A Study of Business Process Reengineering for The Diffusion of High Technology in Manufacturing

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ABSTRACT

The mechanism in the diffusion of high technology through process redesign has been analysed and described in this research. A generic model for implementation of Business Process Reengineering was developed to assist the adoption of technically efficient high technology. The model was developed basing on the Object-oriented method. This method provides for the successfully derivation of useful entities such as the goals, roles, responsibilities, interactions for the implementation. The resulting model consists of basic, reusable building blocks of implementation strategies that are suitable for reengineering within the particular application area.

The generic model has been successfully implemented in a Small Manufacturing Enterprise in Hong Kong. It is significant in the institutionalisation of openness in communication and aggressive technological policy. Results showed that the implementation of the model has significantly improved the manufacturer's ability to select high technology.

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CHAPTER 1

INTRODUCTION

New technology and technology-driven opportunities are developed and presented to managers in the manufacturing industry at an accelerating rate. For example, Computer-aided design (CAD), engineering (CAE), and manufacturing (CAM) support product design, product engineering, and seamless transfer of product engineering to industrial engineering. Whereas materials requirements planning (MRP) and manufacturing resources planning (MRPII) support production control.

Managers are confronted with challenging technology-adoption decisions, yet few appear to be well served by available methodologies [1]. A survey of U.K. banks in 1988 found that 80 percent of the respondents feel technology has fallen short of their expectations, and more than half confirm that technology investments are not generating the anticipated improvements in productivity [2]. Adoption of technically inefficient technology may lead to negative consequence in economic performance, social organisation and organisational learning [3]. However, less attention has been paid to the development of a rational model for the adoption of technically efficient technology.

Business process reengineering emerged in the 90's as a popular approach used by organisations seeking improvements in their business performance [4]. The fundamental nature of reengineering relates to the revamp of business assumptions [5]. It serves to redefine performance requirements at individual, business and even corporate levels.

Therefore, it is regarded as a vehicle for adoption of high technology to support radical achievement in competitive advantage. This research has developed a generic model for implementation of Business Process Reengineering to assist the adoption of high technology that is technically efficient. The generic model was founded on the beliefs that increasing openness within an organisation and increasing responsiveness to the external environment improve quality of adoption decision.

The generic model has been tested and validated through its implementation in a Small Medium Enterprise in Hong Kong. In-depth case study is presented in Chapter 4 to demonstrate the successfulness of implementation. The results show that the implementation of the model has significantly improved the manufacturer's ability to select high technology. An analysis of observation in the preceding case is presented in Chapter 5 and the reasons for success are explained. Finally, scope of applicability of this model is presented in the concluding chapter.

1.1 PROBLEM DEFINITION

In the search for a robust methodology for high technology adoption, the related theories have been dominated by a proinnovation biases perspective [6-11] Proinnovation biases is defined as presumptions that innovations will benefit organisations [12]. However, evidence suggests the otherwise. It was observed that technically inefficient innovations had been repeatedly diffused among U.S. organisations [13]. It was argued that a more sceptical view of innovation had emerged.

Rogers (1983) argued that the dominant perspective, in the literature about the diffusion of innovation literature reinforces proinnovation biases because it relies on a model of choice in which adopters make independent, rational choices guided by the goals of technical efficiency [9]. The efficient-choice perspective is based on two major assumptions [14]: (I) organisations within a group can freely and independently choose to adopt an administrative technology and (ii) organisations are relatively certain about their goals and their assessments of how efficient technologies will attain these goals.

Kimberly (1981) disputed the first assumptions concerning the outside influences by indicating when it is in the interest of organisations outside a group to impel the diffusion of technologies that are technically inefficient for organisations within this group [12]. Government bodies and national labour unions were the examples of powerful outside organisations that were able to force the diffusion and rejection of certain technologies [15-18]. Even when organisations can make choices freely, they are not be able to make independent assessment on the value of a technology.

The proinnovation biases perspective assumes that rational adopters make technically efficient choices based on information that is received via diffusion network [9]. This perspective fails to address the institutional mechanisms that can lead organisations to adopt technically inefficient innovations [13, 19]. DiMaggio and Powell's theory of institutionalised isomorphism suggested that, within those industrial sectors characterised by a high degree of interconnectivity, coupled with poor understanding of technology and environmental uncertainty, organisations will develop homogeneously. Isomorphism refers to 'the constraining process that forces one unit in a population to resemble other units that face the same set of environmental conditions' [19].

With respect to high technology adoption, the implications of this theory are that potential adopters may base their decisions on one or more of the following processes: (i) they may mimic other organisations within their sector that they perceive to be successful (mimetic processes); (ii) they may experience pressure from other organisations upon which they are dependent to adopt particular technologies (coercive processes); and (iii) the norms established by professionals and professional associations may exert pressure on them to adopt particular technologies in order to be seen as legitimate (normative processes) [19]. The first problem being identified in the domain of high technology adoption relates to the association between the adopting organisation and its external environment. The external environment introduces a strong technology push force that undermines the efficient choice perspective. It was because there was potential for organisations to become blinded by the proclaimed benefits of the technology at the expense of adequately addressing how those benefits can assist in meeting their particular needs.

This potential is supported by March & Olsen (1976) who rejected the second assumption of the efficient choice perspective by suggesting that organisations have unclear goals and high uncertainty about the technical efficiency of technologies [20]. Therefore, organisations are unable to make rational choice because they are not able to make assessment on technical efficiency. Also, these organisations do not have clear goals to help them to decide which type of technical efficiency is important in attaining organisational goals. Considering these counter assumptions, Abrahamson (1991) suggested that innovation diffusion should be described as an imitation process in which fads and fashions substituting the efficient-choice as the dominant perspective [13]. And it is in the fads and fashions process that technically inefficient technologies are diffused and efficient technologies are rejected.

The second problem, therefore, associates with an organisation's capability in making a rational judgement on the adoption of high technology. The capability of an organisation increases with its size. The greater its size, the more slack resources it has for investigations of technology and the more expertise it possesses for assessment of technology. This problem indeed strongly relates to the former one as one would intuitively expect an organisation tends to resist an imitation process of high technology adoption when it has greater capability for assessing technology. Hence, we argue that adoption of technically efficient technology is strongly affected by two processes. The first process concerns with the building of capability of assessing technology in an organisation and the second relates to responding to technology information obtained from the external environment.

The work of Kimberly (1981), DiMaggio and Powell (1983) and Abrahamson (1991) have made significant contribution to expanding and refining the theories of innovation diffusion. It provides the understanding of when and why technically inefficient technologies are adopted. The uncertainty concerning environmental forces, goals, and technical efficiency faced by organisations are the major force driving the organisations to heavily rely on external opinion. Therefore, the central issue in high technology adoption is to build a contingent approach that responds to the uncertainties proactively. It leads us to examine the mechanism of adoption of diffusion process so as to identify the observable and controllable parameters. We hope to contribute to a more encompassing theory of innovation adoption by examining how the adoption process unfolds and how it is managed to reduce the uncertainty in the context of technology adoption.

1.2 PROBLEM DOMAIN

The problem domain is formulated for resolving the difficulties of high technology diffusion by taking note of the topics germane to this research. These topics include innovation diffusion, technology transfer, and decision making. It focuses on the constraints confronted by existing model of technology adoption and the critical tasks for adoption of efficient technology.

1.2.1 The Technology Transfer Perspective

Technology transfer, according to Brooks (1966), is the process by which science and technology are diffused throughout human activity [21]. Such process can be intra-organisational or inter-organisational. By intra-organisational process, new scientific knowledge developed by one group in an organisation is incorporated into technology used by other groups. By inter-organisational process, technology used in one institution can be adapted and used in other institutions for a new purpose [21, 22].

Understanding the transfer process is central in identifying the critical links the organisations have with outside world for the exchange of technology information. Robertson (1974), in his research of socio-economic and technological influences on technology transfer, identified two critical links: the economic and the technological environment [23]. The first one links an organisation to the current state of society's needs and the marketplace and thus produces a 'need-pull' (or market pull) effect. The second one links an organisation to the state of current scientific, technical and production know-how and produces a 'knowledge-push' (or technology push) effect. Most important of all, the nature of these links should be examined for their impact on the adoption of efficient and inefficient technology.

Technology transfer has succeeded in expanding the innovation diffusion paradigm by recognising the purposiveness of the diffusion process. The purposiveness is manifested by conscious, predetermined effort and commitment of resources to transplant technology from one setting to another [24]. The linkage between the technological environment and the organisation is usually established in less formal networks. These may include collaboration among firms in industries and universities, professional associations, government and so forth [24-28]. They engaged in active role of diffusing the knowledge for economic purpose.

In the case of diffusing MRPII in the UK and North America, for example, technology suppliers diffused the technology as 'the' best practice, despite evidence to suggest that these technologies are technically inefficient for many organisations [29, 30]. Professional associations imparted knowledge through their formal activities (for example certification programmes and courses) that was used by practitioners and individuals from other sectors, such as technology suppliers, consultants, government bodies, academic etc. [28, 31]. Particular professional associations may focus on those technologies that are considered normatively to be the 'best practice' in that society at the time, and may thus diffuse information that is incomplete or not relevant for particular organisations [28].

In summary, high technology adoption will be affected by the channel through which technology information was obtained, the purposiveness of this channel in shaping the adopters' perception of relative advantage of technology, and the accuracy and relevance of the information.

Their work implies that the lack of capability of collecting, organising and assimilating technology information is related to the adoption of efficient technology. This understanding is supported by the work of Robinson (1967) which classified buying situations into three broad classes: new task buy, modified rebuy and straight rebuy [32]. As a new task buy situation is assumed in high technology adoption, the capability of technology information is essential. However, technology information usually offers an understanding in a functional perspective, an operational perspective becomes a viable alternative that matches high technology information operational requirements of an organisation.

1.2.2 The Decision Making Perspective

In decision making perspective, adoption of high technology is treated as an investment decision. The aim of the decision making process is to compute and appraise the relative advantage [9] of high technology. Tools and techniques of high technology assessment were reviewed.

Discounted cash flow analysis (DCF) has been the most widely used model for investment justification [1]. Technologies that are proved to have a positive net present value (NPV) will be adopted. Positive new present value refers to the present value of the after-tax cash inflows in excess of outflows [33]. According to this simple criterion, technologies that have positive NPV are regarded as efficient and vice versa.

A broad debate is unfolding on the rationality of DCF in judging the efficiency of high technologies [34, 35]. This model is argued as the major cause of rejecting efficient technology that may offer competitive advantage in U.S. [36]. Managers increasingly recognise that many high technologies are not easily justified on a cost-reduction basis [37, 38]

Another problem in decision making of high technology roots in the uncertainty in the economic environment. Functionality risk causes efficient technology to become inefficient. The firms may get the system design or implementation right according to specification but still fail to realise the anticipated benefits [1] as target moved in an unexpected way [39]. A system has been built for what was originally wanted but the world and the business environment has changed. The system as designed is no longer appropriate. Delay occurs between the acceptance of the investment proposal and the eventual time when benefits can be gauged. The effect of this delay is to introduce added uncertainty into assumptions made about market conditions and competitors [1].

The correctly projected value for high technology has to be derived from accurate predictions of the industry's growth, adoption rate of the high technology and competitors response to their newly gained strategic advantage. Even expensive scenario evaluation would not have yielded the full range of future environments for reference before making the strategic commitment.

Facing high uncertainty in the economic environment, strategic process should be used to supplement the DCF to reduce functionality risks. Clemons (1990) claimed that identifying opportunities and threats, and analysing the financial consequences of competitive advantage and strategic necessity have received less attention than they deserve [1]. Furthermore, Fine and Freund (1968) derived the added economic value provided by flexible production capacity when demand is stochastic, and noted that this added value was rarely considered in investment decisions [40]. While labour and material cost reduction is considered as the major value of a high technology, greater flexibility, lower throughput times, should also be the critical determinants of adoption of efficient technology as well.

In summary, expanding the value judgement to competitive advantage [41], strategic necessity [42], and customer value is essential in decision making with respect to high technology adoption. Their works implies that the lack of capability of collecting, organising and assimilating business information is related to the adoption of inefficient technology. Also, a failure to match new or evolving business needs to high technology functionality is related to adoption of inefficient technology.

1.2.3 The Social Change Perspective

Rogers (1983) defined innovation adoption as a process of social change by which alteration occurs in the structure and function of a social system when new ideas are invented, diffused, and adopted [9]. Change models have been developed to facilitate adoption and diffusion of high technology in organisations. Beyer and Trice [43] provided social change model which describes social rites (elaborate, dramatic, planned sets of activities), if effectively undertaken, can facilitate the change management process. The cognitive model constructed by Isabella [44] described the use of four main cognitive phases embracing anticipation, confirmation, culmination and aftermath to manage organisational change. Lewin [45] and Schein [46] developed the contextual models that break changes into three broad phases: unfreezing, moving and refreezing.

These models consider organisational change as a process that can be managed by a set of "pre-planned activities" to intervene an organisation [47]. Although these models have wide applicability in organisational development, strategies for planned change are insufficient to manage the uncertainty in the context of high technology adoption. Misalignment between the technology and the technical system, technology delivery system and the value system [48] was mostly unforeseen and therefore caused the technology to become inefficient in the implementation stage. Therefore, implementation should be treated as a dynamic process of mutual adaptation between the technology and its environment [48].

A high technology might be considered inefficient when the mismatch [48] with the production process occurs. According to Jaikumar and Bohn's characterisation of production process [49], the more unpredictable and ill-understood is a production process, the more it is controlled through human observation and judgement. The more predictable, proceduralized and understood the process is, the more amenable to control by technologies with a specialised and limited, repertoire of response.

Hence, when technology is introduced to enforce a more systematic order within an unpredictable process, poor definition of requirements of the technical and the social system causes adoption of inefficient technology. Severe misalignments between the technology and the stage of knowledge of the production process occur when the underlying operations are in a chaotic state, having grown erratically in a turbulent production atmosphere in which there was little time for rational planning [48]. In those cases, reorganising the operations is required and beneficial.

Technology also affects the significance of activities to the jobs at individual, business unit and corporate levels. Technology may impose negative impact on the performance criteria that are highly valued or positive impact on those less valued. Such misalignments in performance rewards can be addressed through altering the criteria by which job performance is judged for user groups [50].

The work of Leonard-Barton (1988, 1991, 1992) implies the adoption of high technology requires the support of social structure and business processes. It suggested that a social structure that do not support an openness of information sharing within an organisation is related to a lack of capability of collecting, organising and assimilating business information. It also suggested that resistance to information sharing may exist in the context of high technology adoption. These understandings verify the concept that a capacity of sharing, collecting, organising and assimilating business information is fundamental in the problems of high technology adoption.

1.3 OBJECTIVE AND SCOPE

The three dimensions of technology adoption presented in the previous section provide a framework within which to define high technology and to formulate the objective and the scope of our research.

1.3.1 Definition of High Technology

Following the concept of Zaltman et al. [51] who defined an innovation as "any idea, practice, or material artefact perceived to be new by the relevant unit of adoption", high technology in this research is referred as any technology being applied for the first time in an organisation.

High technology is classified as "borrowed", "adaptive" and "inventive" according to Pelz and Munson [52]. Berman (1980) recognised a spectrum of implementation strategies, from heavily pre-programmed to adaptive[53]. Combining that concept with Pelz's and Munson's [52] explanation of "levels of originality" yields the insight that technologies at the "borrowing level" (i.e. those adopted as is from a source outside the organisation) are more amenable to the programmed approach than the technologies that are developed internally ("origination level"). They have not been previously implemented at multiple sites and are therefore still relatively immature. Their interaction with the organisation is not readily predictable; therefore, some adaptation is almost inevitable [48]. These classifications yield valuable insights into the management of high technologies adoption.

However, in reality, technologies may fall in more than one category. For example, the technologies borrowed may be adopted for a new use in the adopting organisations. Therefore, these technologies yield certain level of originality. Also, the misalignment between the technologies and its user environment as well as the external environment will also trigger "re-invention". We assumed the process of borrowed high technologies adoption of not as predictable as it seems.

1.3.2 Research Objectives

This research has three objectives. They are:

1. to develop a model for adoption of high technology that is efficient in supporting the business goals of a manufacturing enterprise by using an extended and modified Business Process Reengineering methodologies.
2. through applying the proposed model in a manufacturing enterprise, to study into the impact on the mechanism of hi-tech adoption.
3. to demonstrate the proficiency of the modified BPR methodology in scrutiny of organisational requirements for technology adoption.

1.3.3 Scope

Rogers (1983) described adoption of innovation in terms of 5 stages: knowledge, persuasion, decision, implementation, and confirmation [9]. Cooper and Zmud extended the model to explain the adoption and diffusion of Information Technology in terms of six stages: initiation, adoption, adaptation, acceptance, routinization, and infusion [54]. Cash, *et al.* described the same process using a four-stage model consisting of identification and investment, learning and adaptation, rationalisation and management control, and widespread technology transfer and maturity [55]. Therefore, adoption of high technology is managed in three broad stages: strategic management, system analysis and investment decision making, and implementation.

The aim of technology adoption is to develop a viable approach to reduce the uncertainty surrounding the adoption process. The purpose of strategic management is to align the high technology with the strategy of an enterprise. The primary goal is to develop enterprise analysis to increase certainty of performance requirements at corporate level.

The purpose of performing system analysis is to develop detailed systems analysis specifications in terms of information requirements, information data flows, logical and physical system design, database designs, system configuration, distributed access, and security. The primary goal is to identify functional requirement at operational level and decision making is to evaluate the impact of high technology on the support of functional requirements.

Ultimately, the functional requirements are aligned with the specification of high technology. The purpose of implementation is to manage adoption and to diffuse the use of high technology. The primary goal is to manage the cycle of mutual adaptation [56].

Business Process Reengineering therefore support adoption of efficient technology by maintaining a balance mix of market and technology information. With a socio-technical approach [57] of reengineering, it helps assess the relevance of technology to the social and operational needs of an organisation. Therefore, misalignment between the technology and the social systems is anticipated and forestalled. It also provides an alternate channel to measure the relative advantage of high technology. Since value adding to customer emerges as the major criteria, business process will be reengineered to create customer value by introducing new dimensions of services made possible by creative use of technology. It focuses on the net positive impact of technology that can be manipulated for strategic use or even reinvented for new use that creates strategic opportunities. Consequently, organisations will be able to test and apply new uses in the iterative process of technology enhancement.

Although consideration of data and information requirements are necessary, it falls into the scope of system analysis and hence out of our scope. Business process is supported by structure, reward system, management systems, and values and beliefs. Therefore, the requirements of the new processes and their supporting systems are considered. Tools and techniques for process analysis will be considered for their application in the reference site. Since various process analysis tools are proficient for specific measurement of outcomes and results, their selection highly depends on the objective of process measurement adopted by organisations. Therefore, the choice is subject to the company. A detail evaluation of the tool will not be provided here. However, the tools that have been selected will be used throughout the project period. Our focus will be on the evolution of organisational requirements for high technology.

1.4 SUMMARY OF REQURIEMENTS FOR BPR MODEL FOR ADOPTION OF EFFICIENT HIGH TECHNOLOGY

The above studies of Innovation Diffusion literatures summarise important requirements that the BPR model for adoption of efficient high technology must achieve. They are:

1. improving the quality of adoption decision for high technology;
2. improving the quality of knowledge in the area of business processes (operations);
3. building a concept of relative importance of business information in relation to the adoption of mission critical high technology; and
4. capturing meaningful knowledge through the understanding of both the characteristics and the quality of business processes (or operations).

CHAPTER 2

LITERATURE REVIEW

2.1 BUSINESS PROCESS REENGINEERING MODELS

Business Process Reengineering (BPR) is "the fundamental rethinking and redesign of business processes to achieve dramatic improvements in critical contemporary measures of performance such as cost, quality, service and speed" [58]. It assumes dramatic improvement in business performance can be achieved through the application of information technology. Therefore, it describes the application of information technology to support broad structural changes in an organisation.

Information Technology is inextricably linked with BPR, because IT offers an obvious mechanism for innovation. Although many have realised this natural partnership, there are few occasions where this relationship has been fully exploited [59]. Recognising that the technical systems interact with organisations at multiple levels and in multiple domains [56], we can deduce BPR plays the role of identifying and examining the requirements for high technologies at multiple levels of an organisation and in multiple domains of work organisations.

2.1.1 Business Process Reengineering

Hammer's work provides a conceptual framework of radical process redesign. Innovative business process should be built by constructing process orientation, searching for dramatic improvement opportunity, shattering assumptions, and using information technology to transform the process [60]. Hammer referred business process reengineering specifically to the design of the new process. It is necessary in the radical change of processes.

According to his theory, business process is built on "assumptions". The assumptions include the presumed logic of workflow developed in the pass, the policies and rules that define lines of responsibility and authority, the value and belief prevailing in the organisation. These assumptions imposed constraints on the improvement of the business processes. Therefore, his work focuses on "rethinking" these assumptions and redefining the objectives of the business process and the associated requirements in the support systems [58].

Hammer's model views business process from a scientific perspective. His work yield two important implications:

- business information is embedded in a form of assumptions underlying the business processes
- a scientific method is necessary to handle the unpredictable, chaotic, and poorly managed business processes

His work is useful to solve sub-problem of collecting and assimilating business information.

2.1.2 Business Process Innovation

Davenport and Short provide a five-step generic approach to redesigning business processes. It is referred as business process innovation for it combines the adoption of a process view of the business with the application of innovation to key processes. What is new and distinctive about this combination is it encompasses the envisioning of new work strategies, the actual process design activity, and the implementation of the change in all its complex technological, human, and organisational dimensions [61].

The five steps include (1) develop business vision and process objectives; (2) identify processes to be redesigned; (3) understand and measure exiting processes; (4) identify IT levers; (5) design and build a prototype of the process [62]. In step 1 a strategic vision is required, where exactly and what the business and its functions are meant to do is established in quantitative terms. Step 2 involves selecting a number of critical processes, not all, for the purpose of gaining executive management commitment. This aids the redesign effort by allowing success to be achieved quickly. Understanding and measuring in Step 3 is extremely important for the management of the process. Also, criteria for measuring the success of the redesign are established. By identifying IT levers in Step 4, it is possible to determine the impact of any BPR initiative; locally in one particular business function, and globally to include all partners in the value added chain. Finally, Step 5 involves implementing or testing the redesigned system [61].

Their work yield two important implications:

- a key area for high technology adoption is required for cost-effectiveness

- the key area must be a process; adoption of a technology to facilitate only the functions of a department is not necessarily a good decision.

Their work is useful to solve the sub-problem of collecting and assimilating business information.

2.1.3 Business Network Redesign

Short and Venkatraman (1994) offer the term 'business network redesign' with reference to the significant opportunities attainable by thinking past the traditional boundaries of an organisation and looking to processes defined across different organisations that serve to deliver value to the customer [63]. In other words, it is important to articulate the larger business network that contains the critical business processes and then adopt a more holistic approach to redesign [59]. Their work implies that business information is embedded in business processes of business partners. Their work is useful to solve the sub-problem of collecting and assimilating business information.

2.1.4 Evaluation of BRP Models

These conceptual models provide an alternate channel through which Information Technology solutions are being scrutinised and selected [64]. The three important model of BRP contributes to our research in the area of collecting the business Information, organising the business Information, assimilating the business Information and translating new business needs to the decision making for technology adoption.

2.2. MECHANISMS OF HIGH TECHNOLOGY DIFFUSION IN REENGINEERING

2.2.1 Linking High Technology to Strategy

High technology adoption begins with integration of business strategy with high technology. Such integration is important in two folds. Firstly, high technology functionality is evaluated for its capability in supporting and shaping the business strategy. Secondly, a strategic fit between business needs and the high technology is achieved. Before linking High Technology to business strategy, the objectives of the enterprise should be established and the strategy derived. It should be noted that objectives are conditions that the firm intends to achieve and they are unambiguous and measurable while strategy refers to how the firm intends to achieve its objectives, for example, cost leadership and differentiation. The objectives and strategy serve as guideline to generate the CSFs (Critical Success Factors) and the KPIs (Key Performance Indicators) [65]. Afterwards, these data are used to develop the firms strategic data model (SDM) and define high return IS opportunities [66]. IT/CSF Linkage Matrix is used to examine the capabilities of Information Technology offers to support the strategic goal of an enterprise.

To support High Technology adoption, CSFs are used to determine the technology requirements at both the corporate level and the functional level. For example, corporate CSFs are used to derive Sales & Marketing CSFs, Finance & Administration CSFs and Production CSFs. The functional CSFs are useful in establishing departmental requirements. In the case of process reengineering, an integrated view of the functions is needed to identify technology requirements in core processes that are supported by multiple functions. Instead of building functional CSFs, core process CSFs should be established to assess the impact of high technologies on the achievement of competitive edge. Therefore, process study is required to identify the core process because enterprise lacks process view as well as a clear definition of the core processes.

2.2.2 Forging a Link between High Technology and Business Process

When the high return high technology opportunities have been mapped to the core processes, the next task is to select the value added technologies to enhance the performance of a particular business process. Therefore, the analysis phase of reengineering serves to determine process specification and technology specification. Process specification contains high level process assumptions and rules on which the new process is designed whereas technology specification contains functional requirements that support the new process.

To determine process specifications, the core process should be modelled, measured and diagnosed. Process modelling, process measurement and process diagnosis are interdependent activities. The choice of modelling tools will enhance or constrain the results of the measurement and the diagnosis. For example, widely used modelling tools as Structured Method (Date Flow Diagram), Object Oriented Analysis and Design [67] exhibit functional and behavioural aspects of the core process. They are useful in diagnose phase but they lack the mechanisms to measure process performance. Service Systems Mapping (SSM) [68] provides a process description with measurement of process cycle time and value-added time but no measurement of activity cost.. Integrated DEFinition Method (IDEF) [69, 70] includes measurement of activity cost but lacks the cycle time measurement. It is important to integrate the results of multi-dimensional process measures to achieve a process design that balances the quality, time, cost performance and customer satisfaction.

Basing on the performance information, process diagnosis should be performed to recognise essential performance problems to identify the rules and assumptions that are sources of these performance problems. These rules formulate and control the mechanism of the core process by enforcing the assumptions in the core process model. The assumptions concern who performs the work, where the work is done, when it is done, what resources it requires and how it is controlled. It should be noted that a structured approach is required to uncover the underlying rules and assumptions. Techniques such as Backward Chaining, Fishbone Analysis, Force Field Analysis, and Pareto Diagramming [71] are useful in this process.

By understanding the impact of the rules on poor performance, one should eliminate or alter these rules. In theory, by strategically redesigning the rules and the associated assumptions, the mechanisms of the process will be altered to achieve radical improvement. Adoption of High Technology is also promoted. For example, according to Taylor's theory of work management, work is organised into functional departments to achieve greatest efficiency. High Technology that promotes a more integrated form of work has been found difficult to be diffused [23]. Therefore assessment of the capabilities of high technology to reform the rules will open organisations to a whole new range of choices of efficient technology.

Based on the process specification, functional specification of high technology is developed to document the information needs of the core process. According to Davenport (1993), the technology specification should include information acquisition and collection, information categorisation and storage, information packaging and formatting, information dissemination and distribution, information analysis and use [61]. The art is to match the high technology to these needs. High Technology that is not developed internally may serve the requirements of some dimensions only, or a certain number of requirements of all dimensions. The evaluation or matching process will be best served by matching the assumption of work embedded in the high technology in supporting the new assumptions that are used to design the new process.

2.2.3 Building High Technology into New Process Design

The process redesign phase should undergo alternative design, high level design and detailed design. When this phase completes, the structure and workflow of the core process are finalised. Redesign phase starts with exploring "unthinkable" alternatives of work flows. The challenge lies in brainstorming creative ideas and then narrowing down the options that are useful. The strategic technology opportunities and technology specification serve as a basic from which the creative design ideas are created. In this process the reengineering team acquire technology knowledge and build an understanding of technology capabilities on changing the workflow of core process. Using the strategic technology opportunities and technology specification will also narrow the available options in a manageable size. The options will be minimised further by validating their impact on business objectives and examining the incompatibilities among the options.

The process options are documented for high level process design. High level design serves to refine mission and scope of the core process, reframe its boundaries, define radical improvement objectives, and develop design principles [68]. The central theme of high level design is to give new definitions to the process assumptions being challenged previously. Detailed design will start with translating the new assumptions to specific activities. To manage complexity, the core process should be managed as components. Objectives of each component should be clarified and process steps filled in each component. The component will later be integrated for sanity check [68] and value analysis [68]. When the steps are being outlined in detailed design, the reengineering team will be able to capture the key information that is required and the necessary skills to perform the tasks. These input are processed to refined the technology specifications that will become a reliable guide for selecting high technology in out-sourcing process. Lastly, detailed design is completed only when business policies are developed, the support structure and human resource architecture are designed and continuous improvement feedback is built in.

The last stage of process redesign is to put the detailed design to test for refinements and enhancements. Master plan of pilot run is important as it defines the means of collecting testing data and quantifying the results. The central theme of pilot run is to reveal what it will take to make the implementation of new process a success.

2.3. SUMMARY OF CHARACTERISTICS OF BPR MODEL FOF ADOPTION OF EFFICIENT HIGH ECHNOLOGY

The conclusion of the above studies of Innovation Diffusion literature and literature of Business Process Reengineering summaries important principles based on which the BPR model for adoption of efficient high technology is to be build. They are:

1. A scientific approach to manage and assimilating business information is the very basis for the development of organisational capacity for high technology assessment
2. Business information must be collected in the study of business strategy, customer requirements (or values), business processes
3. A logical understanding of business processes of an unpredictable nature is central to the understanding of business information
4. Business strategy, customer values, and business processes must be correctly linked to Technology information
5. Encourage information sharing among members of organisation (horizontally and vertically) to facilitate the collection of business information is necessary.

CHAPTER 3

OBJECT ORIENTED BPR MODEL

3.1 OBJECT-ORIENTED MODELING METHOD

This chapter presents an instrument for BPR implementation modelled in Object-oriented approach. This instrument is constructed with an objective of simplifying the mechanism of collecting, organising, and assimilating business information. Referring to the section of Problem domain and Literature review, there are three essential types of information: business strategies, business processes, and high technology. They, presumably, are useful throughout the various phases of process reengineering when they are systematically collected, correctly linked and logically analysed.

Object-oriented modelling method, in theory, offers a powerful tool that categorises and relates information and knowledge. Inheritance [72], one fundamental rule of relating information by object-oriented methods, correlates abstract information using the very simple method of classification. As oppose to normalisation, the method of relating information used by structured methodologies such as SSADM, object-oriented modelling allows any information to be related basing on a cognitive understanding of information. It opens up a wide variety of choices for types of repeatable principles basing on which information is related and correlated.

Given the abstract nature of business and technology information, the whole discussion of object-oriented modelling method implies that the method is a good option for modelling the reengineering process with an information perspective. Unlike the models of Business Process Reengineering discussed in Chapter 2 that adopted an operational and sequential view of processing business information, the object-oriented BPR model to be presented in this Chapter takes an alternative that relates business and technology information by the rethinking of its contribution to the capacity of assessing high technologies.

3.1.1 Jacobson's Method for Model Building

Booch's method [73], Cord and Yordon's method [72], and Jacobson's method [74] are studied and assessed. Jacobson's Objectory Method is shortlist due to a number of reasons:

- its flexibility in handling changes and evolution of object relationships
- the simplicity of its notations and presentation
- the three broad types of relationships (that are Use association, Extend association and Communication, to be discussed in section 3.2.2) that establish connections for both strongly and weakly related information, are more understandable by persons who have limited understanding of object-oriented method and Business Process Reengineering

These characteristics of Objectory Method implies that it is an efficient tool that facilitates the process of model development spanning from a narrow concept to a broader understanding of the complete system of assimilating business and technology information.

3.1.1.1 Objectory Method – A Brief Introduction

Objectory is applied in the industrial development of information systems and has been embodied in the CASE tool Ory SE (Objectory Support Environment) [74]. Based on use case-driven design, Objectory is an excellent way to clarify the inner workings of a system [75].

Objectory handles complexity and volatility of assimilating information by modelling the input, the events that processes the input, the output and other physically existing entity as basic objects. The objects are then grouped into classes that prescribe their role and responsibility. Interactions between objects are handled by means of message passing (Use association, Extend association and Communication).

Objectory relates additions, extensions, changes and deletions of attributes to the basic objects that are treated as the most stable elements and least susceptible to potential changes. Grouping the stable elements to form the basis for organising the reengineering process makes it more identifiable and adaptable to changes. Hence, the roles, the responsibilities and the interactions of the objects can be easily adjusted and implemented.

Objectory allows grouping of objects into classes basing on the understanding of procedure or process (Handler). It simplifies the view of intervention strategies and necessary information. The inheritance structure in Objectory provides a powerful technique for explicit expression of commonality of business and technology information and the associated intervention strategies. Intervention strategies when treated as event objects, their common attributes are clearly specified and interactions among the strategies easily understood. Reusing the intervention strategy objects helps to extend the linkage of business and technology information into varies phases of process reengineering.

3.2 FORMATION OF BPR MODEL

A BPR model is constructed with an aim to formalise the implementation of business process reengineering. The concept offered by Objectory was actualised and improved to transform the requirements of BPR model summarised in section 2.3 into a set of methods. Before the overall model is presented, the components that make up the overall model and the characteristics of each component are explained. In section 3.2.1. actors and use cases are defined. In section 3.2.1.1 the relationships between actors and use cases are explained. The relationships among the use cases are illustrated in section 3.2.1.2. Section 3.2.2.2 presents the overall model will be presented. Decomposition of the overall model is presented in section 3.3.

3.2.1 Actors and Use Cases in BPR Model

Objectory's concept of Actors is used in this model to represent members of an organisation who provide and share essential business information. Therefore actors are one of the sources of information. Actually, they are important sources of information assuming that the organisation is highly informalised and business information is not adequately documented.

The concept of *Use case* is expanded to represent the essential processes of collecting, organising and assimilating business information and the essential information itself. Although entity objects (referring to section for its definition) are used to represent the various types of information to be organised and processed in this model, the all encompassing nature of the Use case is useful in visualising the logical connections among the essential processes based on the understanding of the interdependence of the essential information.

Figure 3-1 shows the schematic symbols denoting use case and actor. The influence of actors on the diffusion of high technology is denoted by an arrow pointing towards the use cases.

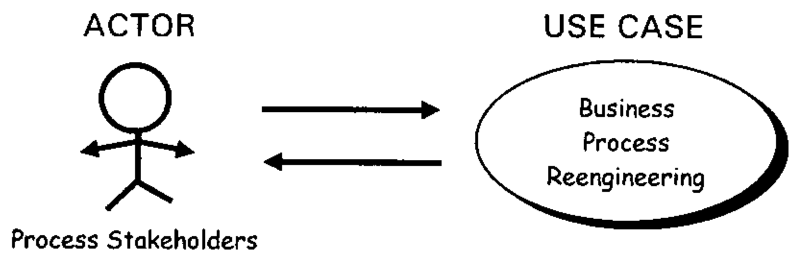

Figure 3-1 Schematic Symbol of Actors and Use Case

3.2.1.1 Characteristics of Actors

Actors affect high technology adoption by providing accurate information of operational performance. In Figure 3-2, the arrows reflect the input relationships between actors and use cases. Input from the actors varies with their role played in the organisation. Actors are broadly classified as product customers, process owners, process users and process customers. They belong to the class of process stakeholders as they share common characteristics as a supplier of business information.

As linking customer value to technology information is important (section 2.3), essential information such as evaluation of products and services is obtained from Product customers. Linking business information embedded in business process (section 2.3) requires the participation of Process owners, Process users and Process customers. Process owners are managers being held accountable for the assessment of process effectiveness. Process users are the staff who do the work in the business processes, therefore they provide data of operational efficiency. Process customers provide assessment of services generated by the process users.

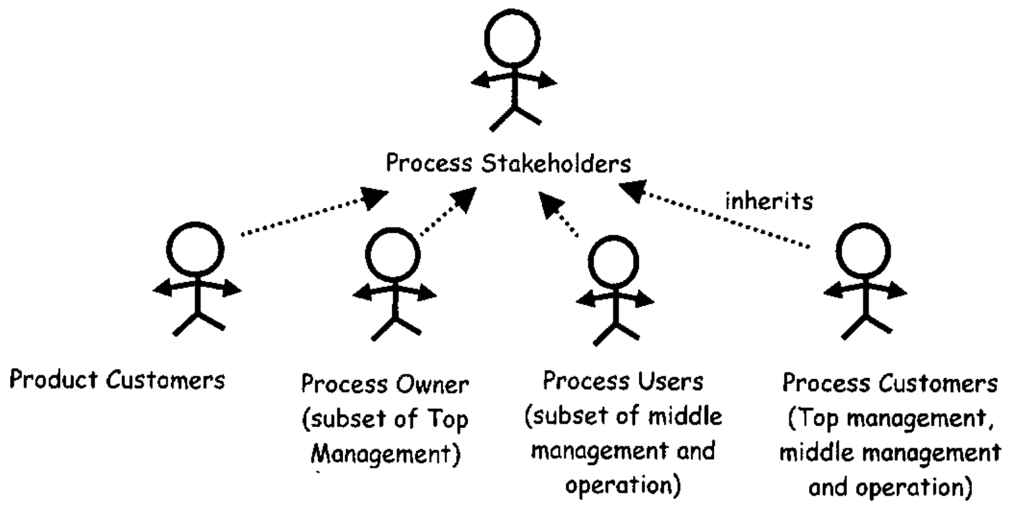

Figure 3-2 Characteristics of Process Stakeholders

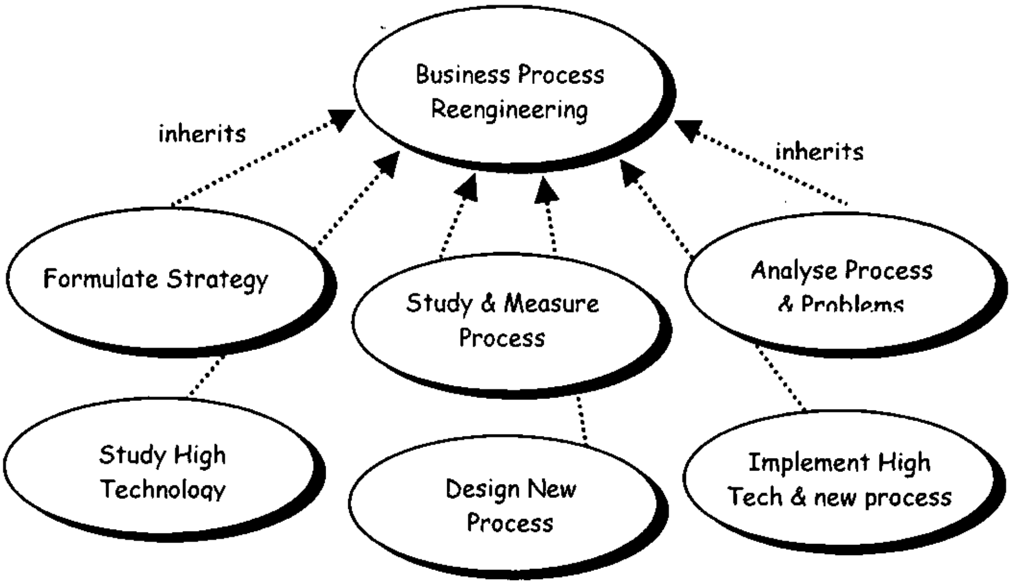

Figure 3-3 Characteristics of Use Cases

3.2.1.2 Characteristics of Use Case

As defined in section 3.2.1, use cases are the essential processes of collecting, organising and assimilating business information. The results of literature review (section 2.2) implies that Strategy formulation, Process Study and Measurement, Process and problem analysis, and Process Design are important processes to link business strategy, business process and new process design to high technology. To complete the model the processes of High Technology study, and Implementation is added to perfect the connection of essential Business and Technology information. The six use cases share common functions of collecting organising and assimilating information

Figure 3-3.

3.2.1.3 Interaction Between Actors and Use Cases

Referring to section 3.2.1 and 3.2.1.1, actors are supplier of business information. In this section Figure 3-4 gives a broad overview of mapping information supplier and their associated types of business information to the six essential processes (use cases). The mapping is indicative of the value of different types of business information to high technology adoption. For example, information provided by Product customers is important for the understanding and the revisiting of Business Strategy (Arrows pointing from Product customers to Strategy Formulation use, see Figure 3-1).

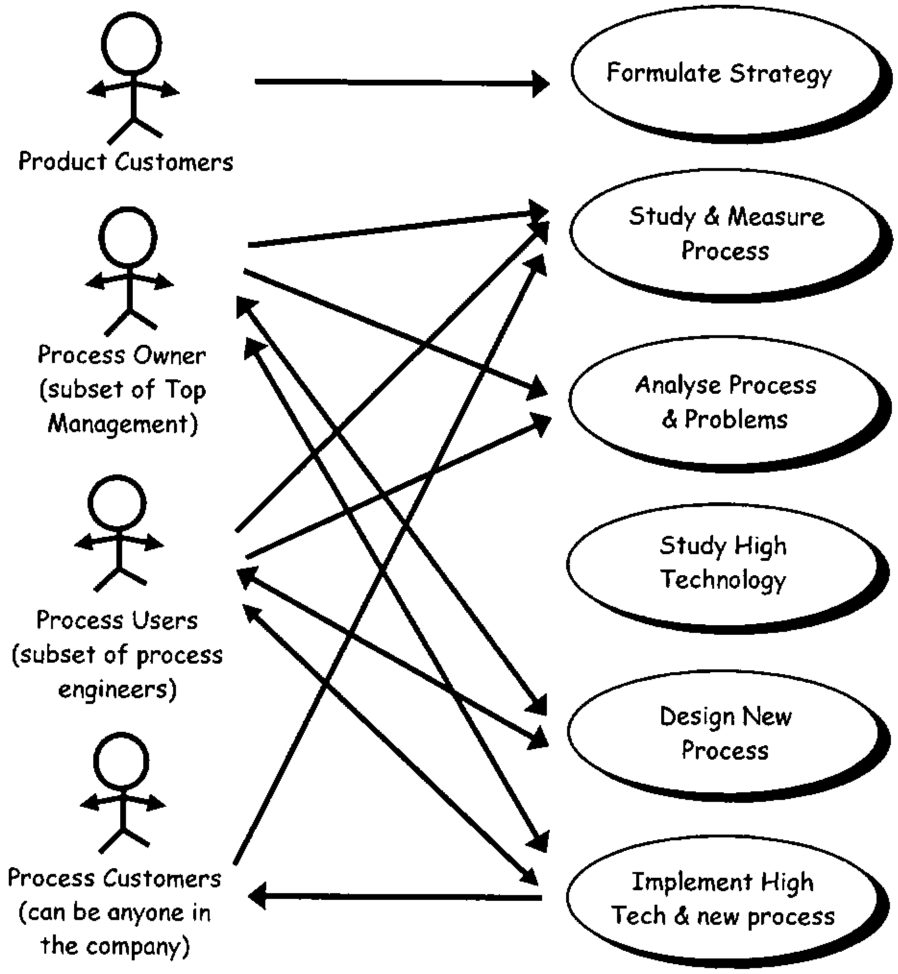

Figure 3-4 Interactions Between Actors and Use Case

3.2.2 Interdependency of Use Cases in BPR Model

Based on the understanding of the value of information derived in section 3.2.1.3, interdependency of the six use cases are modelled by linking their values. Unlike the reengineering models (section 2.1) put forward by practitioners that manage the processes of reengineering in sequence of occurrence, this model manages interrelationships basing on the concept of object associations, that is the connection of information.

3.2.2.1 Concept of Object Associations

An association is a named abstraction of relationships between objects. In the domain of performance improvement, example of association is given in Figure 3-5. The direction of the arrow indicates the direction of the named association from the sources object type to the target object type.

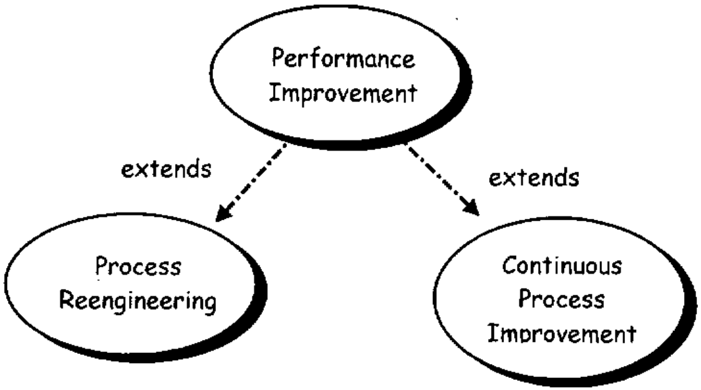

Figure 3-5 Example of Extent Association

The concept of association is adopted to model the connection of essential processes basing on the understanding of the value of business and technology information in the processes of collection, organisation and assimilation. Four types of associations, namely inheritance association, extends association, use association, and communication association [75], are used to explain the connection of various types of business information.

3.2.2.1.1 *Inheritance*

Inheritance association is a static relationship that represents reuse common properties between objects. When the inheriting class (the descendant) is instantiated, all the characteristics (attributes, operations and associations) that are described for the class (the ancestor) from which it inherits will be present in the instance in question.

3.2.2.1.2 *Extends association*

Extends association is used to construct sub-flows of an existing use case. Both the source use case and the extended use case (sub-flow) share similar characteristics. However, the source use case would supplement its extended sub-flows. In another word, the source use case can be initiated independent of its extended one but not vice versa. In this way the extended use case will only be instantiated during some period of life cycle. Also, changes in the characteristics of the fundamental use case will alter the course of action in the extended use case.

3.2.2.1.3 *Use association*

Use association represents reuse of descriptions. These redundant descriptions are divided into non-redundant use case. It therefore represents transactions that are shared by several use cases. Use association between two use cases indicates both are initiated independently and they have different characteristics. Hence, changes in the characteristics of one use case will not affect the course of action of the other.

3.2.2.1.4 Communication

Communication denotes information exchange between two object types. Each object operates independently and communication establishes once the source object transfers its output to the target object which processes information as input.

3.2.2.2 Structure of BPR Model

The reengineering process requires the operation of six use cases. They are Formulate Strategy, Study and Measure Process, Analyse Process and Solve Problems, Study High Technology, Design process and Implement New Process. Input, output and operation of each use case has been illustrated in chapter 3. This section aims at exploring their interdependence in greater depth. Interactions between these six use cases are presented in a hierarchical structure depicted in Figure 3-6.

Referring to Figure 3-6, the Formulate Strategy use case is on the top of hierarchy. It extends its functions to Study and Measure Process use case. In another words, Study and Measure Process use case is considered as a sub-flow of Formulate Strategy. Formulate Strategy is performed to give an organisation a clear goal and missions. Then the divisions and functions of that organisation respond by executing the defined goals and missions.

It will trigger the Study and Measure Process sub-flows on condition that an external threat or opportunity is recognised and organisational change is commissioned thereof. Hence, Formulate Strategy is performed independently. If no environmental force is felt, the reengineering process will be terminated. If radical improvement objectives are envisioned, Study and Measure Process will be initiated to determine the performance gap.

The results of Formulate Strategy will be inserted into Study and Measure Process use case. In this respect a change in Formulate Strategy will cause changes in the course of event in its extended use case. For example, if strategy of cost leadership is pursued, performance measurement will focus on costing measures and cost performance. On the other hand, if differentiation is envisioned, measurement will focus on evaluation of value-adding activities and customer satisfaction.

Study and Measure Process Use Case is in turn used by three use cases essential to the reengineering process. They are Analyse Process and Solve Problem, Design Process and Implement Process use case. The model assumes that Study and Measure Process Use Case is used at the end of each phase mentioned above. For example, Analyse Process and Solve Problem use case aims at identifying the performance problems and recommending feasible solutions at a preliminary stage of reengineering process.

Then the recommended solutions are evaluated against the performance improvement objectives to envision the magnitude of improvement that is possible. If the improvement objectives prove to be much more radical, the use case may need to rerun to make new definitions of problems. For example, organising work in the divisions has long been cherished. Such assumption of organising work will be challenged and established as a root cause of performance problem. Therefore, the target performance objectives are constantly compared to envision radical solutions.

The same "use" association exists between Study and Measure Process Use Case and Design Process use case. The new process specification produced at the end of the Design Process phase will be vigorously evaluated against the target performance objectives. If the target objectives are not fulfilled satisfactorily, the Design Process use case needs to rerun to develop more radical solution.

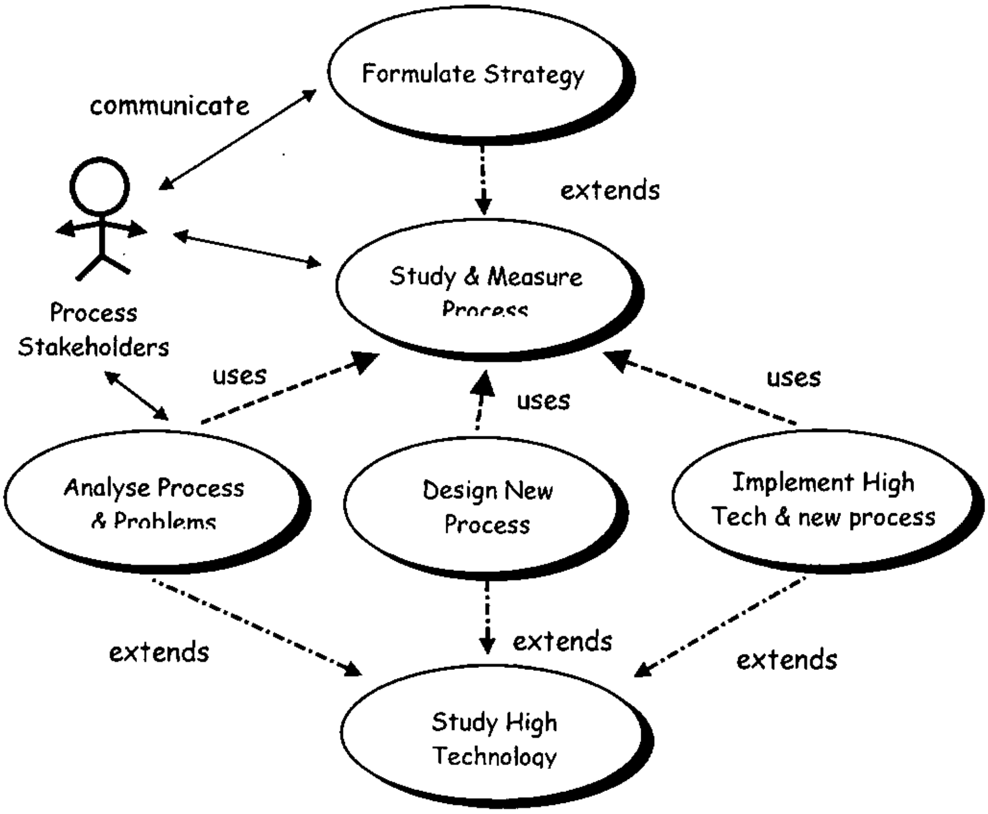

Figure 3-6 Interdependency of Six Use Cases in BPR Model

Implement Process use case uses Study and Measure Process Use Case after the new process is implemented. Snapshot of new process performance data will be collected and evaluated against the target performance objectives. If such objectives are not met, the implementation strategy should focus on organisational adaptation in both the social and technical systems or on envisioning refinement of process design.

By assigning a use association between the Study and Measure Process Use Case and the three use case illustrated above, the high technology is diffused in the reengineering process by pushing the radical improvement objectives through the analysis, redesign and implementation tasks. In this respect, the reengineering process is under extreme pressure to redefine problem, envision new ideas, all in all, to innovate. In the light of achieving radical improvement objectives, high technology will be constantly examined, evaluated and finally adopted. Such mechanism will be elaborated more effectively by revealing the relationships among the three use cases.

Each of the three use cases operates independent of each other. Communication associations exist among the three in that they perform information exchange with one another. Although the communication association seems insufficient to illustrate the sequence of their occurrence, their occurrence is assumed as a natural order, that is, results of the Analyse Process and Solve Problem serve as a basis to build a new process (Design Process), the new process developed in the Design Process use case is actualised in the Implement Process use case.

In the modelling level, they are independent of each other because changes in one use case will not alter the course of action occurs in the others. However, since it is more reasonable to assume the results produced in each use case indeed aggregate to bring about high technology adoption, the communication associations are useful in depicting such accumulating effect. For example, Study High Technology use case is used by the three use cases at different point of time in the reengineering cycle. As mentioned above, in the Analyse Process and Solve Problem use case, when redefinition of problems is required but is difficult to do, the new working assumptions embedded in high technology will be studied or even used to challenged the old assumptions. Sometimes, the new assumptions are adopted and they will affect the results of Design Process.

3.2.3 Object Classes in BPR Model

Object classes are essential components to represent the detail implementation guide of the proposed in BPR model. Having understood the interdependency of the six sub-processes in the context of high technology diffusion, the model has to be operationalised step by step. Three object classes are useful in this scenario. They are input object class, event object class and output object class (Figure 3-7). In this sense the use cases explode into these three object classes. Hence, they are the components at the lowest level in the BPR model. Input objects are useful in depicting the necessary information to be processed by the use cases. Event objects represent the operations that processes the information. Output objects are the results generated by the event objects.

3.2.3.1 Input Vs Output Object Class

The concept of input and output is clear on the top level of BPR model. When they are considered at the lowest level, the characteristics of input and output objects transform in their states. For example, the output objects generated by the Strategy formulation use case are used by Process study and measure use case. Therefore these specific objects become input objects of the later use case. Therefore, building inheritance models of input and output is not practical. To solve this problem, the input and output objects are presented alongside with the event objects for step by step operation of each use case in the BPR model. The concept of Entity objects is adopted from Objectory. Entity objects denote the information that the system will handle, update or access, over a longer time [75]. Hence entity objects are either accessed or generated by the event objects.

3.2.3.2 Event Object Class

Input objects are processed by two types of operations. First, the objects are collected, organised and documented by the members of the reengineering team. Then they are analysed to generate the output objects. Therefore, there are two types of event objects. *Interface objects* represent the first type of events. Interface objects represent a set of operations that involve communicating with the environment of the system. Through these events the process stakeholders provide information to the reengineering team. As these objects allow the actors to communicate with the system, they are directly dependent on the system environment [75].

The second type of events are represented by *Control objects.* They represent transaction related behaviour or functionality that isolate the entity objects from interface objects [75]. Control objects represent specialist tasks that are performed without direct contact with a customer. Recognising the two distinctive kinds of objects that separate the control and co-ordination of use cases from behaviour of process stakeholders, the reengineering process become stable. By keeping external behaviour, internal structure, and dynamics apart, each may be altered and extended independently.

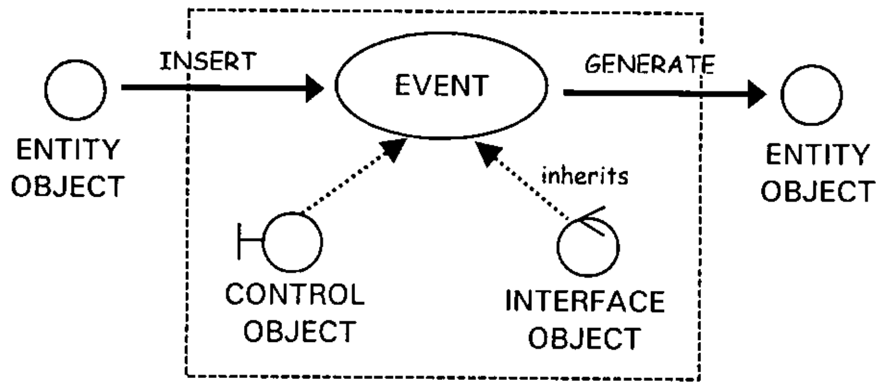

Figure 3-7 Input, Event and Output Objects in Use Case

3.3 BPR MODEL FOR HIGH TECHNOLOGY DIFFUSION

This section explains the operations of input, event and output objects in each of the six use cases.

3.3.1 Strategy Formulation Use Case

This use case performed the tasks of linking business information with technology information. This use case drives the executives of company to validate their understanding of competitiveness. A correct understanding of their business and its market is the very basis on which a useful set of performance measurement standard is generated to give a correct judgement on business process performance.

Basing on our understanding of the mechanism of high technology diffusion in section 2.2.1, this use case is best constructed with Strategic Plan Handler as the centre of it (Figure 3-8). When the executives are highly certain of the competitive environment and highly explicit of its quantifiable business objectives, they may opt to generate a strategic plan that documents the vision and mission statements without having further study on the subject.

On the other hand, Strategic Plan Handler extends to Requirement Handler and Market Communication Handler (Figure 3-8) to enrich the understanding that the executives have regarding the competitiveness and the market requirements when they are less certain about the correctness of their strategic plan. As driven by the Requirement Handler the executives validate or even redefine their understanding of customer needs by sharing information with members of the company. Process Stakeholders, Sales Staff for example, provide input such as customer requirements to the executive for reference.

This process of validation is further perfected by collecting and evaluating the information about the competitive environment (Market Communication Handler). The essential types of data include, but not limited to, products, price information of competitors, and data of the social, economic, and political environment. The data must be neatly stored in database and neatly indexed for searching. A possible result of this process of validation is that the company will be repositioned in the strategic grid.

Basing on customer requirement and market information, Strategic Plan Hander identifies the Critical Success Factors and includes the results in the strategic plan. The finalised strategic plan is an important output of this use case on which the master plan of process reengineering is formulated. Hence the strategic objectives are integrated with the goals and master plan of the reengineering project. Strategic plan is therefore linked to the Process study and measurement use case. In this way the business information embedded in the business strategy is linked to the business process and also the technology information.

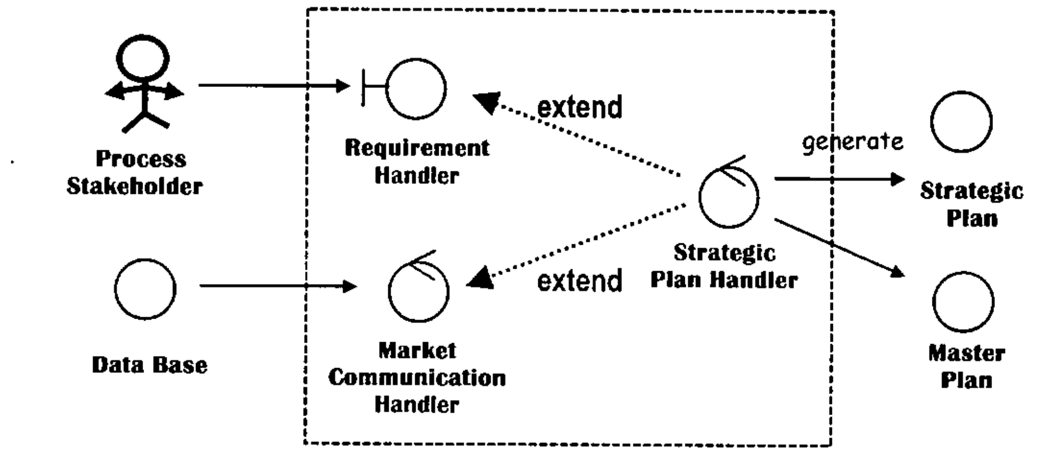

Figure 3-8 Strategy Formulation Use Case

In the case of Digital Equipment Corporation [76], the DEC reengineering team identified their critical success factors when they revisited their strategy. It was very important, as DEC was able to focus on quality, time-to-market, and customer satisfaction in their process design.

3.3.2 *Process Study and Measurement Use Case*

This use case supports the companies in the area of collecting and organising business information in an efficient manner (section 2.2.2). Process Model Handler is placed at the centre of this use case because it supports the company to achieve a good understanding of business processes that increase the reliability of performance assessment. Based on our understanding of Leonard-Barton's work (1988, 1991, 1992), business processes are not as logical as they seem. However, business processes can be quantified and measured only when they are rationalised and well understood. A correct and useful measurement of process performance is built on a logical model of business processes.

The reliability of logical business process model increases with the integrity of process data. However, process data is usually poorly recorded and stored as this BPR model assumes organisations are informalised. This BPR model suggests that business process model should be produced based on process and performance data collected from diverse sources; they are static sources (e.g. documentation, the entity object shown in Figure 3-9) and dynamic sources (process stakeholders, the actor shown in Figure 3-9). The two sources complement each other. Static sources are more reliable but they are historic and also less complete in details. Dynamic sources provide up-to-date information on a broader scope and bigger details but they are less reliable.

Based on a good process model performance measurement is produced. Business process performance is quantified and evaluated against business objectives documented in the strategic plan produced in the use case of Strategy Formulation. Process measurement handler is the next important step in this method that encourages the companies to broaden their concept of performance. It extends to two major activities: evaluating internal performance (event object of Internal Assessment Handle in Figure 3-9) against their own strategic objectives and against the best practise of market leaders (event object of External Assessment Handle in Figure 3-9).

External Assessment Handler creates a radical concept of performance gap based on the results obtained from Benchmarking study. Benchmarking study is an effective tool to assess the performance gap between the companies and the market leaders they look up to. Finally Process measurement handler reconcile the results from both internal and external assessment handlers. It may feedback to Strategy Formulation use case to redefine more radical reengineering objectives. The output of this use case is performance data basing on which a preliminary consensus of the organisational problems and improvement opportunities emerges. Consequently, entity objects of process model and performance data are input to the Process Analysis use case.

In the case of Aenta Life and Casualty [76], the team relied on process study to understand their process. The Aenta team visited field offices and customers to build a good understanding of the process. It allowed the team to collect as much data as possible. An Aerospace Electronics Manufacturer in UK [77] had found it difficult to elicit process measure (e.g. order turnaround, stock turns, repair time) until they identified their order management process. In the process study it mapped the process of a repair job through various stages of commercial, engineering, financial, technical and reliability and the office staff all provided input.

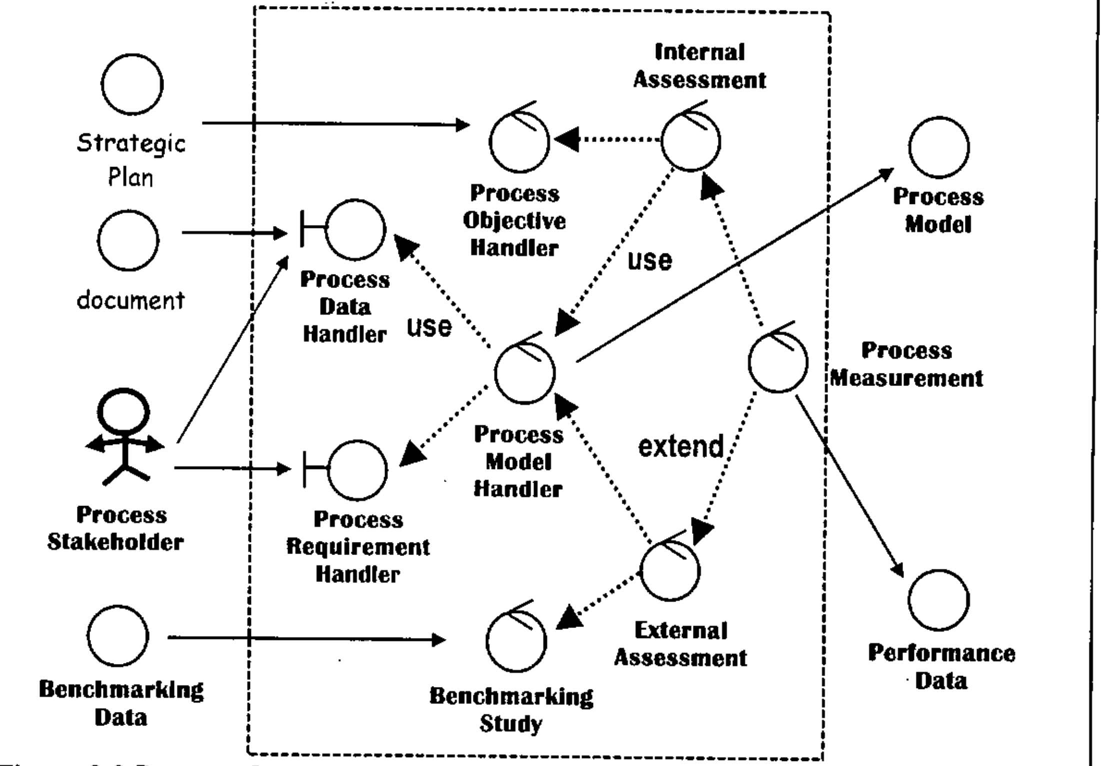

Figure 3-9 Process Study and Measurement Use Case

Both tasks of internal and external assessments rely on the accuracy and completeness of performance data. In most cases, performance data is filtered and thus its accuracy and completeness is harmed. Inaccurate and incomplete data either leads to an optimistic performance figure or an incomplete picture of problem situation. The former may causes inability to establish a cause for reengineering and termination of the project in the worse case. The later will harm the efficiency of process analysis and problem solving phase.

Information filtering occurs when no mutual trust between the middle and the operational levels exists, when the operational levels resist out of fear and of being blamed especially for project of cost cutting nature. To build mutual trust, the middle management may choose to assign representatives from the operations to participate in the process measurement process. In SONY's Barcelona & Bridgend TV assembly plant [78], for example, the management shared information between line workers and managers in the quality circle. By placing responsibility for quality and customer responsiveness at the lowest level of the organisation, where relevant information was most accessible, SONY transferred information up, down and throughout the organisation to support process improvement.

Participation by those affected by the change can be a desirable strategy for dealing with initial resistance [79]. The representative of operation staff will become the change agent acting as a link between the operational level and the middle management. However, this option may be unwelcome by the middle management who hate sharing of authority with the operations staff because the change agent will most likely take part in reengineering throughout the whole process.

The middle management may have the option of assisting the operation staff in perceiving an external crisis. Perception of a crisis situation exists on the part of all participants in an organisation can be a major factor in both reducing resistance to change and in generating propelling forces for change [79].

Process study then begins with articulating the stakeholders' comments on the target process. Process Data Handler will be initiated. These comments, on an abstract level, may be input to benchmarking against best practise to build a preliminary view of the performance gap. The results are feedback to the operation to generate a perception of crisis. When initial resistance is lowered should the objective data collection begin. In most cases of interviewing with process users (operation staff), however, they usually reveal their individual requirements like reducing workload and improving communication with related departments. In this respect, the aim of this process should become the one of building trust by allowing them to elicit their grievances. According to Aenta's experience, process study helped the affected units fully aware of the reasons for change and hence resentment was reduced and possible subversion forestall.

3.3.3 Process and Problem Analysis use case

This use case supports the companies in the area of assimilating the business information that is successfully collected and organised in the use case of Process Study and Measurement. The business information is certainly found useful after having been assimilated with the aid of Process Analysis Handler and Problem Solving Handler (Figure 3-10).

The ultimate goal of Process Analysis Handler is to help the companies to achieve a correct understanding, based on a logical process model and reliable results of performance assessment, of the limitations that the business processes have in maximising business performance. It produces value-added flow analysis (output entity object in Figure 3-10) that forms a basis to quantify and measure the limitations. The limitations unearthed in the business processes become useful to the companies only when they are conceptualised as performance problems that warrant immediate actions. By educating the companies to draw the line between limitations and problems we hope they can correctly identify those limitations that have significant impact on business performance.

In addition, the Problem Solving Handler emphases the correct identification of problem owner. To correctly identify the problem owner is important in the sense that the accountability of solving the problems is correctly assigned. Ultimately, the problem owner will be accountable for the success of implementing the solution (that will be produced in the use case of Process Design, section 3.3.4). This strategy will properly promote a fair basis of discussion during the rest of reengineering exercises because the problem owner will be co-operative when he is fully respected in the sense that no more action will be taken to affect the business processes he is controlling without his agreement. It will hopefully encourage sharing of business information among members of reengineering team.

Finally, this use case encourages the companies to validate their concept of performance problems through the iterative processes of analysis and problem solving. For more scientific validations, the companies may collect new data using the method put forward in the Process Study and Measurement use case. The output from these exercises of assimilating business information is preliminary recommendations (the entity object of Process Design Principle in Figure 3-10) for process design produced by the Recommendation Handler. This use case extends to High Technology Study that will also generate process design principles. Process design principles generated in both use cases will be input to Process Design use case for consolidation. As argued in section 2.2.2, these principles represent the new business assumptions on which the new process will be designed.

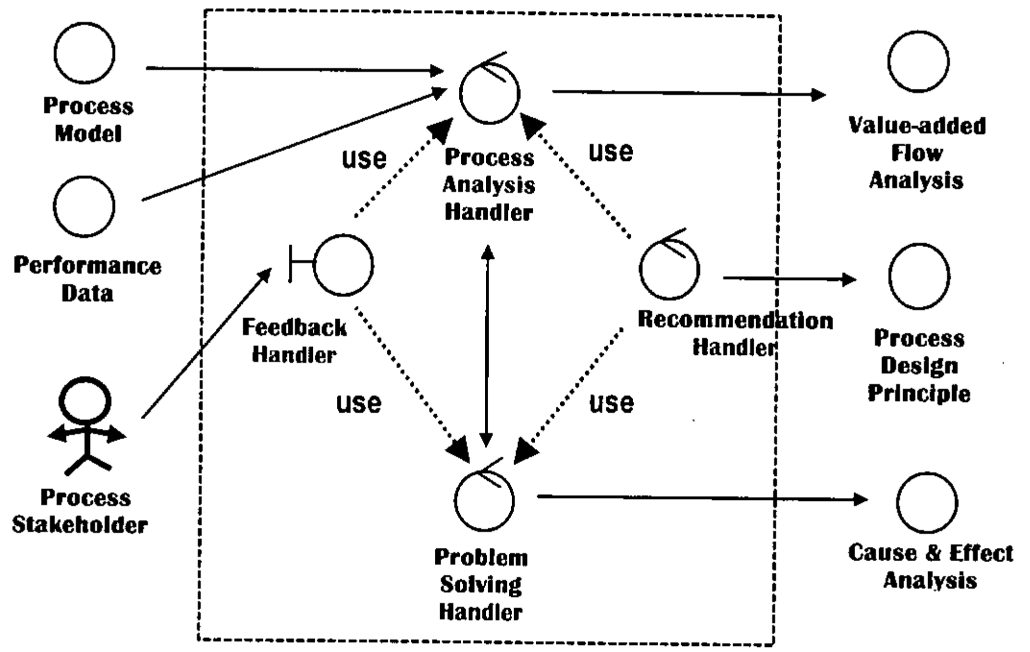

Figure 3-10 Process Analysis and Problem Solving Use Case

Iterating the process of analysis and problem solving are proven to by highly useful in the case of a North American pharmaceuticals company [77]. The clinical trials division in this company performed analysis of the clinical trial process and found how tightly its sub-processes were couple. The results helped them identify and facilitate certain well-known organisational constraints and structural rigidities in the problem-solving phase.

Sometimes participation of the operation staff is invited when, they are professionals with expertise, the size of company is small or they are assigned as change agent, to promote the change programme among the lower levels of the organisation. When the symptoms of a problem become more sever and numerous and as the number of different groups involved in the problem area increases, the problem formulation and conceptualisation requires high level of objectivity among the groups.

In most cases, however, a lack of synchronisation in analysis figures is witnessed. Infighting is generated on definition of problems. Objectivity is difficult to realise because groups involved in the reengineering project anticipate diminution of their power-authority relationships, entrenchment of existing status and even loss of their positions. For example, when marketing and engineering representatives are invited to reengineer the product development process as a customer driven process, the engineers perceive their status being invaded. They may respond by avoiding participation and using a prolonging strategy and hope the project will die down. A number of tactics should be employed to reduce resistance and maintain participation and objectivity.

When aggressive confrontation occurs among competing work groups, power strategy is effective. In this case, should their joint boss head the reengineering team and they will be able to examine the problem with much greater objectivity. As in the case of the Aerospace Electronics Manufacturer [77], the conflict between the IS manager and the project manager died down when the locus of support was shifted from the IS manager to the Middle Management. Representative of Middle Management headed the reengineering team and succeeded in completing the process analysis phase. If each competing group has equal power and influence, the senior management may buy-in the groups that are most acceptable to change. Group pressure is then generated to make the other groups comply.

Perception of a crisis situation exists on the part of all participants in an organisation can reduce resistance to change effectively. Therefore the crisis should be perceived by the participants as soon as possible. In the Analyse Process phase, therefore, the resisting groups have to be isolated and the team will work with each group to help it understand its work. Resistance is reduced when they are fully aware of the reasons for change.

For example, in the case of an acute hospital in the UK National Health Service [77], the National Health Service reforms made sound financial performance a critical issue for hospital. Pressure to act was high and came from radical reforms imposed externally by Government. However it was clear that little could be achieved unless the diverse professional and occupational groupings of which the hospital staff comprised actively supported change. One part of the resulting approach was to involve relevant stakeholders closely in process and problem analysis. The process analysis enabled basic problems to be addressed, established workable alternatives, and also released the energy for change.

3.3.4 Process Design

This use case supports the companies in the area of organising and assimilating the ideas for performance improvement (section 2.2.3). Mainly, it assists companies to migrate themselves from high level design to detail process design (Figure 3-11).

In high-level design phase, the design principles are consolidated and structured into design themes by Consolidation Handler. The design options will be further minimised by Validation Handler. Through the iterative processes of idea consolidation and validation this part of BPR model assists the companies to improve the proposing process designs.

Three iterations are recommended. Firstly, the proposing designs are validated against efficiency targets. Secondly, the applicability of proposing designs is validated against the organisational structure. Thirdly, it is validated in the social environment to foresee possible resistance from the part of the company staff. In these iterations business processes are redesigned in a holistic way when their effect on organisational structure and social norms and values is controlled. For more scientific validations of proposing process design the companies may collect new data out of the pilot test using the method put forward in the Process Study and Measurement use case.

Finally, Design Alternative Handler assesses proposals of new process design. Design Alternative Handler will only extend to Design Process Handler when the proposals are selected and agreed by all members of the reengineering team. This strategy encourages members of the team to exchange business information because it promotes a fair basis for discussion when each member is allowed to influence the process design principle. Detail process design starts after proposals are accepted.

In detail process design, the Interim Steps Designer outlines the interim process steps. The reengineering team captures the key information and new skills that are required to perform the new tasks. The Work System Designer proceeds to develop relevant business policies, the supporting structure and the human resource architecture. These two event objects generate the entity object of new work system and new process flow (Figure 3-11). In the final phase of process design, the new work system and new process flow will be put to test (pilot test in Figure 3-11) in a scalable scope. The results generated in the Pilot Test help the reengineering team assess the effectiveness of new process design and modify the design. When the new process is accepted it will be scheduled for full implementation.

The strategies put forward in this use case is feasible. In Mutual Benefit Life's (MBL) [62], for example, its individual life insurance underwriting process involved 40 steps with over 100 people in 12 functional areas and 80 separate jobs. MBL undertook a pilot project with the goal of improving productivity by 40 percent. To streamline this lengthy and complex process, MBL first built high-level design concepts. It decided to integrate the process and designed a new role, the case manager, who would perform and co-ordinate all underwriting tasks centrally. In detail design phase, the firm learned that two additional roles were necessary on some underwriting cases: specialists such as lawyers or medical directors in knowledge-intensive fields, and clerical assistance. With the new roles and redesigned process, senior managers at MBL are confident of reaching the 40 percent goal in a few months.

Two levels of process design is necessary for the Hong Kong Air Cargo Terminal Limited [59]. When they redesigned its complex distribution and storage process, they first built a high level process model and use simulation to test the model. They were able to identify deficiencies early in the design process, when correction was easily and inexpensively accomplished.

When detail design completes, the Design use case will triggers the use case of High Technology Study to select appropriate technology to best support the new process. In the SONY Bridgent plant [78], for example, the reengineering team started process design and proceeded to investigate and select appropriatě technology. SONY stopped IS projects that lose their relevance or that misalign its corporate dimensions and resources. Among the projects considered no larger appropriate are sophisticated and automated quality feedback systems, bar-coding of all subassembly processes, and the creation of an automated warehouse. Following the guidelines of the reengineering framework, SONY harmonise their use of technologies with the needs of their redesigned business processes rather than shape their processes around the technology they employ. By confining their use of technology to only what is appropriate, SONY avoided using technology that produce and distribute more information than is needed and reduced the risk in investing in low value-added technology.

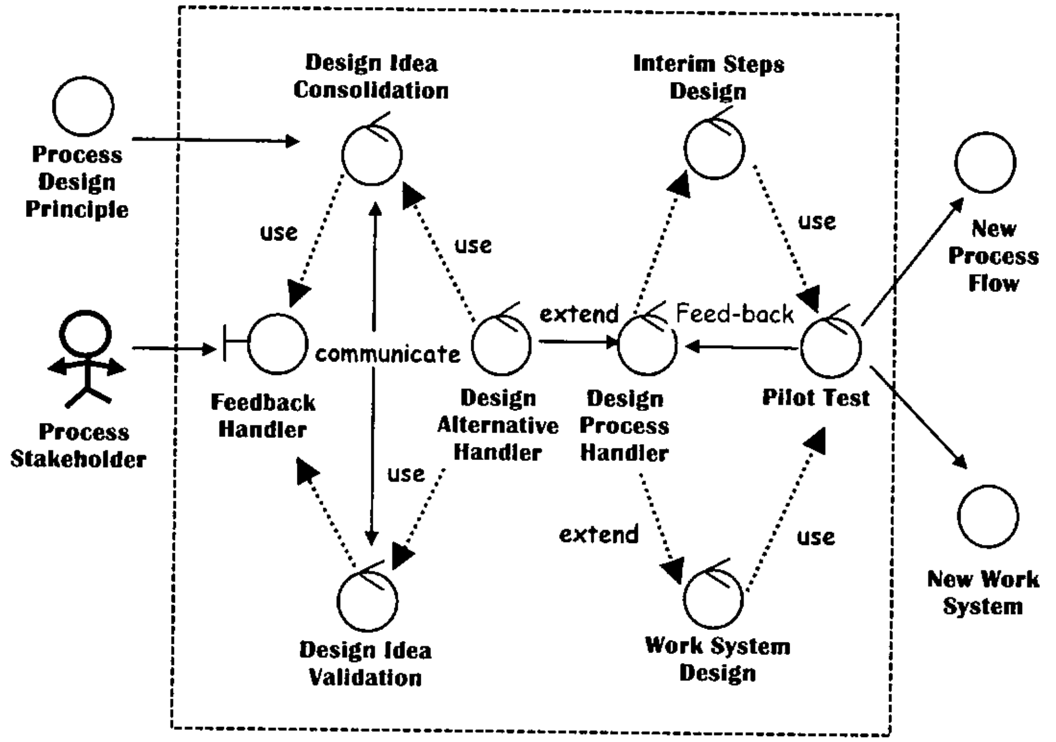

Figure 3-11 Process Design Use Case

The major issue is to provide incentive that will encourage managers to design, develop new process. Radical reengineering, by definition, meant wholesale change in structure, reward systems, skills, culture, and management style. It symbolises a threat to existing work practice and the distribution of power and resources. It generates major political and cultural issues.

For example, management compensation is often a function of the number of employees who report to the manager. Thus a manager's status may be diminished by the elimination of people that can be a consequence of process improvement [76]. Most likely they would jump to high technology study use case. In this process, they will try to examine technology solutions that automate and continue to support the existing processes. Please refer to section 3.3.6 for detail of operation in high technology study use case.

In theory, design of work system is performed simultaneously with design of new process. Work system includes work organisation, organisation structure, reward systems, roles and responsibility, and management system. Therefore, the social system is altered to support the new process for successful implementation.

If altering the work system is perceived as threatening, it should be separated distinctly from the process redesign. Therefore, it will not jeopardise the process redesign altogether. Designing work system should be performed at a later stage. For example, after the new process has been implemented, the work system is revisited and altered to refine the new process. Please refer to section 3.3.5 for further detail of process implementation.

Furthermore, if the new process requires new skills or multiple skills, the team can be encouraged to assess and select High Technology to support these new skills. Hence, lesser breakdown of the traditional skills and lesser degree of retraining are possible.

3.3.5 Process Implementation and Adoption of High Technology

This use case links high technology to business performance (Figure 3-12). High technologies are evaluated and selected in the Technology Study use case (section 3.3.6). The Implementation Plan Handler develops a system that makes sure the new process and the high technology are rollout in a controllable manner. The system is developed based on the theme that encourages the company to draw the line between process implementation and technology implementation (Implementation Plan Handler inherited by Process Implementation Plan and High Technology Adoption Plan in (Figure 3-12).

Technology Adoption Plan Handler controls sourcing, purchasing and implementing high technology. Once funding is approved High Technology Procurement Handler is initiated. This BPR model assumes that it is very costly to develop the high technology and therefore they must be procured from technology vendor for cost effectiveness. This Handler evaluates off-the-shelf technologies and selects a reliable technology vendor as supplier.

Process Implementation Plan encourages the company to plan for an operational assessment of the effect of high technology on business process. The company produces operational and performance assessment using the methods put forward in Process Study and Measurement Use Case (section 3.3.2).

This strategy avoids the common pitfall that the company would have experienced: relying too much on a technical assessment of the high technology. With the results produced by the operational assessment the company is in a favourable position to study for further improvements to be worked on the workflow or the implemented high technology.

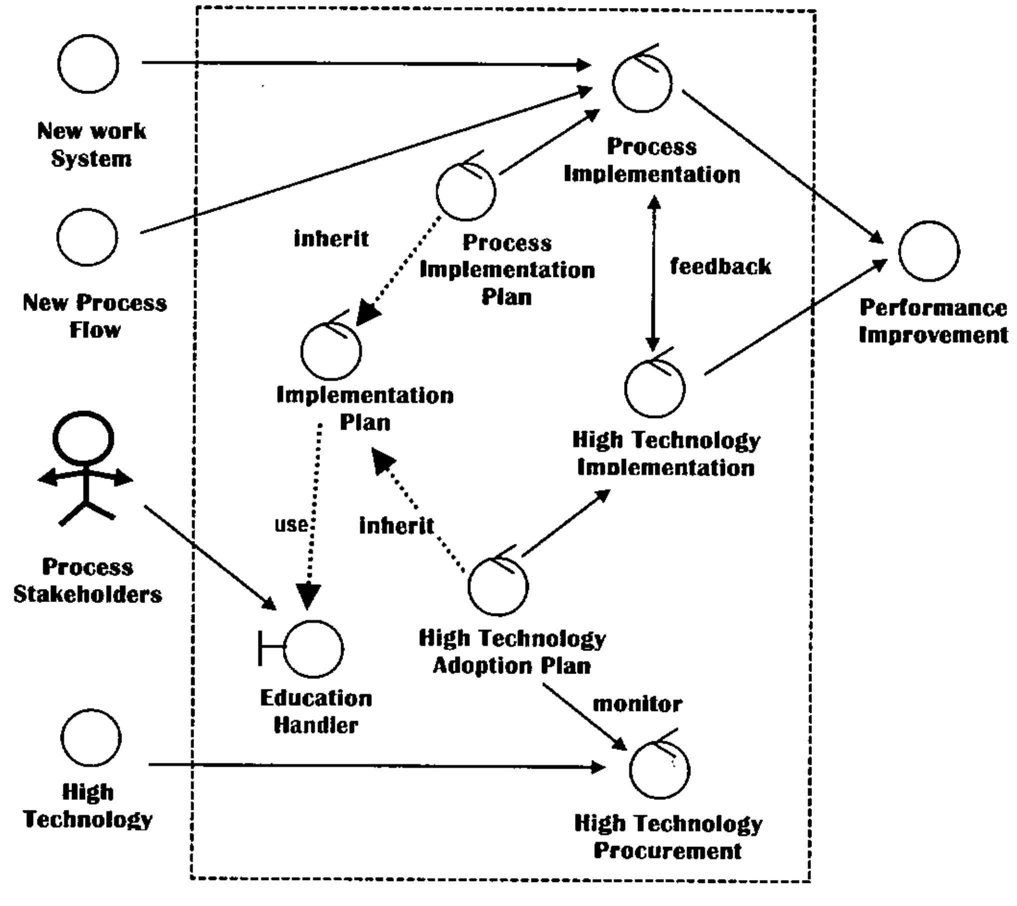

Figure 3-12 Process & High Technology Implementation Use Case

In the planning stage, Education Handler is a very important interface object. In the case of Pacific Bell [80], the roll-out plan of implementation its redesigned provisioning process for each regional office was convened to each regional office. The management and local union leadership in each regional office had to understand and agree to the proposed positions before they could be institutionalised. Each region then went through an abbreviated design process where it chose those components of the corporate Centrex design which addressed its needs. Consequently, the Centrex reengineering project did not meet the initial performance targets and ran out of the original schedule. However, the reengineering process did rolled out in an evolutionary manner and the new process was further refined to better suit the needs of stakeholders.

In the implementation stage, both process and high technology can be implemented simultaneously. In the case of Schlage Lock Company, the reengineering team began simultaneous efforts to reorganise the manufacturing process based on the implementation of the new information system when all the process analysis and design completed and the communication technological platform selected. The foundation of the change in manufacturing was reorganising from a line-work to a production cell orientation and retraining employees. Melteff, the company's director of human resources, believed the company's single greatest mistake was in not recognising that people have an emotional attachment to their jobs, including to the way that job is done. A change in procedure is easily perceived as a threat.

Therefore, top management is reluctant to place the complete organisation in turmoil by implementing radical change through all parts of the organisation at once in most organisations. To reduce the resistance of top management, the implementation process should be contingent to sustain motivation for change. Implementing new process in one part of the organisation can win higher acceptance of the top management. Also, the change will be better managed when it is performed in a controllable scale.

The time span of implementation is crucial as well. If the organisation, for example, has a cash flow problem, then more stringent short-term action is indicated. While a longer-term approach calls for a well-crafted plan, dramatic short-term improvements at the same time as developing new organisational arrangements to support long-term growth will be more feasible in an urgent situation. Therefore, what proved particularly important is the choice to relegate the development and implementation of high technology to a support role. High technology will be acquired and implemented well after processes have been reengineered, and while the working arrangements are being refined. Rolling out the high technology in an incremental and prototyping approach and carefully eliciting the different technology requirements of each group will manage the risk of subverting adoption. In the later case, implementation use case will trigger High Technology Study to search for appropriate technology.

In the case of Amsterdam Municipal Police Force [81], for example, it has reengineered its crime tackling process and altered the responsibility of police chef. Previously, the chef was taken up by day-to-day operational problems and human resources management. Then, he should be able to organise the work as projects, raise funds for the projects and evaluate impact of projects on the performance. Therefore, project management tools were developed to support the new control mechanism.

3.3.6 High Technology Study

This use case supports the linking of technology information to business information (section 2.2.2). Mainly, the linkage is established when capability of high technology is assessed to envision creative process design. It begins with capturing the knowledge embedded in high technology (Event object of Knowledge Capture Handler in (Figure 3-13) by studying the assumptions based on which the technology is developed. The functions of the high technologies are better understood when their underlying assumptions are applied in the target process being studied. Not only will this process make it possible for the company to match generic applications of high technology to the requirements of the new process, but also give birth to creative ideas of new process design. In this case it initiates Creative Design Idea Generation Handler and updates the entity of Process Design Principle.

Technology Assessment will proceed to evaluate and to project on the impact that the high technology may have on process and business performance. Feasibility of high technology implementation is also computed and the results are documented in the entity object of Feasibility Study. A list of feasible high technologies and process alternatives will be generated and documented.

This strategy of linking technology information with business information is proved to be feasible and effective by Hallmark's case [58]. Hallmark decided to improve the flow of sales data from the Hallmark speciality stores to corporate headquarters. They outfitted 250 of the independently owned Hallmark stores which computerised point-of-sales systems that use bar-codes to capture detailed information on every purchase.

First, the retail data was used to graphically interpret trends in the stores. Knowing exactly what sold yesterday, where it sold, what it sold with, what part of the day it sold, and what display it came out of will make dramatic and exciting changes in their business. Having applied the knowledge of Point-of-Sales systems, Hallmark began to capture such knowledge.

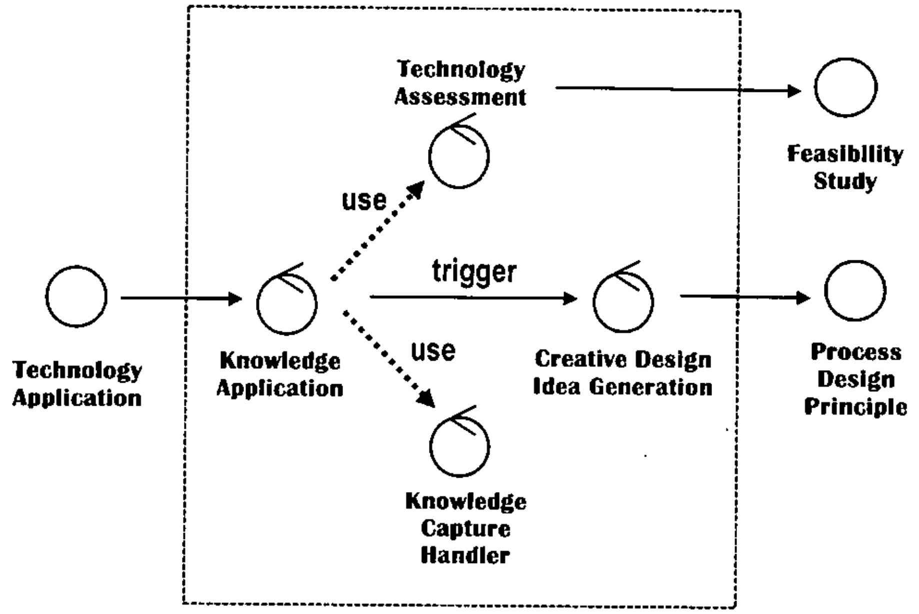

Figure 3-13 Objects that participate in High Technology Study Use Case

"The ability to track the effectiveness of a store layout or advertising campaign more precisely and quickly will reshape the way we merchandise and market." Gradually, Hallmark realised that they can change the process of designing store layout and advertising campaign using the point-of-sales system. Therefore, understanding the capabilities of IT may leave or open up a whole lot of feasible alternatives of improving the processes. This case implies that technology information gives sense when the high technology is assessed from an operational point of view.

CHAPTER 4

OBJECT ORIENTED BPR MODEL: A CASE STUDY

4.1 SYMNOPSIS OF THE CASE

4.1.1 Background of the Case Company

The case company is a small medium enterprise in Hong Kong, named as Company C. Company C was established in 1974 as an Original Equipment Manufacturer of home appliances. It develops leading edge products that keeps the company on top of the market. These products include the world's first cordless electric iron, and the world's first patented scissors-action sandwich toaster.

Its impressive product portfolio covers both cooking and food preparation appliances from simple hand mixers and grills to complex bread makers and premium stand mixers. It's strength and technology lies behind a considerable range of the world's most famous brand name appliances. The Engineering Department develops over 40 models of products every year. More than 25 million products are manufactured and shipped to Middle East, Europe, Australia and US. Annual sales turnover is over HK$800 millions. Over 1000 production workers work in production facilities in China.

4.1.2 Stimuli for Change

Company C's history of high technology adoption revealed insights into its stimuli for change. During the period of 1994 to 1996, it invested in computer-based tools to automate its operation with an objective of maximising work efficiency. For example, an integrated CAD/CAM environment supported by regenerative database with design rules was developed to shorten its product development life cycle. There were isolated benefits such as higher utilisation of their CNC machines. However, breakthrough improvement has yet to come through in the area of reducing the time required to get new products from concept to prototype development and testing. Company C has learnt that its competitiveness relied on strong capability in making technology investment decisions.

4.1.2 Preparation for Change

The BPR model illustrated in Chapter Three was introduced to the top management of Company C as a well thought out method for high technology assessment. After four sessions of briefing they were convinced that the model yielded certain merit in the area of analysing operational efficiency and corporate requirements for technology investment. They agreed to initiate a pilot project of process reengineering. The BPR model was used as an aid to assist the staff in the process of operation analysis and technology assessment. The reengineering project went through four distinctive stages of development evidenced by strategy formulation (section 4.2), business analysis and process design(section 4.3), process redesign (section 4.4), and process implementation (section 4.5).

4.2 THE STRATEGY FORMULATION

The top management was the first group of organisational members being encouraged to apply the BPR model in making strategic decision. To make it easy and convenient for the top management to use the BPR model, the method illustrated in Formulation Strategy Use Case (section 3.3.1) was transformed into a conference agenda to be used in the management meeting.

In the meetings the requirements of Product Customer (Figure 3-8) was discussed to generated critical success factors as predicted by the BPR model in section 3.3.1. The results obtained the telephone interviews of four major customers was presented and reviewed. The four customers had development contracts with Company C that worth 70% of total revenue. Fax, memo, letters and meeting reports were studied to identify customer complaints and dissatisfaction.

Customer requirements were used as a sole basis for determining strategic goals (section 4.2.1) and improvement targets (section 4.2.2). The top management did not discussed the staff requirements for operational management as suggested in the BPR model (section 3.3.1). It was not a custom in the company for top management to consult employee on strategic issues.

4.2.1 Formulation of Strategic Plan

Company C's business strategies were discussed in three meetings among the member of the top management. Cost leadership was a major factor of competitiveness in original equipment manufacturing in Pacific region. Its core processes were the product development process, the production planning process and the material acquisition process. Critical Success Factors (CSFs) of these core processes were defined and evaluated (Figure 4-1). They were prioritised and on top the list were the rapid product development, accurate production planning and low inventory level. They were documented in the entity object of Company C' Strategic Plan.

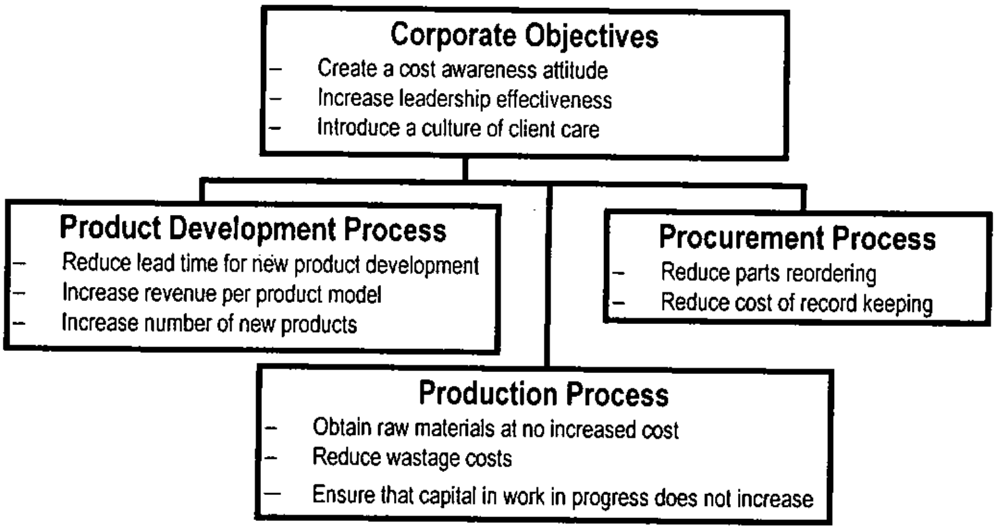

Figure 4-1 Critical Success Factors of Company C's Core Processes

4.2.2 Definition of Project Scope and Objectives

As deduced from the model presented in chapter 3, the top management proceeded to formulate the master plan of reengineering basing on the strategic plan. The exercises were also constructive in preliminary definition of goals and scope of the project. To increase the manageability of the reengineering project, three success factors were selected from the set presented in Figure 4-1 as improvement targets. They were rapid product development, accurate production planning and low inventory level. Using an evaluation matrix that mapped the relevance of the three factors to the corporate goals, the top management determined that rapid product development gave highest customer value.

Based on the information provided in the minutes of sales meeting with customers, customer requirement on product delivery lead time was compared with current lead time performance of product delivery. The result of the evaluation suggested that product delivery cycle time should be reduced by 20%. Also, the top management reviewed and discussed a few success stories about household appliance and cooking utensil manufacturers, and their achievement in inventory management. The top management concluded that a pilot project with an objective of reducing inventory would be beneficial. Since an incremental approach was preferred in the area of improving the inventory management method, the second objective was to reduce inventory by 5%.

In this way measurable reengineering goals were determined. According to the model, the project goals were later assessed in the phase of process analysis and process design (referring to section 4.2). Hence, the new process was linked to the improvement objectives. The scope of the project was limited to the engineering function and the product development process became the target of reengineering.

To provide a scope of implementation, the team selected one representative production to investigate. Steamed iron (model number SI-13) was selected because Company C has accumulated considerable experience and knowledge on building this model. Therefore, the process was rather stable in its course of development. It increased the chance to succeed as the results of process study, measurement, and analysis were stable.

4.3 THE BUSINESS ANALYSIS AND PROCESS DESIGN

4.3.1 Organisation of a Reengineering Team

The reengineering project was assigned to the head of engineering department, who was supposed to assist the team in organisational studies. The head of engineering was the project leader with two engineers to assist him. One of the engineers developed the steamed iron and provided the team with process data in great details for example, number of steps in the process, duration of each step and the number of reworks.

4.3.2 Process Study and Process Measurement

The Process Study and Measurement use case illustrated in section 4.3.2 was performed. As deduced from the model, internal assessment of performance was conducted first. A summary of results is provided in Table 4-1. To increase the reliability of measurement results, the samples of process performance included 15 development projects. These 15 projects were accounted for 32 models of home appliances. As product development performance was correlated with project scope and management practices [82], data of lead-time performance, product strategy and project scope, and method of functional integration were collected.

According to the model, process data has to be collected from process users and owners, and from relevant transaction documents (Figure 3-9). Data were collected by reviewing corresponding project schedules, product specifications, work orders, engineering drawings and Bill of Materials. They were kept in files sorted by project code. Project files were kept by 23 engineers and no central storage was found for the project information of the last two years. To improve the speed and efficiency of data collection, a standard worksheet with closed end questions was designed as a guide of data collection therefore. 15 worksheets were completed. Each worksheet contained information of one single project of one product type. Each product type had 2 to 3 product models. Worksheet and detailed results are presented in Appendix I and II for references. A summary of the results is shown in Table 4-1.

Development Performance	**July 1995 - June 1996**
Total Number of Development Projects	15
Total Number of Successful Projects	12
Total Number of Unsuccessful Projects	3
Lead Time Performance	
Average Cycle Time of Development Process	7 ½ months
Maximum Cycle Process Time	17 months
Minimum Cycle Process Time	3 months
Number of Parts	
Average Total Number of Parts Used	77.75
Percentage of Unique Parts Used	38%
Percentage of Carried over Parts Used	41%
Percentage of Common Parts Used	18%

Table 4-1 Summary of Performance Data of Product Development Process

The results were documented and analysed. The general manager, the engineering manager and the engineers were comfortable with the existing level of performance. They did not recognise the need for radical change because the performance gap was not significant.

To obtain an objective view of the performance gap, the measurement results were used to benchmark against competitors' performance. Hence, external assessment occurred according to the prediction of the model. The second objective of this benchmarking study was to explore methods of reducing cycle time for product development. Thus the benchmarking study was designed to assess the lead time performance, product strategy and management practices of benchmarking companies. However, local competitors were not listed and data of business performance was not available to public. This constraint was overcome by selecting international examples as recommended in Process Measurement use case.

As success stories concerning with electric appliance manufacturers were very limited, the team was encouraged to widen the net to look for world class best practice. Data were drawn from two benchmarking studies that included over 45 international manufacturing corporations [83, 84]. They were manufacturers of automobiles, electric household appliances and electronics. Numerical measures were used to assess the impact of characteristics of their product development process in terms of their performance, products and management practice. Minitab's two sample t test routine was used to assess the significance of the differences [84]. The most valuable insight was gained in assessing the process characteristics of the benchmarking companies and that of Company C (Table 4-2).

Features	**Company C**	**World Class Manufacturers**
Focus	Built product to Cost and Safety	Built product to Functionality & Cost
Organisation	Single Engineer was involved while supporting personnel are organised in functional departments	A team of engineers and supporting personnel was organised around a project
Sequence	Execute tasks sequentially	Execute tasks concurrently
Partnerships	Not involved production and tool development partners in product design	Involved production partners in product design
Customer Voice	No end-user inputs for product design	Monitor customer inputs before design & development

Table 4-2 Product Development Process Benchmark

4.3.2.1 Benchmarking Performance and Perception of Client/Server Technology

After it has compared their performance (Table 4-1) with that of the world class manufacturers, they were sceptical about the results and found the target were not achievable. The team members have made comments like "We do not make automobile, we only make coffee makers." Although they did not think radical change was necessary, they did recognise that radical improvement was possible. Just that they did not have the means to achieve radical improvement. Their perception of client/server technology began to improve in the sense that they started to envision the tremendous relative advantage of high technology.

4.3.3 Analysis of Product Development Process

According to the model, process model has to be built before process measurement is conducted. In the case study, however, process model was not built until the process measurement completed. To build a detailed process model, the team had to collect information of each process step and trace the process flow. Process walk through might be performed to collect the information. As it would cause a great deal of disturbance to the operation, it would not be allowed until the management realised the need for change.

4.3.3.1 Definition of Process Boundary and Sub-processes

In section 5.2.1, the top management has defined the core processes. Based on this broad overview of core processes, the team further narrowed the scope of product development process. Files and documents used by SI-13 were catalogued and classified as input, throughput and output. The classification was determined basing on the general concept that the engineers had for the definition of sub-processes. The product development process consisted of five major activities namely concept generation, product engineering, tool development, parts and material acquisition, and production engineering. Their boundaries are presented in Table 4-3.

Activity	*Input*	*Transformation*	*Output*
Concept generation	product specifications	review product specifications with customer	preliminary design
Product engineering	preliminary design marketing samples	conduct functional and design analysis	functional design
Tool development	part drawings mould specifications	manufacture the tool	finished mould
Parts & Material Acquisition	Bill of material cost of materials	formulate production plan, compute production quantity, process orders	parts materials
Production engineering	product structure, finished mould	design assembly, processes	assembly process

Table 4-3 Delineation of Process Boundary

The engineering department was involved in concept generation and product engineering. It collaborated with Tooling department, PMC department and Production in the last three processes mentioned in Table 4-3. Hence, the process study was further limited to a manageable scope of concept generation and product engineering.

4.3.3.2 Building Product Development Process Model

The team proceeded to build a concrete understanding of the concept generation and product engineering sub-processes. It demanded great level of details about the tasks, the number of tasks and the duration of tasks. Therefore, life data was collected along with the study of files and documents. A structured worksheet was designed. The engineer handling SI-13 was asked to fill in the worksheet (Appendix III) once a week with the description and the date of tasks in ascending order of their occurrence. To avoid missing the steps, direct observation of the process was carried out twice a week.

IDEF was used to build the model of concept generation and product engineering processes. Six levels of decomposition were used to clearly define the hierarchy of tasks, sub-tasks, and sub-sub-tasks required to develop SI-13. Process maps with four levels of decomposition are presented in Appendix IV (Appendix V sites an example) for reference. To limit the disturbance made to the tooling department, PMC department and the production, process information was obtained through interviews.

As deduced from the Process and Problem Analysis use case in the model, the objective of the study was to develop a broad understanding of the related sub-processes to address basic problems. Hence, one representative was invited from each of these 3 departments. To build trust among the reengineering team and the representatives, the interview was structured in three parts. It started with questions asking for objective facts. Personal opinion was not solicited until third section of interview. Since the tooling department and the production were hostile to the PMC department, the representatives were interviewed separately and encouraged to speak up. As a result, nine sessions were held and each lasted about two hours.

In the first part, general questions about the activities of each department and the objectives of these activities were asked. In the second part, the representatives were asked for greater details of their activities described in part one. Also, they were encouraged to assess the relevance of the objectives. In the third part, they were asked of their perceived problems encountered in fulfilling their responsibilities. To avoid their feeling of blame and embarrassment in the discussion of problems, the interviews were not tape-recorded. The results were documented as transcripts for future study. It was interesting to note that the tooling department and the production department were willing to provide a great amount of detail for their good relationships with the engineering department.

This exercise assisted the team in establishing an objective view of the role and responsibilities of their working partners. It increased their understanding of the constraints faced by their partners. It also increased the team's understanding of the mechanism of the complete product development process. The team began to perceive it as a network of interrelated processes with the operation of one process triggers that of other related processes.

Therefore, development lead time was not a simple function of the number of unit tasks and their duration. It was because the organisation of tasks and the organisational structure also affected lead-time. In fact, the elapsed time was affected by the way in which the unit tasks were interrelated. It enhanced the reliability of problem definition. Also, the team was able to trace their roots causes in section 5.3.3.4. It was because the team was not studying the engineering department in isolation. By tracing the transformation of SI-13's product specifications to its development of engineering drawings and to its die cast mould development, the errors of mould design were accounted by errors in the product design which was caused by insufficient understanding of customer's requirements.

4.3.3.3 Process Analysis

When the flowcharts of procedures involved in the product engineering process was finished, the team proceeded to perform the Process and Problem analysis use case (section 3.3.3). According to the model, the team relied on value-added flow analysis to diagnose the process. With the detailed process map constructed in section 4.3.3.2, the team performed a value-added flow analysis to identify strengths and weaknesses of the development process. In forming a value-added concept, the team agreed to define the value basing on customer requirements.

Referring to the customer requirements obtained in section 4.2, the team established the value that was perceived by them as the acceptable level of performance in lead-time, cost, responsiveness and robustness of design. As the product engineering process and the development process as a whole did not involve customers' participation, the team proceeded to link customer values to the throughput created by internal processes. The customer values were used to assess the quality of throughput.

The team found it easy to determine waiting time as non-value added. However, the team members disputed over the concept that checking, recording, testing as non-value adding. For example, product drawings produced by engineers were checked and approved by senior engineers, project manager, and the department head for each revision made. The engineers regarded this process valuable in reducing design errors. They thought there were no better alternatives for producing robust design.

To broaden the concept of non-value adding time for a bigger scope of improvement, the team was encouraged to challenge their long established assumptions about maintaining accountability and performance control. The product development process was a highly structured with clearly defined phases; they were concept generation, product engineering, preparation for production, production engineering and production. Each phase was characterised by the need for formal approval from customers and top management to proceed as milestone of that phase. The team assessed the pros and cons of control and its impact on long lead-time.

To avoid sensitive discussion on the value of middle management's control over the design quality, the team turned to challenge the value of customer's formal approval of design revisions. The first reason was that it increased the waiting time involved in developing the SI-13. Since the steamed iron has been well developed in Company C, the customer endorsed their approval all the way through the development process. However, each approval took four to five days to be processed. An alternative would replace this mechanism for greater customer services. For example, the engineers might update the customer with progress of development or maintain direct contact with the product designers in product study.

Although this exercise did not succeed in broadening the concept of non-adding value, the team began to realise that it was important to link customer value to the assessment of their work. The team proceeded to compute the significant waiting time. They referred to the issue date of each document and the receipt date of its reply. Not all the documents were reviewed. The team drew the project schedule of SI-13 and identified the critical path of process. It was determined that the detail design, tooling development, assembly design and pilot production lied on the critical path. Therefore, the throughputs of these four processes were assessed. The critical path analysis is presented in Appendix VI.

Finally, the waiting time was calculated as 23% of the total development lead-time. It was an optimistic figure since a higher percentage would be obtained if the team broadened its scope of non-value adding time. Therefore, the objective of the reengineering project was further refined to reducing 20% of the total cycle time for product engineering.

4.3.3.4 Problem Analysis

After the development process had been scrutinised, the team proceeded to identify and analyse the problem and determine their root causes. Problems were identified by measuring the frequency of quality problems occurring in the development process of SI-13. Quality problems were measured by the number of rework, error correction, inspection, and checking. It was agreed that quality problem wasted time and lead to non-value adding activities to rework or correct the defects and errors. The team proceeded to identify the likely types of defects or errors so that data could be collected in categories suitable for analysis.

The team found it difficult to establish the definition of errors and reworks. Based on the Critical Path Analysis, the team found that significant waiting time was incurred in the tooling development process. The waiting time was attributed to the errors in the tool design and in the development of the tools. These errors generated various needs for design revisions (engineering changes). Changes were made in the tool design and also the selection of parts and materials. The team found it unacceptable to establish engineering changes as reworks. On the contrary, design revision was the most essential part of their job for improving quality of their products.

The team was encouraged to challenge this assumption by performing problem analysis. Fishbone analysis (Figure 4-1) was performed to assist the team in problem conceptualisation. The team tried to determine the causes for design revision. They were product strategy, project scope, specialisation, method of integration, and information processing capacity of the company. The team realised that the major reason for design revisions was not their lack of expertise in product engineering. The causes found their roots in the long established business rules and traditions. Hence, it has to be added to the model that the selection of problem solving tools might have impact on increasing the objectivity in problem definition.

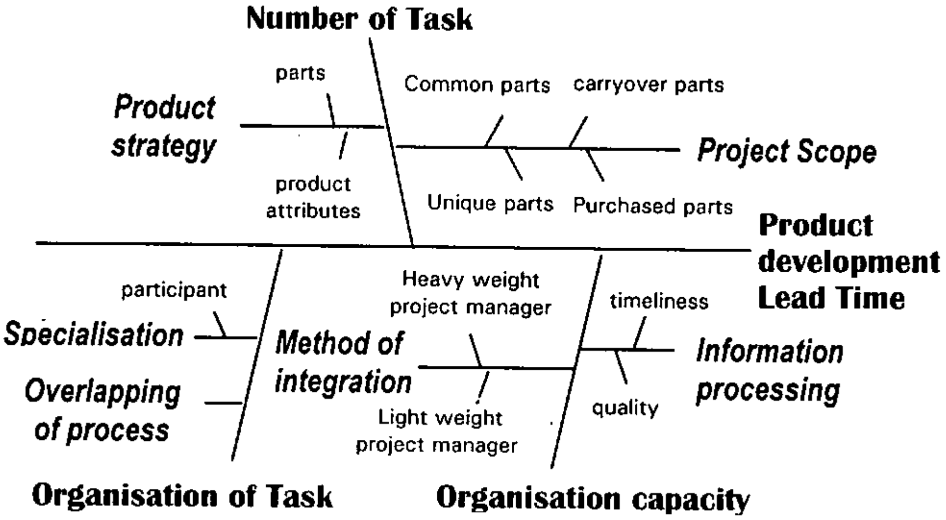

Figure 4-2 Cause and Effect Analysis for Conceptualisation of Problems

For example, the rule concerning the organisation of tasks was assessed. SI-13 underwent sequential phases of development, through which SI-13 was defined, engineered, transferred to manufacturing plant, and shipped to the customers. Activities of these sequential phases were loosely linked with infrequent iteration among upstream and downstream activities. For example, the engineer communicated with the plastic mould developer at a single point of time. It was initiated when the product drawings were roughly completed and the tooling orders were issued to the mould maker. Errors in moulds occurred frequently and it led Company C to continuously rely on the same mould maker.

Finally, the team was comfortable with the new definition of design revisions. The engineering changes were categorised and measured. The objective of the design was determined as reducing the number of engineering changes in the tool development phase.

4.3.3.5 Process Design

Basing on the roots causes examined in the previous section, the team conducted brainstorming sessions to create ideas for the new process. Solutions were recommended to reduce the number of design revisions. They were briefly presented in Table 4-4.

Root Causes	**Suggested Solutions**
Project Scope	• increase ratio of common parts used by each product type • increase use of carryover parts • reduce ratio of unique parts used by single product type
Specialisation	• increase specialisation • increase division of labour in product engineering • separate drafting product drawings from designing product
Overlapping of tasks	• increase overlapping of sub-tasks • conduct prototyping and designing concurrently
Method of Integration	• increase integration of collaborating departments • increase communication between departments
Information Processing	• increase information processing efficiency • redesign document format • establish proper channel of information transfer

Table 4-4 Table of Suggested Process Design Ideas

The challenge of process design lied in narrowing down the options listed in the above table. As deduced from the model, the design options have to be consolidated and validated. The team proceeded to validate their impact on business objectives and examine the incompatibilities among the options. The reengineering team acquired technology knowledge and built an understanding of technology capabilities on changing the workflow of the product engineering process. It involved streamlining information processing in the product engineering process, and then evaluating computer applications to determine which ones best support the options. It studied the capability of CAD/CAM in supporting their options. The high technology study did not occur before the design phase as expected in the model. The case company did not use it to envision new process design approach. They used it to consider and select technologies that best support their design ideas.

Finally, 3 recommendations were proposed and discussed. The first recommendation was centred on a flat structure of organisation. It was suggested that the engineers and the project manager should be empowered. Hence they would make decision concerning operations and budget. However, when it was validated using the worksheet [85] given at Figure 4-3, the team anticipated resistance from top management because it would reduce top management's control over the operation. Its feasibility reduced tremendously.

The second and third recommendations were assessed. The second recommendation aimed at increasing communication between the engineering department and the PMC department and the production. The third one concerned increasing design efficiency and quality. The team accepted the third one because the proposed change would be confined in the Engineering department and therefore the project would be more controllable and manageable.

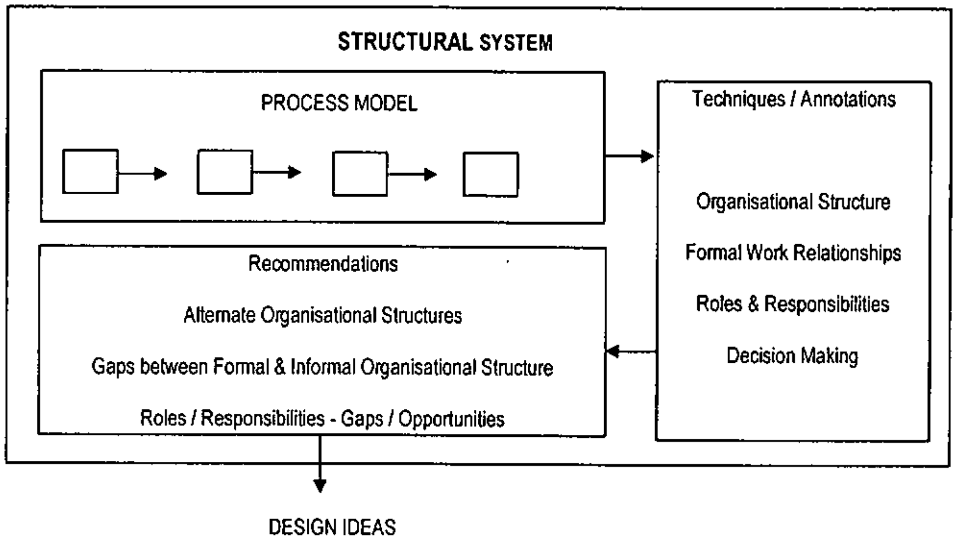

Figure 4-3 Example of Worksheets Used in Brainstorming Design Ideas

4.3.4 Proposal of High Technology Adoption

Report on feasibility study of the alternatives was written and sent to the head of engineering. He forwarded the proposal to the general manager for approval. Evaluation sessions were held by the team to present the report to the general manager. In the report, an electronic inventory database was proposed. This recommendation was made to attack one major cause of engineering change: to reduce the project scope by increasing the ratio of common parts. It would allow engineers to access the data of parts and materials in the inventory. It would therefore assist them in making decisions in parts design and product engineering.

Successful implementation of the electronic inventory database called for changes in the habits of the engineers. This generic model of business process reengineering has created space and environment for the fit between the new technology and the new habits by implementing a few changes in the process. Before they would make decisions on selecting parts and materials, they were required by the new process to search for components with holding period that exceeded two years. They were encouraged to use the components that had not been used for a long time.

The impact is threefold. First, it would increase the ratio of common parts used by different products and therefore reduce the ratio of unique parts. Increase the use of common parts would reduce the time invested in design new parts. Eliminating acquisition procedure for sample parts and the associated waiting time would reduce the Cycle time of product development. Secondly, the holding cost of inventory would decrease and the cost of reordering reduced when the slot size of common parts required expanded. Thirdly, human resources that were required to handle sample parts acquisition and parts reordering would be reduced as well. The proposal was accepted but the general manager considered it was not a right time as there was no slack resource available to implement the new process and to develop the database.

4.4 PROCESS RE-DESIGN

4.4.1 A New Team Leader

In late 1996, a new manager was hired as the key account manager who supervised and co-ordinated the activities of all the related departments for successful product delivery [86]. It was seen as a major attempt in restructuring middle management because it added an additional line of authority. The former department head reported to the new key account manager. The key account manager was appointed as the champion of the reengineering project. The process study and the process analysis use case illustrated in section 4.3.2 and 4.3.3 were rerun.

4.4.2 Change in Project Scope

As the steamed iron project has already been completed, another model has been chosen for study. Toast & Grill (TG275) was selected based on similar reasons provided in section 4.3.1. The most significant implication of an additional line of authority was the expansion of scope of study. The scope of process study was extended to include Sales, PMC (Production and Material Control), tool development and production.

As the previous attempt of adoption was hardly successful, the team learnt that the high technology being proposed should be more substantial in its relative advantage. Therefore, the team was eager to involve stakeholders from the tooling, PMC department and the production in evaluation of relative advantages of high technology. Also, based on previous process study the team gained an objective view of the complete process. Their hostility towards the related departments reduced. They learnt that they should blame the system rather than the people. A wider scope of change was feasible when the project leader had greater power over all the departments.

The key account manager invited the tooling department, PMC department and the production to the reengineering projects. Their resistance to process improvement was assumed to be reduced by involving stakeholders in process design (section 4.3.2 & 4.3.3). However, this strategy was not successful because the stakeholders resisted to act on any issues relating to the reengineering project. The tooling department and the production politely declined the invitation whereas the PMC department refused with prolonging strategies. The key account manager turned to negotiate entry into their departments to collect process data for performance evaluation. The request was turned down abruptly by the three departments.

After several attempts of negotiation, the key account manager obtained entry successfully. Conditions of study were developed to reduce resistance on the part of the three departments. Comprehensive process study attempted in the section 5.3.3.2 was not carried out. The staffs handling the project TG275 were assigned to assist in the team's investigation. However, those staff would not fill out any study worksheets and direct observation of their work was not allowed. The departments were consent with group interviews. The details about the interviews such as the design of interview, questions to be asked and the duration of interviews were drafted and sent to the department heads for approval.

4.4.3 Re-collection of Process Data

The departments developed consensus of the design of process study. It would be carried out in group interviews. 5 sessions of interviews were conducted with each department. Each session lasted for two hours. Two representatives were invited from each department. For the first four sessions, the three departments were interviewed separately. Therefore, 12 sessions were held in total. In order to build a consensus of improvement strategy, all of the six representatives were invited to the final session in which they were encouraged to express their opinion about process improvements.

Due to the limited time span of process study, the objective of the study was to develop an in-depth understanding of the tool development, the parts procurement and the production processes. Based on the results obtained in section 4.3.3.2, the team refined their questions and drafted process maps for the tool development, the procurement and the production processes. Milestones of each process were determined and the representatives were asked of the approximate dates for the milestones. The data were used to validate their findings obtained in process study and analysis for project TG275.

In the third and fourth session, the representatives were asked to conceptualise on the problems they encountered in carrying out their job efficiently. They were asked to identify their root causes and attribute these causes to their own department and other departments. In the final session, representatives from the three departments were gather together to express their view of improvement strategies. They all agreed that they needed to improve their communications and to establish proper channel of information exchange. The results were documented as transcripts for future study.

4.4.4 Re-conceptualisation of Problems

Basing on the problem defined in the section 4.3.3.4, the team referred to the information obtained in the previous section to develop a broader concept of the problems. Besides project scope, overlapping of the product engineering process with tooling, procurement and production process and the method of integration of these processes were found to affect the total number of engineering changes significantly. They also impacted the responsiveness of the related departments in making adjustments to engineering changes. The team discussed operational tactics that would reduce reworks generated by these two causes. With a project leader having a wider span of control, the team was encouraged to envision organisational wide improvement.

After the Process and Problem Analysis use case (section 4.3.3) completed, major problems were found in the project management process. The area of improvement was confined in the project management process. The project management tasks were performed separately in different departments. The engineering department produced its schedule of product engineering and industrial engineering for TG275. The production department produced its production plan and schedule of delivery. These schedules hardly matched and they caused TG275's delivery to run out of schedules. Impact included high retooling costs, compression of production schedule and disturbance to production planning, and extra transport cost to compensate for late delivery.

The causes of the above phenomenon were diagnosed. High Technology Study use case (section 3.2.5) was performed after feasible ideas of process design had been envisioned. It varied from the generic model presented in Chapter 3. High technology that would support integration of related departments were examined. Three platforms were identified as meeting the criteria. IBM AS/400 using UNIX, Microcomputers using NT and Novell were assessed.

Besides the main computing platforms, the team studied Local Area Networks and Wide Areas Network technologies that would link the engineering, the buying office and the manufacturing and warehousing facilities to improve communication and integration. Potential solutions were recommended, discussed and consolidated by the team members. Alternative processes approach was developed and evaluated for their benefits and costs.

4.4.5. Assessment of New Proposal

In the Process Design use case (section 4.3.4), the team conducted a thorough analysis of developing a new project management process. It would mandate the organisation of cross-functional teams for each project. Feasibility study of new process implementation was performed. The major consideration in the process design was stakeholders' acceptance. Since they were consulted, they did not involve in process design. Their resistance to radical change was anticipated. Their reasons of resistance were well understood by the team, which frequently solicited their comments throughout the reengineering process.

However, the team had to balance their evaluation of client-server technology. When its impact on the PMC department, tooling department and the production was assessed, its perceived relative advantage was greatly enhanced. Therefore, the team decided to build a new project management process by introducing a small change to the process. Regular meetings were proposed to institutionalise the project management mechanism.

It would be commonly regarded as an acceptable change because no new skills were required of the process stakeholders.

A report was written to propose the adoption of client-server technology which would support efficient communication among related departments. It was presented to the general manager for assessment. Evaluation meetings were held by the team and the key account manager. These meetings were constructive in formulating a master plan for developing and implementing process innovation. Human resources and funding were granted.

4.5 THE IMPLEMENTATION AND EVALUATION PROCESS

4.5.1 The Reengineered Project Management Process

A new project management process has been developed and introduced as illustrated in the Process Implementation use case (section 3.3.5). The new project management process was executed with a new mechanism founded on innovating assumptions and business rules. The planning and managing development project schedules had been resided in the engineering department. The new mechanism invited the purchasing, engineering, tooling, quality assurance and production to jointly plan and manage the development projects.

4.5.2 Implementation of New Project Management Process

To ensure successful implementation, the implementation of new process and client/server technology was separated according to the recommendation of the model. The project of Stainless Steel TeaKettle (SK-10) was selected for implementation because it required only 3 or 4 months of development. The team needed not wait for a long time before performance data were collected for evaluation.

The new project management process has been implemented. Representatives of production, engineering, material planning and procurement and quality assurance departments were summoned to organise as a project team in product introduction stage. In the product introduction stage, foreseeable production queries were discussed; time-scales for buying materials and tools, for component production and for commencement of production were estimated. Parts lists were produced.

From week 3 onwards, regular meetings were held every Monday in Hong Kong. In these meetings the representative revisited the project schedule and assessed the progress. Documentation standard of product introduction schedule, engineering change approval and product history was introduced to assist the process of relevant information. Example of documents for project schedule management are presented in Appendix VII and those for engineering change management can be found in Appendix VIII for reference. To further reduce the requirement of new skills, the representatives were encouraged to fill in the standard documents that were later circulated around all the related departments for reference.

4.5.2.1 The Project Management Process of Stainless Steel Kettle (SK-10)

SK-10 was scheduled for delivery in 4 months. It was a decision made by all the related departments. PMC department received its product specification and primary parts list. PMC representative estimated that parts and materials would be delivered in month 3. As the product specifications included sketches of appearance design, the tooling department arrived at a preliminary estimation of schedule. It was updated with the progress of metal parts design in subsequent meetings. It provided suggestions to the design of metal parts and the engineers found the suggestions useful to enhance the quality of design and to maintain the problems of manufacturability in an acceptable level. The production included these information to its production planning and released SK-10's production plan once its Bill of Material was finalised.

This new mechanism also increased the responsiveness of various departments to product changes. For example, when sample testing of back handle moulding failed, the engineers consulted with the tooling department for improvement in age and rough usage. Also, for greater strength of the handle assembly, the design of parts was altered. When the engineer recommended to alter the parts of the cover (AKT5001), the ring (AKT5002), handle body (AKT5003), handle cover (AKT5004), terminal cover (AKT5005), button (AKT5011A) and the steam baffle (AKT5021), it was communicated to the PMC department, Tooling department and the Production department for feasibility analysis. The PMC department recommended using PP#6524 for these parts. PP#6524 would be supplied by Himont Inc.

4.5.3 Evaluation of New Process

With the encouraging results obtained in 4.5.2.1, the new process was implemented for all projects. Evaluation studies were conducted to assess the improvement of functional performance in three dimensions: responsiveness, accountability and dependability (Executive summary of evaluation results is present in Appendix IX). The impact of the new process on product development acceleration was limited for a number of reasons. The related departments were not accustomed to their new roles and responsibilities. It was also difficult to build consensus among the representatives. To maintain the momentum of change, the team decided to roll out the client-server technology in the next phase of implementation. The staffs were allowed to manage the change one at a time.

4.5.4 Implementation of Client/Server Technology

The new mechanism called for multidimensional changes in technical and social systems. The social systems were transformed as each department now shared new roles and responsibilities. The cross-functional team took the responsibilities for managing the project, controlling activities and co-ordinating them. A communication system supported by Client/ Server Technology running on NT platform was developed for storage and update of project information. Local Area Network was established to support interdepartmental communication and documentation. Wide Area Network was later installed to support instant and frequent communication between Hong Kong headquarters and the production in China.

4.5.5 Evaluation of Client/Server Technology

Process study and measurement were conducted using similar methods illustrated in previous sections. Detail results are presented in Appendix X. On operational level, the intensity of communication between departments increased. Number of projects with prolonged pilot run to debug the product reduced. In summary, the number of engineering change and reworks decreased in the tool development and pilot run stage.

On tactical level, the firm was able to strategically relocate its functions geographically. The PMC department was moved to the production facilities in China. Thus it maintained close contact with parts suppliers situated in China. It was able to access and to visit a greater population of suppliers with greater proximity in physical distance. Suppliers power diminished. Material cost of production was reduced further and cash flow improved.

It was achieved with the implementation of client/server technology in both sites. Therefore, Hong Kong operation and production facilities in China were connected via Wide Area Network. Product information and design revisions were input and updated at both sites. Instant communications between the two sites increased with the frequency of communications.

On strategic level, responsiveness to customer improved. Since project schedules were updated regularly, the key account manager obtained efficient access to product history and the progress of development. He was able to inform the customers of difficulties and discuss resolutions with them. When the customers had strong grasp of the progress, they were able to provide design input before the design was completed. The customers revealed that they generally felt greater control of the development process. It was possibly due to greater scrutiny of the development process.

CHAPTER 5

ANALYSIS OF OBSERVATION IN THE PRECEEDING CASE

5.1 THE CONTEXT OF HIGH TECHNOLOGY ADOPTION

With the successful implementation of the generic model for Business process reengineering in the case company, we now attempt to illustrate the factors associated with successful high technology diffusion. These three interrelated streams of discipline, innovation, operation management and management science literature, discuss many factors that influence an organisation's adoption of new technology. These factors include variables at the individual, organisational and environmental level of analysis.

We expect that these variables will become the main source of disturbance and uncertainty retarding the high technology adoption by either leading to a decision to reject an innovation or a initial adoption decision and later discontinuance. Illuminating the effect produced by these variables on the decision process will render us answers as how to protect and even adjust the decision process to promote an inclination to adopt.

5.1.1 Individual Level

Variables at the individual level include the adopters personal characteristics [87, 88], attitude towards changes [89] and personal perceptions about innovation [87, 88, 90] Innovation theory [8, 9] argues that subjective perceptions of individuals in an organisation emerge as collective perceptions that are useful in explaining and predicting innovation adoption. Many findings in the literature on innovation have shown a relationship between the perceptions and the adoption of high technology [9, 89, 91-94].

5.1.2 Organisational Level

Variables at the organisational level include size of the organisation [93], organisational slack [9], organisational structure [95, 96, Zaltman, 1973 #4, 97] and innovativeness of the organisation [9, 87, 98, 99]. Strong connections have been found between organisational structure and the adoption of innovations [51, 88, 96, 98, 100-102]. Organisational structure includes various dimensions as formalisation and centralisation [103]. Organisations with more explicitly established rules and procedures are expected to inhibit high technology adoption.

5.1.3 Environmental Level

Variables at the environmental level include organisational dependence [104-106], uncertainty [107], communication [8] and competitive environment generate conditions that organisations need to adopt to in order to survive [106, 108, 109]. Several authors feel that high levels of competition will increase the likelihood of adoption [110-112]. Other found, on the contrary, that low levels of competitions are required for high technology to diffuse at the faster possible rate [113].

5.2 ANALYSIS OF VARIABLES AT INDIVIDUAL LEVEL

The BPR model provided a less aggressive approach in collecting business information and therefore increased the levels of trust and confidence on the part of the engineers in sharing the business information. According to the case study, the engineers provided data on their work on a day to day basis. Later the data was used to develop the process model of product development process. The data the engineers provided were later used to perform the performance assessment. The reengineering team, suggested by the BPR model, did not inform the engineers the results of the performance assessment (section 4.3.2). The engineers has never been blamed for the existence of performance gap.

The process model and performance assessment results were used to help the reengineering team conceptualise performance problems. With the aid of the model, the team were able to attribute performance problems to the factors of product strategy, project scope, organisation of task and organisation capacity (section 4.3.3.4). Human factors such as individual motivation was not considered as a cause of performance problem. The engineers had more trust in sharing the information when they found out that the information was not used against them. Individual resistance to sharing of information reduced during the course of implementing the BPR model.

5.2.1. Resistance to Information Sharing

The engineering manager and the engineers were not willing to provided business information at the beginning of the reengineering project.

5.2.1.2 Resistance at the Middle Level of Organisation

Section 4.3 revealed that the middle management took an avoiding position in sharing information. He tried to postpone the process studies. He also turned down the team's request for collecting process data from the engineers. His attitude of change was probably affected by his solid experiences that did not give way to any innovation that was perceived as a challenge to his engineering skills and knowledge.

5.2.1.3 Resistance to Change at Operational Level of Organisation

The reasons for the engineers to refuse to share information were simple. Their schedule was packed and no slack time was available for communication with the reengineering team. Although they knew there was something wrong with the organisational structure and it needed revitalising, they found it impossible to alter the policy that made up the structure. They also perceived that no high technology was capable of making that change.

5.2.2 *Individual Variables in the first cycle of reengineering*

5.2.2.1 Change Attitude of Top Management

After the process study and measurement has been completed (section 4.3), the resistance of top management was seen reducing. His change attitude was affected by his knowledge of performance gap. Never had any formal and organised effort of performance measurement been performed. For the first time he obtained an objective assessment of the cycle time and cost performance of the organisation. He began to envision a major change in the organisation. Due to the incomplete nature of the measurement data and analysis (referring to section 4.3), the general manager was not yet converted to an attitude favourable to change.

5.2.2.2 Change Attitude of Engineers

In the problem solving phase and the process design phase (section 4.3), the perception of engineers was changing. They were born as a problem solver and were using their problem solving skills during the product development process. They were skilful in formulating problems, applying new ideas and verifying their ideas. When they participated in the reengineering project, they found their engineering skills relevant and useful. Hence, they became interested in reengineering project.

Since they were encouraged to investigate in high technology and bring them to new uses, their role required interaction with others, to obtain ideas, support, approval, and resources for high technology adoption. They began to envision the new opportunities offered by high technology in solving organisational problems. Although they began to perceive the relative advantage of high technology, their resistance to change was not totally removed because their needs had yet been addressed. For example, the engineers were motivated by self-advancement in engineering skills and knowledge. The cost cutting culture was perceived as a major attempt in cutting their slack resources for research and development.

5.2.2.3 Change Attitude of Middle Management

The resistance of the project manager was strong throughout these two phases. Since the general manager insisted on a cost cutting nature of the reengineering project, the project goal was in conflict with the needs of the senior project manager. Frequently he was enable to raise sufficient financial and human resources to run his projects; the reengineering project would further deprive him of authority and human resources.

5.2.2.4 Effect of Resistance to Change on Problem Conceptualisation

Their resistance was observed in assessing the problems and alternative solutions. For example, in the process analysis and problem solving phases, the three types of stakeholders had perceived similar problems. However, their perception about the nature of the same problems differed. More precisely, the three parties all regarded the parts and material acquisition process problematic. The general manager considered frequent issuing of engineering changes as a source of creating unused inventory. The senior project manager considered he should be given higher authority to speed up the execution of parts acquisition requests. The engineers considered negotiating with related department for execution of their requests a waste of labour. Their different perceptions made the tasks of prioritising problems difficult.

5.2.3 Individual Variables in the second cycle of reengineering

5.2.3.1 Middle Management's Perception

The general manager remained sceptical of adoption of high technology and the reengineering team failed to come up with a satisfactory solution in the first cycle of reengineering. Referring to section 4.4, resistance of the middle management was removed because the project manager stepped down from his leadership role in the project. The key account manager took up this role. He perceived his roles as one of articulating changes to envision performance improvement. An attitude that favoured change was witnessed in key account manager's attempt to obtain support, to influence the power structure and to seek out problems as opposed to waiting for them to be pointed out by others.

5.2.3.1 Effect of Lower Resistance on Conceptualisation of Problem & Solution

An open management style was implemented. It reduced the resistance of the engineers. This open style was implemented with being empathic with the problems faced by the engineers and assisting them in problem solving tasks. As research and development was perceived by the middle management as the core competence of the company, the needs of the middle and the operational levels was well align. An important link was created to resolve the difference in the interests and aspiration shared by the top and the lower echelon.

Trust and consensus in the design team gradually developed during the problem solving and design phases of the second cycle of reengineering. The personal characteristic of a key player was proved to be influential in altering the change attitude and innovation perceptions of the stakeholders through open communication.

5.3 ANALYSIS OF VARIABLES AT ORGANISATIONAL LEVEL

The BPR model assisted the reengineering team in overcoming the weakness of Company C's organisational structure that negatively affected information sharing among the departments. The characteristics of Company C's organisational structure are the centralisation of authority, functional specialisation and formalisation of rules.

With the aid of the BPR model, the reengineering team managed to collect correct data that were related to the business processes of product development even when the company was highly informalised that evidence relating to work flow and performance was inadequately documented.

Further, the BPR model assisted the reengineering team in verifying their assumption of performance problems. They verified the possible impact of their proposed business solution by correctly linking their understanding of the business strategy, the product development process and the proposed solutions, as put forward by the BPR model (section 3.2.2.2). By verifying their assumptions and their proposed solution, the reengineering team learnt that its limited understanding on the business process (e.g. they limited their scope of process study to the product development process) caused them to make sub-optimal decision in proposing performance improvement. They were encouraged to communicate with the production and the purchasing department (e.g the team expanded their scope of process study to these departments, section 4.4.2 and 4.4.3). Communication network connecting the engineering department, the production and the purchasing department began to emerge.

5.3.1 Organisational Structure

The variables of organisational structure affected the results in process study and measurement (section 4.3).

5.3.1.1 Centralisation of authority

Company C exhibited the characteristics of a centralised structure. The general manager's span of control of was far and wide. Decisions that concerned human resources, budgeting and costing, marketing and operations management rested with the general manager. Concentrated power arrangements prevent imaginative solutions to problems [102].

Although centralised decision making has been found not significantly related to the acceptance of innovation [114], it did affect the creation of new ideas for process innovation. Adoption of high technology required the approval of the general manager who was busy and impatient for the evaluation. Only a new process that is simple, easy to understand, and have multi-dimensional impacts on organisational efficiency would be approved. During the preliminary discussions of feasible solutions in the process analysis phase, the design team put more emphasis on validating the feasibility of alternatives than exploring new possibilities.

5.3.1.2 Functional Specialisation

Functional specialisation adversely affected the breadth and the depth of the process study and measurement. Performance data could not be successfully obtained to measure the complete product development process. The related functions that supported the development process treasured jurisdiction of their own and forestalled any interference with its daily operation. Investigation in their tasks was further prohibited to prevent their performance gap being revealed. For example, the sales data could not be collected for benchmarking against the performance of its competitors.

Without a thorough study of all the related processes, the reengineering team failed in envisioning a high technology that would satisfy the diversified interests in the organisation. Also, it greatly reduced the number of new ideas to be created in the design process.

5.3.1.3 Formalization of Rules

The informalised structure of Company C further inhabited process study and measurement. Documentation was far less formalised in its content than its storage and collection of hard data was hopeless. Thus, performance measurement in cycle time, cost, quality and customer satisfaction could not be achieved satisfactorily. For example, the lead time performance of the development process could still be determined by making reference to work orders and incomplete project schedule. Efficiency in other dimensions, however, could hardly be measured. The number of sample parts orders, mould revising orders, and engineering change request could not be decided.

Without a precise measurement of existing performance, the magnitude of feasible improvement could not be estimated correctly. Furthermore, it brought about an optimistic performance figure and new ideas for a radical solution might not be necessary.

5.3.2 Organisational Variables in the first cycle of reengineering

5.3.2.1 Diversity of Reengineering Team and Perception of High Technology

Reengineering process considerably increased the diversity of the organisation in a number of aspects. It explained the results presented in section 4.3. The diversity of the organisation has considerable impact on the probability that members will conceive of major innovations. The case study firm had a capacity for gathering and evaluating information about innovations. The professional specialities most crucial to the firm's adoption policies would be engineers and managers in engineering and production.

5.3.2.2 Intensity of Organisational Communication

However, this pool of professional specialities did not function effectively to bring about adoption of high technology. Previously, an elaborate set of communication networks among the process stakeholders did not exist. There was a hierarchical structure of communication to support the centralised network of control. The lower echelon of process stakeholders reported to the upper ranks of the organisational hierarchy. Although the communication was frequent and informal, information was filtered and the communication was instrumental.

5.3.2.3 Communication Network and Intensity of Communication

In the process analysis phase, a more elaborate communication network developed when representatives of stakeholders were gathered to recognise essential performance problems to identify their sources. The reengineering project created a committee (the reengineering team) which held regular meetings for fertilisation of ideas. The number of scheduled meeting per month increased and so with the intensity of scheduled communication. It permitted the proliferation of the amount and the diversity of input of ideas for adoption of high technology. For example, lateral communication was increased among the engineers. They discussed more frequently than ever with their peers the organisational problems. Communication among the higher and lower levels became more frequent and formal.

5.3.2.4 Intensity of Market Communication and Diversity of Organisation

The reengineering process also increased the diversity of new ideas emerged in the organisation. Benchmarking against best practice of market leaders increased the number of reference groups outside the organisations. Since neither did the team members affiliate with any professional body nor participate in extra-organisational professional, benchmarking assisted the team in perceiving relevant innovations. Essentially, the team discovered innovative use of high technologies that they had never perceived.

5.3.2.5 Effect of Diversity on Assessment of High Technology

Furthermore, by revisiting the strategy and the competitive environment, the team obtained a strong grasp of the diversity of the market. There was increasing concern with the possibility that process innovations might open the way to new services and markets. When process innovations were used as a means of generating new services or marketing alternatives, they were evaluated from a wider profit perspective.

Although the level of resistance was reducing among the three ranks of representatives, resistance of other departments still existed. Member of the reengineering team looked after their own interest and therefore they had different beliefs in the conceptualisation of problem and solution. The occupational perspectives and information sources for major innovation to be envisioned were limited. The high technology that proposed by the reengineering team had little implications for the functions outside the engineering department. Eventually, process innovations were evaluated from a limited profit perspective.

5.3.3 Organisational Variables in the second cycle of reengineering

5.3.3.1 Communication Network and Diversity of Organisation

The diversity of the sources of input to the process design was seen on the increase. It explained the results presented in section 4.4. The key account manager was recruited to the reengineering team and became the project leader eventually. With a project champion who at the same time commanded the resources of all the departments and represented the diversified interests of them, a critical communication link between the reengineering team and all the related departments was established. The diversity of specialists who participated in the reengineering process increased. It promoted the generation of large set of innovative ideas.

5.3.3.2 Effect of Increased Diversity on Assessment of High Technology

With the development of an organisational pattern that increased flexibility and opens lines of communication in the first cycle of reengineering, the impact of the diversity of specialists was more profound. The impact is two-fold. Firstly, it promoted a wider variety of occupational perspectives and information sources to be involved. Secondly, capacity for gathering and evaluating information about innovations greatly increased.

Because of large overheads, equipment performance was measured in terms of capacity utilised rather than in terms of benefits returned. The value of high technology under evaluation considerably enhanced as it achieved improvement in all the related functions of the company. It also reduced the resistance of the related department in the creation and acceptance of the high technology being proposed.

5.4 ANALYSIS OF VARIABLES AT ENVIRONMENTAL LEVEL

The BPR model drove the company to adopt a more outward looking mentality in establishing the linkage between the company itself and its business partners. Encouraged by the BPR model, the company produced customer survey (e.g. telephone survey, section 4.2.2) and studied customers requirements (e.g. studied the fax, letter and meeting minutes, section 4.2.2). The information became more and more useful when it was linked to the business strategy, the product development process and the performance problem, according to the method put forward in the BPR model (section 3.2.2.2). After the mechanism of linking customer value to process improvement and high technology adoption proposed by the BPR model was being applied in Company C, the company began to rethink its relationships with the external business environment.

5.4.1 A Period of Rapid Growth

During 1994-95, there was rapid growth of demand for home appliance in the U.S. and Australia. The global manufacturers responded by accelerating their product development and delivery cycle. It was made possible by aggressively contracting out the development and manufacturing tasks to original equipment manufacturers in the Far East. Evidently, Company C experienced rapid growth in revenue and firm size. A new production facility was under construction to cater for increasing demand for mass production.

5.4.1.1 Stability of the Technical Core

Environmental uncertainty as such was handled by the general manager who responded by regulating the inputs to and outputs from the technical core. It was evidenced that Company C expanded with the number of employee. The technical core remained highly stable in its functions to maintain efficient operation. Traditionally, the technical core needed not adapt to violability in market demand and customer requirements.

5.4.2 Environmental variables in the first cycle of reengineering

5.4.2.1 Perceived Uncertainty of the Environment

Company C's technical core generally lacked the knowledge about competition, customers, and governmental regulations. Uncertainty can be defined as actual and perceived. Even if the environment is rather stable by objective measures, it can be perceived as uncertain by the organisation which possesses insufficient information of competitors, customers and the state of economy.

5.4.2.2 Mechanism of Responding to Perceived Uncertainty

In the first cycle of process reengineering, representatives of the technical core were invited to the reengineering team. The team was responsible for conceptualisation of problem and solutions. Actually, a temporary body for evaluation of high technology to close the performance gap was established (section 4.2). A mechanism for actively responding to environmental uncertainly was gradually institutionalised in Company C. Global measure of environmental uncertainty taps into a dimension of active response to the environment. In responding to the uncertainty, the team was moving the organisation toward adoption of major process innovation.

5.4.2.3 Effect of Increased Responsiveness on Perceived Uncertainty

A more aggressive technology policy in turn altered the relationship between the team and the environment. The team moved to further reduce their perceived uncertainty of the environment. In the phase of process study and process analysis (section 4.3), the team actively sought the performance data of the competitors. Though benchmarking the performance against market leaders, the information uncertainty about competitors reduced. Adoption of high technology was promoted when the team anticipated to imitate the technology solution adopted by its competitors. In this respect, the reengineering process broadened the scope of technology assessment to enforce a technology-push and market-pull integration.

5.4.2.4 Effect of Reduction in Perceived Uncertainty on Perception of High Technology

With customer survey being conducted, the team developed a market pull motivation for high technology adoption. Marketing performance deficiencies that stemmed from manufacturing was reviewed. Perceived marketing opportunities were explored to envision possible enhancements to the product development process. The general manager was seen to broaden his focus in assessing the relevant pull forces in the context of technology acquisition.

Therefore, opportunities for pursuing new product-market options were incorporated into the cost-benefits trade-off associated with high technology. It resulted in a more extensive and realistic assessment of the match between corporate needs and the technology's means for addressing those needs. Reduction in information uncertainty about the specific aspects of environment (competitors and customers) has direct impact on the intention to adoption high technology.

5.4.2.5 Effect of Coping Strategy on Adoption of High Technology

However, an intention to adopt high technology was arrested in a downturn of business. In 1996, the projected revenue dropped drastically in its rate of growth. The total value of development contracts declined as compared to 94-95. The general manager responded by reducing head count. Company C was under extreme pressure to reduce costs of development, tooling, inventory and production. The effect was elevated as a huge investment had already been made to establish new production facilities and at the same time the prospect for sale return was poor.

The firm hesitated to commit resources in face of this major, unmanageable change in the environment. The objective measures of uncertainty in the external environment impeded the adoption of high technology because the firm made decisions about which portions of the environment could be systematically adjusted to.

5.4.3 *Environmental variables in the second cycle of reengineering*

5.4.3.1 Short-term Technological Policy and Perception of High Technology

The general manger coped with the uncertainty by adopting a short-term policy orientation in strategic management. It helped the firm to avoid uncertainty by stressing a short run time horizon, financial control, and profit maximisation in decision making. It facilitated the technical design of process innovation. Since capital investment decisions was based on short run, qualitative considerations warranted by social-technical design approach would not be in a better position to be adopted. Violability of the market demand had inverse effect on the adoption of major technology.

5.4.3.2 Effect of Aggressive Policy on Adoption of High Technology

It did not, however, prevented the reengineering team from proposing process innovation and high technology that had quantitative gain on efficiency and control (section 4.4). At the same time the existence of performance gap become more apparent to the staff who had not been involved in reengineering. The crisis has successfully created a burning platform to reduce resistance to change.

All in all, the reengineering team attempted to reduce the dissonance between the perceived and the actual uncertainty of the environment. Its members tended to adhere to issues that had future implications. It contributed to the development of a long-term policy orientation that would attempt to live with uncertainty by emphasising a long run time horizon, adaptive planning, and minimising the chance of disaster.

CHAPTER 6

CONCLUSION

6.1 THE OBJECT ORIENTED MODEL FOR TECHNOLOGY DIFFUSION

This research devises a robust methodology for adoption of high technologies that are technically efficient. The generic model has been implemented successfully in a specific case for testing. The results explain the significance of the institutionalisation of a technical core in the case company for high technology evaluation on improving the quality of adoption decision. The decision quality was measured by user acceptance of the adopted high technology, the impact of high technology on various functions of the company, and the economic return on investment.

The outcome of implementation suggests that an excellent reengineering approach requires the support of a complete model of implementation. The object oriented model assisted the implementation of intervention strategies in the case company. It solved the problems of complexity and violability of the organisational context in which the strategies were implemented.

In dealing with the complexity of the context, Jacobson's Objectory method plays an important part in building a conceptualisation of the intervention strategies by encompassing all the important objects necessary in the implementation scenario. The objects included the information of business, process and technology requirements, the intervention strategies, the reengineering team that executed these strategies, and the stakeholders who affected and were affected by those strategies. Basing on the Objectory method, these objects were properly organised in a structured use-case model. To clearly represent the input, process and output, we further added a class and a object structure to the use case model. Consequently, these useful objects were logically represented in three layers: the use case layer, the object class layer and the object layer.

The three-layer structure offered by the object oriented methodologies was central in reducing the complexity. It assisted the implementers in distributing and managing responsibility, control and communication of the objects. In use case layer, the complicated tasks of reengineering (process modelling, measurement, design, evaluation and implementation) were designed and organised in six use cases. The attributes, the roles and the responsibility of the six cases were clearly identified. Also, the influence of stakeholders were easily mapped into the six cases. Therefore, stakeholders' response to the high technology adoption was well anticipated and contingent strategies were easily formulated.

In object class layer, the architecture, the static model was constructed. The object diagram showed how the classes interact with each other. In this way, the classes, their attributes, their responsibility and their interrelationships were structurally represented in use case layer, object class layer and object layer. The implementation model is therefore complete, simple and logical and becomes a valuable guide for actual implementation.

In dealing with the volatile environment of implementation, Jacobson's Objectory method plays an important part in building the concept of reusability in the design of intervention strategies. With the inheritance structure, the event objects were designed with distinctive roles and responsibilities. The intervention strategies could be easily extended by reusing the event objects and the use cases. Also, the inheritance structure assisted the implementers in understanding the interdependency between the objects and the use cases. Therefore, the chained effect of contingent strategies was well handled.

6.2 EFFECTIVENESS OF THE BPR MODEL

The engineers, with the aid of the BPR Model, found it easier to relate varies types of business information for process evaluation, analysis, and design. The use and for which purposes the many types of business information serves were easily understood. When the purposes were identified and understood it was justified for them to collect business information. The use and the purposes of use for business information provided a basic guideline for classification of the information. As one quality engineer remarked:

> *"I have been a quality engineer for more than three years. I thought no other person in this company, except my boss, could have a better idea of what my job is about. My job is all about improving the quality of finished products. When I am asked for comments in improving the process of measuring the quality of finished products, I can come up with thousands of ideas. I see no reason why I should shared my ideas with others. But when I took a good look at the BPR model as you insisted on, I started to understand that it takes more than what I can imagine to make improvement on my tasks. Also, the very information that I know about can contribute to so many parts of the*

complete tasks of process improvement. I also understand that I should have a good picture of the problems before I make comments and suggestions for improvement. That explains why I did not do any corrective action about the quality process even through I had so many ideas. These new thoughts encourage myself to look for information that was overlooked. I am also convinced that the information must be classified before they can be made good use of."

6.3 CONTRIBUTIONS OF THE STUDY

This research provides valuable insight into the adoption of high technology. Business Process Reengineering has been proved to be a better approach for technology adoption for its well planned and organised approach. Through the implementation of the generic BPR model in a Small Medium Enterprise, the scope of applicability was defined for its generalisation. This model has been proved to be applicable in small to medium size manufacturing companies. Manufacturing companies that are centralised in decision making, informalised in roles and responsibilities and short-termed orientated in coping with market volatility will find the model useful.

This research has made several contributions to expand the knowledge of high technology adoption. Several important generalisations that had been verified in empirical studies were found useful in predicting high technology adoption in this case study. The results (section 5.3.3) suggest that the number of engineers and the number of managers involved in the reengineering process have a profound effect on the firm's ability to evaluate process innovations and to perceive major profit opportunities. It was consistent with the research that the organisations that adopted the greatest number of innovations had a considerably greater capacity for gathering and evaluating information about innovations [100].

The object oriented implementation model helps create an infrastructure in the SME, that expanded its capacity for gathering and evaluating information about innovations. Although it has been widely agreed that new skills, attitudes, systems, procedures, and social structure are needed to support adoption of high technology, the results of this study suggest that social changes are actually required at more earlier stages of adoption than previous researches anticipated.

In the case company, a new social structure was created and nurtured in the reengineering project. The reengineering team provided a cluster of professional specialities. They were most crucial to the firm's adoption policies as they increased the firm's capacity for gathering and evaluating information about innovations. Unless this pool of talent and expertise are carefully managed, the relevant information for evaluation of high technology will not be channelled to the decision maker. In the company, a mechanism was established to introduce new ideas into the firm and to synthesise the ideas that contributed to innovations. The feedback mechanisms given by the object oriented model build mutual trust among the professional specialities. A social structure that supported open communication in vertical and horizontal directions began to emerge. This need is profoundly significant when the organisational structure has characteristics like centralisation and formalisation that inhabit organisational innovation (section 5.3.1).

The institutionalisation of an openness for idea and information exchange has considerable impact on the institutionalisation of an aggressive technological policy. The object oriented model succeeded in institutionalising an aggressive technology policy which have positive impact on adoption of high technology. The establishment of an evaluation group of technology supported the development of a mechanism of environmental scanning (section 5.4.1). This mechanism is crucial for adoption of efficient technology.

As this evaluation group transferred the technological-push forces and the market-pull forces from the environment to the organisation, the case company became proactive in identifying opportunities for pursuing new product-market option. It was because when the opportunities were incorporated into the cost-benefits trade-off associated with high technology, it resulted in a more extensive and realistic assessment of the match between corporate needs and the capability of high technology in addressing those needs.

These results (section 5.4.1) reveal that reduction in the perceived uncertainty of the environment has direct and positive effect on the adoption of efficient high technology because the company was able to recognise opportunities in its assessment of the technology push and market pull factors. It provided insight to the connotation made by Ettlie and Bridges that information uncertainty about the specific aspects of environment impeded innovation in organisations [115].

Although reduction in perceived environmental uncertainly is positively associated with high technology adoption, it is still difficult to anticipate violability in actual environment.

Violability in price and competitive environment was perceived by the management of the company as an uncontrollable and unmanageable threat. The results supported the hypothesis that threat is handled or resolved by increasing control and reducing slack resources when it is assessed as discrete and temporary [116]. It is also consistent with the research that verified an inverse association between violability in competitive environment and high technology adoption [115].

6.4 FURTHER DEVELOPMENT

Manager tends to recognise issues in that threat and opportunity have distinguishing characteristics and ignore issues in that threat and opportunity share common characteristics because threat is distinct from opportunity in that threat has a negative connotation, and it is associated with lack of control and the expectation of loss [117]. We proposed that the model should be enhanced by formulating strategy to assist decision-maker in perceiving opportunities in face of crisis and threats arise in violability of the environment. For strategies that encourage managers to deal with threats when it is feasible to so, please see the work of Jackson and Dutton [117].

Finally, this model addressed the issue of conflict management in vertical conflicts arise in the low, middle and the top level of organisation. This model, however, does not cater for the inter group conflict occurs among related departments. It has great impact on the adoption of high technology but with an inverse direction. In face of such constraint, this issue was resolved by adopting a minor innovation that minimised the threat perceived by the related departments.

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APPENDIX I PERFORMANCE STUDY WORKSHEET

Project Name :

1. How many engineers were directly responsible / in charge of the project ? (Directly responsible/ in charge means involving in the project from when it started to finished)
2. Were there any other engineers helping with the development work of this project?
3. If "Yes", please specify how many engineers were involved in what type of the work.

Product Development Lead-time

A. *Required Lead-time*

4. What is the official start date of this project?

____

5. Is there any documents such as fax or contract in which the start date was indicated?
   Would you specify the deadline stated in this contract?
   Delivery date of finished product ____________
   Delivery date of off-tool sample ____________
   Deadline of starting production ____________

Then the required lead-time is calculated as ____________

7. Do you think the required lead time is realistic? *Yes/No*
8. If "No", please specify the lead time you think appropriate____________

B. *Actual Lead-time*

9. When did the customer agree or refuse to go to production ____________

If the customer refuse to go to production, please answer the question No. 10 - 12

10. At what stage was this project terminated ?
11. When was this project terminated ?
12. Please state 3 reasons of its termination and rank the order of their importance.
    First ____________
    Second ____________
    Third ____________

Then the actual lead-time calculated as ____________

If the customer agree to go to pilot run, please answer the question No.10

13. When did this project completed?
    Actual delivery date of finished product ____________
    Actual delivery date of off tool sample ____________
    Actual start date of production ____________

Then the actual lead-time calculated as ____________

Engineering Changes

14. How many engineering changes have been made in the complete development cycle?
15. Please specify the types of changes and the number of changes in the detail design stage:
16. Please specify the types of changes and the number of changes in the tooling design stage:
17. Please specify the types of changes and the number of changes in the assembly design stage:
18. Did any engineering change occur in pilot run stage? *Yes / No*
19. If "Yes", please specify the types of changes and the number of changes?

Product Complexity

A. *Parts*

Referring to the BOM

17. Please state the number of parts used in this product________________
18. Please state the number of purchased parts ________________
    (unique parts details engineered by external suppliers)
19. Please state the number of carryover parts ________________
    (parts engineered before)
20. Please state the number of common parts ________________
    (parts commonly used for other products)
21. Please state the number of unique parts ________________
    (parts engineered only for this specific product)

B. *New Product Attributes*

22. Was there any product attribute that was new to Chiaphua and needed to be learnt before engineering that product? *Yes / No*
23. If "Yes", please specify the number of new product attributes and what were they.

Methods of Integration

24. Please describe the kind of cooperation among the project group and other departments internal to this company, which are involved in supporting activities of this project by selecting the following options:

    a) Development is organized into functional departments whereas activities are coordinated through the functional hierarchy, rules, procedures, and traditions.

    b) Work is organized into functional departments. A project manager is in charge of coordinating activities but has little influence over the content of this project. The project manager has little influence outside the project, works through lower level liaison people within the project.

    c) Work is organized into functional departments. A project is assigned to the project and he is direct responsible for all aspects of the project. But he still has little influence outside the project, works through lower level liaison people within the project.

    d) A project manager is assigned to the project and he is direct responsible for all aspects of the project. He has strong influence outside the development group and has high status within the organization.

Problem Solving Mechanism

Obviously there were other project groups competing for the same resources of other departments.

A. *PMC Department*

25. Do you know if there is any mechanism of setting priority of resource allocation by the PMC department?
26. Would you tell what the mechanism is?

____

____

27. If no such mechanism exists, how did you get the resources from PMC department?

____

____

B. *Prototype Workshop*

28. Do you know if there is any mechanism of setting priority of resource allocation by the Prototype Workshop?
29. Would you tell what the mechanism is?

____

____

30. If no such mechanism exists, how did you get the resources from the Prototype Workshop?

____

____

C. *Tooling Department*

31. Do you know if there is any mechanism of setting priority of resource allocation by the Tooling department in China?
32. Would you tell what is the mechanism?

____

____

33. If no such mechanism exists, how did you get the resources from the Tooling department in China?

____

____

34. Were the project managers or department head meeting the heads from other departments for setting priority of resource allocation? Yes / No

35. If "Yes", please state the frequency of meeting or the number of meetings

____

____

Pattern of Concurrency

A. *Internal Communication*

36. Please describe the nature of communication concerning the following :

a) Among members in this project group :
☐ Formal Frequency :
☐ Informal Frequency :

b) Among other project groups :
☐ Formal Frequency :
☐ Informal Frequency :

c) Between this project group and PMC department:
☐ Formal Frequency :
☐ Informal Frequency :

d) Between this project group and the production in China:
☐ Formal Frequency :
☐ Informal Frequency :

B. *Pattern of Overlapping*

37. Was 1st working prototype developed before parts engineering complete? *Yes / No*
38. If "Yes", it a formal procedure/ tradition/ you own way of doing things

39. Was draft BOM had been sent to PMC department before the authorized BOM was formally released? *Yes / No*
40. If "Yes", it a formal procedure/ tradition/ you own way of doing things

41. Had Process Design started before parts engineering or off-tool sample completed? *Yes / No*
42. If "Yes", it a formal procedure/ tradition/ you own way of doing things

C. *Information Mismatch*

43. Did the dispatching of the engineering changes to other departments lead to the following problems happened in the project
☐ increase in tooling cost
☐ insufficient material or parts prepared for pilot run or production
☐ material or parts purchased deviated from specification

Inventory Level

Do you regard the following as factors affecting the high level of inventory in Chiaphua.

- Please put a "✓" in the box provided in *column A* if you think appropriate.
- Please also put an order of importance of the following factors in *1, 2, 3 and 4* in descending order in *column B.*
- Please, finally, indicate the extent of contribution of these factors to the high inventory level by allocating a *percentage* in *Column C.*

	A	B	C
1. Late delivery of parts to production	☐	____	______________
2. Defective parts	☐	____	______________
3. Part Shortage	☐	____	______________
4. Parts deviated from specification	☐	____	______________

APPENDIX II DATA OF PERFORMANCE MEASUREMENT (July 1995 - June 1996)

Project Code	ACM2-A	AST 8	AST 7	AST 6	AWK4-A	AWK5-A	SR 5,6,7	EX 4	Rotissene Grill	CB 1	SSK 5	PM 1	Electrical Blanket	EW 2,3,4	MG 10
Performance Indicators															
Planned Leadtime	4 Ms	5 Ms	7 Ms	7 Ms	3 2/1 Ms	4 Ms	9 Ms		7 Ms	9 Ms	4 Ms	9 Ms	10 Ms	4 Ms	6 Ms
Actual Leatime	5 Ms	8 Ms	8 Ms	8 Ms	3 Ms	8 1/2 Ms	9 Ms	19 Ms	7 1/2 Ms	17 Ms	8 1/2 Ms	14 Ms	15 Ms	4 1/2 Ms	8 1/2 Ms
Delays	1 Month	3 Ms	1 Ms	1.5 Ms		4 1/2 Ms (3 Ms p)			1/2 Ms	8 Ms	4 1/2 Ms (3 Ms p)		5 Ms	1/2 Ms	2 1/2 Ms
Completed / Closed	Completed	Completed	Completed	Completed	Completed	Completed	Completed	Closed	Completed	Closed	Completed	Closed	Completed	Completed	Completed
Manufacturability appl															
Total Number of Engineering Changes	115	87	98	133	50	85	43		97		82		126	71	87
No. of engineering changes in detail design	41	27	38	42	21	29	18		29		33		29	19	21
No. of engineering changes in tooling design	49	42	41	59	24	40	19		45		37		57	29	41
No. of engineering changes in assembly design	15	14	16	21	5	11	6		12		11		22	14	13
No. of engineering changes in pilot run stage	10	4	3	11	0	5	0	0	11	0	1	0	18	9	12
Project Strategy															
Number or parts	83	74	71	73	64	70	54	108	45	102	61	75	69	67	73
Number of new product attributes appl	3	0	0	0	1	1	1	0	5	1	1	4	7	1	1
Project Scope															
% of Unique parts engineered by suppliers	19	16.2% (12)	26.7% (19)	36% (27)	14% (9)	12.8% (9)	42.5% (23)	2.7% (3)	24.4% (11)		9		23	10	9
% of carryoover parts	39	48.6% (36)	60% (43)	23.3% (17)	60% (39)	58.5% (41)	0	0	28.8% (13)		35		39	39	41
% of common parts	20	25.6% (19)	23.9% (17)	27.3% (20)	18.7% (12)	17.1% (12)	24% (13)	24% (26)	17.7% (8)		11		20	14	13
% of Unique parts engineered only for this proj.	5	9.4% (7)	2.8 % (2)	12.3% (9)	6.2% (4)	11.4% (8)	33.3% (18)	73% (79)	28.8% (13)		6		7	4	9
Problem Solving Cycle															
Pattern of Specialization															
Number of participating engineers	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
occasional helper applll	0	0	0	0	0	2	1	1	customer engin.	0	2	1	2	0	0
Methods of Integration	functional	functional	functional	functional	functional	functional	functional	functional	functional	functional	functional	functional	functional	functional	functional
Resource allocation mechanism in PMC	Rank & File	Rank & File	Rank & File		Rank & File	Rank & File	Delivery Dates	Delivery Dates	Rank & File	Rank & File	Rank & File	Rank & File	Rank & File	Rank & File	Rank & File
	Friendship				Friendship	Friendship	Friendship	a lot of pushing			Friendship	Friendship	Friendship	Friendship	Friendship
Resource allocation mechanism in Prototype W.	Rank & File	Rank & File	Rank & File		Rank & File	Rank & File	Friendship	Deadline	Rank & File	Rank & File	Rank & File	Rank & File	Rank & File	Rank & File	Rank & File
	Friendship	Friendship	Friendship		Friendship	Friendship		Friendship	Friendship	Friendship	Friendship	Friendship	Friendship	Friendship	Friendship
Resource allocation mechanism in China Plant	Unknown	No	No		Rank & File	Rank & File	Friendship	Delivery Dates	No	No	Rank & File	Rank & File	Rank & File	Rank & File	Rank & File
								a lot of pushing							
Meeting between Department Heads for setting priority of resource allocation		once a month	once a month		2 /month	2 /month	1 / 2 months	Nil	once a month	once a month	2 /month	2 /month	2 /month	2 /month	2 /month
Pattern of Concurrency															
Overlapping of processes															
Was 1st working prototype developed before 1st set of parts engineering drawing completed	Yes (tradition)	Yes (tradition)	Yes (tradition)	Yes (tradition)	Yes (tradition)	Yes (tradition)	Yes (tradition)	Yes (tradition)	Yes (tradition)	Yes (tradition)	Yes (tradition)	Yes (tradition)	Yes (tradition)	Yes (tradition)	Yes (tradition)
Was draft BOM sent to PMC before the authorized BOM formally released	Yes (tradition)	Yes (tradition)	Yes (tradition)	Yes (tradition)	Yes (tradition)	Yes (tradition)	Yes (tradition)	Yes (tradition)	Yes (tradition)	Yes (tradition)	Yes (tradition)	Yes (tradition)	Yes (tradition)	Yes (tradition)	Yes (tradition)
Had manufacturing process started before off-tool sample completed	No (tradition)	No (tradition)	No (tradition)	No (tradition)	No (tradition)	No (tradition)	No (tradition)	No (tradition)	No (tradition)	No (rule)	No (tradition)	No (tradition)	No (tradition)	No (tradition)	No (tradition)
Information Processing															
Formal communication with PMC	2 times / week	once / 2 weeks	once / 2wks	once / 2 weeks	2 / week	2 / week	1 / 3 weeks	daily	4 times / week	3 times / week	2 / week	2 / week	2 / week	2 / week	2 / week
informal communication with PMC	once a week	once a week	once a week	once a week	2 / month	2 / month	daily	daily	2 times / week	3 times / week	2 / month	2 / month	2 / month	2 / month	2 / month
Formal communication with China Plant	daily	daily	daily	daily	daily	daily	daily	once a week	daily	daily	daily	daily	daily	daily	daily
informal communicaiton with China Plant	once a week	once a week	once a week	once a week	daily	daily	daily	once a week	3 times / week	daily	daily	daily	daily	daily	daily
Information Mismatch															
Increase in tooling cost	Yes	Yes	No	Yes	No	Yes	No	No	No	No	Yes	Yes	Yes	Yes	Yes
Insufficient parts or material for pilot run or production	No	No	No	No	Yes	Yes	Yes	No	Yes	No	Yes	Yes	Yes	Yes	Yes
Parts or material purchased deviated from specification	Yes	Yes	Yes	Yes	No	No	No	No	Yes	Yes	No	No	No	No	No
Internal Communication in Engineering Dept.															
Formal communication with group members	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
Informal communication with group members	10 times/wk (seni)	2 /wk (senior)	2 /wk (senior)	twice a week	daily (senior)	daily (senior)	1 / 3 weeks	daily	daily (senior)	once a wk (senior	daily (senior)	daily (senior)	daily (senior)	daily (senior)	daily (senior)
Formal communication with other project groups	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
Informal communicaiton with other project gps	Nil	Yes	Yes	once a week	once a week	once a week	Nil	2 times / month	once a month	Nil	once a week	once a week	once a week	once a week	once a week

APPENDIX III DETAIL PROCESS MAP IN LIST FORM

ACTIVITY	TIME	
	Value-added	Non-value-added
Total Time :		

Total Steps :
Value-added Steps :
% Value-added Steps :
Total Time :
Value-added Time :
% Value-added Time :

*from : "**Breakthrough Process Redesign**" by Charlene B. Adair and Bruce A. Murray[1]*

REFERENCE

1. Adair, C.B., and Murray, Bruce A., *Breakthrough Process Redesign: New Pathways to Customer Value*. American Management Association. New York: AMACOM., 1994.

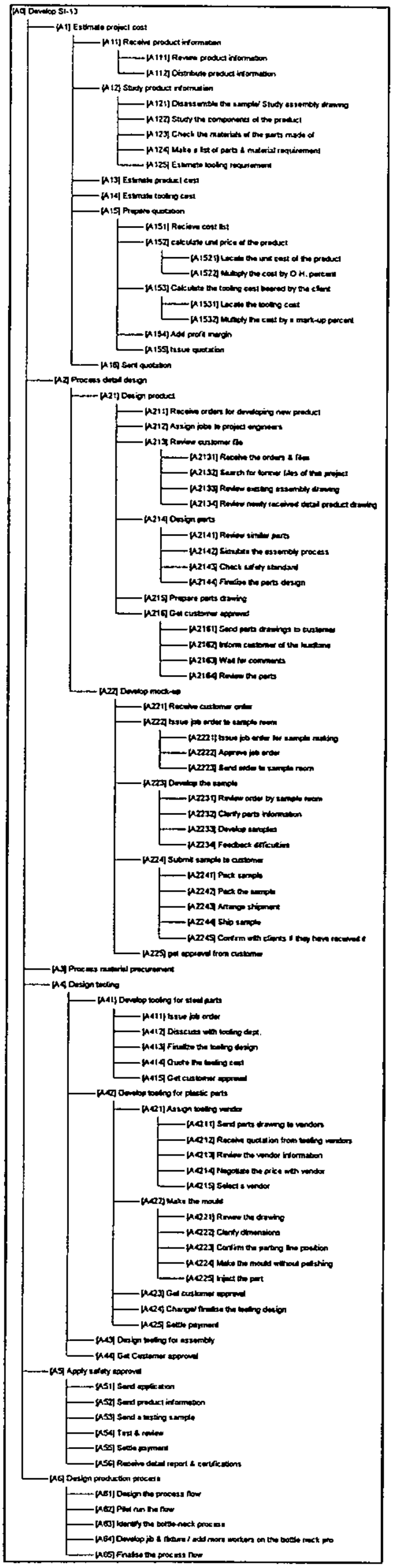


Figure IV-1 Decomposed View of SI-13 Product Development Process

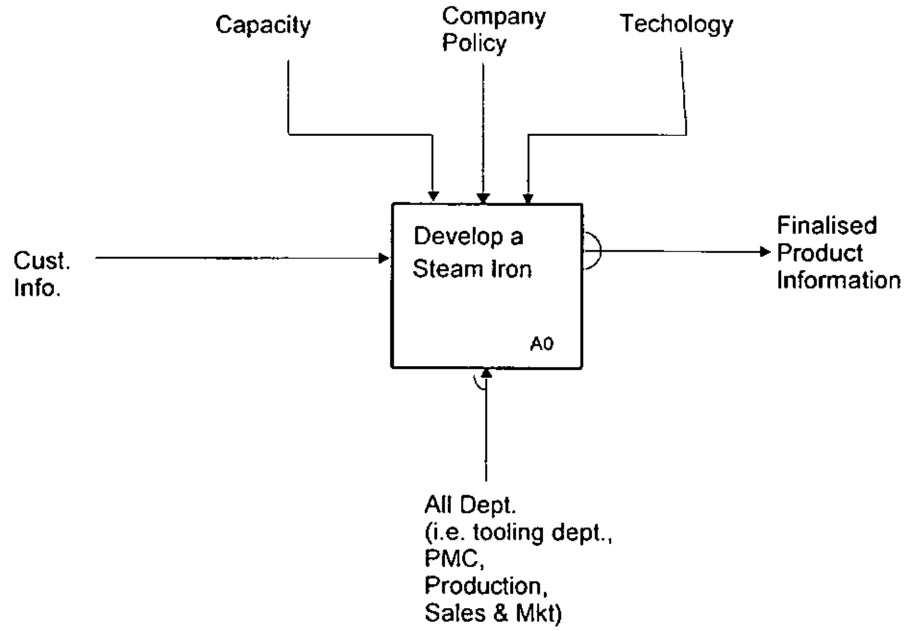


Figure V-1 SI-13 Product Development Process (Level 0)

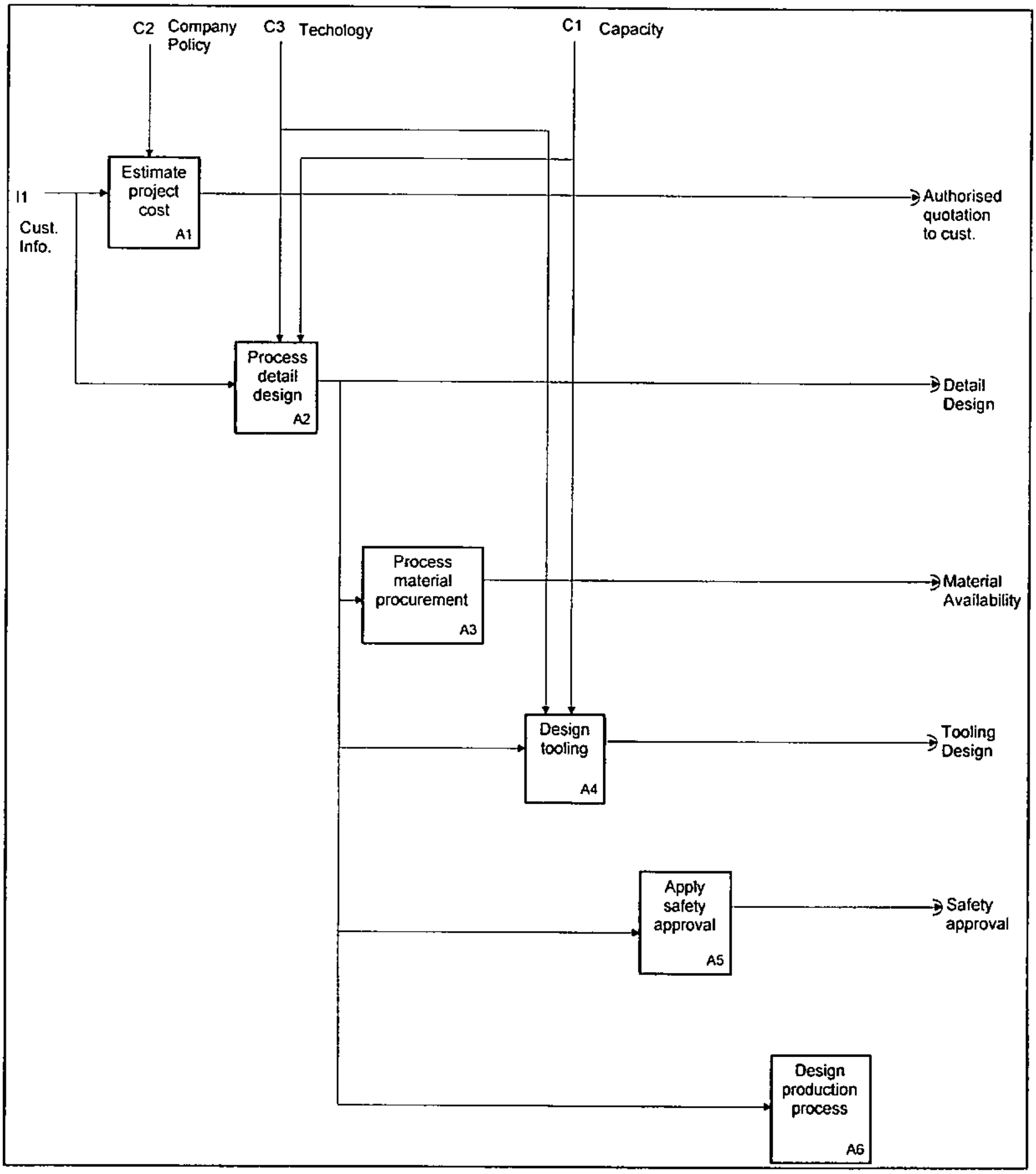


Figure IV-2 SI-13 Product Development Process (Level 1)

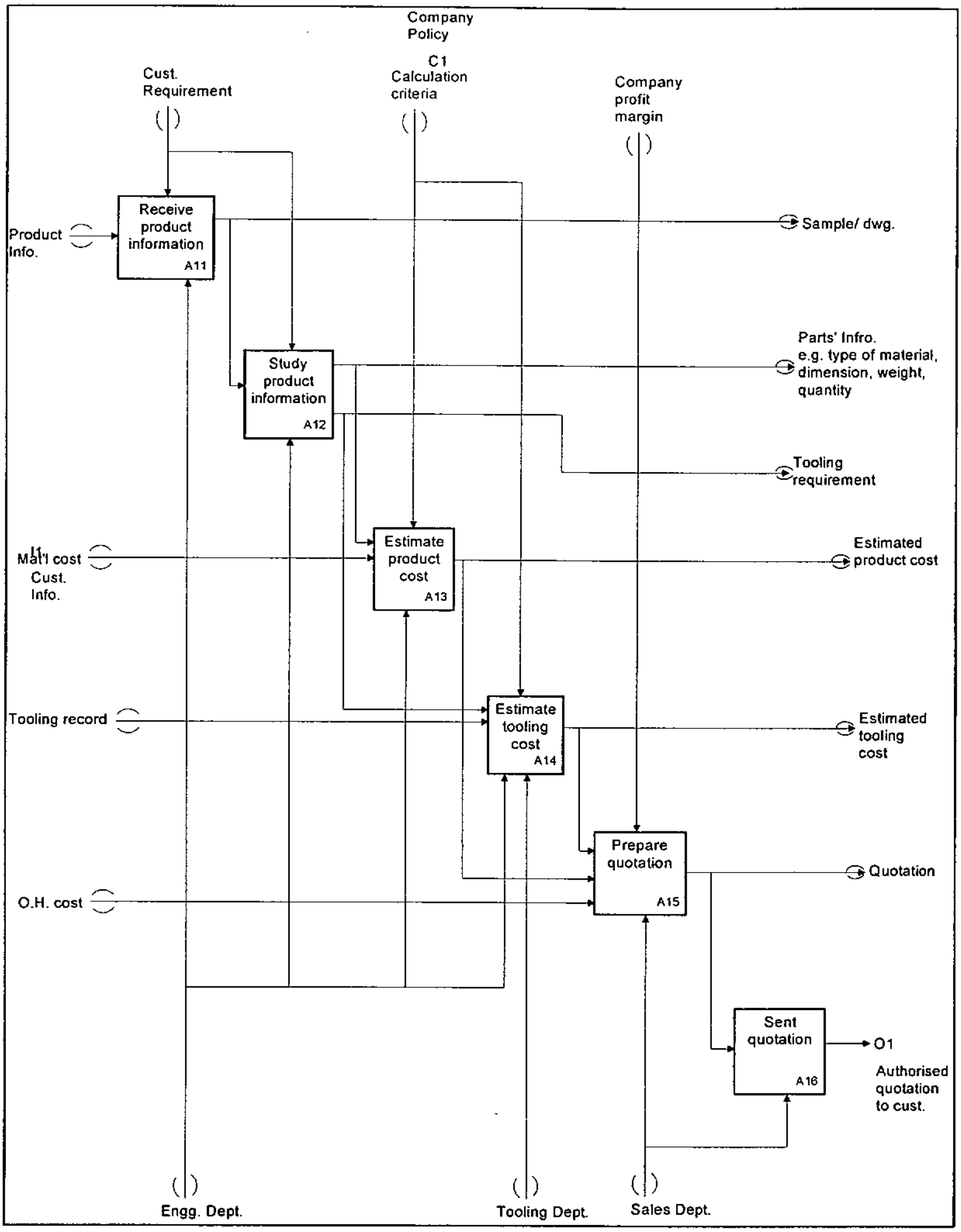


Figure IV-3 Product Development Process (Level A1:Estimate Product Cost)

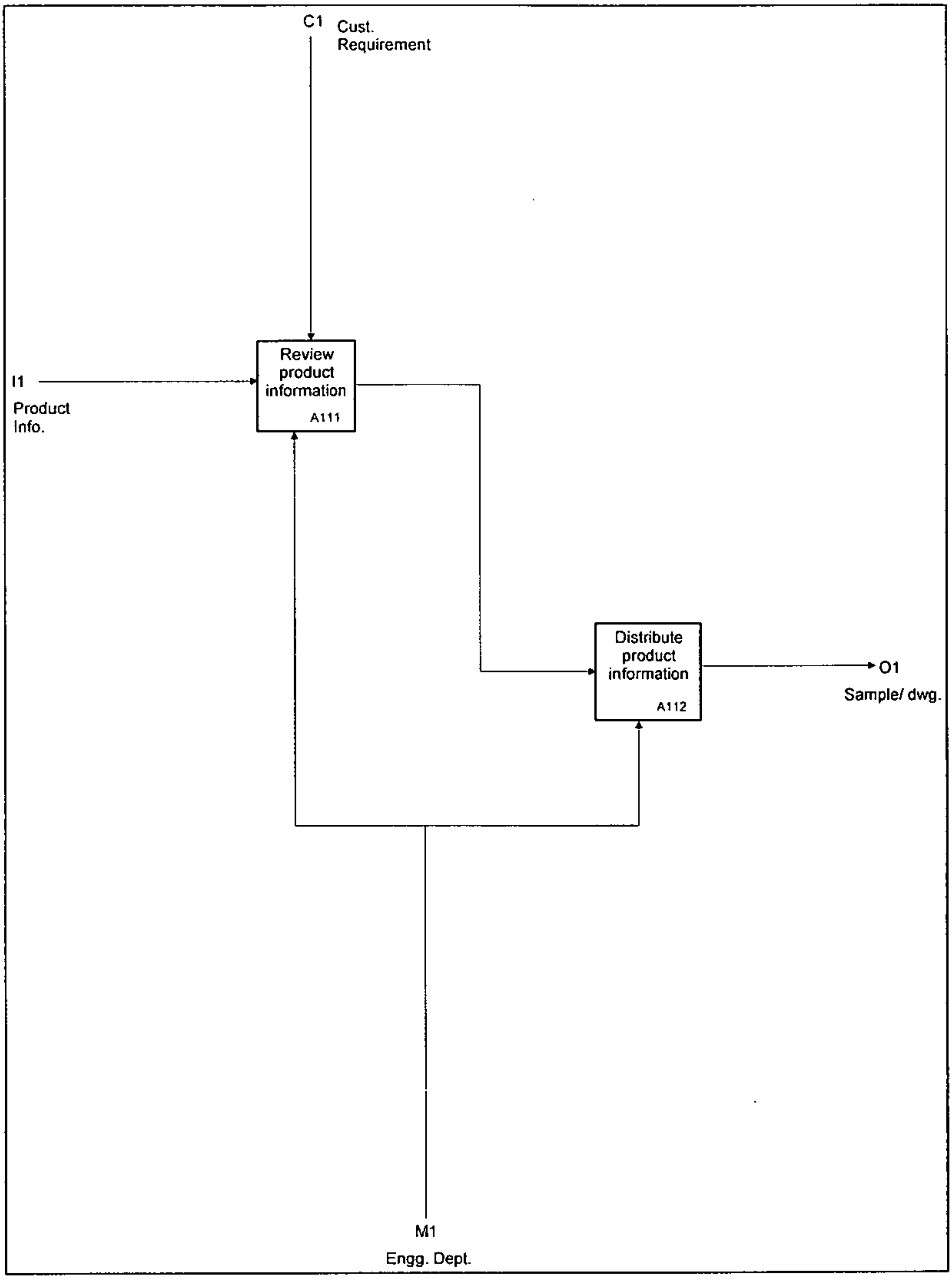


Figure IV-4 Product Development Process (Level A11: Receive Product Information)

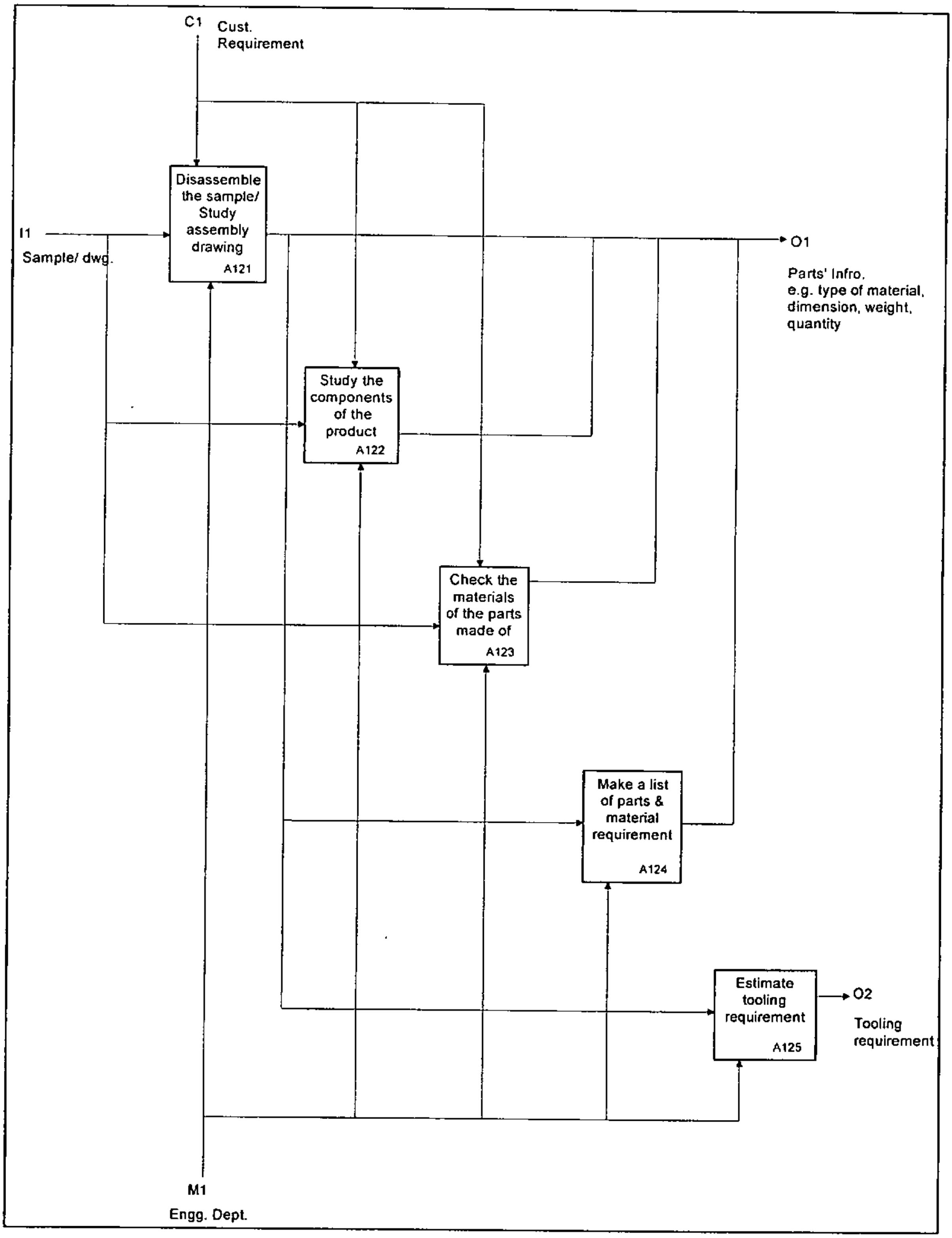


Figure IV-Error! No text of specified style in document.-5 **Product Development Process (Level A12: Study Product Information)**

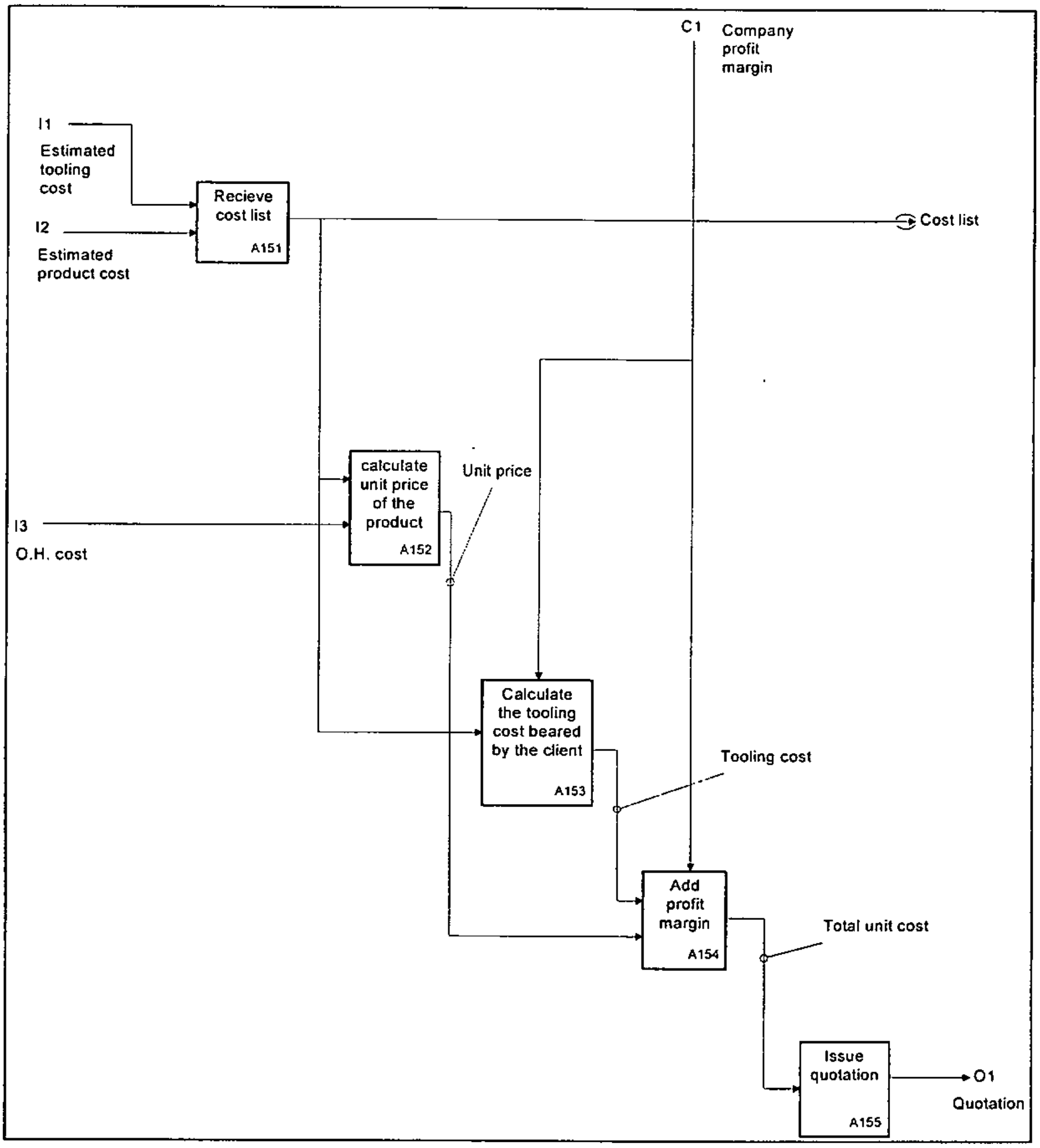


Figure IV-6 Product Development Process (Level A15: Prepare Quotations)

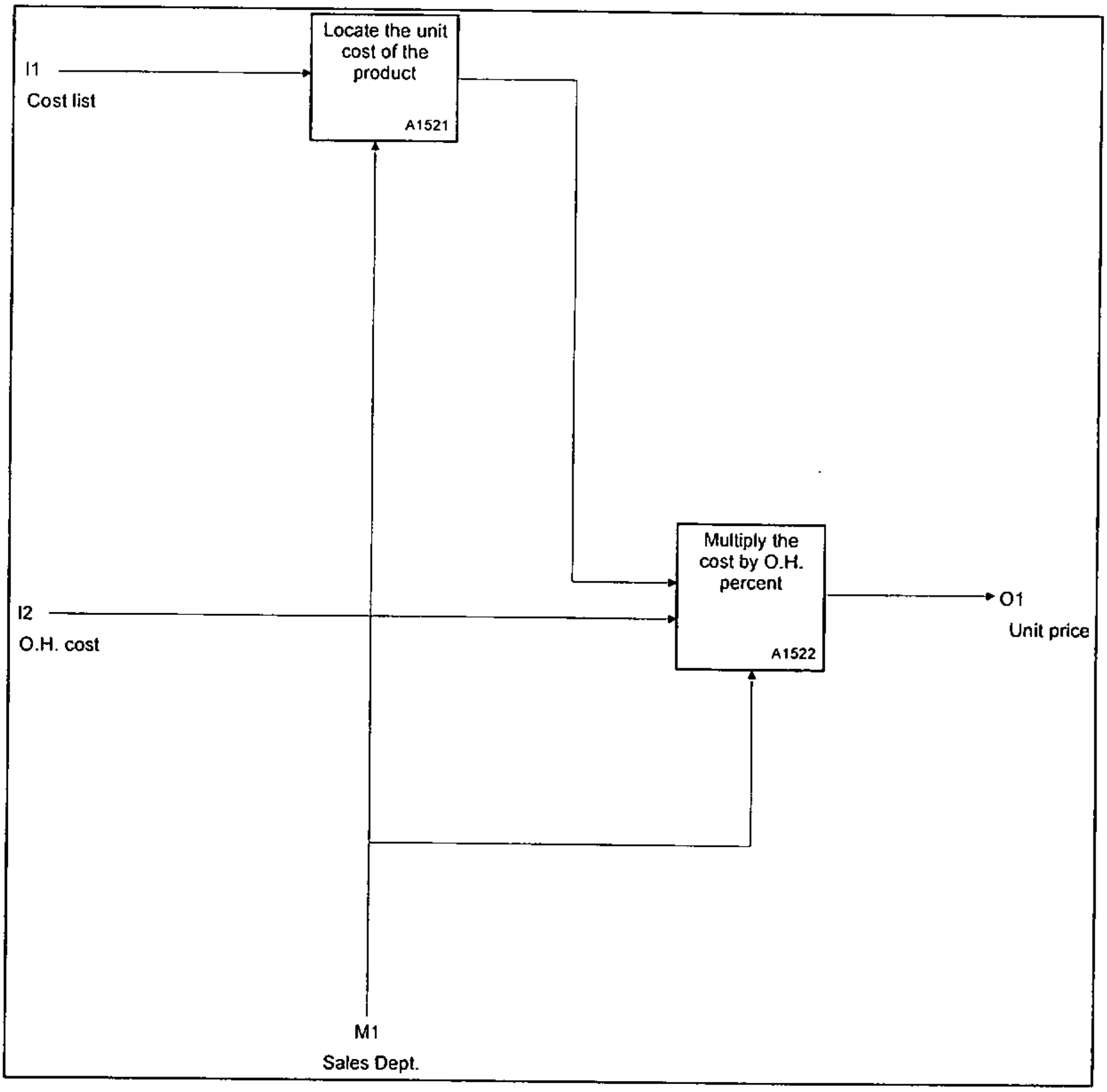


Figure IV-7 Product Development Process (Level A152: Calculate Unit Price)

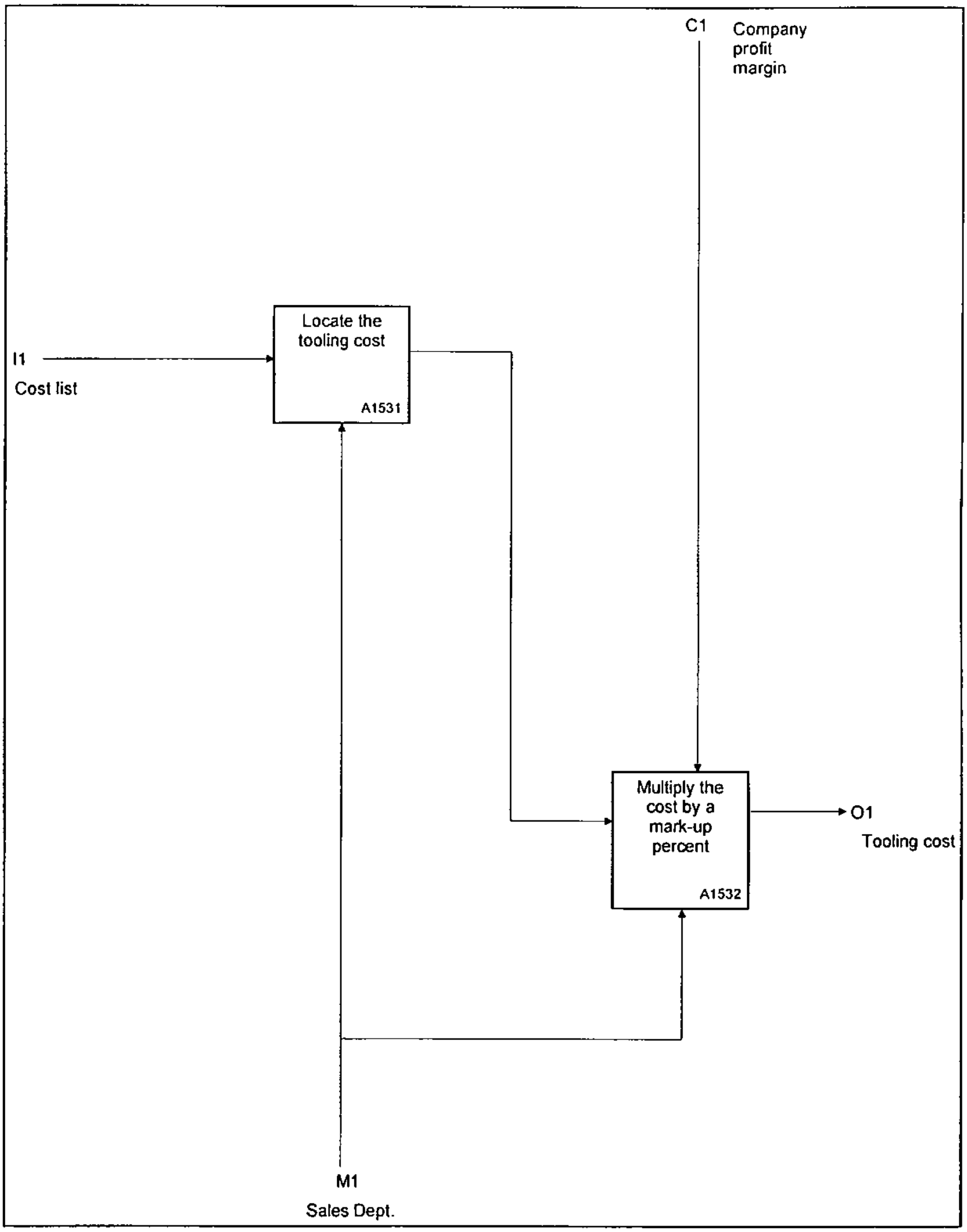


Figure IV-8 Product Development Process (Level A153: Calculate Tooling Cost Beared by Clients)

APPENDIX VI THROUGHTPUT TIME ANALYSIS

A) Details of Analysis Technique

This method of measuring throughput time is adopted from the study of Jeswiet, Verhoek and Metsemaakers [1]. It was originally designed to measure throughput time of manufacturing processes and to identify areas of improvement. Total throughput time involved by a complete process is defined as Integral Throughput Time, D_i. It is calculated by adding up throughput time incurred by each process, D_p. The uniqueness and simplicity of this method involves its comparison of two uses of time. One is the total time currently used to execute a work process; the other is the percentage of that process time used in waiting for design revisions, work order requests, movement of jobs, and checking. Comparing these times helps identify where the greatest reductions in D_p can be achieved, leading to increased efficiency of the entire product engineering process. The comparisons can be calculated as follows:

The percent of time used up = $\delta_p = (D_p/D_i) \times 100\%$

and the waiting time = $(\alpha_p = (D_p - B_p)/ D_p \times 100\%$

where B_p equals the actual job processing time (value-added time) in a process.

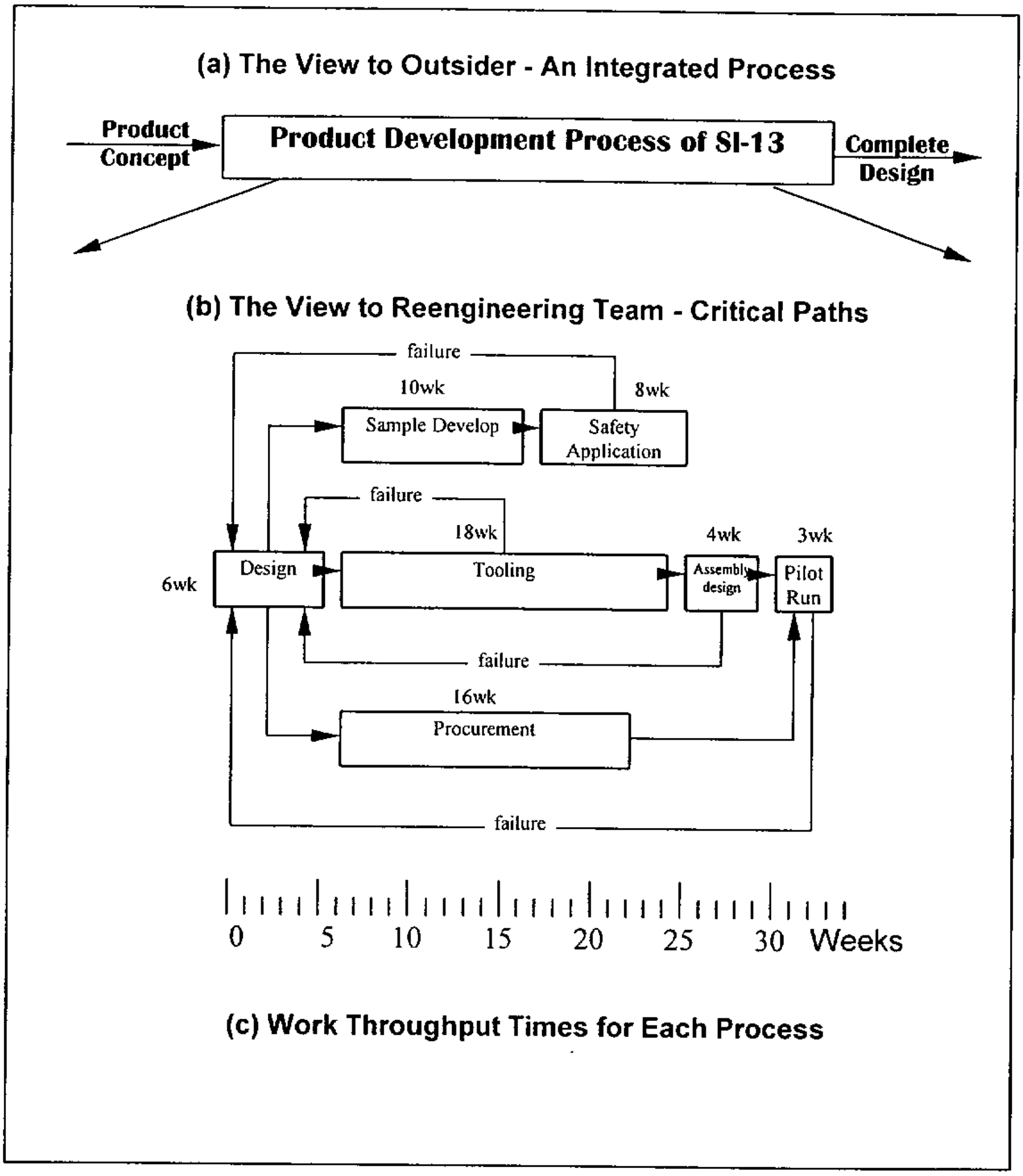
A process that shows a combination of maximum δ_p, and cop (called the max $\delta\alpha$ comparison) is easy to identify; this is shown in a later example. Reducing α_p for a process that shows maximum δ_p and α_p can help reduce D_i for the total system. Concentrating on a process where δ_p and α_p are lower usually yields significantly smaller savings; more time can be saved where more time is already being used. By following the results of each change through an entire work process cycle, we can identify both the effects of one change and the need for another. Applying the max 8a comparison shows where the most time can be saved next, even if the current work process cycle differs from the last.

B) Results of Throughput Time Analysis

This method of analysis has been used to assist Company C in process analysis. From the company database, we selected a representative product (Steam Iron, SI-13) and all inputs needed to develop this product. The inputs were then traced to its internal supplier.

The overall product development process was divided into six major processes, as shown by the flow chart in Appendix IV. The six major processes were then broken down further into a series of steps, with times allotted to each. With this, we identified a critical path which is present in Figure VI-1. The waiting time and value-added time were then calculated for each process, with the percentages represented by waiting time and time used up as shown in Table VI-1. All process times were based on an eight-hour day and a six-day work week. If a process required an overnight waiting period, a block of eight hours was added.

In this analysis, the most benefit can be realised in the tooling development process (Figure VI-2). The tooling department process required 52% of the integral throughput time of the complete product development process. Waiting time incurred in this important process amount to 27% of throughput time of this process. Diminishing waiting time in this process would bring significant improvement to the lead-time performance.



(a) The View to Outsider - An Integrated Process

(b) The View to Reengineering Team - Critical Paths

(c) Work Throughput Times for Each Process

Figure VI-1 Critical Path of Product Development Process & Throughput Times for Each Process

	DETAIL DESIGN	TOOLING DEVELOP-MENT	ASSEMBLY DESIGN	PILOT RUN	Di
WEEKS	6	18	4	3	31
(6-DAYS WEEK)					
DAYS	36	108	24	18	186
Bp, DAYS	28	79	21	16	144
(8-HOURS DAY)					
D_p, HOURS	288	864	192	144	1488
B_p, HOURS	224	632	168	128	1152
δ_p	19%	52%	13%	10%	
α_p	22%	27%	13%	11%	

Table VI-1 Data for Stainless Steel Kettle (SI-13)

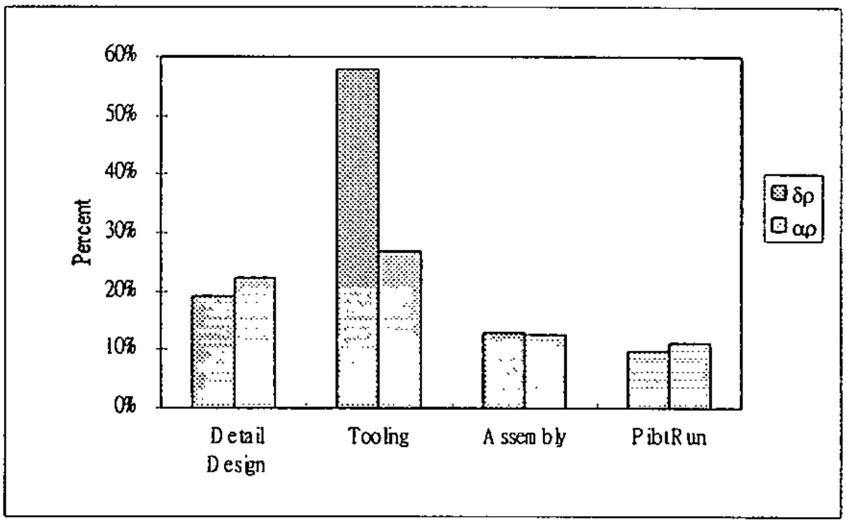


Figure VI-2 Bar Graph Showing δ_p and α_p for

SI-13 Critical Path Processes for Eight-Hour Schedule

C) Reference

1. Jwswiet, J., Verhoek, N., and Metsemaakers, M., *Measuring Performance and Decreasing Work Throughput Times in a Small Company.* The Journal of Applied Manufacturing Systems, (Spring): p. 27-32., 1995.

PRODUCT INTRODUCTION SCHEDULE

PROJECT CODE:
PRODUCT NAME:
PROJECT LEADER:

CUSTOMER MODEL NO.
C.I.L. NO.
M.F. NO.

THIS ISSUE:
NEXT ISSUE:

KEY ACTIVITY	SCHEDULE DATE	1ST REVISED DATE	2ND REVISED DATE	3RD REVISED DATE	4TH REVISED DATE
STATUTORY APPROVAL					
TOOL DEVELOPMENT					
RAW MATERIAL					
MANUFACTURED PARTS					
PURCHASED COMPONENTS					
MATERIAL COST REVIEW					
ASM JIGS & FIXTURES					
ASM LINE SET UP					
PILOT RUN					
PRODUCTION START					

DISTRIBUTION: F.K. / W.Y. / T.P.K./ C.S. / D.S. / V.P. / J.C. / P.K.
CC: J.Y. / P.W. / M.L. / C.Y.L. / J. MCN

TOOL DEVELOPMENT SCHEDULE

PROJECT CODE: ACT-4
PRODUCT NAME: TWIN COOL FLOW
PROJECT LEADER: FRANK KEUNG

CUSTOMER MODEL NO.
C.I.L. NO. ACT1-U
M.F. NO. ACT1

THIS ISSUE:
NEXT ISSUE:

TOOLING ACTIVITY	SCHEDULE DATE	1ST REVISED DATE	2ND REVISED DATE	3RD REVISED DATE	4TH REVISED DATE	REPRESENTATIVE
1.1 ACT1001 BASE						
QUOTE/ORDER						
1ST OFFTOOL SAMP						
MODIFY						
2ND OFFTOOL SAMP						
COMPLETE						
1.2 ACT1002 COVER						
QUOTE/ORDER						
1ST OFFTOOL SAMP						
MODIFY						
2ND OFFTOOL SAMP						
COMPLETE						
1.3 ACT1003 BOTTOM						
QUOTE/ORDER						
1ST OFFTOOL SAMP						
MODIFY						
2ND OFFTOOL SAMP						
COMPLETE						
1.4 ACT1004 BLOWER FR						
QUOTE/ORDER						
1ST OFFTOOL SAMP						
MODIFY						
2ND OFFTOOL SAMP						
COMPLETE						

RAW MATERIAL DELIVERY SCHEDULE

PROJECT CODE: ACT-4
PRODUCT NAME: TWIN COOL FLOW
PROJECT LEADER: FRANK KEUNG

CUSTOMER MODEL NO.
C.I.L. NO. ATC1-U
M.F. NO. ATC1

THIS ISSUE:
NEXT ISSUE:

KEY ACTIVITY	**SCHEDULE DATE**	**1ST REVISED DATE**	**2ND REVISED DATE**	**3RD REVISED DATE**	**4TH REVISED DATE**	**REPRESENTATIVE**
2.1 HIPS STYRON 6075						
SPEC ISSUE						
QUOTE/ORDER						
PROD. QTY						
2.2 CELCON M90						
SPEC ISSUE						
QUOTE/ORDER						
PROD. QTY						
2.3 PREFILTER NET						
SPEC ISSUE						
QUOTE/ORDER						
PROD. QTY						

MANUFACTURED PART DELIVERY SCHEDULE

PROJECT CODE: ACT-4
PRODUCT NAME: TWIN COOL FLOW
PROJECT LEADER: FRANK KEUNG

CUSTOMER MODEL NO.
C.I.L. NO. ACT1-U
M.F. NO. ACT1

THIS ISSUE:
NEXT ISSUE:

MANUFACTURED PART	SCHEDULE DATE	1ST REVISED DATE	2ND REVISED DATE	3RD REVISED DATE	4TH REVISED DATE	REPRESENTATIVE
3.1 ACT1001 BASE						
PROD. QTY						
3.2 ACT1002 COVER						
PROD. QTY						
3.3 ACT1003 BOTTOM						
PROD. QTY						
3.4 ACT1004 BLOWER FR						
PROD. QTY						
3.5 ACT1005 CROSS						
PROD. QTY						
3.6 ACT1006 ENCLOSURE						
PROD. QTY						
3.7 ACT1007 ENL. COVER						
PROD. QTY						
3.8 ACT1008 GRILL						
PROD. QTY						
3.9 ACT1009 FILT GUIDE						
PROD. QTY						

PURCHASED PART DELIVERY SCHEDULE

PROJECT CODE: ACT-4
PRODUCT NAME: TWIN COOL FLOW
PROJECT LEADER: FRANK KEUNG

CUSTOMER MODEL NO.
C.I.L. NO. ACT1-U
M.F. NO. ACT1

THIS ISSUE:
NEXT ISSUE:

PURCHASED PART	**SCHEDULE DATE**	**1ST REVISED DATE**	**2ND REVISED DATE**	**3RD REVISED DATE**	**4TH REVISED DATE**	**REPRESENTATIVE**
4.1 ACT1027 RING						
DRWG ISSUE						
QUOTE/ORDER						
PROD. QTY						
4.2 ACT1028 VALVE						
DRWG ISSUE						
QUOTE/ORDER						
PROD. QTY						
4.3 ACT1029 SPRING						
DRWG ISSUE						
QUOTE/ORDER						
PROD. QTY						
4.4 ACT1034 O-RING						
DRWG ISSUE						
QUOTE/ORDER						
PROD. QTY						

RAW MATERIAL DELIVERY SCHEDULE

PROJECT CODE: ACT-4
PRODUCT NAME: TWIN COOL FLOW
PROJECT LEADER: FRANK KEUNG

CUSTOMER MODEL NO.
C.I.L. NO. ACT1-U
M.F. NO. ACT1

THIS ISSUE:
NEXT ISSUE:

KEY ACTIVITY	SCHEDULE DATE	1ST REVISED DATE	2ND REVISED DATE	3RD REVISED DATE	4TH REVISED DATE	REPRESENTATIVE

NEW PRODUCT RELEASE

PRODUCT NAME:
DETAIL DESCRIPTION:

CUSTOMER NAME:	CUSTOMER MODEL NO.
PROJECT CODE:	PROJECT LEADER:
ISSUE NO.	ISSUE DATE:
C.I.L. NO.	M.F. NO.
EST. PROD. COST:	EST. DEV. COST:

TECHNICAL REQUIREMENTS
STATUTORY APPROVALS
FEATURES / FUNCTIONS
PACKING
OTHERS

ISSUED BY:	APPROVED BY:
DATE:	DATE:

REQUEST FOR CHANGE

PROJECT CODE:	DATE
PRODUCT NAME:	RAISED BY:
CUSTOMER MODLE NO.	APPROVED BY:
C.I.L. NO.	C.R. NO.
M.F. NO.	

REQUSTED CHANGE	
FROM STATUS:	
TO STATUS:	
REASON FOR CHANGE	
REQUIRED INTRODUCTION DATE	
FINAL DISPOSITION	**ACCEPT/REJECT**
COMMENTS	
SIGNATURE	DATE
IMPLEMENATION APPROVAL	
PRODUCTION	DATE
ENGINEERING	DATE
QUALITY CONTROL	DATE

DEPARMENTAL COMMENT

PROJECT CODE:	DATE
PRODUCT NAME:	RAISED BY:
CUSTOMER MODLE NO.	APPROVED BY:
C.I.L. NO.	C.R. NO.
M.F. NO.	

ENGINEERING DEPARTMENT	
SIGNATURE	DATE
TOOL DEVELOPMENT DEPARTMENT	
SIGNATURE	DATE
PMC DEPARTMENT	
SIGNATURE	DATE
PRODUCTION	
SIGNATURE	DATE
QUALITY CONTROL	
SIGNATURE	DATE
SALES & MARKETING DEPARTMENT	
SIGNATURE	DATE

CHANGE INTRODUCTION SCHEDULE

PROJECT CODE:
CHANGE DESC:
STATUTORY APPROVAL:
CUT-IN DATE:

C.R. NO.

ISSUE DATE:
LAST ISSUE:

COMPONENT / ASSEMBLY		**DELETED**	
PART NO.	DESCRIPTION	TOTAL STOCK	BALANCE
SPARE PARTS	REQ		
REVISION			
COMPONENT / ASSEMBLY		**ADDED**	
PART NO.	DESCRIPTION	TOTAL STOCK	PROD. QTY
SPARE PARTS	REQ		
REVISION			
COMPONENT / ASSEMBLY		**CHANGED**	
PART NO.	DESCRIPTION	TOTAL STOCK	PROD. QTY
SPARE PARTS	REQ		
REVISION			

APPENDIX IX INTEGRATED PROJECT MANAGEMENT PROCESS: AN EVALUATION OF EFFECTIVENESS IN SK-10

A) Outline of this report

Referring to integrated project management process tested in project SK-10 (Stainless Steel Tea Kettle), this report summarises the findings of evaluation study of its effectiveness. Part B reveals the objectives of this process, part C presents the major issues resolved by this process and part D presents the effectiveness measure in Attendance, Responsiveness, Accountability and Dependability.

B) Five Objectives of Integrated Project Management Process

This new project management process has 5 objectives

1. deliver finished products on schedule agreed in the supply order
2. provide formal channels of communication among the engineering department, tool development department, PMC department, Quality Assurance department, production
3. foresee design and manufacturibility problems
4. increase the responsiveness of each related department to engineering changes
5. align the development activities with project schedule

C) Nature of Issue and Resolution

Representatives from the Engineering department usually lead the meeting by reporting on the recent progress of the projects concerned. Agendas usually covered the followings as the main issues concerning product design, assembly design, project schedule and progress:

- schedule of tool development, procurement, assembly design, pilot run and production.
- design and manufacturability problems
- quality of raw materials and purchased parts
- engineering changes

Issues that were raised occasionally and not of major concern:

- production progress of certain projects
- availability of manufactured parts
- availability of packing materials and accessories
- readiness of assembly lines

D) Effectiveness Measurement

Its effectiveness was measured by Attendance, Responsiveness, Accountability and Dependability. Results are presented as follows.

i. Attendance

The Heads of production plant in China, Engineering, New Business, PMC and Quality Assurance were present in each meeting. Senior project engineers from the Engineering department and team leader from the PMC department also joined the meeting for their direct responsibility of the projects.

ii. Responsiveness

30% of issues being discussed were resolved immediately whereas 70% needed to be followed. The responsiveness of each department generally improved as the average lead time of providing feedback (e.g. inform the related party the date of completion of their request) was reduced to 2 or 3 days despite the fact that the lead time required to fulfill the request remained the same.

iii. Accountability

Accountability of each related department increased. Task priority was determined by the Engineering Department and communicated to all other departments. The production plant and PMC were more committed to ensuring the availability of resource required in pilot run and production. Raw material, purchased parts, packing materials and assembly line were ready before pilot run for most of the projects. However, the accountability of tool development department, PMC department, production was limited. For example, when quality problem existed in raw material and purchased parts, the Engineering department was held accountable for corrective actions.

iv. Dependability

The schedule of engineering build, pilot run and production of SK-10 was revised 4 times. Causes of revision included engineering changes, quality problems of parts and materials, and manufacturing problems exposed in the pilot run stage.

E) Conclusions

The project engineer of SK-10 spend less time on coordinating the jobs of related departments at the final stage of product development cycle. However, judging on the fact that the follow-up lead time of each request remains the same (*refer to ii)* and the assembly design, pilot run and production of projects was rescheduled 4 times (*refer to iii*), the impact of holding regular meetings on product development lead-time was therefore limited. As the process embraced in the development cycle remains unchanged, for example, the approval process for tooling quotation, once the Engineering department issues and even raise such a request to PMC in the meeting, the PMC still needed 2 weeks to get the request done. The integrated project management process had little effect on speeding up this process. However, it does provide a formal communication channel for all the related departments. Since the development progress of SK-10 was reported by each department, they felt a bigger pressure than before especially when they should make promises in front of colleagues.

APPENDIX X DATA OF PERFORMANCE MEASUREMENT (June 1997-May 1998)

Project Code	EW 2,3,4	SE 8	AST 7	AC 7	RG 3	CLK 4,5,6	MG 2	AWK 5	SSK 6	BT 3,4,5
Performance Indicators										
Planned Leadtime	4 Ms	4 Ms	5 Ms	7 Ms	7 Ms	4 Ms	8 Ms	4 Ms	4 Ms	7 Ms
Actual Leatime	4 1/2 Ms	4.5 Ms	7 Ms	8 Ms	7 1/2 Ms	4 1/2 Ms	8 1/2 Ms	4 Ms	5 1/2 Ms	8 1/2 Ms
Delays	1/2 Ms	0.5 Ms	2 Ms	1 Ms	1/2 Ms	1/2 Ms	0.5 Ms		1.5 Ms	1 1/2 Ms
Completed / Closed	Completed	Completed	Completed	Completed	Completed	Completed	Completed	Completed	Completed	Completed
Manufacturability appl										
Total Number of Engineering Changes	74	57	92	87	115	69	120	67	83	103
No. of engineering changes in detail design	30	19	38	30	43	24	47	23	32	44
No. of engineering changes in tooling design	33	23	37	39	45	29	41	31	39	39
No. of engineering changes in assembly design	9	9	14	16	12	14	14	10	10	13
No. of engineering changes in pilot run stage	2	6	3	2	15	2	18	3	2	7
Project Strategy										
Number or parts	64	83	71	74	53	65	78	70	61	73
Number of new product attributes appl!	1	3	0	0	5	1	5	1	1	1
Project Scope										
No. of Unique parts engineered by suppliers	11	17	12	9	11	10	11	9	9	11
No. of carryoover parts	36	39	34	41	21	39	29	41	34	41
No. of common parts	14	22	18	19	13	14	19	12	12	12
No. of Unique parts engineered only for this proj.	3	5	7	5	8	4	19	8	6	9
Problem Solving Cycle										
Pattern of Specialization										
Number of participating engineers	1	1	1	1	1	1	1	1	1	1
occasional helper appl!!	0	0	0	0	customer engin.	0	customer engin.	2	2	0
Methods of Integration	functional	functional	functional	functional	functional	functional	functional	functional	functional	functional
Resource allocation mechanism in PMC	Rank & File	Rank & File	Rank & File	Rank & File	Rank & File	Rank & File	Rank & File	Rank & File	Rank & File	Rank & File
	Friendship	Friendship				Friendship		Friendship	Friendship	Friendship
	negotiation	negotiation	negotiation	negotiation	negotiation	negotiation	negotiation	negotiation	negotiation	negotiation
Resource allocation mechanism in Prototype W.	Rank & File	Rank & File	Rank & File	Rank & File	Rank & File	Rank & File	Rank & File	Rank & File	Rank & File	Rank & File
	Friendship	Friendship	Friendship	Friendship	Friendship	Friendship	Friendship	Friendship	Friendship	Friendship
	negotiation	negotiation	negotiation	negotiation	negotiation	negotiation	negotiation	negotiation	negotiation	negotiation
Resource allocation mechanism in China Plant	Rank & File	negotiation	negotiation	negotiation	negotiation	Rank & File	negotiation	Rank & File	Rank & File	Rank & File
						negotiation		negotiation	negotiation	negotiation
Meeting between Department Heads for setting priority of resource allocation	4 /month	3 /month	4 /month	4 /month	4 /month	2 /month	3 /month	3 /month	2 /month	4 /month
Pattern of Concurrency										
Overlapping of process										
Was 1st working prototype developed before 1st set of parts engineering drawing completed	Yes (tradition)	Yes (tradition)	Yes (tradition)	Yes (tradition)	Yes (tradition)	Yes (tradition)	Yes (tradition)	Yes (tradition)	Yes (tradition)	Yes (tradition)
Was draft BOM sent to PMC before the authorized BOM formally released	Yes (tradition)	Yes (tradition)	Yes (tradition)	Yes (tradition)	Yes (tradition)	Yes (tradition)	Yes (tradition)	Yes (tradition)	Yes (tradition)	Yes (tradition)
Had manufacturing process started before off-tool sample completed	No (tradition)	No (tradition)	No (tradition)	No (tradition)	No (tradition)	No (tradition)	No (tradition)	No (tradition)	No (tradition)	No (tradition)
Information Processing										
Formal communication with PMC (Weekly)	5	3	3	2	3	4	4	4	5	2
Informal communication with PMC	1	2	2	1	1	1	2	1	2	2
Formal communication with China Plant	daily	daily	daily	daily	daily	daily	daily	daily	daily	daily
Informal communicaiton with China Plant	daily	once a week	3 times / week	once a week	once a week	daily	3 times / week	daily	daily	daily
Information Mismatch										
Increase in tooling cost	No	No	Yes	No	Yes	No	No	No	Yes	Yes
Insufficient parts or material for pilot run or production	Yes	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes
Parts or material purchased deviated from specification	No	Yes	Yes	No	Yes	No	Yes	No	No	No
Internal Communication in Engineering Dept.										
Formal communication with group members	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
Informal communication with group members	daily (senior)	10 times/wk (seni)	2 /wk (senior)	2 /wk (senior)	daily (senior)	daily (senior)	daily (senior)	daily (senior)	daily (senior)	daily (senior)
Formal communication with other project groups	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
Informal communicaiton with other project gps	once a week	Nil	Yes	Yes	once a month	once a week	once a month	once a week	once a week	once a week