily been fashioned for a study team made up of a company's own staff. The use of outside consultants as part of the study team is not necessary, but may prove valuable if the skills and experience are not readily available in-house.

5.2 - OBJECTIVES & BENEFITS OF IQ*Analyst*

The purpose of the Methodology is to produce for a manufacturing business unit quickly yet effectively:

- An *Information Systems Applications Strategy* in the form of a portfolio of applications development projects which reflects strategic ambition, business information needs and priorities, and systems and technology improvement opportunities.

- A *Specification of Requirements* to maximise the likelihood of success of the portfolio of applications development projects identified in the Information Systems Strategy by determining and articulating their functional requirements.

The specific objectives of the Methodology are:

- To provide a structured method for management to identify the business's IS needs and priorities.

- To guarantee that the systems development effort will supportthe strategic plans of the business.

The Methodology provides a manufacturing business with the opportunity to utilise IS to help carry out business ambition successfully. The primary benefits of IQ*Analyst* are:

- IS development initiatives are effectively prioritised and accurately targeted on business needs;

- an evaluation of the effectiveness of existing information systems;

- a plan leading to information systems that are integrated yet open to change;

- the ability to make sound decisions regarding the use of resources and IT.

5.3 - OVERVIEW OF THE METHODOLOGY

To achieve its objectives, the Methodology provides a multi-activity process to creating a portfolio of IS development initiatives and a requirements specification for each initiative. To this end, the Methodology consists of two Phases:

- Phase 1 - Strategic-Led Information Systems **Planning**
- Phase 2 - Information Systems Requirements **Analysis**

In the first Phase, Planning, a major part of the enterprise is analysed, and documented in terms of its major functions, processes and information flows. Business objectives and their priorities, end-user needs and priorities, effectiveness of current systems and IS/IT improvement opportunities are captured, synthesised and evaluated, and a portfolio of apllications development projects is drawn up.

In the second Phase, Analysis, the highest priority projects are considered individually so that specific areas of the business can be investigated to the required level of detail to thoroughly reveal and understand their operation so that a requirements specification can be drawn up.

There are a total of five activities (referred to as Stages) that an organisation completes to develop its strategic IS plan (Phase 1), and five activities to develop a requirements specification (Phase 2). Figures 5.1 and 5.2 show a simplified version of the elements and purpose of each Stage.

PHASE 1 - PLANNING

STAGE	ACTIVITY	PURPOSE
1	Project Start-Up & Business Overview	Select a study team, define business objectives so that business activities are analysed within a strategic context, scope & completion of study
2	Develop Information Model	Provide a framework with which to discuss the project and plan and analyse future developments
3	Analyse Business Requirements	Establish linkage between strategic plans and actual business operations
4	Analyse Information Quality	Evaluate the effectiveness of existing information systems
5	Define IS Needs & Priorities	Investigate improvement opportunities, determine development priorities & formulate systems strategy

FIGURE 5.1 - Phase 1 stages & objectives

PHASE 2 - ANALYSIS

STAGE	ACTIVITY	PURPOSE
6	Project Start-Up & Business Area Overview	Select a study team, provide an overview of the area under investigation, prepare completion schedule.
7	Undertake Detailed Modelling	Provide a detailed framework with which to analyse the business area, plan future developments and evaluate discrepancies.
8	Examine Data & Data Processes	Identify and evaluate data deficiencies.
9	Analyse User Requirements	Determine feasible and detailed user requirements.
10	Formulate Specification	Summarise improvement requirements, review improvement opportunities, formulate requirements specification.

FIGURE 5.2 - Phase 2 stages & objectives

The sequence of tasks is more or less as Figures 5.1 and 5.2, yet some can be worked on simultaneously. This is reflected in the Methodology Route Maps shown in Figures 5.3 and 5.4. Each Stage is an activity with its own goals. techniques, constraints, inputs and outputs.

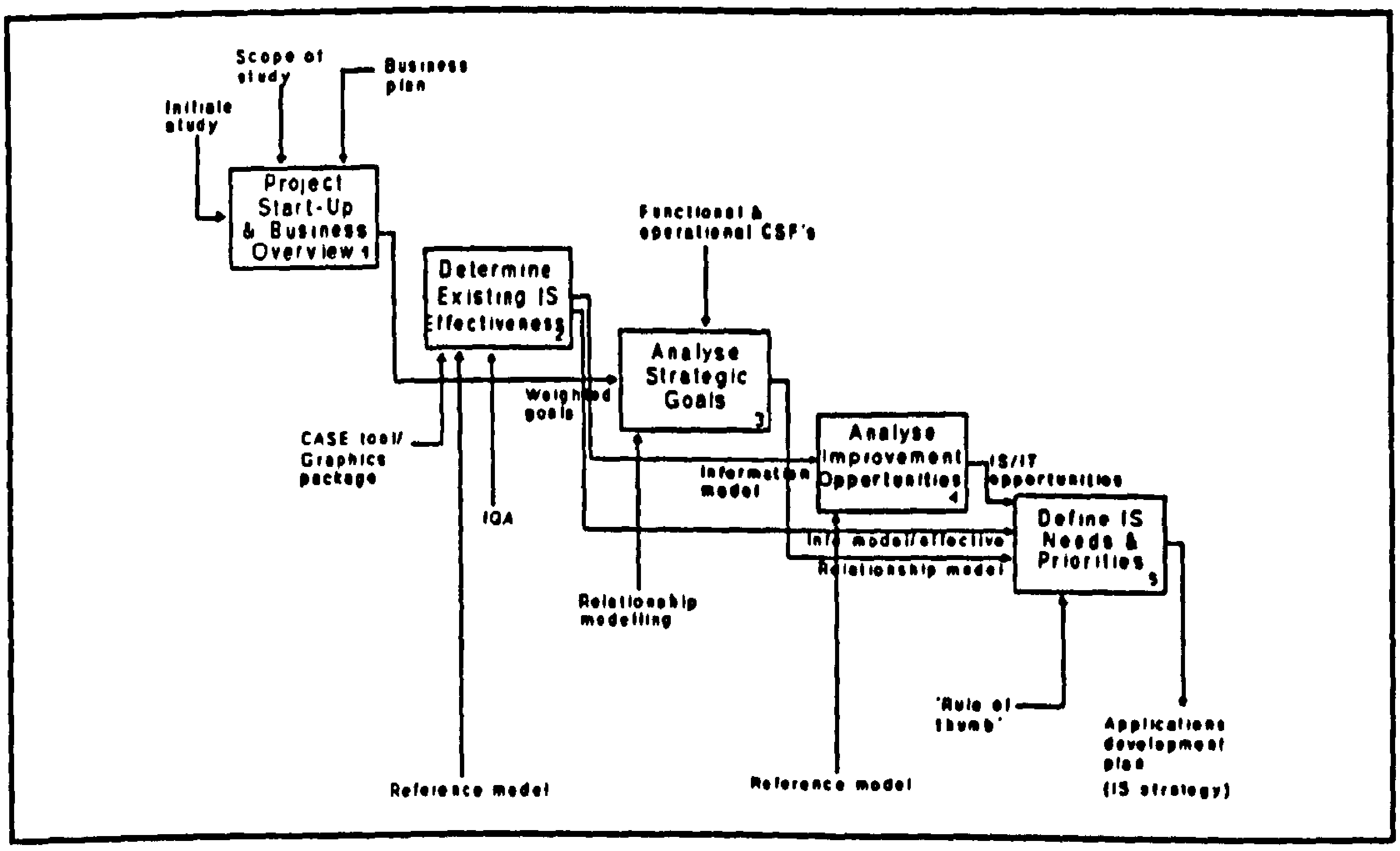

FIGURE 5.3 - Planning route map

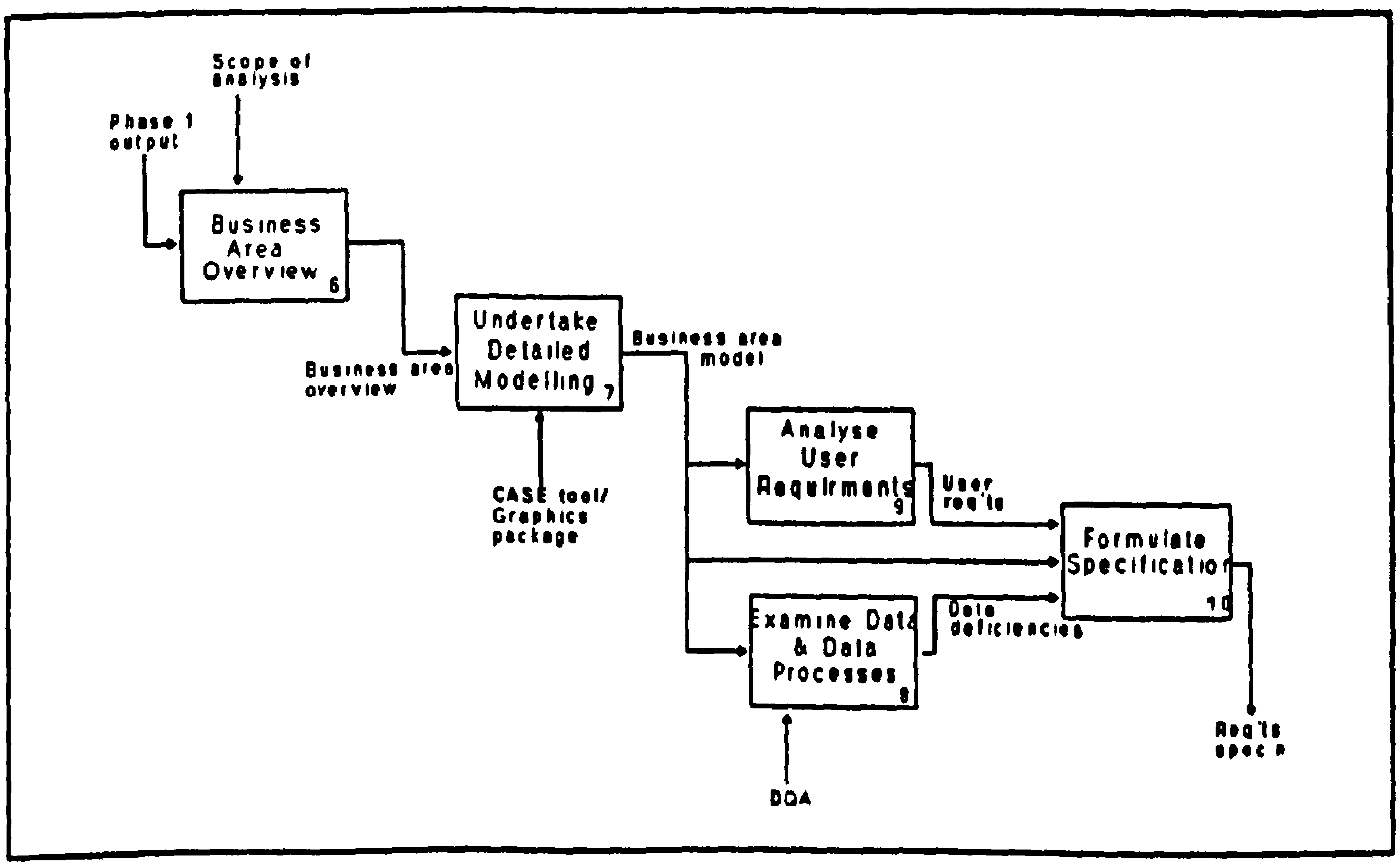

FIGURE 5.4 - Analysis route map

For a full decsription and executable level of detail of the Methodology, the IQ*Analyst* workbook [158] should be consulted.

5.4 - PROJECT START-UP & BUSINESS OVERVIEW (STAGE 1)

Stage 1 involves a series of preparation and project management tasks that are required to facilitate the application of the Methodology. The major driving forces of the business are also examined at this early stage; IQ*Analyst* requires complete understanding of the key strategic issues and cannot be undertaken without knowledge of them, so it is essential to identify business ambition and the competitive environment from the earliest stage. There are six tasks (referred to as Steps) required to complete the Stage:

1.1 - Ensure Organisational Readiness
1.2 - Select Study Team
1.3 - Assess Business Strategy & Competitive Environment
1.4 - Define Scope of Study
1.5 - Prepare Planning Completion Schedule
1.6 - Prepare & Issue Orientation Package

5.4.1 - Ensure Organisational Readiness

As soon as the desire to carry out IQ*Analyst* has been realised and agreed upon, arrangements should be made to conduct a Methodology awareness session for all key managers impacted upon by the study. This should consist of a meeting or presentation outlining the purpose of the study, its proposed benefits, and estimates of the resources and time required. Lucht [34] appropriately advises addressing the following key question for such an activity; "Do managers of the business understand that to improve existing IS sometimes means that old, possibly outmoded ways if doing things will have to be changed?" Management awareness and commitment to the Methodology must be gained from this session. It is likely to be the most vital ingredient to success (sic).

5.4.2 - Select Study Team

At this point, a study team is selected to drive the first phase of the methodology through to completion and formulate the IS strategic plan. The team should normally consist of two or three full-time members composed of user and IS personnel, and a part-time senior manager (who may have been responsible for sponsoring the study and should possess the authority to sanction capital investment decisions). Team members should command the respect of their peers, possess a deep knowledge of business and IS activities, and be able to objectively evaluate existing IS and systems practice. Employees with *axes to grind* and/or *emotional attachment* to any of the existing IS should be avoided as study team members. One of the members of the team should be designated as the 'study leader', preferably someone who has previous systems planning experience in the company. The study leader identifies a pool of potential team members and discusses their availability and potential contribution with the sponsor of the project. The sponsor then approaches management to see if these individuals can be made available for the Planning effort. Once chosen, the team should undergo a methodology training session led by the study leader. The characteristics of the different team members can be seen in Figure 5.5 (based on a selected evaluation of [137]).

5.4.3 - Assess Business Strategy & Competitive Environment

The planning process must recognise and address those issues which are of greatest importance to the future prosperity of the business. Evaluation of information flow, business functions, installed applications, people, techniques and methods, systems and projects can all subsequently be based upon their satisfaction of these issues. The team begins by reviewing any existing strategic business plans in order to gain an understanding of the company's direction and future ambitions.

Team Members	Knowledge	Power	Contribution
Senior management	• Detailed knowledge of corporate strategy & competitive pressure • Executive IS requirements	• Guarantee financial & managerial resources • Decide strategic IS investments	• Business strategy analysis • High level of control
User management	• Business unit operation & tactics	• Business unit responsibility	• User requirements • Linking business strategy to business operations • IS improvement capabilities
Systems/data processing staff	• Technicalities of existing IS/IT • IS development techniques • Cost & technology awareness	• IS/IT procurement & development	• IS architecture development • Feasibility of user requirements • IT opportunities
External consultants (optional)	• IT awareness • New ideas • Broad IS development experience	-	• Unbiased viewpoint • Administrative & project management duties

FIGURE 5.5 - Characteristics of the study team

The level of business planning sophistication differs from organisation to organisation and business unit to business unit. Tozer [145] writes "that it is not unusual for business plans to exist in the minds of senior managers (implicit) but not in writing (explicit), and on occasion, business plans exist neither explicitly or implicitly". Generally, the more explicit the plan the less challenging this aspect of the methodology. However, whatever the level of sophistication, the study team uses a standard questionnaire (Appendix C section 3) to understand the company's current and future plans, its activities and strategic objectives. The questionnaire is aimed at senior management. The executive sponsor should be able to provide most of what is required, but the team may wish to at least interview one other top-level manager in order to firstly, provide a richer and more varied description of business ambition, and, secondly, to identify any differences in opinion and documentation concerning the relative priorities of the goals constituting that ambition. The questionnaire is aimed at eliciting business direction and performance targets from an analysis of:

- competitive position,
- business objectives and plans,

- critical success factors (CSFs).

Via the questionnaire, the team also examines the organisation's products, operations, structure and functional responsibilities, industry maturity, competitive position in terms of strengths, weaknesses, opportunities and threats, and the effectiveness of MIS. Any major strategic and/or tactical planned changes are also examined, as is a high-level view on how IS can be improved, add value and help achieve business objectives.

Based on its understanding of these issues, the team attempts to articulate their findings into a prioritised set of strategic goals. These *study drivers* should be independent of one another, be specific and unambiguous, and assigned specific weights - the sum of all weights being 100 points. From the weights, the relative significance of each goal can be identified.

5.4.4 - Define Scope of Study

The level of scope determines the area of the organisation segment for which the planning process is to be undertaken. The selected area is called the *Business Unit* of the *Methodology*, and may comprise an entire organisation, a company business unit within an organisation or a significant portion of a business unit. The boundary is based on the identified strategic issues and senior management requirements. The Business Unit may exclude particular functions or departments (eg. Personnel). It must be noted that a study with an excessively wide scope might be too ambitious and prove to be superficial, while one with an excessively narrow scope might miss important opportunities.

5.4.5 - Prepare Planning Completion Schedule

To aid project management by providing an outline of resource and time requirements, a completion schedule (Gantt Chart) should be prepared and distributed by the study team. The Chart should depict the completion dates of each of the Planning activities (Stages and Steps). The responsibility for completion of each Step should also be clearly specified.

5.4.6 - Prepare and Issue Orientation Package

An orientation package tailored to each functional area of the business should be prepared by the study team. This package facilitates the analysis of each area and should contain:

- Methodology workbook and overview
- Organisation charts
- Methodology reference model
- Completion schedule
- Interview guides and questionnaires
- Strategic issues, business plans and potential IS requirements
- A summary of previous IS studies

5.5 - DETERMINE EXISTING SYSTEMS EFFECTIVENESS (STAGE 2)

The essence of IQ*Analyst* is to identify ways in which improved use of company-wide IS could help meet required business direction. This requires an appraisal of the existing IS situation, including hardware, applications software, databases, data communications networks, electronic, paper and verbal communication. This is done to establish the business's current position before promoting and determining suitable directions in which to guide it. The Steps required to accomplish this Stage are:

2.1 - Identify Business Entities and Information Flow Patterns
2.2 - Document Existing Information and Systems
2.3 - Assess Information and Systems Effectiveness

2.4 - Assess Effectiveness of Systems Support

5.5.1 - Identify Business Entities and Information Flow Patterns

A 'macro' inventory of the existing IS is carried out (see Appendix C section 4 for questionnaire). This includes identification of all key *Business Areas*, essential *Business Functions*, their major information processing activities (*Business Processes*), associated *Information Flows* (broad data classes), computer systems and applications software.

Business Areas are broad organisational segments that are required to manage the resources of the business. Business Functions are groups of sustainable, logically related decision-making and information processing activity areas within each Business Area that represent a definition of the business and its IS that is independent of organisation structure. These Functions form the basis for interviews, the broad definition of the existing and future information architecture, and various other subsequent study activities. All Business Functions have Customers in terms of operations within or outside of the busineess which they serve. Such relationships should be clear and explicit. Business Processes are decision-making and activity areas that make up each Business Function and transform data in some way. The Reference Model (Appendix A) provides a checklist to help define Areas, Functions, Processes and Information Flows.

From this inventory, an *Information Model* of the Business Unit can be constructed.

5.5.2 - Document Existing Information and Systems

The team then develops an Information Model of the Business Unit. Business Areas, Functions, Processes and Information Flows are represented in a series of Data Flow Diagrams (DFDs). The Information Model provides a framework with which to communicate and understand the operation of the business and the flow of information, to provide a means for conducting what-if analyses concerning changes to business parameters, and to analyse and fashion future developments.

The Information Model represents the current status of IS within the Business Unit. It is a simplified hierarchical representation of the area under analysis, and displays its requisite functions, processes and boundaries and the inter-connectivity between the various activities performed within the study area and its external environment (either inside or outside of the organisation).

The Model identifies the elements of information (at least all of the key decison making and most widely used exchanges) that are exchanged between different business activities. The Model illustrates the principle that information generated by one activity is consumed in other activities, and therefore a seamless use and consistent quality of this information across the whole business is essential.

The Information Model is composed of four layers referred to as *Levels*:

- Level 0 - Business Unit
- Level 1 - Business Area Map
- Level 2 - Function Maps
- Level 3 - Process Maps

Each layer consists of a set of functional elements, each of which serve a particular need in the execution of the overall business information system. The different activities and entities within each layer are represented by the symbols shown in Figure 5.6.

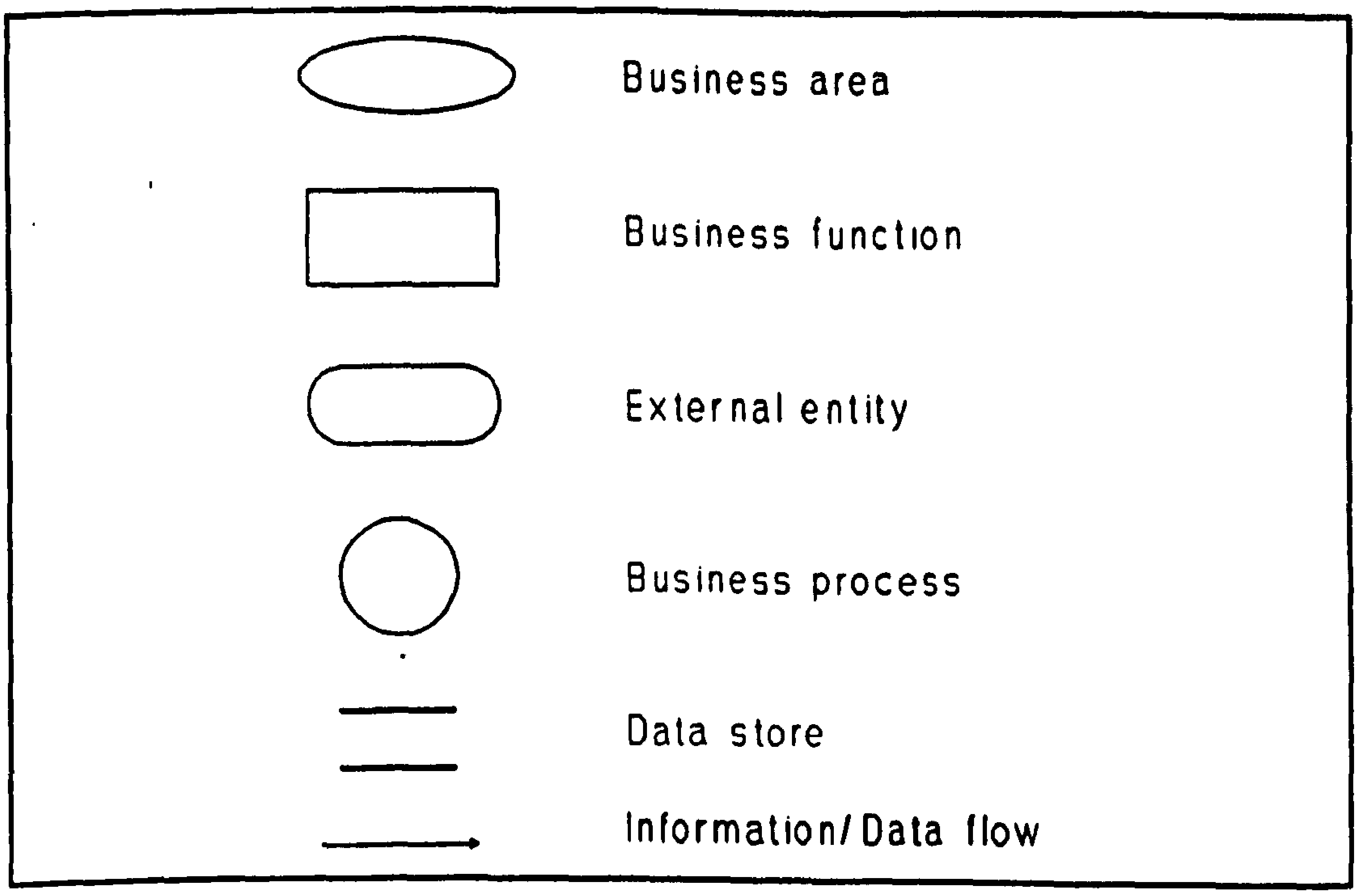

FIGURE 5.6 - Information Model icons

Changes to organisational structures and personnel occur very frequently in manufacturing companies. Adoption of new technology occurs less frequently but still at a pace which precludes technological applications forming the foundation and orientation of an information architecture. Product changes occur even less frequently but product development (particularly engineered products) is never a stagnant activity. The dynamic nature of manufacturing industry means the search for a suitable focus for systems development is difficult. The very nature of competition prevents a steady state. Thus, the Information Model needs to be oriented towards the integral, non-changing Business Functions and their major processing activities (Business Processes) rather than to products or the more transient personnel, technology or organisation structure. The Model is functionally-driven. Proper function definition is essential to the success of the project. Decomposition is based on *'what essential business activities or sub-functions are carried out to achieve this higher-level function?'* and not *'what person, department or organisational unit is responsible for carrying out this function?'*.

The nature of the model means that all of the input and output data elements that flow into or emanate from a Level 1 (Business Area Map) activity show up in the Level 2 (Function Map) decomposition of that activity. Similarly, data flows into and out of a Level 2 (Function Map) activity show up in the Level 3 (Process Map) decomposition of that activity. Individual data flows at higher levels are always represented at lower levels. The same is true of external entities. However, at lower levels new 'internal' data flows may be introduced that are part of an aggregated higher-level data flow.

The Level 0 diagram depicts everything within the scope of the study as a single process, it also includes the information flows between this process and external entities (Customers and Suppliers for example).

The Business Area Map acts as a starting point for analysing the Business Unit in a top-down fashion. It shows the inter-relationships between those areas that are required to manage and administer the operations of the Business Unit. It represents a high-level overview of the company.

The Function Maps are essentially high-level information flow diagrams. Like the Business Area Map, they are based on a simple input-output analysis technique, showing each of the Business Functions and the inter-relationships between them. Business Functions are a decomposition of the Business Areas represented by the Business Area Map.

A Process Map is constructed for each Business Function to enhance business understanding and to depict the activities and information flow patterns at a third level of detail. As with higher-levels, each Process Map depicts the activities performed by the Function as a network of Processes. Each Process represents an activity that manipulates data. The Information Model is validated by the study team through a short follow-up series of interviews before any further analysis is undertaken.

5.5.3 - Assess Information and Systems Quality

The study team conducts a series of information auditing analyses based on existing IS (manual and computerised), planned future systems and changes to operations. This is in order to evaluate the existing IS and determine their effectiveness in satisfying the needs of key users. The exercise examines the quality of information transfer as depicted by the Function Map in order to identify strengths and weaknesses in information effectiveness. The technique helps identify problems and provides objective criteria for improvement. The exercise treats user attitudes and perceptions as a surrogate method for defining and measuring IS effectiveness.

The team first focuses on Business Functions and information deficiencies. An information auditing exercise is undertaken to evaluate how well current IS meet users' needs. The exercise is quantitative and involves the construction of two separate analysis matrices for each Business Function, from which a numeric information effectiveness indicator called an *Information Quality Variance (IQV)* can be calculated.

The first matrix, an *Information Matrix*, is constructed by listing vertically and rating the information items input to the Function against a set of information attributes listed horizontally. The ratings are based on the degree to which each information item fulfils each attribute. In effect, the relative importance of each of the information input items is identified and compared with the actual quality of the inputs which support the Function. This is done by assigning values from a 0 to 10 Likert scale for each information item in terms of each of the information attributes. The attributes used are:

- *relevance,*
- *timeliness,*
- *accuracy,*
- *accessibility,*

- *comprehensiveness* and
- *format.*

'Relevance' represents the importance of each information item (or end-user priority), the remaining five attributes constitute the actual quality of the information (or end-user problems). (Attribute definitions can be seen in Appendix C section 2.) At this point, the Reference Model is used to identify any 'missing' information requirements which are assigned the appropriate 'relevance' rating but zeroes for the remaining attribute ratings.

Function Matrices are derived from their respective Information Matrices. In this case, the 'relevance' ratings are expressed as percentages and the remaining attribute ratings as a weighted contribution to an overall *Function Total* percentage. The weights of the attributes are in the ratio of 8:6:3:2:1 from 'timeliness' to 'format' respectively. The ratio is flexible and can be changed if circumstances justify it. The difference between the Relevance and Function Total is the IQV in the transfer of information from one Function to the other.

Each of the calculated IQVs are collated and listed in decreasing numerical order to produce a *Variance List* for the Business Unit. This List provides a basis for subsequent cross-reference with the results of the objectives alignment exercise (Stage 3), and the opportunites analysis (Stage 4).

5.5.4 - Assess Effectiveness of Systems Support

In the final activity of this Stage, the study team focuses on the Information Systems department. The effectiveness of its service, the skills of its members, its management practices, policies and procedures are all analysed and assessed (see Appendix C section 1 for questionnaire) in terms of their ability to support existing and planned IS.

5.6 - ANALYSE STRATEGIC GOALS (STAGE 3)

The strategic potential of information and IS must be understood in order to identify and evaluate suitable information and IS improvement opportunities and formulate a competent IS strategy. This goal is accomplished by establishing linkage between information and IS improvement opportunities to the Strategic Goals of the Business Unit in a precise and clear manner, so that areas of the Information Model that influence and support Strategic Goals are identified. Two Steps are required to accomplish this Stage:

3.1 - Review Strategic Goals
3.2 - Relate Strategic Goals to Information Model

5.6.1 - Review Strategic Goals

Strategic Goals are associated with the Level 0 process. At the next level down, Level 1, the components of the Level 0 process are identified. For each defined Level 1 process, the study team identifies business objectives that support the objectives of Level 0. This exercise is repeated throughout the Information Model.

At the Business Function and Business Process levels (Levels 2 and 3 respectively), a set of functional and operational sub-objectives that show how each Function and Process can achieve its parent objectives are identified. For each Function, these parent objectives are Level 1 (Business Area) objectives; for Processes, parent objectives are functional objectives. This ensures the examination of objectives at each level of the business in increasing levels of detail, and if carried out with the required integrity, establishes linkage between strategic plans and actual business operations. Functional objectives are related to management control, operational objectives are mainly transaction-oriented and related to operational control. Performance targets to assess the attainment of each objective are also established.

Each identified Strategic Goal has been assigned a weight which is used to establish its relative importance against other objectives. A table is constructed, in rank (weight) order, depicting the decomposition of each Strategic Goal throughout the Information Model. The table consists of three columns: prioritised strategic goals, functions and functional objectives, and processes and operational objectives. (Appendix C section 5 includes the appropriate questionnaire.)

5.6.2 - Relate Strategic Goals to Information Model

Each Goal has been assigned a priority to reflect its relative significance and judge the potential benefits of related activities, and has been broken down into lower-levels of detail, reflecting the breakdown of the Business Areas, Functions and Processes as depicted by the Information Model. At each level, the study team has identified a set of sub-objectives that establishes how each Area, Function and Process can achieve the higher-level objectives. By relating objectives at one level to those at higher and lower levels, the extent to which disparate business activities can support and influence business strategy can be traced throughout the Business Unit. For the lowest-level, the Process Map, the team identifies information that is either directly related to Process performance or required to monitor performance against objectives. The resulting *Business Information Needs* are automatically allied to the Strategic Goals they have been derived from, and are assigned the same priority. This enables activities that are considered critical to the future success of the business and supporting IS requirements to be readily identified.

5.7 - ANALYSE SYSTEMS IMPROVEMENT OPPORTUNITIES (STAGE 4)

The desired result of Stage 4 is the identification of a set of IS improvement capabilities that are directly connected to the strategic goals of the business. The Stage consists of two Steps:

4.1 - Identify Improvement Opportunities

4.2 - Examine Feasibility of Each Opportunity

5.7.1 - Identify Improvement Opportunities

This Step requires an investigative study to identify areas of the Information Model where there is potential for IS improvement and IT exploitation. Team members from the Systems department begin the search for opportunities by investigating developments in IT. They study the use of IT within the company's own organisation (companies within a group are often unaware of innovative IS use by other companies in the same group), by competitors and in other industries. A benchmark of IT adoption can thus be formulated. Simultaneously, the user members of the team (and, via interview, all other key users involved in the study) try to identify ways to re-engineer and improve Business Processes. The team assesses users' understanding of current IS not only to identify potential applications for improvement but also unearth existing capabilities and functionality with which the users are unfamiliar. The Opportunities Framework described and shown in Appendix B is a valuable aid to this Step. (The user questionnaire is shown in Appendix C sections 3 and 4.)

5.7.2 - Examine Feasibility of Each Opportunity

Each identified improvement capability is assigned a rating on a 1 to 5 scale that signifies its effectiveness in achieving Process objectives (lowest-level CSFs). Some capabilities are considered effective (5), while others are peripheral (1).

5.8 - DEFINE INFORMATION SYSTEMS NEEDS & PRIORITIES (STAGE 5)

In Stage 5, IS needs and priorities are defined in order to formulate a plan which focuses on those areas of the Business Unit where better use of IS could help meet the Strategic Goals. Three Steps are undertaken:

5.1 - Determine Development Priorities

5.2 - Identify Risk and Resource Implications

5.3 - Formulate IS Strategic Plan

5.8.1 - Determine Development Priorities

Priorities for IS development need to be established. These are based upon a synthesis of the following:

- business information needs - Step 3.2;
- effectiveness of information flow - Step 2.3;
- IS/IT improvement opportunities - Steps 4.1 and 4.2;
- estimated development costs - Step 5.2.

By cross-referencing and identifying any correlation between the outputs of these Steps, a list of IS development initiatives is provided.

This exercise can be validated via the following rule of thumb:

Development priority = methodology metric / estimated development cost

where,

Development priority = unit contribution to business requirements per £ spent on IS development;

methodology metric = strategic goal priority X IQV X IS/IT improvement capability;

estimated cost = cost to fulfil IS capability.

5.8.2 - Identify Risk and Resource Implications

IS implementation is often a significant change process and therefore involves risk so it is necessary to assess the potential benefits of proposed changes against their potential risks. A matrix is prepared to show the various risks that may be associated with each proposed improvement initiative. User acceptance/rejection and likelihood of success are identified to quantify the overall improvement risk.

5.8.3 - Formulate IS Strategic Plan

The purpose of the final Step of the Planning Phase is to review the issues that have been raised so far and mould them into a series of development initiatives. This is done in order to identify and rank a series of development projects.

Various IS development options available are evaluated with reference to

- calculated priority (strategic and tactical impact),
- project clustering and synergy,
- perceived benefits,
- perceived risk (likelihood of success, estimated cost, time).

The preferred strategy is selected and documented.

5.9 - PROJECT START-UP & BUSINESS AREA OVERVIEW (STAGE 6)

Stage 6 involves the necessary preparation and project management tasks required to facilitate the application of Phase 2 of the Methodology. The principal outputs of Phase 1 are re-examined, and an overview of the Business Area under analysis is undertaken.

The Steps required to accomplish this Stage are:

6.1 - Select Study Team
6.2 - Review Information Systems Strategy
6.3 - Overview of Business Area
6.4 - Prepare Analysis Completion Schedule

5.9.1 - Select Study Team

A study team is selected to drive the Analysis effort (Project 1) through to completion and formulate the requirements specification. The team should be composed of user and IS members, and to ensure continuity, at least one of whom should have been part of the Planning team. The team should normally consist of two or three full-time members who should have previous systems analysis and requirements specification experience. The team is selected with reference to the following criteria:

- size of business area,
- time and resource availability,
- familiarity with business area operations,
- experience and skills.

5.9.2 - Review Information Systems Strategy

The key outputs and deliverables of the Planning Phase are reviewed in order to familiarise the study team with:

- the current IS architecture within the Business Area,
- the effectiveness of IS within and impacting upon the clustered Analysis area,
- improvement opportunities and capabilities,
- the strategy for systems development.

The following documents are collated and distributed among the study team:

- Business Area Function Maps
- Business Area Process Maps
- IQV List and technical assessment
- Selected completed questionnaires
- Project proposal

5.9.3 - Overview of Business Area

Depending on the level of information obtained in the application of Phase 1, it maybe necessary to expand the analysts' understanding of the activities and processes within the Business Area. The following should be identified and summarised:

- responsibilities of analysis area,
- personnel and job tasks,
- current practice including technology, systems and data processing,
- objectives, CSFs and level of performance with respect to the identified targets,
- information requirements and systems effectiveness.

From the above, an information source and distribution diagram is constructed focusing on the processing activities (DFD processes) of the Business Area.

5.9.4 - Prepare Analysis Completion Schedule

To aid project management by providing an outline of resource and time requirements, a completion schedule (Gantt Chart) should be prepared and distributed by the study team. The Chart should depict the completion dates of each of the Analysis activities (Stages and Steps). The responsibility for completion of each Step should also be indicated.

5.10 - UNDERTAKE DETAILED MODELLING (STAGE 7)

In Stage 7, a detailed analysis of the areas under investigation is undertaken so that a thorough understanding of the areas can be obtained and a complete documentation of current business practice in these ares can be prepared. Much of the understanding is gleaned from a representation of the information which should be available ('normative study') and/or is actually available ('empirical study') in accordance with managerial need. It is important to remember that the study team should not delude themselves that systems behave as they were set up. What is important is what they actually do. If they are not responding to real needs, the system needs to be changed.

The Steps required to accomplish this Stage are:

7.1 - Construct Normative Model
7.2 - Construct Empirical Model
7.3 - Define & Evaluate Discrepancies

5.10.1 - Construct Normative Model

A Normative Information Model for the Business Area is constructed. The Model is concerned with the information processing activities and the events that should, or, are supposed to occur, and the information and data that should be available in accordance with the Business area 'design' as it is presently perceived. The Model leads to a greater appreciation of the 'as designed' IS.

The Normative Model is by no means an ideal model but one for which there is a facility to transmit the information depicted and undertake the actions and processes that are represented. Three techniques are used to construct the Normative Model:

- functional modelling (data flow diagrams - DFDs),
- entity modelling (entity relationship diagrams - ERDs),
- sequence modelling (action diagrams - ADs).

The Process Map(s) for the Business Area constructed in Stage 2 of the Phase 1 application and forming a part of the Information Model for the Business Unit, are decomposed to a level of abstraction that comprehensively describes the activities of the Business Area.

An AD is constructed to provide a means of identifying the relative sequence of the DFD processes. An ERD is constructed to understand and document the data complexities of the Business Area. Only a specific part of the Business Area need be modelled on the ERD and AD.

5.10.2 - Construct Empirical Model

An Empirical Information Model for the Business Area is also constructed. The Empirical Model is concerned with the information processing activities and the events that actually do occur, and the information and data that is available within the Business Area. The Model enables the 'actual' IS to be understood and represented.

The techniques for constructing the Empirical Model are the same as those for the

Normative Model, that is, DFDs, ERDs and ADs, but applied to the 'actual' rather than the 'as designed' IS.

5.10.3 - Define & Evaluate Discrepancies

The differences between the two sets of diagrams (DFDs, ERDs and ADs) used to articulate the Normative and Empirical behaviour of the Business Area are identified and listed. The differences are usually depicted in the form of a simple table. The implications of the differences are illustrative of the failings of the 'as designed' IS, and as such are important factors for consideration in the specification of any improved design.

5.11 - EXAMINE DATA & DATA PROCESSES (STAGE 8)

In Stage 8, the idiosyncrasies and characteristics of the data and processes of the Analysis area are examined.

The Steps required to accomplish this Stage are:

8.1 - Analyse Data Quality
8.2 - Analyse Problems & Causes
8.3 - Summarise Data Deficiencies

5.11.1 - Analyse Data Quality

In order to evaluate the current data flow and determine data effectiveness in satisfying key users; a data auditing exercise is undertaken. The technique helps identify problems and provides objective criteria for improvement.

The exercise treats user attitudes and perceptions as a surrogate method for defining and measuring data effectiveness.

Data Quality Analysis (DQA) involves the analysis of the quality (adherence to requirements) of data items associated with the information interchanged between the Functions and Processes within the Business Area. This is the same technique as applied in Stage 2 of Phase 1 and is done with reference to the quality of the content and transfer procedures of data, via the analysis of a number of attributes.

The exercise is quantitative and involves the construction of two separate analysis matrices for each Business Process, from which a numeric data effectiveness indicator called a *Data Quality Variance (DQV)* can be calculated. The matrices (a *Data Matrix* and a *Process Matrix*) correspond respectively to the *Information* and *Function Matrices* used in the Information Quality Analysis technique. The Matrices are constructed for each interchange of information between the Functions under investigation. The information is broken down into its constituent data elements and each element is rated on a 1 to 10 scale against a set of data attributes (Data Matrix). Each Process Matrix is derived from its respective Data Matrix. As before, the 'Relevance' ratings are expressed as percentages and the remaining attributes as a weighted contribution to an overall Process Total percentage. The difference between the Relevance and Function Totals is the DQV in the transfer of data from one Function to the other.

5.11.2 - Analyse Problems & Causes

In this Step, the principal reasons for any data deficiencies and their causes and their implications of those reasons are identified, so that the issues that need to be addressed to tackle each qualitative data problem are apparent. This is done by interviewing the generator and/or the recipient of the information/data to identify the causes and subsequent effects of data deficiencies. Each category of 'cause' represents a data attribute to which should be assigned the specific reasons for the deficiencies. A *Fishbone Diagram* is used to represent the problems and their causes.

5.11.3 - Summarise Data Deficiencies

Data analysis highlights the most important and major data problems via the analysis of data attributes and characteristics. The 'cause and effect' analysis identifies the principal reasons for those problems and their implications for the business. The findings of these two Steps are summarised to highlight the greatest contributors to poor performance and identify opportunities for improvement.

5.12 - ANALYSE USER REQUIREMENTS (STAGE 9)

In Stage 9, user requirements are determined so that the needs of those most affected by any IS change will be incorporated and met in an improved system.

The Steps required to accomplish this Stage are:

9.1 - Determine User Requirements
9.2 - Determine Feasibility of Requirements
9.3 - Summarise Requirements

5.12.1 - Determine User Requirements

In looking to make constructive change to IS, it is advised that maximum involvement of end users is considered. Determining user requirements helps to assure that the needs of those affected by the system will be addressed in any improved system.

Information users are provided with an opportunity to state their objectives, needs and comments. These requirements are identified and assigned to one of six categories: five of which are the attributes that have been used to represent information and data quality and one to represent any other requirement. Requirements are tabulated when a clear improvement in one of the attributes is needed.

5.12.2 - Determine Feasibility of Requirements

To establish a reasonable balance between the cost and value of information and hence determine the feasibility of each user requirement, an appraisal of each of the identified requirements is undertaken. This is usually done through a series of discussions with systems / data processing staff.

5.12.3 - Summarise Requirements

A prioritised list of feasible user requirements is compiled based on the output from the previous two Steps.

5.13 - FORMULATE SPECIFICATION (STAGE 10)

Stage 10 involves a synthesis of the evaluative issues discovered in each of the previous Analysis Stages so that a requirements specification supporting strategic change can be developed.

The Steps required to accomplish this Stage are:

10.1 - Review IS/IT Improvement Capabilities
10.2 - Summarise Improvement Requirements
10.3 - Formulate Requirements Specification

5.13.1 - Review IS/IT Improvement Capabilities

The relevant IS/IT improvement capabilities are reviewed in the light of the Phase 2 activities so that the feasibility of each can be determined.

5.13.2 - Summarise Improvement Requirements

A summary of required improvements is formulated based on the Phase 2 findings.

5.13.3 - Formulate Requirements Specification

To transfer business priorities from information to applications, a specification of requirements is formulated. The specification must conform with business and user requirements and be organised to include:

- current IS environment,
- proposed IS environment,
- implementation strategy,
- financial analysis,
- benefit analysis.

5.14 - SYSTEMS DEVELOPMENT LIFE-CYCLE

It is important to realise that IQ*Analyst* logically precedes a number of system development activities that ultimately lead to the implementation of an IS. These typically include system design, prototyping, programming and/or system selection, testing and implementation.

CHAPTER SIX

CASE STUDY COMPENDIUM

PURPOSE OF THIS CHAPTER

The purpose of this Chapter is to present a discussion of the results obtained from applying both Phases of the Methodology (in both their developmental and final forms) in a number of manufacturing business units. Disparate types of manufacturing environment at varying degrees of maturity and success were deliberately chosen as test sites in order to properly develop and validate the appropriateness of the approach. The remit of IQ*Analyst* covers all types of manufacturing company of an appropriate size (at least large enough to warrant delineation of the business into discrete information consuming and generating functions and activities), so testing in a variety of business units was necessary. The descriptions have been summarised, and where considered appropriate, repetition of results of individual tasks has been avoided.

6.1 - OVERVIEW OF THE TEST SITES

Company A was established in 1978 and manufactures transmission systems (axles and gearboxes) for on/off highway vehicles. The company employs approximately 300 people and has a turnover of approximately £50m (@1993). After continued growth, the company is entering a period of consolidation where the need to reduce costs yet sustain market share is seen as a key business objective.

Companies B and C are business units of a UK manufacturer of materials handling equipment. B manufactures a large range of standard overhead cranes and C is responsible for the manufacture of large, specialised lifting and transportation cranes and equipment. Both B and C have over the past several years suffered a drop in sales volume.

Company D maintains and overhauls jet engines for the world's major airlines. It is owned by an American road transportation and aviation company. The company works in a highly specialised field. Essentially an engineer-to-order (ETO) facility, it does not have the luxury of a visible workload forecast, minimum variations on jobs or flexibility of lead times, rather, it has unique characteristics that mean an extremely difficult task in scheduling and planning, and consequently unpredicabilities and uncertainties in its information flow. The company is successful and expanding, making approximately $16.3m on a $214m turnover (@ 1993) and employing approximately 800 people. Overhaul can be complicated and comprise many operations using sophisticated process technologies. The need to provide short door to door *turn-round-times* (TRT) is the key order-winning criterion. There are 24 major customers including engine manufacturers in addition to another 30 customers for whom ad hoc repair work is carried out.

Company E is a subsidiary of a privately-owned Group. The company manufactures valves for the water provision and treatment industries and has a turnover of approximately £10m (1993). The company is one of four manufacturers supplying a wide range of valves. It has around 5% of the total market. Some 92% of home sales is destined for the water companies (in England and Wales), water departments or regional councils (Scotland) and similar bodies in Ireland. In many instances valves are purchased by civil contractors who are working for the water utilities often on a project basis. Since being acquired by the Group in 1985, operational improvements have been ongoing throughout the company, yet it is loss-making and its future is uncertain. A new management team took charge in 1993.

A summary of characteristics of the test sites is provided in Figure 6.1.

Test Site	Nature of Customer Orders	IS Positioning Metaphor (based on McFarlan et al) [108]	Organisational Configuration*	IS Characteristics
Company A	MTS	Turnaround	Entrepreneurial Conglomerate	Informal IS; intuitive decision making; IS applications identified as vital for the company's strategic objectives.
Company B	ATO	Factory	Stagnant Bureaucracy	Poor internal/external IS; IS applications unlikely to significantly affect future performance.
Company C	MTO	Factory	Stagnant Bureaucracy	Poor internal/external IS; IS applications unlikely to significantly affect future performance.
Company D	ETO	Strategic	Successful Firm Under Moderate Pressure	Analytical decision making; business strategies depend on IS for their implementation.
Company E	MTS / ATO	Turnaround	Aftermath	Ad hoc decision making; incompatible IS; poor planning; IS applications identified as vital for the company's strategic objectives.

Figure 6.1 - Test site summary

6.2 - PILOT STUDY 1

Stages 2, 3, 4, 7, 8 and 9 were undertaken as a series of exploratory studies at company A to develop and test the techniques necessary to carry out the Methodology. Chapter 4 described the main outputs of these developmental stages and improvements to the Methodology identified as a result of the studies.

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* Based on work by S.Blenkinsop [16].

Based on these analyses, a requirements specification for improved maintenance management was developed. This ultimately led to the implementation of a computerised maintenance management IS. The identification of the Maintenance business function as a key problem area and the clustering of the Manufacturing to Maintenance interface as the *number one* project for IS development was seen to be independently validated by an in-company, team-based *complete customer quality* initiative. By analysing *importance of output versus key business goals*, *the extent of improved customer satisfaction*, *the size of likely business benefit*, *the estimated timescale of any improvement project implementation* and *the level of resources likely to be needed* of every company (organisation chart) department, Maintenance was similarly identified as the number one company-wide headache by the quality improvement team. This result was obtained at considerable expense (far greater than IQ*Analyst*) directly in terms of 'quality' documentation and consultancy, and indirectly, in terms of key management time and resources.

6.3 - CASE STUDY 1

A developmental Phase 1 of IQ*Analyst* was applied at Company B, a business unit of a UK materials handling equipment manufacturer. The company identified seven main competitive criteria for establishing a strong competitive position in the market, and these were used as the strategic drivers of the study. In order of priority, they were:

1) Price - selling at the lowest.
2) Delivery lead-time - delivering the product within the lead-time required by the Customer.
3) Delivery reliability - always delivering to schedule.
4) Quality - producing a product that performs well to specification.
5) Product features - adding capability to the product or choice for the Customer.
6) Design flexibility - having the ability to produce products to a Customer

specification.

7) Volume flexibility - having the ability to supply fluctuating volumes without compromising lead-times.

No detailed tactics for achieving these objectives had been identified. The exact thrust of the objectives was vague. They were more of a *wish-list* rather than an articulation of business ambition developed from a deep understanding of company strengths and weaknesses and market conditions. Based primarily on a relationship analysis of these objectives and a detailed IQA study, two clear and independent improvement projects were identified.

The first was a request to improve the interface between the Customer and the Sales Area in terms of the information elicited from the Customer in its specification of requirements and the continual contact made via the Sales and Contracts department between Customer and company.

The Sales activities were represented by five sequential DFD processes - 'Respond to Enquiries', 'Produce Technical Tender', 'Prepare Estimate', 'Negotiate with Customer' and 'Process Order'. The general order of activities for the Sales Area, as represented by its Process Map was as follows:

(a) Receive 'Customer enquiry' from which a 'crane estimate' is produced.

(b) Enter 'Customer enquiry' onto Data Manager (DM) - a Sales Management Control System.

(c) Enquiry details are used to produce a 'technical tender' using a data selection book (DSB). All technical information - girders, dimensions, loads for example are included in the tender.

(d) Any extra details to be considered for the final estimate are entered onto the spreadsheet within DM. Examples of these details would be any optional extra costs, transport costs, price list updates from Hoist Division (not identified) or manufacturing improvement details.

(e) DM processes all relevant details and a final 'quote' is calculated. This is then sent with a 'Sales package' to the Customer.

(f) A copy of the quote is given to a Sales engineer 'in the field'. A file copy is kept in the 'quotation mode' on DM. The Salesman continues the negotiation with the Customer and sends back 'quotation progress' (job status) updates which are fed into DM.

(g) If the order is achieved, the Sales Engineer produces a 'signing-off report'.

(h) A unique part no. is created for the crane and a 'sales order entry' (containing prices, names, addresses etc) is generated and given to Accounts.

(i) 'Order acknowledgement' is returned from Accounts.

(j) 'Order acknowledgement', 'signing-off report', 'quotes' and 'as sold estimate' constitute the 'sales pack' which is then handed over to Contracts.

Once the 'sale' has been made in the form of the 'signing-off report', it is then handed over to Contracts who see it through to its conclusion. The major activities of the Contracts Function were represented by three DFD processes - 'Monitor Contract', 'Co-ordinate Activities' and 'Arrange Installation'. The general responsibilities of the Contracts Functions are to supervise the contract once it has been signed, to handle any correspondence with the Customer, to co-ordinate the activities of the division and to arrange for the crane to be installed. The general order of activities, accepting that Customer correspondence is continuous, as represented by the DFDs is as follows:

(a) Receive 'sales pack'/'contract documents' from Sales.

(b) Issue 'contract instructions' to D.O., Manufacturing and Quality.

(c) Handle queries from all parties involved in the completion of the contract. (Not all of these queries were identified.)

(d) Receive 'drawings/progress updates' from D.O., 'production plans/progress updates' from Manufacturing and 'quality plans' from Quality.

(e) Interchange of cost information with Accounts (transport costs etc.).

(f) Arrange installation.

(g) Raise invoices.

Key problems concerned the completeness of customer specifications, the speed with which Sales was able to generate 'sales packs' for Contracts and the issue of contractual instructions to Quality for 'quality plan' development.

The second improvement project concerned the Crane Design to Manufacturing interface. The Design function takes the initial 'tender design' and the 'drawing office instructions' and from these produce the contract designs, calculations and detail drawings for manufacture and completion of the contract. The main outputs of the Function are 'approval drawings', 'detail drawings', 'parts lists' and 'purchase requisitions'. Also included in its responsibilities are handling any modification requests and producing test schedules, installation schedules, manuals and quality inspection documentation and programmes.

The Manufacturing DFD was represented by four processes; 'Co-ordinate Manufacturing Activities', 'Control Inventory', 'Plan Manufacture' and 'Manufacture Product'. 'Co-ordinate Manufacturing Activities' represented the majority of the information gathering and processing activities of the Function, for instructions to be issued in the form of 'material lists', for schedule creation and production control. 'Control Inventory' represented the maintenance of inventory control records, the allocation of material to Customer orders and the replenishment of standard stock items. 'Plan Manufacture' represented the production engineering activities of the Manufacturing Function, that is, the determination of process plans required for machining the parts identified in the 'material lists' and the alteration of any existing process layouts. 'Manufacture Product' represents the actual machine shop activities of the Manufacturing Function. The machine shop operated as a jobbing shop as all cranes are made to order and are scheduled directly to order requirements. There are no sales forecasts.

Key problems relating to the interface concerned the timeliness and completeness of the drawings and parts lists.

The case study was primarily used to refine the art of DFD construction and IQA application, and so the Methodology was applied with at least part of its teeth drawn. The following points about the study should be noted:

- Strategic Goals were not decomposed to lower levels of detail with the rigour and integrity that the final version of IQ*Analyst* suggests.

- For most Business Functions, a thorough Information Matrix was constructed, however, in certain instances, because of the nature of the interview (i.e. time constraints) it was noted that several items had been omitted from the Information Model and consequently these items were not rated - hence underlying the importance of a *validation* Step, an interview checklist and a Reference Model in the Methodology.

- The questionnaire to assess the effectiveness of systems support was not applied.

- The Reference Model was not completed at the time of the case study, and as such a systems improvement opportunity analysis, a template to help construct the Information Model and a checklist to aid Function definition were not used.

- The risk and resource implications of each proposed development project were not analysed.

- Absolute information flow effectiveness as well as a 'group' interface effectiveness would have enhanced the results produced.

6.4 - CASE STUDY 2

A developmental Phase 1 of IQ*Analyst* was also applied at Company C. The Strategic Goals for the study were the same as those for Company B in case study 1. For this business unit, two clustered areas of the business were targeted for improvement. The first, like the second for business unit B, concerned the Crane Design to Manufacturing interface and primarily the quality of the drawings and parts lists produced. The second, centred around the Estimating Function and its interaction with the Tender Design and Manufacturing Functions.

The Tender Design Function prepares the initial tender design from the 'Customer specification' which the Estimating Function then uses to prepare the 'estimated cost' for the contract. The 'crane specification' which will be given to the Customer and any technical documentation that is required by the Customer is also prepared by Tender Design. No significant benefit was obtained from constructing a Process Map of the high level information processing activities of the Tender Design Function. Its only inputs were the 'Customer specification/technical details' from Sales together with any revisions to these if they occur and any 'quotes' from Suppliers that are requested. These inputs were used to produce one of three technical tenders - a 'full tender' for a firm order enquiry, an 'approximate tender' for an approximate order enquiry and a 'budget tender' for a general enquiry. The firmer the order enquiry, the more time is devoted to producing the tender and hence the more exact and comprehensive the Tender Design outputs to the Customer (via Sales) and Estimating. The 'tender design sheets' (estimate) given to Estimating consisted of an overall crane design concept, the tender design specification and any quotations from Suppliers.

There are three levels of estimate provided by the Estimating Function, these were: 'budget cost', 'approximate cost' and 'full cost'. As with Tender Design, which of these is required is specified by Sales and depends on the possibilities of actually obtaining the contract. Again no significant benefit was obtained from constructing a Process Map of the Function since it had relatively few inputs and outputs. It was noted that due to time constraints, a certain amount of historical data has to be used to produce its two main outputs - 'estimated cost' to Sales and 'estimated hours' to Manufacturing.

Key problems related to the timeliness and accuracy of the 'tender design sheets', and the very poor quality of the calculated 'estimated hours' for jobs (IQV of 41). The constraints imposed upon these projects were the same as those in case study 1.

6.5 - CASE STUDY 3

Final, if unrefined, versions of Phases 1 and 2 of IQ*Analyst* were applied at company D. For Stage 1 of the approach, organisational readiness and management commitment were assured via a series of meetings and presentations with, and to senior managers. The systems manager acted as the sponsor of the study. Access to the company *business plan* and interviews with senior managers yielded the following Strategic Goals:

- Improve *turnround (TRT) time* (weight - 80)
  - achieve controlled 49-56 day average TRTs
  - commence implementation to achieve controlled 35-42 day average TRT

- Retain high quality (weight - 20)
  - maintain current quality statistics

Both objectives were formulated to improve gross margins by bringing $3m repair work in-house @ 50% g.m. The marketing mix consisted of price, quality, delivery and competition. The company has been highly successful on quality at average prices with average delivery with limited competitor capacity. However, competitors' quality and capacity are perceived as increasing drastically. The company foresaw three possible strategic alternatives:

- Downsize to suit increasing capacity
- Compete as a high quality, short delivery supplier
- Compete as the low cost average quality/delivery supplier

The second of these alternatives provides the driving force for the company's ambitions.

The wide remit of the study drivers dictated that the study scope should encompass all major activities within the general 'engine overhaul' cycle. A planning completion schedule was put together, organisations charts obtained and an interview schedule formulated.

Fifteen middle-level user managers were interviewed in order to develop an Information Model of the Business Unit and determine systems effectiveness for Stage 2 of the Methodology application. Figure 6.2 depicts the developed Function Map, and the top-most section of the calculated IQV list can be seen in Figure 6.3.

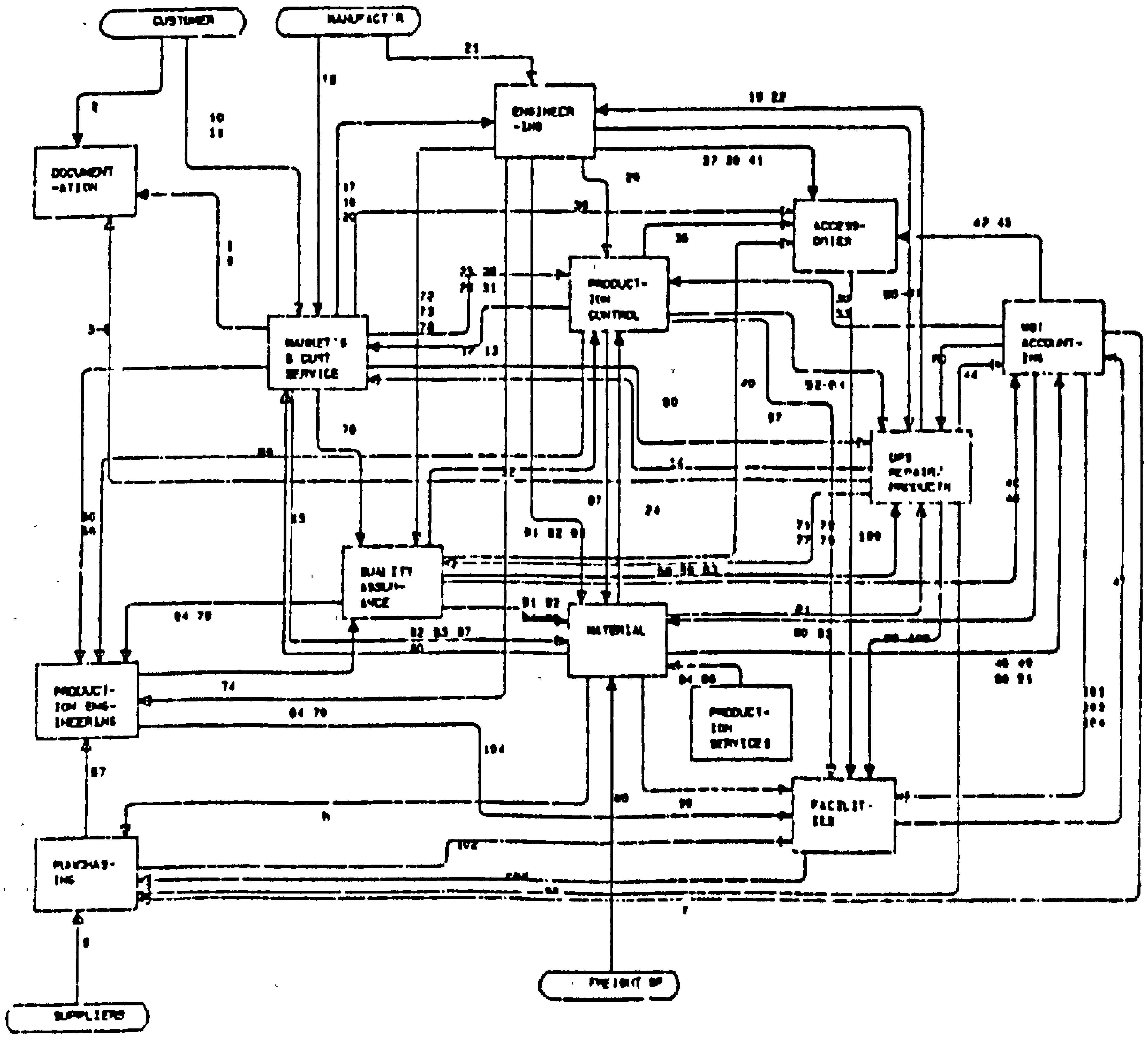

FIGURE 6.2 - Function map (company D)

In the application of Stage 3 of the Methodology, sub-objectives supporting the overall Strategic Goals were identified in each of the key business areas within the scope of the study. Prominent *business information needs (BINS)* that were found to relate explicitly to TRT (priority rating 80) through the objectives decomposition process were 'work packages' produced by Engineering and 'work schedules' produced by Production Control. These items were thus assigned an importance rating of 80, and following the application of Stages 4 and 5, the development projects outlined in Figure 6.4 were identified.

No.	Information requirement	Produced by	Produced for	IQV
1	Plant availability	Operations	Facilities	57.5
2	Material shortages	Production Control	M & CS	54.5
3	Receipt details	Materials	Facilities	50.5
4	Repair schedule	Production Control	Operations	50
5	Incident report	Operations	Quality Assurance	47
	Invoice queries	Quality Assurance	Materials	47
7	Work order	M & CS	Engineering	44.5
8	WIP priority	Production Control	Operations	44
9	Splan	Production Control	Operations	43.5
10	Budget variance	Finance	Production Control	42.5
11	Forecast report	Marketing	Materials	42
12	WP, SB, Repair card	Operations	Documentation	40.5
13	Engine forecast report	Marketing	Materials	40
	Incident report	Quality	Materials	40
15	Material sales	Materials	Mgt Accounting	39.5
16	Workscope packages	Engineering	Operations	39

FIGURE 6.3 - IQV list (section)

Development project	Development priority
1. Investigation of workscope package development	1
2. Production schedule development	2
3. Investigation of material shortages	3
4. Forecasting	4

FIGURE 6.4 - Development projects (company D)

Projects 1 and 2 were simultaneously undertaken through Phase 2 of IQ*Analyst*. Stage 6 of the approach involved an overview of the Business Areas under study.
The Engineering function is responsible for assessing the work required for an engine (unit) overhaul and documenting and issuing this work in such a way that the work content needs of the Operations function, the contractual requirements of the Customer and the standards conformance needs of the OEM's are all satisfied. The Operations function undertakes the required inspection, material processing and testing activities of the company. It has full capability for repair and overhaul of General Electric CF6, Pratt & Whitney JT8D and CFM International CFM56 engines including all accessories. Production Control is responsible for controlling and scheduling the work issued by Engineering through the shop.

The Engineering personnel comprise 1 manager, 5 senior engineers, 7 engineers, 1 project engineer, 4 technicians, 4 technical assistants and 1 clerk. Operations personnel comprise 1 general manager, 2 shift production managers, 5 unit shop managers, over 20 section leaders and a number of mechanics, electricians and technicians. Production Control consists of 1 manager, 1 shop controller, 2 engine controllers (d/s & n/s), 8 dispositioners and 2 clerks. An additional project team is responsible for the implementation of MCC (Manufacturing Control Code), a simulation-based production control system.

Engineering review the information supplied on the work order by Customer Services as agreed in the contract with the Customer, including the cause of rejection and any work instructions, and together with information obtained from a rigorous receipt inspection, formulate a workscope proposal which is issued to the Customer for agreement. If agreed, this proposal forms the basis of a workscope summary which is an overall assessment of the work required for an overhaul and is issued throughout the company. From the workscope summary, a detailed workscope package is produced which constitutes all of the documentation required to allow labour and resources to be booked against the work order number and to provide instructions on what operations are to be carried out. These specific operations are marked on standard sheets by an engineer's stamp. The stamped operations tell the mechanic where to get the detailed instructions that tell him exactly how to carry out the operation. All the stamped activities must in turn be stamped by a lead mechanic upon their completion. At present, the generation of a work package takes between 2 and 2.5 days. Further instructions to the work package are issued as and when defects are found. Changes to the workscopes are agreed by the Customer before they are carried out.

The work packages supplied by Engineering contain barcoded reference numbers. These codes are utilised by a shop floor data collection system and are wanded by various personnel to identify what time, resources and labour have been booked against that particular work order. The shop schedule or 's-plan' is initiated by the work package and the job is added to the production schedule. The presence of the splan on-line results in several more detailed 'child' schedules to be automatically generated. Job packages are held by Production Control until the schedule dictates that they be released to the shop floor. The schedules are based on 'time blocks', the shop is assumed to have almost infinite capacity and jobs are passed through as and when they arrive. Workflow is unpredictable and depends on a series of tests and inspections that lead to changes in the assumed workload and long waits for parts. The implementation of MCC is intended to minimise the effect of such deviations by bringing accuracy and realism to the production schedules.

Each engine undergoes the same strip, clean, inspect, repair, build, test and despatch routine. Inventory and parts issue as required by Production is controlled by an Advanced Material Allocation Scheduling System (AMASS). Engines, modules and accessories are stripped and built in purpose-designed unit managed product areas. Labour is booked onto a package by wanding both the mechanic's personal identification bar code and the bar code specific to the package. This action tells the computer system to print off the required RIS tags. These tags describe the cleaning and inspection requirements for specific components or assemblies. They are attached to parts immediately after they are removed from the engine or module.

Material removed from an engine is passed through a variety of cleaning processes as described on a RIS tag or a shop manual process card. Components and sub-assemblies are sent to the relevant inspection area. Inspection may be purely visual (referred to as condition monitoring) or it may involve more detailed examination (shop manual inspection). After cleaning and detailed inspection, any repairs that need to be carried out are detailed on a repair card. These cards are made out by inspectors and refer to operations described in engine manuals that are provided by the engine manufacturer. Upon completion of repair work, parts are arranged and kitted as per the updated schedule and re-assembled into engine module units (EMU's). A WIP status report for each operation detailing the WIP status of all material is formulated by the engine controllers daily and is used to update the production schedule.

In an environment where TRT is the key critical success factor (CSF), the most applicable performance measures are those that relate to schedule date adherence.

Hence, typical performance indicators are as follows:

- percentage of work orders that are 'opened' prior to an engine arrival,
- adherence to splan dates,
- receipt-inspection duration,
- strip-despatch duration,
- build-despatch duration,
- TRT variances.

Obviously, there are many other valid measures of performance that the company can and does use within each of the areas under analysis. However, the emphasis of this study was the information activities relating to unit TRT and as such the above mentioned measures are most appropriate.

Splan - The splan is the overall shop schedule. It is essentially a visibility document, primarily based on a 'first-in first-out' (FIFO) system and is generated via a sofware product called Info. It acts as the main driver for the shop and is triggered by the issue of a work package by Engineering. An 'engine strip package' generates the splan automatically. For an 'as received test package', the splan has to be manually generated. It is updated daily and issued once a week throughout the company. It provides unit and Customer details, job priorities and the dates for which major operations are to be completed.

Shop schedule inspection order (Front end or FE shop schedule) - The FE shop schedule is generated automatically from the splan, details the 'front end' (i.e. the received, inspection, clean and strip) dates for incompleted operations down to module level and in priority order. It is issued twice weekly to the areas concerned with those operations.

Work to list - The work to list is generated automatically from the splan, is issued weekly and acts as a detailed priority list for the strip, build, inspection and test shops.

Repair schedule - The repair schedule provides a complete list of items to be repaired in-house. It is issued twice weekly and driven by the repair dates on the splan. The dates on the schedule are two days before the corresponding repair dates on the splan for the high pressure compressor (HPC) and high pressure turbine (HPT) items to cover kitting of the HPC and HPT.

Single items - The single items schedule is a status report tied in with the repair schedule. Single items do not appear on the splan and are assigned a low priority until ten days before despatch.

Workscope package - The workscope package constitutes all of the documentation required to allow labour and resources to be booked against the work order number and to provide instructions on what operations are to be carried out. Further instructions to the work package are issued as when defects are found or if the Customer has requested additional req'ts.

Standards modifications - Standards modifications are based on service bulletins or otherwise and are work standards conformance requirements.

Figure 6.5 depicts the source and distribution of the information that was analysed during the course of the study. It is not a comprehensive list of the information passed to or from every function or department within the company, but an overview of the information that is significant to the originators and recipients of information within the Engineering, Production Control and Operations (Production) functions.

Information / FUNCTIONS	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
OEM'S	O	O								O					X			
CUSTOMER			O	O					X		O	X						X
SHIPPING					O	O												
M & CS		X	X	X	X	X	O	O	X	X	X	X						O
ENGINEERING							X								O			
Formulate & scope	X	X		X				X	O				O					
Update & scope											X	O		O				
PROD'N CONTROL		X					X											
Work scheduling									X				X	X				
Shop co-ordination																	X	
PRODUCTION																		
CPS receipt S/B/I							X		X				X	X	X	O	O	
RR receipt S/B/A							X		X				X	X	X	O	O	
Frames/Comb repair							X		X				X	X	X	O	O	
Component repair							X		X				X	X	X	O	O	
Test & despatch							X		X				X	X	X	O	O	
MATERIALS							X		X									
QUALITY							X		X									
STORES															X			
DOCUMENTATION		X					X		X							X		
FINANCE							X		X									

Information / FUNCTIONS	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
OEM'S																		
CUSTOMER	X																	
SHIPPING												X					X	
M & CS	X	X	X				X			X		X					X	
ENGINEERING			X									X						
Formulate & scope																		
Update & scope										X								
PROD'N CONTROL											X	X	X					
Work scheduling			O	O	O	O	O	O										
Shop co-ordination	X	O												X				
PRODUCTION											X	X						X
CPS receipt S/B/I			X	X				X					O	O		O		
RR receipt S/B/A			X	X				X					O	O		O		
Frames/Comb repair			X			X							O	O		O		
Component repair			X			X	X						O	O		O		
Test & despatch			X		X			X		O			O	O		O		
MATERIALS	O		X						O			X			O			
QUALITY			X								O	X	X		X			
STORES			X						X									
DOCUMENTATION			X		X							X				X	O	
FINANCE			X									O						O

FIGURE 6.5 - Source and distribution of information

O - source of information

1. Workscope updates
2. Service bulletins
3. Contract/work requirements/unit/serial no.
4. Times/cycles/unit history
5. Engine arrival date
6. Receiving document
7. Shop visit report
8. Work order
9. Workscope summary
10. Warrantee/product improvments
11. Workscope amendments
12. Workscope amendments
13. Workscope package
14. Further instructions to package
15. Standards mofifications
16. Completed workscopes
17. Defect sheets
18. Status reports

X - distribution of information

19. Material shortages
20. Completion date
21. S-plan
22. Front-end (FE) shop schedule
23. Back-end (BE) shop schedule
24. Repair schedule
25. Single items
26. Work-to-list
27. Picking list
28. Engine test report
29. Quality audits
30. Trend analysis/budgets
31. Incident reports
32. WIP status
33. Vendor audit report
34. Requests for technical support/queries
35. Notification to ship engine
36. Labour hour and overtime status

FIGURE 6.6 - Key to Figure 6.5

Detailed modelling from both a normative and empirical viewpoint was undertaken in the application of Stage 7. Examples of the diagrams constructed can be seen in Figures 6.7 to 6.10. Figure 6.7 depicts the activities associated with the production of the 'S-plan', 'inspection order', 'despatch order' and the 'repair schedule', and concentrates on the issue of these schedules to Production. Three of the eight processes explode to further DFDs to represent those activities in more detail. Figure 6.8 represents the activities associated with the production of the 'workscopes'. 'cycle limited part requirements' and 'service bulletin requirements'. Three of the four processes shown explode to represent the activities in greater detail.

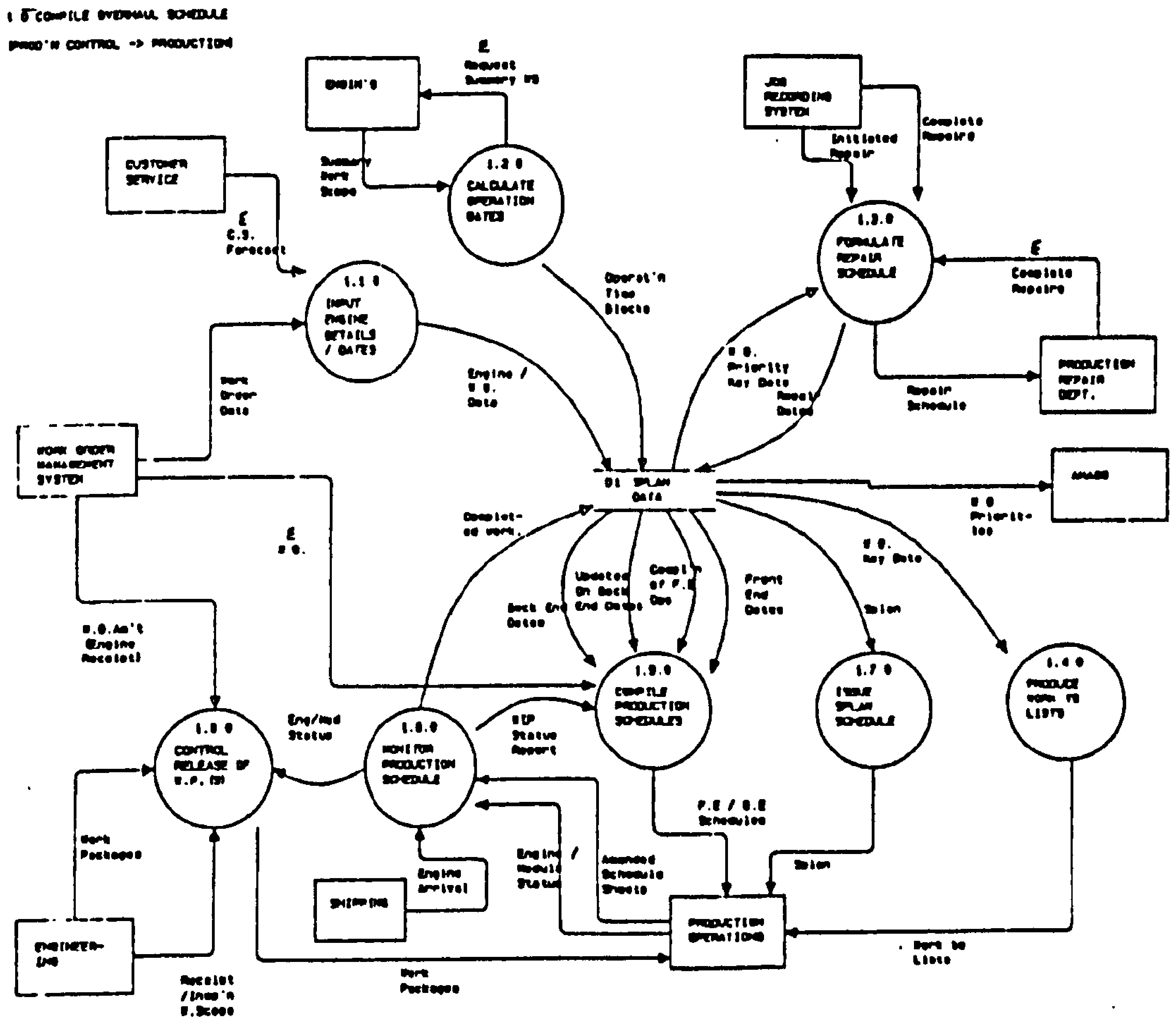

FIGURE 6.7 - Process map (*Compile job overhaul*) (company D)

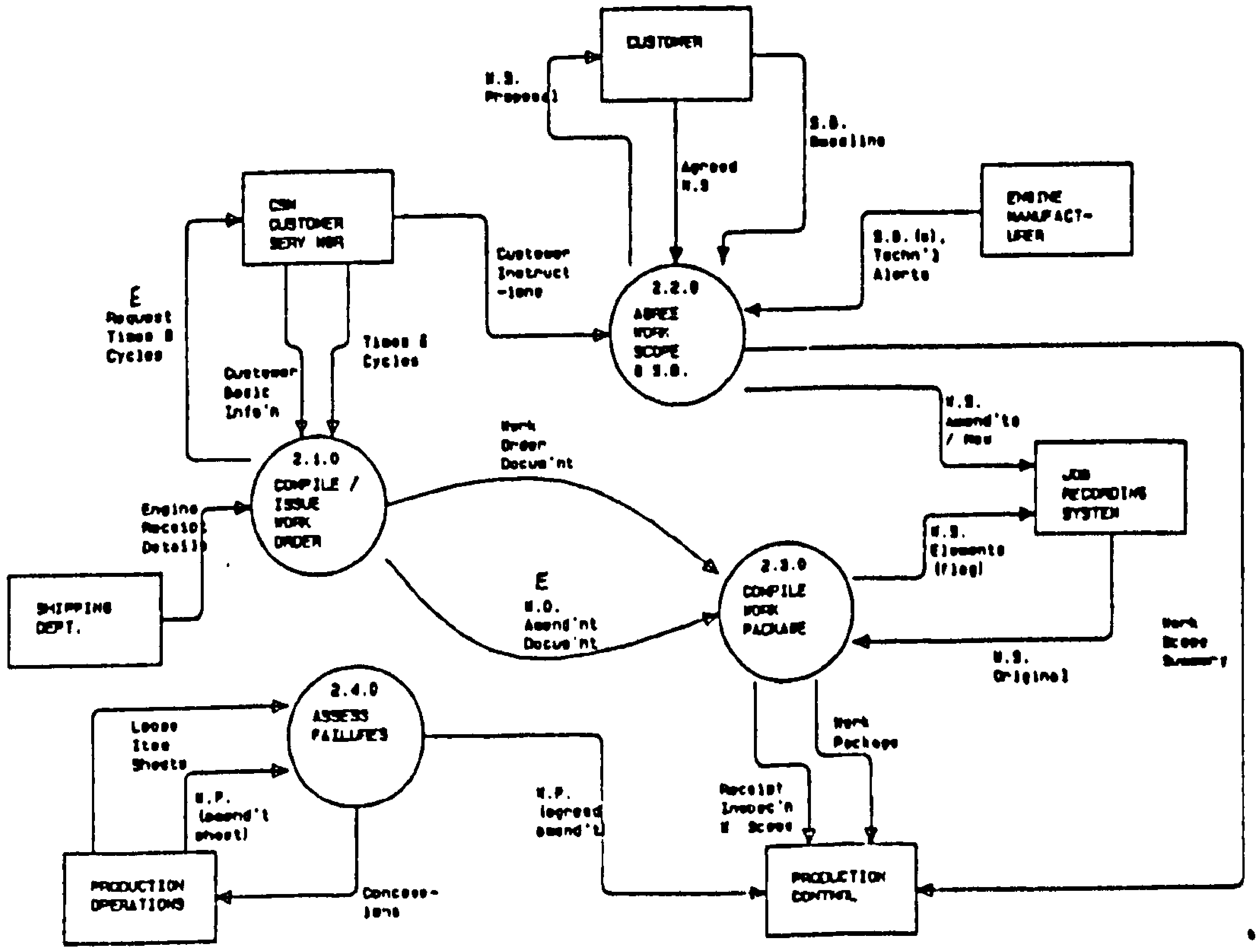

FIGURE 6.8 - Process map (*Formulate workscope packages*) (company D)

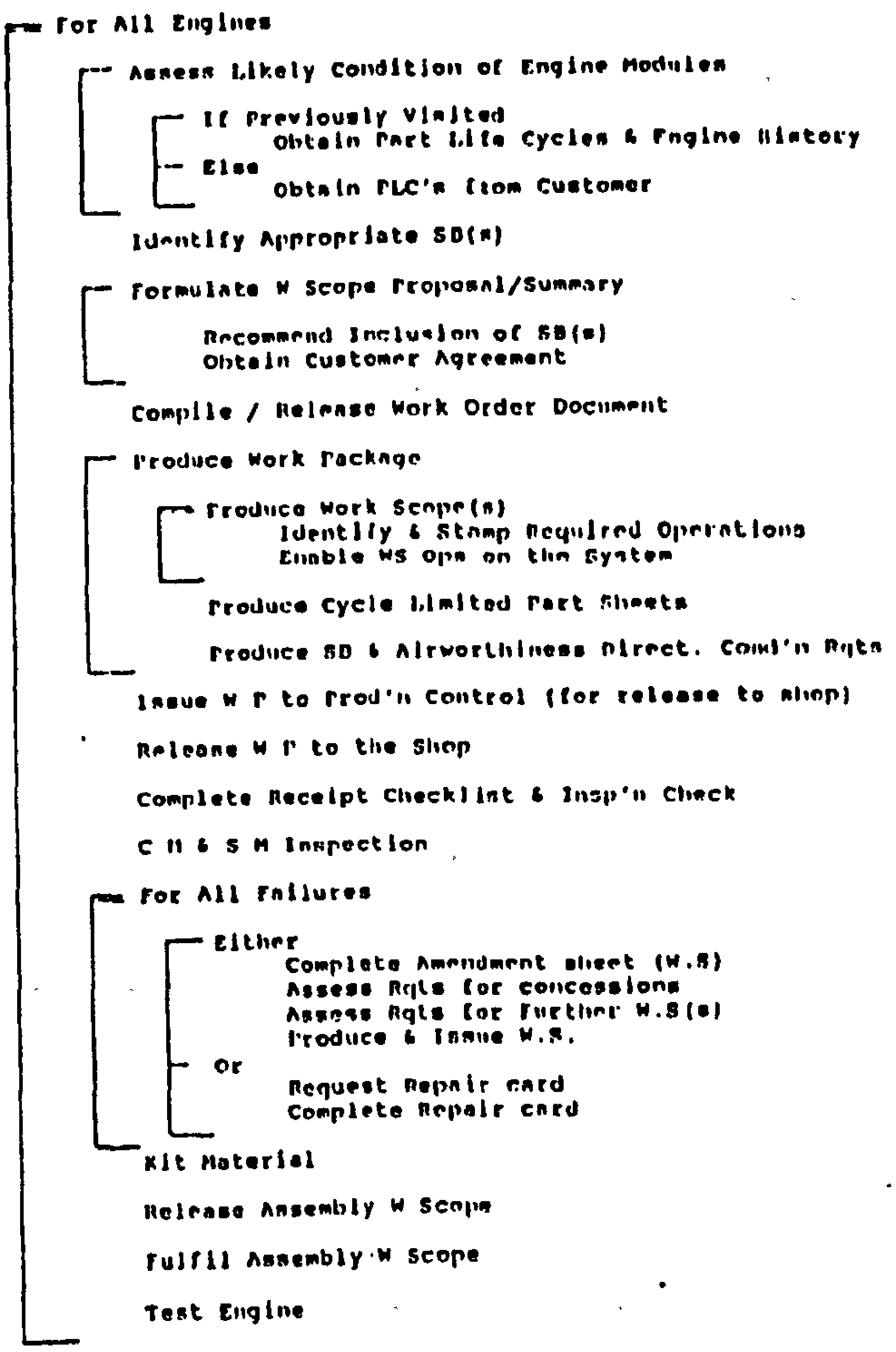

FIGURE 6.9 - Normative action diagram (Engineering to Production) (company D)

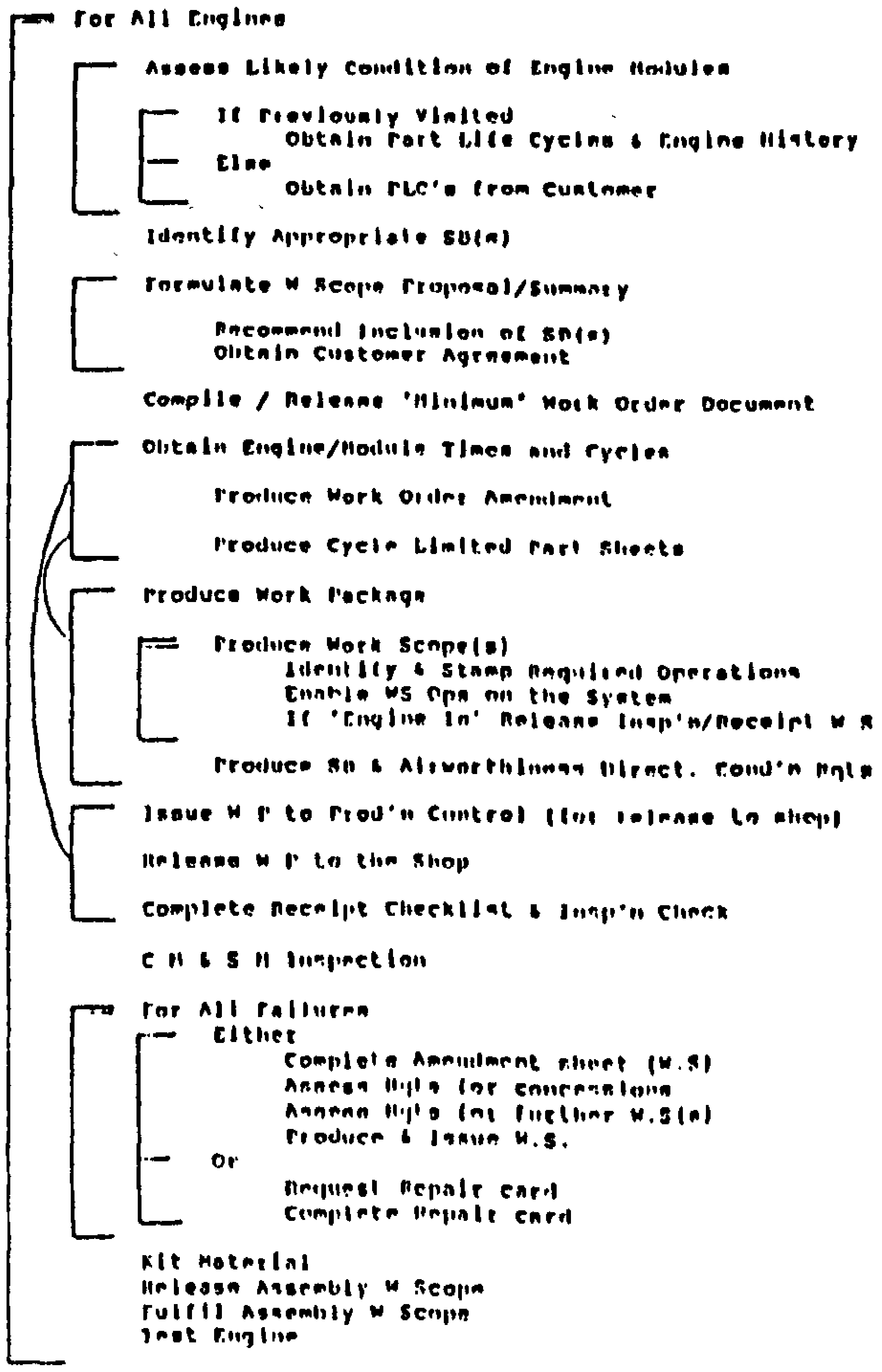

FIGURE 6.10 - Empirical action diagram (Engineering to Production) (company D)

Figures 6.11 and 6.12 depict the main discrepancies between the normative and empirical models constructed.

Normative	Empirical
Engine times and cycles available prior to an engine arrival.	Time and cycles supplied on engine arrival or beyond.
Work order document issued complete.	... issued without times and cycles followed with a work order document amendment.
Work order open prior to engine arrival.	Work order generated after engine arrival.
Issue complete work package.	Issue inspection/receipt workscope in advance of complete work package.
Work package issued prior to an engine/module arrival.	Work package predominantly issued after an engine arrival.
Complete cycle limited part sheets.	Missing data.

FIGURE 6.11 - Engineering to Production normative & empirical discrepancies

Normative	Empirical
Engine details input to s-plan automatically from the work order.	If a work order has not been opened, engine details are manually input from the customer forecast two days prior to its arrival.
Work orders entered on to the despatch order automatically.	For engines 'as received test', the work order is written on to the despatch order.
Operation dates used in the s-plan are calculated from the workscope summary document.	Delay can occur as the result of the workscope summary being late.
Manpower/resources are allocated based upon the requirements of the inspection order.	... requirements of the s-plan.
Concurrent schedules.	S-plan and WIP schedules are issued less frequent tha inspection and despatch order schedules.
Schedule dates feasible.	... dates overlap.
Repair completions are updated automatically from scanning the job record system.	In addition completed repairs are cleared from the repair WIP schedule manually.

FIGURE 6.12 - Production Control to Production normative & empirical discrepancies

In many instances, a complete work package will not have been generated before an engine/module arrives; either the receipt/inspection workscope will be issued to avoid or minimise the time the engine/module is awaiting initial inspection, or the work package may be issued without 'cycle limited part' requirements and/or required 'service bulletins'. The implication of waiting to release the complete work package would be to delay the initial inspectiona nd increase the TRT.

Through releasing the initial receipt/inspection workscope, a period of 2/3 days is available to complete and issue the proceeding workscope(s). If information relating to cycle limited parts is not available at this point, the workscope may be released to prevent further delay.

The main reasons for delaying the generation of a work package is due to the late issue of a work order document to Engineering. This document provides Engineering with a reference 'bar code' to include on each of the workscope sheets. There are many instances when a work order document is issued to Engineering without engine times and cycles present, so preventing the generation of a full work package. There are also occurrences when an engine arrives before a work order has been 'opened'. The implications of this are greater as the minimum time delay includes that to open the work order and to generate the initial workscope. Also ineffective use is made of labour and resources.

Regarding the Production Control to Production interface, engine details are automatically input to the s-plan schedule through the generation of a work order. In the event of a work order not opened, engine details can be input manually. There are cases when an engine has arrived without appearing on the s-plan schedule, resulting in an immediate delay in work commencing on that unit.

The workscope summary issued by Engineering provides Production Control with information relating to the level of work required by an engine/module, which is subsequently used to set operational dates on the s-plan. Delays in receipt of this document have resulted in an engine arriving which does not appear on the s-plan schedule.

The inspection order schedule (generated automatically from the s-plan) provides Production with requirements for engine modules, and is intended as a more detailed schedule. This schedule does not take into account unit capacity, and as a result the dates are considered impractical. Consequently the unit manager has a greater task with scheduling all units against the s-plan date requirements.

For Stage 8, an analysis of the data elements comprising the interfaces between the Production Control to Production and the Engineering to Production functions was carried out.

In order to do this, the first step was to obtain/examine the relevant documents (either on screen or paper) and identify through discussions with the document users; the precise use, relative significance and purpose of each element of data. Having done this, any problems and unfulfilled requirements pertaining to those elements were identified and attributed to one or more of a number of qualitative criteria.

Figure 6.13 represents the outcome of the interviews. It should be noted that the 'qualitative data characteristics' were transient, applied only to certain data elements and were not applicable to every occurrence of the document.

Interface	Data (Information)	Data Characteristics
Production Control to Production	Dates of major operatiions (s-plan)	Inaccurate
Production Control to Production	Inspection, clean & strip dates (FE shop schedule)	Untimely, inaccurate, inaccessible
Production Control to Production	Strip, build, inspection & test dates (work-to-list)	Untimely, inaccurate, inaccessible
Production Control to Production	Repair dates (repair schedule)	Untimely, inaccurate, inaccessible, poor format
Production Control to Production	Priority, repair dates (single items schedule)	Untimely, inaccurate, inaccessible
Engineering to Production	Operations, times & cycles (workscope package)	Untimely, inaccurate, inaccurate, insufficient detail
Engineering to Production	New standards (stds mods.)	Untimely

FIGURE 6.13 - Data problems

The data quality analysis technique was not considered to be practicable in this case.

In order to understand the reasons for the deficiencies identified in the analysis of the data elements and their implications for the business, the results of the Data Analysis became the focus for a Cause and Effect or Fishbone Analysis. The detailed results have been represented by way of the two fishbone diagrams shown in Figures 6.15 and 6.16. Each category of 'cause' represents a data attribute to which were assigned the specific reasons for the deficiencies. It must be noted that delays and the inability to adhere to scheduled dates and consequently increased TRT were the most damaging potential effects in the shorcomings of the analysed information. However, for both interfaces, other possible effects include:

- reduced throughput,
- queuing at work centres,
- ineffective resource planning,
- allocation of overtime.

It must be noted that 'information' was only one of several contributory factors to these 'effects'.

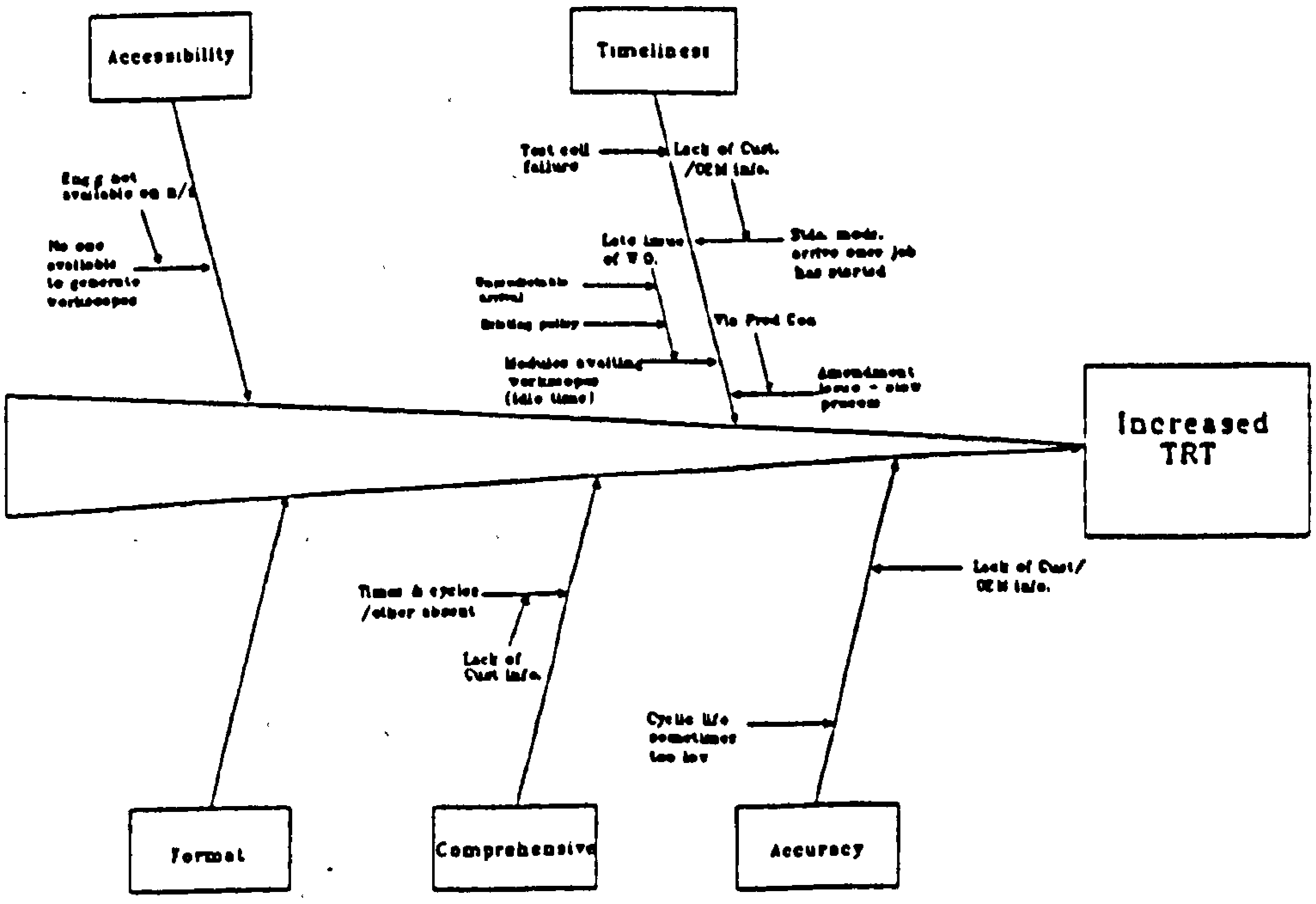

FIGURE 6.15 - Fishbone diagram (Engineering to Production) (company D)

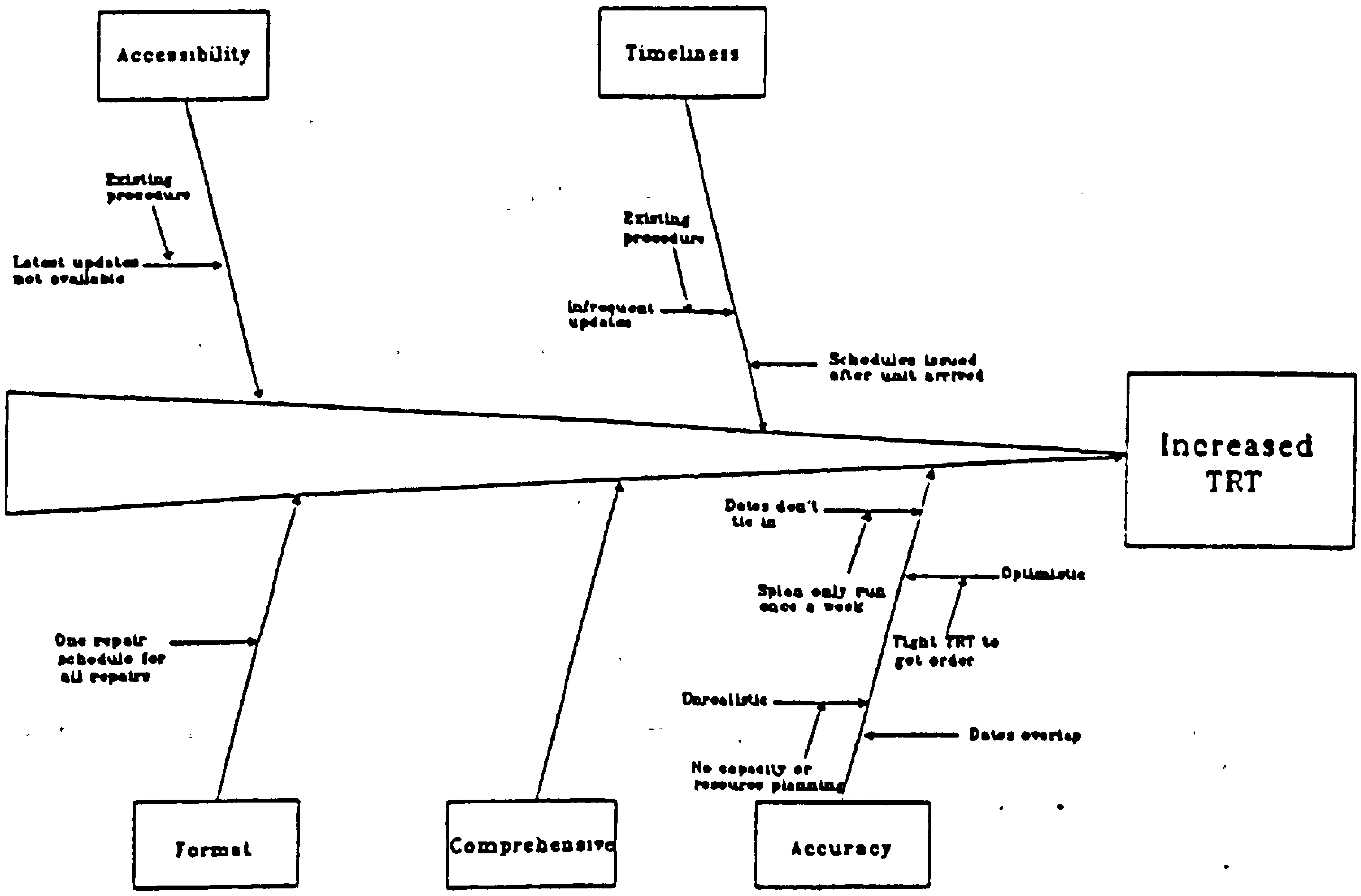

FIGURE 6.16 - Fishbone diagram (Production Control to Production) (company D)

For the Production Control to Production interface, the majority of the 'causes' listed can be attributed to one of the following;

- the availability of the latest schedule updates,
- the time and frequency by which schedules are issued,
- the realism and integrity of the various target dates.

Schedules are updated every day from information based on any foreseeable 'shop' problems and the WIP status of material in each area, but the latest versions of these updates are not always available for Production as the splan and work to list are issued weekly and the remaining schedules twice weekly. This is mainly due to the fact that the target dates on the splan are the main drivers for the shop and are primarily based on promised TRT. Hence, there is a reluctance to amend these, and unit shops are required to 'catch up' where and whenever possible. This usually means the allocation of extra overtime when schedule dates overrun.

Each of the principal schedules are either generated or derived from the splan, and so dates on the 'child' schedules often don't tie in with those of the splan due to the difference in the number of times the splan and the other schedules are issued, i.e. the latest issue of the FE schedule will have incorporated any updates based on WIP status and will be more up to date than the current version of the splan.
This can result in an ambiguity as to which is the target or required date for a unit shop to work to. At times, schedules are issued after an engine or unit has arrived and there is an immediate delay in work starting on that unit. The usual reason for this is the late generation of the workscope summary and work package by Engineering which in turn may have been caused by an unexpected engine arrival or the late issue of a work order by Customer Services.

Scheduled dates often have the following characteristics:

- optimistic,
- unrealistic,
- don't correlate between schedules,
- overlap from one schedule to another.

Short delivery supply is a necessary business requirement and as such, tight TRT's and schedule dates will be quoted to a Customer or potential Customer. The nature of the business means that 100% accuracy in planning is never possible and these dates tend to be optimistic. At present, the schedules assume unlimited capacity in all work centres, whereas in reality some work centres always behave as bottlenecks; consequently schedule dates always overrun. Realistic schedules will only become apparent when effective job prioritising and capacity and resource availability are taken into consideration. As already stated, schedule dates don't always correlate and can overlap if a particular job has overrun.

For the Engineering to Production interface, the majority of the 'causes' listed can be attributed to one of the following:

- 'hardware available but paperwork not' (idle time),
- lack of Customer and/or OEM information.

Engineering cannot issue a workscope package for an engine or unit until that unit has been assigned a work order number by Customer Services. A work order can only be produced once the information required to overhaul the unit has been collated. Packages are initiated and supplied to the shop floor by Production Control, and ideally, this is done immediately before the unit it refers to is received at the factory. Once the package has been initiated i.e. the job numbers made available on the job recording system, the order may be scheduled and work on the unit may commence. However, even though a work order can be 'opened' or 'pre-allocated' with the identification of the type of unit to be overhauled, the Customer and the serial number (so that its previous overhaul history can be looked up), a complete workscope package cannot be generated and issued by Engineering until the necessary 'times and cycles' information (TSN, CSN, TSO and CSO figures) pertaining to that unit has been identified. This information can literally arrive at any time between obtaining the contract and receiving the unit and beyond, and is one of the biggest uncertainties in the business. It can result in considerable 'idle time' through the delay of the generation and issue of a complete work order document by Customer Services and hence the production of workscopes by Engineering and the initiation and release of these workscopes by Production Control.

Upon receipt of the unit, a CT (line tag) number and a RR (receiving document) number are raised by Shipping, and if an initial work order has been opened, a work order amendment is raised to incorporate these numbers. Amendments are issued whenever any additional information required to compile the work order, such as times and cycles or additional Customer requirements, is obtained.

There are several other reasons for the late generation of accurate and complete work packages to the shop floor; several of which are attributable to the lack of Customer and/or OEM information. They include:

- unpredictable arrival of unit at factory,
- no Customer Service personnel available to authorise the issue of a work order (at weekends for example),
- times and cycles incomplete or incorrect,
- no Engineering personnel available to generate workscopes and answer queries (weekends, nightshifts),
- unpredictable time of receipt of the latest OEM service bulletins,
- amendment to workscopes is a slow process.

For Stage 9, an analysis of the requirements of the recipients and users of the information interchanged between the Production Control to Production and the Engineering to Production functions was undertaken.

The results of the findings have been represented in Figures 6.17 (Production Control to Production) and 6.18 (Engineering to Production). Requirements have only been tabulated where a clear need was identified. Each of the identified requirements has been assigned to one of six categories; five of which are the information attributes hich have been used before and one 'other' category to represent any requirement which cannot be assigned to any of the attributes. (The requirements were the interpretation of the views obtained from interviews with key Production personnel.)

Timeliness	- FE and repair schedule to be updated more frequently (a)
Accuracy	- All schedule dates to equate (b) - All schedule dates to be realistic (c) - Splan to take account of capacity, potential bottlenecks & resource availability (d)
Accessibility	
Completeness	- Splan to take account of capacity, potential bottlenecks & resource availability (d)
Format	- Comp. repair & frame/combustor repair to be on different repair schedules (e)
Other	- Job priorities to be based on times for operations & available capacity as well as 'FIFO' (f) - Gradual rather than abrupt increase of single items priority (g)

FIGURE 6.17 - Requirements of information from Production Control

Timeliness	- To always receive the necessary standards mods. prior to the arrival of an engine or unit (a) - Workscope package to be available as soon as a unit arrives (b) - Amendments to workscopes to be issued as soon as they are formulated (c)
Accuracy	- Times & cycles to be correct/reliable (d)
Accessibility	- Engineering personnel to be available at all times to answer queries & generate workscopes (e) - Workscope package to be available when shop ready for the 'job' (f)
Completeness	- Relevant times & cycles to be incorporated in each workscope (g) - Minimum unforeseen additions to workscopes (h)
Format	
Other	- OEM information to be available (i)

FIGURE 6.18 - Requirements of information from Engineering

To identify a reasonable balance between the cost and value of information, a cost/benefit analysis of the users' specifications was undertaken.

Reqt	Benefits	Feasibility/Costs
(a)	Better visibility & planning & therefore problems (bottlenecks) could be anticipated easier & reacted upon.	More paperwork for Production Control to generate. Version control problems would arise.
(b)	No ambiguity of target dates.	All schedules would have to be issued an equal number of times each week. (Note: it is deliberate that the repair dates for the HPC & HPT on the splan & repair schedule are different.)
(c)	Minimal re-scheduling, slack for any unforeseen problems, better visibility & less overtime.	Quoted TRT may have to be increased. Capacity & resource planning required (see (d)).
(d) (f)	Increased throughput & therefore reduced TRT, ability to name exact dates when jobs complete & better efficiency.	Expensive requirement to fulfil comprehensively. It will eventually be met by MCC system.
(e)	Easier for repair unit managers to visualise their workload.	Existing repair schedule would have to be sub-divided.
(g)	Adherence to single item due dates.	An additional 'single items controller' function or position would be required.

FIGURE 6.19 - Cost/benefit analysis of information from Production Control

Reqt	Benefits	Feasibility/Costs
(a)	Any tooling & work requirements could be catered for & therefore less delay.	Dependent on timely information from OEM's.
(b)	No idle time.	Work order would always have to be issued prior to an engine arrival as would the receipt of relevant Customer information.
(c)	Reduced idle time.	Procedural change - jobs would have to be 'rushed through'.
(d)	No unnecessary revisions or amendments.	Dependent on accuracy of information supplied by the Customer.
(e)	No idle time - workscopes could be generated at any time & queries could be answered.	Extra overtime &/or personnel required.
(f)	See (c).	See (c).
(g)	See (d).	See (d).
(h)	See (d).	See (d).
(i)	For reference & to see how any recommendations have been incorporated in workscopes.	Feedback from Engineering.

FIGURE 6.20 - Cost/benefit analysis of information from Engineering

Since it is usually necessary to rely at least partially on subjective evaluation of information benefits, it is important and taken for granted that key users have a good conceptual grasp of the factors that contribute to value, but it is quite evident that for several of the identified users' requirements, there is an obvious imbalance between the costs and resources required to implement these requirements and the potential rewards obtained from them. However, the potential benefits obtained in increased efficiency for addressing and implementing two 're-occurring' requirements in particular, namely:

- the production of timely and accurate schedules with effectively prioritised operations taking into account the availability of existing capacity and resources, and,
- the issue of accurate and complete workscope packages to the shop floor prior to the arrival of an engine at the factory,

would appear to far outweigh any costs incurred in satisfying those requirements.

In an environment where short delivery supply is the key business driver and consequently cycle times have to be at their optimum for business success, it is imperative that information flow between essential business functions is timely and of sufficient quality to ensure its reliability, accuracy and completeness.

Two information-related issues were considered to be significantly detrimental to TRT (and hence the information flows pertaining to these isues showed considerable deviation from the optimum) in the analysis of the Production Control to Production interface:

- schedules are based on time blocks, not available capacity and resources, and as such tend to overload the shop;
- jobs are added to the schedule as and when they arrive - no prioritising criteria are considered to calculate a near-optimum schedule.

Both of these issues together mean that each unit shop is rarely capable of adhering to its due dates without allocating overtime and smoothing resources. As a result, schedules are unrealistic and overrun and consequently 'child' schedules are undermined and only used as guidelines by the unit shop personnel who channel their energies into achieving an optimistic splan target date.

Current practice is that jobs are passed through the factory on a 'FIFO' basis, production schedules assume infinite capacity in all work centres and 'queuing' of jobs at critical machines and processes has become the norm. The root cause of the throughput problem is not solely information; the main contributory factor is the inherent, unpredictable nature of the business which depends on a series of state-of-the-art test and inspection processes which can go awry, lead to changes in the assumed workload and long waits for parts.

'Rough cuts' based on workscope summaries to highlight future workload and provide an initial view of potential trouble spots, the recognition of bottleneck machines and processes and staggering input within the shop and the arrival dates of engines at the factory would go some way to combating shop overload and controlling job priorities.

The company is addressing these problems and has envisaged that MCC will improve throughput and efficiency by producing precise schedules based on a model of the shop floor and the simulation of the effect of changes in materials needs and available man hours using realistic capacities in every department.

Other information-related findings worthy of note were:

- the frequency with which schedules are issued (which means that the latest updates are not always available as and when required) inhibits effective resource planning and the anticipation of potential problems;

- although each engine's arrival is known in advance, receipt can be unpredictable and delays can occur to prevent the airline delivering on time, such as faults in other engines that mean the scheduled unit is required for use;

- the 'Info' system does not distinguish weekends from week days and 'work' can be set up for a weekend at a time when no one is available;

- single items due dates are rarely achieved as they are effectively ignored until ten days before the promised despatch date.

The one overriding issue identified in the analysis of the Engineering to Production interface was that engine workscope packages are rarely issued prior to the arrival of that engine. As a result there is an inevitable delay in the initiation of the workscopes and the receipt-inspection duration, and hence TRT are adversely affected. The root cause of the problem usually lies with the Customer, and the inability of the Customer to consistently provide all of the required information for a complete work order to be raised and for Engineering to generate the necessary workscopes. This means that, in the main, a large portion of the time it takes to generate a complete work package (usually 2 to 2.5 days) is unnecessarily added to TRT and the shop is immediately required to 'catch up'.

However, the late issue of complete work orders and consequently work packages is not solely attributable to the inadequacies of information supplied by a Customer:

- Customer Services and Engineering personnel work neither night-shifts nor weekends regularly and are therefore not always available to authorise work orders, generate workscopes and answer any queries that arise;

- Customer Services pre-allocate work orders whenever possible even though the work order may not provide enough data for Engineering to generate a full workscope summary or work package. However, workscopes are not pre-allocated and are triggered only by the receipt of a work order by Engineering. When an engine arrives prior to the issue of a work order, the first workscope, which for any package consists of a set of standard receipt inspection operations and can define in some instances the remainder of the work package, is delayed. Pre-allocation of work would prevent this delay.

Other information-related findings worthy of note were:

- information (for example 'times and cycles') provided by the Customer is not always completely accurate;
- standards mods. pertaining to a workscope are often issued after the arrival of that workscope;
- the issue of amendments and further instructions to workscopes is a slow process.

A typical manufacturing company that has the luxury of a visible workload forecast, minimum variations on jobs and flexibility of lead-times simply has an easier row to hoe than a company in the aero engine overhaul business which has none of these, but has unique characteristics that mean an extremely difficult task in scheduling and planning and consequently unpredictabilities and uncertainties in its information flow.

The application of IQ*Analyst* identified several of these uncertainties in the interchange of information between essential business functions. Each uncertainty is recognised as being detrimental to TRT, the key business driver, and as such as a key loss-making or profit-inhibiting area that needs to be addressed by senior managers as part of their overall business strategy. The need to insulate the business from the causes of these uncertainties was emphasised and the issues that needed to be addressed to do this were identified.

6.6 - CASE STUDY 4

6.6.1 - Application of Stage 1 (Project Start-Up & Business Overview)

The company *Strategic Plan* consisted of a series of market position objectives, operating strategies and resource plans designed to ensure future profitability and to realise the company's long-term mission to be the leading UK valve supplier.

The most salient points of this document were extracted and summarised as follows:

- Increase unit volume sales in commodity products (MS Gate Valves, RS Gate Valves, Hydrants) through annual and multiple year contracts by promoting the company's capability as a reliable supplier with a quality product and by identifying and aggressively bidding for contracts. Cost reduction activities for this objective will focus upon re-design to achieve commonality of parts across product ranges. Target cost reduction is 30%. This objective also requires CNC turning and Hydrant manufacturing capabilities to be increased.

- Achieve two orders of over £100,000 per month by developing a response procedure and package that establishes the company's credibility as perceived by the Customer. This will involve a greater emphasis on integration of the Engineering and Sales databases.

- Achieve 2.5% market share in Spain and Portugal mainly through commodity sales by developing the direct distribution capability in the Iberian Peninsula.

- Increase Butterfly Valves sales by responding to enquiries with competitive prices and suitable specifications. This will require design improvements throughout the existing Butterfly range and increased CNC capabilities.

- Develop niche sales of Automatic Valves by refining existing designs. This requires

- a comprehensive cost reduction programme to be set up and machining capability to be increased.

Although the quality of product provided by the company is generally appreciated by Customers, the gaining of contracts for orders has become fiercely competitive. In the past, the company was able to follow a general pricing policy. Now, price is the most important factor in deciding which valve supplier gains a contract. Recently, the company's inability to control internal costs, coupled with heavily devalued pricing from sheer competitive intensity and fiercely competitive bidding for contracts have increasingly depressed margins.

It was generally agreed amongst the management team that for the foreseeable future the demand for goods would remain relatively static in both the specialist and commodities sections of the market but increase and be potentially quite lucrative in niche markets (i.e. Automatic Valves). By value, the company had about 2% global market share, 15% UK market share in commodities valves and 35-40% UK market share in specialist valves.

The company's competitive position was generalised by the following matrix in Figure 6.21.

Prospects for profitability -------> Current position	Poor	Steady	Good
Weak			*Niche*
Medium		*Commodities*	
Strong		*Specialist*	

FIGURE 6.21 - Competitive position matrix

The company's name and engineering reputation were amongst its most valuable assets, along with its commitment to new product development and willingness to compete. However, it had suffered from its poor delivery performance, high internal costs and a lack of aggression in bidding for contracts. Strengths and weaknesses were summarised using a SWOT analysis (FIgure 6.22).

Strengths	Weaknesses
Strong brand name. Solid engineering expertise. Value of Group association. Recent investment. Willingness to compete. Commitment to new product development. Fighting spirit.	Poor delivery performance. Lack of aggressive selling. High internal costs. Low margins. Inconsistent performance. Resistant to change. Sub-optimal information systems.
Opportunities	**Threats**
Cost reduction through improved efficiency. New designs. Global demand. Specialist expertise. Niche market penetration.	Political instability in certain markets. Price war. Competitor reactions. More effective competition.

FIGURE 6.22 - SWOT analysis

An analysis of order-winning criteria and the company's performance against those criteria was undertaken through the consolidation of the results of a senior management questionnaire and from those of a market research study undertaken by MBA students from the local Business School.

Figure 6.23 represents a summary of the criteria identified.

Priority	Critical Success Factor	Performance
1	Price (Profit on price)	N/A (Poor)
2	Delivery	Poor
3	Speed of quotation submission	Fair
4	Product quality	Good
5	Previous track record	Good
6	Product design	Good
7	After sales service	Good
8	Technical assistance	Good

FIGURE 6.23 - CSF summary

A synthesis of the company's *Strategic Plan*, its competitive position, SWOT profile and performance against order-winning criteria highlighted the following key issues (Figure 6.24) that were subsequently used for IS planning in the application of Phase 1 of the Methodology. The issues represent the ambition of the business in a form which is suitable for IQ*Analyst*.

Strategic Issue	Relative Priority
Reduce costs.	40
Improve 'quotes to orders' conversion rate.	40
Improve delivery performance.	20

FIGURE 6.24 - Strategic Goals (company E)

6.6.2 - Application of Stage 2 (Determine Existing Systems Effectiveness)

An Information Model representing the current status of IS within the company was constructed. Figures 6.25 to 6.26 depict examples of sections of the Model.

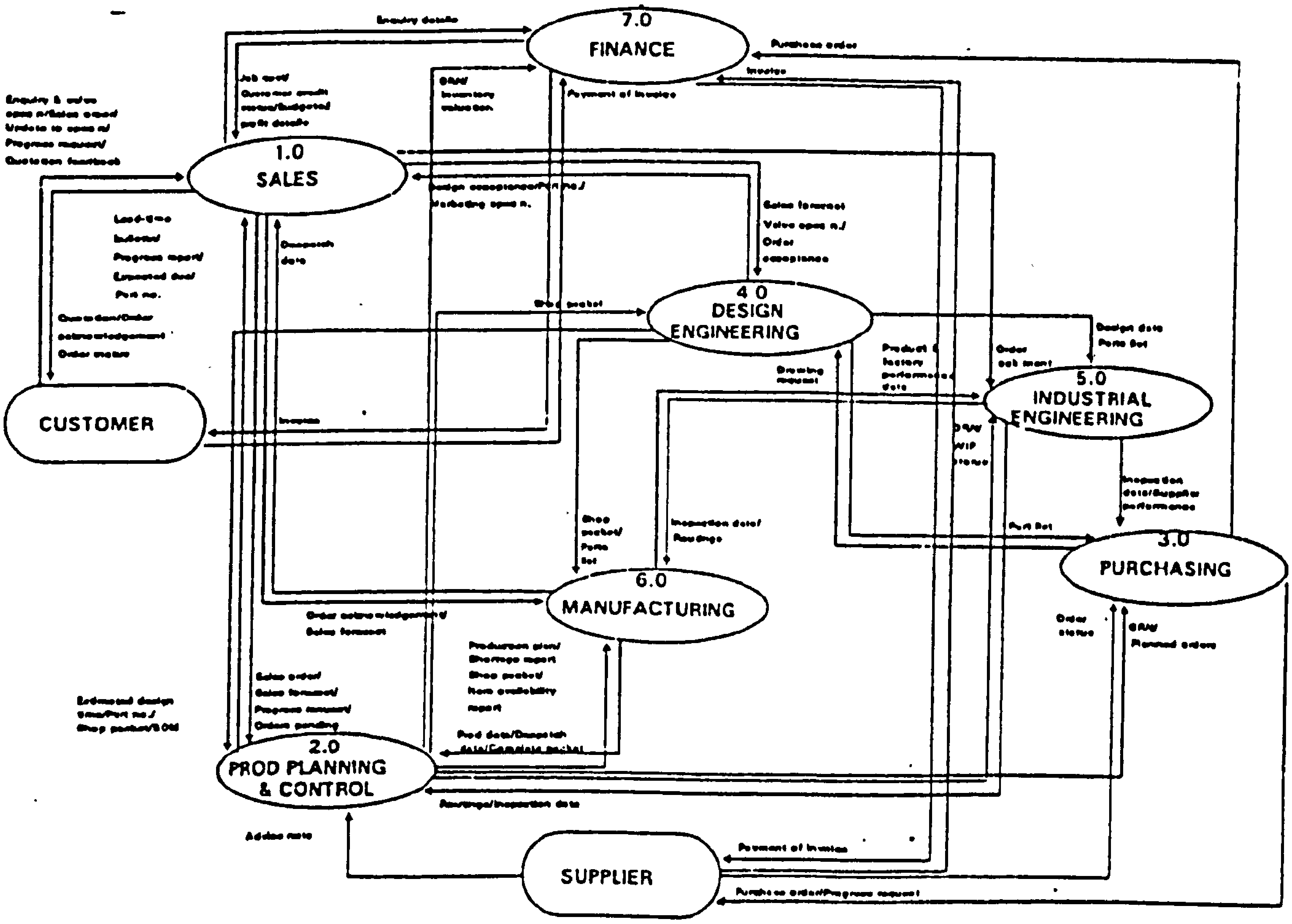

FIGURE 6.25 - Enterprise map (company E)

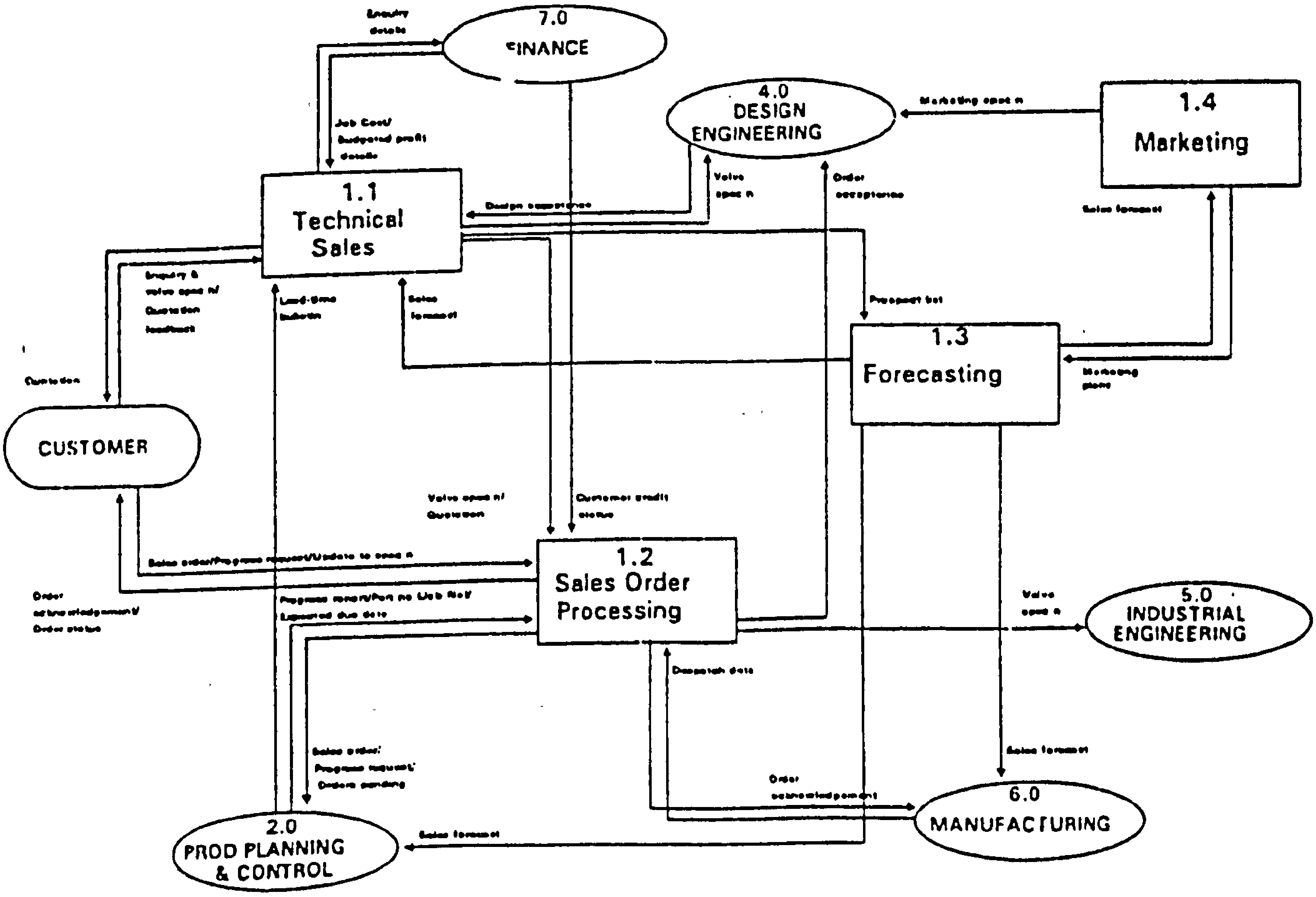

FIGURE 6.26 - Function map (section) (company E)

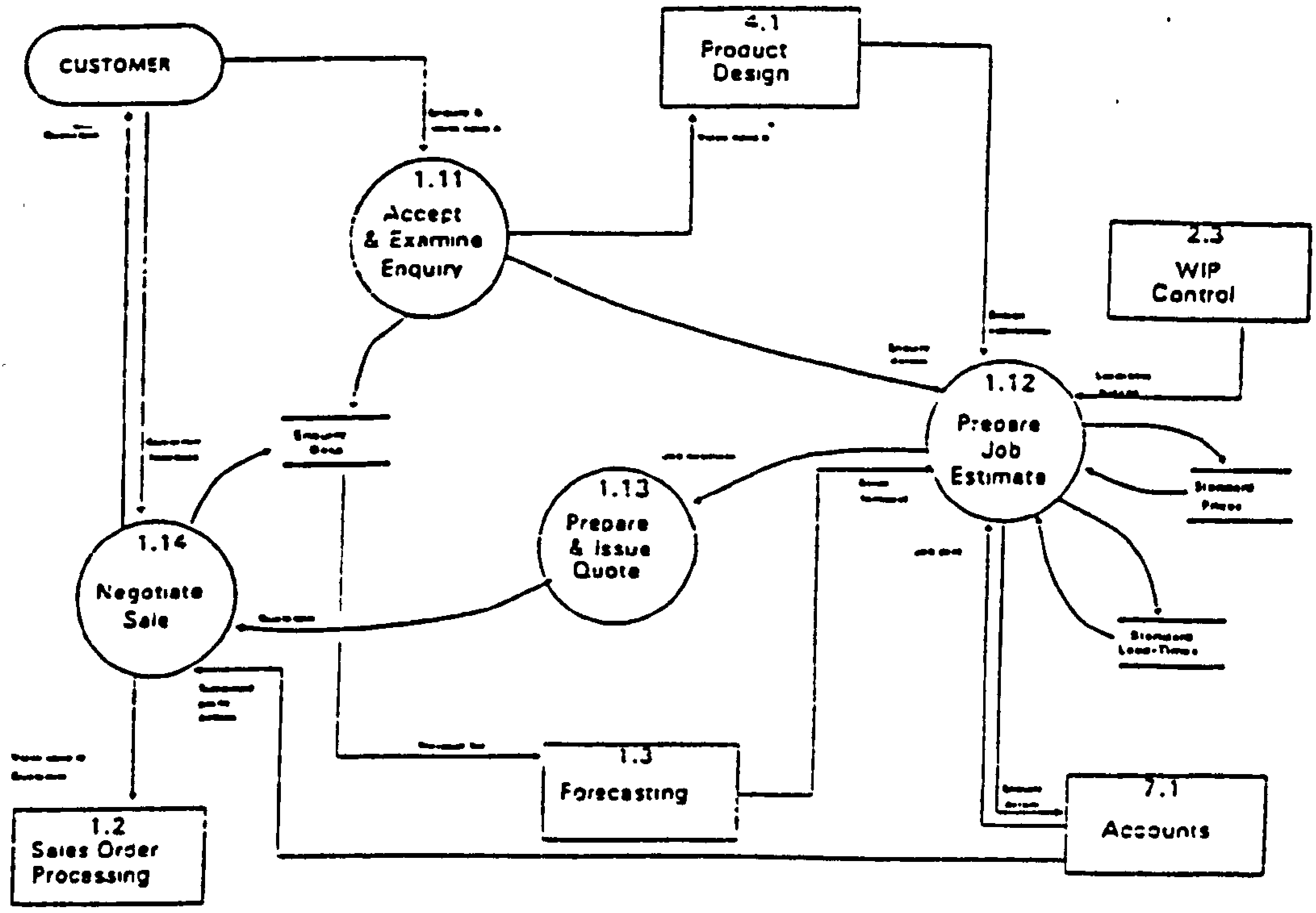

FIGURE 6.27 - Process map (section) (company E)

The company's *Information Model* was a pot-pourri of manual and computerised IS. Many of the traditional data processing functions had been automated within the company on IBM AS/400 equipment. In recent years the company has converted its IBM MAAPICS applications to the latest MAAPICS/DB upgrade. However, the individual MAAPICS modules had been implemented in a piecemeal fashion with no formal commissioning and implementation strategy. As a result, there are significant shortfalls in the existing systems. The major computerised systems were as Figure 6.28.

Application	System
Quotation processing	Stand-alone database
Sales order processing	MAAPICS/DB module
Forecasting	Stand-alone database
Inventory control	MAAPICS/DB module
Material planning	MAAPICS/DB module
Manufacturing control	MAAPICS/DB module
Product drafting	Autocad
Manufacturing data management	MAAPICS/DB module
Shipping & invoicing	MAAPICS/DB module

FIGURE 6.28 - Computerised IS (company E)

Through data gathering and interviewing, many problem statements were collected. These statements were grouped into meaningful problem areas that were directly related to the *business functions* and *processes* as shown on the Function Maps and DFDs.

In reviewing the list of problems, many of them were found to be directly related to the quality of information. To quantify these information deficiencies, each interviewee was asked to assign a series of ratings to each of the key information items required by the *business functions* for which they were responsible (IQA).

Deficiencies fell into five basic classifications of information attribute:

- timeliness - the extent to which users experience delay in obtaining information,
- accuracy - the extent to which information is factually and numerically correct,
- accessibility - the extent to which information is readily available,
- comprehensiveness - the extent to which information is free of omissions,
- format - the extent to which information is in a useable form.

The ratings for these attributes represent the effectiveness of existing systems support' for each business function. The importance or relevance of each information requirement is also established. The relevance' rating is based on the perceived impact that the information has on the business function for which it is required. The assignment of ratings to information requirements enabled the following set of function-oriented matrices to be constructed:

1.1 - TECHNICAL SALES

Information requirements v. information attributes	Rel	Tim	Acc	Acs	Com	For
Enquiry & valve spec'n (Customer)	10	10	8	10	8	10
Lead-time bulletin (WIP Control)	10	3	4	10	10	10

1.2 - SALES ORDER PROCESSING

Information requirements v. information attributes	Rel	Tim	Acc	Acs	Com	For
Expected due date (Scheduling)	10	4	1	10	10	10
Sales order (Customer)	10	10	8	10	8	10
Progress report (WIP Control)	10	8	8	1	4	5
Part no. (Scheduling)	10	5	6	10	10	10
Customer credit status (Accounts)	10	6	10	6	10	10
Despatch data (Despatch)	9	4	8	4	9	9

2.1 - INVENTORY CONTROL

Information requirements v. information attributes	Rel	Tim	Acc	Acs	Com	For
Advice note (Supplier)	10	6	6	8	6	7
Shop packet (Product Drafting)	10	6	7	8	7	10
Complete shop packet (Materials Processing)	10	7	8	7	8	9

2.2 - MATERIAL PLANNING

Information requirements v. information attributes	Rel	Tim	Acc	Acs	Com	For
WIP status (WIP Control)	10	6	7	9	7	9
Castings inventory status (Inventory Control)	10	5	9	10	9	9
Inventory status (Inventory Control)	10	5	7	10	9	9
Sales forecast (Forecasting)	10	7	6	7	7	8
Sales order (Sales Order Processing)	10	7	9	8	8	7
BOM (Product Design)	10	7	9	9	8	7

2.3 - WIP CONTROL

Information requirements v. information attributes	Rel	Tim	Acc	Acs	Com	For
Inspection data (Quality Engineering)	10	8	9	9	9	9
Production data (Manufacturing Control)	10	7	8	8	4	7

2.4 - CAPACITY PLANNING

Information requirements v. information attributes	Rel	Tim	Acc	Acs	Com	For
Routings (Process Planning)	10	6	6	6	8	6
Standard times (Process Planning)	8	0	0	0	0	0

2.5 - SCHEDULING

Information requirements v. information attributes	Rel	Tim	Acc	Acs	Com	For
WIP status (WIP Control)	10	6	7	9	7	9
Castings inventory status (Inventory Control)	10	5	9	10	9	9
Inventory status (Inventory Control)	10	5	7	10	9	9
Sales forecast (Forecasting)	10	7	6	7	7	8
Sales order (Sales Order Processing)	10	7	9	8	8	7
Orders pending (Sales Order Processing)	8	8	9	10	8	9
Estimated load (Capacity Planning)	8	6	2	4	2	2
Despatch data (Despatch)	8	8	8	5	8	5

3.1 - PURCHASE ORDER PROCESSING

Information requirements v. information attributes	Rel	Tim	Acc	Acs	Com	For
Planned orders (Material Planning)	10	3	4	10	8	10
Parts list (Product Design)	10	7	8	7	8	9
GRN (Inventory Control)	10	10	8	10	7	10
Purchase requisitions	9	5	9	10	8	10

4.1 - PRODUCT DESIGN

Information requirements v. information attributes	Rel	Tim	Acc	Acs	Com	For
Order acceptance (Sales Order Processing)	10	7	8	9	8	10
Marketing spec'n (Marketing)	10	7	8	6	7	7
Sales forecast (Forecasting)	8	8	3	6	5	5

4.2 - PRODUCT DRAFTING

Information requirements v. information attributes	Rel	Tim	Acc	Acs	Com	For
Shop packet (Scheduling)	10	3	7	10	10	10
Drawing request (Purchasing)	10	6	6	10	7	10

5.1 - QUALITY ENGINEERING

Information requirements v. information attributes	Rel	Tim	Acc	Acs	Com	For
WIP status (WIP Control)	10	8	8	8	8	8
GRN (Inventory Control)	10	6	10	8	8	8
Test report (Manufacturing Control)	10	8	9	9	9	9
Order acknowledgement (Sales Order Proc'g)	10	6	7	6	8	8
Part list (Product Design)	10	7	8	9	9	9

6.1 - MANUFACTURING CONTROL

Information requirements v. information attributes	Rel	Tim	Acc	Acs	Com	For
Shortage report (Scheduling)	10	6	8	10	7	9
Production plan (Scheduling)	10	4	9	7	10	6
Parts list (Product Design)	10	7	9	10	10	10
Shop packet (Inventory Control)	10	6	6	8	6	7
Inspection data (Quality Engineering)	10	8	8	3	9	10

6.3 - MAINTENANCE

Information requirements v. information attributes	Rel	Tim	Acc	Acs	Com	For
Maintenance request (Material Processing)	10	10	8	10	8	10
Breakdown sheet (Material Processing)	10	8	10	10	7	10
Budget feedback (Accounts)	8	7	6	8	9	10

6.4 - DESPATCH

Information requirements v. information attributes	Rel	Tim	Acc	Acs	Com	For
Order acknowledgement (Sales Order Proc'g)	10	7	7	7	4	7
Production plan (Scheduling)	10	4	8	8	8	8
Item availability report (Inventory Control)	10	10	9	10	7	7
Order complete (Manufacturing Control)	10	10	7	10	7	7

A second, corresponding set of matrices was derived from the first set of information matrices. In this case, the relevance ratings are expressed as percentages. The remaining attribute ratings are weighted to reflect their relative significance and compounded to produce a function total for each information requirement.

The difference between each relevance and function total rating is an information quality variance and as such a measure of the effectiveness of each information requirement. Each variance can be used to assist prioritising proposed developments. The following represent the set of matrices obtained.

1.1 - TECHNICAL SALES

Information requirements v. weighted information attributes	Rel	Tot	Var
Enquiry & valve spec'n (Customer)	100	92	8
Lead-time bulletin (WIP Control)	100	54	46

1.2 - SALES ORDER PROCESSING

Information requirements v. weighted information attributes	Rel	Tot	Var
Expected due date (Scheduling)	100	49	51
Sales order (Customer)	100	92	8
Progress report (WIP Control)	100	64	36
Part no. (Scheduling)	100	68	32
Customer cred status (Accounts)	100	78	22
Despatch data (Despatch)	90	59	31

2.1 - INVENTORY CONTROL

Information requirements v. weighted information attributes	Rel	Tot	Var
Advice note (Supplier)	100	63	37
Shop packet (Product Drafting)	100	69	31
Complete shop packet (Materials Processing)	100	75	25

2.2 - MATERIAL PLANNING

Information requirements v. weighted information attributes	Rel	Tot	Var
WIP status (WIP Control)	100	70	30
Casting inv status (Inv Con)	100	75	25
Inventory status (Inv Con)	100	69	31
Sales forecast (Forecasting)	100	67	33
Sales order (Sales Order Pro'g)	100	78	22
BOM (Product Design)	100	80	20

2.3 - WIP CONTROL

Information requirements v. weighted information attributes	Rel	Tot	Var
Inspection data (Quality)	100	86	14
Production data (Man'g Control)	100	71	29

2.4 - CAPACITY PLANNING

Information requirements v. weighted information attributes	Rel	Tot	Var
Routings (Process Planning)	100	62	38
Standard times (Process Plan'g)	80	0	80

2.5 - SCHEDULING

Information requirements v. weighted information attributes	Rel	Tot	Var
WIP status (WIP Control)	100	70	30
Castings inv. status (Inv Con)	100	75	25
Inventory status (Inv Con)	100	69	31
Sales forecast (Forecasting)	100	67	33
Sales orders (Sal Order Pro'g)	100	78	22
Estimated load (Cap Planning)	80	39	41
Order pending (Sal Order Pro'g)	80	86	-6
Despatch data (Despatch)	80	74	6

3.1 - PURCHASE ORDER PROCESSING

Information requirements v. weighted information attributes	Rel	Tot	Var
Planned orders (Mat'l Planning)	100	52	48
Parts list (Product Design)	100	75	25
Purchase requisitions	90	75	15
GRN (Inventory Control)	100	91	9

4.1 - PRODUCT DESIGN

Information requirements v. weighted information attributes	Rel	Tot	Var
Order acceptance (Sal Ord Pr'g)	100	78	22
Marketing spec'n (Marketing)	100	71	29
Sales forecast (Forecasting)	80	57	23

4.2 - PRODUCT DRAFTING

Information requirements v. weighted information attributes	Rel	Tot	Var
Shop packet (Scheduling)	100	63	37
Drawing request (Purchasing)	100	69	31

5.1 - QUALITY ENGINEERING

Information requirements v. weighted information attributes	Rel	Tot	Var
WIP status (WIP Control)	100	80	20
GRN (Inventory Control)	100	78	22
Test report (Man'g Control)	100	86	14
Order acknowledgement (SOP)	100	66	34
Parts list (Product Design)	100	79	21

6.1 - MANUFACTURING CONTROL

Information requirements v. weighted information attributes	Rel	Tot	Var
Shortage report (Scheduling)	100	74	26
Parts list (Product Design)	100	85	15
Production plan (Scheduling)	100	66	34
Shop packet (Inventory Control)	100	63	37
Inspection data (Quality)	100	74	26

6.3 - MAINTENANCE

Information requirements v. weighted information attributes	Rel	Tot	Var
Maint request (Mat'ls Pro'g)	100	92	8
Breakdown sheet (Mat'ls Pro'g)	100	89	11
Budget feedback (Accounts)	80	72	8

6.4 - DESPATCH

Information requirements v. weighted information attributes	Rel	Tot	Var
Order acknowledgement (SOP)	100	67	33
Production plan (Scheduling)	100	64	36
Item availability (Inv Con)	100	92	8
Order complete (Man'g Con)	100	86	14

The variances were collated to produce a variance list for the business unit. Figure 6.29 is an absolute list of the variances (>20) obtained.

No.	Information requirement	Produced by	Produced for	IQV
1	Standard times	Process Planning	Capacity Planning	80
2	Expected due date	Scheduling	Sales Order Processing	51
3	Planned orders	Material Planning	Purchase Order Processing	48

4	Lead-time bulletin	WIP Control	Technical Sales	46
5	Estimated load	Capacity Planning	Scheduling	41
6	Routings	Process Planning	Capacity Planning/ Material Planning	38
7	Advice note	Supplier	Inventory Control	37
7	Shop packet	Inventory Control	Manufact'ing Control	37
7	Shop packet (Drawing request)	Scheduling	Product Drafting	37
10	Progress report	WIP Control	Sales Order Processing	36
10	Production plan	Scheduling	Despatch	36
12	Production plan	Scheduling	Manufact'ing Control	34
12	Order acknowledgement	Sales Order Processing	Quality Engineering	34
14	Order acknowledgement	Sales Order Processing	Despatch	33
14	Sales forecast	Forecasting	Scheduling/ Material Planning	33
16	Part no.	Scheduling	Sales Order Processing	32
17	Despatch data	Despatch	Sales Order Processing	31
17	Inventory status	Inventory Control	Scheduling/ Material Planning	31
17	Drawing request	Purchase Order Processing	Product Drafting	31
17	Shop packet	Product Drafting	Product Drafting	31
21	WIP status	WIP Control	Scheduling/ Material Planning	30
22	Marketing spec'n	Marketing	Product Design	29
22	Production data	Manufac'ing Control	WIP Control	29
24	Inspection data	Quality Engineering	Manufact'ing Control	26
24	Shortage report	Scheduling	Manufact'ing Control	26
26	Castings inventory status	Inventory Control	Scheduling/ Material Planning	25
26	Complete shop packet	Materials Processing	Inventory Control	25
26	Parts list	Product Design	Purchase Order Processing	25

29	Sales forecast	Forecasting	Product Design	23
30	Customer credit status	Accounts	Sales Order Processing	22
30	Sales order	Sales Order Processing	Scheduling/ Material Planning	22
30	GRN	Inventory Control	Quality Engineering	22
30	Order acceptance (Job file)	Sales Order Processing	Product Design	22
34	Parts list	Product Design	Quality Engineering	21
35	BOM	Product Design	Material Planning	20
36	WIP status	WIP Control	Quality Engineering	20

FIGURE 6.29 - Variance list

6.6.3 - Application of Stage 3 (Analyse Strategic Goals)

A systematic analysis was undertaken of three Strategic Goals in order to identify and explore the implications of the company's ambition. Figure 6.30 depicts the issues that were analysed.

Strategic Goal	Relative Priority
Reduce costs	*40*
Improve 'quotes to orders' conversion rate	*40*
Improve delivery performance	*20*

FIGURE 6.30 - Strategic goals

Consider the first strategic goal, *reduce costs*, and the Forecasting function. It was concluded that there was a major impact of this function on the objective, i.e., what could be done in Forecasting to *reduce costs*. The following objectives were arrived at:

- *Produce an accurate and reliable sales forecast so that WIP and finished goods stocks are minimised.*

- *Produce an accurate and reliable sales forecast so that stock-outs are prevented.*

These then became the objectives for the *Forecasting* function.

When this function is decomposed, its constituent *processes* included *Collate information* and *Forecast sales*. The effort was then repeated for these DFD *processes* using each of the *function* objectives.

Figures 6.31 to 6.33 represent the decomposition of each goal throughout the Information Model.

A. Reduce Costs

Function	**Function Sub-objectives**	**Process**	**Process Sub-objectives**	**Current Performance**	**Information Needs**
1.3 Forecasting	•Produce an accurate & reliable sales forecast so that WIP & finished goods stocks are minimised, & stock-outs are prevented	1.3.1 Collate Information 1.3.2 Forecast Sales	•Ensure accuracy & integrity of forecast data •Use effective forecasting tools & policy	The accuracy of the forecast on a monthly basis is relatively poor. Finished goods stocks tend to be high.	•Prospect list, sales order history, annual contracts
2.2 Material Planning	•Produce an accurate & reliable material plan to minimise inventory levels	2.21 Execute MRP	•Ensure quality of MRP inputs	Material is regularly unavailable - this does not directly affect cost	•BOM, sales forecast, sales orders, routings, WIP status, inventory status, order status
3.1 Purchase Order Processing	•Ensure quality & cost-effectiveness of purchased material	3.11 Negotiate Order Details	•Attain cost-effective contracts with reliable suppliers		•Planned orders, purchasing policy

3.2 Purchase Planning	• Source reliable suppliers	3.21 Monitor Order Progress & Supplier Performance	• Ensure quality of order progress & supplier performance data	Supplier performance is adequately monitored	• Order status, supplier approval list, inspection data
4.1 Product Design	• Produce designs that minimise material usage & facilitate ease of manufacture	4.13 Prepare Valve Design	• Increase the commonality and reduce the complexity of existing product structures	Product structures are, in general, complex & large	• Valve spec'n
			• Design for manufacture	Routings available, informal communication	• Manufacturing data
6.1 Manufacturing Control	• To achieve production plans with cost effective use of labour, materials & machinery	6.12 Prioritise & Schedule Jobs	• Adhere to schedule, minimise overtime	Schedule adherence is poor - overtime has been prevalent	• Production plan, shortage report
		6.13 Monitor Shop Activities	• Anticipate production problems	N/A	• Production data
6.2 Materials Processing	• Minimise manufacturing costs	6.21 Machine Components	• Reduce scrap	~91% success	• N/A
6.4 Despatch	• Timely & cost-effective shipment of customer orders	6.42 Manage Distribution	• Minimise carriage costs	Penalties are often incurred on carriage because of poor customer service - order due date	• N/A

FIGURE 6.31 - Decomposition of *reduce costs*

B. Improve Delivery Performance

Function	Function Sub-objectives	Process	Process Subobjectives	Current Performance	Information Needs
1.2 Sales Order Processing	•Timely clearance & release of orders	1.23 Establish Order Clearance	•Timely receipt of part no. & customer credit status	Orders pending often spend weeks in Quote 400	•Part no., customer credit status
2.2 Material Planning	•Ensure material is available to meet production plans	2.21 Execute MRP	•Ensure quality of MRP inputs	Material availability is the biggest inhibitor of effective delivery performance	•BOM, sales forecast, sales orders, routings, WIP status, inventory status, order status
2.5 Scheduling	•Provide timely & accurate production plans	2.51 Review Resource & Material Availability to Meet Demand	•Ensure quality of 'available resources' information	WIP & inventory accuracy is poor	•WIP status, sales forecast, order status, sales orders, orders pending, inventory status
		2.52 Schedule Operations	•Effective & reliable scheduling policy. Economic batches	Schedules inaccurate. Many uneconomic batches	•Anticipated work centre load, estimated design time, part no.
2.4 Capacity Planning	•Provide accurate work centre load	2.41 Id Order Due Dates & Op'ns for Identified Work Centres	•Ensure quality of process plans	Clear improvement required	•Sales orders, routings
		2.42 Allow for Machining Time	•Identify accurate machining times	Machining time is based upon approximate load units	•Standard times
4.2 Product Drafting	•Timely issue of drawings	4.23 Release Design Changes	•Rapid access of stored drawings	Drawing issues takes between 1 & 3 days	•Shop packet, drawing

6.1 Manufacturing Control	•Ensure minimal time spent on manufacture	6.11 Examine Production Plans	•Assign meaningful priorities to jobs	The production plan does not dictate accurately what is to be processed on a machine at a given time	•Production plan, shortage report, shop packet
6.2 Materials Processing	•Minimise machining time	6.21 Machine Components	•Reduce number of set-ups	Large number of uneconomic batch sizes	•Shop packet

FIGURE 6.32 - Decomposition of *improve delivery performance*

C. Improve 'Quotes to Orders' Conversion Rate

This is not an independent objective. It encompasses the results of the decomposition of the two goals above, as well as the following:

Function	Function Sub-objectives	Process	Process Subobjectives	Current Performance	Information Needs
1.3 Forecasting	•Produce a forecast whereby the company is responsive to customer requirements	1.33 Forecast Sales	•Effective forecasting policy	The company is unable to respond quickly to forecast changes	•N/A
1.1 Technical Sales	•Provide effective pre-order customer service	1.13 Prepare & Issue Quote	•Timely quotation issue	Quotation performance is inconsistent - can be up to a week	•Job cost, sales forecast, lead-time bulletin
			•Accurate job estimate	Manufacturing costs & lead-times are unreliable	
		1.14 Negotiate Sale	•Provide follow-through on quotations	Inconsistent	

1.2 Sales Order Processing	•Provide effective post-order customer service	1.25 Monitor Order	•Provide accurate order progress	Order progress & expected due date accuracy are poor	•Progress report, expected due date, despatch data
5.1 Quality Engineering	•Adhere to customer spec'n	5.11 Set standards & QC limits	•Ensure standards integrity	•~91%	•Order acknowledgement
6.2 Materials Processing	•Adhere to customer spec'n	6.21 Machine Components	•Provide latest spec'n	•Generally good	•Shop packet, quality requirements

FIGURE 6.33 - Decomposition of *improve conversion rate*

6.6.4 - Application of Stage 4 (Analyse Systems Improvement Opportunities)

The desired result of the next exercise is the identification of a set of improvement opportunities connected in a very direct and specific way to the strategic objectives of the company. These were developed for several business functions and processes. For example, consider the *Machine Components* process. It has an objective *to reduce set-ups time* that is derived from the function objective to *minimise machining time* associated with the *Materials Processing* function. Improvement opportunities that could help achieve this objective could be:

- *longer batch runs,*
- *improved shop floor layout.*

The importance of these opportunities is evaluated in terms of their contribution to the stated strategic goals.

Figure 6.34 was constructed to document identified opportunities:

Function/Problem	Improvement Opportunities	Able to influence
Technical Sales	• Use part nos. to describe valve features • Accurate lead-time bulletins • Improved sales negotiation	• Conversion rate (Improved customer service)
Sales Order Processing	• Faster customer credit clearance	• Delivery performance (Reduce orders pending time within Quote 400)
Forecasting	• Sub-assembly forecasting / focus forecasting software	• Cost reduction (Reduced inventory) • Delivery performance (Accurate lead-time quotation/Better material planning) • Conversion rate (Better response to customer orders)
Inventory Control	• Paperwork integrity - accurate & timely updates • Use of consignment stocks • Forecast valves stocked at a sub-assembly level	• Delivery performance (Accurate inventory for MRP) • Cost reduction (Pay when use) • Cost reduction (Reduce monies tied up in finished goods)
Material Planning	• Improved MRP inputs & procedures	• Delivery performance (Improve material availability)
WIP Control	• Improved SFDC & order tracking	• Delivery performance (Better control / Improved WIP & inventory accuracy)
Capacity Planning	• MAAPICS CRP module (depends on accurate standard times)	• Delivery performance (Accurate loads - improved scheduling & reduced queueing)
Scheduling	• Frequency of production plan issue (i.e. weekly, bi-monthly)	• Conversion rate (Better control - incorporate production changes quicker)
Purchase Planning	• Vendor rating system	• Conversion rate (Quality)
Product Design	• Quote 400 access • BOM flattening & simplification / Part no. reduction	• Delivery performance (Anticipate orders pending) • Cost reduction (More common parts/ design for manufacture)
Product Drafting	• New printer	• Delivery performance (Reduce drawing issue time)
Process Planning	• Accurate standard times to replace load units	• Delivery performance (Improved capacity planning & scheduling) • Cost reduction (Accurate manufacturing costs)

Manufacturing Control	• Production variance reporting	• Conversion rate (Customer service - target jobs behind schedule)
Materials Processing	• Longer batch runs • Improved shop floor layout	• Delivery performance (Fewer set-ups / less move time between jobs)
Accounts	• Prices linked to standard costs (based on standard times not load units)	• Conversion rate (Quicker quotation response) • Cost reduction (Improved costing)

FIGURE 6.34 - Improvement opportunities (company E)

6.6.5 - Application of Stage 5 (Define IS Needs & Priorities)

The purpose of the final stage was to review the issues that had emerged so far in order to identify and rank a series of development projects that, if undertaken, would potentially support the strategic direction of the company and produce constructive change in business operations.

The current state of information systems within the company was reviewed and the greatest needs and opportunities were identified. An attempt had also been made to capture these needs as a specific set of measurable criteria (i.e *information quality variances* and *strategic impact*) against which the merit of proposed development projects can be judged. Figure 6.35 represents a summary of key results:

Information Improvement Requirement	**Business Function Requirement**	**Strategic Impact**	**Variance**	**Viable Opport-unity**	**Comments/Issues**
Standard times	WIP Control/ Process Planning	Delivery performance/ Conversion rate (60) - high	80 - very poor	Yes	Improved capacity planning & scheduling. Better control over manufact'ing costs.
Expected due date	WIP Control/ Scheduling	Conversion rate (40) - medium	51 - very poor	Yes	Improved customer service would be the biggest benefit.

Planned orders	Material Planning	Delivery performance/ Conversion rate (60) - high	48 - very poor	Yes	Improved material availability.
Lead-time bulletin	WIP Control	Conversion rate (40) - medium	46 - very poor	Yes	Confidence of quoted due date.
Estimated load	Capacity Planning	Delivery performance/ Conversion rate (60) - high	41 - very poor	Yes	Accurate loads needed for improved scheduling & reduced queuing.
Shop packet	Scheduling/ Product Drafting	Delivery performance/ Conversion rate (60) - high	37 - poor	Yes	Improved routings accuracy required.
Sales forecast	Forecasting	Delivery performance/ Cost reduction/ Conversion rate (100) - very high	33 - poor	Yes	Influences all 3 strategic issues.
WIP status	WIP Control	Delivery performance/ Conversion rate (60) - high	30 - poor	Yes	WIP only accurately assessed after machining, assembly & test.
Inventory status	Inventory Control	Delivery performance/ Conversion rate (60) - high	31 - poor	Yes	Poor quality means poor MRP input.
BOM	Product Design	Cost reduction/ Conversion rate (80) - very high	20 - medium	Yes	Simplification & increased commonality required.
Orders pending	Sales Order Processing	Delivery performance/ Conversion rate (60) - high	-6 - very good	Yes	Authority to work (design) orders pending is required.

FIGURE 6.35 -Summary of key results (company E)

Figure 6.36 represents the series of project proposals resulting from this exercise:

Project	Information Viewpoint
Improved forecasting	✓
BOM simplification & re-structuring	✓
WIP (SFDC) monitoring	✓
Order clearance - an examination of Quote 400	✓
MRP inputs - an examination of MRP input discipline & quality	✓
Operations monitoring - the formulation of standard times	✓

FIGURE 6.36 - Clustered projects

The final step was to evaluate the benefits and risks associated with each project. This evaluation serves as the basis for assigning priorities to each project, one of which would subsequently provide a case study for the application of Phase 2 of the Methodology.

Priorities were assigned to projects based on the following criteria

- strategic impact,
- current performance,
- perceived benefits (ROI, project synergy),
- perceived risk (likelihood of success, estimated cost, time).

Project	Priority	Strategic Impact	Current Performance	Benefits	Risk
Improved order clearance	1-2	Medium	Good	Quick	Low
Improved forecasting	1	Very high	Poor	Very high	High
BOM re-structuring	2	Very high	Medium	High	Medium
MRP inputs	3	High	Very poor	High	Low
Operations monitoring	4	High	Very poor	High	Low
WIP monitoring	5	High	Poor	High	Low

FIGURE 6.37 - Project benefit/risk evaluation (company E)

The portfolio of projects is summarised below.

1) Improved Order Clearance

This project would provide for a thorough investigation of the delay incurred by the Quote 400 system. Particular attention would be paid to the need to hold order clearance until customer credit status has been established and the subsequent effects caused by such delays.

2) Improved Sales Forecasting

This project would examine the feasibility of forecasting high-level assemblies which are common to a number of end valves.

At present, approximately 70% of end-items are made-to-forecast. On a monthly basis, the forecast is inaccurate. The price of this inaccuracy is high stocks of finished goods and uneconomic WIP. Forecasting at a level of common assemblies would provide much of the flexibility that is required to respond to changing demand. Machining would be predominantly sub-assembly forecast driven and would allow for economic batch runs. Assembly and MRP input would be customer order driven.

3) BOM Re-structuring

This project would provide an assessment of existing BOM structures with a view to increasing BOM simplification and commonality, and reducing the number of part numbers.

4) MRP Inputs

This project would attempt to establish procedures for improving the base discipline required to run MRP effectively. As such, a detailed analysis of all MRP inputs would be carried out.

5) Operations Monitoring

The current load unit system of assessing capacity and determining production costs has been neglected and, for certain valves, is prone to considerable inaccuracy. This project would attempt to identify an effective mechanism for determining accurate set-up, processing and queue times.

6) WIP Monitoring

This project would examine existing shop floor data collection (SFDC) / WIP monitoring and inventory transactions. This would be done with a view to determining the main causes and effects of ineffective inventory and WIP control and to present some guidelines to improve job traceability and introduce real-time SFDC.

6.6.6 - Application of Stage 6 (Project Start-Up & Business Area Overview)

An improvement initiative aimed at investigating the quotation processing system weas already in progress at the time the Methodology was applied. As such, Project 2, *Improved Sales Forecasting*, was selected as a focus for Phase 2 of the Methodology.

The criteria which led to the selection of the project, that is,

- strategic impact,
- current performance,
- benefits, and
- risk

were reviewed by the study team.

The Phase 2 completion schedule can be seen in Figure 6.38.

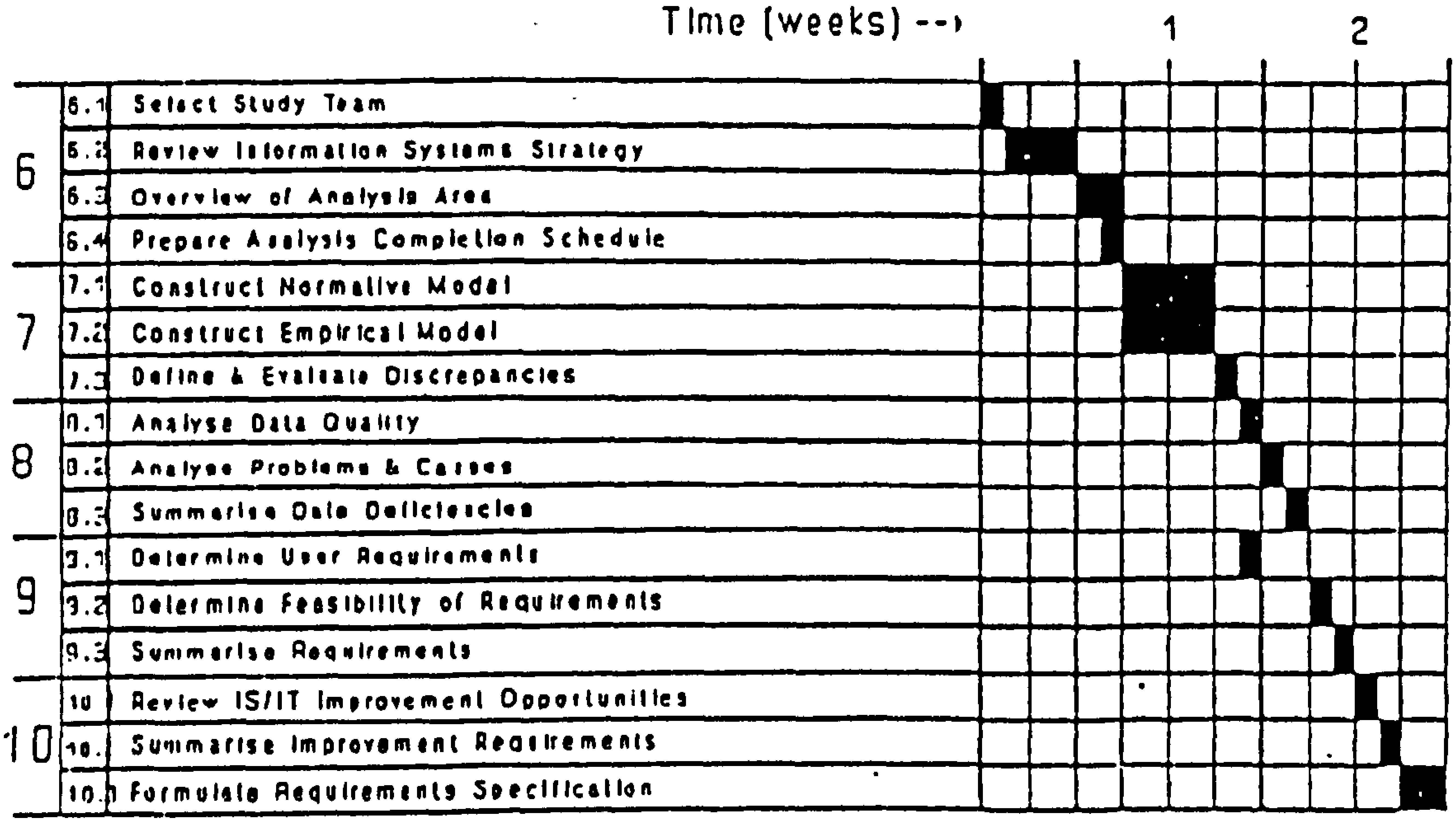

FIGURE 6.38 - Phase 2 completion schedule (company E)

6.6.7 - Application of Stage 7 (Undertake Detailed Modelling)

There were no apparent differences between the Normative and Empirical Forecasting behaviour, that is, predominantly the function operated as it was designed to; based on end item manufacture (see Figure 6.39). The root cause of the problem lay not with the operation of the system but with the forecasting policy itself.

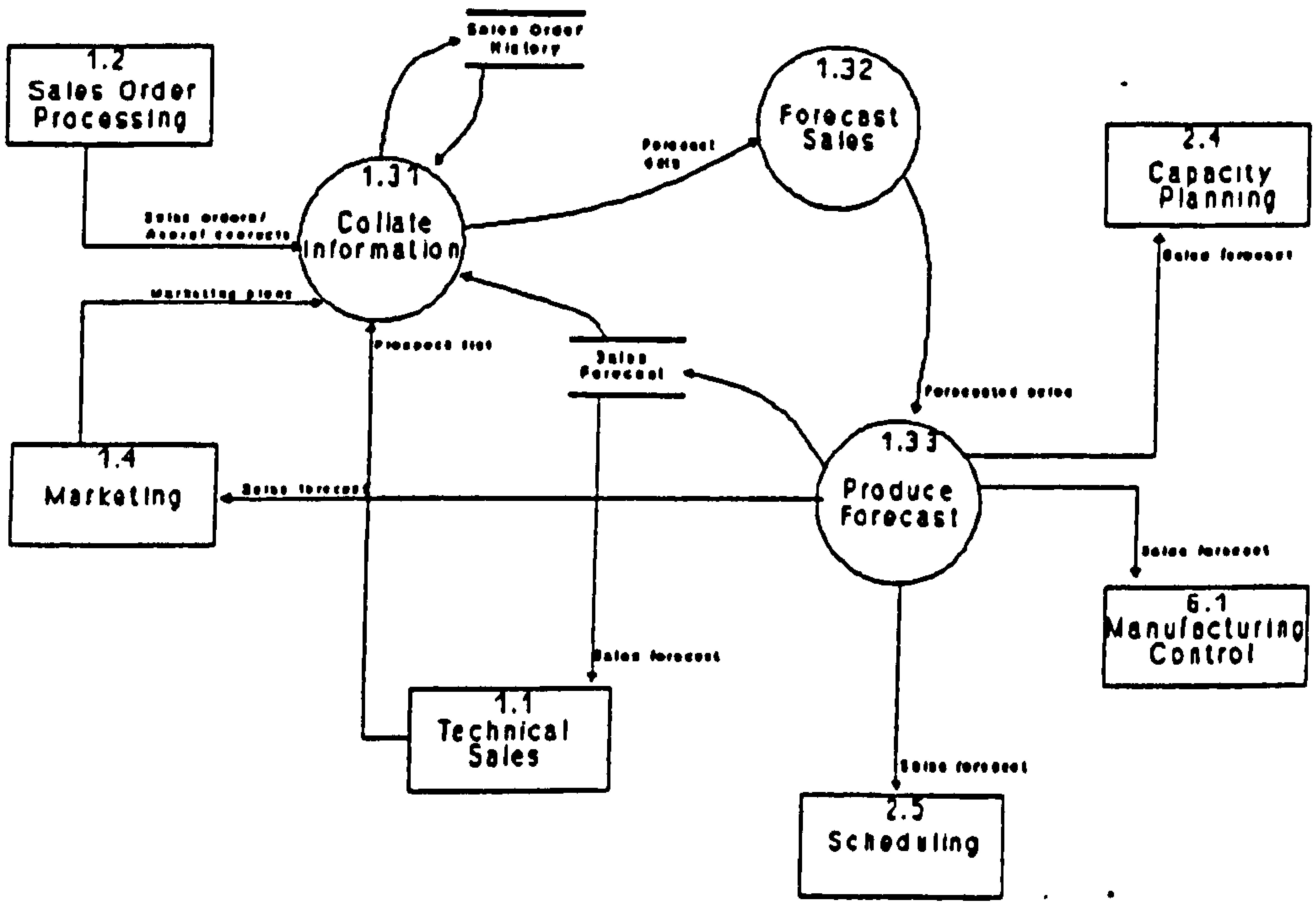

FIGURE 6.39 - Normative & empirical forecasting behaviour (level 1)

6.6.8 - Application of Stage 8 (Examine Data & Data Processes)

The forecast/master schedule is often late, and on a monthly basis, significantly inaccurate. These problems cannot be attributed to particular data elements but to forecasting policy. However, forecast elements where a clear improvement in data quality is needed include:

- load units,
- priority,
- job date.

Problems associated with the forecasting policy are represented in Figure 6.40.

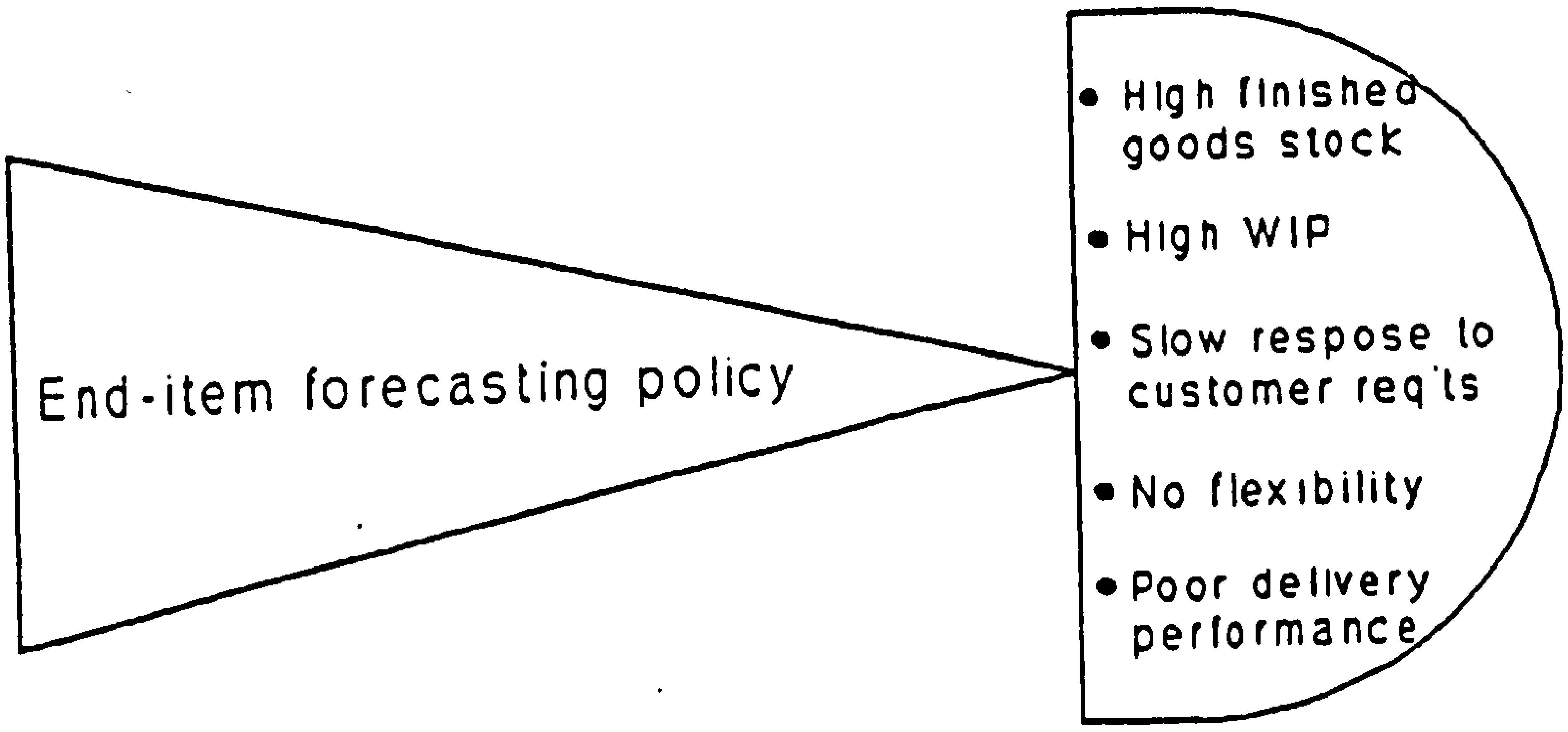

FIGURE 6.40 - Forecasting problems

6.6.9 - Application of Stage 9 (Analyse User Requirements)

User requirements are represented in Figure 6.41.

Timeliness	
Accuracy	Accurate estimate of demand.
Accessibility	On-line access required.
Completeness	Sub-assembly levels corresponding to end-item levels required.
Format	Valve/sub-assembly variance.
Other	Job dates often unrealistic.

FIGURE 6.41 - User requirements of *sales forecast*

6.6.10 - Application of Stage 10 (Formulate Specification)

The following Forecasting improvement requirements and procedural changes were proposed:

- Forecast against all valve type/size combinations, other than complete 'specials', which should still be channelled directly through to the D.O.
- Forecast at common levels of assembly.
- Use modularised BOMs to allow for flexible valve configuration. Costs (and base price) to be configured at quotation entry.
- Use planning BOMs for material planning and sub-assembly production planning. Machining will be predominantly Forecast /MPS driven. Lead times to customers will be based on the final assembly lead times, enabling availability to be seen during quotation entry, and valve assembly and MRP to be entirely customer order driven.

Forecasting at a common level of assembly is the desired policy. Air relief valves, for example, come in small, large and double orifice types. Each type has a range of options offered, where each option is based on a standard valve. In the case of the small orifice valves, the standard consists of an orifice cover, a cover, an orifice bracket, a fulcrum pin, a sealing face, an adjusting screw, a float and lever, and a body. Options, for example, include an inlet with an isolating cock, a drilled and faced flange screwed to the isolating cock, or a flange screwed directly to the body. Similar options/standard arrangements exist for the large and double orifice types, and similar standard/options combinations are available for butterfly, and pressure reducing valves.

Such proposals would lead to:

- viable material plan;
- for the majority of valves, planning BOMs would allow the economic production and stock of sub-assemblies;
- machining element of production lead time can be eliminated from delivery lead time;
- assembly planning facilitates a more flexible response to customer orders;
- more economic batching employed throughout the machining process;

- less period end pressure due to machining and assembly being 'disconnected'.

In summary, such requirements would produce

- cost benefits, therefore price benefits;
- improved customer service;
- greatly reduced lead times on delivery;
- greatly improved adherence to delivery lead times;
- easier material planning, therefore better availability.

CHAPTER SEVEN

SUMMARY & CONCLUSIONS

PURPOSE OF THIS CHAPTER

The purpose of this Chapter is to summarise the importance and need for the research area, illustrate and bring to a conclusion the results of the work undertaken indicating how the research objectives have been achieved, and indicate where further research is required.

7.1 - SUMMARY

The ability of information systems to act as enablers of business success is unquestioned. In manufacturing, information systems may not change a company's products and services like they can in the financial sector, but they can certainly make a positive contribution to a company's strategy, and positively influence competitive forces by improving key internal operations. So, it is important to think about information systems strategically. This is best done through the development of an information systems strategy. This is not a simple process, but one that demands a robust approach that enables a manufacturing concern to develop its own strategy in the context of its competitive ambition, and conducive to its operations, systems and staff.

This research has attempted to develop an approach to information systems strategy formulation that guarantees a successful alignment between information systems development and organisational needs. It may not be the ultimate solution, but it is both theoretically sound and industrially practical.

7.2 - CONCLUSIONS

The research has provided a distinct contribution to knowledge in a number of forms.

- Firstly, and most conspicuously, the research has provided a new methodology, IQ*Analyst*, for formulating an information systems applications strategy relevant to manufacturing industry.

- A suite of both new (*information quality analysis*, *opportunities analysis*, *reference modelling* and *normative & empirical analysis*) and refined (*objectives decomposition*, *relationship modelling*, *function mapping*, *investment justification*, *data modelling*, and *cause & effect analysis*) techniques have been provided for information systems planning and analysis.

- New theories concerning the elements of a successful approach to information systems strategy formulation have been developed. To maximise the chances of success, up to 11 different criteria were seen to be required:

  - *structured, top-down methodology,*
  - *top management commitment and involvement,*
  - *establishment of a business-wide perspective,*
  - *integration with the overall business planning process,*
  - *independence of organisation structure,*
  - *formalised user involvment,*
  - *an examination of IS opportunities,*
  - *improvement-oriented,*

- *a flexible and integrated information architecture,*
- *a reference framework,*
- *specific and dependable results.*

- New ideas concerning the application and emphasis of an approach to information systems strategy formulation have been promoted. This has provided a wider range of techniques for IS planners to adopt.

- New information systems planning and analysis case studies have been undertaken. The results of these studies have tested the theoretical and industrial validity of both new and established information systems planning and analysis concepts.

- Existing state-of-the-art approaches (8 frameworks and 9 methodologies) to information systems planning have been investigated and evaluated.

IQ*Analyst* is the culmination of the research undertaken. The simplicity with which the methodology can be applied, an often under-rated virtue, belies the sophistication of the theoretical framework upon which it is based. This framework has been seen to be corroborated through rigorous and successful application of the methodology in five manufacturing business units.

The intention has not been to 'reinvent the wheel'; the methodology is necessarily different from existing approaches. It has many differentiating and necessary virtues such as its methodology success criteria base, its comparative simplicity and ease of application, its emphasis on in-house, rather than outside consultancy application through the use of open, unambiguous and structured techniques, and its ability to formally facilitate employee involvement in IS decision-making. IQ*Analyst* can also be applied with meagre resources in a relatively short space of time, and empirical evidence has illustrated the methodology's ease of understanding, wide applicability and reproducibility.

7.3 - FUTURE WORK

Although satisfying a broad strategic information systems planning goal-set, IQ*Analyst* is open to change, it is not a static methodology. Opportunities analysis, for instance, can always be improved upon. The current opportunities framework, although effective, requires more empirical investigations for it to be fully validated, and improve its ability to match a specific information system improvement opportunity to a given manufacturing situation. Such investigations need not necessarily take the form of a strategic information systems planning study; the analysis of any manufacturing information system implementation could contribute to the framework. In particular, the *Integrated Solutions* sub-framework, potentially the most valuable aspect of the framework as opportunities are derived from a number of inter-related variables, would benefit from a richer variety of case studies to enable more cross-reference between the variables identified, i.e., functions, strategic goals, and nature of customer orders, and the inclusion of other variables, industry types, for example. Similarly, the Reference Model, could be extended and sub-divided into sub-models articulating information flows and business functions and processes pertaining to different manufacturing situations.

At present, the delivery instrument for IQ*Analyst* is a detailed workbook [158] that provides a step-by-step guide to carrying out the methodology. There is scope, however, to make the delivery of the methodology more efficient by computerising several of the steps. The opportunities framework could feasibly be delivered by an expert or rule-based system; IQA, although spreadsheet administered, could be delivered using a database to make cross-reference of the results with strategic goals alignment and opportunities analysis more mechanistic; and the process of priorities determination and cluster analysis could benefit from a similar database approach.

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APPENDIX A - METHODOLOGY REFERENCE MODEL

Explanation

The IQ*Analyst* Reference Model is a simplified view of a manufacturing enterprise and a generalised Information Model. It is generic and displays make-to-stock (MTS) as well as make-to-order (MTO), and flow as well as batch-type characteristics. It is a hierarchical, function-oriented architecture based on data flow analysis. The Model is composed of three layers: *Enterprise*, *Function* and *Process*, corresponding to the strategic, managerial and operational levels typical in decision-making. Each layer is composed of a variety of business activities each of which have a particular role to play in the execution of an overall business information system. Relationships between activities are represented by information flows. Such a representation could never be exhaustive, and to attempt such a very detailed analysis would render the Model unusable, so IQ*Analyst* users may wish to augment from personal experience.

The Model is used to:

- act as a template for Information Model construction,
- stimulate the thinking of information users,
- streamline the process of interview, and thus IQ*Analyst* application,
- help users to articulate their needs and describe their job tasks,
- identify IS improvement opportunities.

Reference Model Business Function Hierarchy

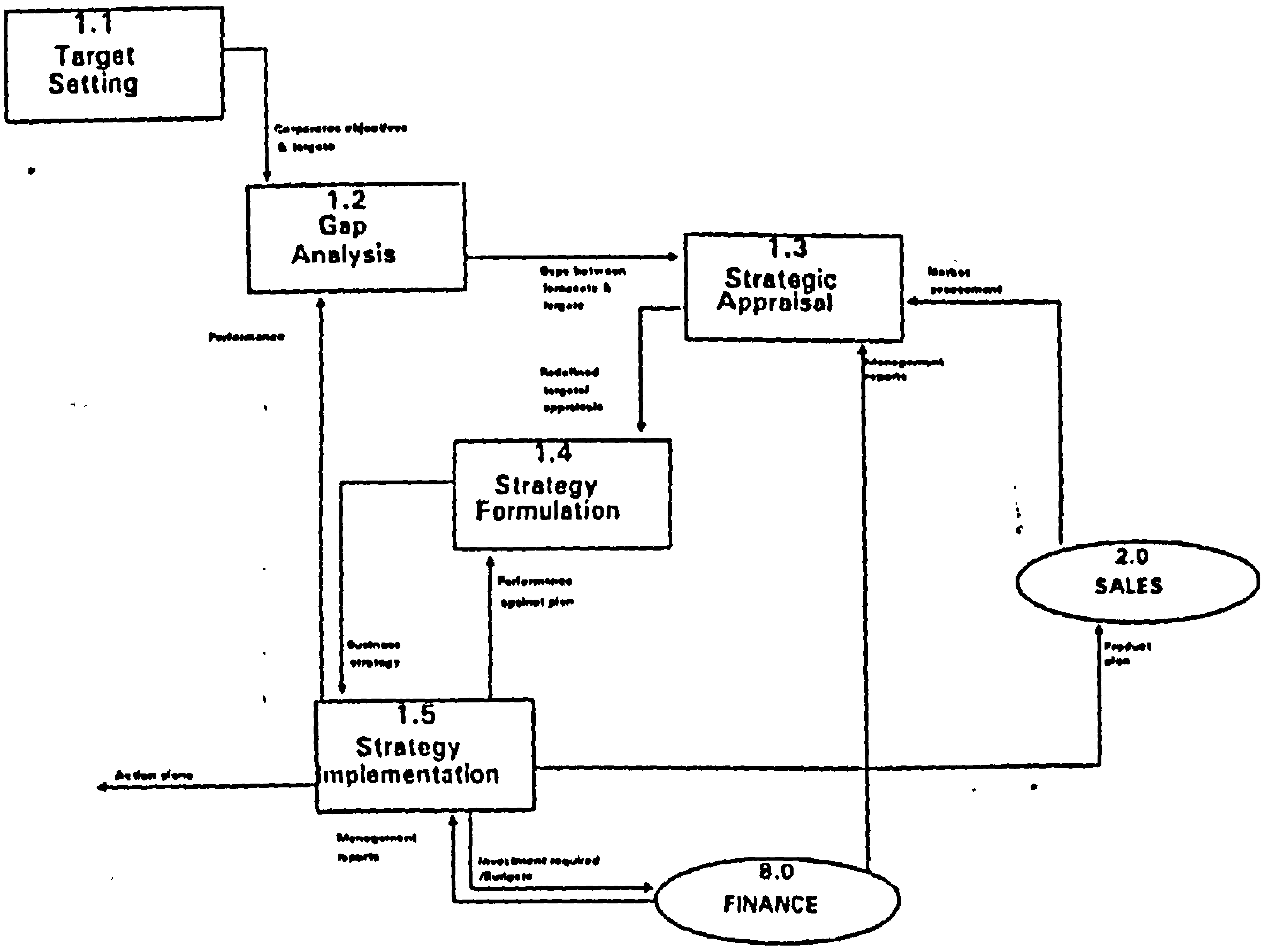
Enterprise Map	Function Map	Process Map
1.0 Corporate Management	1.1 Target Setting	1.11 Clarify Corporate Objectives 1.12 Set Target Levels of Objectives
	1.2 Gap Analysis	1.21 Forecast Future Performance on Current Strategies 1.22 Identify Gaps Between Forecasts & Targets
	1.3 Strategic Appraisal	1.31 Appraise Internal Operations 1.32 Appraise External Influences 1.33 Identify Competitive Advantages 1.34 Re-define Targets
	1.4 Strategy Formulation	1.41 Generate Strategic Options 1.42 Evaluate Strategic Options 1.43 Take Strategic Decision
	1.5 Strategy Implementation	1.51 Draw Up Action Plans & Budgets 1.52 Monitor & Control
2.0 Sales	2.1 Technical Sales	2.11 Accept Enquiry 2.12 Examine Product & Customer Data 2.13 Identify Available Capacity 2.14 Cost Job 2.15 Prepare Quote
	2.2 Sales Order Processing	2.21 Accept Order 2.22 Check Stock 2.23 Create Back Order 2.24 Monitor Order
	2.3 Master Scheduling	2.31 Forecast Sales 2.32 Balance Orders & Schedules Against Sales 2.33 Produce MPS
	2.4 Marketing	2.41 Monitor Competition 2.42 Undertake Market Research 2.43 Develop Marketing Strategy

3.0 Production Planning & Control	3.1 Inventory Control	3.11 Maintain Stock Status Information 3.12 Establish Inventory Control Parameters 3.13 Provide Inventory Valuation & Physical Stock
	3.2 Material Planning	3.21 Consolidate Requirements as a Gross Plan 3.22 Net Off Stock & Current Orders (allow for Scrap) 3.23 Calculate Quantities & Due Dates for Orders
	3.3 WIP Control	3.31 Orchestrate Resources to Execute Schedule 3.32 Monitor Job Status & Timings 3.33 Report WIP
	3.4 Capacity Planning	3.41 Identify Order Due Dates & Operations for Identified Work Centres 3.42 Allow for Queue & Move Times Between Operations 3.43 Anticipate Load at All Work Centres
	3.5 Scheduling	3.51 Review Resource Availability 3.52 Schedule Operations & Produce Paperwork 3.53 Release Schedule
4.0 Purchasing	4.1 Purchase Order Processing	4.11 Accept Orders 4.12 Negotiate Prices 4.13 Place Order 4.14 Authorise Payment
	4.2 Purchase Planning	4.21 Monitor Supplier Performance 4.22 Generate Purchasing Policy

5.0 Design Engineering	5.1 Concept Design	5.11 Identify Materials Required 5.12 Identify Manufacturing Operations 5.13 Prepare Concept Design
	5.2 Detailed Design	5.21 Design Product 5.22 Define Product Structure 5.23 Release Design Changes 5.24 Create Part Standards
	5.3 Prototyping	5.31 Build Solid/Mathematical Model 5.32 Build Prototype
6.0 Industrial Engineering	6.1 Quality Engineering	6.11 Set Standards & QC Limits 6.12 Undertake Quality Standards 6.13 Report Quality Achievement
	6.2 Process Planning	6.21 Establish Manufacturing Operations 6.22 Specify Capacity & Loading Details
	6.3 Manufacturing Engineering	6.31 Manage Tooling & Fixtures 6.32 Establish Optimum Plant Layout 6.33 Monitor Plant & Equipment
	6.4 Test Engineering	6.41 Test Product 6.42 Report Results

7.0 Manufacturing	7.1 Manufacturing Control	7.11 Produce Shop Floor Schedule & Manufacturing Instructions 7.12 Determine Work Centre Performance 7.13 Manage Shop Activities
	7.2 Materials Processing	7.21 Machine Components 7.22 Assemble Product 7.23 Package Product
	7.3 Materials Handling	7.31 Execute Movement Requests 7.32 Track Flow of Material
	7.4 Receiving	7.41 Receive Materials 7.42 Notify Relevant Areas
	7.5 Despatch	7.51 Receive Product 7.52 Manage Distribution
	7.6 Maintenance	7.61 Respond to Maintenance Requests 7.62 Plan Resources to Execute Requests 7.63 Plan Preventive Maintenance
8.0 Finance	8.1 Accounting	8.11 Manage Accounts Payable 8.12 Manage Accounts Receivable 8.13 Manage Payroll 8.14 Consolidate Finances & Produce Balance Sheet
	8.2 Financial Planning	8.21 Monitor Budgets & Administer Investment 8.22 Assess Business Profitability 8.23 Produce Management Reports

1.0 Corporate Management Function Map



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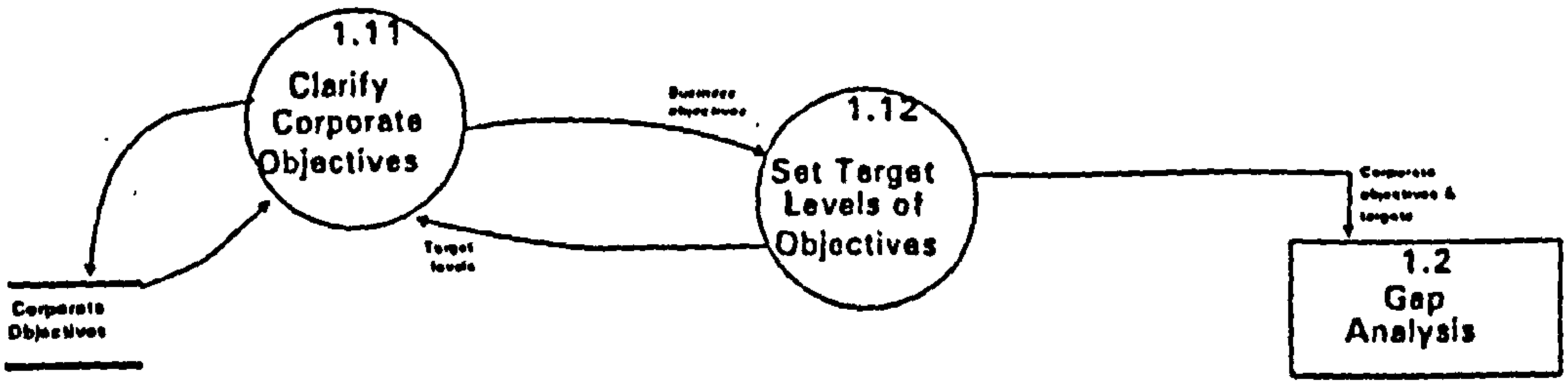

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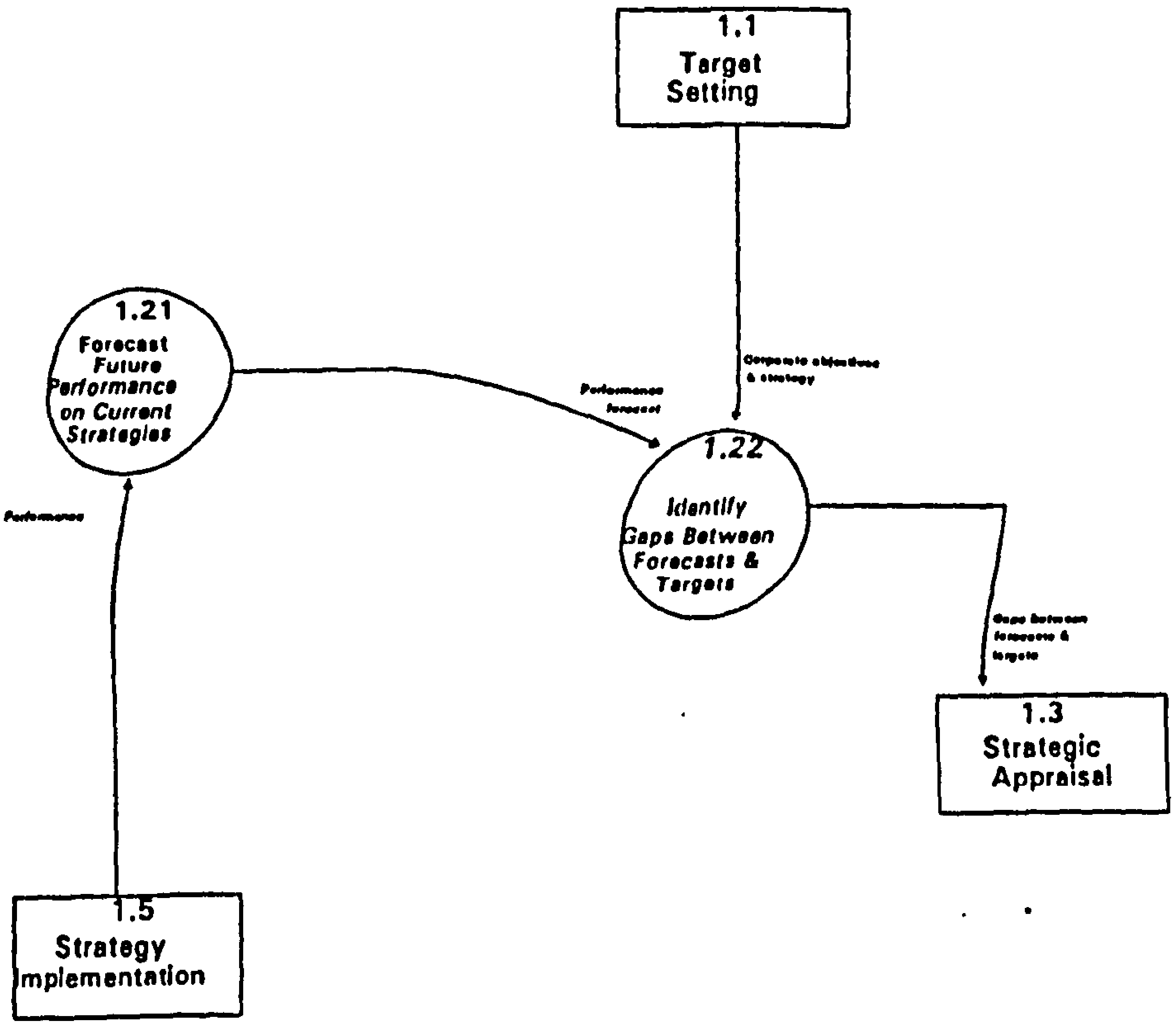

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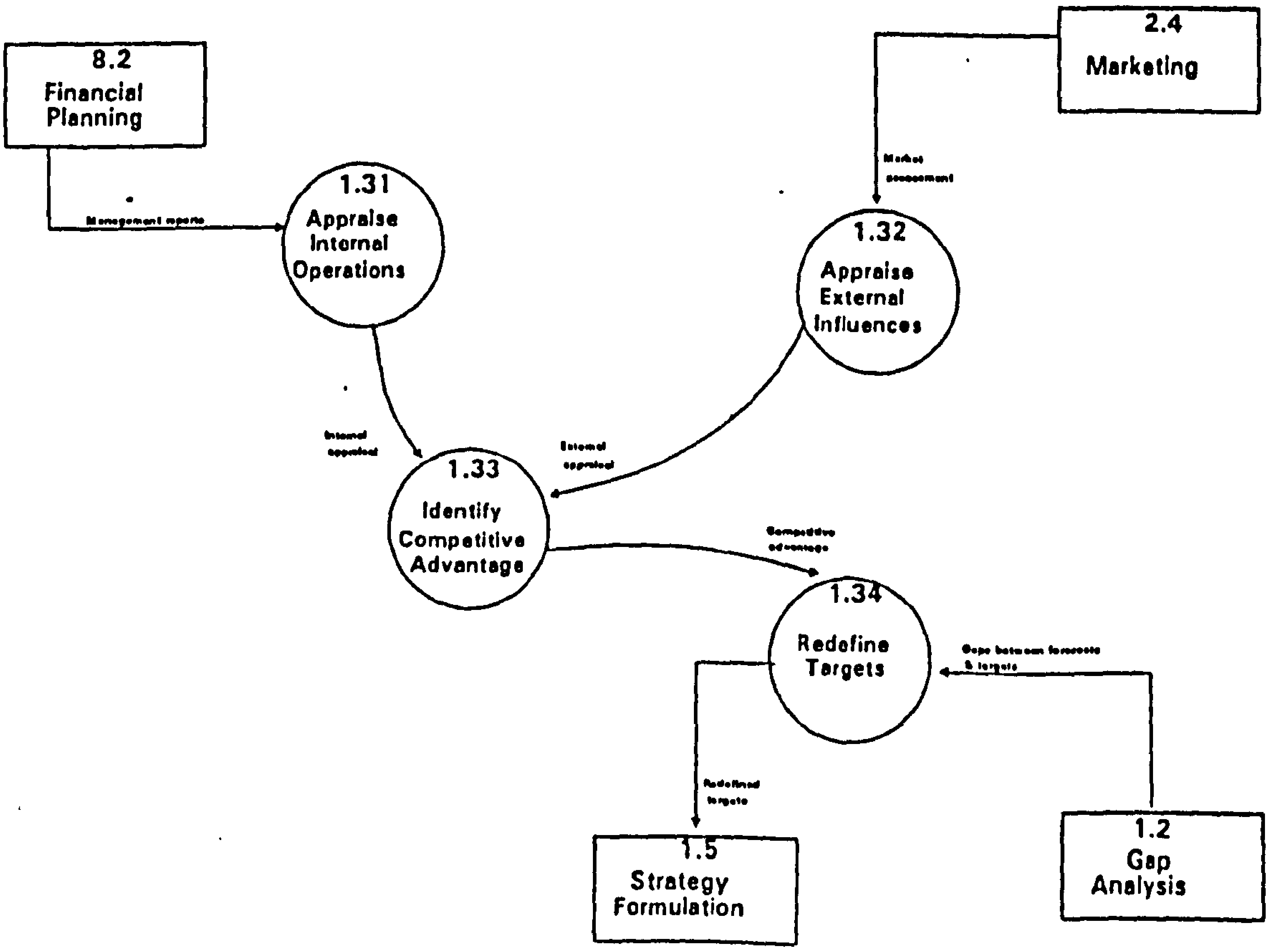

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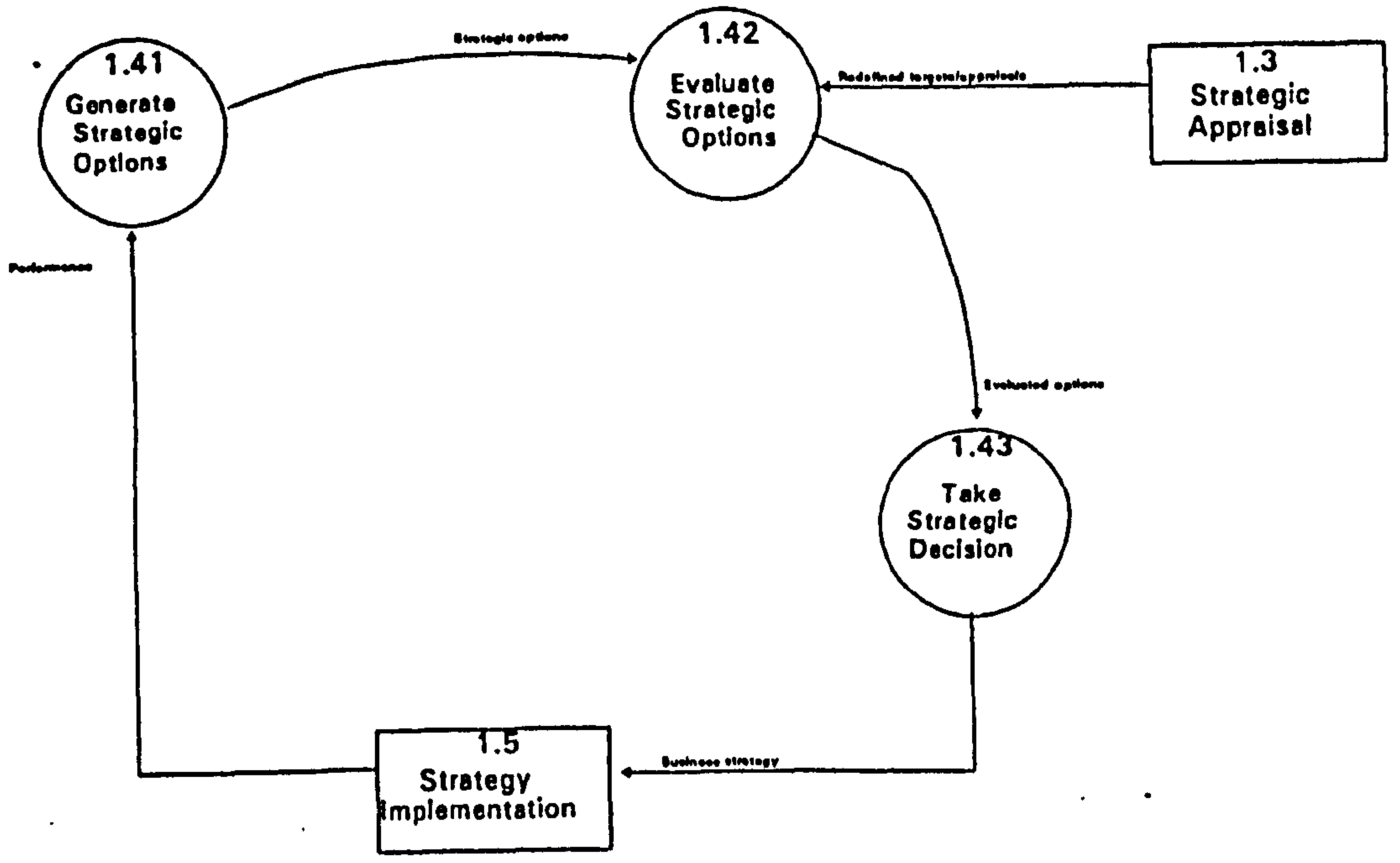

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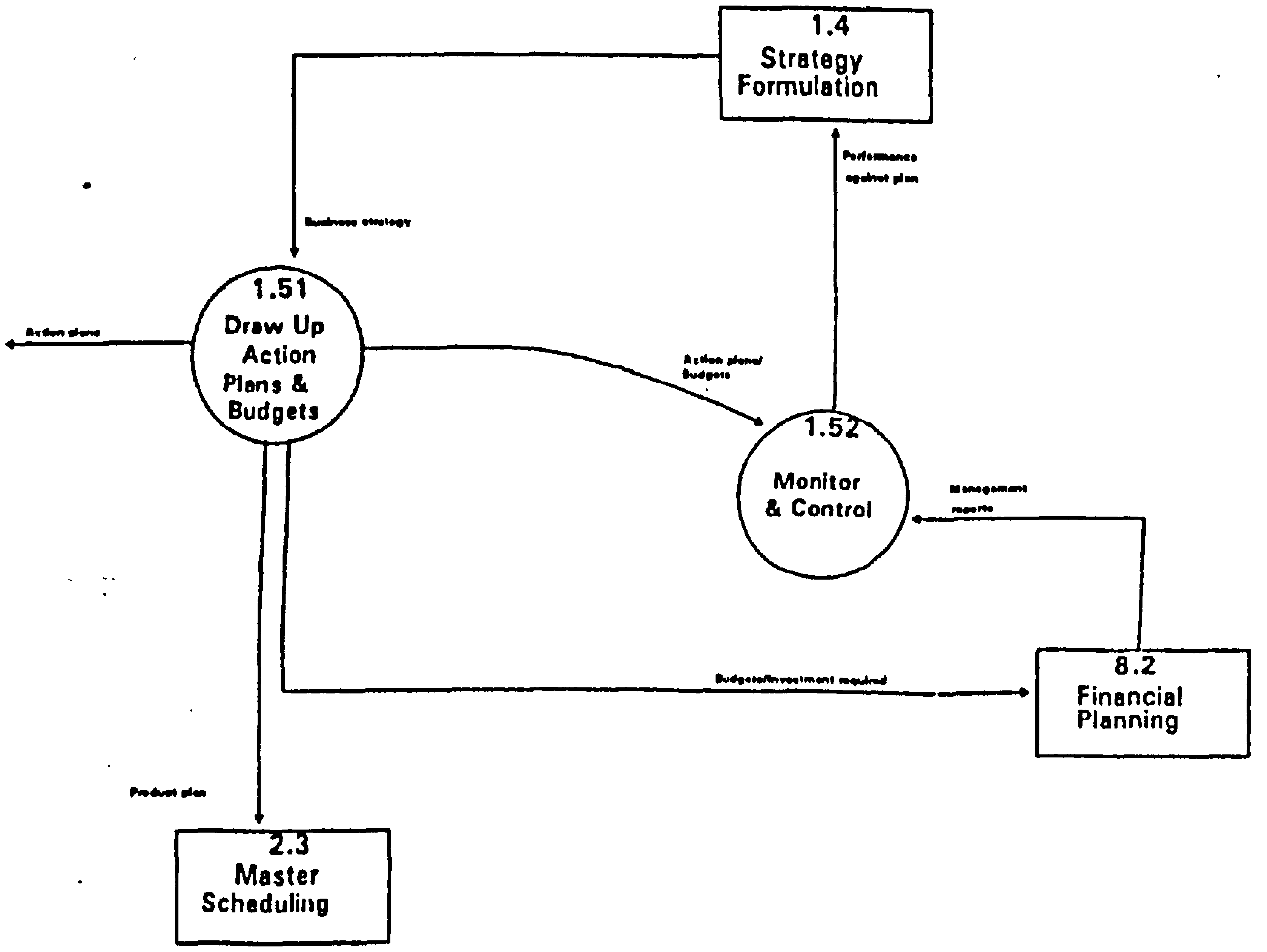

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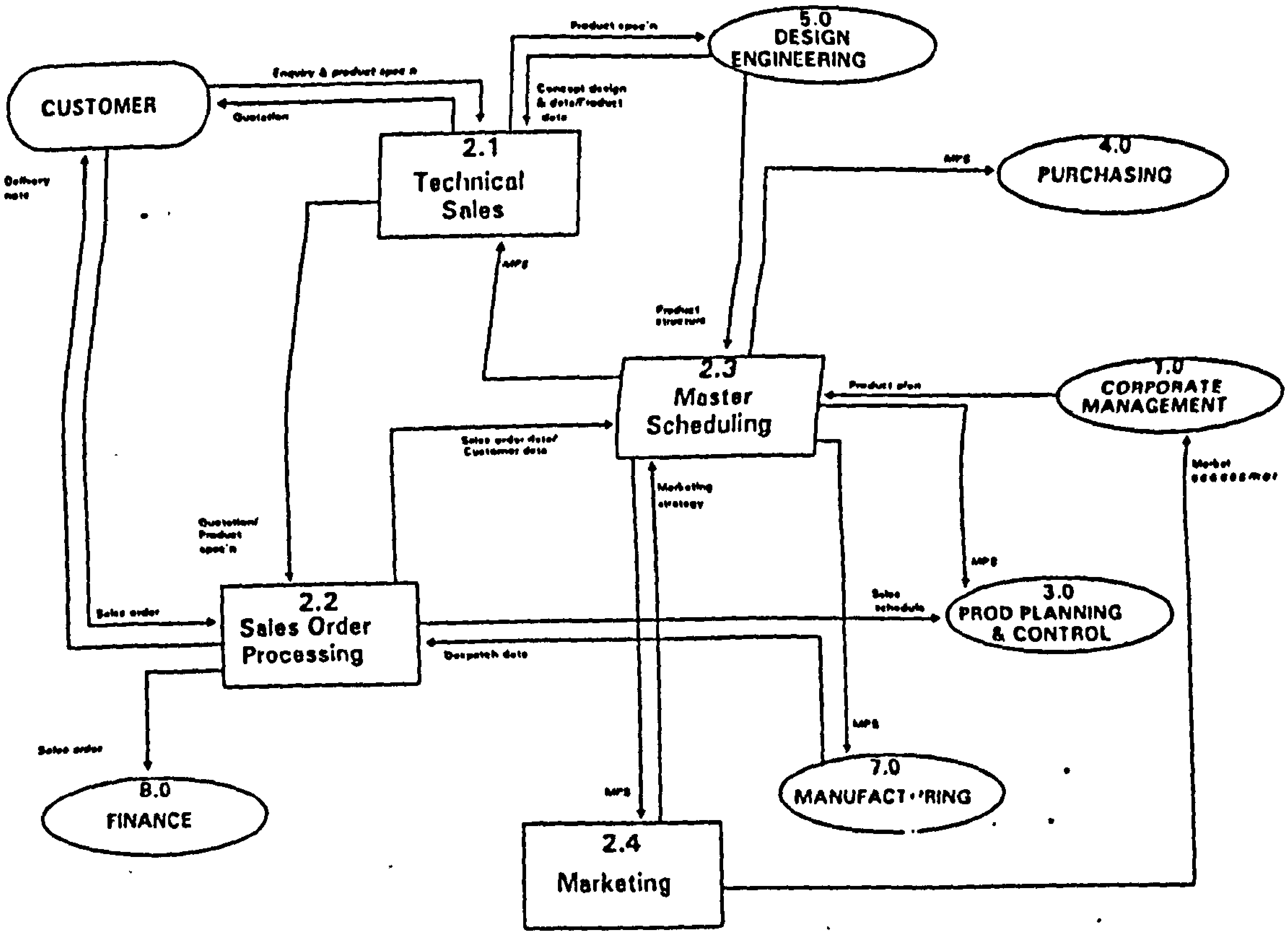

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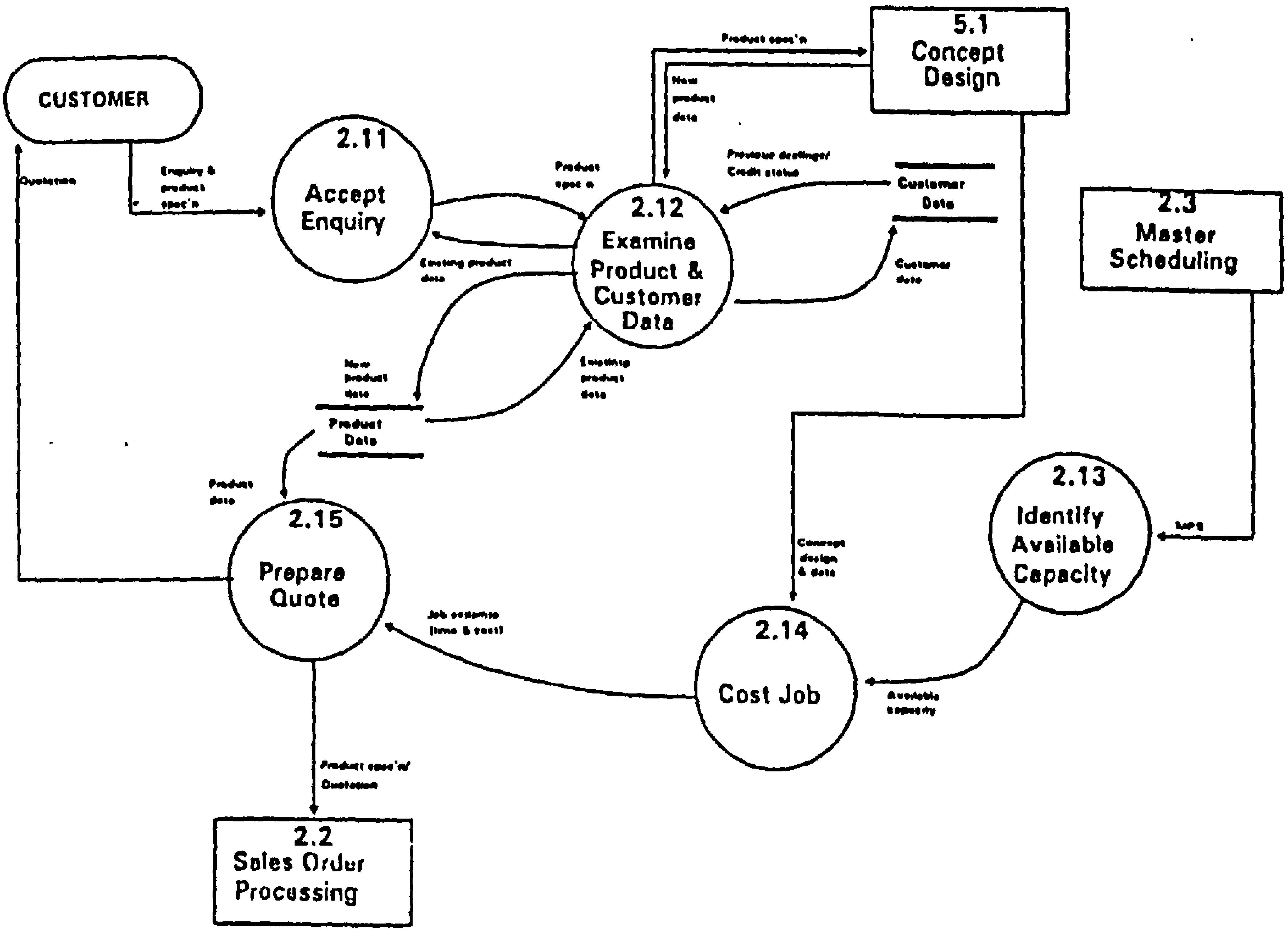

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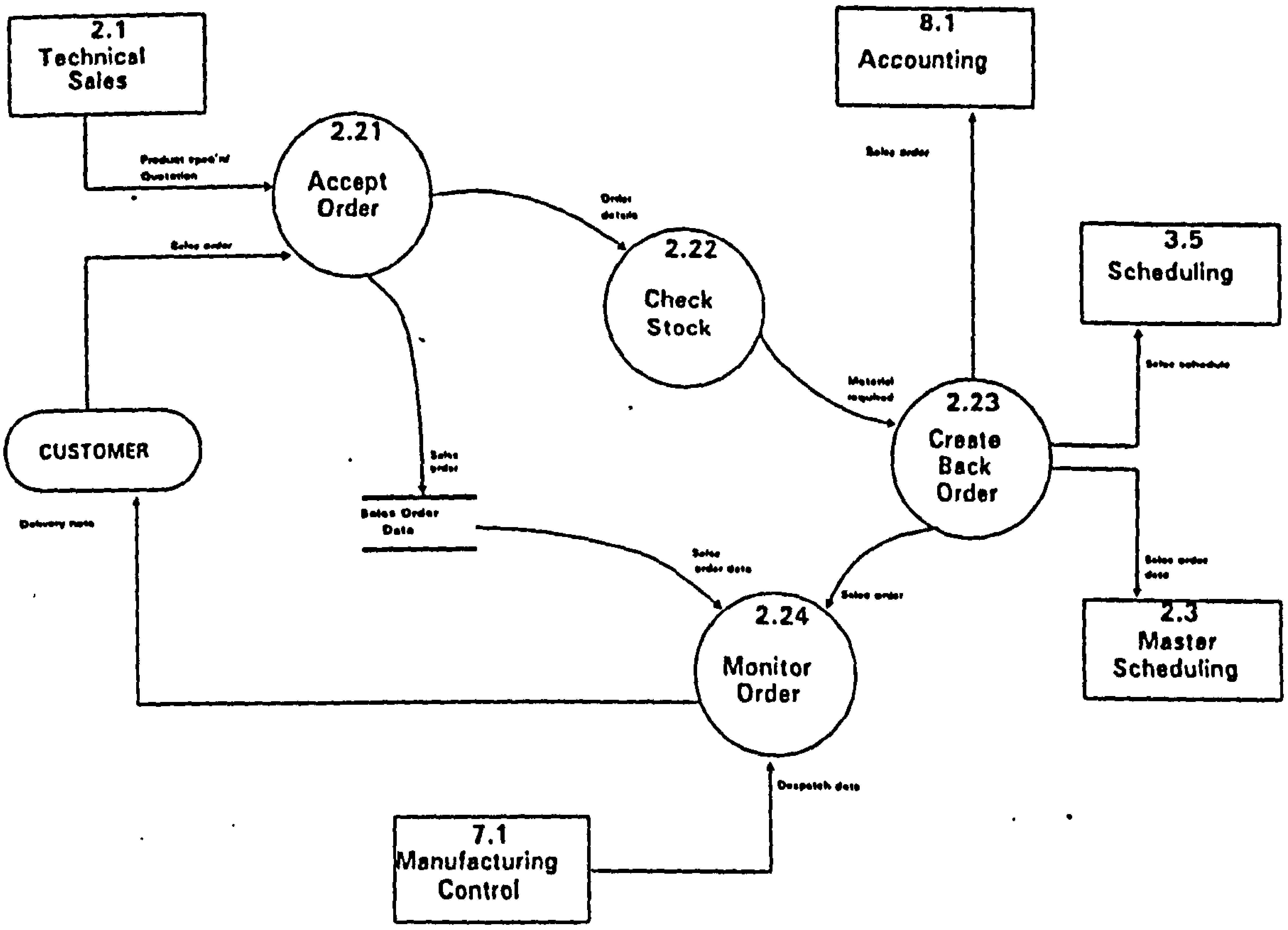

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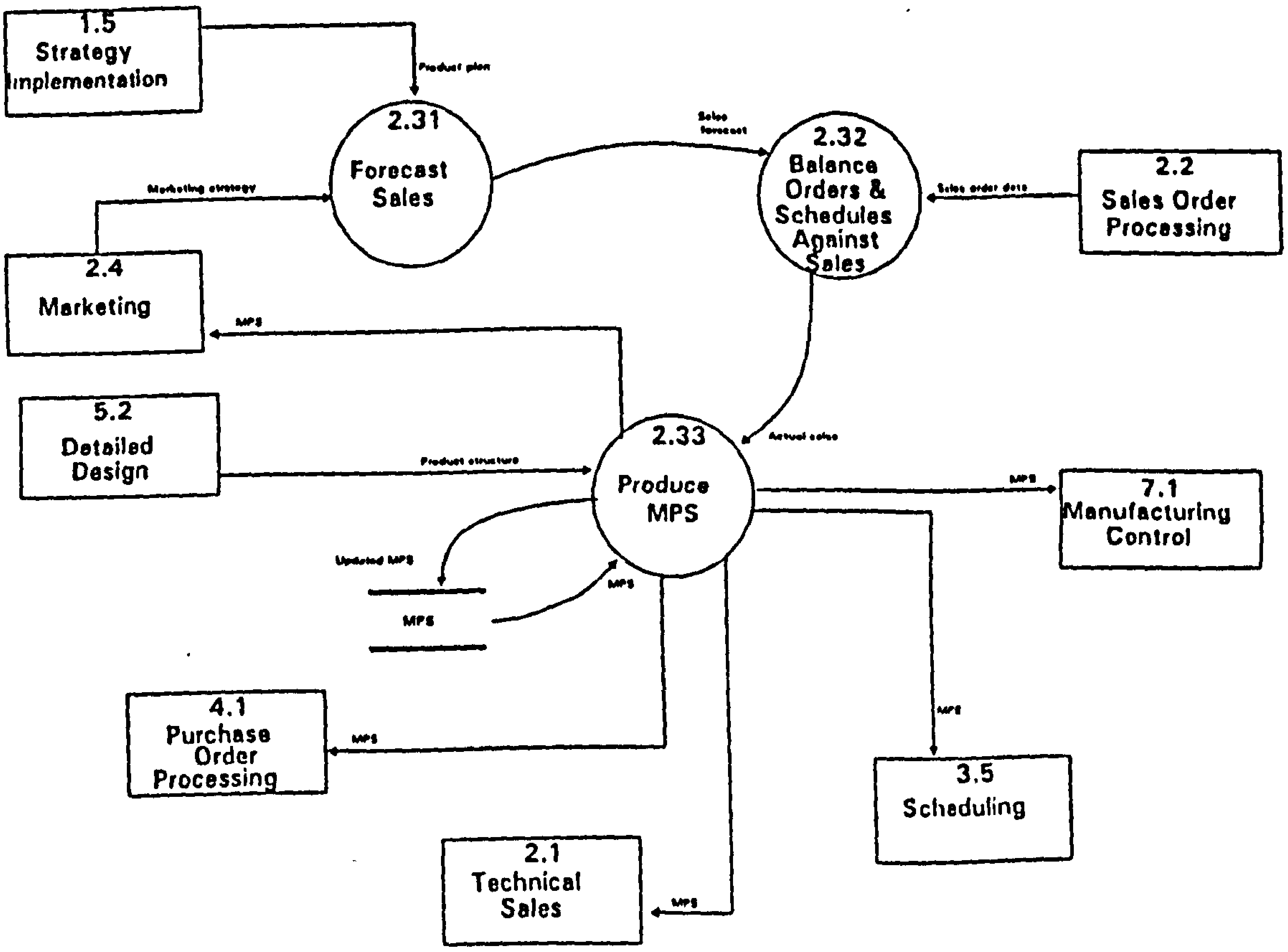

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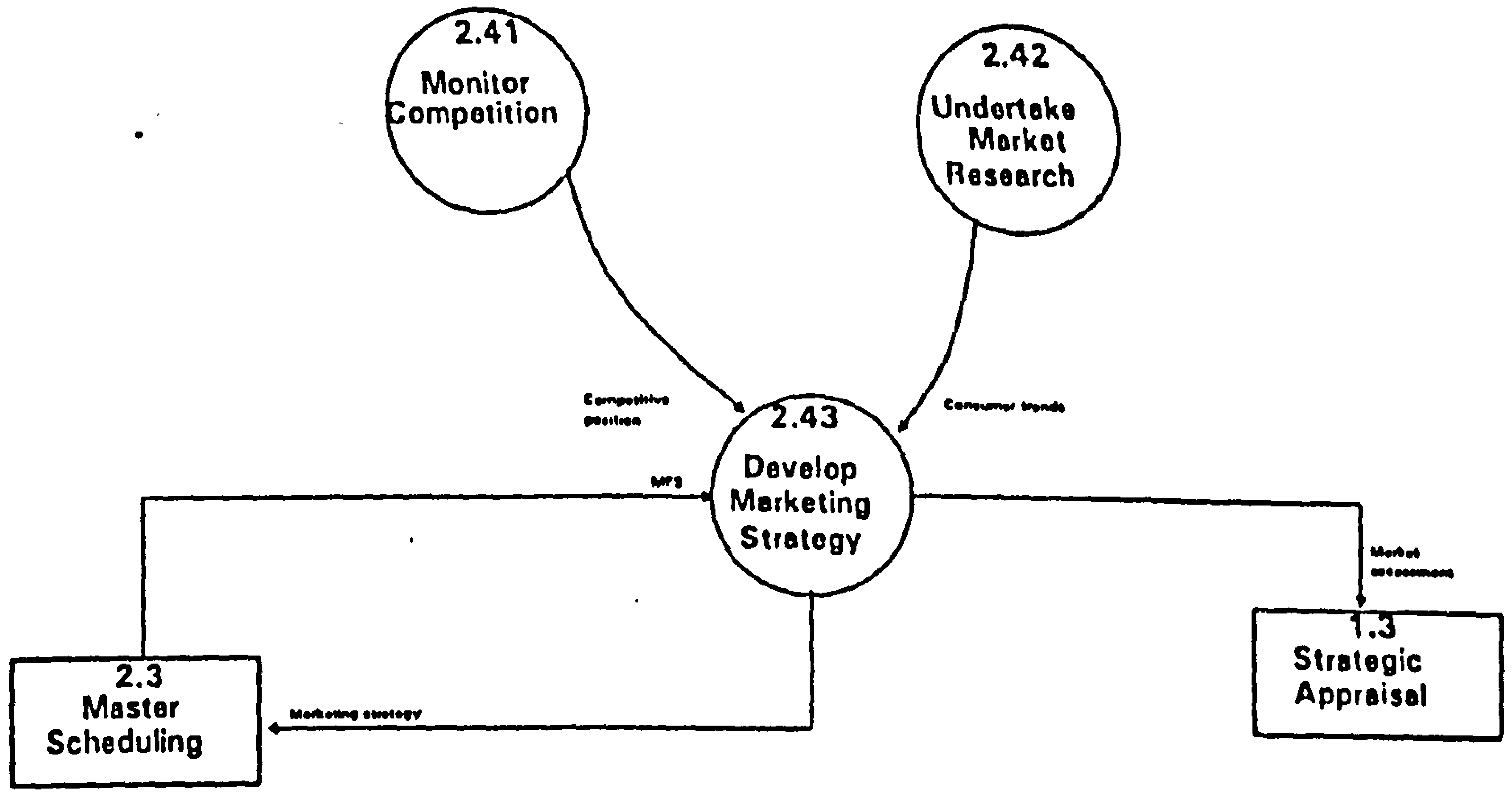

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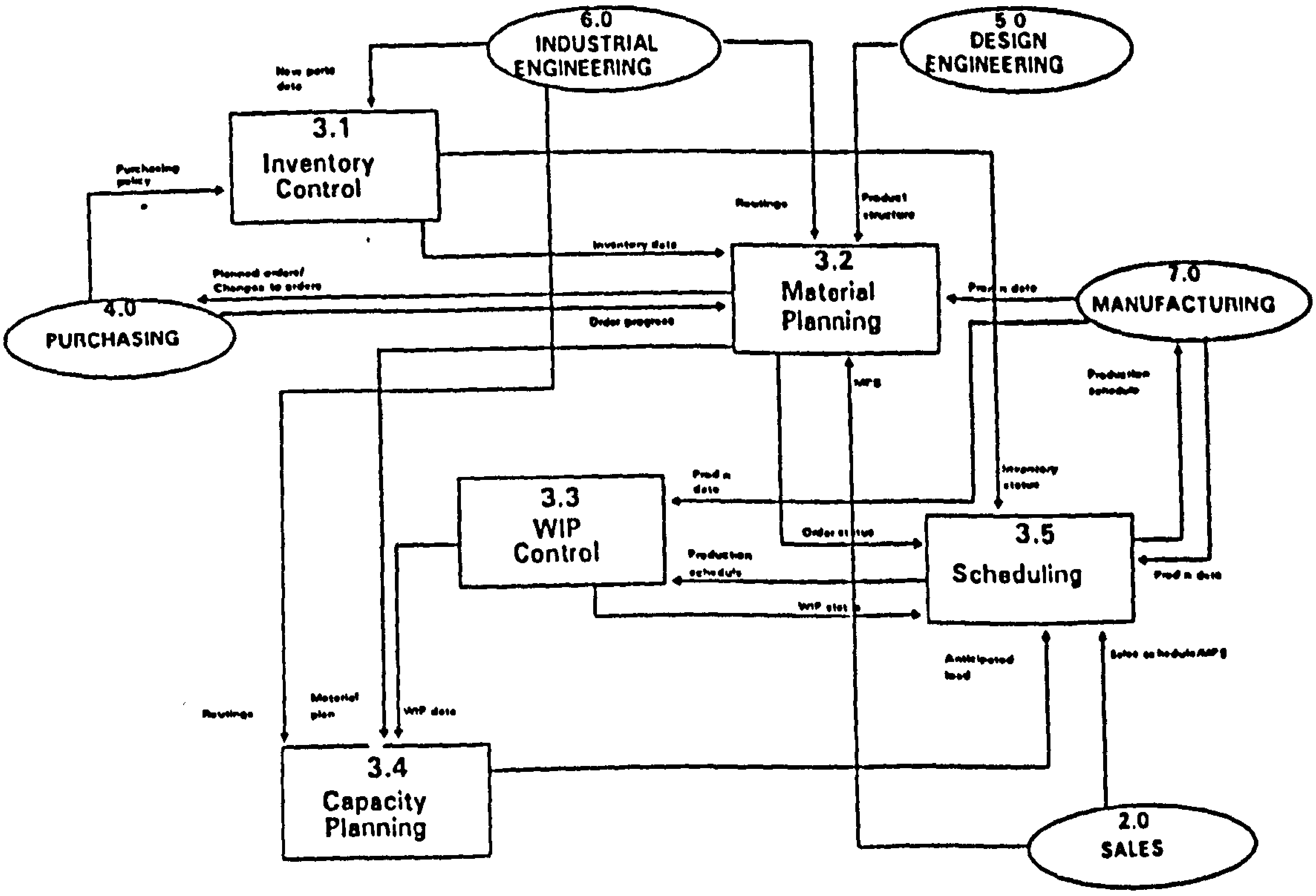

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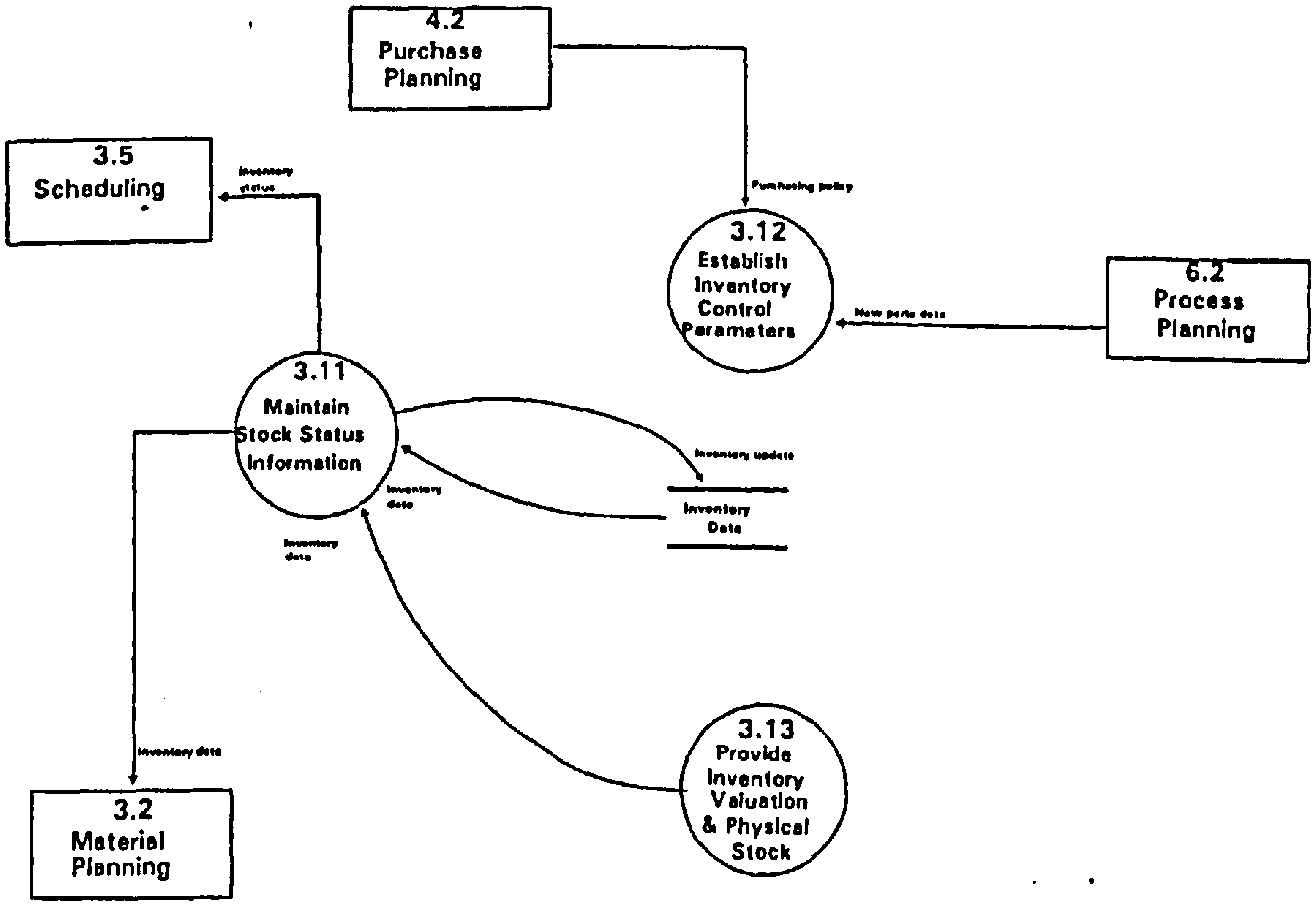

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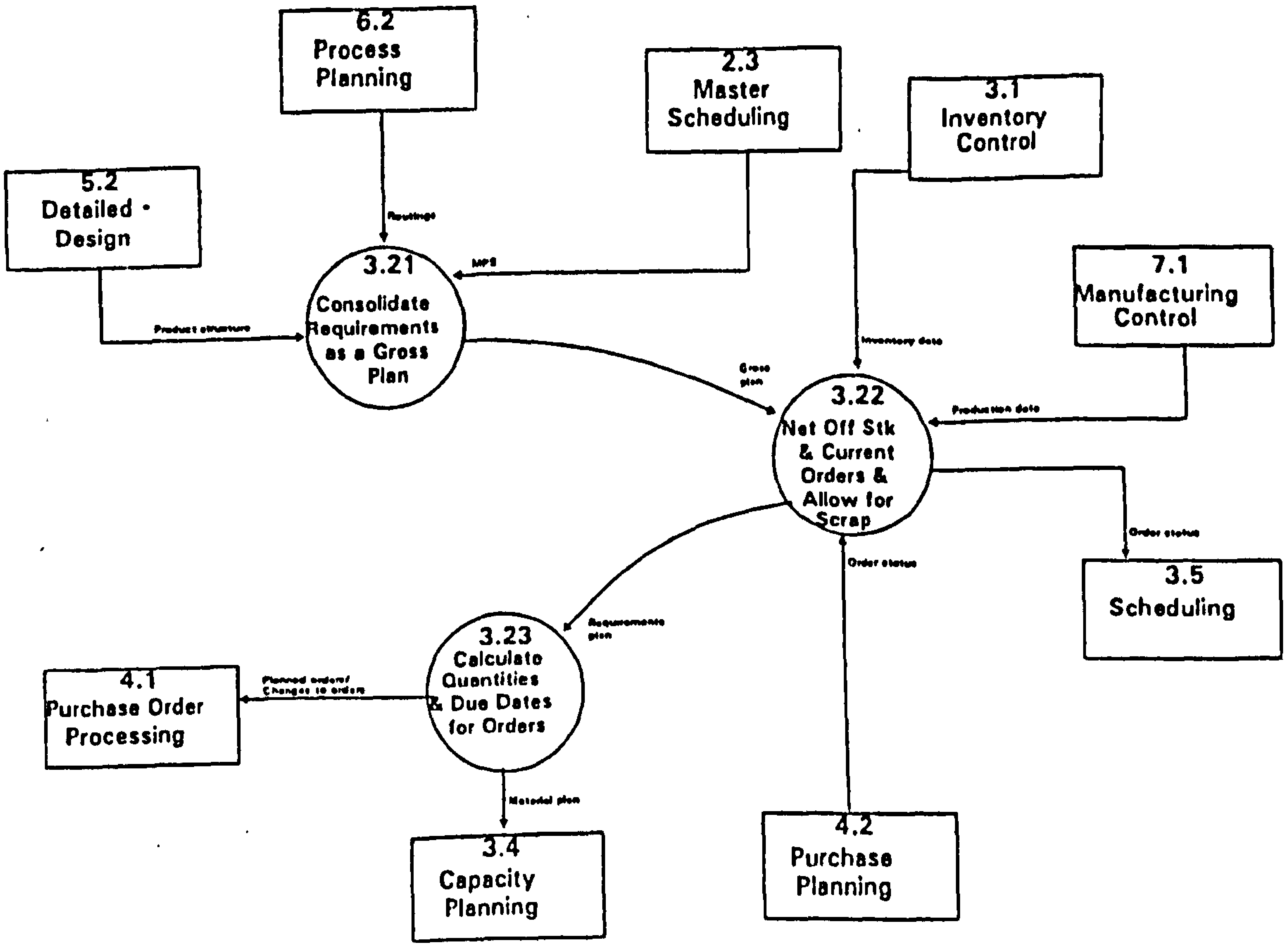

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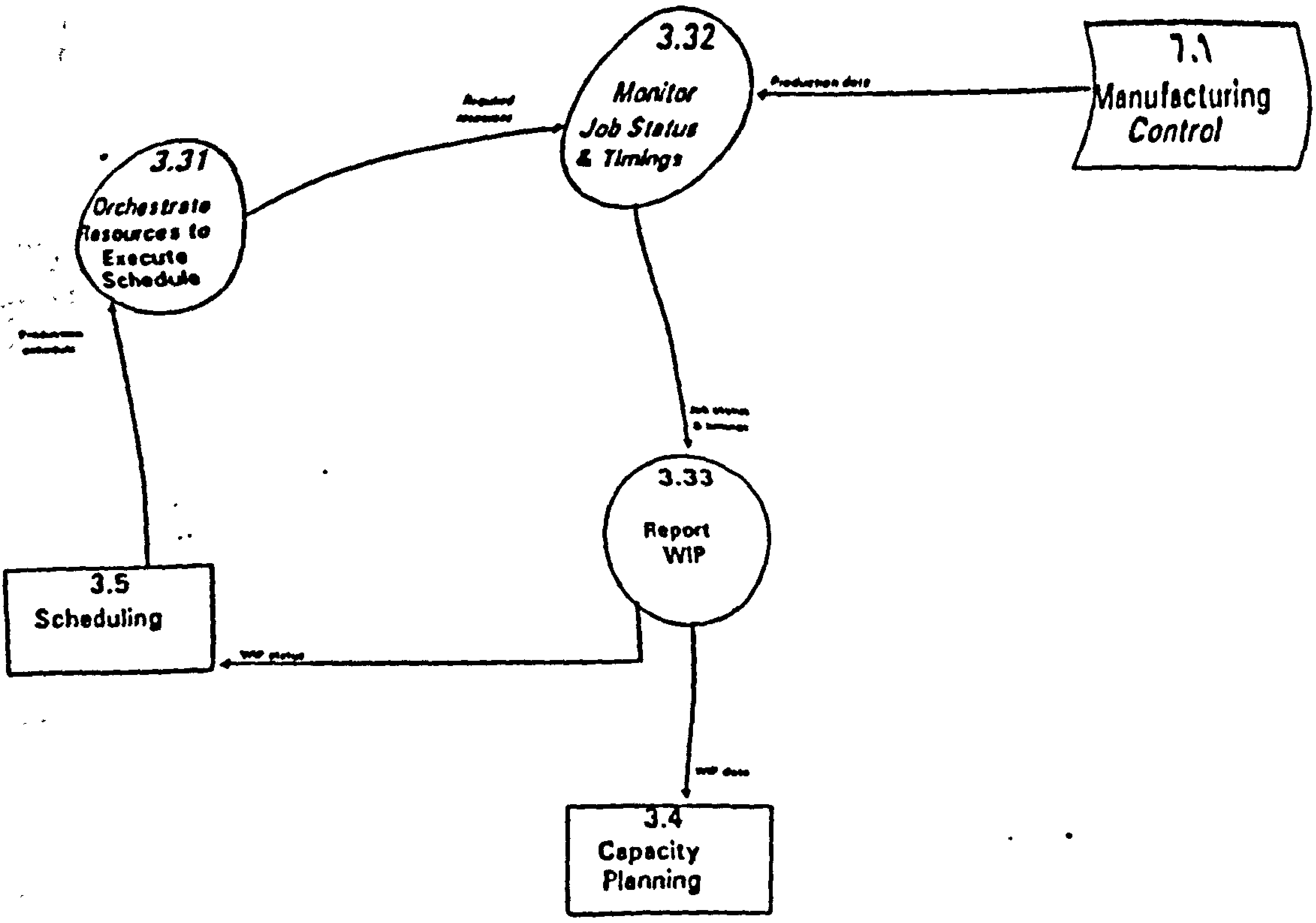

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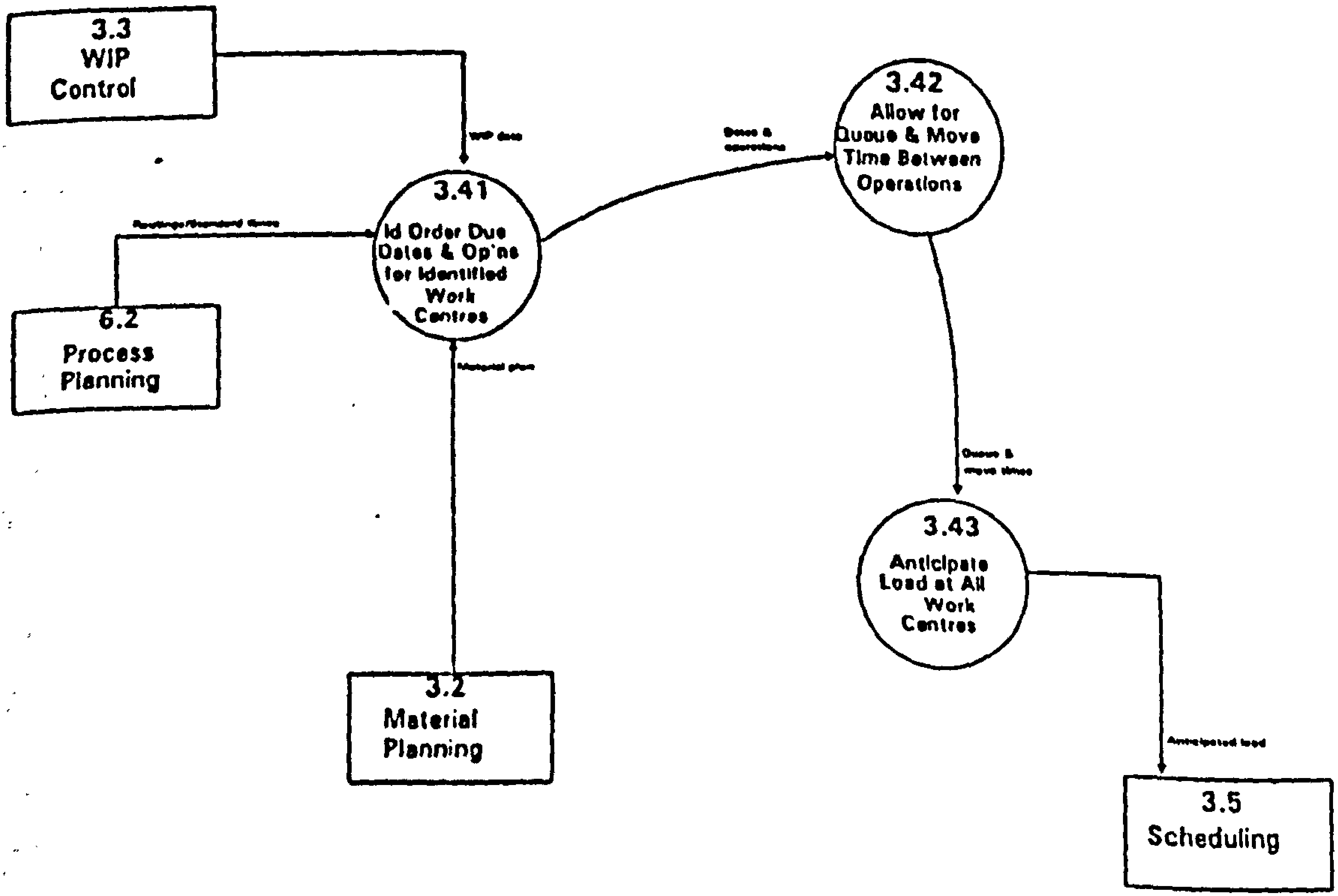

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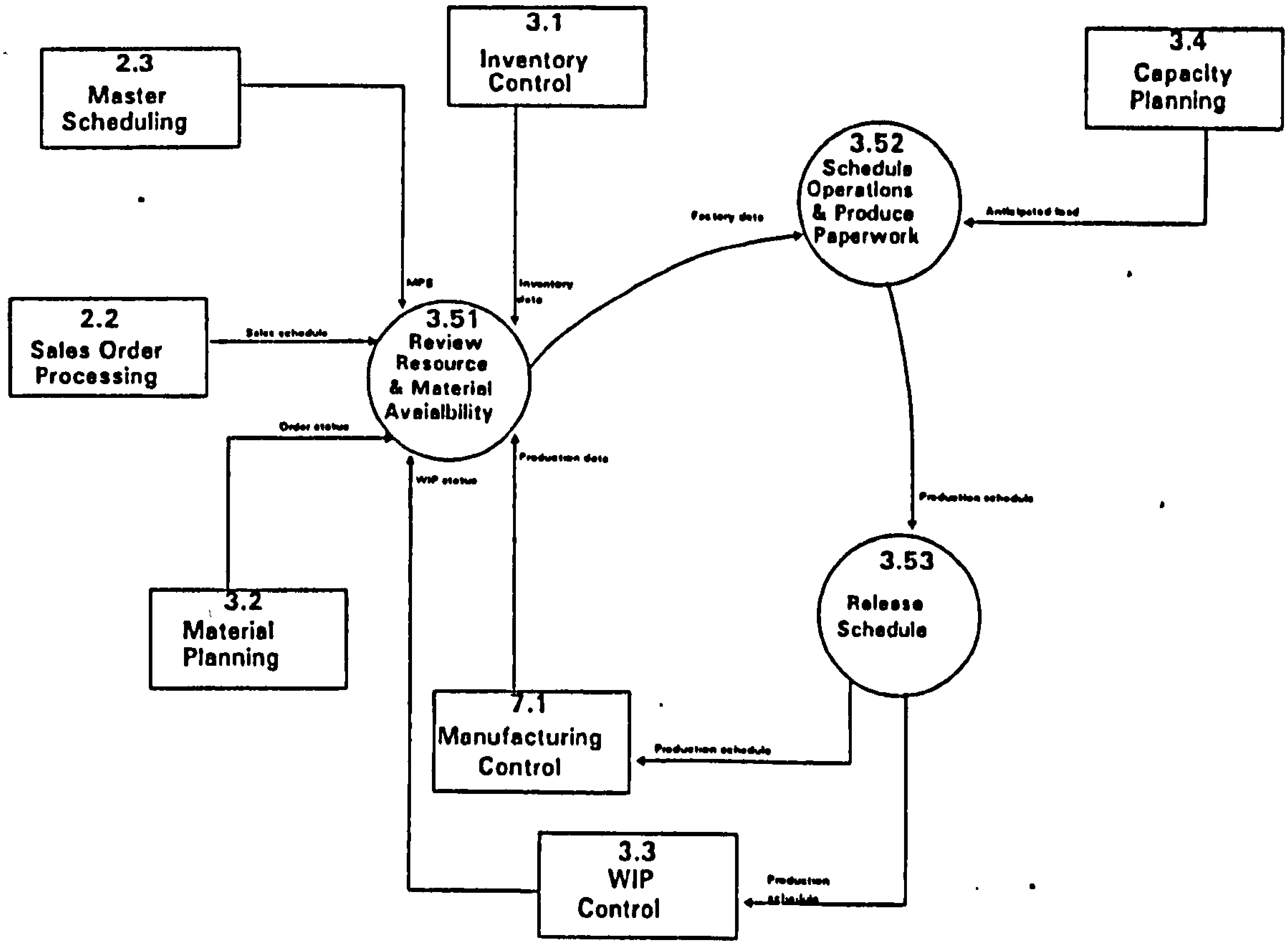

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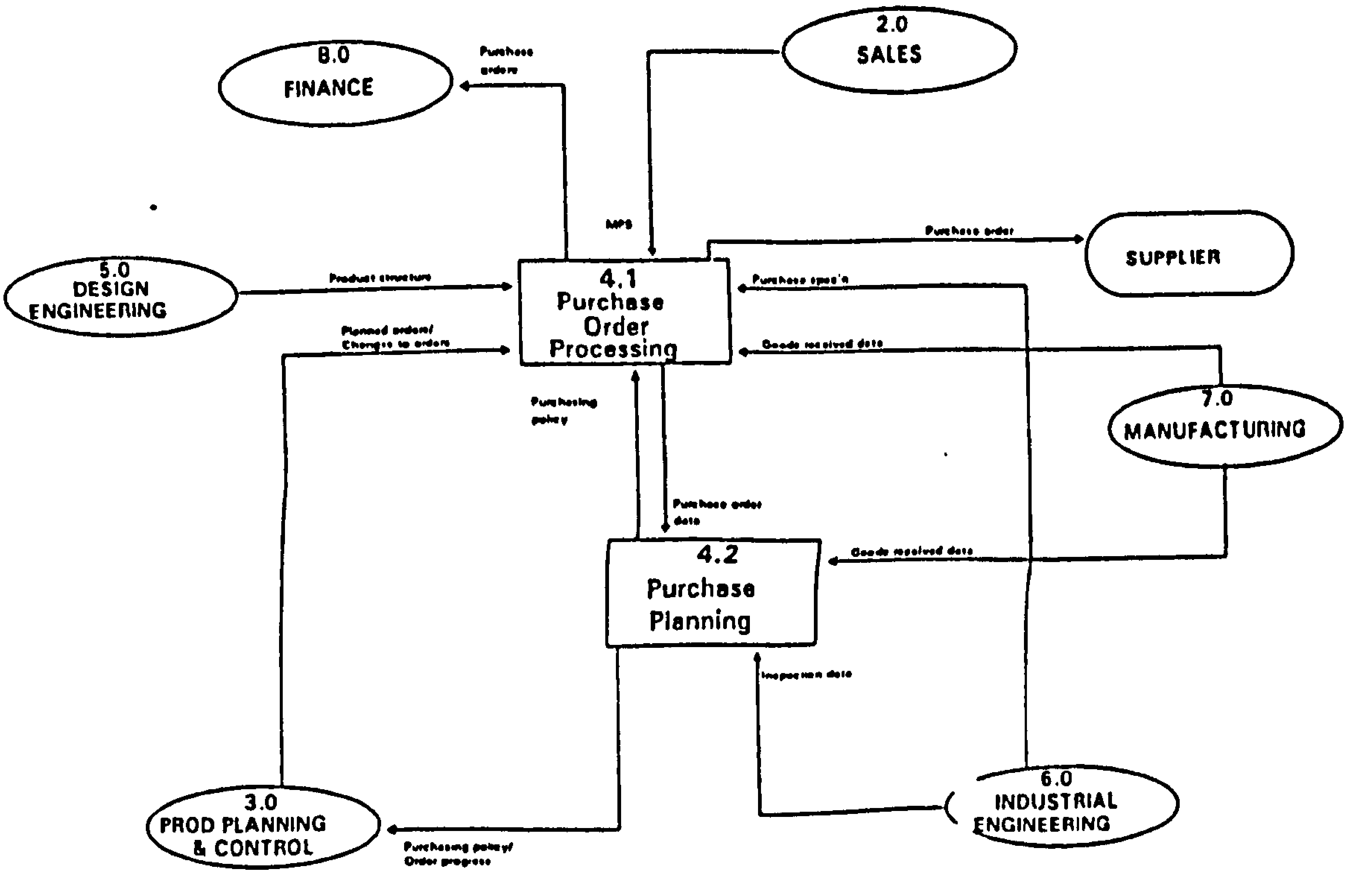

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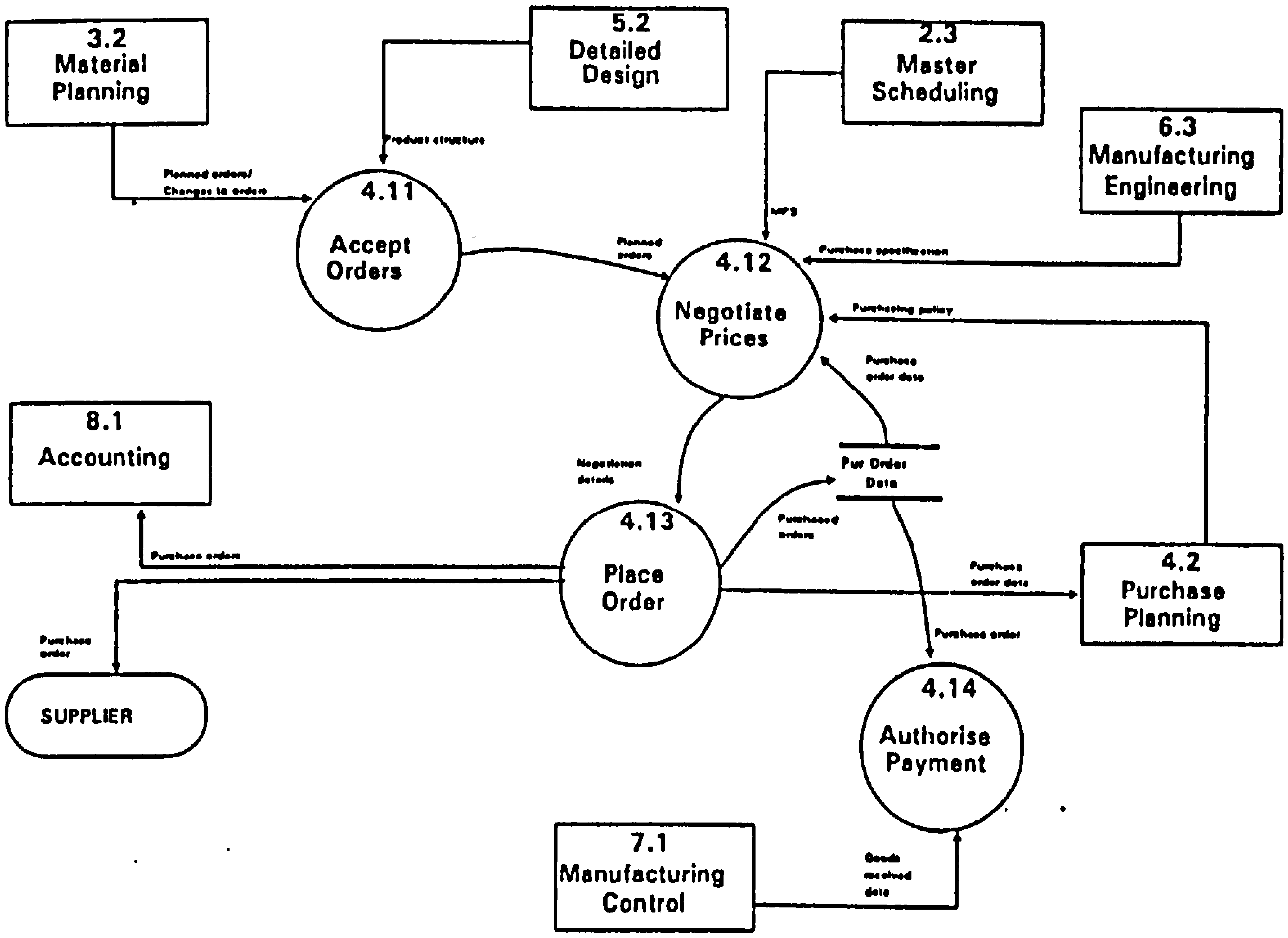

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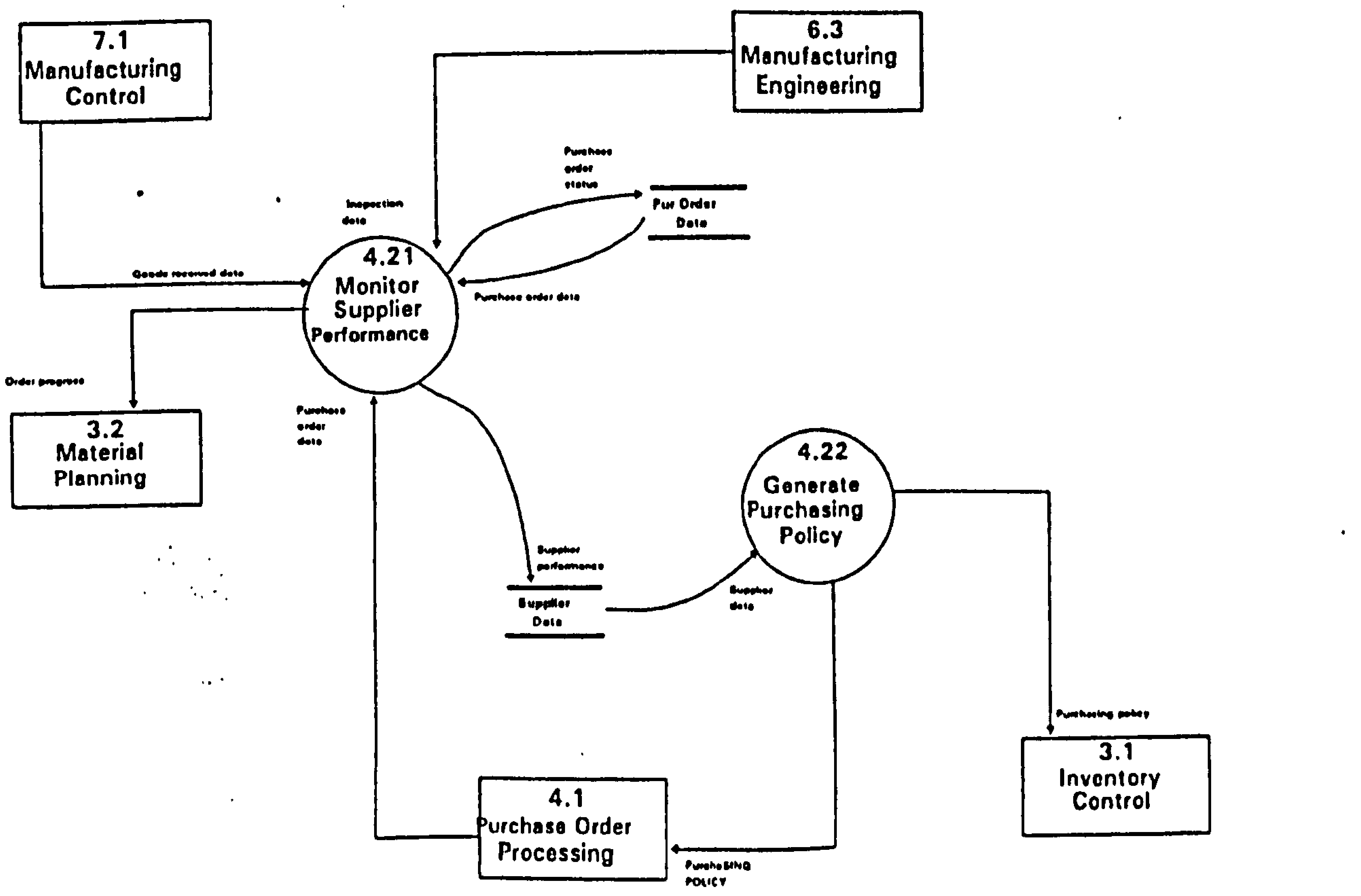

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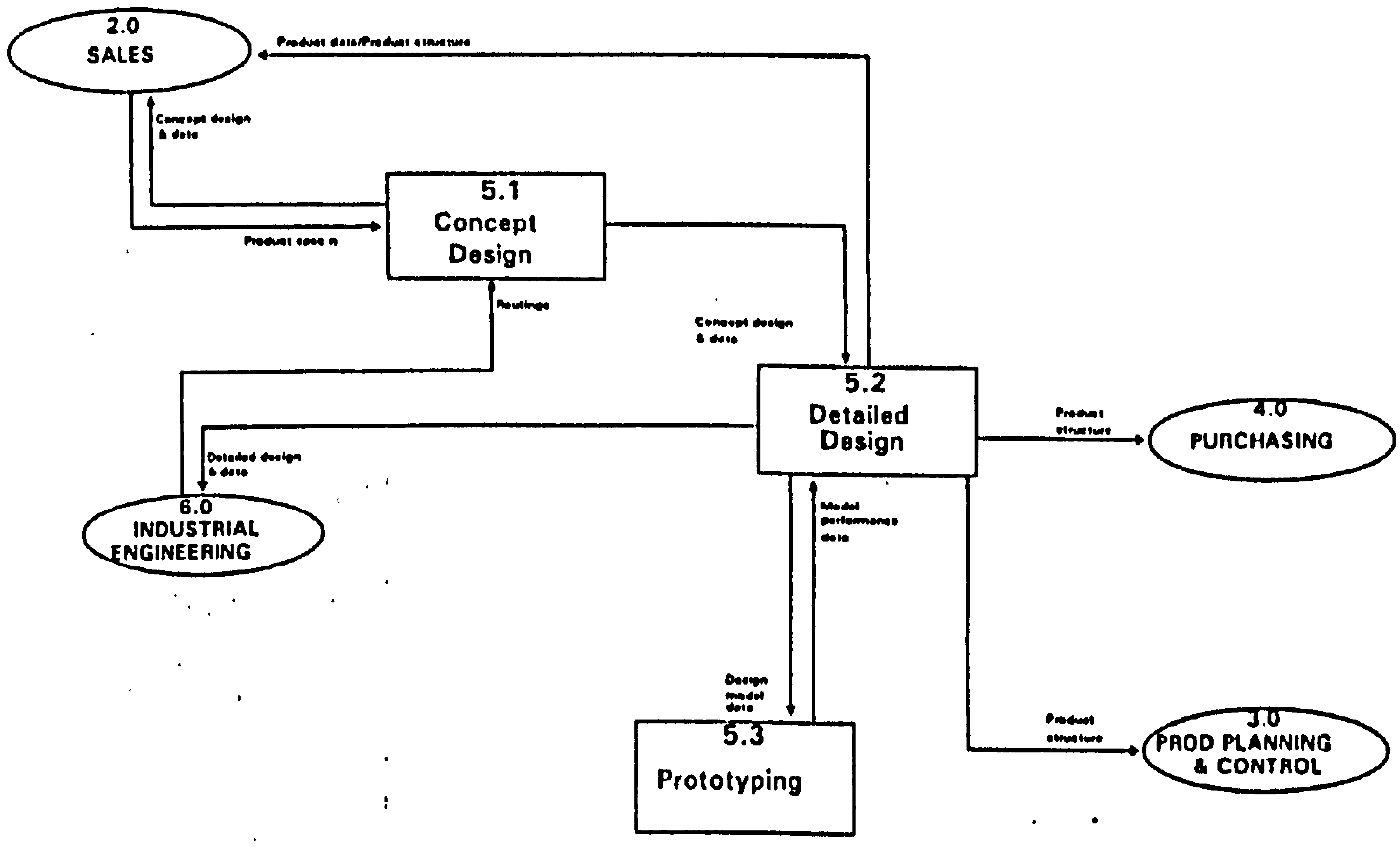

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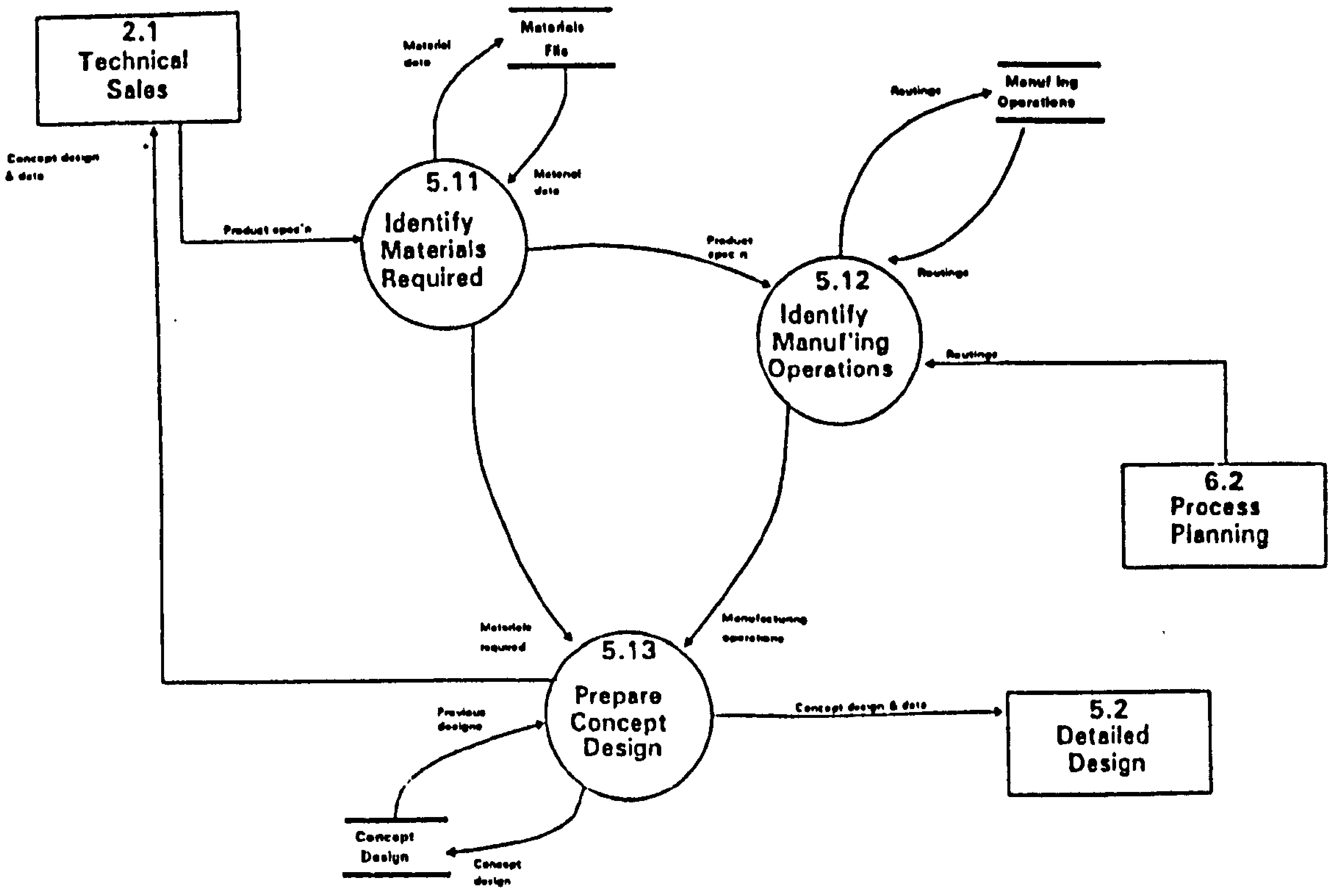

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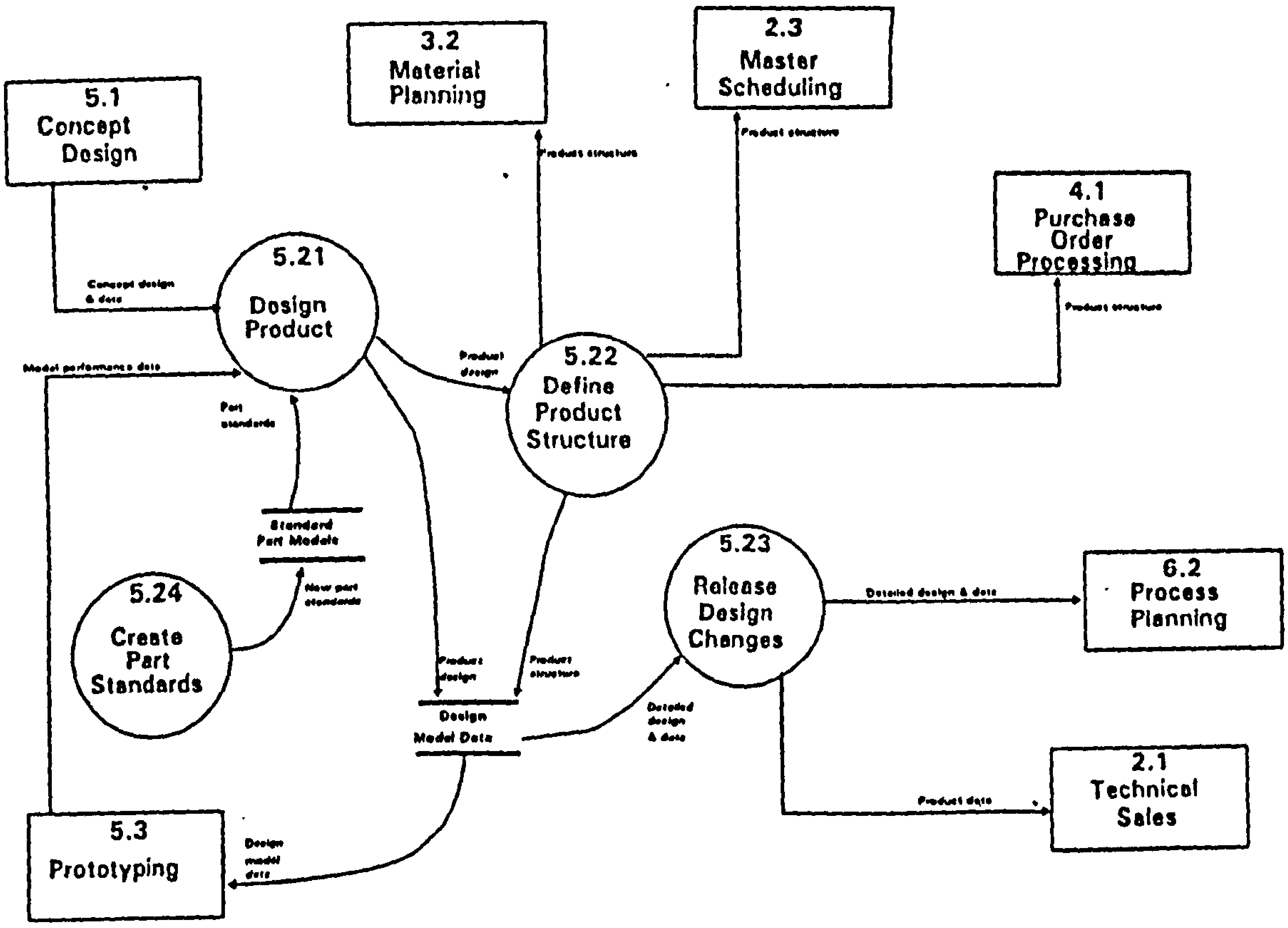
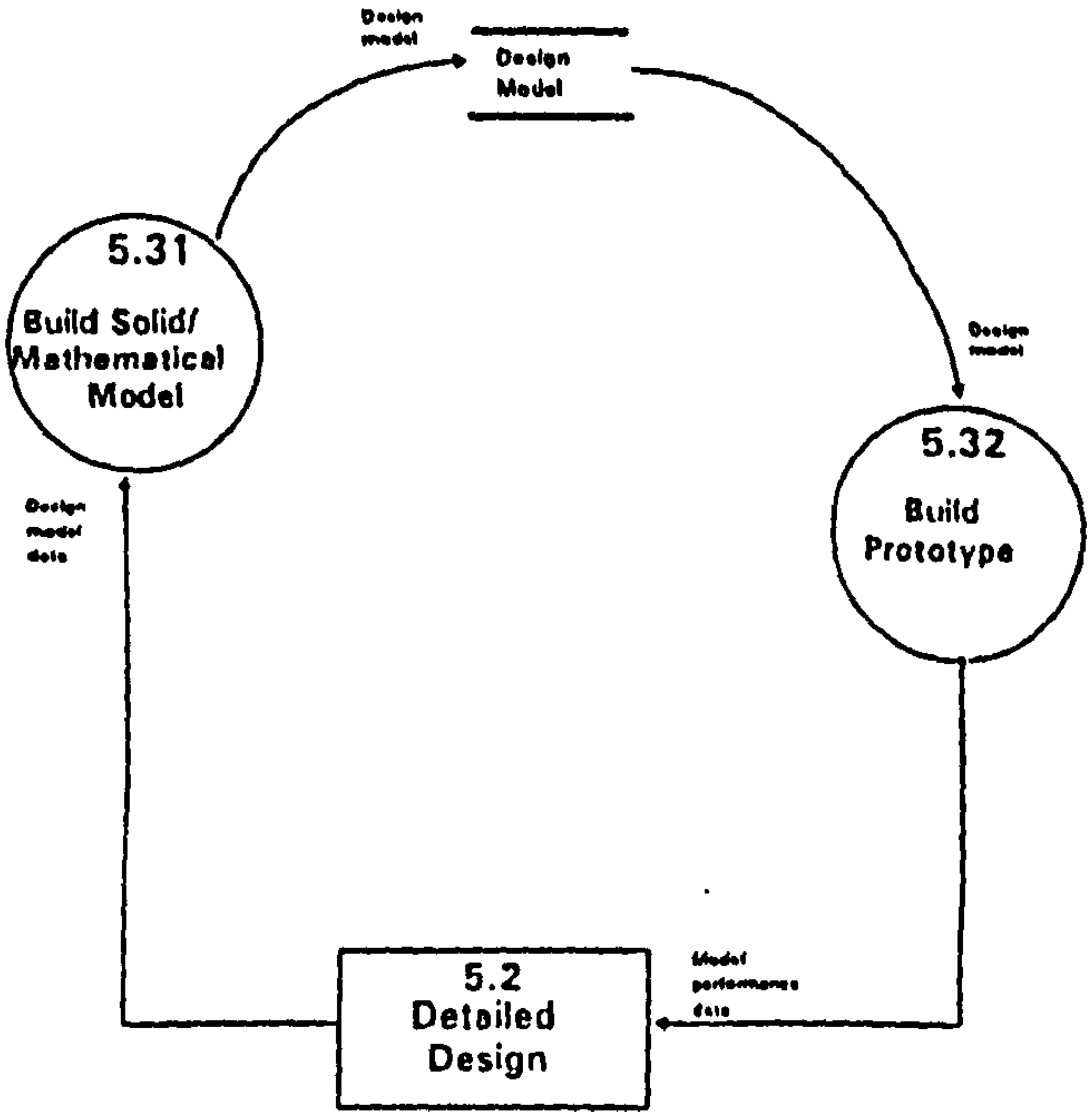
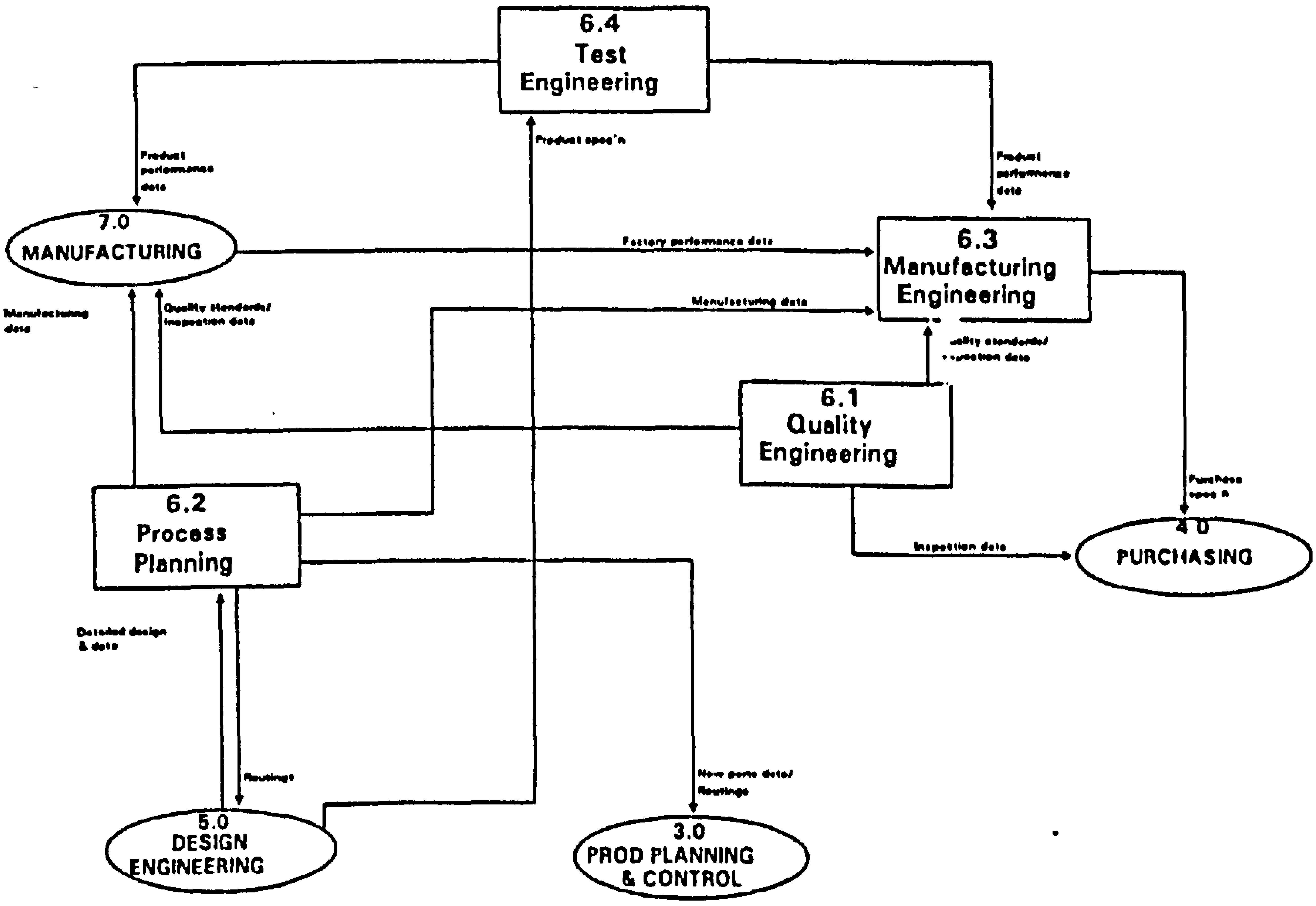


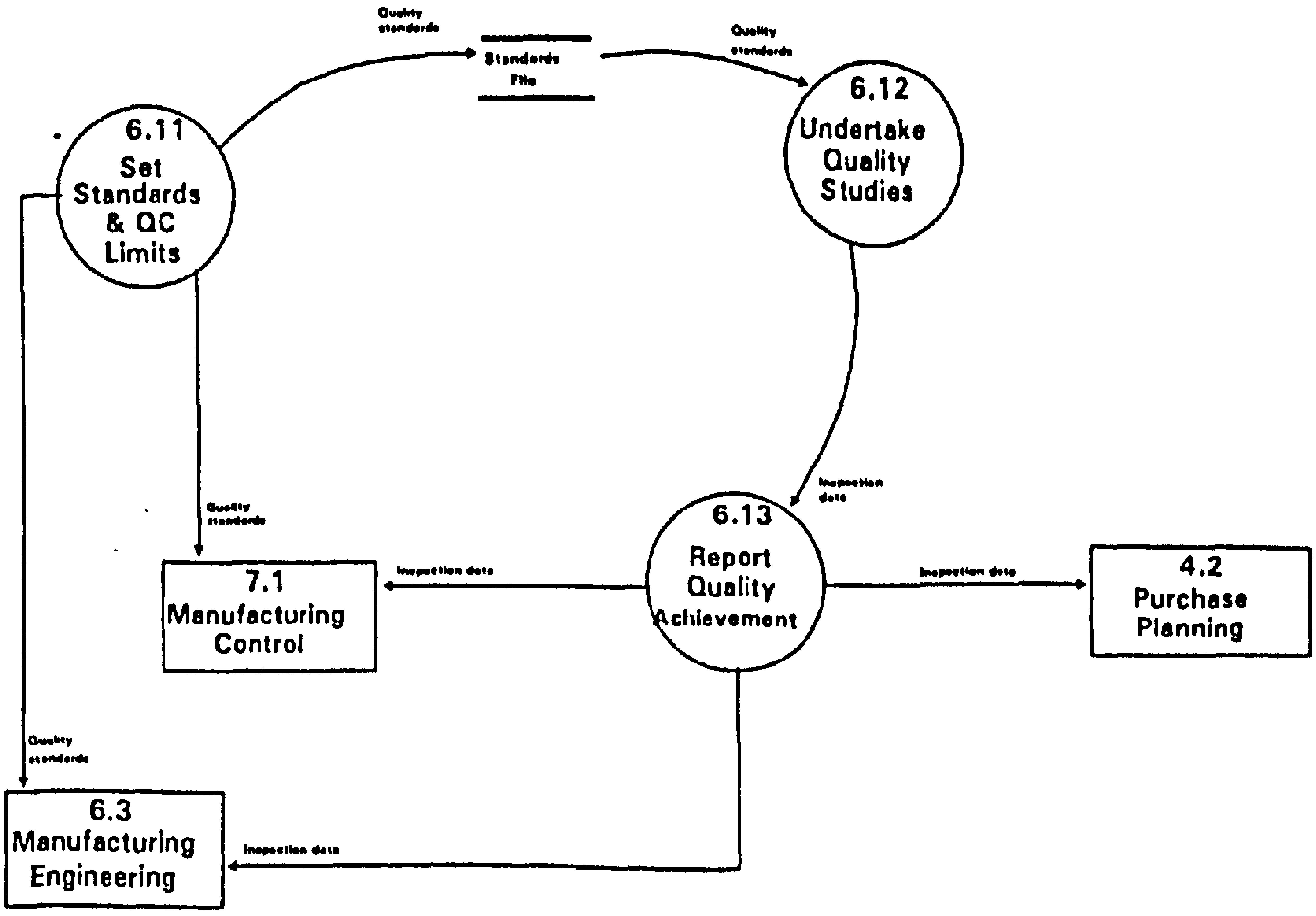
5.3 Prototyping Process Map



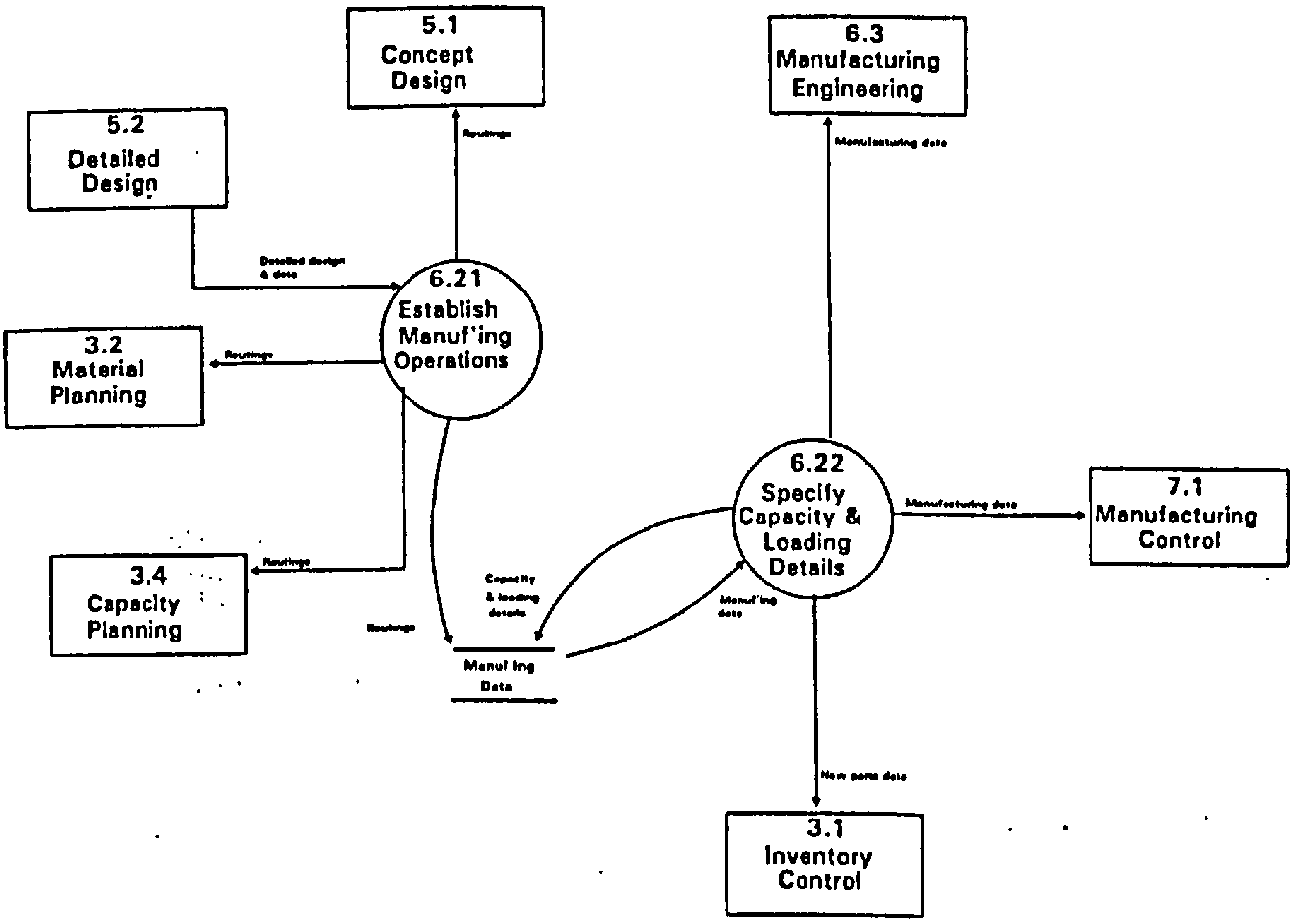
6.0 Industrial Engineering Function Map



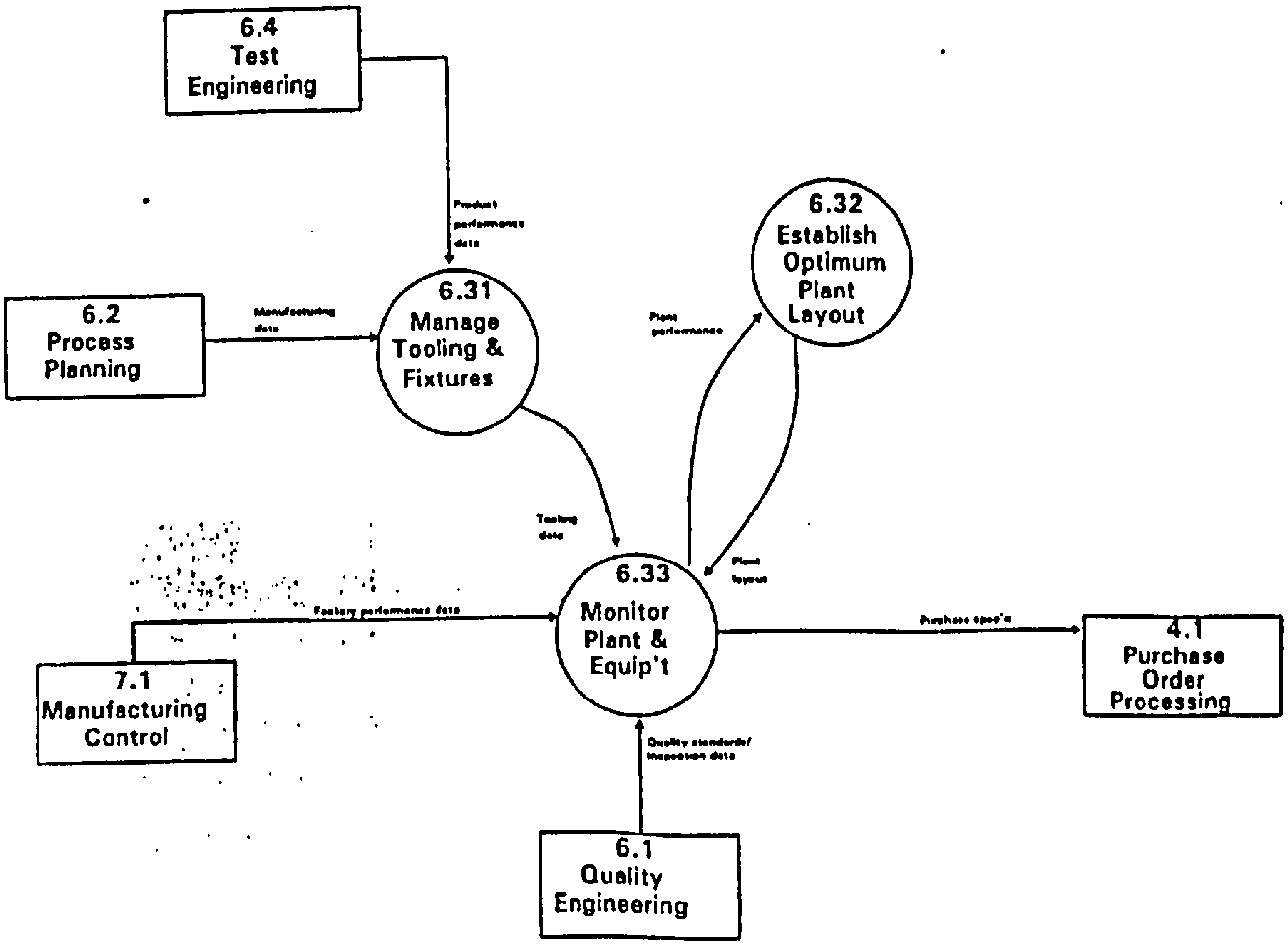
6.1 Quality Engineering Process Map



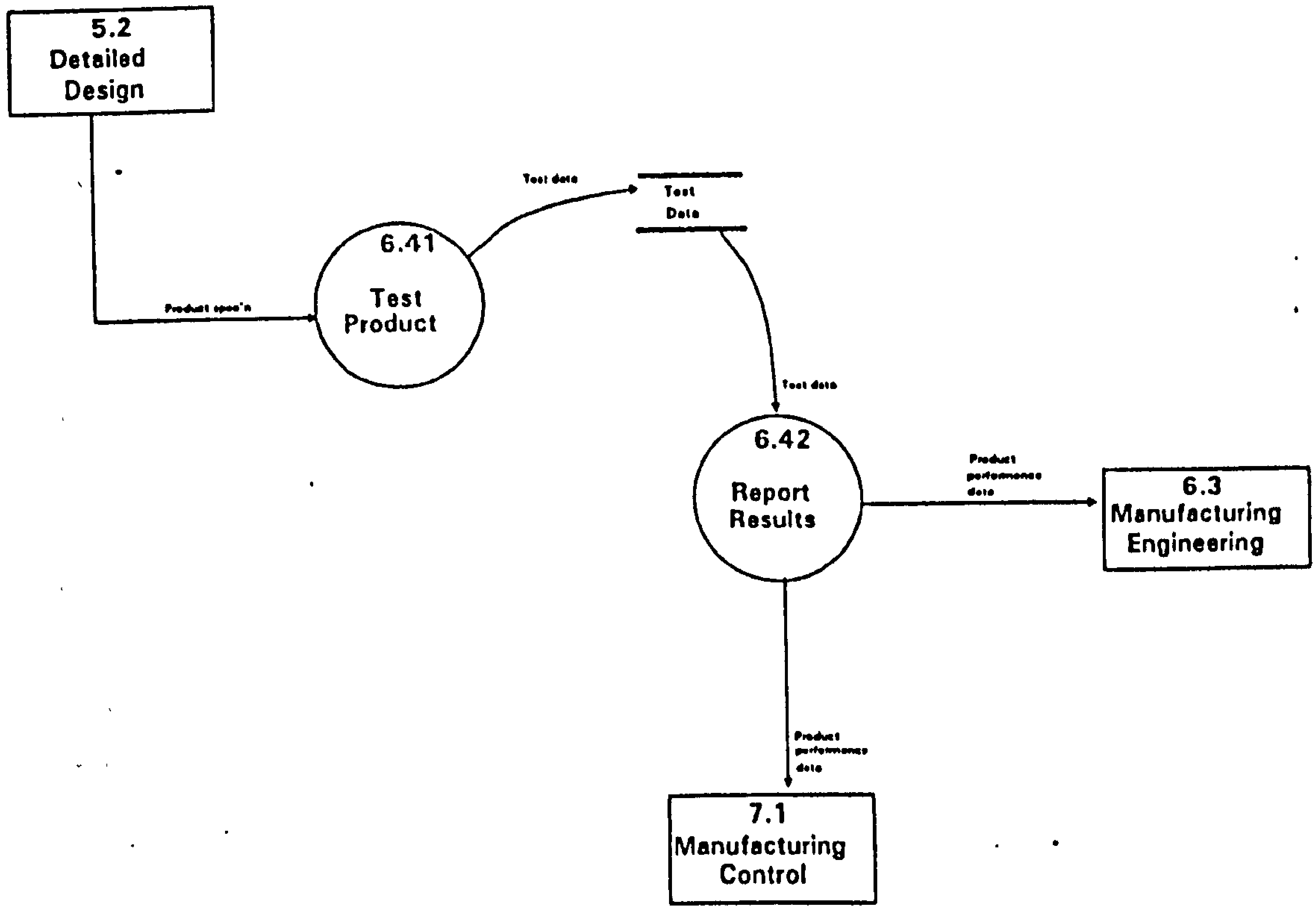
6.2 Process Planning Process Map



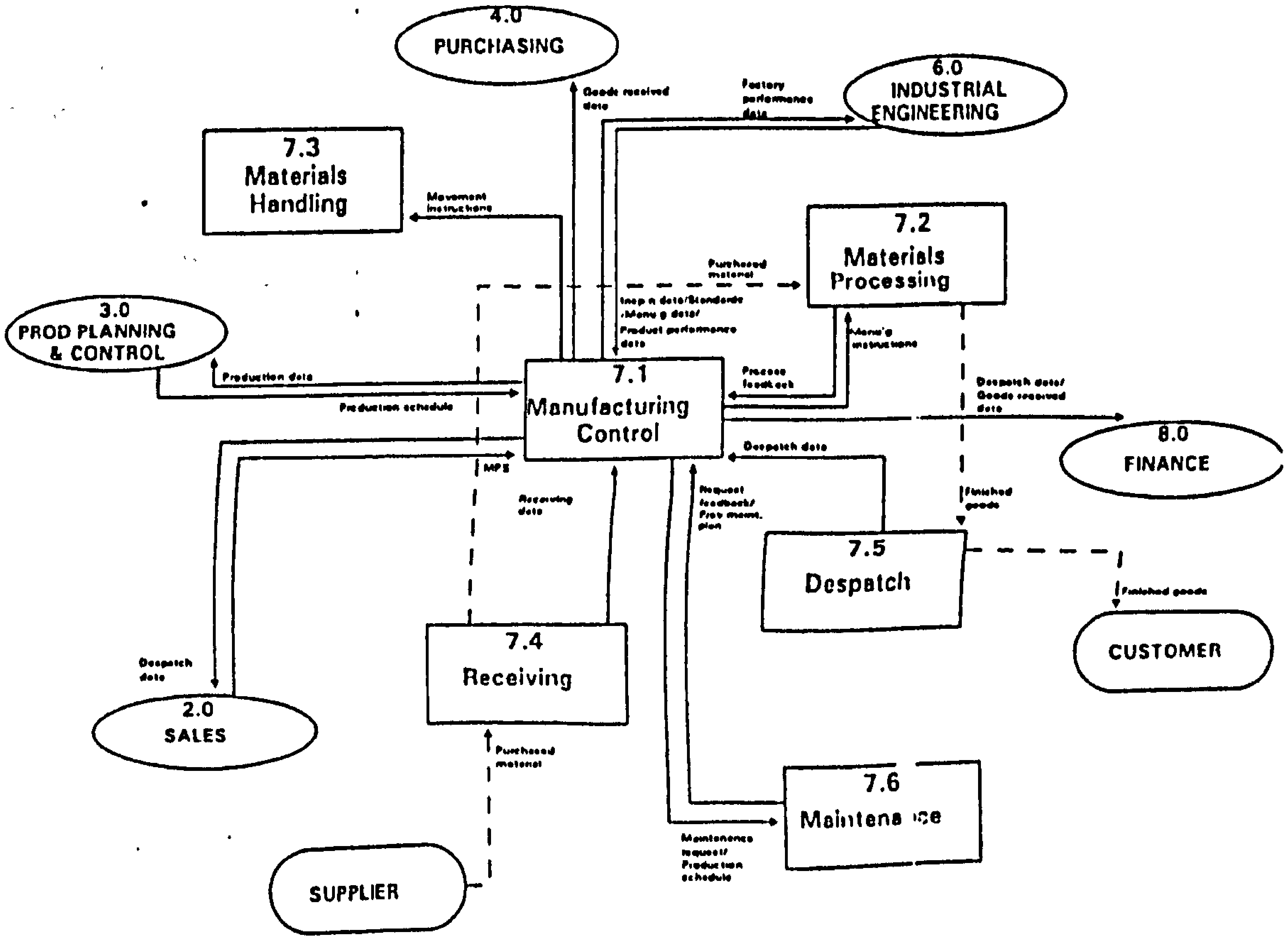
6.3 Manufacturing Engineering Process Map



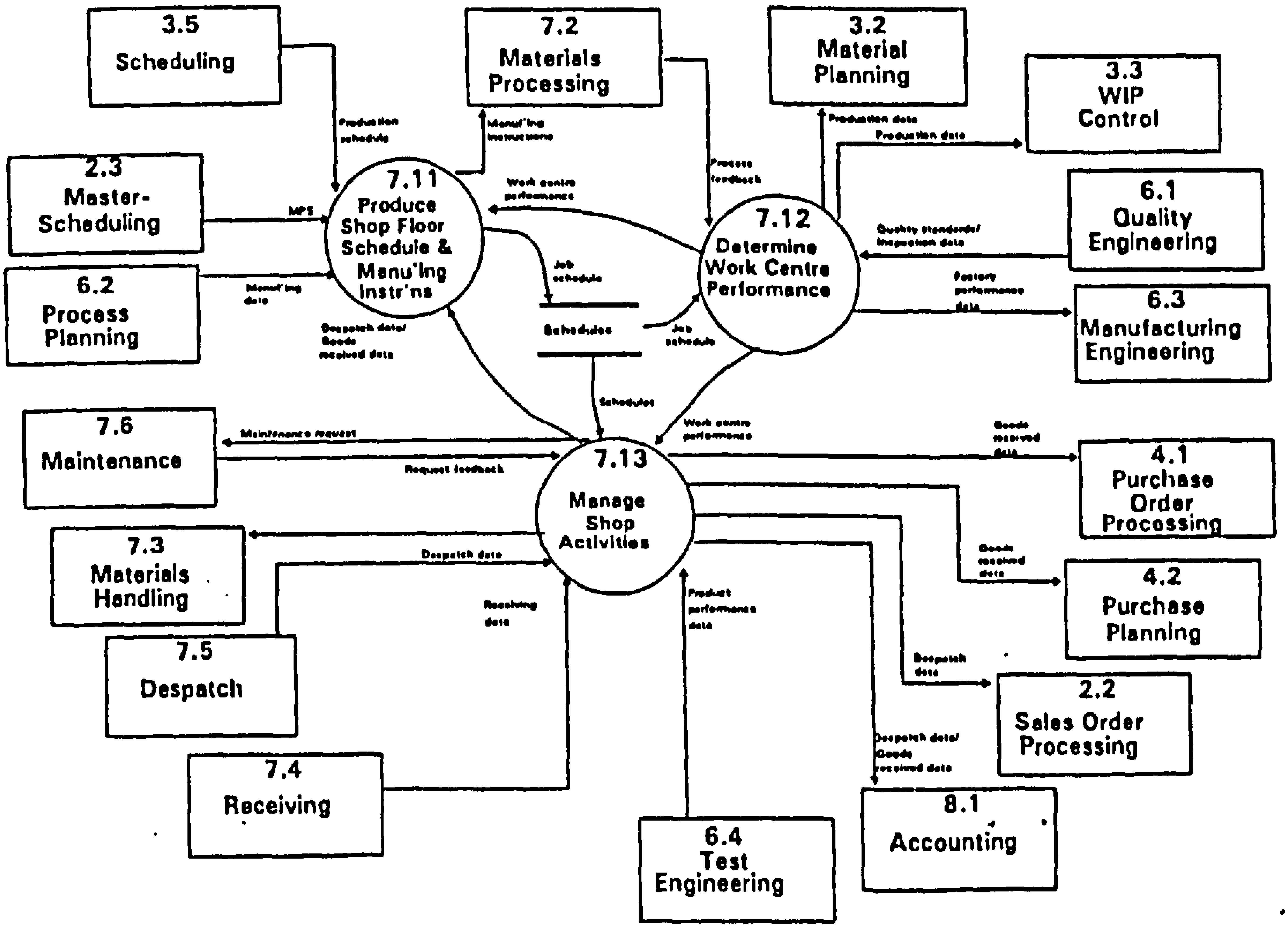
6.4 Test Engineering Process Map



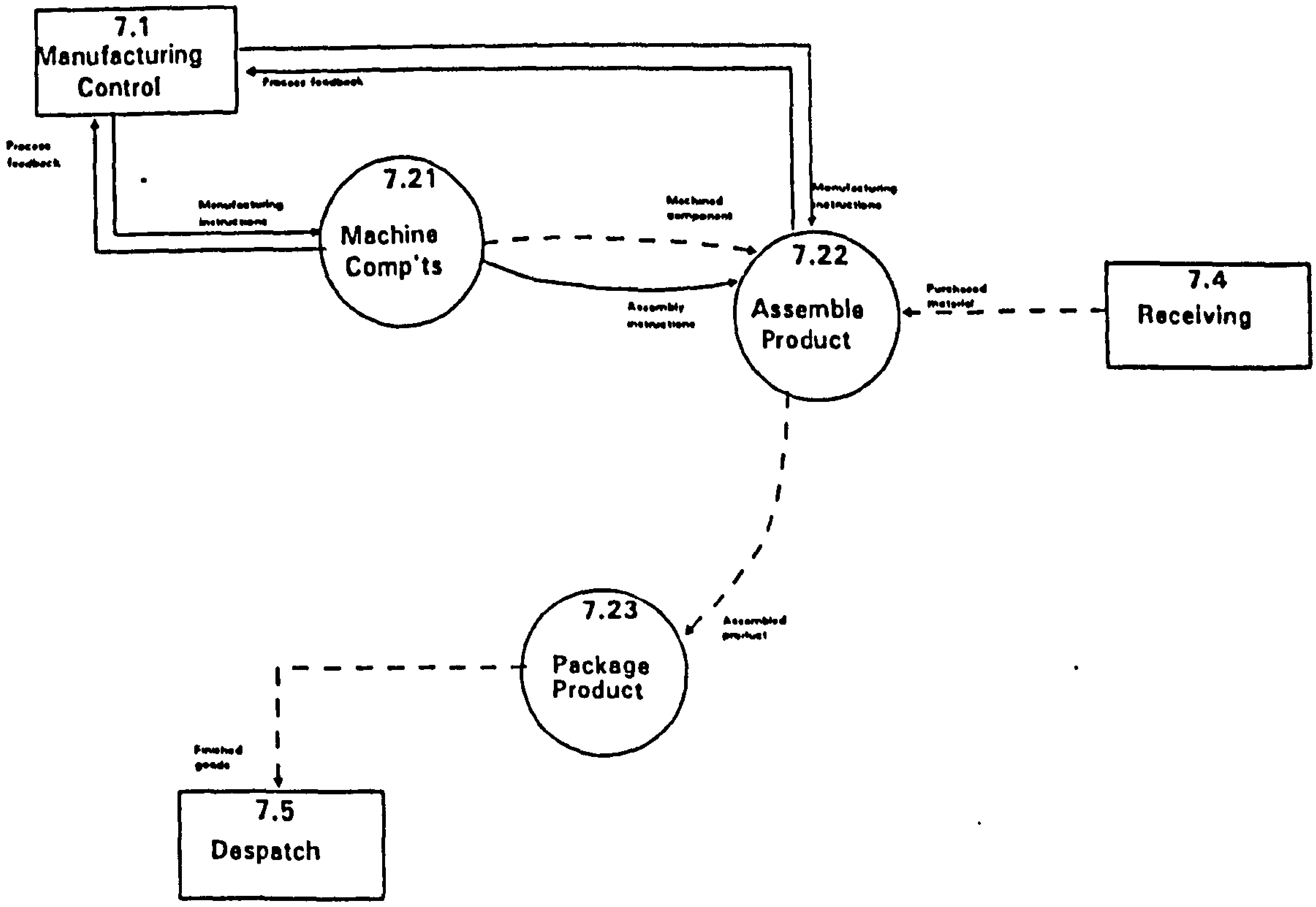
7.0 Manufacturing Function Map



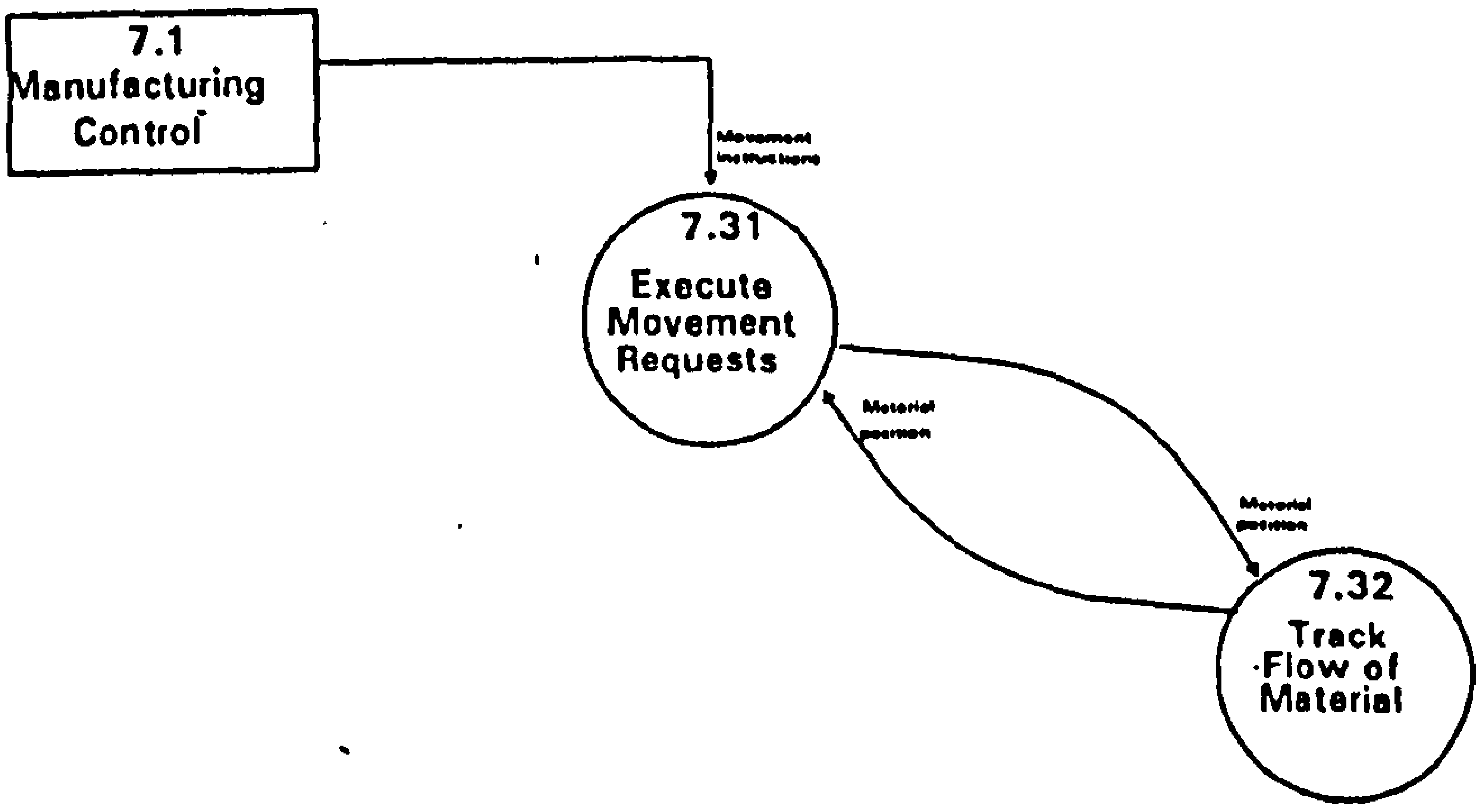
7.1 Manufacturing Control Process Map



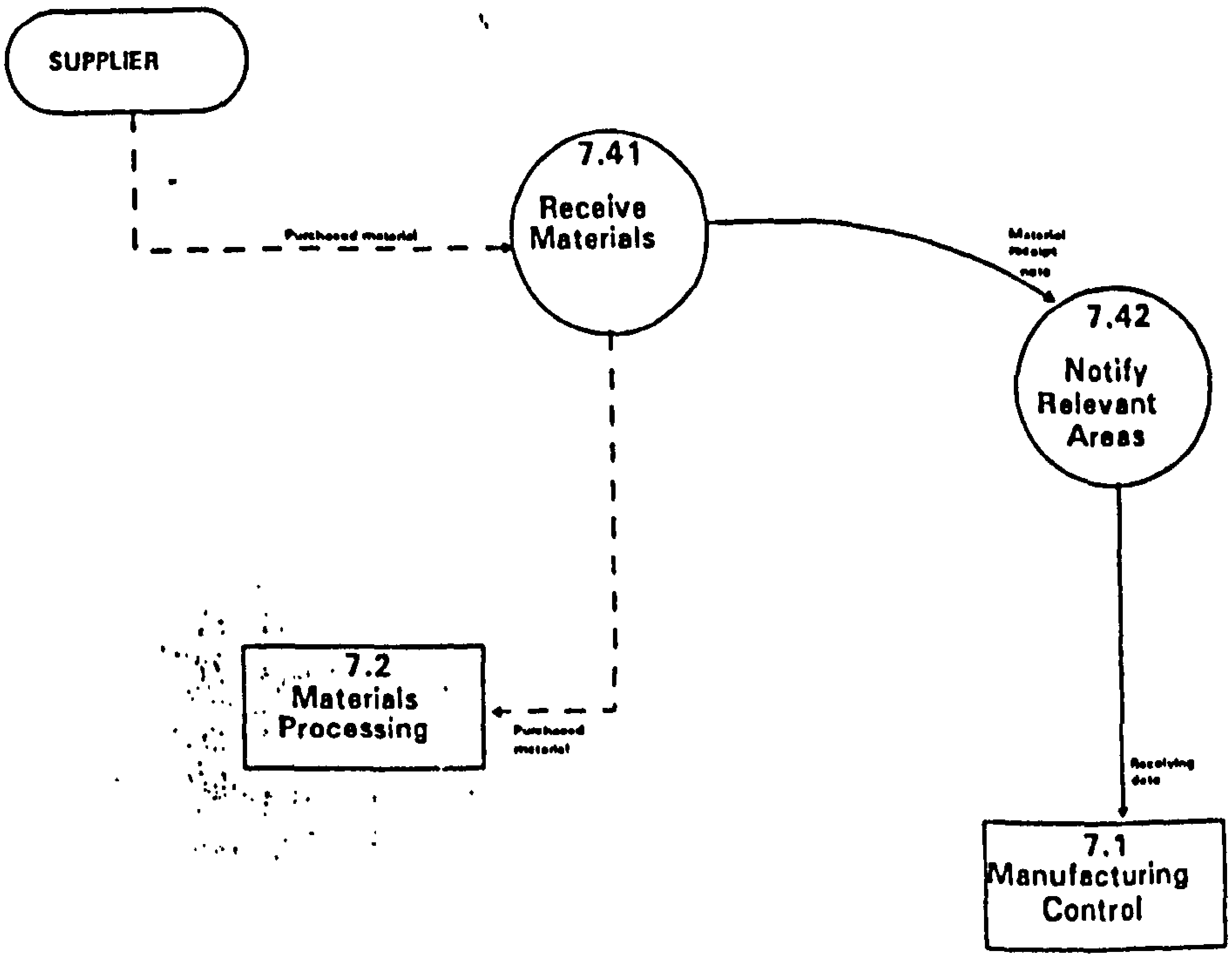
7.2 Materials Processing Process Map



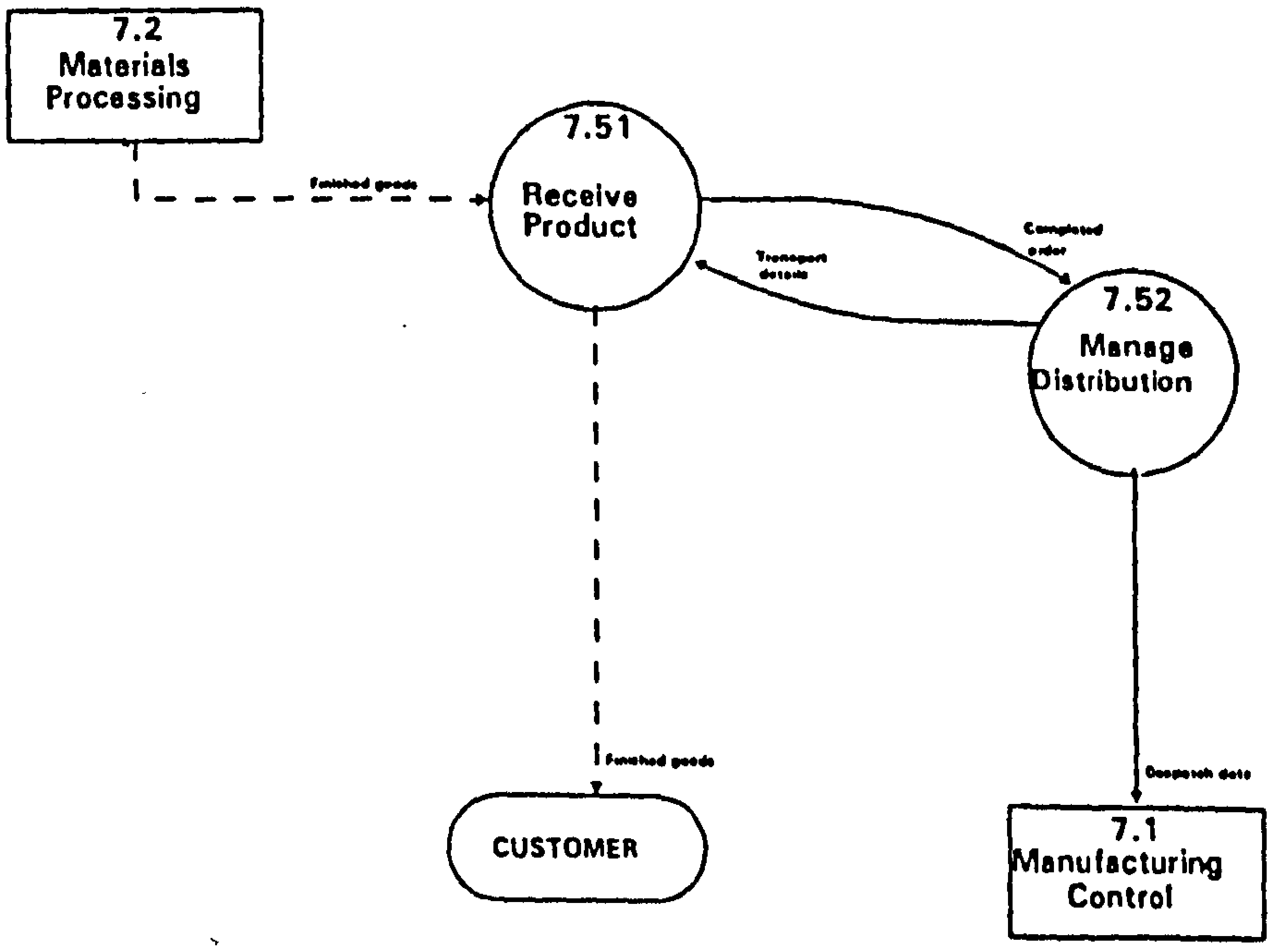
7.3 Materials Handling Process Map



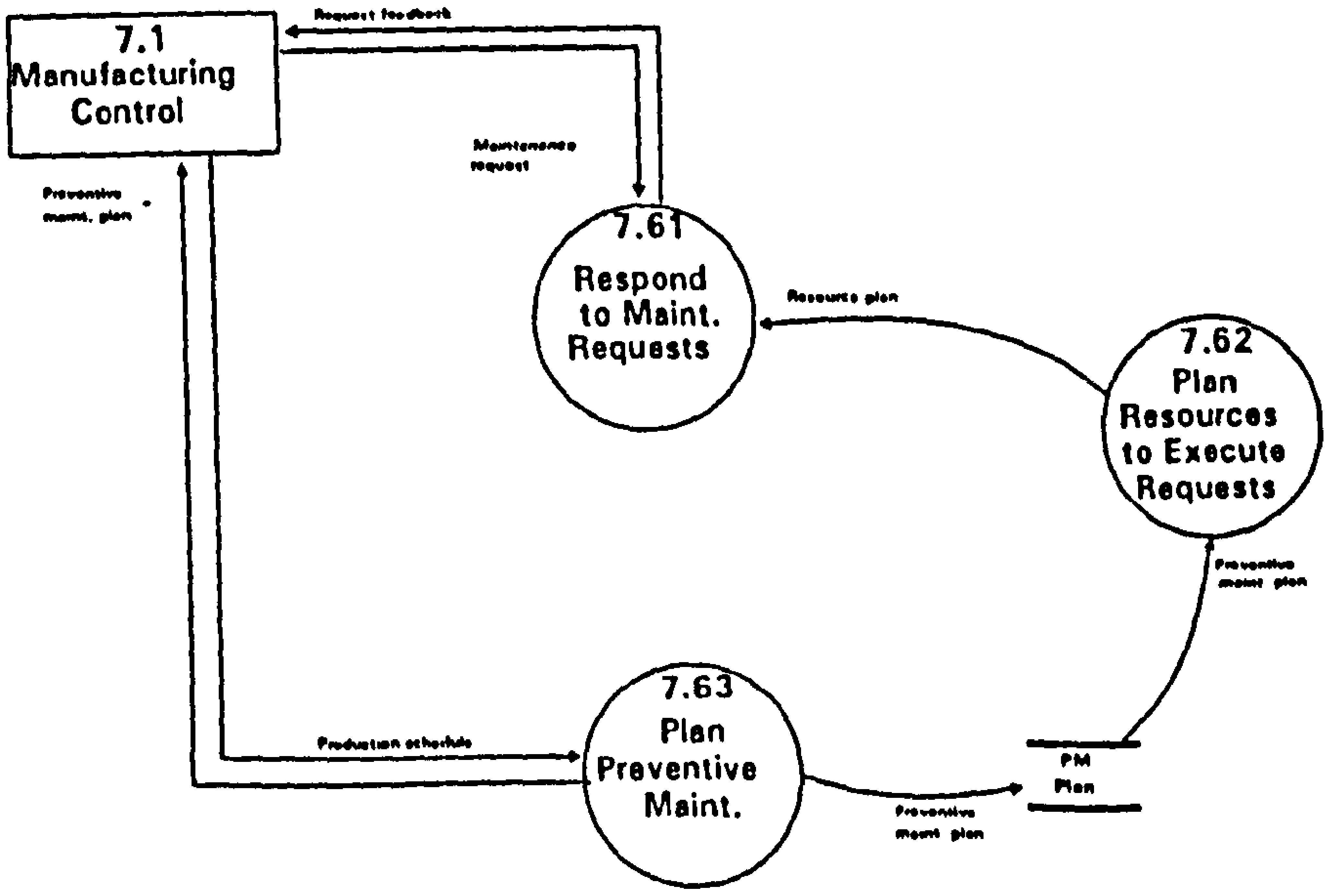
7.4 Receiving Process Map



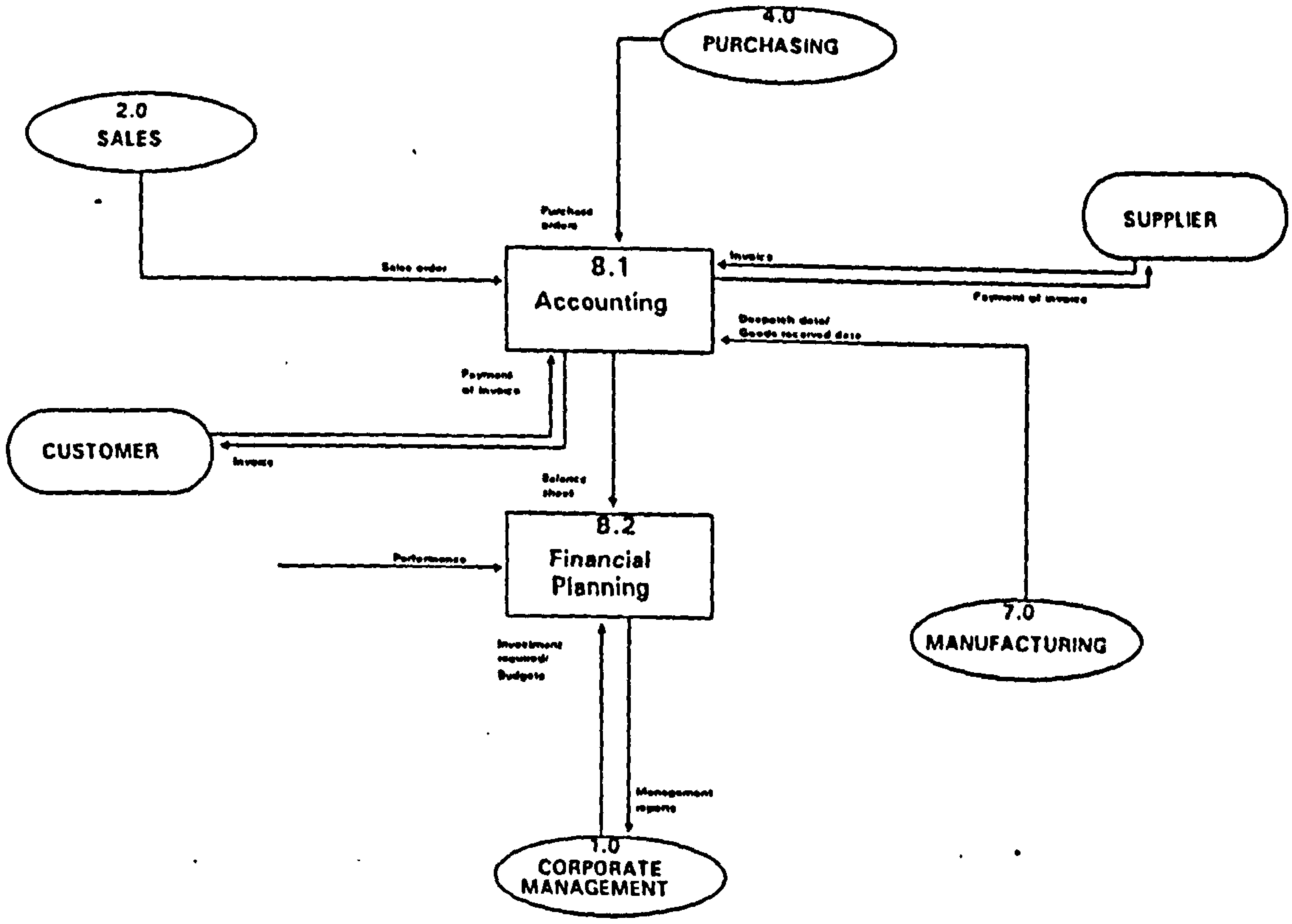
7.5 Despatch Process Map



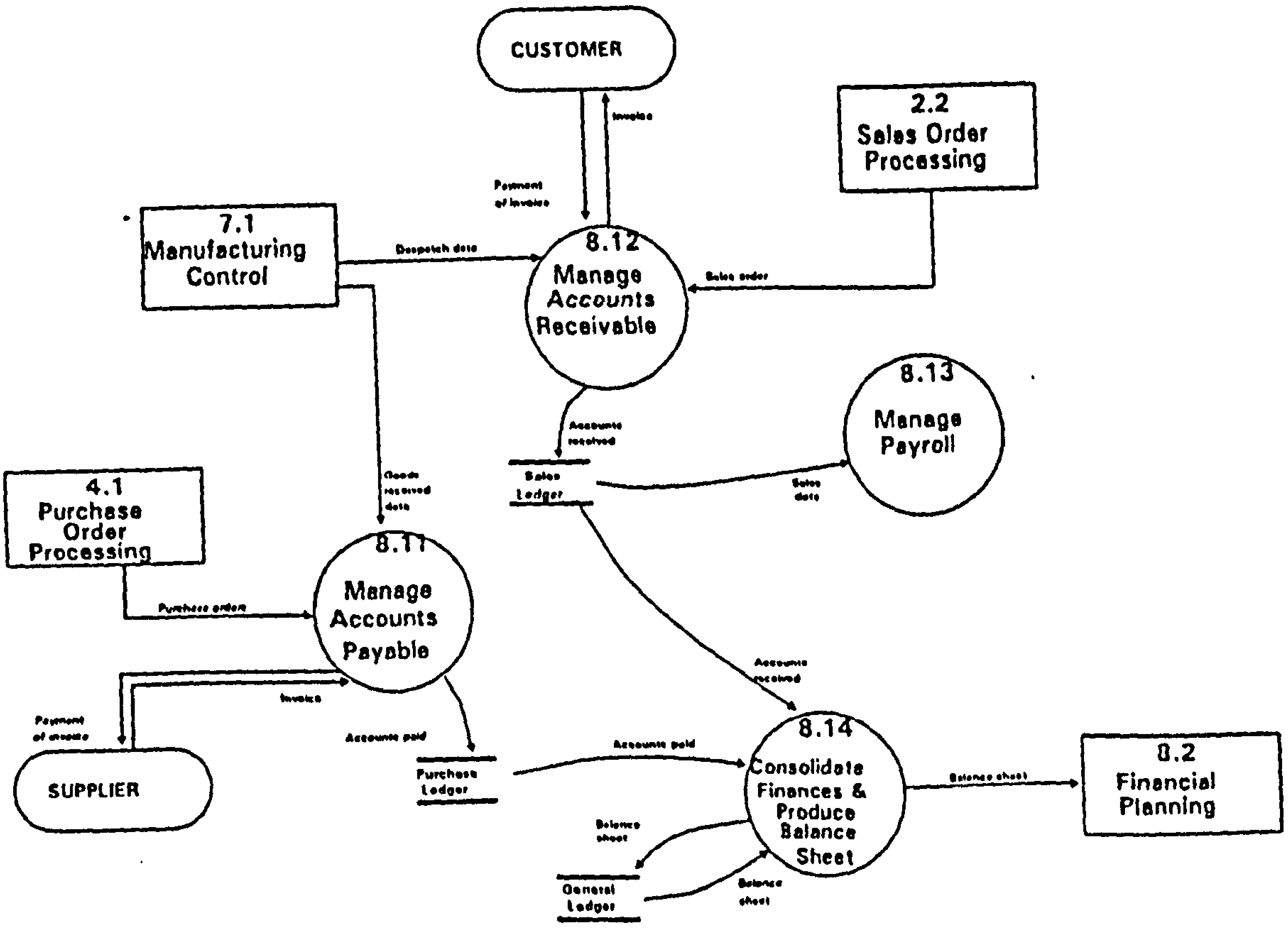
7.6 Maintenance Process Map



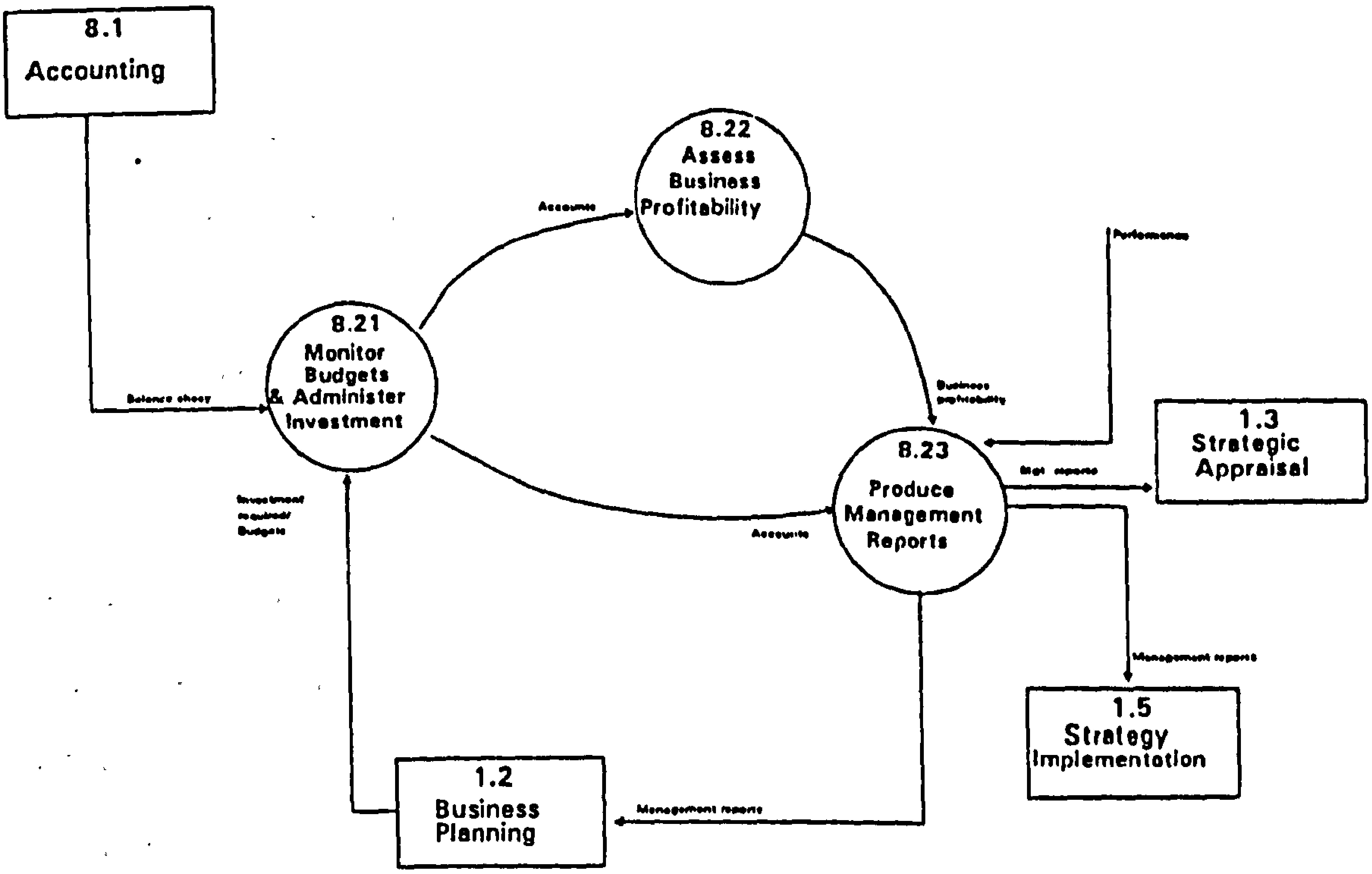
8.0 Finance Function Map



8.1 Accounting Process Map



8.2 Financial Planning Process Map



APPENDIX B - OPPORTUNITIES FRAMEWORK

The Opportunities Framework is segmented into 5 sections or sub-frameworks. Each is a contextual advisory system for aiding the identification of suitable manufacturing information support applications. Names of particular systems, their suppliers and hardware and software vendors have been deliberately omitted. Together the 5 sub-frameworks enable the proper application of Stage 4 of IQ*Analyst*. The sub-frameworks are as follows:

1. Technology Management
2. Functional Support
3. Objectives Alignment
4. Classified Results
5. Integrated Solutions

B1. Technology Management

This section represents the identification and description of the types of IS found in manufacturing environments. It is the most basic element of the *Opportunities Framework*. It provides an inventory of IS 'forms' and its principal intents are to educate IQ*Analyst* users to help categorise IS, formalise the process of IS classification, and to indicate both established and innovative uses of manufacturing IS. IS can be categorised as follows:

- Transaction processing systems
- Management information systems
- Decision support systems
- Office automation systems
- Expert systems

B1.1 - Transaction Processing Systems

Most manufacturing IS are designed to process transactions, for example, inventory issue and receipt, order entry, invoices, payroll, personnel, purchase orders and so on. Information scientists have traditionally called such systems transaction processing systems [66]. Their essential functions are to provide information reporting, collection and transmittal. Advantage over competitors can generally be obtained through automating such systems, and thereby gaining transaction speed and accuracy benefits as well as cost reduction. A recent development in processing transactions is the use of bar coding to encode data for fast and accurate readability. Parts data are automatically captured by devices that monitor operations. For this to happen, parts have bar-coded labels attached. Each code is a series of vertical lines of varying widths, where the width of lines and the spacing between them are arranged to represent letters and numbers.

B1.2 - Management Information Systems (MIS)

MIS are designed to obtain, manipulate and present data in the form of information to managers when needed. The information is often evaluative and presented via appropriate measures of performance. Definitions of such measures coupled with the use of exception reporting are essential for MIS success.

B1.3 - Decision Support Systems (DSS)

DSS aid decision making through the formulation of decision models. DSS enable 'what if' analyses to be carried out and decision alternatives to be evaluated. They exhibit themselves in the form of decision trees, precedence diagrams, simulated models, network diagrams and linear programmes. Typical uses include forecasting, production planning, plant location decisions, investment appraisal, and shop floor scheduling.

B1.4 - Expert Systems

An expert system is a computer programme, inherent in which is knowledge or expertise concerning a particular problem domain. Through such a system, specific and pertinent information can be made available to the non-expert. The ability to 'represent' and 'search' a problem domain forms the basis of expert system technology. Representation of the problem is done via a knowledge base, which contains the knowledge or information codified in a structured form. Searching is done via an inference engine, which enables problems to be solved by tapping into the information contained within the knowledge base. A user interface usually in the form of a series of questions enables the knowledge base to be accessed via the inference engine.

Daly [32] pointed out a key difference between expert and conventional systems; expert systems work more with information (*knowledge acquired through experience or study*) rather than with data (*a series of facts yet to be interpreted*). Applications include plant layout, process planning, equipment fault diagnosis and shop-floor scheduling.

B1.5 - Office Automation Systems

Office automation systems encompass word processing, spreadsheet, database, electronic mail, fax and voice mail applications.

B2. Functional Support

This section is an overview of IS' impact on manufacturing business functions. It is represented in the form of a table consisting of each business function identified in the Reference Model (Appendix A), the typical objectives of the function, and potential IS applications to support the objectives. The list could not be exhaustive (and the functions have in three cases been slightly but necessarily manipulated, for example, *Forecasting* has been included as a separate function), but is intended to provide potential *solution seekers* with a direction and an indication of commonly used IS and techniques. Obviously such functions will be supported by office automation and some will be electronically networked. No attempt has been made to represent either of these types of technology.

Function	Objective	Potential IS Application/Technique
Strategic Planning	The determination of how the organisation will compete effectively in the marketplace.	Benchmarking & performance measurement.
Business Planning	Establish investment requirements to meet strategic objectives.	Investment appraisal techniques such as discounted cash flow.
Technical Sales	Customer quotation preparation.	Standalone data base or MRP-based order entry software.
Sales Order Processing	Administering the sales order.	Standalone data base or MRP-based order entry software.
Forecasting	The best estimate of what customer demand will be for a product.	Qualitative methods (generally for long-term applications) include Delphi, market research, sales force estimation & management estimation. MRP or standalone PC-based forecasting software for short-term applications with quantitative analyses such as simple & weighted moving averages, exponential & trend & seasonal-adjusted exponential smoothing, linear regression, Box-Jenkins & seasonal index calculations possible.
Master Scheduling	Establishment of production levels for end products or product options usually on a weekly basis over a short-term horizon.	MRP-based master production scheduling software.
Marketing	Strategy development for marketing product.	Market research; standard consumer surveys available.
Production Planning	Establishment of production and inventory levels usually by product groups on a monthly basis over a medium range planning horizon.	MRP-based production planning software incorporating operations research techniques such as linear programming, linear decision rule, management coefficients, & simulation-type analyses.
Inventory Control	Maintain appropriate inventories of raw materials, WIP, & finished goods - in the correct locations.	Standard PC-based software. Fixed-order quantity & fixed-time period systems for independent demand; MRP systems for dependent demand, kanban for high-volume repetitive. Manual & computerised transaction recording systems including bar coding (more than 50 systems in use).

Material Planning	Enables the right part to be available at the right time to meet schedules for completed products.	The material requirements planning (MRP) technique is well established and almost universally accepted as the standard materials planning system for time-phased analysis in batch environments. Kanban is apprpriate in repetitive rate-based environments.
WIP Control	The controlled release of works orders to Materials Processing. Collection of feedback data.	MRP-based order release software. Shop-floor data collection (various methods).
Capacity Planning	The process of estimating total capacity that is available at each work centre or machine to satisfy a production schedule.	Methods of overall & resource factors for rough-cut capacity planning. MRP-based capacity requirements planning software for CRP.
Scheduling	Assigning due dates to specific jobs & jobs to work centres.	Kanban & line-balancing algorithms for high-volume discrete environments, MRP-based scheduling software, PC-based schedulers & dispatching rules for batch environments, & PERT/CPM for very low volume project-based production. Expert systems successful for re-scheduling, OPT for complicated environments. Other IS include Gantt schedule and load charts
Purchase Planning	Price negotiation & supplier assessment.	Vendor rating systems off-the-shelf; often tailor-made.
Purchase Order Processing	Administering the purchase.	Internal electronic mail, EDI with suppliers, standard purchase order processing software, MRP module.
Concept Design	Identifying market needs & product concepts & functionality to satisfy those needs.	Computer-aided design (CAD) systems with styling & concept visualisation functionality. Expert systems for materials selection.
Detailed Design	Specification of precise shape, dimensions & tolerances, confirmation of material selection & consideration of manufacturing & tooling methods; change control & documentation.	CAD, computer-aided engineering (CAE), integrated design, engineering & manufacturing system software, quality function deployment (QFD), failure modes & effects analysis (FMEA), Taguchi methods, design for manufacture & assembly (DFMA) engineering data management (EDM), geometric & solid modellers, graphics exchange standards, simultaneous engineering.
Prototyping	Product creation to evaluate manufacturing & assembly problems.	Rapid prototyping techniques.
Quality Engineering	Ensure product conforms to customer requirements.	Statistical process control (SPC), FMEA, QFD, vendor rating systems.
Process Planning	Establishment of the sequence of individual manufacturing operations needed to produce a given part or product.	Computer-aided process planning (CAPP) systems; retrieval-type systems use parts classification & coding as a foundation, generative systems automatically create an individual process plan from scratch.
Manufacturing Engineering	A discipline that covers tool design, machine set-up & changeover, layout planning, work study & work measurement.	Expert systems for layout planning; single minute exchange of die (SMED) principles for set-up & changeover; process flow analysis for work study; computer-generated time standards for work measurement.

Test Engineering	Assessment of the functional performance of a final product.	Data acquisition systems; automated testing cells.
Materials Processing	Machining, assembly & packaging processes.	Numerical control (NC), computer NC (CNC), direct NC (DNC), adaptive control, FMS, robotics.
Materials Handling	The management of materials from the point of origin to the point of consumption.	AGVs (painted floor, embedded wire, navigable types).
Receiving	Material receipt.	Transaction recording (bar coding)
Despatch	Despatch is the beginning of the delivery system that sends the customer the product ordered.	Transaction recording (bar coding)
Maintenance	Activities carried out to keep equipment in working order.	Over 100 maintenance management IS on market geared to planned preventive maintenance programme management including equipment history, inventory control, costs, condition monitoring, and works order analysis. Expert systems for fault diagnosis increasingly common. Total productive maintenance (TPM) state-of-the-art maintenance practice.
Accounting	Accounts management.	Standard costing; activity accounting; MRP module.
Financial Planning	Management reporting.	MIS; MRP module.

B3. Objectives Alignment

This segment consists of a framework designed to identify CSFs, information support applications and information flows that support typical strategic goals. Typical strategic goals are identified to formulate a vision of how IT can be used as a competitive weapon. Having established the ambition of an enterprise, the table makes it possible to establish potential IS opportunities to support that ambition and specify areas of the Reference Model that are affected by the opportunities. This is based on a simpler framework with similar objectives produced by the DTI [37].

Typical Strategic Goals	**Potential Critical Success Factors / Functional Goals**	**Information Support Applications**	***Key Information Influences (from Reference Model)***
Shorter product development lead time	Simultaneous engineering	Design/manufacturing databases & data management; groupware; networking.	*Manufacturing data; routings; product specification; design data*
	Standardise & reduce number of parts	CAD; CAE; DFMA	*Product specification; part standards; model performance data*
Shorter manufacturing lead time	Improve/optimise scheduling	MRPII; OPT; CAPP	*Planned orders; production schedule; production data*
	Flexible manufacturing	FMS; CNC; DNC	*Manufacturing data*
	Set-up reduction	GT; SMED; DNC	*Manufacturing data*
	Planned/predictive maintenance	Maintenance management IS; condition monitoring	*PM plan; maintenance request; request feedback*
	Simplify BOM	DFMA	*BOM; part standards; routings*
	Eliminate non-value adding activities	JIT	*Production schedule; process feedback*
Reduced inventory / improved stock turn	JIT	Electronic links to suppliers; vendor rating system; kanban; bar coding	*Purchase orders; process feedback; production data; GRN; purchasing policy; inspection data*
	Set-up reduction	GT; SMED; DNC	*Manufacturing data*
	Forecast accuracy	Computerised forecasting	*Sales forecast; historical demand data*
	Enhanced control; stock record accuracy	MRPII; inventory recording systems; ASRS	*GRN; material receipt; inventory status; inventory data*
	Required customer service level		
Improved quality / TQM attainment	Total employee involvement; continuous improvement, elimination of non-value adding activities	Quality standards; quality circles; supplier integration; JIT; inventory reduction (as above)	*Factory performance data; process feedback; inspection data; production schedule*
	Machining precision	Shop-floor inspection; SPC; CNC; robotics	*Manufacturing data; process feedback; fault diagnosis*

Responsive to market demands	Manufacturing flexibility	Re-programmable machine tools/cells; CAPP	*Manufacturing data; production schedule; quotation; routings*
	Throughput efficiency	MRPII; networking (integrated IS); computer-aided estimating; capacity planning; MPS visibility & integrity	*Process feedback; factory performance data; MPS; load details*
Improved ROI	Improve stock turnover	As above	*As above*
	Increase machine utilisation	GT; FMS; SMED	*Planned orders; manufacturing data; production schedule; set-up procedure*
Reduce cost	Reduce direct labour cost	CAPP; CNC; networking	*Manufacturing data; routings*
	Reduce inventory (as above)	-	
	Reduce material cost	Vendor rating; DFMA; CAE	*Inspection data; design data; manufacturing data*
Environmentally acceptable manufacturing	Review processes & materials used	Process monitoring; BS7750	*Process feedback*

B4. Classified Results

This segment classifies manufacturing environments according to length of production run and nature of customer order. IS opportunities to combat typical problems in each classification have been identified and represented.

B4.1 - Length of production run

Type	Description	Perceived Problems	IS Opportunties to Combat Problems
Project	Very low volume production of generally large, complex units.	• Managing interrelated activities • Budget adherence • Research & development • Location	• PERT/CPM used for scheduling • Project management software; vendor rating IS • EDM; design optimisation & databases • Linear programming
Job Shop	Production of small batches of a large number of different products, most of which require a different set sequence of processing steps.	• Design to manufacture interface efficiency • Balancing the costs of idle time against the cost of having jobs waiting • Moving bottleneck	• Simultaneous engineering; part classification & coding design retrieval database; CAD; CAE; groupware; networking; FMEA • Forecasting; capacity planning; work cells; parts classification & coding systems • OPT
Batch	A standardised job shop producing many standard products; repeat orders are expected.	• Set-up & changeover reduction; high WIP • Order traceability & progress, process control • Long process routings	• GT (production flow analysis, parts classification & coding); SMED; kanban; EDI • MRPII; SFDC (bar coding) • GT
Flow	High-volume production of discrete units.	• Line balancing & sequencing • Process planning • Process monitoring • Consistent quality of supply	• Line balancing & sequencing software & algorithms; kanban • Forecasting; market research; CAPP • Poka yoke; condition monitoring IS, CMMIS; TPM; IKBS fault diagnosers • Vendor rating IS; SPC; QFD
Continuous Flow	High-volume production of non-discrete product.	• Uninterrupted production	• Poka yoke; condition monitoring IS; CMMIS; TPM; IKBS fault diagnosers

B4.2 - Nature of customer order

Type	Description	Perceived Problems	IS Opportunities to Combat Problems
Make-to-Order	Customers' orders are received prior to manufacturing product.	• Poor design to manufacture interface efficiency • Moving bottlenecks	• Simultaneous engineering; part classification & coding design retrieval database; CAD; CAE; computer-aided estimating; groupware; networking; FMEA • OPT
Assemble-to-Order	Customers' orders are assembled from standard components & subassemblies.	• Component cannibalism in assembly • Assembly to finished product integrity (stock & lead time optimisation)	• MRPII; effective use of time fences • DFA; modular MPS using planning BOMs; product data management; assembly forecasting
Make-to-Stock	Products are finished prior to customer orders arriving.	• Large finished goods inventories • Variety restrictions	• Focus forecasting; sequencing software • GT & cells; parts classification & coding systems

B5. Integrated Solutions

This section shows how the sub-frameworks in sections B2, B3 and B4 can be combined so that IS opportunities can be related to a very specific rather than a general situation. The objective is to piece together a suitable IS initiative from different shards of contextual information. Two scenarios are provided: strategic goals against nature of customer order, and business functions against nature of customer order. In both cases, only examples where IS opportunities differ significantly as the nature of customer orders differ, have been tabulated.

B5.1 - Primary variable: strategic goal; secondary variable: nature of customer order

Strategic Goal	Nature of Customer Order	IS Opportunity
Shorter product development lead time.	• MTO • ATO • MTS	• CAD; simultaneous engineering. • CAD; simultaneous engineering; DFA. • (Less emphasis).
Shorter manufacturing lead time.	• MTO • ATO • MTS	• Project management software (less emphasis). • MRP/JIT; condition monitoring; computerised maintenance management. • MRP/JIT; condition monitoring; computerised maintenance management.
Reduced inventory.	• MTO • ATO • MTS	• (Less emphasis). • Computerised assembly forecasting; option planning MPS; planning BOMs. • JIT; kanban; focus forecasting; electronic links to suppliers.
Responsive to market demands.	• MTO • ATO • MTS	• Re-programmable machine tools/cells; CAPP; networking & integrated IS; CAD; CAE. • Re-programmable machine tools/cells; CAPP; networking & integrated IS; CAD; CAE. • Re-programmable machine tools/cells; CAPP; networking & integrated IS.

B5.1 - Primary variable: business function; secondary variable: nature of customer order

Business Function	Nature of Customer Order	IS Opportunity
Technical Sales	• MTO • ATO • MTS	• Product database; computer-aided estimating; modular BOM generator; DFA. • Product database; computer-aided estimating; modular BOM generator; DFA. • N/A
Forecasting	• MTO • ATO • MTS	• Qualitative; quantitative (less sophisticated); customer order focus. • Quantitative trend & seasonally adjusted time-series analysis; product option/major sub-assembly focus. • Quantitative trend & seasonally adjusted time-series analysis; end item focus.
Master Scheduling	• MTO • ATO • MTS	• MPS software customer order focus (other if long lead time). • MPS software product option/major sub-assembly focus. • MPS software end item focus.
Material Planning	• MTO • ATO • MTS	• MRP-based software for time-phased medium volume. • Mixed. • Kanban; mechanical pacing.

APPENDIX C - METHODOLOGY QUESTIONNAIRES, DEFINITIONS & RATING SYSTEMS

C1. Technical Effectiveness Questionnaire

1) Effectiveness of systems support (systems professional view)

Questionnaire

- *What IT systems & applications software are currently owned/used? (hardware/software, languages, packages, suppliers, peripherals, storage devices etc.)*
- *What is the function of each of these systems?*
- *What manual/informal IS and communication exist?*
- *Do any of the computerised or manual systems suffer from: a) user rejection, b) user irritation, c) unreliable operation, d) slow operation e) excessive maintenance f) poor vendor support*
- *How are systems connected?*
- *Are users aware of all the features provided by the systems?*
- *Which systems are subject to misuse? How?*
- *What systems consistently underperform?*
- *Does the company have an IS or IT strategy? What approach was used to generate it?*
- *What plans are there for further computerisation?*
- *What further systems developments have been planned?*

Quality Scales (1 to 10)

- *Vendor support*
- *Priorities determination (fairness)*
- *Security of data*
- *Senior management involvement*
- *Hardware & system downtime*
- *Technical sophistication of new systems*
- *Quality & technical competence of IS staff*
- *Documentation of systems & procedures*
- *Response/turnaround time*
- *Communication between users & systems staff*
- *Users' feeling of participation/influence*
- *Users' understanding of systems*
- *Degree of training in user proficiency*
- *Responsiveness to changing user needs*

2) Effectiveness of systems support (user view)

Questionnaire

- *How do you rate your information support services within the company? What are the main strengths and weaknesses of information services?*

Quality Scales (1 to 10)

- *Documentation of systems & procedures*
- *Response/turnaround time*
- *Communication between users & systems staff*
- *Users' feeling of participation/influence*
- *Users' understanding of systems*
- *Degree of training in user proficiency*
- *Responsiveness to changing user needs*

C2. Attribute Definitions & Rating System

Relevance. Information is relevant if users benefit in their decisions or actions because of it. This means that relevant information leads to a better decision or action.
10 - the information is essential; ....; 0 - the information is unimportant

Timeliness. Timeliness refers to the degree to which information is available in time for decisions or actions relating to that information to be made. Generally, the frequency of retrieval, or, how often information is produced varies according to its use. Low-level decisions in an organisation, for example, for budgeting and scheduling requirements, must have current and timely information. For higher-level decisions, for example, for strategic planning purposes, the information is needed less frequently. Timeliness can be summarised as the extent to which users experience delay in obtaining information.
10 - users never experience delay in obtaining information; ....; 0 - the information is always late.

Accuracy. Accuracy of information refers to its precision in defining events and transactions, in other words, the degree to which it is from error. Thus, an inventory report is accurate if the stated levels agree with actual inventory status. A sales forecast is accurate if it correctly estimates future sales.
10 - the information is always factually and numerically correct; ....; 0 - the information is never factually or numerically correct.

Accessibility. Information can only be quantified and put to use if it is available. Accessibility refers to the degree to which information is readily available, irrespective of the transfer medium employed.
10 - the information is always readily available; ......; 0 - the information is never available.

Comprehensiveness. Comprehensiveness (or completeness) of information refers to the level of completeness and detail with which it is conveyed, or, the degree to which it is free from omissions and redundant data.
10 - the information is free of omissions; ....; 0 - the information is complete.

Format. The format of information governs the effectiveness with which it is perceived and is in a useable form, which is a prerequisite to it having any value for decision making.
10 - the information is in a useable form; ....; 0 - the information is unintelligible.

C3. Strategy Questionnaire

1) Responsibilities

- *What is your area of responsibility?*
- *What are you trying to achieve within your area of responsibility?*
- *What is/could help/hinder your progress to fulfilling these achievements*

2) Company background

- *What is the current product range?*
- *What customers do you have?*
- *Who are your competitors? Differentials? Comparative performance / market share?*
- *How many workers are employed in the organisation? in each business unit?*
- *What is the annual turnover?*
- *What is the relative percentage of total sales for each product? / each business unit? / each customer?*
- *Are markets declining / static / expanding? At what rates?*
- *What are the future prospects for profitability of each product? (good, steady or poor)*
- *What do you perceive to be the company's main strengths and weaknesses?*

3) Management information systems

- *How effective are MIS?*
- *What information is difficult to obtain?*
- *What important decisions do you have to make regularly?*
- *Is quality information to hand to make these decisions?*
- *In terms of IQ attributes, how effective are the following information items?*
  - *performance in your assigned area of responsibility*
  - *overall business performance*
  - *business objectives*
  - *critical success factors*
  - *turnover*
  - *orders per time period*
  - *sales forecasts*
  - *profits*

4) Critical success factors

- *What factors affect the customers' willingness to buy?*
- *What in your opinion are the things that a company has to be good at to succeed in your markets? (In what areas of the business is good performance necessary for the business to fluorish?)*
- *How well would you rate your own company?*

5) Business objectives

- *What is the company trying to achieve over the next few years?*
- *Specifically, what performance targets are to be achieved?*
- *How are these targets to be achieved?*
- *If you had £100 to spend in achieving the company's objectives, how would the money be allocated?*