A model driven methodology to measure the Level of Application of Management Process (LAMP) in manufacturing enterprise

A Model Driven Methodology to Measure the **L**evel of **A**pplication of **M**anagement **P**rocess (LAMP) In Manufacturing Enterprise

By

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Abstract

Increasingly Manufacturing Enterprises (MEs) need to perform competitively to survive in today's global markets. This thesis investigates the notion that competitive product realisation is not simply dependent on deploying state of the art 'operational' and 'infrastructural support' processes but also depends upon the adoption of 'management' processes that ensure efficient and effective use of human and non human resources.

Having an experience of more than two decades working in a public sector ME located in Pakistan the author has observed that improvements in timelines, quality and profit begins from measurement; followed by goal, problem & solution understanding, then planning and control of needed change. Therefore, a desire to enhance best practice qualitative and quantitative measurement of management processes triggered and focussed this research. Consequently the aim of this research has been to contribute to knowledge by using state of the art modelling techniques to structure and enable quantitative measurement of management processes within MEs. Subsequent research of the author has conceived, implemented and case tested a modelling methodology that is designed to measure the Level of Application of Management Process (LAMP) in pursuit of ME productivity improvement.

In order to achieve the aim of this research, a semi generic model of 'management processes deployed in MEs' was defined and explicitly modelled by using an ISO Enterprise Modelling technique. The definition of this semi-generic model was realised consequent upon (1) a literature review and (2) conducting semi-structured interviews with experts (n=42) in three public sector MEs located in Pakistan. Use of the Enterprise Modelling technique enabled decomposition and classification of management processes into so called Domain Processes, which subsequently were explicitly defined as Business Processes at a more detailed level of modelling abstraction. Then during subsequent research the author conceived and developed the use of a methodology to apply a LAMP scorecard the use of which was tested whilst conducting structured interviews with project managers (n=25) in three public sector MEs located in Pakistan that operate on project oriented management structures.

The case study results partially validated the 'fitness for purpose' of the model driven measurement methodology, identified opportunities for future methodological research and illustrated how LAMP identified and enabled measurements can help to define, quantify and direct potential opportunities for ME enhancement.

Keywords: Productivity improvement, performance management, transformational processes, process thinking, management processes, enterprise modelling.

Abbreviations

ARIS	Architecture for Information Systems
BP	Business Processes
CIM	Computer Integrated Manufacturing
CIMOSA	CIM Open Systems Architecture
DP	Domain Processes
EA	Enterprise Activities
EM	Enterprise Modelling
GERAM	Generalized Enterprise Reference Architecture and Methodologies
GRAI	Graphs with Results and Activities Interrelated
GIM	Graphs with Integrated Methodology
HR	Human Resource
IEM	Integrated Enterprise Modelling
IT	Information Technology
LAMP	Level of Application of Management Process
ME	Manufacturing Enterprise
MoU	Memorandum of Understanding
MSI	Manufacturing System Integration
OEEC	Organization for European Economic Cooperation
PERA	Purdue Enterprise Reference Architecture
PMBoK	Project Management Body of Knowledge
PMI	Project Management Institute
PMS	Performance Measurement System
RPM	Rahimifard P Monfared
SM	Simulation Models

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Chapter 1: Introduction

This chapter considers the research problem and the reasons for undertaking this research. The background rationale for the chosen research focus is explained. Subsequent sections outline the research aim, the study objectives and the approach to be adopted to achieve the research aims. Finally, the structure of the thesis is outlined.

1.1 Research Problem

An incident that triggered the research is an observation noticed by the author during the production of a sub assembly in a public sector Manufacturing Enterprise (ME) of Pakistan. A request was made to provide a sub assembly as a replacement for a non-conformant product. Having followed normal planning procedures of that organisation, the company middle management allocated a time period of 35 days for the team responsible to produce a sub assembly that could provide a suitable replacement. But senior management deemed that the time allocation was unacceptably long and became involved in negotiations; such that ultimately the production team agreed to reduce the project duration to 21 days without demanding additional resources. The team started working and was able to produce a suitable replacement in 18 days while working within normal working hours. A product that could have taken 35 days to produce was made ready in 18 days without using extra resources. This observation compelled the author to think that there was something of importance, which contributed to the timeliness of this product realisation.

In the above incident a commitment to continuous monitoring and decision making at all hierarchical levels of management allowed the working team to use the resources available to them in an efficient and effective way. The observation highlighted to the author that producing a product is not only dependent on technical processes but it is also linked to the efficient and effective use of human and non-human resources. Therefore the author deduced that efficient and effective product realisation has a strong dependence on the management of available resources. This observation by the author was subsequently illuminated further by his literature study and by subsequent project management experiences. Therefore in his PhD research the author chose to study the following: how ‘productivity improvement of product realisation can be achieved through improved management processes’ a research topic. Having reviewed the literature at some length the enormity of this study area became apparent so that for reasons explained in this thesis the author more definitively focused his study on ‘measuring and quantifying the extent to which management processes are deployed within manufacturing enterprises (MEs)'.

1.2 Research Context

Manufacturers in almost every industry find themselves competing with companies from every corner of the globe. The competition is fierce and the competitors are outstanding. In order to succeed, a manufacturing enterprise (ME) needs to change with the changing environment to become more productive. Productivity is of vital importance to a company's ability to compete and grow over time and is considered as one of the basic variables governing economic production activities, perhaps the most important one (Singh et al, 2000). A company that is not able to efficiently and effectively utilize its resources in creating value for its customers will not survive in the competitive business environment of today (Mask ell, 1991). According to Bernolak (1997), productivity means how much and how well we produce from the resources used. Resources can be human and physical i.e. the people who produce the goods or provide the services, and the assets by which the people can produce the goods or provide the services. Productivity can be considered to increase when more or better products are produced from the same resources or the same goods are produced from lesser resources. **Performance management of resources** to improve productivity and effectiveness of an ME is the context of this research.

1.3 Research Focus

Researchers have classified the transformational processes as manage, operate and support processes (Pandaya et. al., 1997). Productivity refers to the ratio between the actual result of the transformation process and the actual resources used (Jan Ree, 2002 cited by Tangen, 2004). Researchers have made many efforts to improve operate and support processes which has resulted in the development of many methods, tools, techniques and technical systems such as 'lean manufacturing, just-in-time, kaizen and kanban' etc. Scheer (1994) emphasized the dynamic nature of decision and action making about processes, with respect to a) the need to transform material (physical) and informational (logical) entities, and b) resource allocation and the design of information systems. Weston (1997) realises that multi-purpose organizations do not focus solely on product realization but also on efficient management of resources and processes. Having an experience of more than two decades, of working and managing in a public sector manufacturing enterprise the present author also believes that a) to improve productivity usually 'operate' (technical) and 'support' processes are targeted as areas of improvement and the ‘management’ process may not be given much consideration and rather may be inherited from in post, or previously in post, managers, and b) performance improvement begins from measurement.

Management processes are known however to facilitate the achievement of organizational goals, by engaging in four major functions; planning, organizing, leading and controlling (Stephen and Dennis, 1987). The quality and quantity of these functions are crucial to effective management (Bernolak, 1997). Quality is related to ‘how well’ the functions are being performed. The quantity is linked to ‘how much’ of these functions are applied or carried out. In this research, measuring the application level of management processes to improve the performance of adopted manage process in ME is the focal point of study.

1.4 Research Aim and Objectives

It follows that this research was initiated from a general observation. Namely that industry at large requires improved methods of quantifying the extent to which management processes are being carried out, such that in any given ME its products and services will be realised in alignment with productivity goals. Therefore, developing a methodology to measure the level of application of management process in subject manufacturing enterprises, in pursuit to improve productivity and effectiveness, is the aim of this research. In order to fulfil this aim, the following study objectives were defined:

- To decompose the management processes of ME to a level where suitable indicators can measure these.
- To represent and visualize the management process decomposition of any given ME by using an appropriate modelling technique.
- To develop a methodology to measure the level of application of management process (LAMP) in MEs
- To conduct testing of the proposed methodology of LAMP in case MEs.
- To analyze and validate the test results and highlight improvement potentials.

1.5 Research Assumption

The following critical research assumptions are made to avoid complexity and remain focused on the research aim and its associated objectives:

- Improvements can be gained through the measurement of management processes, as ultimately this will positively affect the performance of the product realization processes being managed. But resultant impacts of these affects will not be considered in any detail in this study.
- Measuring the extent (or completeness) to which any selected management approach has been adopted may not be particularly fruitful if that approach is not well suited to the issues faced by a particular ME and/or the environment in which the ME has to operate. It is assumed therefore that the management approach that should be applied in any case MEs is deemed previously to be 'fit for purpose'.

1.6 Research Approach

The authors' research study was initiated by observing a specific problem during production. This was followed by a study of relevant management literature and this triggered a thought process aimed at finding methods for measuring the level of application of management process (LAMP). It follows that this research is basically an applied research study (Kumar, 2005). However the research approach adopted to scientifically test the proposed methodology can be classified as being case study research based (Yin, 2003). The overall research journey followed by the author has been divided into the research phases shown in figure 1-1 and explained in table 1-1:

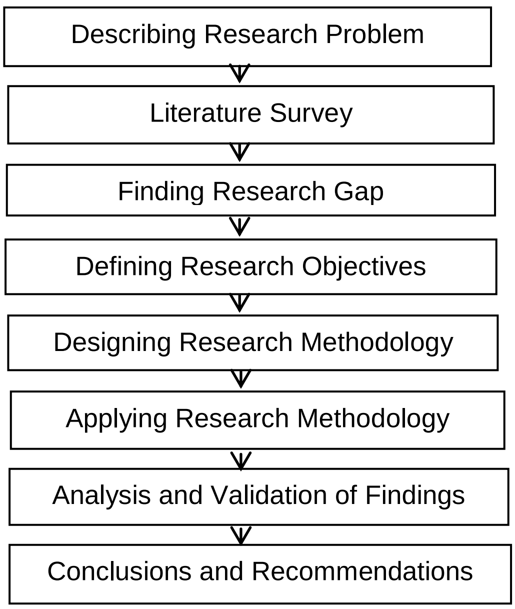

Figure 1-1: Research Journey process flow

Table 1-1 presents the general research approach, which was proposed to fulfil the needs of this research.

S#	Research Phases	Description
1	Describing Research Problem	Overview of research problem, context, focus, objectives, approach and thesis structure.
2	Literature Survey	Literature survey on productivity, management process, enterprise modelling and key performance indicators. Reviewing other peoples opinion
3	Research Gap	In the light of literature review find what is lacking in order to solve the observed problem
4	Defining Research Objectives	Specifying the research aim and defining explicit and measurable objectives
5	Designing Research Methodology	Conceptualizing and developing the research methodology to be able to conduct the research.
6	Applying Research Methodology	Undertaking case study to apply and test the research methodology while gathering the research data.
7	Analysis of Research Findings	Applying standard tools and techniques to analyze the research data.
8	Conclusions and Recommendations	Highlighting constraints and drawing conclusions based on the analysis of research data. Discussing contribution made to pre-existing knowledge. Recommending future work.

Table 1-1 Research journey

1.7 Thesis Structure

Chapter 1 includes an overview of the research problem and describes the context, focus, objectives, approach and thesis structure.

In chapter 2, a literature survey on productivity, management process, enterprise modelling and key performance indicators is detailed.

In chapter 3, the research gap is identified and general literature about research methods and data collection techniques are presented.

In chapter 4, the research methodology specifications are conceptualized to fulfil research aim.

In chapter 5, a detailed research methodology is designed and developed to meet the research objectives.

In chapter 6, a suitable enterprise modelling technique is identified and used to visualize the decomposed management process segments of case MEs.

In chapter 7, the level of application of manage process (LAMP) scorecard is developed; case studies are conducted in three MEs; and results so obtained are presented.

In chapter 8, an analysis of management processes modelling carried out, LAMP scorecard results, a validation of results is carried out, research limitations are considered and research conclusions are drawn related to the new knowledge generated and future research opportunities observed.

Chapter 2: Literature Review

The foregoing highlights problems faced by multi-functional MEs towards performance management of resources in pursuit to improve ME effectiveness. The description of the research focus highlighted important disciplinary areas in which further literature needs to be reviewed. Keeping this in mind following sections describe some of the key literature on productivity, productivity improvement, transformational processes in ME, management processes, performance management and enterprise modelling.

2.1 Productivity

In a formal sense the word productivity was mentioned for the first time, in an article by Quesnay in 1766. More than a century later, in 1883, Littre defined productivity as the "faculty to produce" that is the desire to produce (Tangen, 2004). The concept of productivity (generally defined as the relation between output and input) has been available for over two centuries and applied in many different circumstances on various levels of aggregation in the economic system. It is argued that productivity is one of the basic variables governing economic production activities, perhaps the most important one (Singh et. al., 2000). It was not until the early twentieth century, however, that the term acquired a more precise meaning as a relationship between output and the means employed to produce that is input. In 1950, the Organization for European Economic Cooperation (OEEC) offered a more formal definition of productivity "Productivity is the quotient obtained by dividing output by one of the factors of production. In this way it is possible to speak of the productivity of capital, investment, or raw materials according to whether output is being considered in relation to capital, investment or raw material, etc." (Sumanth, 1994). Tangen, (2004) has organized different definitions of productivity, which are tabulated in table 2.1.

Definition	**Reference**
Productivity = Faculty to produce	(Littre, 1883)
Productivity is what man can accomplish with material, capital and technology. Productivity is mainly an issue of personal manner. It is an attitude that we must continuously improve our self and the things around us.	(Japan Productivity Centre, 1958 (from Bjorkman, 1991))
Productivity = Units of output / Units of input	(Chew, 1988)

Productivity = Actual Output / Expected Resources Used	(Sink and Tuttle, 1989)
Productivity = Total income / (Cost + goal profit)	(Fisher, 1990)
Productivity = Value added / Input of production factors	(Aspen, 1991)
Productivity is defined as the ratio of what is produced to what is required to produce it. Productivity measures the relationship between output such as good and services produced, and inputs that include labour, capital, material and other resources.	(Hill, 1993)
Productivity (output per hour of work) is the central long-run factor determining any population's average of living	(Thurow, 1993)
Productivity = the quality or state of bringing forth, of generating, of causing to exist, of yielding large result or yielding abundantly	(Koss and Lewis, 1993)
Productivity means how much and how well we produce from the resources used. If we produce more or better goods from the same resources, we increase productivity. Or if we produce the same goods from lesser resources, we also increase productivity. By 'resources', we mean all human and physical resources, i.e. the people who produce the goods or provide the services, and the assets with which the people can produce the goods or provide the services.	(Bernolak 1997)
Productivity is a comparison of the physical inputs to a factory with the physical outputs from the factory	(Kaplan and Cooper, 1998)
Productivity = Efficiency * Effectiveness = Value adding time / Total time	(Jackson and Petersson, 1999)
Productivity = (Output / Input) * Quality = Efficiency * Utilization * Quality	(Al-Darrab, 2000)
Productivity is the ability to satisfy the market's need for goods and services with a minimum of total resource consumption	(Moseng and Rolstadas, 2001)
Productivity refers to the ratio between the actual result of the transformation process and the actual resources used	(Jan van Ree, 2002)
Productivity = Customer value / Used resources	(Tangen, 2004)

Table 2-1 Different definitions of Productivity (Tangen, 2004)

Productivity development is based on the four phases of the productivity management cycle (see figure 2.1) (Sumanth, 1994).

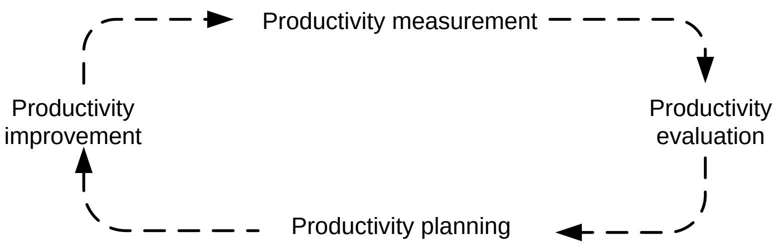

Figure 2-1: Productivity management cycle (Sumanth, 1994)

2.1.1 Forms of Productivity

Forms of productivity mentioned by Sumanth, (1994) are:

- **Partial productivity** - it is the ratio of output to one type of input. For example, labour productivity (ratio of output to labour input) is a partial productivity measure.
- **Multi-factor productivity** - it is the ratio of net output to the sum of associated different inputs, for example ratio of labour, material and capital assets inputs to net output.
- **Total productivity** - it is the ratio of the sum of total input factors. Thus a total productivity measure reflects the joint impact of all the inputs in producing the output.

Kurosawa, (1991) has given a model explaining the forms of productivity (see figure 2.2).

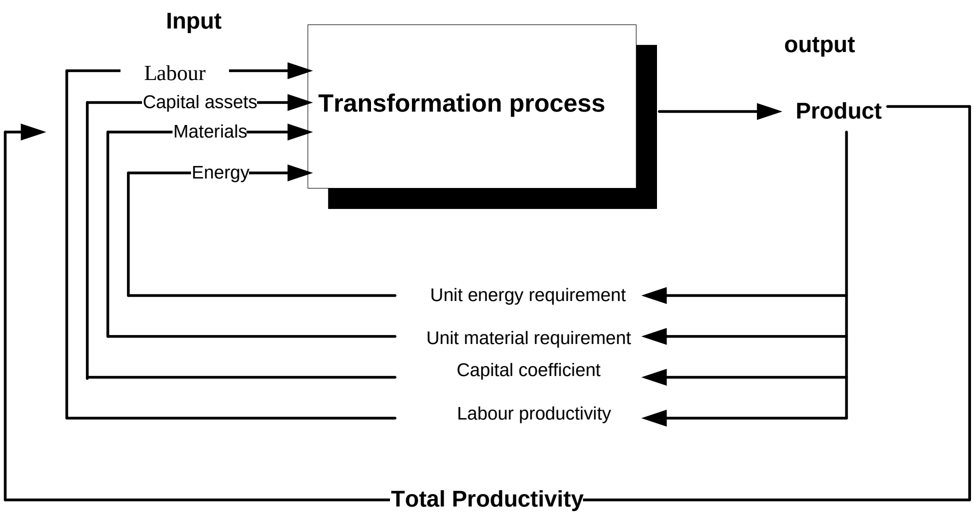

Figure 2-2: Forms of Productivity (Kurosawa, (1991)

Productivity improvement is a multidisciplinary issue and must therefore be addressed from several different angles at the same time. One way to improve productivity in a company could, for example, be to focus on the reduction of waste and implement strategies like Just-In-Time (JIT) or Lean Production, which makes it possible to use resources more efficiently. Another way could be to introduce new Advanced Manufacturing Technologies (AMT), which enables a company to manufacture its products faster and more effectively (Tangen, 2004).

2.2 Productivity Improvement

Productivity is a relative concept (Tangen, 2004). Basically, improvements in productivity can be caused by five different relationships (Misterek et. al., 1992):

- Output increases faster than input, but the increase in input is proportionately less than the increase in output (managed growth).
- More output from the same input (working smarter).
- More output with a reduction in input (the ideal).
- Same output with fewer input (greater efficiency).
- Output decreases, but input decreases more, but the decrease in input is proportionately greater than the decrease in output (managed decline).

Productivity is in industrial engineering defined as the relation of output (i.e. produced goods) to input (i.e. consumed resources) in the manufacturing transformation process. Productivity is therefore, on the one hand, closely connected to the use and availability of resources. This means in short that productivity is reduced if a company's resources are not properly used or if there is a lack of them. On the other hand, productivity is strongly linked to the creation of value. Thus, high productivity is achieved when activities and resources in the manufacturing transformation process add value to the produced products (Tangen, 2002b). Furthermore, the opposite of productivity is represented by waste, which must be eliminated in order to improve productivity.

Productivity means 'how much' and 'how well' is produced from the resources used. If it produces more or better goods from the same resources, it increases productivity. Or if it produces the same goods from lesser resources, it also increases productivity. By 'resources', it means all human and physical resources, i.e. the people who produce the goods or provide the services, and the assets with which the people can produce the goods or provide the services. The resources that people use include the land and buildings, fixed and moving machines and equipment, tools, raw materials, inventories and other current asset" (Bernolak, 1997).

2.3 Transformational Processes in Manufacturing Enterprise

2.3.1 Process Thinking

Many organisations can benefit from encouraging personnel to collectively engage in 'process thinking', i.e. thinking about current and possible future ways in which organised sets of value added activities can realise business goals by transforming inputs (such as material, sub-products, information and knowledge) into outputs (like products and services) required by customers (Vernadat, 1996; Weston, 1999). In principle, process thinking naturally enables choices to be made between alternative candidate resources (be they human or technical resources) that possess abilities needed to accomplish sets of value added activities required within defined constraints, including cost and time. Process thinking can underpin key aspects of detailed system design and implementation, such as by enabling related operating sequences, information and control flows, and supporting information structures to be specified and realised. Process thinking can lead to the creation of models of robust system operation (and systems interoperation) in the field, such as by helping to create visual and computer executable models of dynamic (time dependent) process behaviours that might be subject to bottlenecks and fault conditions. Resultant process simulation can help to analyse and predict potential problems, and can ultimately lead to improved progression and coordination of product and service flows (Weston, et. al., 2004).

2.3.2 Process Classification

Vernadat (1996) states that 'processes represent the flow of control in an enterprise'; they constitute 'a sequence of enterprise activities, execution of which is triggered by some event'; 'most processes have a supplier of inputs and all have customer(s) using outputs'. Scheer (1994) emphasized the dynamic nature of decision and action making about processes, with respect to (a) the need to transform material (physical) and informational (logical) entities, and (b) resource allocation and the design of information systems. Weston (1999) observed that: (a) process models are a conceptualization of actions needed to achieve real-world transformations within finite timeframes; (b) different process types involve different actions, or order actions differently, so as to achieve alternative real-world transformations, during a given process instance; and (c) commonly multiple instances of processes are realized so as repetitively to achieve similar real-world transformations over extended timeframes that can be considered to constitute the useful process lifetime.

Pandya et al. (1997) has classified process in three main classes namely; a) generic management process, b) generic operate process and c) generic support process. An enterprise can be considered to consist of a number of processes that are realized concurrently by enterprise resources that contribute towards the overall objectives of the organization (Kosanke, (1997), Mertins et. al., (1995)). Literature classifies common processes (i.e. ordered sets of activities carried out by human and technical resources that add value to process inputs including material, information and knowledge) used by manufacturing enterprises (MEs). Two such classifications are shown in figure 2.3 (Salvendy, (1992), Pandya et al. (1997), Rahimifard and Weston, (2005)).

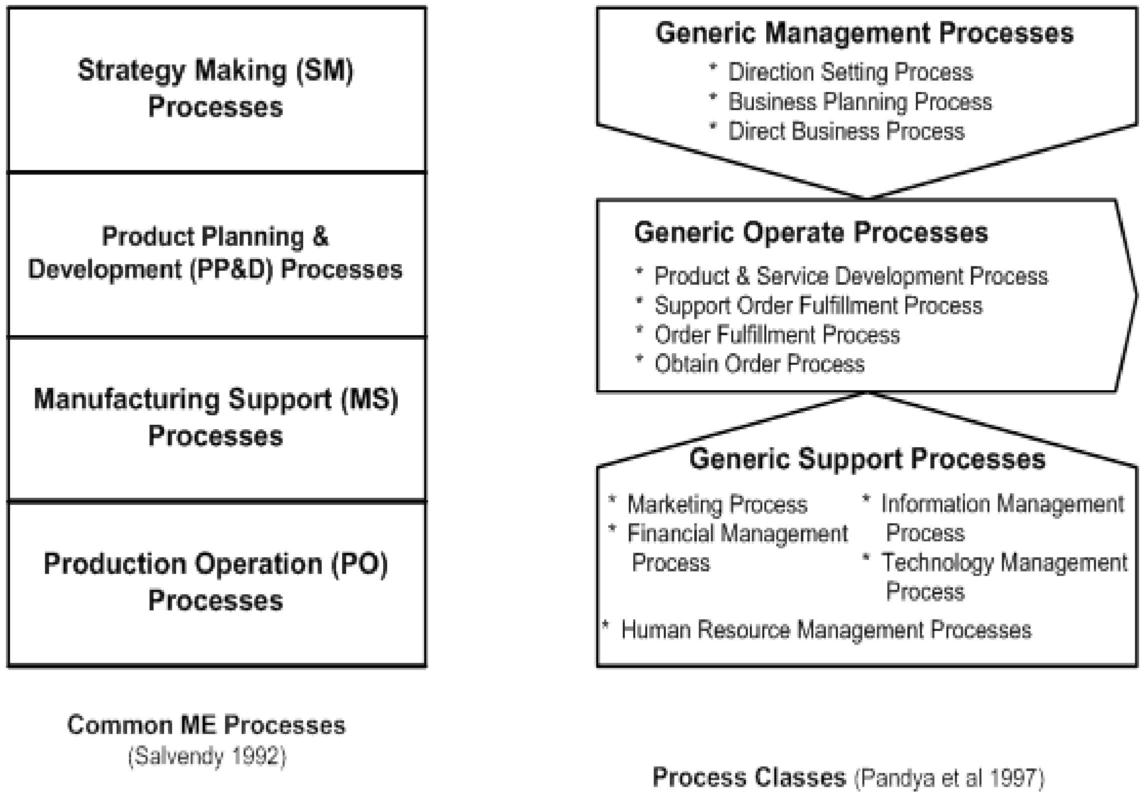

Figure 2-3: Common Process Types Found in ME's (Rahimifard and Weston, (2005))

A number of authors have classified common ME processes. Table 2.2 compares and contrasts three such classifications developed independently by Weston et. al., (2004).

Salvendy (1992) Process Classification	Pandya et al. (1997) Process classification	Chatha, (2004) Process and activity classification
Strategy making process	Generic Management process group, includes: ‘direction setting process’; ‘business planning process’;’ direct business process’	Strategic process: predominantly ‘what activities’: that decide what the ME should do and develop business goals and plans to achieve the ME purposes defined.
Product planning and development process	Generic operate process group, includes: ‘obtain an order process’; ‘product and service development process’;’ order fulfilment process’	Tactical process: predominantly ‘how activities’: that decide how segments of the business plan might best be achieved and as required specifying, designing, developing new products, processes and systems with ability to achieve business plans.
Manufacturing Support process	Generic support process group, includes: ‘human resource management process’ ‘financial management process’ ‘information management process’ ‘marketing process’ ‘technology management process’	Operational process: predominantly ‘do activities’ that repetitively Create products and services for customers, and thereby realize business objectives and goals
Production operation Process	-----	----

Table 2-2 Different concepts of Process Classification (Weston et. al., 2004)

Process type descriptions enable similarities and differences to be drawn between MEs (Weston, et. al., 2004). In reality all MEs are unique because they:

- Differently decompose process segments into organizational units.
- Resource processes and process segments differently
- Have very different numbers and patterns of process instances so that they can realize large or small batches of products for customers; achieve lean, as opposed to agile manufacturing; and so forth.

Another important observation that can be drawn is that ‘operational processes’ comprise those activities that should be repeated to realize products and services for customers (Weston, et. al., 2004). Whereas 'strategic processes' and 'tactical processes' should collectively ensure that all needed operational processes are specified, designed, implemented, resourced, managed, monitored, maintained, developed and changed through their lifetime, such that they continue to realize products and services of quality, on time and at an appropriate price for customers, whilst also ensuring that the ME achieves its defined purposes for stakeholders so that the ME renews itself at appropriate points in its lifetime. Pandya et. al., (1997) process classification separates out a support process group, that is 'infrastructural' in nature, i.e. the purpose of this support group is to enable other process groups, rather than control or directly contribute to strategy, process, system, product or service realization. Such a conceptual separation promotes separated execution and (re) engineering of processes over appropriate timeframes.

2.4 Management Process

A study by Stephen and Dennis (1987) shows that management process is the input of work agenda, work methods and roles along with knowledge base and key management skills fed into the core management functions to achieve organizational goals. An extended model of management process is shown in figure 2.4.

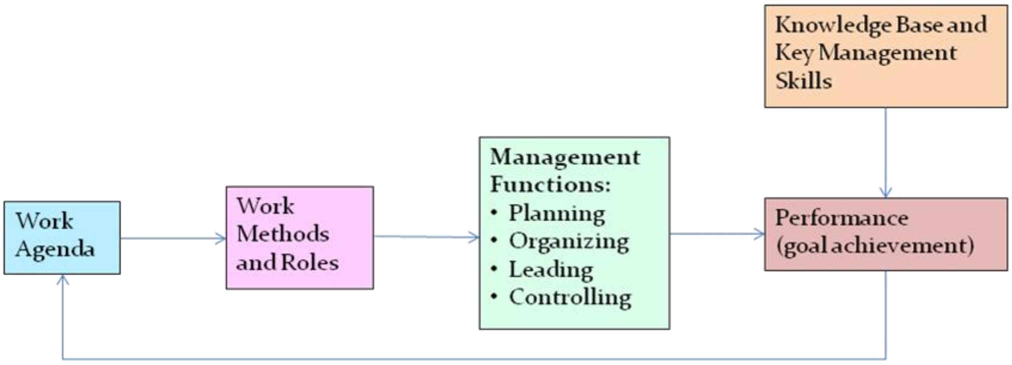

Figure 2-4: An extended model of the management process (Kathryn and David, 1998)

2.4.1 Work Methods and Roles

According to Mintzberg (1980), "a role is an organized set of behaviours associated with a particular office or position". He categorized the managers' various activities during their workday into three general types of roles as interpersonal roles, informational roles and decisional roles. He found that instead of systematic planning and formal reports reviewing, the work methods include unrelenting pace, brevity, variety and fragmentation of tasks. Managers prefer to build network of contacts in order to have influence and to operate effectively.

2.4.2 Knowledge Base

Knowledge base includes information about an industry and its technology, company policies and practices, company goals and plans, company culture, personalities of key organizational members and important suppliers and customers (Kathryn and Dravid, 1998).

2.4.3 Key Management Skills

Richard (1982) defined skill as the ability to engage in a set of behaviours that are functionally related to one another and that lead to a desired performance level in a given area. Management skills are classified as technical, human and conceptual (Kathryn and Dravid, 1998).

- **Technical Skills** - Skills that reflect both understanding and proficiency in the specialized field.
- **Human Skills** – The ability to work well with others both as a member of a group and as a leader.
- **Conceptual Skills** – Are related to the ability to visualize the organization as a whole, discern interrelationships among organizational parts and understand how the organization fits into the wider context of the industry, community and world.

2.4.4 Management Functions

Management is the process of achieving organizational goals by engaging in the four major functions of planning, organizing, leading and controlling (Stephen and Dennis (1987). Figure 2.5 gives an overview of the functions of management (Kathryn and David, 1998).

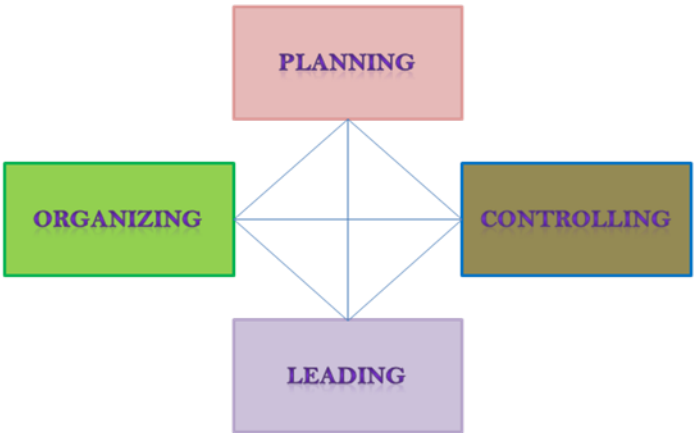

Figure 2-5: The functions of management (Kathryn and David, 1998)

The four management functions are defined as (Kathryn and David (1998)):

- **Planning:** The process of setting goals and deciding how best to achieve them.
- **Organizing:** The process of allocating and arranging human and non-human resources so that plans can be carried out successfully.
- **Leading:** The process of influencing others to engage in the work behaviours necessary to reach organizational goals.
- **Controlling:** The process of regulating organizational activities so that actual performance conforms to expected organizational standards and goals.

2.4.5 Levels of Management

Management levels can be divided on the basis of two important dimensions such as vertical dimension and horizontal dimension as illustrated in figure 2.6.

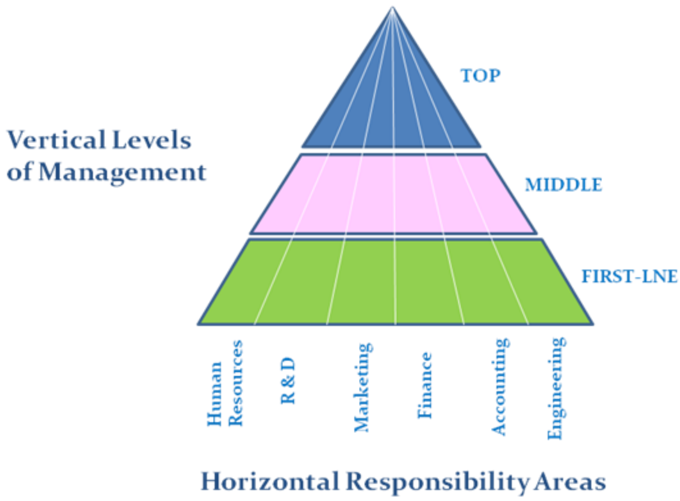

Figure 2-6: Managers types by hierarchical level and responsibility area (Paula and Dalton, 1991)

2.4.5.1 Vertical Dimension: Hierarchical Levels

The vertical dimension focuses on three different levels of managers in the organization: first line, middle and top level management. These three levels of management are briefly explained as (Paula and Dalton, 1991) and (Rosabeth, 1989):

- **First-line managers:** First-line managers are directly responsible for the work of operating (non-managerial) employees and operate at the lowest level of the hierarchy. Their titles include supervisors, group leaders, section in-charge etc. They are mainly responsible for planning, executing and monitoring the day-to-day operations at micro level and to ensure that the daily activities run smoothly in order to achieve the organizational goals.

- **Middle managers:** Middle managers are directly responsible for the work of managers at lower levels and are located beneath the top levels of the hierarchy. Their titles include manager, chief, division head, department head etc. They have the responsibility of implementing and monitoring specific organizational plans so that overall organizational targets can be achieved.
- **Top Managers:** Top managers are ultimately responsible for the entire organization and are located at the top levels of the hierarchy. They work to some extent with middle managers in implementing the overall plans of the organization, and maintain an overall control over the progress of the organization. Their typical titles include president, executive director, chief executive officer etc.

2.4.5.2 Horizontal Dimension: Responsibility Areas

The horizontal dimension addresses variations in managers' responsibility areas that include human resources, research and development (R&D), marketing, finance, accounting, engineering, etc.

2.4.6 Emphasis of Management Functions at Different Hierarchical Levels

Management functions apply to all three hierarchical levels; however, there are some differences in emphasis as mentioned in figure 2.7 (Kathryn and David, 1998).

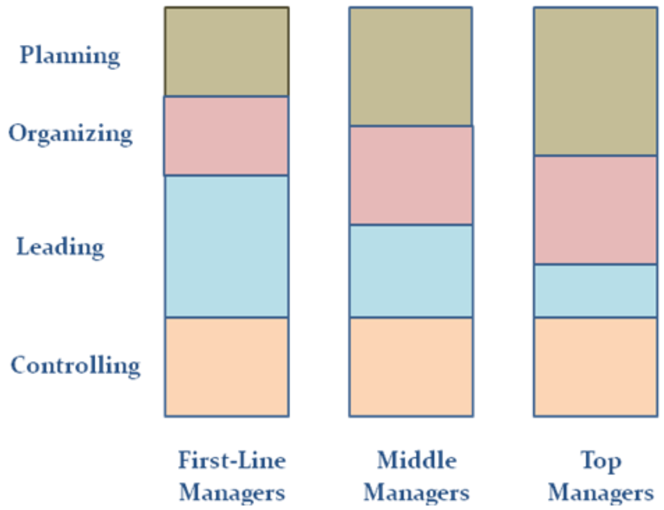

Figure 2-7 Emphasis of management functions at different hierarchical levels (Kathryn, 1998)

From figure 2.7 it appears that strategic planning tends to be more important for top managers because top managers are responsible for determining the overall direction of the organization. Middle and first-line managers also carry out planning but its nature differs i.e. tactical planning. Organizing seems more important for both top and middle managers because they are mainly responsible for arranging and allocating resources for different project activities. Leading tends to be more important for first-line managers because they are mainly responsible for the on-going production of goods or services. First-line managers engage in substantially high degree of communication, motivating and directing than the managers at higher levels. Common degree of emphasis is required for monitoring activities and taking corrective actions at all hierarchical levels (Kathryn and David, 1998).

2.4.7 Effect of Management Levels on Goals

Organizations typically have three levels of goals: strategic, tactical and operational. Strategic goals are long-term goals and are set by top-level management. Tactical goals are medium term and are set by middle managers whereas the first line managers are responsible for setting the short-term (operational) goals. According to Luis et, al,. (1985), relative importance of four management functions varies somewhat based on managerial level.

Chatha and Weston (2005) mentioned that manufacturing organization could be conceptualized as comprising three classes of processes, namely: strategic class of processes, tactical class of processes, and operational class of processes (BS ISO-14258, 1998). The primary purpose of strategic class of processes is to decide long-term objectives and make strategic plans for an organization. The prime purpose of tactical class of processes is to explore means of realizing strategic plans, thereby enacting product and process development in order to ensure that the organization has capabilities and resources required to realize strategic intent. Whereas the operational process class constitutes mostly ordered sets of activities that produce valuable outputs needed by customers.

2.4.8 Importance of Management Skills on Hierarchical Levels

Same management skills apply to all three hierarchical levels of management, however, major differences stem mainly from the relative importance of the key management skills at different levels of management (Figure 2.8).

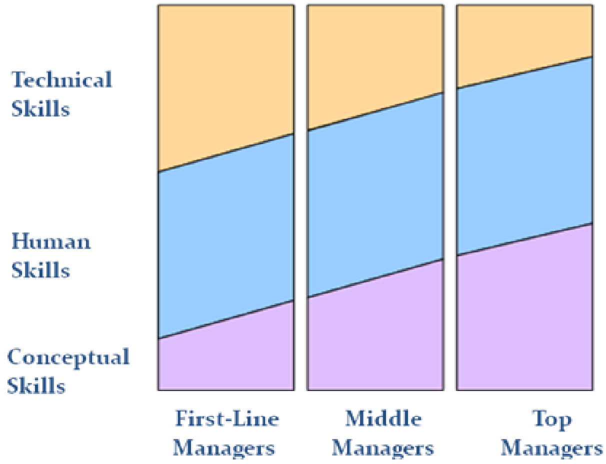

Figure 2-8 Importance of key management skills at different hierarchical levels (Kathryn, 1998)

First-line managers directly supervise most of the technical and professional employees who are not managers, therefore, they need to have the greatest need for technical skills as illustrated in figure 2.8. At the same time, middle managers often need sufficient technical skills because they have to coordinate with the subordinates and identify major problems (Derek and Jane, 1987). When technology is particularly an important part of the product/service of the organization then top managers must have some technical skills. Otherwise, they may have difficulty in devising strategies to stay ahead of the competition, fostering innovation and allocation of resources efficiently. Since all three levels of management must get things done through people, therefore, they all require strong human skills (Cynthia and Alan, 1987). Managers lacking sufficient human skills may run into serious difficulties while dealing with people inside and outside the organization. Surprisingly, promotions criteria of first-line managers are often based on good technical skills with little or no attention is given to the importance of human skills. Managers who reach relatively high levels may find little chance of upward movement due to lack of personal skills (Ellen and Jean, 1995). Figure 2.8 shows that conceptual skills are considered more important for top managers because top managers need to understand how the various parts of the organization relate to one another and associate the organization with the world outside (Kathryn and David, 1998).

2.5 Performance Management

Peter Drucker pointed out that performance achieved through management is actually made up of two important dimensions namely effectiveness and efficiency (Drucker, 1967).

- **Effectiveness:** The ability to choose appropriate goals and achieve them (doing the right things).
- **Efficiency:** The ability to make the best use of available resources in the process of achieving goals (doing things right).

In order to be good performers, the organizations need to demonstrate both effectiveness (doing the right things) and efficiency (doing the things right). Performance measurement provides the basis for an organization to assess how well it is progressing towards its predetermined objectives, helps to identify areas of strength and weaknesses, and decide on future initiatives with the goal of improving organizational performance. Measurement is not an end in itself but a tool for more effective management. Results of performance measurement indicate what happened, not why it happened or what to do about it (Amaratunga and Baldry, 2002).

2.5.1 Performance Measurement

Performance measurement systems historically developed as a means of monitoring and maintaining organizational control that is the process of ensuring that an organization pursues strategies that lead to the achievement of overall goals and objectives (Nani et. al., 1990). Neely et. al., (1995) describes performance measurement as the process of quantifying action, where measurement is the process of quantification and action correlates with performance. Performance measurement is defined as the process of quantifying the efficiency and effectiveness of action (Tangen, 2004).

Fitzgerald et. al., (1991) concluded in a study of the service industry that there are two basic types of performance measures in any organization: those that relate to results (competitiveness, financial performance) and those that focus on the determinants of the results (quality, flexibility, resource utilization and innovation). Namely, different performance measures are needed for various hierarchical levels of an organization. For instance, the management of a company will not have the same performance measures as the personnel working at an assembly line. However, it is vital that there is a clear link between the performance measures at all hierarchical levels, so that each function in a company works towards the same objectives. Normally, most decisions at the top of an organization have a strategic focus, while decisions at lower levels are more tactically and operationally oriented (Tangen, 2004):

- At the strategic level performance measures are related to decisions having effect on issues with a time scale of several years. Such measures can tell an organization about the soundness of their strategic decisions.

- At the tactical level performance measures covers a monthly up to a yearly period, and can be said to encompass issues like which suppliers are used, which overall manufacturing technologies are utilized etc. These measures are important in setting boundaries for the actual operations of the organization.
- At the operational level performance measures deals with operations and business processes of the organization on a daily, weekly or monthly basis.

A strategic performance measure without related tactical and operational measures is not appropriate (Flapper et al, 1996). In other words, it is important that a performance measure can be divided and correlated between these three levels. As shown in figure 2.9, a performance measure at the strategic level should be broken down into specific measures in the tactical level, and further down to the operational level (Jackson, 2000).

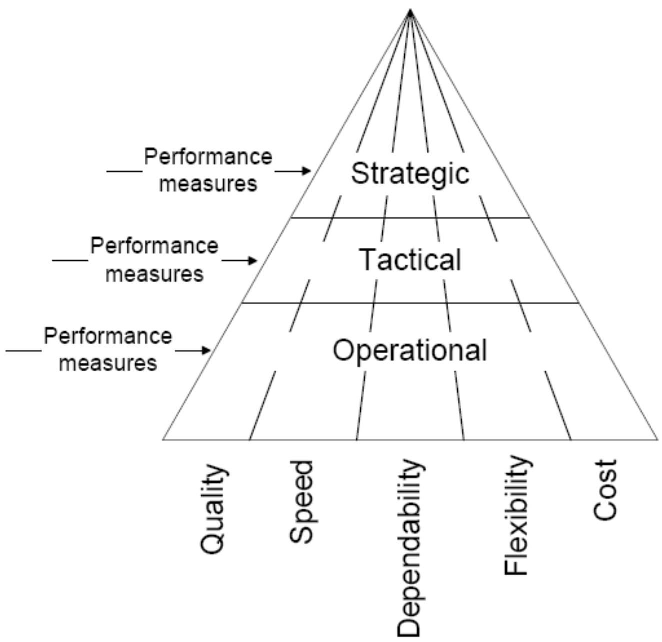

Figure 2-9 Performance measurements at different hierarchical levels (Jackson, 2000)

The traditional way to measure performance is to use financial performance measures, such as return on investment, profit and cash flow. However, these types of measures have been found to include a number of limitations and it is argued that a performance measurement system cannot solely rely on financial performance measures, since they do not properly reflect the requirements that a company must fulfil in today's competitive business environment (Maskell, 1991).

2.5.2 Examples of Conceptual Frameworks of Performance Measurement

2.5.2.1 The Sink and Tuttle Framework

The Sink and Tuttle framework is a classical approach to design a PMS (see figure 2.10), which claims that the performance of an organization is a complex interrelationship between seven performance criteria (Sink and Tuttle, 1989).

- **Effectiveness**, which involves doing the right things, at the right time, with the right quality. In practice, effectiveness is expressed as a ratio of actual output to expected output.
- **Efficiency**, defined as a ratio of resources expected to be consumed to resources actually consumed.
- **Quality**, where quality is an extremely wide concept. To make the term more tangible, quality is measured at several checkpoints.
- **Productivity**, which is defined as the traditional ratio of output to input.
- **Quality of work life** is an essential contribution to a well performing system.
- **Innovation**, which is a key element in sustaining and improving performance.
- **Profitability**, which represents the ultimate goal for any organization.

Although much has changed in industry since this model was first introduced, these seven performance criteria are still important. However, the model has its limitations, for example it does not consider the need for flexibility that has increased during the last two decades. The model is also limited by the fact that it does not consider the customer perspective (Tangen, 2004).

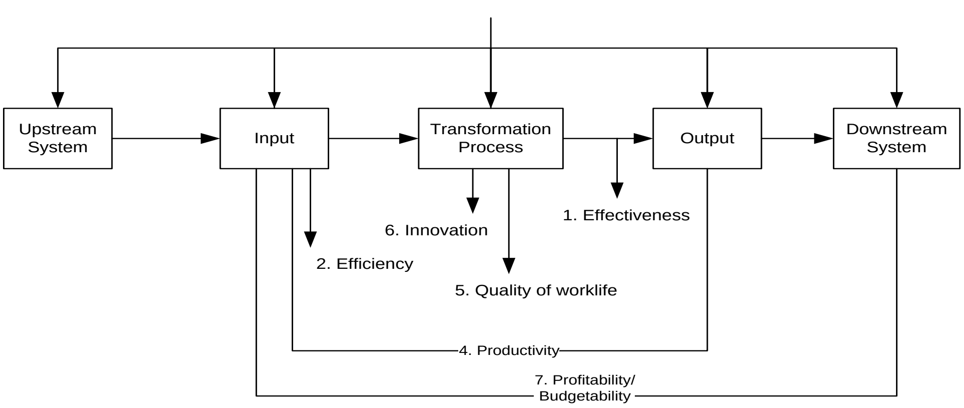

Figure 2-10 Definitions of seven performance parameter (Sink and Tuttle, 1989)

2.5.2.2 The TOPP Performance Model

The researchers within the TOPP project looked at performance as integration of three dimensions: efficiency, effectiveness and adaptability, see figure 2.11. The first two dimensions in the TOPP performance model are the same as in the Sink and Tuttle model, while the third expresses to which extent the company is prepared for future changes (Moseng and Bredrup, 1993).

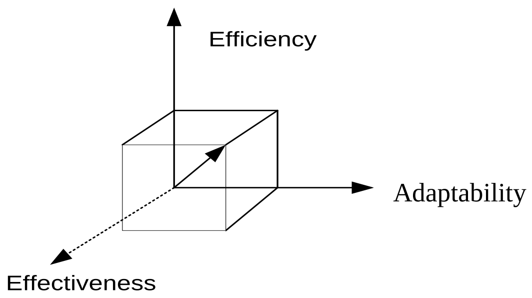

Figure 2-11 Performance model from TOPP (Moseng and Bredrup, 1993)

2.5.2.3 The Balanced Scorecard

One of the most well known conceptual performance measurement frameworks is the balanced scorecard developed and promoted by Kaplan and Norton, (1996). The balanced scorecard proposes that a company should use a balanced set of measures that allows top managers to take a quick but comprehensive view of the business from four important perspectives, see figure 2.12. In turn, these perspectives provide answers to four fundamental questions:

- How do we look to our shareholders (financial perspective)?
- What must we excel at (internal business perspective)?
- How do our customers see us (the customer perspective)?
- How can we continue to improve and create value (innovation and learning perspective)?

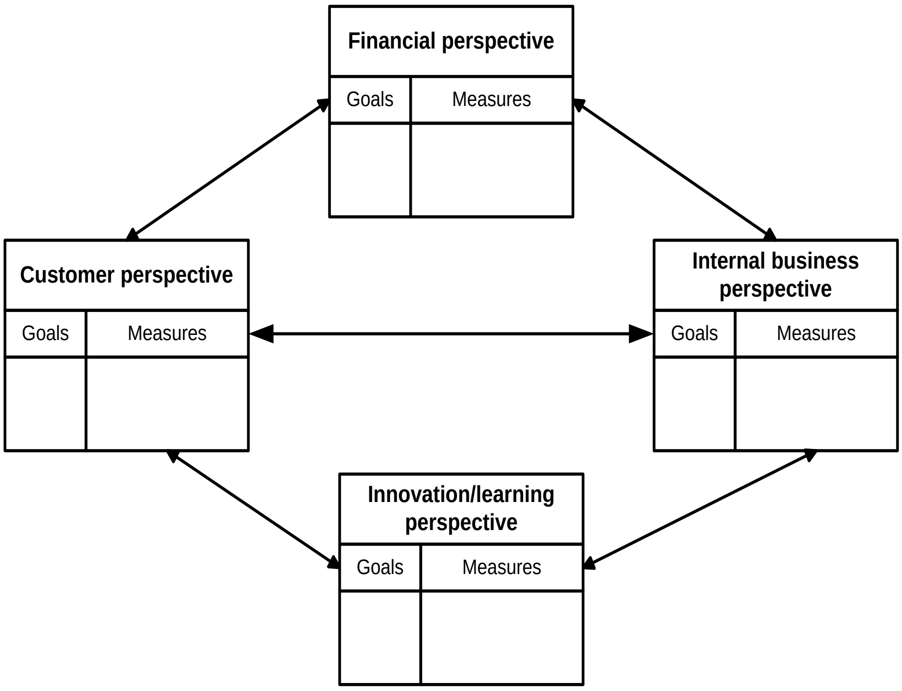

Figure 2-12 Balanced score card (Kaplan and Norton, 1996)

Evidently, the balanced scorecard includes financial performance measures giving the results of actions already taken. It also complements the financial performance measures with more operational non-financial performance measures, which are considered as drivers of future financial performance. Kaplan and Norton, (1996) argue that giving information from four perspectives, the balanced scorecard minimizes information overload by limiting the number of measures used. It also forces managers to focus on the handful of measures that are most critical. Further, to use several perspectives also guards against sub optimization by compelling senior managers to consider all measures and evaluate whether improvement in one area may have been achieved at the expense of another. According to Ghalayini et. al., (1997), the main weakness of this approach is that it is primarily designed to provide senior managers with an overall view of performance. Thus, it is not intended for or applicable at the factory operations level. Further, they also argue that the balanced scorecard is constructed as a monitoring and controlling tool rather than an improvement tools. Furthermore, Neely e.t al., (2000) argue that although the balanced scorecard is a valuable framework suggesting important areas in which performance measures might be useful, it provides little guidance on how the appropriate measures can be identified, introduced and ultimately used to manage business. They also concluded that the balanced scorecard does not at all consider competitors.

2.5.2.4 The Performance Prism

One of the more recently developed conceptual frameworks is the performance prism (see figure 2.13), which describes that a PMS should be organized around five distinct but linked perspectives of performance (Neely et. al., 2001):

- **Stakeholder satisfaction** – Which are the stakeholders and what do they want and need?
- **Strategies** – What are the strategies we require to ensure the wants and needs of our stakeholders?
- **Processes –** What are the processes we have to put in place in order to allow our strategies to be delivered?
- **Capabilities –** What are the capabilities we require to operate our processes?
- **Stakeholder contributions –** What do we want and need from stakeholders to maintain and develop those capabilities?

The performance prism has a much more comprehensive view of different stakeholders (e.g. investors, customers, employees, regulators and suppliers) than other frameworks. Neely et. al. (2001) argues that the common belief that performance measures should be strictly derived from strategy is incorrect. It is the wants and needs from stakeholders that first must be considered. Then, the strategies can be formulated. Thus, it is not possible to form a proper strategy before the stakeholders have been clearly identified.

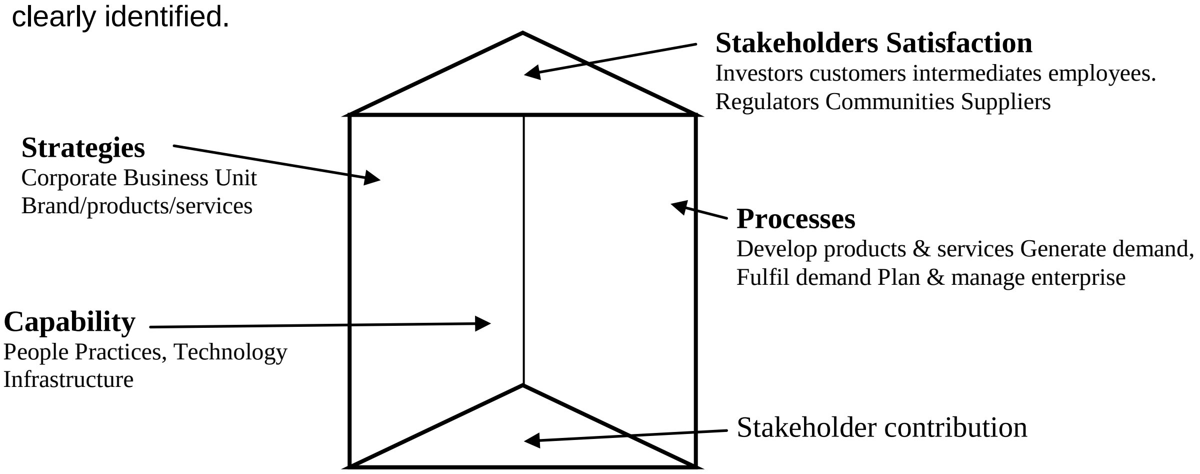

Figure 2-13 Performance Prism (Neely et. al. 2001)

The strength of this conceptual framework is that it first questions the company's existing strategy before the process of selecting measures is started. In this way, the framework ensures that the performance measures have a strong foundation to rely on.

The performance prism also considers new stakeholders (such as employees, suppliers, alliance partners or intermediaries) that are usually neglected when forming performance measures. However, a problem is that the attention has been placed on the process of finding the right strategies that the development of a PMS should be based on, but little concentration is given on the process of the actual design of a PMS. In other words, the performance prism extends beyond performance measurement, but tells little about how the performance measure is going to be realized. "The Neely Group" has previously published many useful tools in this area and should, if possible, create a better link between such tools and the performance prism. Another weakness, which also applies to the previously described frameworks, is that little or no consideration is given for existing PMS that companies may have in place (Medori and Steeple, 2000). Notable is that this issue has even been pointed out by Neely in an earlier publication (Neely et al, 1994):

"Business rarely wants to design PMS from scratch. Usually managers are interested in eliminating any weaknesses in their existing system".

In order for the organization to perform according to developed plans, performance measures are defined at different levels in an organization (Chatha 2004), as shown in figure 2.14.

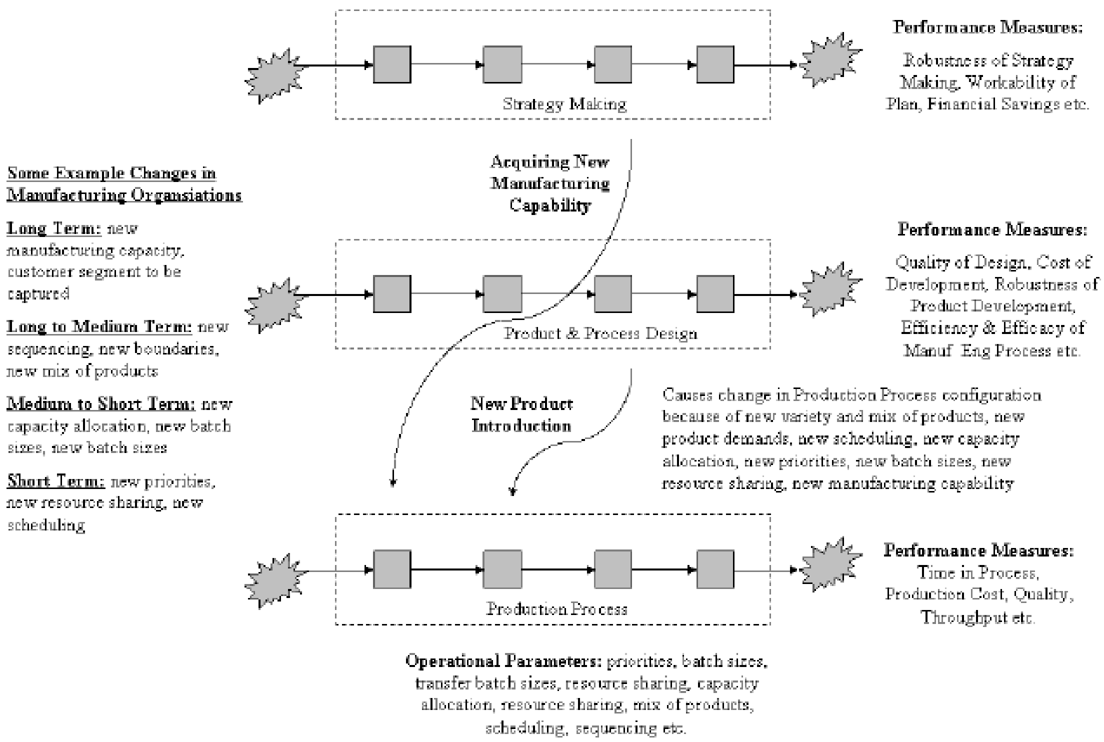

Figure 2-14 Process-based organization and change

2.6 Enterprise Modelling

A model is an approximate design of some actual process or object. The term ‘model’ has been defined differently in various fields of science and engineering. For example, engineers use models as a tool in designing and building physical objects. Similarly, system and software engineers use models to represents the characteristics of a system from several points of view. Weston, (1993) consider a model as: "a representation of some aspect of product realization which can be used to facilitate visualization, analysis, design, etc." Monfared, (2001) defined model as: “A model is a logical method to visualize the real status of an event (or process) in a system that can facilitate analysis and control of the system."

Enterprise models capture certain perspectives (or foci of concern) about an enterprise, such as financial, business, information and function views. When formally modelling complex systems it is necessary to decompose (or breakdown) the system into manageable system elements. The modelling elements should preferably be defined in a generic and reusable manner to improve the generality of the model (i.e. enable its use and reuse) in different domains and also to reduce the design time and cost of producing and using models (Monfared and Weston, (1997)). There are many potential benefits from using enterprise modelling in respect of the life cycle of a manufacturing system (Weston, 1996). A model provides insights into system capabilities and highlights alternative solutions and application scenarios that prepare the system to adapt to business change (Craig and Douglas, 1997). Business change may influence many facets of an enterprise, including its processes, communication systems and information requirements, and the way that its resources are organized and operate (Weston, 1998). To satisfy new business or environmental needs a deep understanding of cause and effect relationships and constraints on change is required. Modelling methods can help to analyse alternatives and, to determine new system configurations that best fulfil requirements change before any real system reconfiguration needs to be activated (Uppington and Bernus, 1998).

In theory enterprise modelling approaches facilitate the development of better processes and systems, and can improve the timeliness and cost effectiveness of change projects in MEs. But unfortunately in practice the full potential of enterprise modelling has yet to be realized and partial benefits have been realized in only a small percentage of enterprises (Chatha and Weston, 2005). Enterprise modelling concepts are primarily geared towards capturing and reusing coherent models of static (i.e. relatively enduring) aspects of model types referred to under that:

- Predictions can be made about alternative future behaviours of processes, by exercising simulation models to enable selection to be made between alternative candidate process designs and so that the influence of possible, but uncertain future requirements and conditions, can be analysed in advance of their happening,
- Computer executable process models can be 'connected' to the actual resource systems used to realize the business processes, such as by using workflow management systems to exert 'change capable' controls and 'change capable' information gathering and managing facilities, and
- (Separately modelling time dependent flows of material, sub products, products, information, controls and exception handling that place a 'workload' on modelled process segments and their selected resource systems (Chatha and Weston, 2005).

Also Rahimifard and Weston (2006) pointed out that Enterprise Modelling (EM) offers mechanisms for systematically modelling common processes and relatively enduring structures that govern the way MEs operate. However, EM has insufficient modelling concepts to represent organizational dynamics. Consequently complementary modelling concepts are needed to enable the capture and reuse of simulation models (SM) that help predict and qualify possible future organizational behaviours.

In order to provide support for modelling dynamics i.e., time dependant behaviour it is necessary to integrate enterprise modelling, simulation modelling and work flow modelling concept to facilitate the systematic capture and reuse of both static and dynamic models of complex manufacturing enterprises (see figure 2.15) (Chatha and Weston, 2005).

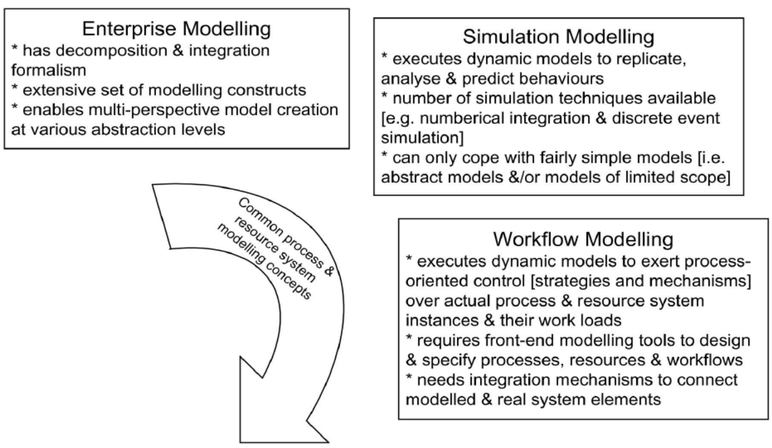

Figure 2-15 integrated modelling concepts (Chatha and Weston, 2005)

2.6.1 Enterprise Modelling Architectures

Following are some of the enterprise modelling architectures explored through the literature survey.

2.6.1.1 GRAI/GIM

The Graphs with Results and Activities Interrelated (GRAI) and GRAI Integrated Methodology (GIM) was developed at the University of Bordeaux in France to help designers to model production management systems (Chen and Doumeingts, 1996). It has taken its current form since 1988. The GRAI method was first published in 1977. GRAI-GIM is modelling methodology intended for general description, focused on details in manufacturing control system (Atbreman, 2012). Initially GRAI/GIM focused on modelling decisional structures of a manufacturing enterprise related to strategic, tactical and operational planning. GRAI concepts were extended to support the design of CIM systems leading to GIM as an integrated methodology for business process modelling (Kosanke, 1997). It is a structured approach supporting the whole life cycle of a system and is divided into two parts: User oriented and technical. GRAI – GIM is used as a reference guide during the implementation or operational phase of a project (Bernus, Nemes, and Williams, 1996).

2.6.1.2 ARIS

Architecture for Information Systems (ARIS) was developed at the University of Saarbrücken in Germany (Sheer, 1998) and is proposed by Professor Scheer (Scheer, 1992, 1999). The ARIS approach focuses on issues related to enterprise information system design. Therefore it provides specific modelling support (i.e. IT concept support) for Information Technology (IT) parts of enterprise engineering projects (Kosanke, 1996). It follows CIMOSA ideas in terms of modelling levels (requirements definition, design specification and implementation description) and integrated modelling (i.e. providing a set of integrated and non redundant modelling constructs). It differs in the structure of modelling views (function, control, data and organization views) and uses a different modelling language based on process-event chains to model business processes (Scheer, 1992, Scheer 1999). ARIS (Architecture of Integrated Information Systems) has four views. The three main views used are data, function, and organization. Depending on context (information or business system) the fourth view is either called the resource or control view (Scheer, 1989).

2.6.1.3 PERA

The Purdue Enterprise Reference Architecture (PERA) was developed at the University of Purdue in USA (Williams, 1992). The PERA methodology is characterized by its layered structure. It was developed for enterprise modelling for a CIM (Computer Integrated Manufacturing) factory at Purdue University. PERA establishes a basis for the treatment of human-implemented functions. It represents information system tasks with manufacturing tasks and human-based tasks. PERA clearly defines the extent of automation by distinguishing between humans to those done by the system (Bernus and Nemes, 1996). Its life-cycle starts with a definition of the Business Entity to be modelled, identifying its mission, vision, management philosophy, mandates, defines project sponsors, leaders and members, etc. and ends with obsolescence of the plant at the end of the operational phase (Kosanke, 1996), with implementing a pseudo time scale (Williams, 1994). The most significant contribution of PERA is that it is the first architecture that fully considers the human factor (Williama, 1992 & Williams, 1994).

2.6.1.4 IEM

The Integrated Enterprise Modelling (IEM) approach was initially developed by the Fraunhofer Institute in Germany (Mertins et. al., 1998) and proposed by IPK-Berlin (Mertins et al., 1995; Spur et al., 1996). IEM supports the creation of enterprise models for business reengineering. It supports the modelling of process dynamics to enable the evaluation of operational alternatives (Kosanke, 1996). IEM concepts have a scope that covers the main phases in the life cycle of enterprise engineering projects, including requirements, design, implementation and model up-date. It is fundamentally based on the IDEF0 activity construct but in addition advocates a strong object-orientation for business process modelling. It primarily considers only two modelling views: function view and information view. IEM defines three fundamental types of object classes in any enterprise: Orders (i.e. objects stimulating execution of activities), Products (i.e. objects that are processed) and Resources (i.e. objects executing the activities) (Mertins et al., 1995; Spur et al., 1996).

2.6.1.5 GERAM

The Generalized Enterprise Reference Architecture and Methodologies (GERAM) (enterprise modelling framework) has been defined by the IFAC/IFIP Task to provide necessary guidance for enterprise engineering processes (Kosanke, 1997). GERAM is a generalization of existing architectures GRAI-GIM, PERA, and CIMOSA. This architecture combines the best features of all the existing architectures reviewed by IFIP / IFAC task force (Mills and Kimura, 1999). The work force has sought to develop the GERAM specification as a semantic unification of concepts and models used in public domain enterprise engineering approaches (Kosanke, 1997). Therefore GERAM has been designed as a reference model of engineering architectures and methodologies (Kosanke, 1996). It is a useful framework for describing, in a coherent way, the lifecycle of an enterprise and for defining the associated support. Unlike the other approaches, GERAM focuses on the methods, models and tools that are needed to build an enterprise and address the complete lifecycle of an enterprise. It also allows the coverage of the lifecycle of an entity that is produced by the enterprise (IFIP-IFAC Task Force, 1998).

2.6.1.6 IDEF

IDEF is an acronym meaning ICAM DEFinition, where ICAM, in turn, is an acronym for Integrated Computer Aided Manufacturing. The IDEF techniques have been developed in projects sponsored by the US Air Force in order to describe, specify and model manufacturing systems in structured graphical form. Following structured system analysis methodology, IDEF methods supply a powerful means of analysis and development. Different methods within the IDEF family have been developed and these can be classified in two categories: the “modelling” and the “descriptive” varieties. IDEF3 is a process description capture method, which captures the domain expert’s knowledge about the behavioural aspects of an existing or proposed system. The development of IDEF3 is related to the need to distinguish between the description of what a system is supposed to do and the “model” which is used to predict what a system will do (Plaia and Carrie, 1995). IDEF3 offers both a process flow capability that can be linked to IDEF0 and ability to model information in object centred descriptions. The results obtained with the IDEF3 method provide key information for the creation of classes with attributes and operations that can then be used in the design of computational systems using UML. The resulting UML class diagrams show the relationships and inheritances that are the main input to the creation of object-oriented databases that hold the data of the information models (Dorador and Young, 2000).

2.6.1.7 CIMOSA

CIM Open Systems Architecture has progressively been developed by the AMICE Consortium (ESPRIT Consortium, 1993) within a number of ESPRIT Projects. CIMOSA was designed to help companies to manage change and thereby to integrate their facilities and processes to face worldwide competition (CIMOSA Association, 1996). The CIMOSA architecture supports process oriented modelling of different manufacturing enterprises. It also provides execution support for the operational phase of manufacturing systems (Vlietstra, 1996). The CIMOSA framework supports the engineering of enterprise models with a scope that covers requirement definition through to implementation description and the operational use and maintenance of manufacturing systems. The CIMOSA modelling framework provides the user with architectural constructs and guidelines for the structured description of business requirements and their translation into system design and implementation (Bogdanowicz, 1992), as illustrated by figure 2.16.

2.6.1.8 CIMOSA Modelling Approach

The Derivation Process guides the user through the three modelling levels: from the definition of enterprise business requirements (Requirements Definition) through the optimization and specification of the requirements (Design Specification) to the implementation (Implementation Description). On each modelling level in the Generation Process the enterprise is analyzed from different viewpoints (Modelling Views).

CIMOSA defines four modelling views for different aspects of an enterprise, including:

- The Function View describes the workflow of the Enterprise Functions.
- The Information View describes the inputs and outputs of the Enterprise Functions.
- The Resource View describes the structure of resources (Humans, machines, Data Processing- programs) required to perform the Enterprise Functions.
- The Organization View defines authorities and responsibilities regarding functions, information and resources.

To reduce modelling effort CIMOSA defines three levels of generality from purely generic to the highly particular. The first Generic Level is a reference catalogue of basic CIMOSA architectural constructs (building blocks) for components, constraints, rules, terms, service function and protocols. The second Partial Level contains a set of partial models applicable to a specific category of manufacturing enterprises. The third Particular Level is related to one particular enterprise and is defined in the Instantiation Process by the modeller using already prepared building blocks from the Generic and Partial Level and developing new particular enterprise specific components.

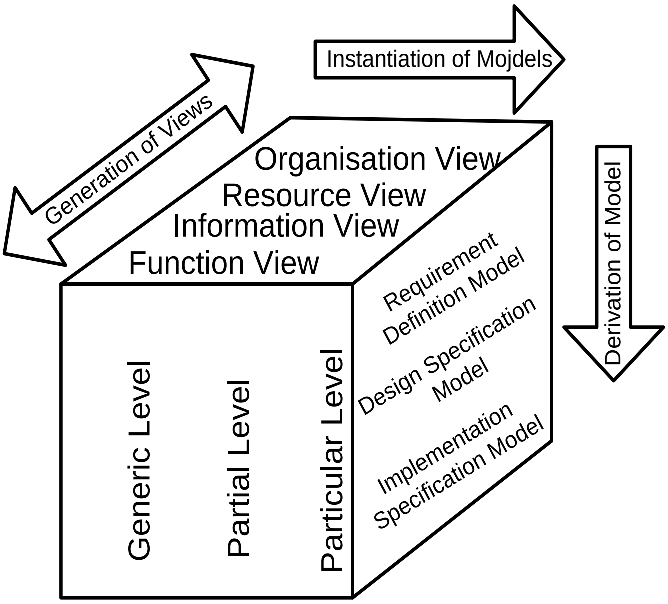

Figure 2-16 The CIMOSA modelling approach (CIMOSA Association, 1996)

The CIMOSA function model consists a set of modelling constructs (or business entities) that decompose functional processes into structured modelling entities (Tham, 1993), as illustrated by figure 2.17.

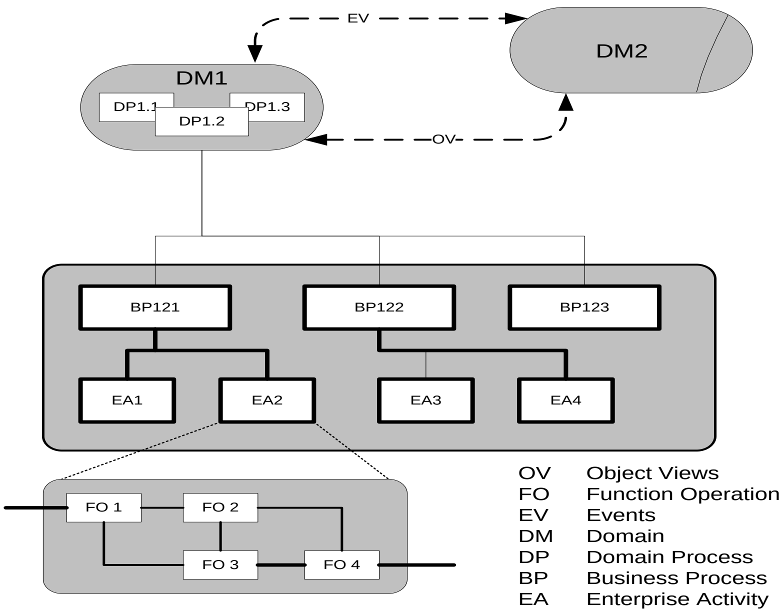

Figure 2-17 The CIMOSA functional modelling (Vernadat, 1997)

The business entities include the following modelling constructs:

- Domain is a construct, which is used to define the part of the enterprise relevant for achieving a defined set of business objectives, i.e. it is used to specify the overall scope and contents of the particular model of the enterprise. A Domain description consists of: Domain Objectives and Domain Constraints, Domain Relationships describing the Domain Boundaries, Domain Objects, and Domain Processes.

- Domain Process is a construct used to define which Enterprise Functions influence the achievement of the related Domain Objectives. The Domain Processes are identified during the establishment of the Domain. Each Domain Process is then expanded in terms of the generic Enterprise Function construct during the function decomposition phase.
- Business Process is a special type of Enterprise Function, which aggregates all the lower level Business Processes and/or Enterprise Activities required to carry out the defined tasks and defines the complete sequence of operation for these activities. A Business Process always has a functional, behaviour and structural part defined, and is initiated by an Enterprise Event so that its execution will result in the fulfilment of the identified business objectives.
- Enterprise Activity is a special type of Enterprise Function and is defined as a non-decomposable or low-level Enterprise Function. Enterprise Activities describe the basic functionality of the enterprise. Enterprise Activities are not part of any given Business Process as such, but are utilized by one or more Business Processes through their associated set of Procedural Rules. This relationship of Enterprise Activities and Business Processes via the Procedural Rules make it possible for the sharing of Enterprise Activities amongst different Business Processes, and also accommodates the behaviour changes of the enterprise by only altering the set of Procedural Rules while maintaining the basic functionality of the Enterprise Activities intact. At the design specification modelling level enterprise activities may be further decomposed into Function Operation, which can operationalize enterprise activities.

2.6.2 RPM’s Approach to Enterprise Modelling

A Process Modelling Approach developed by R.P.Monfared (RPM) (Monfared, 2000) at the MSI Research Institute (Loughborough University) essentially formed the basis of Multi-Process Modelling (MPM) approach and its enrichment. RPM’s enterprise modelling approach is primarily based on use of the CIMOSA function view. An organized use of four types of diagram was developed namely: context-diagrams, interaction-diagrams, structure-diagrams and activity-diagrams. Each one of these constituted an important fragment of the process modelling approach developed, and collectively they provided a coherent and complementary set of views of process attributes at needed levels of abstraction. These diagrams give a step-by-step understanding of how CIMOSA concepts can be partially depicted and implemented in a graphical form. Attributes of these diagrams can be summarized as follows:

2.6.2.1 Context Diagram

The context diagram is used to define domains to be modelled using CIMOSA formalisms. The context diagram organizes an enterprise into manageable modules and hierarchically breaks down system complexity. These modules are called Domains. Modules that are of concern in a project, and for which models will be produced, are termed CIMOSA-Domains and those that are not of concern are called non-CIMOSA-Domains. Oval-shaped bubbles may represent domains. Simple bubbles may represent CIMOSA domains, while crossed-out bubbles may represent non-CIMOSA domains. Contact Diagrams can be decomposed into sub-level context diagrams to identify sub-domains and domain processes (see figure 2.18) (Rashid et. al. 2007).

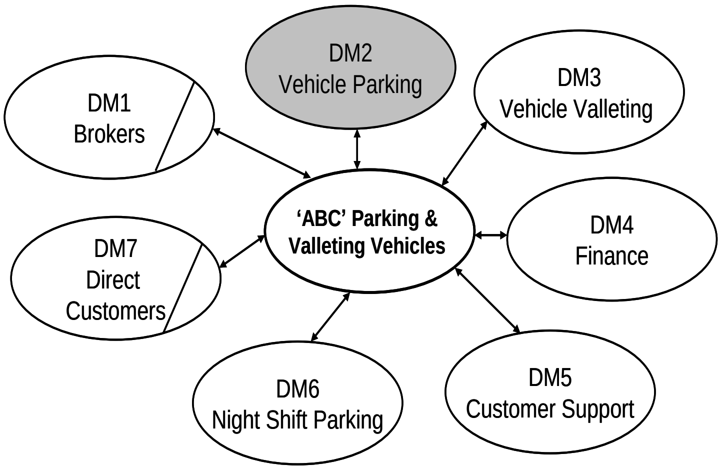

Figure 2-18 An example Context diagram (Rashid et. al. 2007)

2.6.2.2 Interaction Diagram

Domains interact with each other by means of events (which typically take the form of requests or triggers to do something) and results (defined as being views on enterprise objects). The interactions among domains take the form of information exchange, human resource exchange, physical resource exchange and events. Creating interaction diagram specifies these interactions. Interaction diagrams can be drawn to identify, define, organize, and represent the interactions involved among domain processes (see figure 2.19).

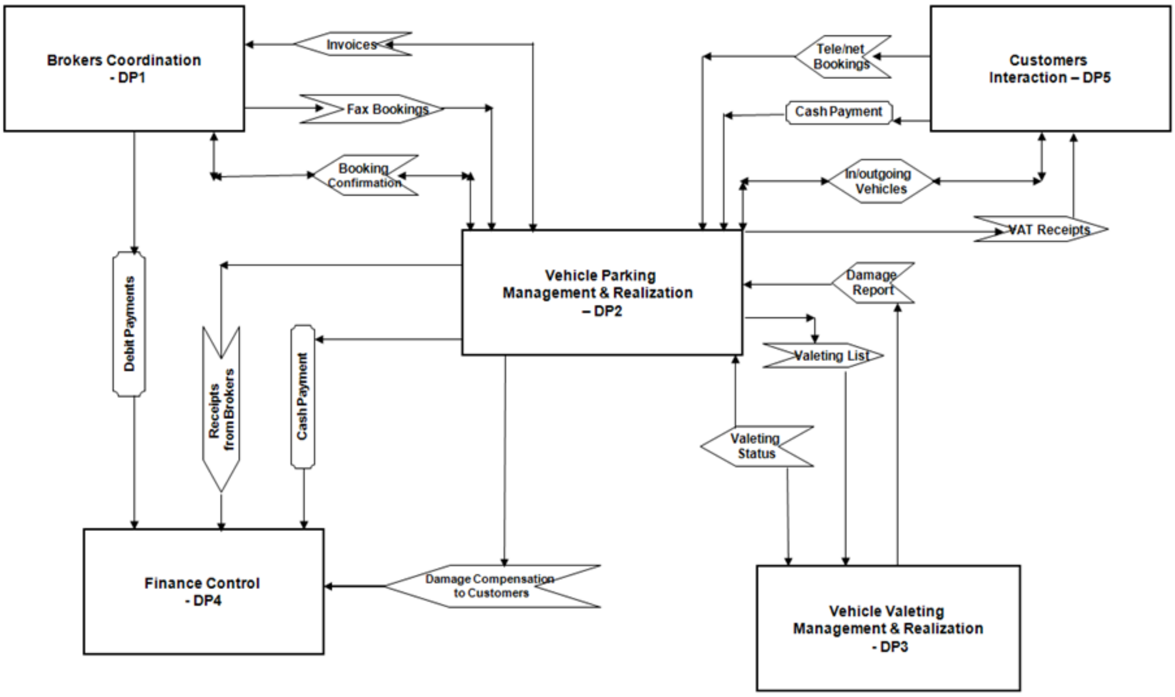

Figure 2-19 An example Interaction diagram (Rashid et. al. 2007)

2.6.2.3 Structure Diagram

A structure diagram is the one that identifies structures and organizes the business processes and enterprise activities that collectively compose a domain process or sub-domain process (see figure 2.20).

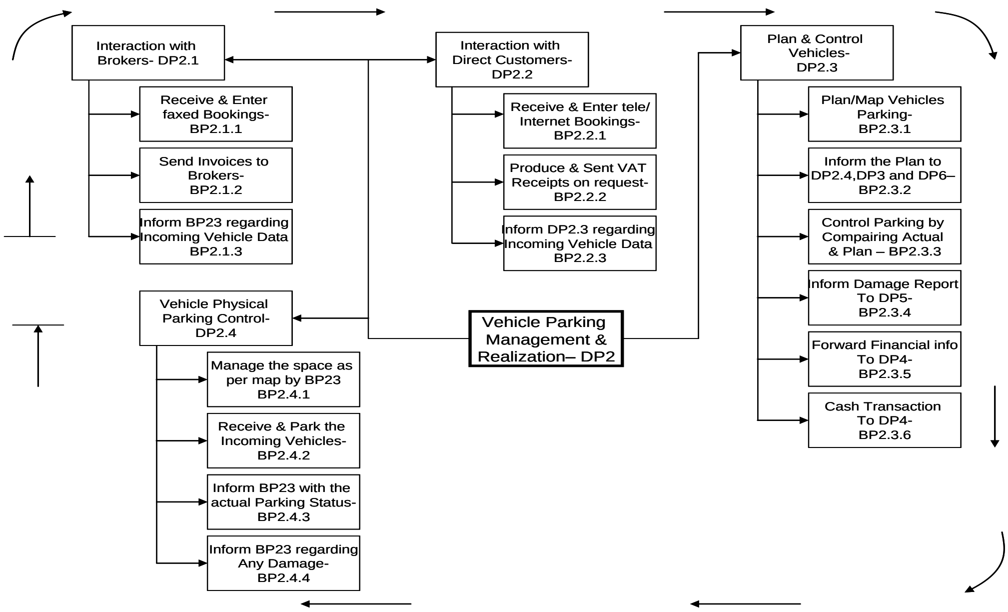

Figure 2-20 An example Structure diagram (Rashid et. al. 2007)

2.6.2.4 Activity Diagram

An activity diagram encodes a sequence of enterprise activities and business processes. Enterprise activities, business processes and control flows are represented by graphical model building blocks (see figure 2.21 (Rashid et. al. 2007)).

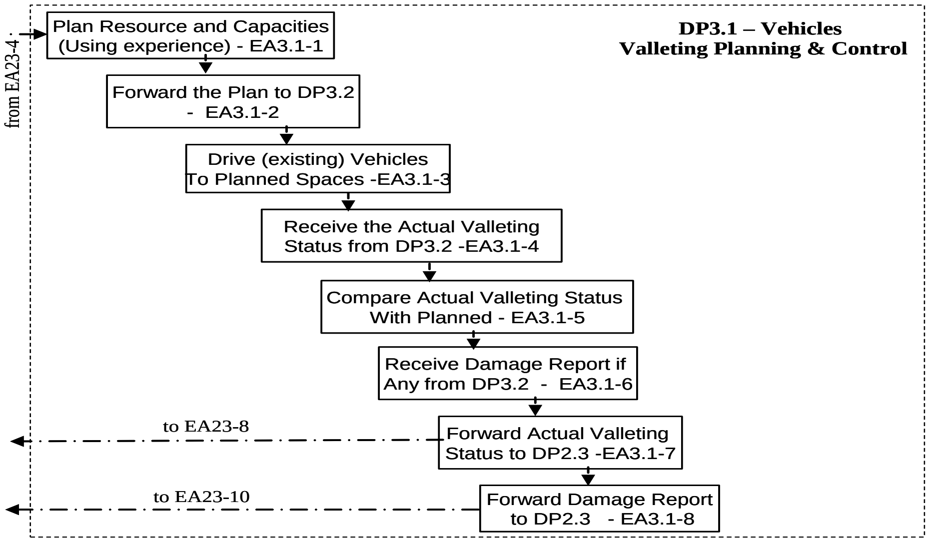

Figure 2-21 An example Activity diagram (Rashid et. al. 2007)

Chapter 3: Research Gap and General Research Methodology

This chapter considers the research gap highlighted by the literature review and considers this gap with respect to the research aim and objectives. It includes a discussion about general research methodologies and data collection methods. The purpose of presenting general concepts about research is to describe the style of research appropriate for this research environment and therefore likely research problems in achieving the study objectives. Also described is the choice of general research style and data collection methods.

3.1 Research Gap

The review of the literature presented in chapter 2 revealed the nature and potential benefits of 'Process thinking'. Namely that this is centred on thinking about current and possible future ways in which organised sets of value added activities can realise business goals by transforming inputs (such as material, sub-products, information and knowledge) into outputs (like products and services) required by customers (Vernadat, 1996 and Weston,1999). In the case of realizing the processes required by a manufacturing enterprise (ME), potentially viable candidate systems will be some configuration of human and technical resources that collectively have the abilities (capabilities, competencies and capacities) to accomplish needed instances of the defined process logic within defined timeframe, cost and quality of service constraints (Vernadat 1996 and Ajaefobi et al. 2004).

Chatha et al. (2006) distinguished between two schools of thought on processes and aligned these with so called 'systems engineering' and 'business' viewpoints. Business school thinking couples requirement and solution viewpoints whereas; fundamental to the system's viewpoint about processes is a conceptual separation of 'process requirements' (i.e. the process logic) from 'models of candidate system solutions'. This is because conventionally the job of systems engineers is to analyse and choose between alternative ways of realizing specified requirements (Weston, et. al., 2007).

Similarly, the literature survey explains that Manufacturing Enterprises (MEs) carry out transformational processes like 'operate', 'support' and 'manage' processes by utilizing resources to fulfil their requirements long and short term. Operate processes are those processes which directly produce value for customers. Their main responsibility is to provide customers with products and services that satisfy their requirements. Support processes are required to underpin operate and management processes so that they can fulfil their objectives and give value to customers (Pandaya et al., 1997). Management is the process of achieving organizational goals by engaging in the four major functions of planning, organizing, leading and controlling (Stephen and Dennis, 1987). As discussed earlier in chapter 2, the literature reports widely on tools and methodologies developed and used to design and improve actual product realization processes such as lean manufacturing, just-in-time, kaizen, total quality management etc.

Peter Drucker (1967) pointed out that the performance achieved through management is actually made up of two important dimensions namely effectiveness and efficiency. While Tangen, (2004) defined performance measurement as the process of quantifying the efficiency and effectiveness of actions. Additionally, Amaratunga and Baldry, (2002) stated that measurement should not be an end in itself but should be a tool for more effective management.

While working in MEs for more than two decades, the author experienced that a) improvement very often begins with measurement, and b) if a well chosen theory or technique is applied in full it provides greater benefits than if it is applied partially. These observations gave rise to a thought that there should be some method to measure the level of application of a chosen management theory or technique. The literature review confirmed that little attention has previously been paid to measuring the level of application of management functions like planning, organizing, leading and controlling in MEs; so that the author concluded that there is a significant gap in current industry provision which may be filled by developing a methodology to measure the performance of adopted management processes in ME’s. Indeed no public domain methodology was found in the literature, which quantitatively seeks to measure the extent to which management processes (planning, organizing, leading and controlling) are being applied in a given manufacturing enterprise (ME). It was presumed therefore that developing and applying such a methodology, with respect to various management processes, should usefully indicate areas of possible improvement needed to increase the productivity of any enterprise. Hence the author of this thesis decided to design and test a methodology to measure the Level of Application of Management Processes (LAMP).

3.2 Research Scope

In order to bridge the research gap found through literature review, the scope of this research is limited to the development and testing a methodology for measuring the level of application of management processes in pursuit of improved productivity in MEs. Within this research scope it was decided that the author should accomplish the following:

- To decompose the management processes of MEs to a level where these can be measured by suitable indicators.
- To explicitly document, represent and visualize the decomposed ME management processes using an appropriate modelling technique.
- To develop a methodology to measure the level of application of the management processes (LAMP) in MEs.
- To conduct testing of proposed methodology of LAMP in case MEs.
- To analyse and validate the test results from the case studies and to highlight improvement potentials.

3.3 General Review of Research Methodology

It was necessary to adopt well-proven generally renowned methods during this PhD study. Hence the following more general literature survey and review was conducted.

3.3.1 What is Research?

There are several ways of defining what is meant by 'research methods' which can range from fairly informal research based upon clinical impressions, to strictly scientific research which adheres to conventional expectations of scientific procedures (Kumar, 1999). Research can be defined as a systematic and methodological search for knowledge and new ideas or as producing knowledge and relating theory to reality (Tangen, 2004). It has also been defined as the systematic study of materials and sources in order to establish facts and reach new conclusions (AskOxford, 2009). It can be defined as an investigative inquiry that uses scientific methodology to systematically explore either a known or unknown study area with a view to authenticating and validating existing assumptions or theories, proffering possible solutions to some known problems, and generating some new concepts, problems and/or hypothesis for further investigation (Ajaefobi, 2004).

3.3.2 Type of Research

Research can be classified from three perspectives (see figure 3.1) (Kumar, 1999);

- The application of research study,
- The objectives in undertaking the research, and
- The type of information sought.

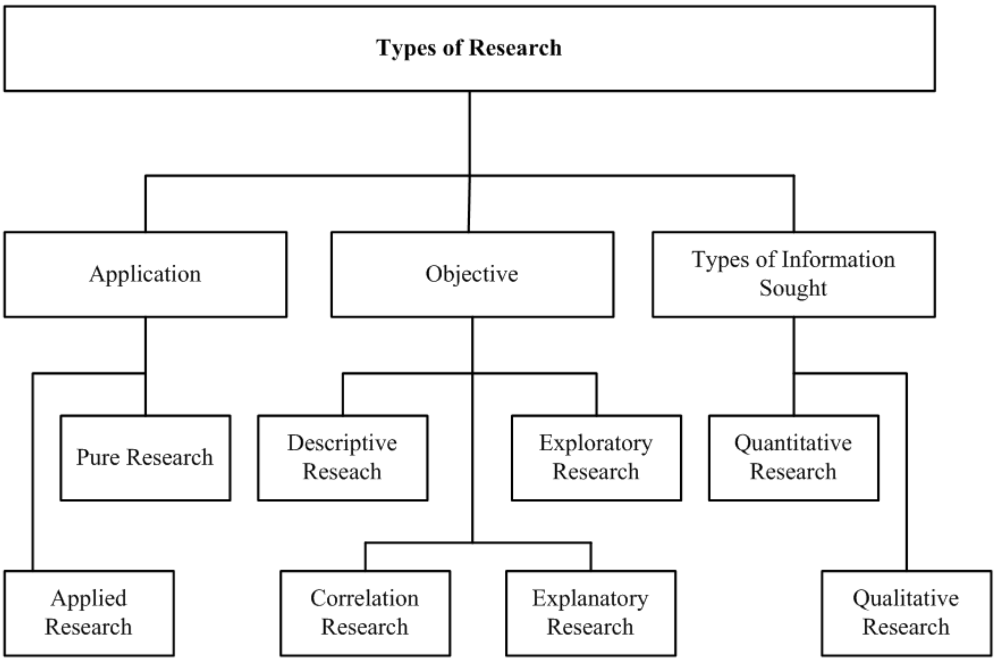

Figure 3-1: Types of Research (Kumar, 1999)

3.3.3 Selection of Research Methodology

In this study the choice of research methodology was made on the basis of the research environment, research problem, and research case studies included. The environment of this research required a selection of different techniques to graphically represent and describe management process application and then to quantify and analyse it. This was observed to require a use of both numeric and subjective data and data analysis. The research problems of this research are to develop a methodology to model and measure the level of application of management process in pursuit to improve productivity. Therefore, one or more case studies are required in this research to test usefulness of the developed methodology. Keeping in view the needs of this research, the author deduced that applied research, descriptive research and combination of quantitative and qualitative research are the most relevant types of research required to be undertaken.

3.3.4 Data Collection Methods

There are two major approaches to gather information about a situation, person, problem or phenomenon. Sometimes, information required is already available and need only be extracted. However, there are times when the information must be collected. Based upon these broad approaches to information gathering, data are categorised as (Kumar, 1999);

- Primary data, and
- Secondary data.

Information gathered regarding primary data is said to be collected from secondary sources whereas the sources used in the secondary data collection are called primary sources. Different methods of data collection related to each of the sources are presented in Figure 3.2 (Kumar, 2005).

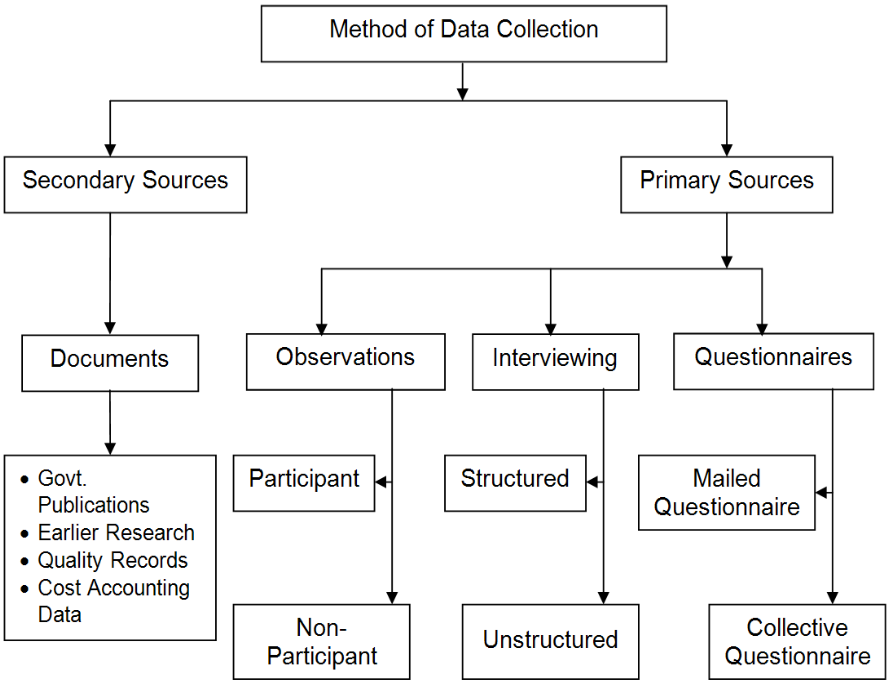

Figure 3-2: Methods of Data Collection (Kumar, 2005)

3.3.5 Selection of Data Collection Methods

Keeping in view the type of research chosen in section 3.3.3, i.e., applied research; descriptive research and a combination of qualitative and quantitative research, both primary and secondary sources of data were required. The choice of the data collection method and the reasons for this choice are presented in Table 3.2.

Data Source	Data Collection Method	Data Collection Method Type	Suitability to the Research	Remarks
Primary	Interviewing	Structured	Yes	Semi structured interviews of relevant people can be required in case study to understand the management process in a given ME.
		Unstructured	No	
	Observation	Participant	Yes	Walk through to observe and capture actual details of management process can be done along with the participation of the process owner to verify the captured activities.
		Non-Participant	No	---
	Questionnaire	Mailed Questionnaire	Yes	Questionnaire to be emailed/posted to relevant managers to get feedback about management process application
		Collective Questionnaire	No	---
Secondary	Documents	Plans and Progress Reports	Yes	Can be required to know about the management performance and other related problems.
		Earlier Research Data	Yes	Can be a very useful source to avoid the segments of work already done.

Table 3-1: Choice of data collection methods

To summarise, it was determined that this research requires use of both primary and secondary data collection methods including interviews, observations, questionnaires and different types of case company documents dependent on their availability.

Chapter 4: Research Methodology Specifications

In chapter 3 the research gap was found after literature review that ultimately resulted in defining the research objectives. In order to achieve those objectives a research methodology specification needed to be specified. This chapter highlights the strategy to be adopted to visualize management processes by discussing aspects of enterprise architectures and enterprise integration. Furthermore, discussion has been made on the concept by which a methodology to measure the level of application of management process (LAMP) can be developed.

4.1 Research Design Concept

4.1.1 Management Process Visualization

An enterprise is one or more organizations sharing a definite mission, goals and objectives to offer an output such as a product or a service (ISO 15704). Architecture is a description of the basic arrangement and connectivity of parts of a system (either a physical or a conceptual object or entity) (ISO 15704). Usually architecture has various meanings depending on its contextual usage; i) a formal description of a system at a component level to guide its implementation, ii) the structure of components, their interrelationship and the principles and guidelines governing their design and evolution over time and iii) organizational structure of a system or a component (Open Group TOGAF, 2000).

Like in civil engineering, enterprise architecture aims at creating a vision of the future. This vision is represented as a high abstraction level solution that lays down the foundation for design. It is a kind of skeleton focusing on essential features and characteristics of the system (Chen et. al., 2008). Enterprise integration is the process of ensuring the interaction between enterprise entities necessary to achieve domain objectives (EN/ISO19439, 2003). Enterprise integration can be approached in various manners and at various levels, e.g., i) physical integration (interconnection of devices, NC machines. e.g. via computer networks), ii) application integration (integration of software applications and data base systems) and iii) business integration (coordination of functions that manage, control and monitor business processes) (Vernadat, 1996).

Monfared, (2001) defined the term model as follows: “A model is a logical method to visualize the real status of an event (or process) in a system that can facilitate analysis and control of the system." Weston, (1993) consider a model as: "a representation of some aspect of product realization which can be used to facilitate visualization, analysis, design, etc."

Modelling a system in an enterprise needs an architectural framework, which can be used to develop a model that can represent the structure and interconnectivity of processes at different levels. Management in ME deals with the production, quality and finances of products to be manufactured. Therefore, an architectural framework is required which can map the processes from all these aspects and can allow decomposition of processes to measurable activity level.

4.1.2 Management Process Measurement

Vernadat (1996) states that ‘processes represent the flow of control in an enterprise’, they constitute a sequence of enterprise activities. Processes are a conceptualization of reality, not reality in itself (Chatha, 2004). Therefore, measuring a process is somewhat different from physical measurement which may not be measured directly but require some activity indicators.

A performance measure is defined as a metric used to quantify the efficiency and/or effectiveness of an action (Tangen, 2004). According to Neely 1995, the literature on measuring the performance system offers many examples of procedures for identifying, selecting and implementing appropriate performance measures. Ideally, a broad-based and well-developed performance management system could enable organizations to direct their actions towards achieving their strategic objectives (Kaplan and Norton, 1992). According to Ghalayini and Noble (1997), up to 1980 the performance measurement emphasis was on financial measures or cost related performance measures and after that in late 1980’s and still proceeding, the emphases shifts to non cost related performance measures.

Kaplan and Norton, 1992 stated that the financial measures are inadequate to measure the company’s performance as financial measures tell the story of past events. The companies have to create future value through investments in customers, suppliers, employees, processes, technology and innovation.

The researchers then focused on the development of balanced and integrated, rather than piecemeal, performance measurement systems. These new frameworks placed emphasis on non-financial, external and future looking performance measures (Tangen 2004). As emphasized by Bitichi (1994), the objective with the new frameworks was to encourage a proactive management style rather than a reactive one. The conceptual performance measurement frameworks were then followed by the development of management processes specifically designed to give practicing managers the tools to develop or redesign their performance measurement systems (Neely et al, 2000). Researchers have now realized that the concept of multiple stakeholders has increased in importance. Companies can no longer be satisfied with only considering shareholders and customers. Employees are also seen as important stakeholders, as are suppliers, regulators and the community at large and these stakeholders need to be incorporated into the performance measurement system (Bourne et al, 2003).

Kululanga and Kuotcha (2010) stressed that the performance measurement merely highlights an organization's under-performance without giving clues to the root causes of under-performance. According to Garvin (1991), one of the characteristics that have contributed significantly for improving the business process lies in the methodology of measuring business processes, which often provides quick feedback for addressing under-performance within manufacturing organizations. A methodology provides a framework to an organized and systematic approach to the problem; one or more steps of the methodology will be applied by the use of a technique. Therefore, a technique can be seen as the means by which the methodology is performed and supported (Pandaya et. al., 1997). Garvin (1991) stated that measurement of management processes is a strong feature of their corporate establishments for the sake of continuous improvement, innovation and superior performance.

A number of researchers have developed methodologies to measure different enterprise processes by using various performance management frameworks. Badri et al 1995, carried out a study for measuring quality management and provided a synthesis of quality literature by identifying eight critical factors in a business unit in the United Arab Emirates (UAE).

Ramalall (2003) in his research of measuring the HR management's effectiveness in improving performance examined the HR strategic role and its main practices, and explained critical reasons for measuring HR's efforts and proposes a framework for assessing HR. The framework consists of respective HR cluster, its outcomes, and possible measurement to determine its effectiveness in creating value. The framework proposed does not merely explain the cost for each of the major HR activity but demonstrates the value of the activity and hence, the opportunity to determine if it is a worthwhile investment and strategy for creating a competitive advantage. The framework has proven its effectiveness at many companies showing how HR creates value, by utilizing information collected to increase investments in specific HR strategies and eliminating ineffective investments. This was shown to be useful as a critical resource in the strategic business planning and budget allocation.

Kululanga and Kuotcha (2010) employed a management process framework based on an established series of steps with statement indicators linked with numerical scores to ascertain the degree to which current risk management practices were implemented in the construction industry of sub-Saharan region-Malawi. His research focused on employing a questionnaire survey based on process measurement. Different statistical tests were performed which reveal the reasons why under performance prevails in an organization and provides construction contractors with potential solutions to address their root causes.

The literature review reveals that much research has been carried out in developing methodologies for measuring processes like risk management, quality management, and HR management effectiveness. One of the objectives of this research is to develop a methodology to measure the management processes in terms of its sub-processes like planning, organizing, leading and controlling. Measurement can be carried out qualitatively and quantitatively. Quantitative means how much a process is being applied and qualitative means how well a process is being carried out. As mentioned earlier in chapter 3 that a well chosen theory if applied in full can provide greater benefits than if it is applied partially, therefore the focus of this research is based on quantitative measurement. So, a methodology to measure the management processes is required to be developed considering the basis & guidelines used by other researchers discussed previously.

4.2 Research Strategy

The main strategy of this research is a journey from the visualization of a given management process through modelling application and thereby establishing a methodology for management process measurement by using measurement methods developed by other researchers in pursuit of enterprise process measurement.

In order to understand what the process does and how the process operates, a model which describes in a clear manner all the relationships and dependencies between its elements of the system will be required. The development of a model is never a “one-through” activity: there will be a continuous review and refining during the entire activity. This will lead to a continuous updating of the model being developed, with adding, deleting or modifying the existing set of data and information. To be able to map and visualize the network of processes within any subject ME (and the system of systems it needs to deploy), a suitable technique which can facilitate explicit description of multi-perspective models that facilitate understandings about key aspects of that ME needs to be adopted to develop an enterprise process model.

The management processes are commonly composed of sub processes. Planning, organizing, leading and controlling are commonly considered to be key components for achieving enterprise goals. Based on the literature reviewed, this research will assume that these four sub-processes comprise the domains that require a means of management process measurement in MEs. It is widely reported that MEs comprise of complex systems with a suitable means of handling complexity. In this respect enterprise modelling will provide the means for decomposing higher level management processes into its sub-processes leading to the level of activities which can be measured by activity indicators. The following ladder illustrates the strategy proposed by the author for scoring the Level of Application of Management Processes (LAMP).

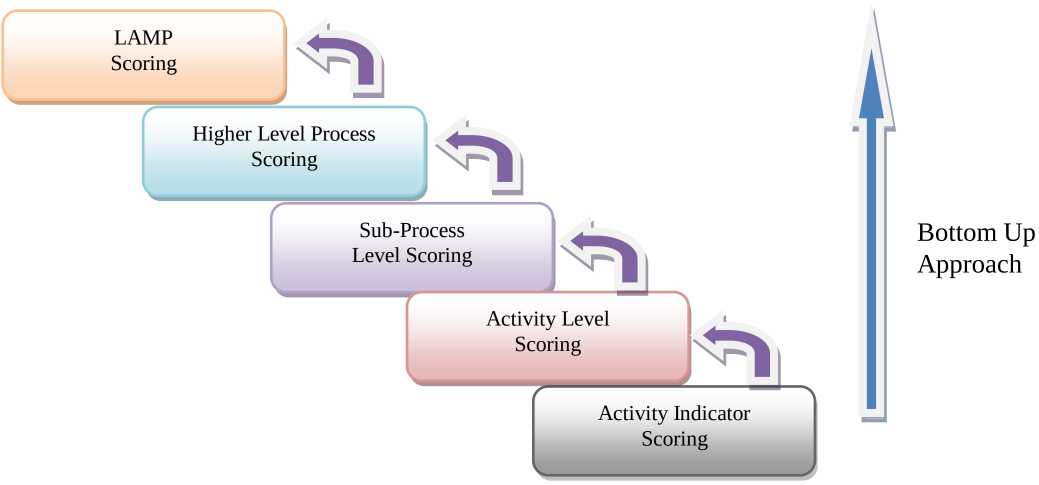

Figure 4-1: LAMP Scoring Ladder

In figure 4.1 a bottom up approach is shown which means the scoring will be made at the lowest activity level. Selection of sub-processes will be specified through subsidiary research in which semi-structured interviews will be conducted with experts of MEs. Using the Project Management (PM) practices & guidelines will do further decomposition of these sub-processes. Enterprise activity scoring will be carried out by using a questionnaire survey that will lead to scoring of business processes, domain processes and ultimately to the measurement of LAMP.

Chapter 5: Research Design Development

This chapter describes the development of a research design for this study in the light of the research concepts and strategy presented in the previous chapter. The first section describes the overall research methodology planned and adopted for this research. The next section explains the different levels of decomposition of management processes, which can lead to measurable enterprise activity indicators, provides a brief introduction to the case study manufacturing enterprises (MEs) and introduces the subsequent research needed to explicitly specify a semi-generic model of business processes.

5.1 Research Methodology

The development of a research methodology requires the specification of a step-by-step method to design, test, analyse and validate hypothesis in order to meet the key objectives of research (Saunders, 2000; Kumar, 2005); which in this study are:

- To visualize the application of management processes in ME and,
- To measure the level of application of management processes (LAMP) in ME

It was decided that the methodology to be followed when conducting this research study would include five stages.

In stage I, the 'management process' would be decomposed starting from higher level processes until reaching the unit activity level at which key indicators could be attached to measure attributes of unitary activities.

In stage II, the decomposed management processes would be modelled and graphically documented by deploying a suitably selected standard modelling technique. This would help in visualizing the structure and interaction of decomposed management processes being carried out in MEs.

At stage III, guided by the content and structure of the documented decomposition of management processes, a scorecard will be designed and developed which can be used to measure the level of application of management processes (LAMP) in MEs.

Stage IV of this research will be centred on case testing the use of the LAMP scorecard in selected MEs thereby obtaining necessary results for further necessary analysis.

In the final stage of research, reflection & results validation will inform a review of the utility of the LAMP methodology prior to arriving at conclusions and recommendations. The primary stages of this research are illustrated in figure. 5.1

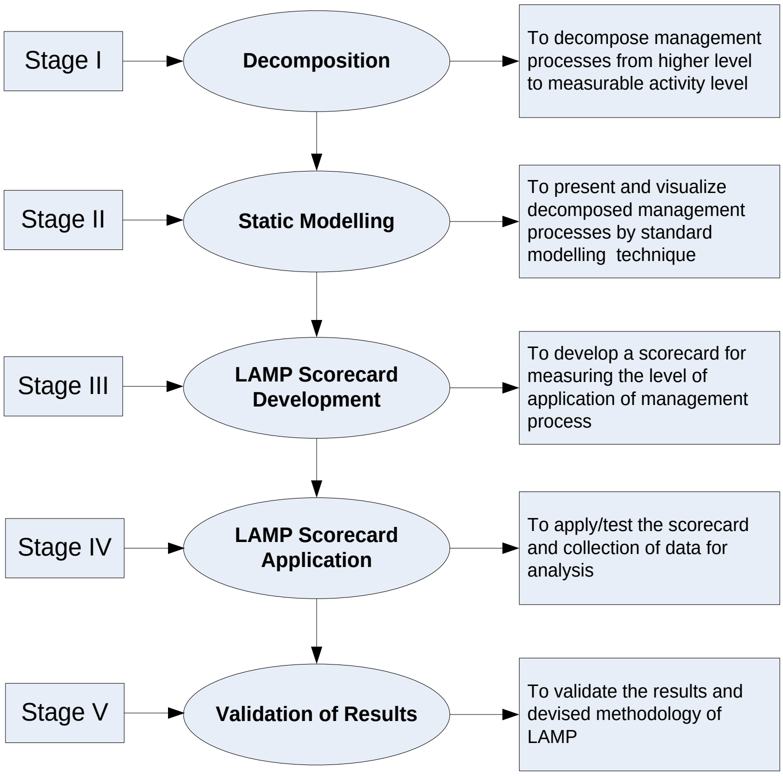

Figure 5-1: Stages of Research

5.2 Management Process Decomposition

Stage I concerns the decomposition of the management process into so called domain processes, business processes, enterprise activities: here terminology defined by the CIMOSA Enterprise Modelling approach which was conceived to describe a hierarchy of structural relationships amongst complex processes has been adopted. Also as an extension of CIMOSA concepts the author decided to attach key indicators at the lowest hierarchical level of the management process decomposition to enterprise activities, so as to attribute to those activities a measure of the application of that management activity in a given ME as illustrated in figure 5-2. This figure indicates the primary source of information used to guide the decomposition process.

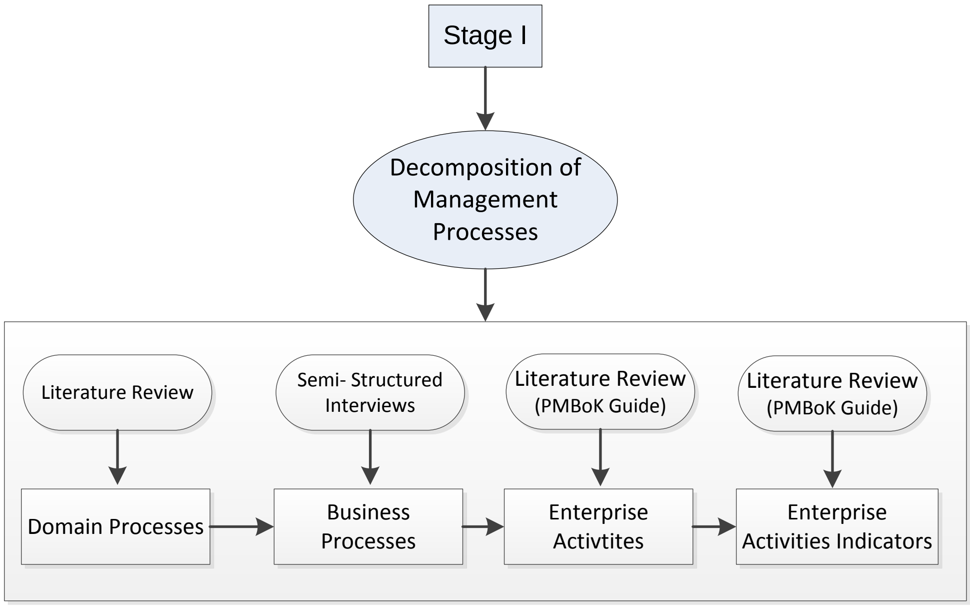

Figure 5-2: Stage I of Research (Decomposition)

Figure 5-3 conceptualises the author's systematic approach to decomposition, which essentially involves four levels of modelling abstraction. The following sub-sections consider the approach taken at each abstraction level.

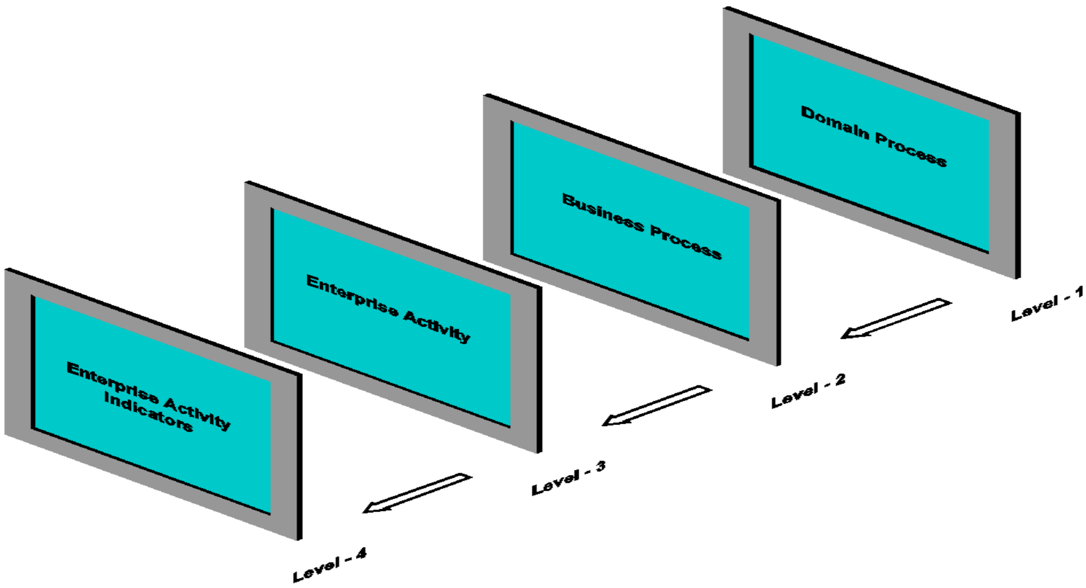

Figure 5-3: Systematic decomposition of management process

5.2.1 Level 1: Domain Processes

According to Carroll and Gillen, 1987, four management functions; planning, organizing, leading and controlling are considered to be key 'components' for achieving organizational goals. These four management functions will implement their associated management processes and adoption and definition of those management processes has formed the basis and starting point for this research as shown in figure 5.4.

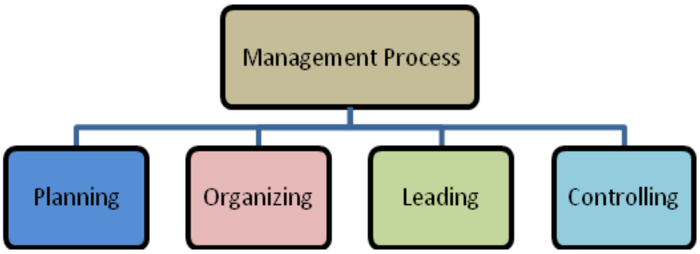

Figure 5-4: Management Process Decomposition into Domain Processes

At level 1, management processes that are reported in the literature to have been widely applied were classified as members of the following domains: ‘planning’, ‘organizing’, ‘leading’ and ‘controlling’ management domains. Management processes within each of these domains (which are considered to be Domain Processes (DPs) in this research) were then decomposed into so called Business Processes (BPs). At this stage of organizing and modelling the management processes were considered to be generic (or at least semi-generic) in the sense that they can be observed in many MEs. Indeed during this research there was a focus on modelling management processes that at least conceptually are transferable between enterprises (rather than being related to a specific set of management processes adopted by a particular enterprise). This is because an aim of this research has been to formally document, within one over arching structure, a transferable set of management concepts that can help any given ME to understand the extent to which it is applying current best management practice ideas previously published in the literature. As indicated above the management processes identified for further modelling by the author were observed and collated primarily via literature review of theory and practice (see chapter 2). Therefore they are considered to be at least partially generic but they are not claimed to be comprehensive or universally applicable: although the author believes that it is likely that missing management process types can be readily positioned within the authors developed management structure.

5.2.2 Level 2: Business Processes

At level 2, each domain process of the management process was further decomposed into business processes. The literature seems sparse on highlighting the decomposition of planning, organizing, leading and controlling domain processes. In this regard in order to gather more detailed information about common management processes, a subsidiary research was conducted in three MEs.

5.2.3 Introduction to MEs

In this research because the author had access to and experience of working in a leading public sector ME located in Pakistan so the information gathering about common management processes at the business process level was centred on observing best management practices. Three out of twelve public sector MEs, that have a key role in producing precision manufacturing parts in Pakistan were selected for this research. These MEs were selected mainly because it was perceived that a key ingredient of successful business and management research is ‘suitable access to data’ and the author has good connections with the case study enterprise. Secondly, the enterprises chosen have a high level of knowledgeable and experienced individuals who could provide the study with reliable data. Finally, the case study enterprises are of strategic importance to Pakistan’s public sector and hence that country’s economy; so the findings could be beneficial to other precision manufacturing public sectors.

In order to keep to signed confidentiality agreements, the names used for the MEs will be ME1, ME2 and ME3.

Case ME1: This is the third largest public sector manufacturing enterprise working in Pakistan. It makes various high precision products in batches as per its customer requirement. It has approximately 2500 regular employees. At the time of modelling it was handling 11 complicated projects through 11 project managers.

Case ME2: This is also a precision parts manufacturing enterprise and is located in the North of Pakistan. IT realises a number of types of high precision product on make to order basis. ME2 is a small to medium sized public sector enterprise with approximately 500 regular employees and at the time of modelling was handling five projects through project managers.

Case ME3: This is a high precision parts manufacturing enterprise located in the South of Pakistan and is considered to be a medium sized public sector enterprise with 1500 employees. At the time that modelling work was carried out in ME3, a workload of 9 projects was being undertaken which was managed through 9 project managers.

It follows that all three of the chosen MEs deploy a project-oriented structure which perform different product realization activities in various departments; namely design, manufacturing, chemical treatment, integration, quality and project management departments. The financial details of these case study enterprises are not revealed due to the MoU signed with the case enterprises at the start of this research.

5.2.4 Research Resulting in the Decomposition of Management Domain Processes

Domain processes decomposition was achieved in the three case study MEs using approaches described in this thesis sub-section. Here different types of data collection method were adopted.

Sampling Approach: Selection of appropriate samples and sample size is often a critical step in any research process aimed at obtaining valid and reliable results' particularly if those results are to be used to facilitate generalization of the findings over the whole case (Saunders, 2000; Ghauri, 2002). This research is based on exploring the nature of the business processes, enterprise activities and enterprise activity application indicators (and their interrelationships) in subject MEs; with a view to using the identified model of management processes as a basis for measuring the level of application of management processes in any given ME. Fulfilling this aim require an in-depth study of subject MEs. Therefore a non-probability (non-random) sampling approach is adopted during project case study interviews.

Questionnaire: In the three case studies under investigation, it was not feasible financially or time wise to interview a large number of people. But it was decided that it would be practical to conduct a number of in-depth, interactive discussions with a representative number of experts. The experts were identified and selected through use of the questionnaire shown in Appendix A, which is focussed on assessing the knowledge and experience of respondents. This approach to data collection as part of the case study method allowed the author to target in-depth discussions at relevant people who were considered to have an appropriate level of experience of management area relevant to this research. Following which the in-depth interview guide (included into Appendix B) was designed with a focus to identify sets of business processes that are relevant to planning, organizing, leading and controlling functions in the three case study MEs.

Pilot Interview: Initially, pilot interviews were conducted with management officials of the three public sector manufacturing enterprises. The purpose of these interviews was to refine the questions, to check the quality of answers that the questions provoked, to verify the length of interview time and to provide author with some practice in conducting in-depth interviews.

In-depth Interviews: During subsequent interviews with management experts, the focus of investigation was based on identifying, exploring and understanding key management processes at the business process level of MEs. At the beginning of each interview, the author informed the interviewee about the purpose of his research and provided a standard ethical protocol to enable them to be at the same starting point to ensure reliability. The aim was to ensure that all participants give their informed consent prior to commencing the data collection. The interviews lasted between 15 to 25 minutes.

By such means an identification and decomposition of domain processes was made based on semi structured interviewing of knowledgeable and experienced experts. In order to identify these experts, a criterion for selection of respondents for semi-structured interviews was defined as being greater than 7 years of experience. Categorization of responses received through respondents based on their experience is illustrated in table 5-1.

Domain Process	Experience (<3 years)	Experience (3-7 years)	Experience (>7 years)			
			ME1	ME2	ME3	Total
Planning	18	15	6	2	4	12
Organizing	14	12	5	2	3	10
Leading	15	13	6	2	3	11
Controlling	12	11	5	1	3	9
Total						42

Table 5-1: Respondents based on their experience of management processes

Altogether 152 responses were received from the three MEs through the use of the questionnaire, out of which 42 were found to be within the defined criteria. The response received through the questionnaire indicated that few respondents have an experience greater than 7 years in more than one domain process. In such cases selection of respondent for a particular domain process was carried out based on their current role/position in case ME and through discussion with their line managers which ensured their suitability as an expert.

Following which semi structured interviews were conducted with the 42 selected experts. In the light of responses given by the experts from the three case study MEs, sets of business processes related to each domain processes were identified. However, the only business processes selected for further study were those that had common feedback given by a majority of the experienced respondents interviewed in each of the domain categories. A summary of key business processes identified through the process of interviewing respondents against domain processes is given in table 5-2.

Domain Process	Key Business Processes Identified	No. of Respondents
Planning	Time planning	10
	Quality Planning	9
	Risk Planning	8
	Resource planning	11
Organizing	Organizing Human Resource	10
	Organizing Financial Resource	9
	Organizing Procurement	8
Leading	Communication	10
	Direction Setting	8
	Motivation	9
Controlling	Monitoring	8
	Progress Analysis	9
	Corrective Action	7

Table 5-2: Summary of key business processes identified through semi structured interviews

Based on the feedback provided by the experienced respondents, a decomposition of management domain processes into key business processes was identified. Respondents were selected from three case study public sector manufacturing enterprises working in Pakistan (as opposed to a single ME), therefore, the nature of these decomposed business processes is considered to encode a combination of semi-generic and particular management processes.

Figure 5-5 provides a graphical representation of the domain processes and their associated decomposed key business processes identified through interviews with experts of three case study MEs during this research. This graphical model was viewed as providing a semi-generic reference model of management processes used in Pakistan MEs; in addition the author considered that it is likely that this reference model, or at the least segments of it, can have wider application in other MEs.

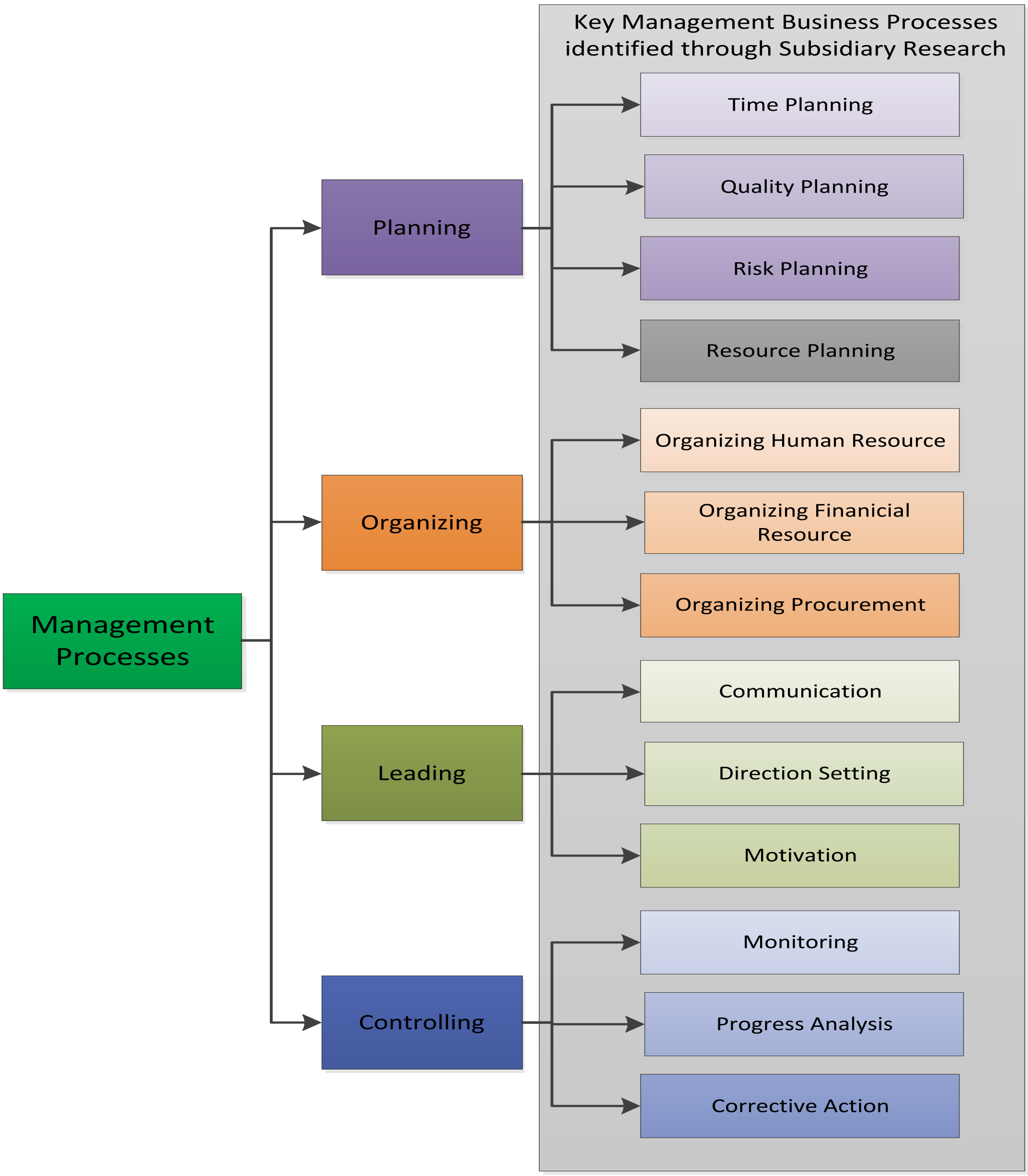

Figure 5-5: Decomposition of Domain Processes into Business Processes

5.2.5 Level 3: Enterprise Activities (EA)

In the introduction to case study MEs it was mentioned that the selected MEs all have a project-oriented structure. This means that projects are separately managed via different project managers. In Pakistan most enterprises, especially public sector MEs, are encouraged by the Pakistan Government to follow USA standards related to areas of project management knowledge areas. The Project Management Body of Knowledge (PMBoK) is a standard guide, which conforms to the recommendations of the Project Management Institute (PMI), USA (PMBoK, 2008). Therefore, bearing in mind the need to conform to government guidelines the next stage decomposition of each business process into EA was carried out with reference to the PMBoK guide. It follows that at this third stage of management process decomposition (from business processes into enterprise activities) was essentially based upon a literature/standards review.

Table 5-3 shows key EAs identified by the author as being constituent activities of Business Processes by referencing the PMBoK guide.

Domain Process	**Business Process**	**Enterprise Activity**
Planning	Time Planning	Define Scope
		Create WBS
		Develop Schedule
	Quality Planning	Quality Management Planning
	Risk Planning	Risk Management Planning
	Resource Planning	HR Planning
		Budget Planning
		Procurement Planning
Organizing	Organizing Human Resources	Acquire HR
		Allocate HR
	Organizing Financial Resources	Acquire Budget
		Allocate Budget
	Organizing Procurement	Inventory Management
Leading	Communication	Distribute Information
	Direction Setting	Aligning Resources Efforts
	Motivation	HR Growth and Development
		Compensation System
Controlling	Monitoring	Time Monitoring
		Cost Monitoring
		Quality Monitoring
		Risk Monitoring
	Progress Analysis	Schedule Analysis
		Cost Analysis
		Quality Analysis
		Risk Analysis
	Corrective Action	Revisions of Plans

Table 5-3: Decomposition of Business Processes into Enterprise Activities

To recap: the first Domain Process definition stage was based on literature review but the second stage decomposition (from Domain Process into Business Processes) was based of case study investigation in three MEs. The third stage decomposition from

Business Processes into management EAs was informed from the literature by referencing the PMBoK guideline.

5.2.6 Level 4: Enterprise Activities (EA) Application Indicators

The PMBoK guide is divided into nine knowledge areas and five process groups. A Process Group includes the constituent Project Management (PM) processes that are linked by the respective inputs and outputs necessary for the execution of a PM process.

Enterprise activities identified as being relevant to this research (see table 5-3) were selected by the author in the light of his understanding (based on many practical experiences) of the PM processes mentioned in PMBoK guide. Next so called 'EA indicators' which can be used to quantify the extent to which a particular EA has been applied in any given ME were attached to EAs. The author selected those indicators by making reference to PMBoK recommended inputs and outputs associated with entities comprising the PM processes in each knowledge area.

Table 5-4 shows the resultant business process decomposition into EAs and their associated EA indicators, which was conceived by the author.

Business Process	**Enterprise Activity**	**Enterprise Activity Application Indicator**
Time Planning	Define Scope	Project Charter
		Stakeholder Register
		Scope Statement
	Create WBS	WBS
		WBS Dictionary
	Develop Schedule	Activity List
		Milestone List
		Activity Duration Estimate
		Activity Sequencing
Quality Planning	Quality Management Planning	Quality Criteria
		Quality Standard Documents
		Quality Compliance Procedure
Risk Planning	Risk Management Planning	List of Identified Risks
		List of Potential Responses
		Risk Breakdown Structure
		Risk Mitigation Plan
Resource Planning	HR Planning	Activity HR Requirements
		Responsibility Assignment Matrix (RAM)

		Organizational Charts
		Staffing Management Plan
	Budget Planning	Activity Cost Estimates
		Budget Plan
	Procurement Planning	Make or Buy Decisions
		Source Selection Criteria
		Procurements Statements of Work
		Procurement Documents
Organizing Human Resources	Acquire HR	Recruitment Manual
		Register for HR Acquisition Time
		Preventive Turnover Procedure
	Allocate HR	Placement Policy and Procedures
		Employee Turnover record
Organizing Financial Resources	Acquire Budget	Policies to Acquire Budget
		Register for Budget Acquisition Time
	Allocate Budget	Disbursement Procedures
Organizing Procurement	Inventory Management	Inventory Management Manual
Communication	Distribute Information	Communication Management Plan
Direction Setting	Aligning Resources Efforts	Production Review Management System
		Financial Review Management System
		Quality Review Management System
Motivation	HR Growth and Development	Promotion Policies
		Performance Appraisal Document
		Training and Development
	Compensation System	Monetary Reward and Recognition System
		Non-Monetary Reward and Recognition System
Monitoring	Time Monitoring	Time Process Flow Diagram
		Time Feedback report
	Cost Monitoring	Cost Process Flow Diagram
		Cost Feedback report
	Quality Monitoring	Quality Process Flow Diagram
		Quality Feedback report
	Risk Monitoring	Risk Process Flow Diagram
		Risk Feedback report
Progress Analysis	Schedule Analysis	Schedule Performance Analysis Report

	Cost Analysis	Cost Performance Analysis Report
	Quality Analysis	Quality Performance Analysis Report
	Risk Analysis	Risk Performance Analysis Report
Corrective Action	Revisions of Plans	Time Management Plan Update
		Cost Management Plan Update
		Quality Management Plan Update
		Risk Management Plan Update

Table 5-4: Identification of Enterprise Activity (EA) Application Indicators

In chapter six, which reports on stage II of this research, there is a discussion about selecting a suitable standard modelling technique to explicitly and visually represent this decomposition of the management process: in such a way that it can conforms to the state of the art in enterprise modelling and be formally documented within suitable computer tools.

Chapter 6: Enterprise Modelling of the Case MEs

This chapter explains how an International standard enterprise modelling technique was use to model the application the management process decomposition conceived in chapter 5. The chapter begins with the selection of suitable enterprise modelling approach necessary for developing an enterprise model to visualize the way in which decomposed management process are applied in MEs. Next it reflects on the significance and usefulness of the enterprise modelling in specific case MEs. The chapter concludes by presenting different models of management processes adopted by case study MEs, where those models were developed using standard CIMOSA modelling concepts coupled to the use of representational extensions to CIMOSA that had previously been conceived and tested as part of the RPM approach.

6.1 Enterprise Modelling of MEs

6.1.1 Enterprise Modelling Requirements

One of the objectives of this research is to select and test suitable means of creating an enterprise model in order to visualize the application of management processes in any given ME. Because typically MEs are complex man made organisations, in order to visualize interrelationships between management processes and the operational and infrastructural processes they manage in any given ME the author decided that a suitable architectural framework would be required to structure the modelling process itself. Such a modelling framework would need to support the development and explicit representation of process models in a way that represents organisational structures that constrain the interconnectivity of processes at different levels of modelling abstraction.

Management in ME deals with the production, quality and finances of products to be manufactured. Therefore, it was presumed that an architectural framework is required which can support the following:

- Mapping of processes at macro level
- Representation of micro level processes
- Multi perspective interconnectivity of processes.
- Representation of micro level processes to measurable activities

6.1.2 Selection of Suitable Enterprise Modelling Technique

According to Vernadat (1992), Weston (1993), Kosanke (1997) and Bernus (1996), process modelling in an enterprise needs an architectural framework. A significant body of research has been carried out to develop and industrially apply enterprise architecture frameworks (Chatha, 2005). Among these the most known are; Computer Integrated Manufacturing Open System Architecture (CIMOSA, 1993), Architecture for Information Systems (Scheer, 1998), the Integrated Enterprise Modelling (Mertin et al, 1998) and IDEF3 (Kim, 2001). Comparing these architectures CIMOSA and ARIS present strong similarity and are both process oriented approaches aiming at integrating functions by modelling and monitoring the action flow (Chen et. al., 2008). Table 6-1 shows comparison of enterprise modelling architectures (Chatha, 2004).

Organisation Design Requirements		CIMOSA	Monfared's Process Modelling Approach	IDEF3	IEM
Process Lifecycle		**	**	**	***
Multi-process oriented organisation structure enforcing decomposition principle	Multi-process oriented structure	*	---	---	---
	Decomposition principle	***	***	**	**
Generic process modelling language for generating semantically rich process specifications		**	***	***	***
Process modelling method to support process lifecycle		***	***	---	***
Modelling concept framework		****	---	---	---
Exceptions handling		**	---	---	---
Resource coordination		---	---	*	---
Coverage	*****Very High	****High	***Medium	**Low	* Very Low

Table 6-1: Comparison of enterprise modelling architectures (Chatha, 2004)

As illustrated in Table 6-1, CIMOSA and Monfared's process modelling approach provides a better coverage of process-oriented decomposition principles and process modelling methods as compared to IEM and IDEF3.

For approximately two decades researchers in the MSI Research Institute at Loughborough University have contributed to Enterprise Modelling developments. The PhD research of (Aguiar, 1995), (Singh, 1994), (Coutts, 2003) and (Monfared, 2000) conceived and deployed enterprise modelling methods and tools. Their approaches to modelling: (1) build upon concepts originally developed as part of IDEF (Kim, 2001), CIMOSA (Vernadat, 1992), GRAI/GIM (Chen, 1996) and the Purdue (Williams, 1992) reference architectures; and (2) have contributed towards GERAM standardization (Bernus, 1996). Since then (Weston, 1998a), (Harrison R, 2001), (West, 2003), (Chatha, 2004), (Byer, 2004), (Ajaefobi, 2004), (Rahimifard and Weston, 2007), (Zhen, Accepted April 2008. In press.), (Masood et al., Accepted August 2008. In press. 2010), (A-Kodua K., 2008), (Wahid, 2008) and (Weston, 2008) have significantly enhanced CIMOSA modelling by building upon its key process oriented decomposition and modelling strengths and addressing some of its previous weaknesses; such as by enabling more effective resource and organization modelling and by unifying the use of enterprise modelling, and (discrete event and continuous) simulation modelling techniques (Rashid et al., 2009).

Keeping in view the above mentioned strength and enhancement of CIMOSA based Monfared's process modelling approach and the Enterprise Modelling Requirements mentioned in Section 6.1.1, CIMOSA based Monfared's process modelling approach is considered suitable for this research.

6.1.3 Application of the Selected Enterprise Modelling Technique

Many researchers in the MSI Research Institute at Loughborough University have worked for more than two decades researching and prototyping new modelling concepts, architectures, methods, and tools which facilitate the unified modelling of complex systems (Rashid et. al., 2009). A process modelling approach based on the CIMOSA framework was developed at the MSI and is termed the RPM (Radmehr P. Monfared) approach. This approach is primarily based on use of the CIMOSA function view. Monfared provided an organized use of four types of graphical modelling diagrams known as context diagrams, interaction diagrams, structure diagrams, and activity diagrams (Monfared, 2000). These diagrams are used for documenting relatively enduring aspects of the interactions between Domain Processes (DPs), Business Processes (BPs), and Enterprise Activity (EAs) in the form of transfers of physical, information, human, or financial entities (Chatha and Weston, 2005). Each one of these diagramming templates is populated with case data and thereby constitutes an important fragment of a specific case enterprise model under development and use. Collectively the four types of graphical models can be used to capture and graphically represent a coherent and complementary set of views about process attributes at needed levels of abstraction. Together these diagrams provide a big picture (or organizational context) of the requirements of an organization under study, and of how this big picture is explicitly composed of dependent process segments (Rashid et. al., 2009). Attributes of these diagrams are summarized as follows (Monfared, 2000).

Context diagram: The context diagram is used to define domains to be modelled using CIMOSA formalisms. The context diagram organizes an enterprise into manageable modules and hierarchically breaks down system complexity. These modules are called domains. Modules that are of concern in a project, and for which models will be produced, are termed CIMOSA domains and those, which are not of concern, are called non-CIMOSA domains. Domains may be represented by oval shaped bubbles. Simple bubbles may represent CIMOSA domains, while crossed-out bubbles may represent non-CIMOSA domains. Context diagrams can be decomposed into sub level context diagrams to identify sub domains and domain processes.

Interaction diagram: Domains interact with each other by means of events (which typically take the form of requests or triggers to do something) and results (defined as being views on enterprise objects). The interactions among domains take the form of information exchange, human resource exchange, physical resource exchange, and events. Creating an interaction diagram specifies these interactions. Interaction diagrams can be drawn to identify, define, organize, and represent the interactions involved among DPs.

Structure diagram: A structure diagram is the one that identifies key structural dependencies between process segments, by organizing and graphically depicting enduring relationships between the Business Processes (BPs) and Enterprise Activities (EAs) that collectively compose a domain process, or sub domain process.

Activity diagram: An activity diagram encodes a sequence of EAs and BPs. EAs, BPs, and control flows are represented by graphical model building blocks. From one viewpoint the activity diagrams explicitly define temporal relationships between process segments and their elements. However, only static temporal relationships can be defined using activity diagrams. CIMOSA activity diagrams do not have representational concepts for changes in the states of process variables.

6.2 Significance of Enterprise Modelling in the Chosen Case MEs

Enterprise modelling provides a formal way of capturing, representing and analysing relative enduring characteristics of a manufacturing enterprise (ME) from different perspectives; such as from physical, informational, human and financial points of view. CIMOSA is considered by many authors to be the most comprehensive of current public domain EM approaches. As part of this study the author deployed CIMOSA to visualize the “As-Is” picture of decomposed management processes carried out in a chosen case study ME. CIMOSA's systematic approach to complex systems decomposition was adopted to structure the first step of a new modelling methodology aimed at 'measuring' the extent to which specified management processes have been adopted by a subject ME.

Here a founding research assumption made which needed to be tested is that measuring the extent of the application of management processes via formal decomposition and explicit modelling will provide benefit by highlighting areas where improved application of management processes should be considered.

Further it is presumed that potential improvements in manage processes identified in this way can have a significant positive effect on operate and support processes of MEs: but as explained earlier that for this research operate and support processes are assumed to be constant and so the study of these various possible effect is out of the scope of this research.

6.3 Modelling Stage of Research

In the modelling stage of research, the author decided that the decomposition of management processes should be presented in the manner illustrated in figure 6-1.

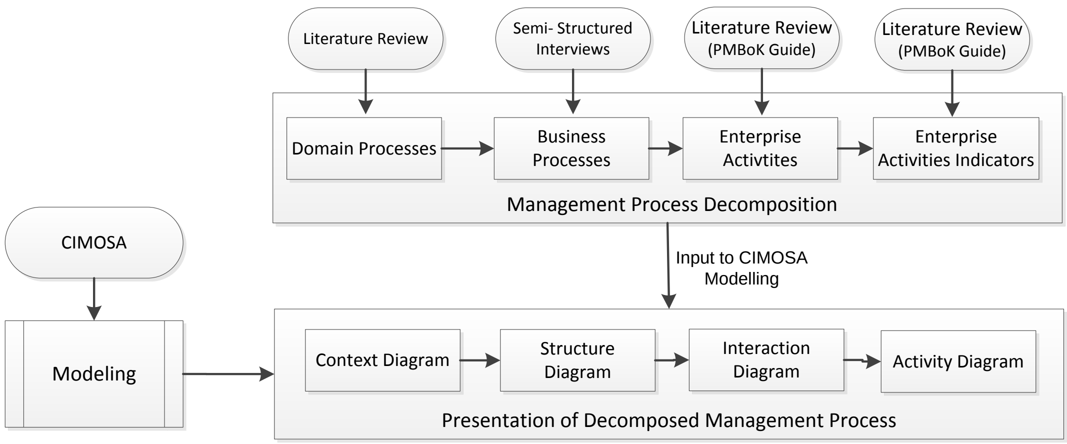

Figure 6-1: Modelling stage of research

Therefore the author used best in class EM techniques to classify and decompose a variety of management processes into their respective domains, domain process, business process, enterprise activity and enterprise activity indicators. This process-oriented decomposition was carried out through four levels of modelling abstraction (the first three of which were previously defined by the CIMOSA consortium) as indicated in figure 5-3 and explained in section 5-2.

6.4 Enterprise Modelling of Case ME1, ME2 and ME3

As earlier discussed ME1, ME2 and ME3 are all public sector enterprises located in the same country .It followed that in essence the organizational structure, culture and management style of all three case MEs are similar (the introduction to the three MEs was already presented in section 5.2.3). Similarly during subsequent research of the author, which was carried out, to further decompose domain processes into respective business processes, management expert respondents working in the three case study MEs were selected and interviewed, as also described in Chapter 5. Therefore the reference model of management processes created by the author and reported in Chapter 5 is considered to be equally applicable to the three case MEs.

Therefore during the second stage of this research study reported in this chapter, enterprise modelling was carried out in the three case MEs, by using CIMOSA based RPM enterprise modelling approach within the well defined CIMOSA modelling architecture. Normally when using the RPM approach, modelling is initiated by developing a context diagram. Figure 6.2 illustrates how the author initiated CIMOSA modelling of the management process decomposition specified during the first stage of his research.

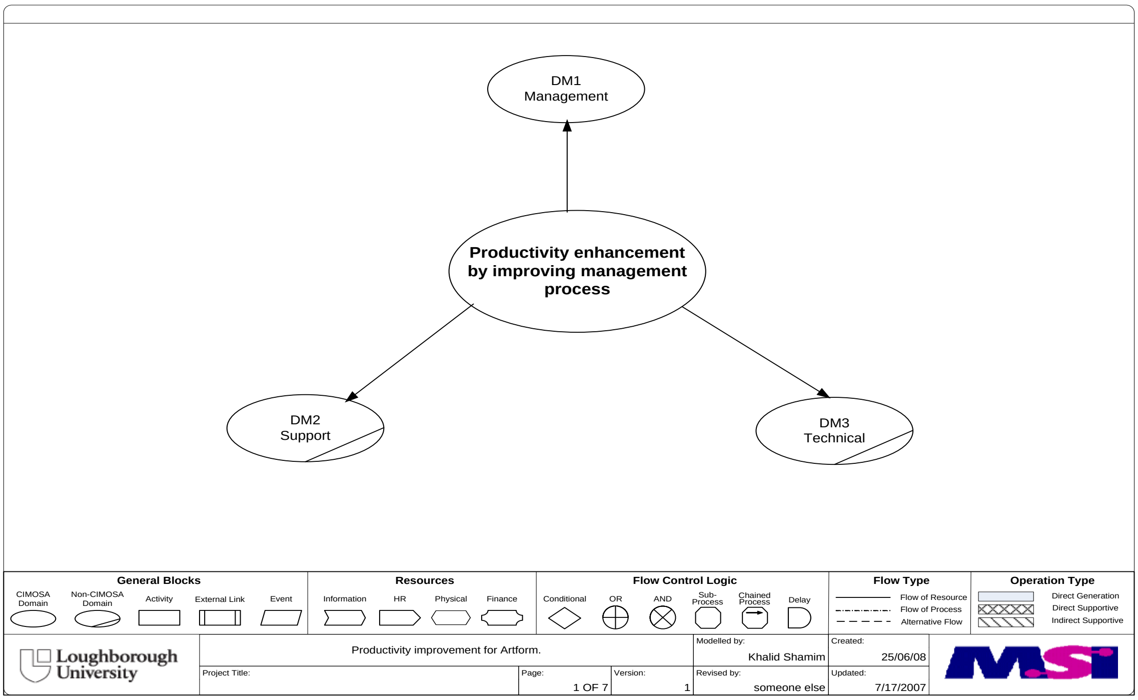

Figure 6-2: Context diagram for ME1

Figure 6.2 shows the aim of this research work i.e. measuring the level of application of management processes (LAMP) in any subject ME for the purpose of finding potential improvements to enhance productivity. In this 'context' diagram, three main domains are presented which contribute in converting the inputs to an ME into outputs: but only the management domain is considered during this stage of modelling to be CIMOSA conformant domain, while the other two domains "Support" and "Technical" are assumed to be Non-CIMOSA domains for the purpose of carrying out this research in accordance with the research assumption presented in section 1-5.

6.4.1 Modelling Domain Processes

A sub context diagram is presented in figure 6.3. This sub context diagram illustrates the four sub domains of the management domain. The included sub domains are planning, organizing, leading and controlling.

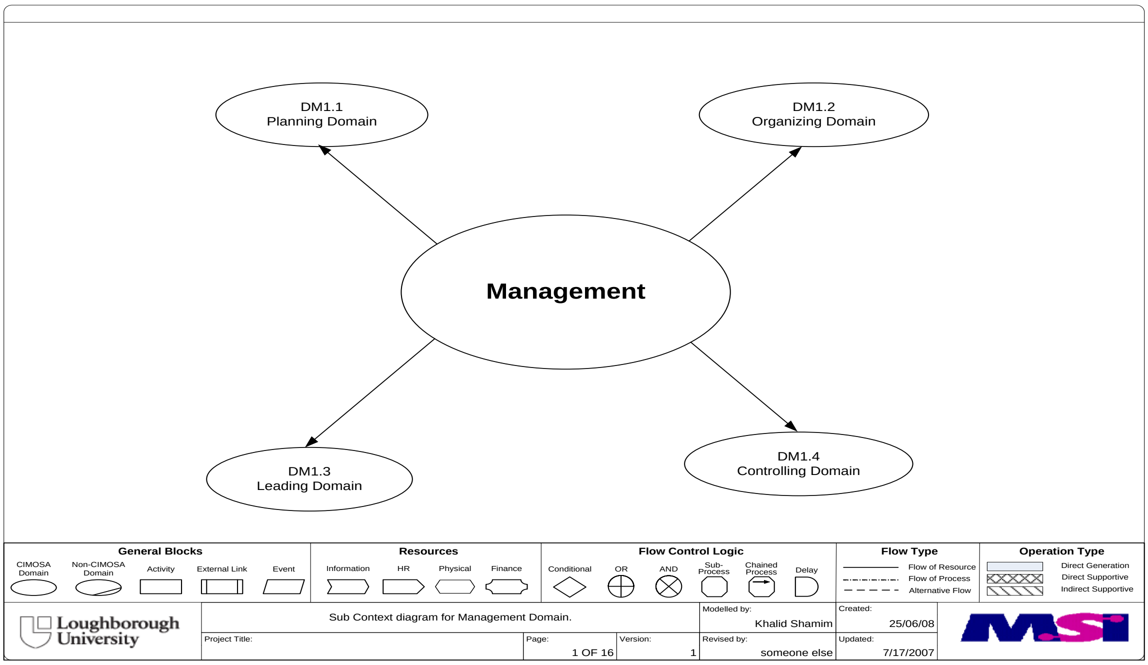

Figure 6-3: Sub Context diagram for Management Domain

As shown in figure 6.3, the CIMOSA conformant domain "Management" contains four CIMOSA conformant domains namely planning, organizing, leading and controlling, while there is no Non CIMOSA domain. All of these four CIMOSA conformant domains will be decomposed further and modelled in depth in order to understand and document the As-Is process network of MEs including all the management processes. For this purpose the CIMOSA based modelling templates "Structure diagram", "Interaction diagram" and "Activity diagram" are used. Example uses of these templates are illustrated in the following sub-sections.

6.4.2 Modelling Business Processes

A top-level 'structure' diagram is presented in figure 6.4. This diagram presents the decomposition of each of the four CIMOSA domains presented in figure 6.3 into their respective business processes. It also indicates the normal sequential flow of those processes via the circulating arrows.

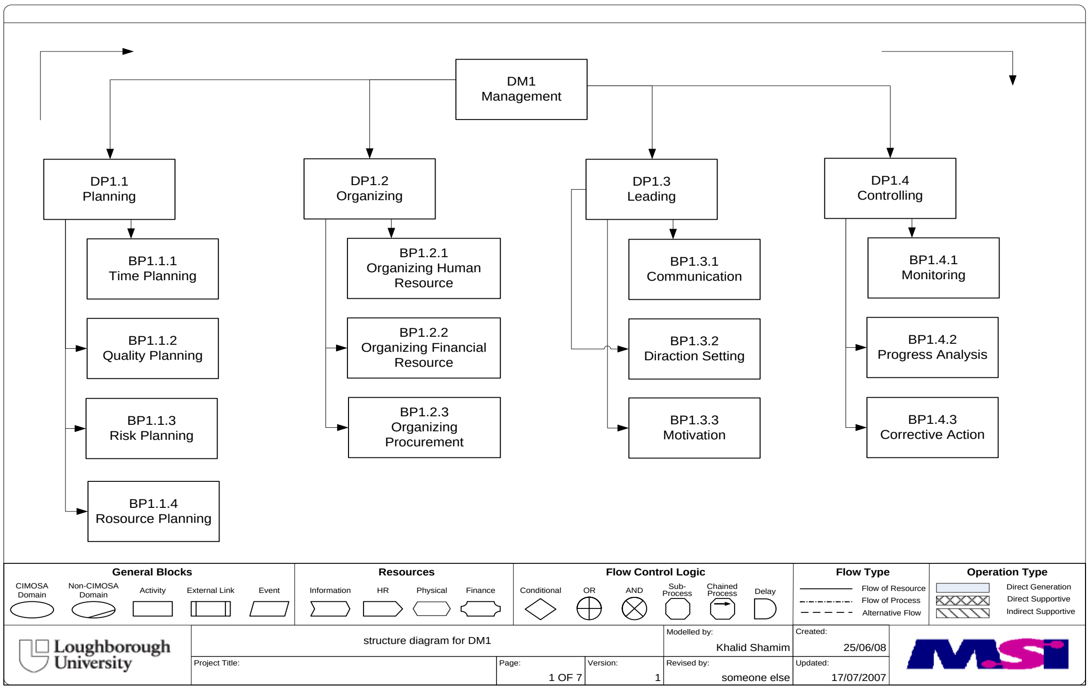

Figure 6-4: Structure diagram for MEs

The structure diagram of Figure 6.4 presents organised groupings of 13 business processes (BPs) in total related to domain processes of the 4 CIMOSA conformant domains. These 13 BPs were specified based on common responses of the 42 management experts in the three MEs cases studied. The circulating arrows at the top presenting the flow from left to right and from top to bottom show the deduced sequential flow of the business processes. Some exceptions regarding parallel processing also exist, details of which will be illustrated in the CIMOSA activity diagrams later in this section.

6.4.3 Modelling the Interconnectivity between Management DPs and BPs

The presented business processes interact with each other, as well as with specific ME case operational and infrastructural support processes. A CIMOSA top-level interaction diagram was created by the author and is presented in figure 6.5, which illustrates only interactions between management processes. Here the focus was on modelling management interactions only to maintain the clarity and generality of the models. The diagram presents interactions between all the businesses processes (BPs) included in the management domain (DM1). It also represents the interaction of the BPs with Non CIMOSA domains (DM2 and DM3), which are presented as external links. In figure 6.5, the interactions are shown using four of the available interaction constructs namely information, physical, human and finance.

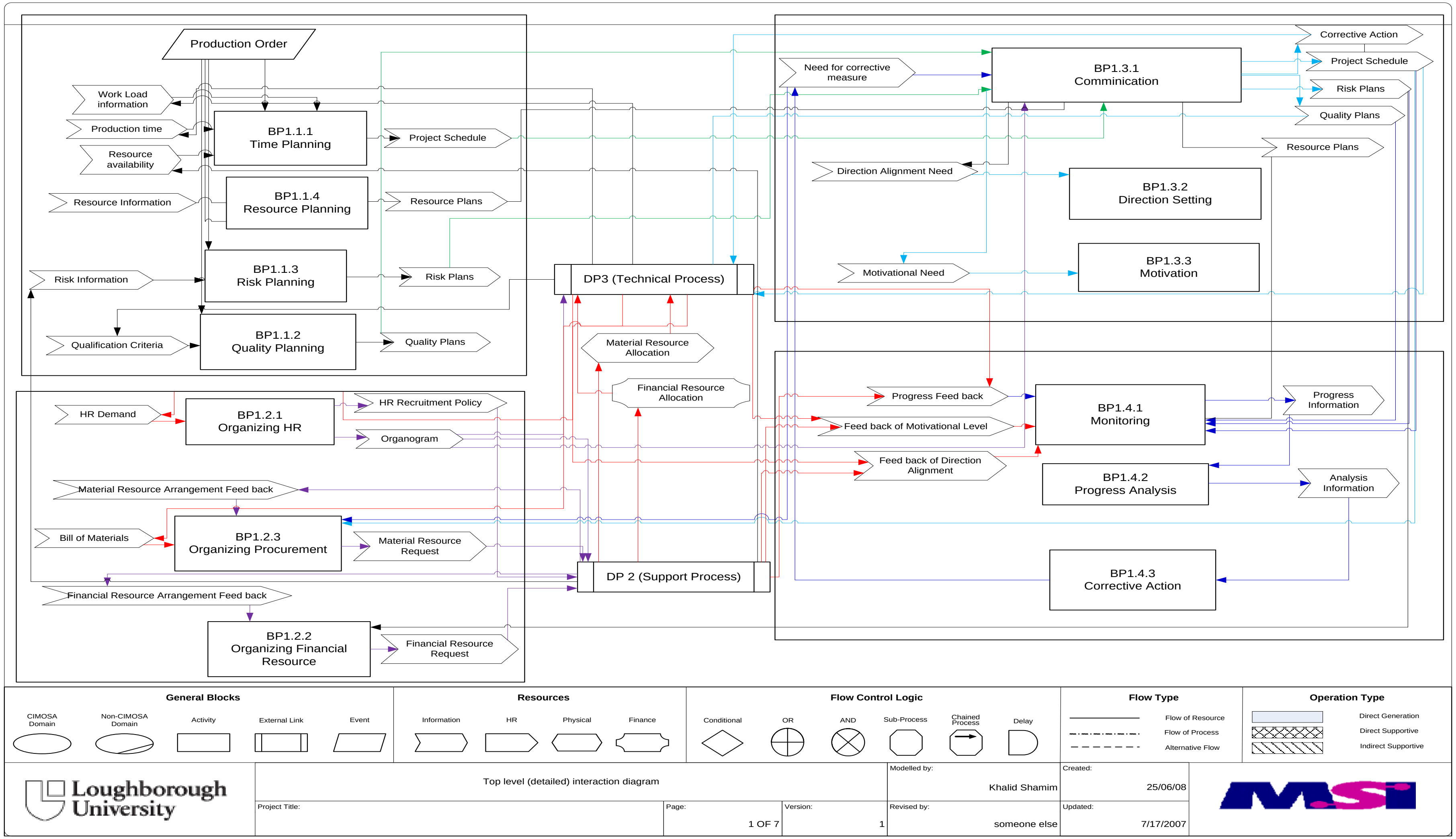

Figure 6-5: Top-level interaction diagram for MEs Management Domain.

In figure 6.5 the top-level interaction diagram for management processes in the study MEs shows an event, which is availability of a “Production order”. This is assumed to trigger all the related management processes needed to realize that order. For instance, it is presented in relation to the elements in the interaction diagram that realize a production order, namely “time planning”, “quality planning”, “risk planning” and “resource planning”. All of these planning processes are performed with reference to relevant information. The resultant outcomes are plans, which are then forwarded to relevant processes. The structure diagram shows that the next domain in the sequence of operation of the management process is typically the “Organizing” domain. BPs of the organizing domain is shown in the interaction diagram as realizing the plans. Various segments of the plans are achieved by using BPs like “organizing human resource”, “organizing procurement” and “organizing financial resource”; and by such systematic means the user of the enterprise model can visualize how the resources are (or should be) organized in the MEs. The output from this ‘organising’ domain is shared with internal and external domains. The natural third sequential member of the CIMOSA domain is the “Leading” domain, which is comprised of more elemental business processes, namely “Communication”, “Aligning direction” and “Maintaining Motivation”. The fourth CIMOSA conformant domain “Controlling” is decomposed into BPs like “monitoring”, “progress analysis” and “corrective action”. These BPs are interacting with other domains to control and regulate the requirements placed in the production order.

6.4.4 Modelling Enterprise Activities

It follows that management business processes interact with other domains and the enterprise model of the management processes provides an explicit and visual picture showing how management processes are or should be carried out to make sure that the direction of ME efforts are; (i) aligned with productivity goals and (ii) maintain motivation levels.

The most detailed level of the management of business process realization is represented in the author’s enterprise model of management processes in the form of activity diagrams. As earlier discussed, to populate the CIMOSA based activity diagramming template, the author chose to populate enterprise activities by using source information from a combination of the Project Management Institute (PMI) Body of Knowledge and the findings of semi structured interviews of relevant knowledge holders of the enterprise. Figure 6.6

represents an activity diagram developed for the domain process “planning”; which include four business processes namely “time planning” (BP1.1.1), “quality planning” (BP1.1.2), “risk planning” (BP1.1.3) and “resource planning” (BP1.1.4).

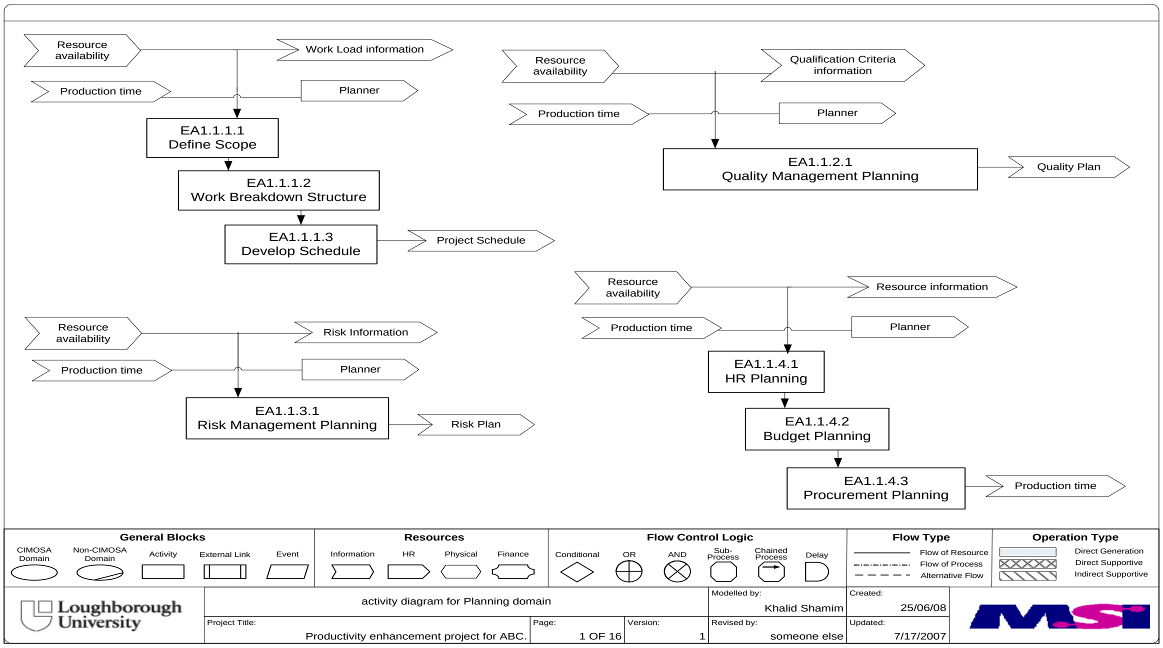

Figure 6-6: Activity diagram for MEs Planning domain

Figure 6.6 also shows that to realize the business processes of the planning process domain, all the activities are not in serial rather some activities are performed in parallel with each other. Each business process consumes some inputs and generates one or more outcomes. For instance, in figure 6.6, the inputs to time planning process (BP1.1.1) are “production time”, “resources availability”, “work load information” and “planner” whereas the result is a “project schedule”. Similarly figures 6.7, 6.8 and 6.9 show developed activity diagrams related to the organizing, leading and controlling domain processes.

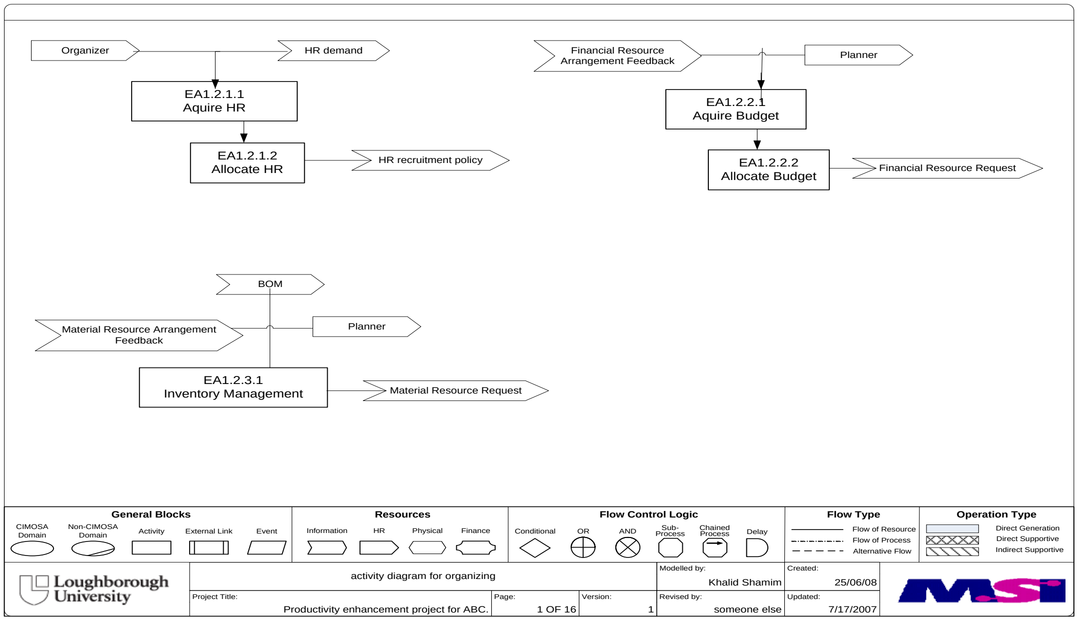

Figure 6-7: Activity diagram for MEs Organizing domain

Figure 6.7 illustrates the activity diagram created for the organizing domain. It shows activities related to three business process elements of the organizing process namely: "organizing human resource", "organizing financial resource" and "organizing procurement" (along with their inputs and results).

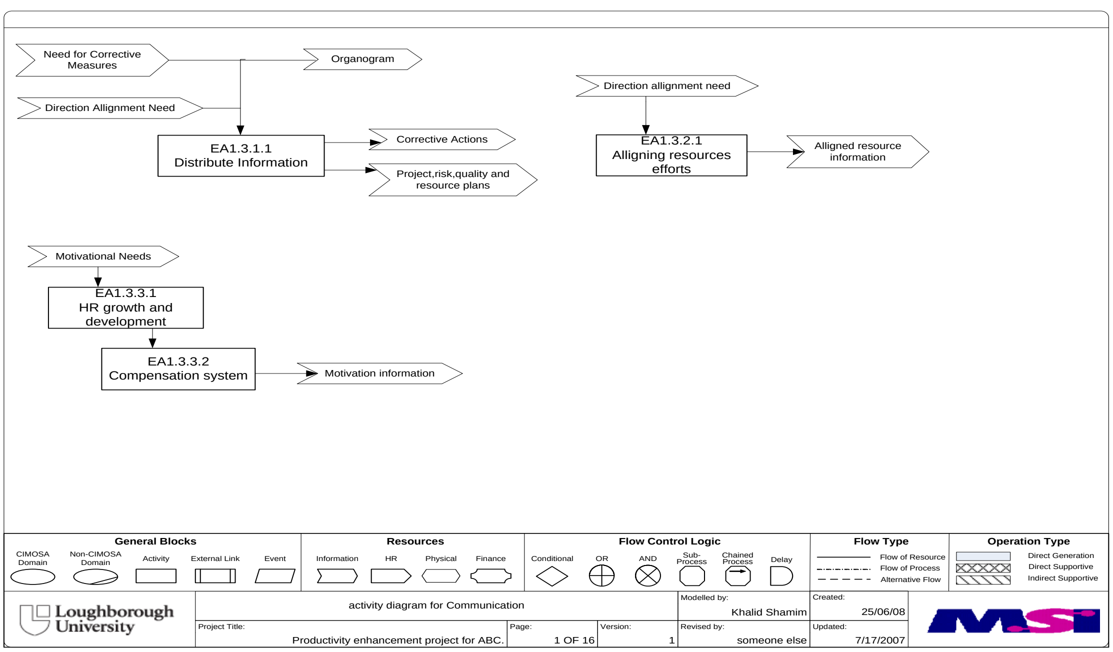

Figure 6-8: Activity diagram for MEs Leading domain

Figure 6.8 shows the activity diagram created for the leading domain. It presents activities related to three business processes of the leading process, namely: “communication”, “direction setting” and “motivation” (also along with their respective inputs and outcomes).

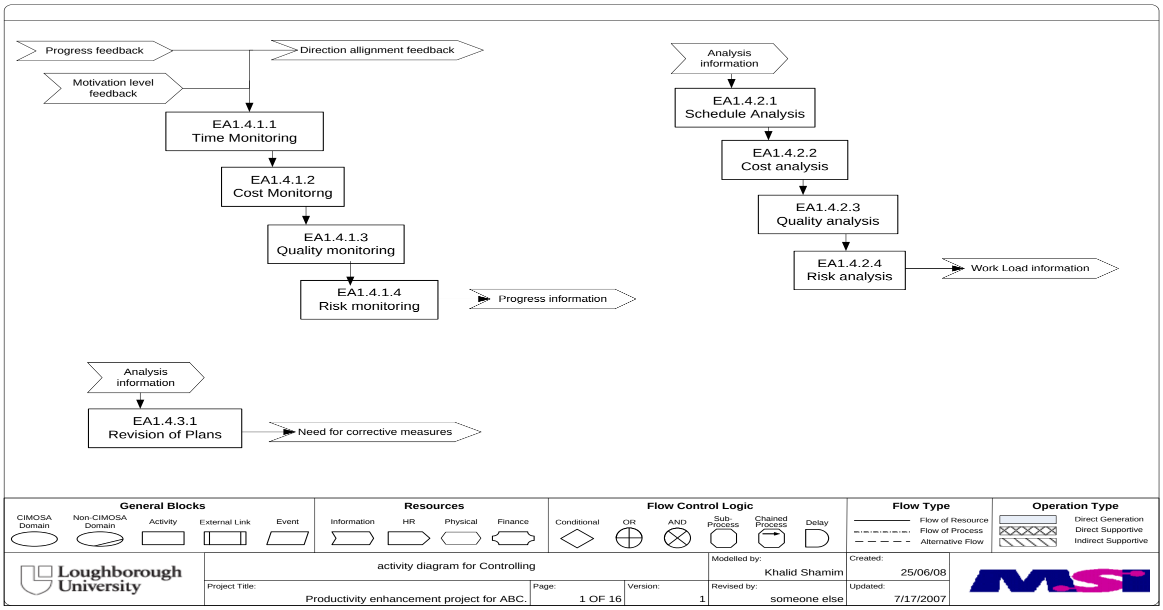

Figure 6-9: Activity diagram for MEs Controlling domain

Figure 6.9 illustrates the activity diagram created for controlling the domain. It shows activities related to the three elemental business processes of the controlling process namely: “monitoring”, “progress analysis” and “corrective action” (along with their inputs and results). From the activity diagrams shown in figures 6.6, 6.7, 6.8 and 6.9, enterprise activities related to the 13 business processes of MEs management process are visually presented along with their inputs and outcomes.

In the next chapter, based on the use of the explicit enterprise model of the decomposed management process a scorecard was developed to measure the level of application of management processes. Subsequently this scorecard was tested with respect to the three case MEs.

Chapter 7: Quantification of Management Process in Case MEs

This chapter describes how the author conceived a method of quantifying the extent to which the reference model of management processes, specified and modelled in previous chapters, is applied in case MEs. In the first section of this chapter the development of a LAMP Scorecard is described which involved designing a 'LAMP template' and 'LAMP scoring method'. Subsequent chapter sections explain how the LAMP scorecard was applied and tested for the purposes of collecting data about the extent of application. of the management reference model in a subject ME.

7.1 Development of LAMP Scorecard

One of the objectives of this research is to develop a methodology to measure the Level of Application of Management Process (LAMP) model in Manufacturing Enterprises (ME). This section explains the approach adopted to develop a so-called LAMP scorecard.

7.1.1 Methodology to Develop the LAMP Scorecard

In chapter 5, a reference model of management processes was created based on literature review and case study analysis. This reference model is well structured having referenced the CIMOSA enterprise modelling architecture, such that its elemental processes are organized as a process-oriented decomposition into domain processes, business processes and enterprise activities. Enterprise activities application indicators were also conceived, identified and are attached to process elements at the enterprise activity level of modelling abstraction in MEs. Further the decomposed management processes were explicitly and visually modelled by deploying the CIMOSA modelling technique. This enabled visualization of the reference model of management processes in the form of context diagrams, structure diagrams, interaction diagrams and activity diagrams. The Context diagram formalism was used to represent the four domains of management processes, namely planning, organizing, leading and controlling. The structure diagram showed the decomposition of different Domain Processes (DP) into constituent Business Processes (BP). While the interaction diagram was used to identify, define, organize, and represent the interconnectivity among DPs and BPs. These interactions take the form of events and exchange of data regarding information, human resource and physical resource. At the bottom-most level of the modelling hierarchy, a number of activity diagrams were used to represent the flow of activities related to different business processes.

This explicit and visual reference model of management processes formed the conceptual basis and inputs for designing an application template for LAMP, a LAMP scoring method and a LAMP scorecard. This methodology followed when realizing the LAMP scorecard is illustrated in figure 7-1.

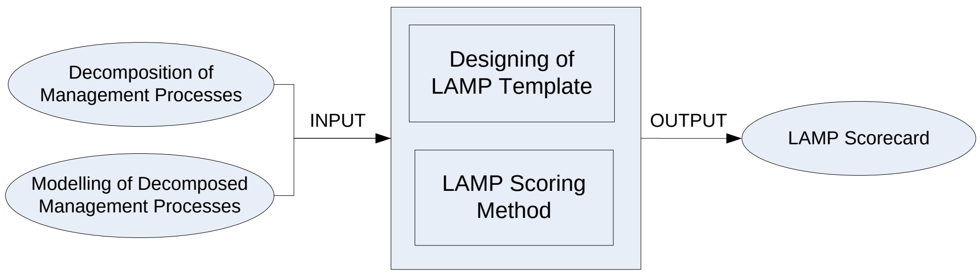

Figure 7-1: Methodology to develop LAMP scorecard

7.1.2 Template of LAMP Scorecard

As mentioned earlier measuring the level of application of management process in any ME requires measurable indicators to be assigned to processes at suitable stages of operation of those processes. Consequently the author presumed a need to decompose, or break down, management processes into their elemental parts (or building blocks of management processes) so that measurable indicators could be attached to those elements. This was the founding rationale for identifying those elements of enterprise activities at a suitable level of modelling abstraction, as reported on in section 5-2.

Consequently the author also decided that LAMP (which is an acronym designed to convey a need to provide a quantitative measure of the extent to which the reference model of management processes is applied in practice) required the development of a scorecard which is capable of measuring whether or not recommended management processes (at the domain process, business process and enterprise activity levels of abstraction are/ or are not being carried out in any subject ME. Here though it was decided that measurements could most usefully and generally be attached to elemental enterprise activities, following which an analysis of groups of those indicators could be used to consider conformance to the management reference model at the business process and domain process levels.

In order to detect the occurrence of any given recommended enterprise activity in a subject ME, one or more indicators were identified as being appropriate to deploy. Here it was observed that the level of application of enterprise activity could be represented by a number of possible key indicators. Keeping these requirements and ideas in view, the template of a LAMP scorecard was designed in the form shown in table 7-1.

Domain Process (Percentage)	**Business Process (Percentage)**	**Enterprise Activity (Number)**	**Enterprise Activity Application Indicator**	**Response from Expert of ME (Yes/No)**
Controlling [ ]	Corrective Action [ ]	Revisions of Plans 0 | 1 | 2 | 3 | 4	Time Management Plan Update	Yes | No
			Cost Management Plan Update	Yes | No
			Quality Management Plan Update	Yes | No
			Risk Management Plan Update	Yes | No

Management Process Application Level

0-25% (Very Low)	26-50% (Low)	50-75% (Medium)	76- 100% (High)

Table 7-1: Template of LAMP Scorecard

The above-mentioned scorecard includes a reference to business processes, enterprise activities and enterprise activity application indicators related to specific domains of the reference management process. It also includes a ‘YES/No’ response about the application of enterprise activity indicator in the case ME. Each YES has one (1) score and each No has zero (0) score which is represented in the form of enterprise activity score (see enterprise activity column in table 7.1). To score the management process application in ME, a scoring ladder is used as indicated in chapter 4.

For instance, the enterprise activity ‘revision of plans’ has four enterprise activity application indicators namely time management plan update, cost management plan update, quality management plan update and risk management plan update. If a couple of these four indicators are applied in an ME then the enterprise activity ‘revision of plans’ will have two (2) score. Business process related to revision of plans is ‘corrective action’. The score of corrective action is calculated in the form of percentage, which in the above mentioned case is 50% (2/4*100%). To calculate the value for domain process, the average of its constituent business processes will be taken and this score will be presented in the form of percentage.

7.1.3 Level of Application of the Management Process Scorecard

Based on the LAMP template designed above and its scoring method, the methodology developed to measure the application of LAMP is presented in the form of a LAMP scorecard that is shown in table 7.2

Domain Process (Percentage)	Business Process (Percentage)	Enterprise Activity (Number)	Enterprise Activity Application Indicator	Response from Expert of ME (Yes/No)
Planning [ ]	Time Planning [ ]	Define Scope [0 | 1 | 2 | 3]	Project Charter	Yes | No
			Stakeholder Register	Yes | No
			Scope Statement	Yes | No
		Create WBS [0 | 1 | 2]	WBS	Yes | No
			WBS Dictionary	Yes | No
		Develop Schedule [0 | 1 | 2 | 3 | 4]	Activity List	Yes | No
			Milestone List	Yes | No
			Activity Duration Estimate	Yes | No
			Activity Sequencing	Yes | No
	Quality Planning [ ]	Quality Management Planning [0 | 1 | 2 | 3]	Quality Criteria	Yes | No
			Quality Standard Documents	Yes | No
			Quality Compliance Procedure	Yes | No
	Risk Planning [ ]	Risk Management Planning [0 | 1 | 2 | 3 | 4]	List of Identified Risks	Yes | No
			List of Potential Responses	Yes | No
			Risk Breakdown Structure	Yes | No
			Risk Mitigation Plan	Yes | No
	Resource Planning [ ]	HR Planning [0 | 1 | 2 | 3 | 4]	Activity HR Requirements	Yes | No
			Responsibility Assignment Matrix (RAM)	Yes | No
			Organizational Charts	Yes | No
			Staffing Management Plan	Yes | No
		Budget Planning [0 | 1 | 2]	Activity Cost Estimates	Yes | No
			Budget Plan	Yes | No
		Procurement Planning [0 | 1 | 2 | 3 | 4]	Make or Buy Decisions	Yes | No
			Source Selection Criteria	Yes | No

			Procurements Statements of Work	Yes / No
			Procurement Documents	Yes / No
Organizing [ ]	Organizing Human Resources [ ]	Acquire HR (0 / 1 / 2 / 3)	Recruitment Manual	Yes / No
			Register for HR Acquisition Time	Yes / No
			Preventive Turnover Procedure	Yes / No
		Allocate HR (0 / 1 / 2)	Placement Policy and Procedures	Yes / No
			Employee Turnover record	Yes / No
	Organizing Financial Resources [ ]	Acquire Budget (0 / 1 / 2)	Policies to Acquire Budget	Yes / No
			Register for Budget Acquisition Time	Yes / No
		Allocate Budget (0 / 1)	Disbursement Procedures	Yes / No
	Organizing Procurement [ ]	Inventory Management (0 / 1)	Inventory Management Manual	Yes / No
Leading [ ]	Communication [ ]	Distribute Information (0 / 1)	Communication Management Plan	Yes / No
	Direction Setting [ ]	Aligning Resources Efforts (0 / 1 / 2 / 3)	Production Review Management System	Yes / No
			Financial Review Management System	Yes / No
			Quality Review Management System	Yes / No
	Motivation [ ]	HR Growth and Development (0 / 1 / 2 / 3)	Promotion Policies	Yes / No
			Performance Appraisal Document	Yes / No
			Training and Development	Yes / No
		Compensation System (0 / 1 / 2)	Monetary Reward and Recognition System	Yes / No
			Non-Monetary Reward and Recognition System	Yes / No
Controlling [ ]	Monitoring [ ]	Time Monitoring (0 / 1 / 2)	Time Process Flow Diagram	Yes / No
			Time Feedback report	Yes / No
		Cost Monitoring (0 / 1 / 2)	Cost Process Flow Diagram	Yes / No
			Cost Feedback report	Yes / No
		Quality Monitoring (0 / 1 / 2)	Quality Process Flow Diagram	Yes / No
			Quality Feedback report	Yes / No
		Risk Monitoring (0 / 1 / 2)	Risk Process Flow Diagram	Yes / No
			Risk Feedback report	Yes / No

	Progress Analysis [ ]	Schedule Analysis 0 | 1	Schedule Performance Analysis Report	Yes | No
		Cost Analysis 0 | 1	Cost Performance Analysis Report	Yes | No
		Quality Analysis 0 | 1	Quality Performance Analysis Report	Yes | No
		Risk Analysis 0 | 1	Risk Performance Analysis Report	Yes | No
	Corrective Action [ ]	Revisions of Plans 0 | 1 | 2 | 3 | 4	Time Management Plan Update	Yes | No
			Cost Management Plan Update	Yes | No
			Quality Management Plan Update	Yes | No
			Risk Management Plan Update	Yes | No

Management Process Application Level

0-25% (Very Low)	26-50% (Low)	50-75% (Medium)	76- 100% (High)

Table 7-2: LAMP Scorecard

It was decided that the effectiveness of this LAMP scorecard should be established by testing through conducting research in the three case MEs.

7.2 Application/Testing of the LAMP Scorecard

The effectiveness of this LAMP scorecard was ascertained by applying the scorecard to obtain test data from the three case MEs. The data collection method adopted for testing the LAMP scorecard was through semi-structured interviews. As earlier stated the case MEs were operating on project oriented structure. Therefore, project managers were selected as key respondents for providing the feedback needed to fill in the LAMP scorecard. It was understood that the validity and reliability of the test results needed to be evaluated to facilitate generalization of the findings over the whole case.

7.3 Selection of Sampling Techniques

The selection of an appropriate sample and sample size was a key step in the research process, in order to obtain valid and reliable results. This research is based on exploring the business processes, enterprise activities and enterprise activity application indicators in MEs and then measuring the level of application of management processes based on the identified indicators. This was considered to require an in-depth study of any subject MEs, so a non-probability sampling approach is adopted initially during project case study interviews. In each case study under investigation, it was not feasible financially and time wise to interview a large number of people. It did, however, require conducting a number of interactive in-depth discussions with a representative number of experts. This approach used for data collection allowed the author to target respondents and have in-depth discussions with relevant people who were considered to have appropriate level of experience of the area under research. The sampling techniques adopted for this stage has characteristics of a purposive sampling technique. Use of this kind of for data collection arguably guaranteed adequacy of the data in terms of its amount and quality.

In the second step, a questionnaire was administered to measure the level of application of management processes in the case study MEs. For the questionnaire survey in this research, the probability sampling method was adopted and a stratified random sampling technique was considered as appropriate. It is impractical in quantitative methods to include the total population with which the research project is concerned: especially when the population is large in size. It was therefore necessary to obtain data from only a part of the total population. On the basis of the sample findings, results can be generalized to the whole population of case MEs. Each of the three case study MEs is handling a number of projects through separate project managers. These project managers play a pivotal role in bridging the link between top management and the functional areas of enterprise. The overall role of each project manager in all three case MEs is to look after all activities related to the project from its beginning until completion. This includes aspects of projects like cost, quality and time line. Therefore, each project manager is considered to need to access updated and reliable information about project activities and other enterprise issues as an insider. Keeping in view their knowledge, experience, vision and involvement, project managers were considered by the author to be appropriate experts and respondents who could furnish reliable data for this stage of the research.

In ME1, project managers are coordinating eleven projects, whereas project managers in ME2 and ME3 are coordinating nine and five projects respectively. In total therefore it was decided that twenty-five project managers would be respondent participants in this research stage.

7.3.1 Evaluation Indicators

This section provides a brief overview of potentially applicable evaluation indicators, before discussing them in relation to the present research.

7.3.1.1 Reliability

Reliability is the extent to which a procedure, or test by the investigator, produces a similar response or results under constant conditions on different occasions (Saunders, 2000; Yin, 2003). Another definition by Simon (1985) states that: "…reliability is essentially repeatability – a measurement procedure is highly reliable, if it comes up with the same result in the same circumstances time after time, even employed by different people". Data obtained through surveys from large well-known organizations and government departments are likely to be trustworthy and reliable as their existence depends upon the credibility of their data (Saunders, 2000). Reliability can be assessed by asking the following two questions (Easterby-Smith, 2001):

- Will the measure yield the same results on different occasions?
- Will different researchers make similar observations on different occasions?

7.3.1.2 Validity

According to Easterby-Smith (2001), validity refers to the extent to which 'the researcher [has] gained full access to knowledge and meanings of informants by carefully collecting data based on samples. A concern researchers may have in the design of questionnaire is the 'external validity of the data'. External validity refers to the extent by which any research findings drawn from studying one group or sample can be generalized beyond the immediate research sample or settings in which the research took place (Remenyi, 1988; Yin, 2003). It is stated by Creswell (2003) and Yin (2003) that qualitative and quantitative research using in-depth interviews and questionnaire survey will not be able to make generalizations about the entire population if it is based on small or un-representative number of cases. Saunders (2000) further argued that validity of findings of any research is dependent upon the adequacy of the data collected for generating ideas.

7.3.1.3 Selection of Evaluation Indicators

The sample size used in both 'case study interviews' and the 'questionnaire survey' is considered to be adequate to achieve validity and generalization of findings. This conclusion is drawn firstly because of the quality and amount of data collected on the area under research, and secondly because of the size and representation of the sample. There are inherent limitations in the use of each of these methods of data collection, which ultimately could have affected the reliability of the results. It is argued that using a single respondent for each case under study reduces the chances to achieve reliable and efficient data (Saunders, 2000). However, the use of multi-respondent approach from each case MEs allowed the researcher to obtain more reliable results. As mentioned earlier, the interviewed respondents were chosen carefully and the purpose of the research project explained to each respondent to enable them to be at the same starting point in order to optimize the reliability of the outcomes.

It is important to avoid the intentional introduction of bias in order to ensure that the research remains reliable, objective, and precise. To avoid this bias and to gain sufficient insight and understanding to answer the research questions, the need to obtain and analyze primarily qualitative data from both primary and secondary sources was identified. This approach is supported by other researchers, who advocate the use of multiple resources to ensure “construct validity” (Yin, 2003). To support the validity of the research, the sources of secondary data are gathered primarily from the academic refereed journals and published books. The empirical study to gather the primary data for this research follows on from the literature survey to gather from the secondary data, which has established the theoretical perspective of LAMP.

To measure validity, the author conducted pilot interviews to check whether the questions were valid in the investigation of the research questions. To increase the validity of findings of this research, adequate numbers of interviews (25 in total) were conducted with representative and experienced respondents. As McCraken (1988) points out, the first principle of the interview is “less is more” i.e. it is better to work more and with greater care with fewer and experienced people than less with more people. The interviews were also tape recorded to concentrate more on the discussion than on keeping notes and this was one of the ways of keeping the level of uncertainty low. The scorecard was administered to project managers (n=25) in the three case MEs. However, the numbers of replies received from each case ME were 11, 9 and 5 respectively. In total, the author received 25 feedbacks.

7.4 Data Collection and Results

Different stages of the research methodology adopted for this research are explained in section 5-1. The data for stage IV of this research was collected through discussion with the twenty-five project managers working in the three case MEs. During the discussion, the LAMP scorecard was filled in. The data obtained through the entire LAMP scorecard was coded numerically. Numeric coding is simply numbering the responses for computer analysis. Once the data were received it was arranged, coded and recorded into 'spread sheets' using EXCEL. For the questionnaire, the data needed to be entered manually into the spread sheet. The results obtained through the application of LAMP scorecard in case MEs are presented in the following tables.

Analysis of the data collected during LAMP scorecard testing is to be discussed in the next chapter to arrive at the conclusions and recommendations of this research.

LAMP Score	Domain Process	Business Process	Enterprise Activity (EA)	
			EA	**EA Score**
Management 52.86%	Planning 46.15%	Time Planning 57.32%	Define Scope	42.42%
			Create WBS	59.09%
			Develop Schedule	70.45%
		Quality Planning 51.52%	Quality Management Planning	51.52%
		Risk Planning 20.45%	Risk Management Planning	20.45%
		Resource Planning 55.30%	HR Planning	40.91%
			Budget Planning	59.09%
			Procurement Planning	65.91%
	Organizing 86.11%	Organizing Human Resources 83.33%	Acquire HR	66.67%
			Allocate HR	100.00%
		Organizing Financial Resource 75.00%	Acquire Budget	50.00%
			Allocate Budget	100.00%
		Organizing Procurement 100.00%	Inventory Management	100.00%
	Leading 33.33%	Communication 66.67%	Information Sharing	66.67%
		Direction Setting 0.00%	Aligning Resources Efforts	0.00%
		Motivation 33.33%	HR Growth and Development	66.67%
			Compensation System	0.00%
	Controlling 45.83%	Monitoring 37.50%	Time Monitoring	50.00%
			Cost Monitoring	50.00%
			Quality Monitoring	50.00%
			Risk Monitoring	0.00%
		Progress Analysis 50.00%	Schedule Analysis	100.00%
			Cost Analysis	0.00%
			Quality Analysis	100.00%
			Risk Analysis	0.00%
		Corrective Action 50.00%	Revision of Plans	50.00%

Table 7-3: Summary of LAMP Scoring for ME1

LAMP Score	Domain Process	Business Process	Enterprise Activity (EA)	
			EA	**EA Score**
Management 55.50%	Planning 44.37%	Time Planning 53.40%	Define Scope	40.74%
			Create WBS	61.11%
			Develop Schedule	58.33%
		Quality Planning 51.85%	Quality Management Planning	51.85%
		Risk Planning 19.44%	Risk Management Planning	19.44%
		Resource Planning 52.78%	HR Planning	44.44%
			Budget Planning	55.56%
			Procurement Planning	58.33%
	Organizing 88.58%	Organizing Human Resources 85.19%	Acquire HR	70.37%
			Allocate HR	100.00%
		Organizing Financial Resource 80.56%	Acquire Budget	61.11%
			Allocate Budget	100.00%
		Organizing Procurement 100.00%	Inventory Management	100.00%
	Leading 35.80%	Communication 74.07%	Information Sharing	74.07%
		Direction Setting 0.00%	Aligning Resources Efforts	0.00%
		Motivation 33.33%	HR Growth and Development	66.67%
			Compensation System	0.00%
	Controlling 53.24%	Monitoring 48.61%	Time Monitoring	61.11%
			Cost Monitoring	61.11%
			Quality Monitoring	61.11%
			Risk Monitoring	11.11%
		Progress Analysis 55.56%	Schedule Analysis	100.00%
			Cost Analysis	0.00%
			Quality Analysis	100.00%
			Risk Analysis	22.22%
		Corrective Action 55.56%	Revision of Plans	55.56%

Table 7-4: Summary of LAMP Scoring for ME2

LAMP Score	Domain Process	Business Process	Enterprise Activity (EA)	
			EA	EA Score
Management 69.44%	Planning 81.67%	Time Planning 71.67%	Define Scope	60.00%
			Create WBS	80.00%
			Develop Schedule	75.00%
		Quality Planning 66.67%	Quality Management Planning	66.67%
		Risk Planning 60.00%	Risk Management Planning	60.00%
		Resource Planning 81.67%	HR Planning	85.00%
			Budget Planning	80.00%
			Procurement Planning	80.00%
	Organizing 86.11%	Organizing Human Resources 83.33%	Acquire HR	66.67%
			Allocate HR	100.00%
		Organizing Financial Resource 75.00%	Acquire Budget	50.00%
			Allocate Budget	100.00%
		Organizing Procurement 100.00%	Inventory Management	100.00%
	Leading 46.67%	Communication 66.67%	Information Sharing	66.67%
		Direction Setting 40.00%	Aligning Resources Efforts	40.00%
		Motivation 33.33%	HR Growth and Development	66.67%
			Compensation System	0.00%
	Controlling 75.00%	Monitoring 50.00%	Time Monitoring	50.00%
			Cost Monitoring	50.00%
			Quality Monitoring	50.00%
			Risk Monitoring	50.00%
		Progress Analysis 100.00%	Schedule Analysis	100.00%
			Cost Analysis	100.00%
			Quality Analysis	100.00%
			Risk Analysis	100.00%
		Corrective Action 75.00%	Revision of Plans	75.00%

Table 7-5: Summary of LAMP Scoring for ME3

Chapter 8: Research Analysis and Conclusions

This chapter presents the analysis and conclusions of this research. Section one briefly describes the research review. The next section provides an overview of the study findings based on an analysis of the modelling work carried out which led to the application of the LAMP scorecard in case MEs. Subsequent sections concern the validation of LAMP scorecard applications and discuss limitations and weaknesses of the research work. Concluding sections reflect on the study, consider contributions to knowledge made and recommend future work.

8.1 Research Review

This research study started with an observation of the author while working in a public sector ME located in Pakistan that product realization is not simply dependent on deploying state of the art 'operational' and 'infrastructural support' processes but also depends upon the adoption of management processes that ensure efficient and effective use of human and non human resources.

Extensive literature review revealed potential advantages of better understanding management functions by adopting 'process thinking', i.e. thinking about current and possible future ways in which organised sets of value added activities can realise business goals by transforming inputs (such as material, sub-products, information and knowledge) into outputs (like products and services) required by customers (Vernadat, 1996; Weston, 1999). Previous researchers had classified transformational processes involved in realizing products and services in ME into manage, operate and support process classes (Pandaya et. al., 1997). Operate processes directly produce value for customers, support processes are required to underpin operate and manage processes whereas management is the process of achieving organizational goals by engaging in the four major functions of planning, organizing, leading and controlling (Pandaya et al., 1997; Stephen and Dennis, 1987).

As discussed earlier in chapter 3, the rationale for the research objectives were as follows: (a) improvements in MEs begins from measurement and (b) a well chosen management theory or technique if applied in full will provide greater benefits than if it is applied partially. The literature also revealed that potentially there is a gap in current industry provision which may be filled by developing a methodology to (a) measure the extent of to which a pre-selected set of management processes is applied in any given

ME and (b) measure enhancements in performance gained by adopting that selected set of management processes in the given ME's. With respect to (a) no public domain methodology was found which quantitatively seeks to measure the extent to which management functions are being carried out in a given ME. Whereas the complexity of achieving (b) in any generalised manner was perceived to be beyond the scope of any single PhD study. Future systematic and well-organised approaches to management performance measurement could be founded upon a capability to realise (a).

Consequently the chosen aim of this research has been to contribute to knowledge by using state of the art modelling techniques to structure and enable quantitative measurement of the 'extent to which an agreed set of management processes are implemented' within any given MEs; thereby providing a basis for measuring 'management performance outcomes' related to (b). Subsequent research of the author has therefore conceived, implemented and case tested a modelling methodology that is designed to measure the Level of Application of Management Processes (LAMP) in pursuit to enhance productivity.

8.2 Analysis of Research Findings

The aim of this research was achieved by developing a semi generic model of 'management processes deployed in public sector MEs in Pakistan' that was explicitly modelled by using a proven extension to the CIMOSA Enterprise Modelling (EM) technique. Use of this EM technique enabled decomposition and classification of management processes into so called Domain Processes; which subsequently were explicitly defined (at a more detailed level of modelling abstraction) as Business Processes. During the subsequent research the author used this semi-generic model of management processes to conceive and develop the use of a methodology to apply a LAMP scorecard; the use of this scorecard was then tested in three public sector MEs'.

8.2.1 Analysis of Process Modelling

The enterprise models developed in this research were considered to be equally applicable to all of the three case MEs studied. This is due to the fact that the decomposition of domain processes into respective business processes and management activities was carried out during subsidiary questionnaire based research conducted in all three case MEs where significant commonality of management process classification was observed amongst experience respondents. Further the three MEs were located in the same geographical location and operate with a similar organizational structure, culture and management style. Based on the use of the CIMOSA framework (and its RPM extended graphical modelling approach) the management processes of the case study MEs were classified and visually presented through an organized use of four types of graphical modelling diagrams; known as context diagrams, interaction diagrams, structure diagrams, and activity diagrams.

The context diagram helped to hierarchically breakdown the system complexity into manageable domains. Domains which are of concern to modeller of a given ME, and hence are subsequently represented using CIMOSA modelling concepts, are termed 'CIMOSA domains' whereas others that are of lesser concern to the modeller and are not explicitly modelled are defined as 'non CIMOSA domains'. In this way despite the high levels of complexity found in most MEs, the modellers attention can be focussed on issues of concern to would be end- users of the models; which in the case of this study are senior ME managers and government auditors that are responsible for ensuring that management processes are adhered too in any given ME. Use of this modelling step allowed the author to visualize graphically and document the decomposed view of management processes which are of concern to given ME. The outcomes of this study stage are illustrated in figures 6-2 & 6-3.

'Context diagrams' were further decomposed through the use of 'structure diagrams' into 'sub level context diagrams' to identify sub domains processes. The structure diagramming technique was found to usefully identify the key structural dependencies and sequential flows of BPs between the processing segments of case MEs as presented in figure 6-4. The structure diagramming approach was also found to help in visualizing the sequential flow of BPs. However in most if not all MEs, it is likely that entities within domain processes and business processes also commonly interact with each other by exchanging information and resources like physical, human and finances. To capture structural relationships that govern this kind of interaction, 'interaction diagrams', such as the diagram illustrated by figure 6-5, assisted in defining, organizing and representing the interaction of BPs included in the management domain. This domain was designated (DM1) and its interactions with non-CIMOSA domains DM2 and DM3 were presented using 'external link' modelling constructs'. This interconnectivity was thus presented graphically by using four modelling constructs namely 'information', 'physical', 'human' and 'financial' entities and this was observed to provide enterprise managers and 'enterprise transformer' with an effective way of capturing, visualizing and documenting interactions between process segments in the three case MEs. 'Activity diagrams' presented in figures 6-6, 6-7, 6-8 and 6-9 were also observed to usefully encode sequences of EAs and BPs via the linking of graphical model building blocks and assisted in visualizing a more detailed level of business process realization.

These four types of graphical modelling diagrams populated with case data constituted an important model fragment of the case MEs. Collectively these diagrams were observed to provide a big picture (or organizational context) of the requirements of the case MEs under study. They were also found to represent graphically a coherent and complementary set of views about process attributes at needed levels of abstraction. However, only static temporal relationships were defined using these CIMOSA conformant diagrams; which do not have representational concepts for changes in the states of process variables.

8.2.2 Analysis of LAMP Scorecard Application

Both the decomposition of management processes and the subsequent modelling of decomposed processes formed the basis for the design and development of the LAMP scorecard. This scorecard was later tested in three case MEs and the results of this empirical research are presented in tables 7-3, 7-4 and 7-5, which relate to ME1, ME2 and ME3 respectively. The authors' subsequent analysis based on these results is presented and discussed in the following sub-sections.

8.2.2.1 Analysis of LAMP Scoring in ME1

Because its structure is inherited from the CIMOSA-defined management process decomposition, according to the developed LAMP scorecard the planning domain process is composed of four business processes namely; time, quality, risk and resource planning. The overall scoring of DP planning in ME1 (established through interviewing its managers) is 46.15%; which is calculated as an aggregate which is based on individual scoring of each BP, as indicated in figure 8-1.

The score of the BP 'time planning' is 57.32%, which was calculated as an aggregate of the scoring of enterprise activities presented in table 7-3. The score of each enterprise activity was obtained through parameter analysis at the application level of EA indicators. For instance, for EA 'develop schedule' there are four application indicators namely 'activity list', 'milestone list', 'activity duration estimate' and 'activity sequencing'. The table included into appendix C-1 highlights the application level of EA indicators in ME1 identified by the respondents. The particular EA indicator 'activity list' was considered by 9 out of 11 respondents as being applied. Similarly, 'milestone list', 'activity duration estimate' and 'activity sequencing' are viewed by 8 out of 11, 6 out of 11 and 8 out of 11 respondents respectively as being applied. Based on these responses during semi-structured interviews, the application level of the EA 'develop schedule' was averaged as 70.45%.

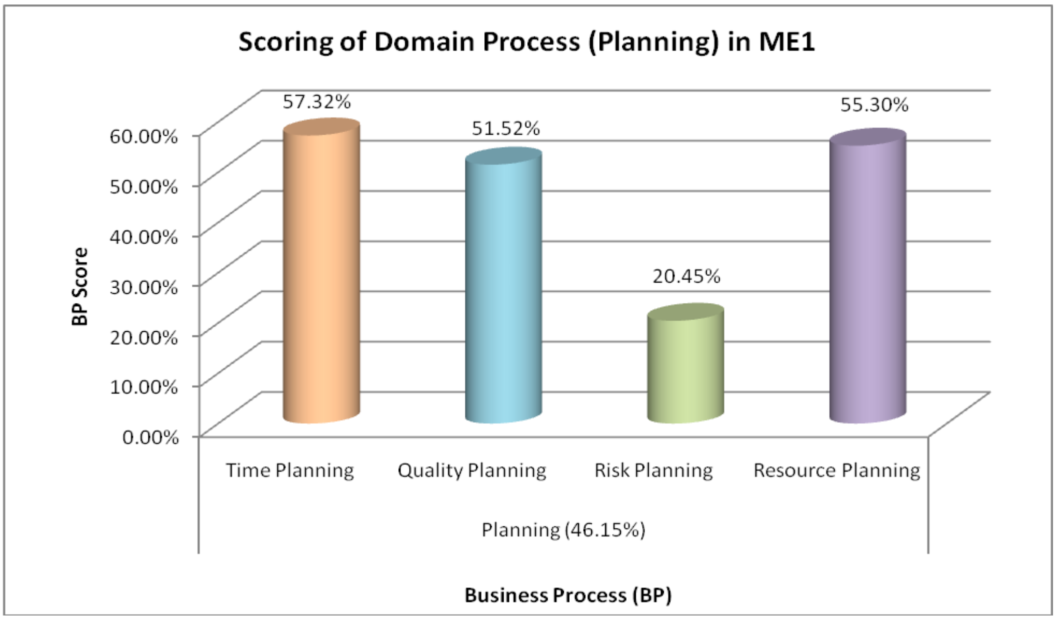

Figure 8-1: Scoring of Domain Process (Planning) in ME1

Although the score of EA ‘develop schedule’ is calculated as 70.45% the overall average of DP ‘planning’ is 46.15%. This obviously indicates a lower scoring of the other BPs comprising DP ‘planning’. In figure 8-1, it can be observed that the score of one BP ‘risk planning’ is only 20.45%. The majority of the respondents indicated a very low level of application of the EA indicator associated with ‘risk management planning’, namely ‘list of potential responses’, ‘risk breakdown structure’ and ‘risk mitigation plan’. This quantitative scoring methodology indicates that improving the application level of those EA indicators, which are at an unacceptably low application level, can enhance the application level of DP ‘planning’.

The level of application of DP ‘planning’ is briefly explained above. The scoring of all of the four domain processes in ME1 is shown in figure 8-2, which illustrates that the level of application of DP ‘organizing’ is at the highest level (86.11%) as compared to other DPs, whereas DP ‘leading’ is identified as being at the lowest level of application (33.33%). These values indicate that the level of DP’s application was obtained through an analysis of the values of BPs, their respective EAs and EAs indicators; as reflected in table 7-3 and appendix C-1.

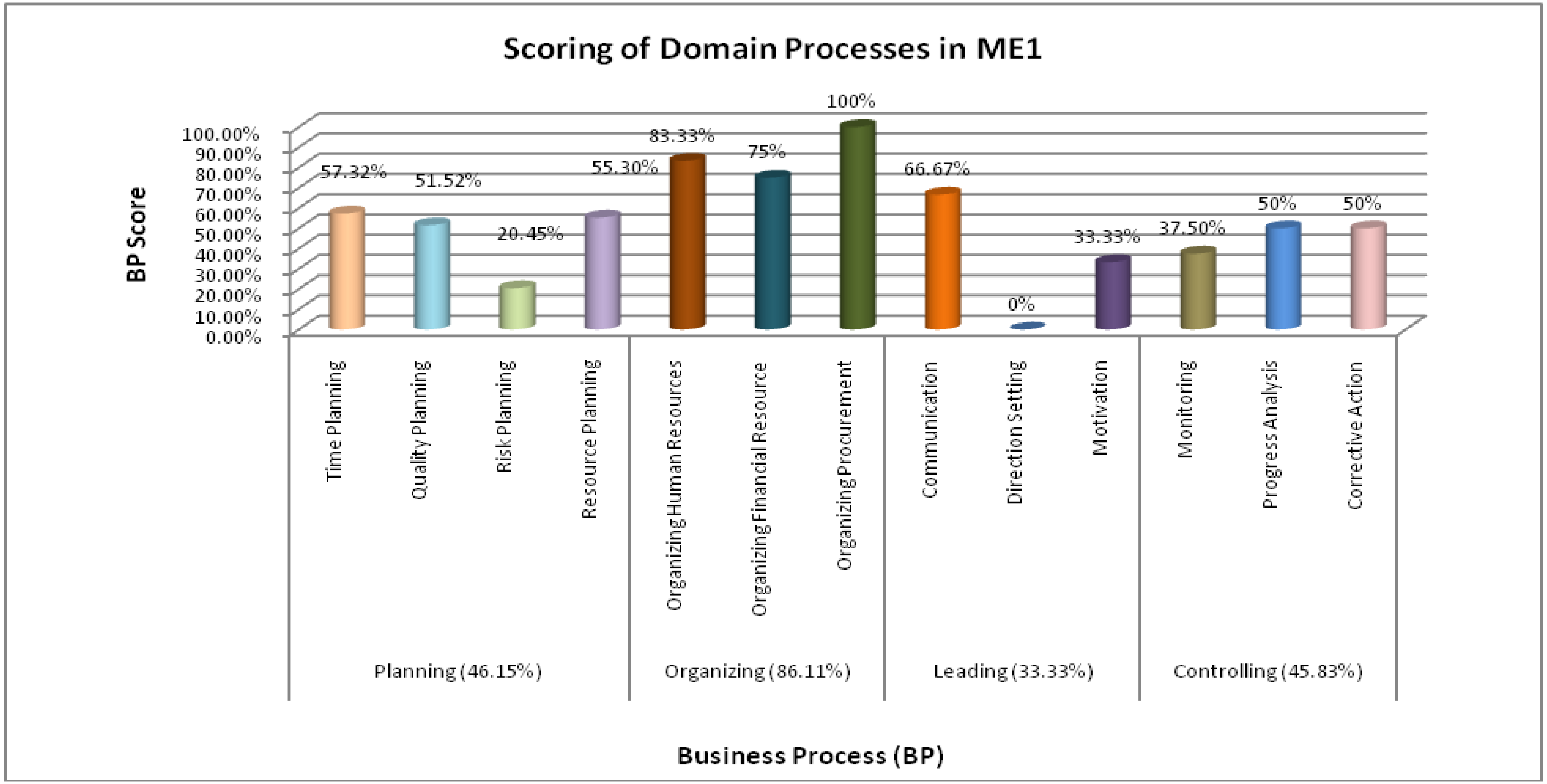

Figure 8-2: Scoring of Domain Processes in ME1

Figure 8-3 shows that the overall LAMP score obtained for ME1 is 52.86%; which the author perceived indicates a medium level of management processes application. The defined rating convention for this research (see table 7-2) reflects that in ME1 the application of DP 'organizing' is at high level, whereas DPs 'planning', 'leading' and 'controlling' are at a low level. The values of DPs, BPs and EAs are therefore indicative of potential improvement areas of management processes in ME1.

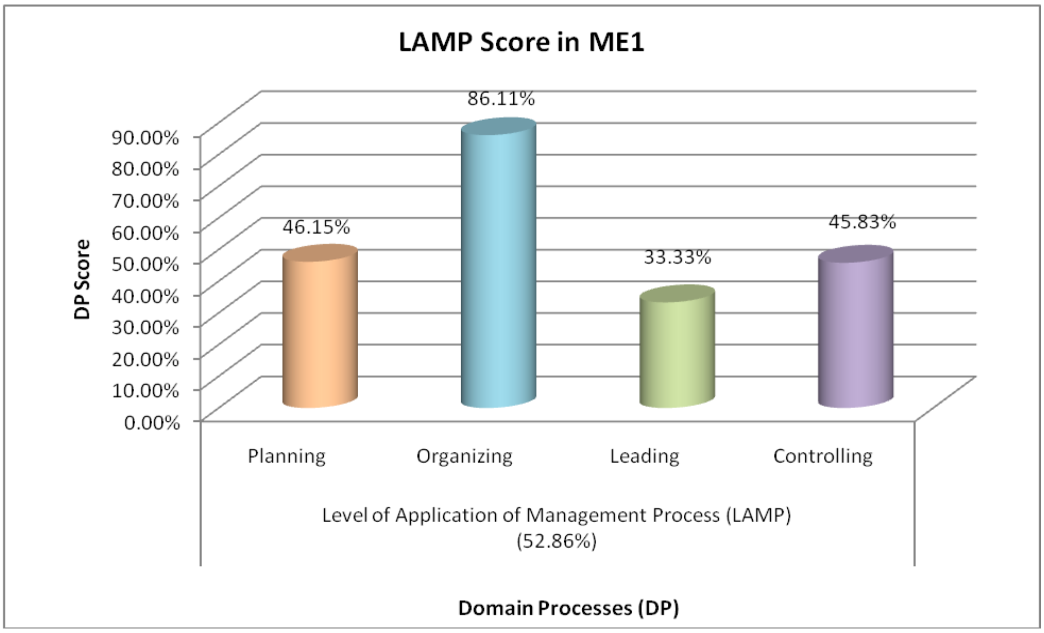

Figure 8-3: Overall LAMP Score in ME1

8.2.2.2 Analysis of LAMP Scoring in ME2

As earlier discussed, in alignment with the CIMOSA model the developed LAMP scorecard specifies that the domain process (controlling) is composed of three business processes namely; monitoring, progress analysis and corrective action. The overall scoring of DP 'controlling' in ME2 is 53.24% which is calculated on the basis of individual scoring of each BP as indicated in figure 8-4.

The score of BP 'monitoring' is 48.61%; which is dependent on the scoring of the enterprise activities presented in table 7-4. The score for each enterprise activity is obtained through the application level use of EA indicators. In case of the EA 'risk monitoring'; there are two application indicators namely 'risk process flow diagram' and 'risk feedback report'. The table mentioned in appendix C-2 scores the application level of EA indicators in ME2 attributed by the respondents. The EA indicator 'risk process flow diagram' is considered to be implemented by none of the respondents whereas 'risk feedback report' is viewed by only 2 out of 9 respondents as being applied. Similarly, 'feedback report' (regarding time, cost and quality) is viewed as being implemented by all of the respondents; while 'process flow diagrams' (regarding time, cost and quality) are considered by 2 out of 9 respondents as being applied. During the semi-structured interviews, the responses from the managers interviewed showed that the application level of EAs 'time monitoring', 'cost monitoring', and 'quality monitoring' is averaged as 61.11% whereas, average of 'risk monitoring' is calculated as 11.11%.

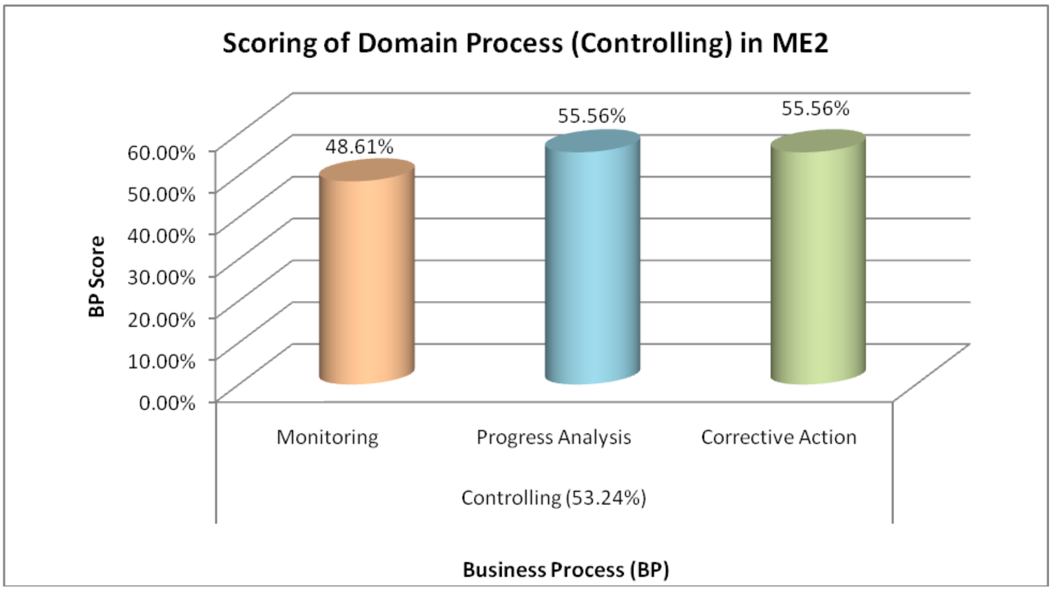

Figure 8-4: Scoring of Domain Process (Controlling) in ME2

The score of BP 'monitoring' is calculated as 48.61% but the average of DP 'controlling' is 53.24%. This indicates that scoring of other BPs, namely 'progress analysis' and 'corrective action' is relatively on the higher side i.e. 55.56% each. From table C-2, it appears that score of one of the EAs, namely 'revision of plans', is also 55.56% but the majority of the respondents indicated very low level of application of two of its EA indicators which were 'cost and risk management plan update'. The analysis indicated that improving the application level of specific EA indicators, which are implemented at an un-acceptably low level, could enhance application level of DP 'controlling'.

The application level of DP 'controlling' is discussed briefly above. The scoring of all four ME2 management domain processes is shown in figure 8-5, which illustrates that the level of application of DP 'organizing' is at the highest level (88.58%) when compared to other DPs, whereas DP 'leading' is identified as being at the lowest level of application (35.80%). As for ME1, these values indicate the level of DP's application have been obtained through the analysis of values of BPs, their respective EAs and EAs indicators as reflected in table 7-4 and appendix C-2.

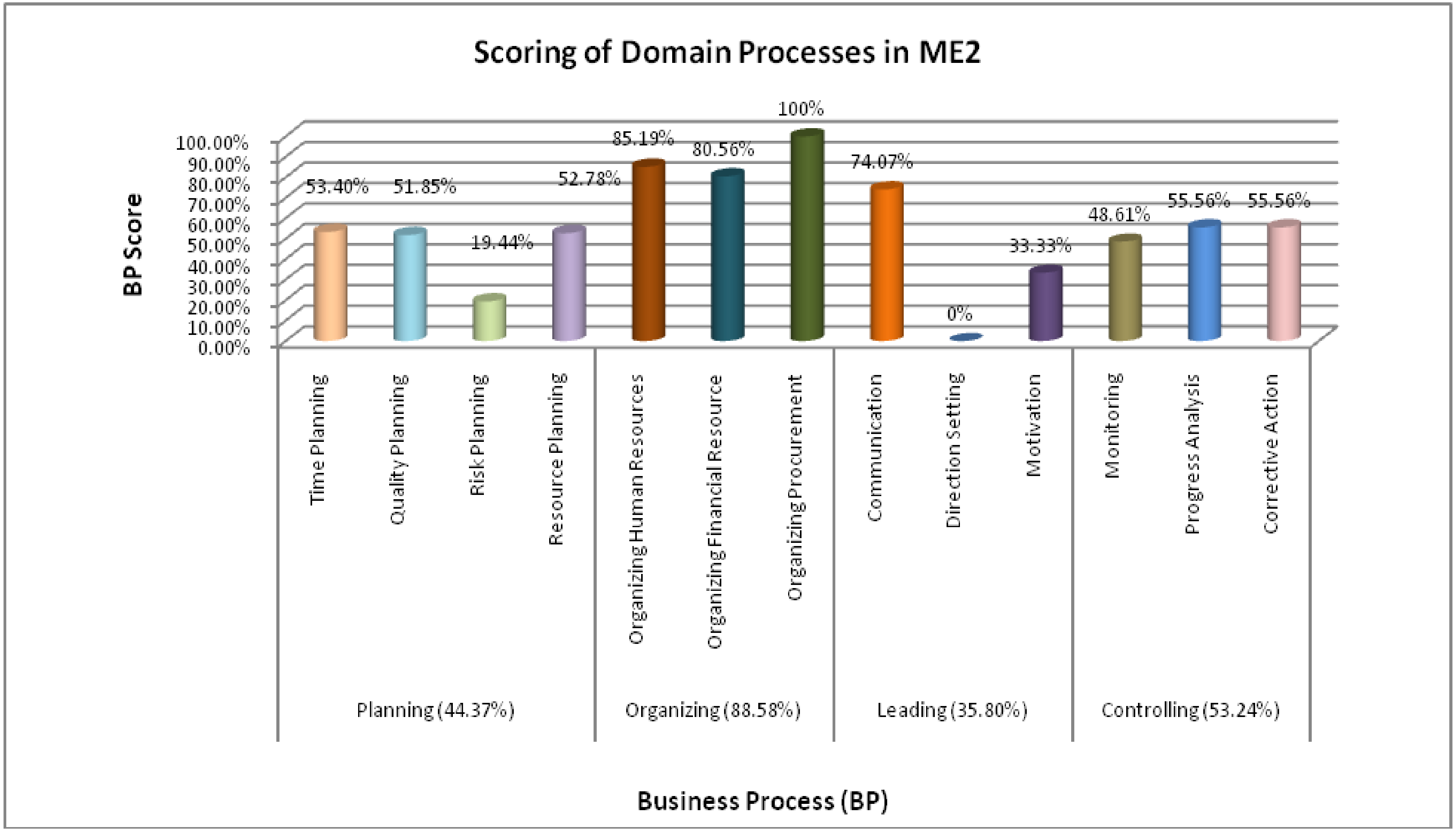

Figure 8-5: Scoring of Domain Processes in ME2

Overall the LAMP score obtained for ME2 is 55.50%, see figure 8-6, which the author perceives indicates a medium level of application of management processes. The rating convention for this research reflects that in ME2, the application of DP 'organizing' is at high level, DP 'controlling' is at medium level, whereas DPs 'planning' and 'leading' are at low levels, thus highlighting the potential improvement areas of management processes in ME2.

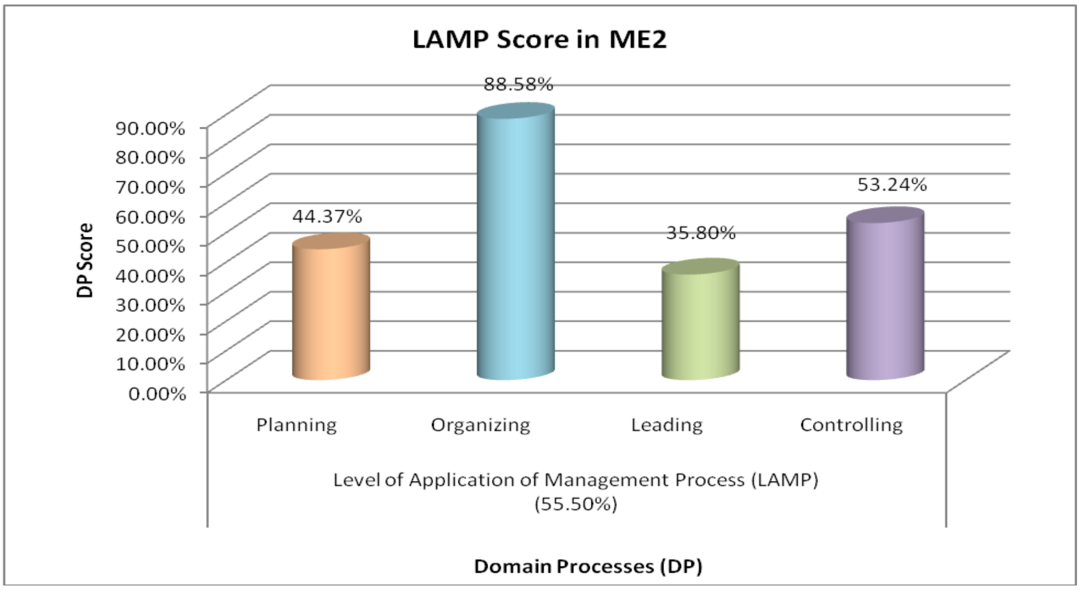

Figure 8-6: Overall LAMP Score in ME2

8.2.2.3 Analysis of LAMP Scoring in ME3

As discussed previously the domain process (leading) is considered in this study to be composed of three business processes namely; 'communication', 'direction setting' and 'motivation'. The overall LAMP scoring of DP 'leading' in ME3 is 46.67%; which again was calculated on the basis of individual scoring of each BP indicated in figure 8-7.

The score of BP 'motivation' is 33.33% and it is dependent on the scoring of enterprise activities presented in table 7-5. Again the score of each enterprise activity was obtained through analysis of the application level of EA indicators. For example, for EA 'compensation system', there are two application indicators namely 'monitory and 'non-monitory reward' and 'recognition system'. The table mentioned in appendix C-3 highlights the application level of the relevant EA indicators in ME3 identified by the respondents. Both EA indicators for the EA 'compensation system' are considered by none of the respondents as being applied. Similarly for EA 'HR growth and development', EA indicators 'promotion policies' and 'performance appraisal document' are viewed by all of the respondents and 'training and development' is considered by all five respondents as being applied. Based on these responses during semi-structured interviews, the application level of EAs 'GR growth and development' and 'compensation system' is averaged as 66.67 and 0% respectively.

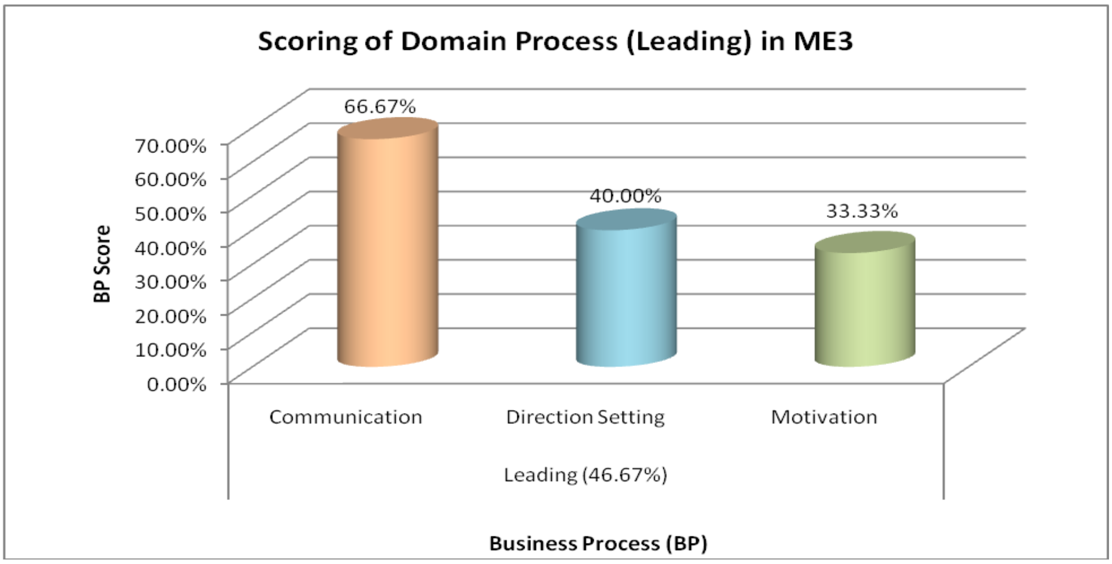

Figure 8-7: Scoring of Domain Process (Leading) in ME3

The score of BP 'motivation' is calculated as 33.33% but the average of DP 'leading' is 46.67%. It indicates that scoring of other BPs 'communication' and 'direction setting' is on the higher side. From table C-3, it appears that score of one EA 'information sharing' is 66.67% but all of the respondents indicated a very low level of application of one of its EA indicators, namely 'organizational strategy'. This proposed quantitative scoring methodology reflects that improving the application level of those EA indicators that are at low application level can enhance the application level of DP 'leading'.

The level of application of DP 'leading' is briefly explained above. The scoring of all the four management domain processes in ME3 was as illustrated in figure 8-8, which indicates that level of application of DP 'organizing' is at the highest level (86.11%) when compared to other DPs; whereas DP 'leading' is identified as being at the lowest level of application (46.67%). Again these values indicate that the level of DP's application have been obtained through the analysis of values of BPs, their respective EAs and EAs indicators as reflected in table 7-5 and appendix C-3.

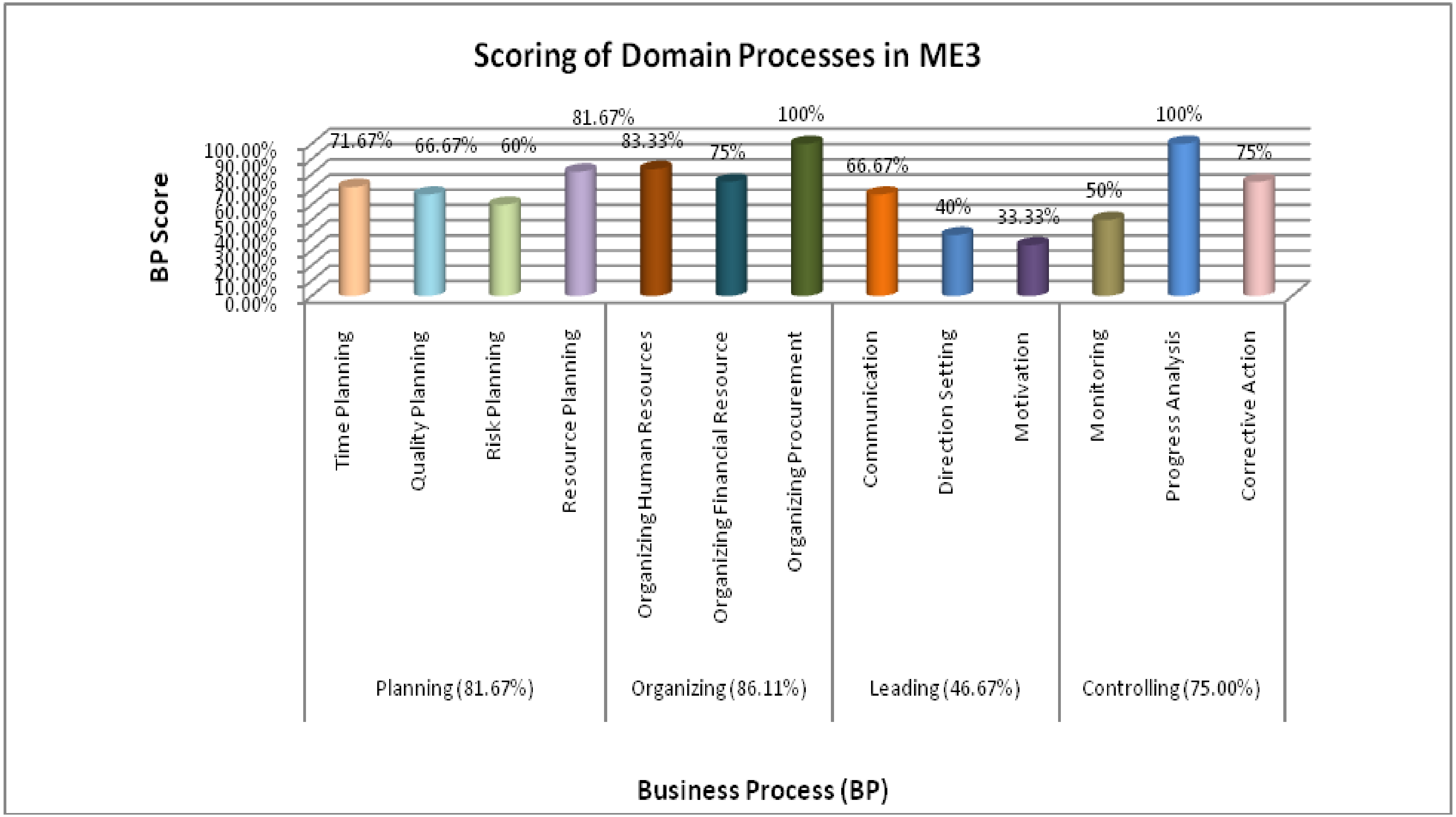

Figure 8-8: Scoring of Domain Processes in ME3

Figure 8-9 shows that the overall LAMP score obtained for ME3 is 69.44%, which is viewed as indicating a medium level of management process application. The rating convention defined for this research reflects that in ME3, the application of DPs 'planning' and 'organizing' is at high level, DP 'controlling' is at medium level, whereas DP 'leading' is at low level. Once again it was observed that the proposed methodology could usefully indicate potential improvement areas of management processes in ME3.

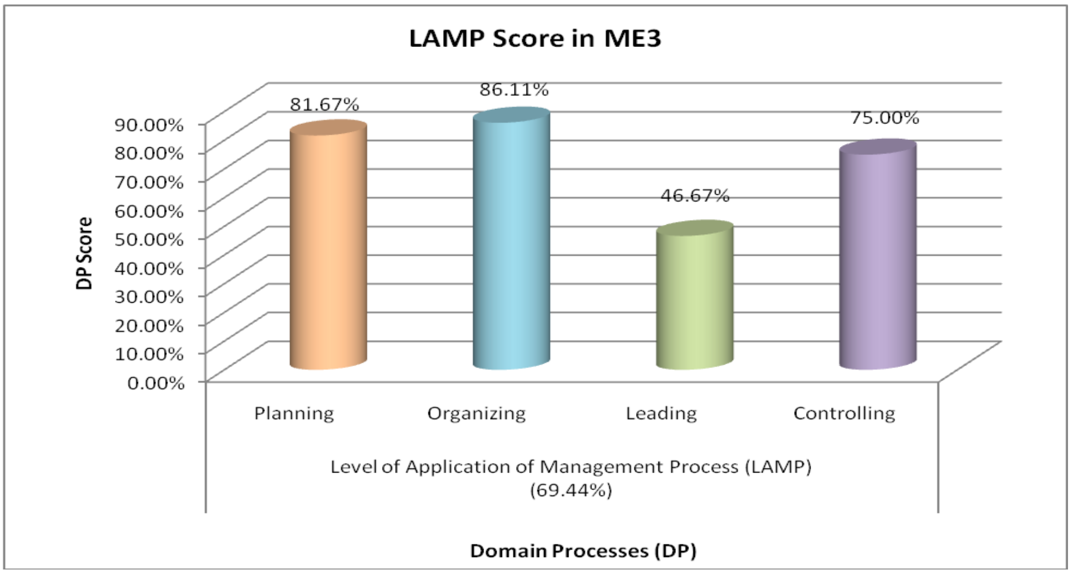

Figure 8-9: Overall LAMP Score in ME3

8.2.2.4 Overall Analysis of LAMP Scoring in ME1, ME2 and ME3

A comparison between the LAMP scores of case ME1, ME2 and ME3 was drawn and is illustrated in figure 8-10. It can be seen that the DP 'organizing' is at the higher level of management processes application in all the case MEs. DP 'controlling' is accomplished at a medium level of application for ME2 and ME3, whereas for ME1 it is at a low application level. In case of ME1 and ME2, DP 'planning' is implemented at a low level of application and for ME3 it is at medium level of application. Similarly, DP 'leading' is observed to be at the low level of application for all case MEs.

Considering the calculated values of DPs for the three case MEs, it is observed that the overall LAMP scores are: for ME1 52.86%; ME2 55.50%; and 69.44% ME3. These results indicate that the level of application of management processes in ME3 is relatively higher compared to the other two case MEs. As discussed earlier that the overall LAMP scoring of each case MEs is dependent on the scores of DPs which are calculated on the basis of its respective BPs and EAs. Further, EA indicators formed the basis for scoring of the associated EAs (see table 7-2). By looking at the overall LAMP scores of case ME, it can be seen that the application level of EA indicators in ME3 is higher compared to ME1 and ME2. Therefore, it is deduced that in order to improve the LAMP scoring of ME1 and ME2 it would be required to increase the application level of its proposed EA indicators. The same methodology can be used to improve the LAMP scoring of ME3.

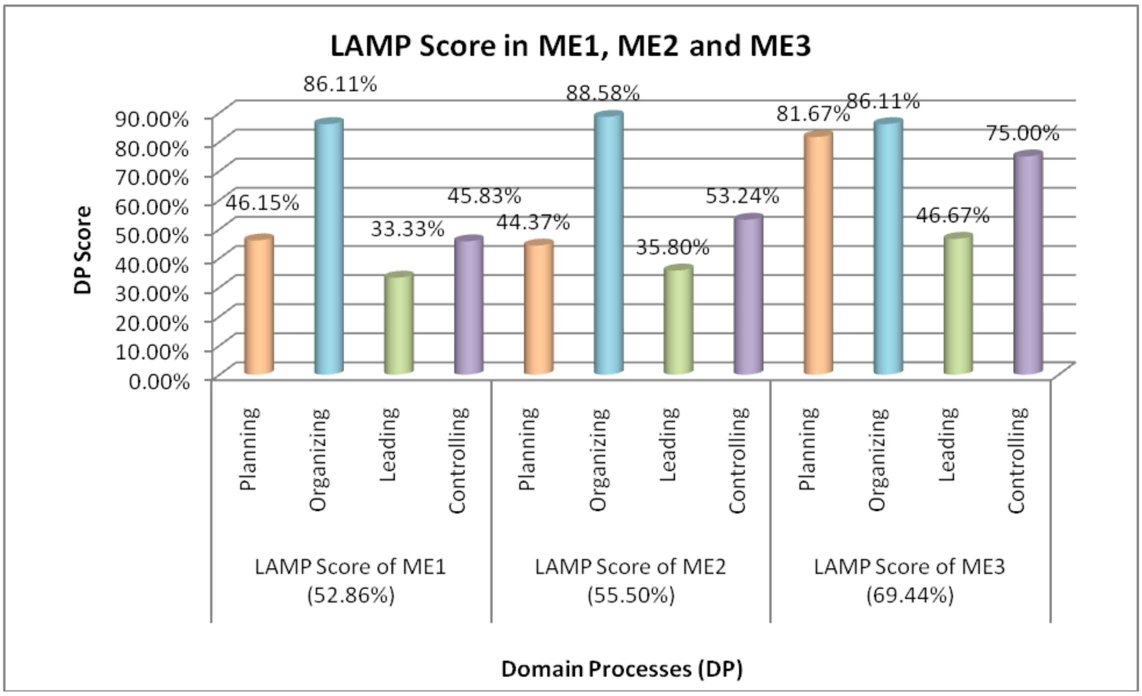

Figure 8-10: Overall LAMP Score in ME1, ME2 and ME3

It is pertinent to highlight that the proposed methodology is being developed and applied in MEs of Pakistan for the first time, so there exist no industrial reference values for comparison. It also follows that the proposed methodology and adopted rating convention for this research can for the first time in Pakistan (and elsewhere in the authors knowledge) indicate potential improvement areas of management processes in case MEs. In principle therefore the study results could benefit many government organisations (including those in Pakistan) concerned with ensuring uniformity of and/or conformity to best practice management guidelines.

8.3 Validation of LAMP Scorecard Findings

According to Farber (2005), the validation process is a critical part of research, which ensures that responsible research is being carried out, and to ensure that legitimate results are being produced. Validation strategies help to assess the 'accuracy' of study findings (Potter, 2008). Keeping in view the importance of applying a validation process, the author used a validation strategy to check the extent to which the research findings are close to the actual situation prevailing in the three case MEs.

8.3.1 Validation Strategy

The strategy adopted for the validation of results obtained through applying the proposed LAMP scorecard in case MEs is highlighted in figure 8-11.

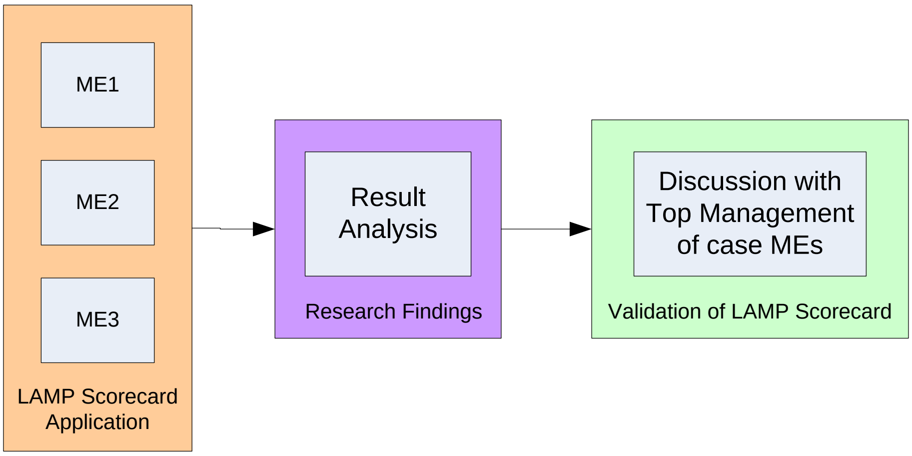

Figure 8-11: Strategy for LAMP scorecard validation

In this study as discussed at length, the proposed LAMP scorecard was applied in all of the three case MEs. The data acquired through this application process was analysed and this resulted in useful research findings as discussed in section 8-2. These research findings were presented to the top management in the final validation meetings. Their comments served as a source of validation of the research findings.

8.3.2 Validation Process

During initial meetings prior to the start of case study an introduction to the research problem and to the proposed research methodology were both discussed in detail with the top management of the three case MEs. At that time, the top management of each case ME showed their interest in conducting this research in pursuit of finding potential improvements for productivity enhancement; while remaining within their existing constraints on the cost of human and non-human resources. The top management of all three case MEs were then kept informed about the research progress during the subsequent meetings and they were found to be keen about understanding and benefitting from the potential research outcomes.

At the end of the research, the validation of research findings was discussed in detail with the ME's top management. Validation discussions were designed in such a way that initially a brief introduction to the proposed methodology of the LAMP scorecard and its application was given followed by a presentation of the findings of research; highlighting the strengths, weaknesses and potential areas of improvements of management process application, that were deduced from the research results.

The research findings showed that DP ‘organizing’ was at higher level of application. The DP ‘planning and controlling’ was observed to be at medium to high level, whereas DP ‘leading’ was at low application level in all MEs. It was highlighted during the meeting that the scoring of DPs was dependent upon the application level of BPs, EAs and their respective EA indicators. Based on the knowledge, experience and observations made during the working in MEs, the top management generally agreed to the results of DP ‘planning, organizing and controlling’. However, they showed disagreement to the results of DP ‘leading’. In this regard, the top management were informed about the details due to which DP ‘leading’ was identified at low application level.

According to the proposed methodology of the LAMP scorecard the DP ‘leading’ was dependent on BPs ‘communication, direction setting and motivation’. These BPs were further dependent on EAs ‘information sharing, aligning resource efforts, HR growth and development and compensation system’. Analysis results (see appendix D-1, D-2 and D-3) revealed that respondents reported the application of EA indicator ‘organizational strategy’ is not communicated to those concerned in the three MEs. It was also identified that resource efforts were not aligned with the organizational goals; which was due to the low application level of the following EA indicators: ‘review systems for production’, ‘quality’ and ‘finances’. Similarly, due to non-applicability of EA indicators ‘monetary and non-monetary reward and recognition system’, the scoring of associated EA ‘compensation system’ and BP ‘motivation’ was very low.

The detailed discussion explaining the reasons of this perceived weak application level for DP ‘leading’ resulted in changing the comments of top management. Similarly, the reasons for a few other observed differences were also explained in the light of the adopted methodology. In general the top management acknowledged that the LAMP scorecard methodology had been successfully applied and had highlighted the strengths, weaknesses and potential areas of application improvement of management processes in each case ME.

8.4 Limitations of the Research

According to Pinto (1986), the value of research can frequently be assessed by the limitations arising from the study. Due to the time and resource constraints associated with a single PhD study only the concepts and methodology presented earlier have been studied and tested. However, some limitations and weaknesses of this research work may prove to be:

- Firstly, the study was limited to the national context of Pakistan. It could not be validated in order to generalize the findings to MEs operating in other countries unless resources could be released to enable testing in other locations around the globe.
- Secondly, the samples were drawn from public sector MEs in Pakistan; therefore, the findings of this research would be specifically related to the MEs under research. It could not be valid to make generalization about other industries such as textile, IT and construction etc. without considering their unique characteristics.
- Thirdly, the study was likely limited to the MEs operating a project-oriented structure and accordingly project managers were selected as respondents for providing useful data for this research.
- Another limitation concerned the fact that the identification of activity indicators (used in the LAMP scorecard) was based on PMBoK (USA) because in the MEs under investigation, PMI BoK is followed as a guideline.
- As discussed earlier the transformational processes that convert input to output of an ME are classified by researchers as ‘manage’, ‘operate’ and ‘support’. In this research, ‘manage process’ application level was investigated and potential areas of improvement were identified whereas, the effect of actual product realizing processes like ‘operate’ and ‘support’ were not studied nor critically was the effect that management processes have on the performances of ‘operate’ and ‘support’ processes in any given ME.
- The management processes could have been measured quantitatively and qualitatively, but this research work is limited to the investigation of quantitative measures.
- Due to the non-availability of industrial reference values of weight factors for the decomposed domain and business processes, this weighted effect was not considered during calculations of the LAMP scores in MEs.

8.5 Research Conclusions

The aim of this research was to enhance productivity in MEs by improving the Level of Application of Management Processes (LAMP). To achieve this aim, a number of objectives were defined with a focus on conceiving, developing and case testing a modelling methodology designed to measure the LAMP. These objectives have been addressed in the following form:

- A basis to decompose management processes into domain processes, business processes, enterprise activities and its measurable application indicators was developed.
- A semi generic model of 'management processes deployed in MEs' was defined and explicitly modelled by using an ISO Enterprise Modelling technique CIMOSA.
- A graphically presented reference model of the interconnectivity between management process segments was conceived and explicitly defined; by using four sets of modelling constructs, namely information, physical, human and financial entities that support the visualization and documentation of interactions in any given case MEs.
- A LAMP scorecard was conceived and developed. The use of which was tested in three public sector MEs located in Pakistan that operate under project oriented management structures.

Having analysed the research achievements, case study findings and considering the strengths, weaknesses and limitations of this research study, it is claimed that the general objectives of the study have largely been achieved. The case study results partially validated: the 'fitness for purpose' of the model driven measurement methodology; identified opportunities for future methodological research; and illustrated how LAMP identified and enabled measurements can help to define, quantify and direct potential opportunities for ME enhancement. In order to establish a generalization of proposed methodology, it needs to be tested in other locations around the globe having different operating structures and cultures. It is pertinent to highlight that some of the concepts that have been conceived have yet to be tested and consequent on that testing may need to be further enhanced before the complete methodology can be widely applied.

8.6 Contribution to Knowledge

This research work has some significant academic and practical implications in the area of production management in MEs. Previous researchers had classified the transformational processes (that convert customer desire and demand inputs to ME into product and service outputs of increased value) into operate, support and manage process classes. Also previous research literature and management experience of the author had highlighted the importance of process performance measurement and much previous work has been carried out to develop tools and techniques for measuring parameters of the main stream operate and support product realization processes. Additional previously researched had been many management theories, concepts and strategies that can be matched to organisational types and their different styles of management. However, the literature was observed to be sparse with respect to methods and techniques to measure the extent to which these concepts are applied in any given ME.

Bearing in mind the foregoing from dual academic and industrial perspectives this research contributes to knowledge by:

- Conceiving and developing a **methodology** which can be instrumented by a coherent set of model driven tools and systematically deployed to **measure the extent to which management processes' are being applied** in any given ME.
- Using state of the art modelling technique the study has explicitly defined a novel and re-usable **reference model of project-oriented management processes**. This reference model is (a) **semi-generic** in the sense that its use has been validated by being usefully reapplied in more than one ME and is (b) **eclectic** in the sense that different or improved process elements can be added to the reference model to match specialist ME requirements; to cater for their distinctive management styles and the management needs of their operate and support processes. Thus far the use of this reference model has been proven to structure and enable quantitative measurement of management processes within three case MEs.
- Conceptually designing and developing a LAMP (Level of Application of Management Processes) scorecard: the interview based use of which is structured by the reference model of management processes, such that quantitative measures can be determined about the extent to which pre-defined management processes are applied.

- Identifying strengths, weaknesses and potential areas for improved application of management processes in MEs by systematically following the steps of the methodology in respect to the target ME and therefore by deploying the reference model of management processes in conjunction with the interview based application of LAMP scorecards.

8.7 Recommendations for Future Work

During the process of achieving the research aim and objectives and keeping in view the limitations and weaknesses of this research, some new issues and ideas have been identified. Further areas for future research are suggested below:

- The current research is based on quantitatively (how much) measuring the extent to which planning, organizing, leading and controlling function of management processes are being applied in MEs. Given the limitation of this research identified earlier, it is proposed that a similar research should be undertaken to qualitatively (how well) measure the performance of management processes in MEs.
- Performance measurement of management processes may be qualitative or quantitative and the improvement of these measures can have a profound effect on cost, quality and timeliness behaviours of more direct product realization processes; such as specific operate and support processes deployed by any given ME. Improvements through measurement of management processes ultimately affects the performance of operate and support processes. But a critical research assumption made in this study is that by more completely applying recommended management processes the impacts on the ME will be positive; such that improved operate and support process behaviours will ensue. The author believes that this simplifying assumption has enabled a first stage advance in the measurement of management processes by formally cutting through some of the inherent complications of measurement in large-scale systems of systems (such those used by MEs). But that during future stages of research, qualitative and quantitative measures that encode relationships between ‘changes in management processing elements’ and ‘resultant performance improvements of ME operate and support processes’ can be studied. Here the author anticipates that a viable starting point for such a study would be to further develop the organisational decomposition and modelling techniques deployed in this study and to use these in conjunction with the reference model of management processes reported on in this thesis. A further developed use for example of enterprise

modelling could provide an explicit model of mappings between management, operate and support processes onto which notions about performance indicators and scorecards could be mapped and applied to study aspects of those relationships.

- The current study was limited to the context of public sector MEs in Pakistan and also the weight factor associated with management process segments was not considered during LAMP scoring. Further research is recommended to generalize the findings of this research by applying the proposed methodology to other industries operating with various cultures and practices, different management styles and emphasis on management process segments.

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Appendix A-1: Research Publication 1

Productivity Enhancement in a Manufacturing Enterprise by Improving Management Processes

S.Khalid, S.Rashid & R.H.Weston, MSI Research Institute, Wolfson School of Mechanical and Manufacturing Engineering, Loughborough University.

ABSTRACT

This paper describes research findings when focussing on the key area of management in order to improve the productivity of a manufacturing enterprise. To quantify effects of alternative management processes on productivity, CIMOSA enterprise modelling principles are used in a unified way with those of simulation technologies. This is done by describing a case study of 'Precision Parts' manufacturing enterprise working in Pakistan. In this case study models of most business processes of the company are documented. Also dynamic (simulation) models of key process segments have been developed. In this case study, outcomes from modelling have been given new qualitative & quantitative understandings about (1) effects of different management processes on productivity, (2) testing and quantifying outcomes on productivity enhancement of alternative management processes. These outcomes are useful particularly to the case company but also potentially to this business sector.

Key words: Productivity Improvement, Management Process**,** Enterprise Modelling(EM), Simulation Modelling(SM), Manufacturing Enterprise (ME).

1 INTRODUCTION

This paper illustrates a way of undertaking an analysis of how alternative management processes have causal impacts on the productivity of specific manufacturing enterprises. Often manufacturing enterprises are focusing on the physical and harder aspects of the system like technology and technical activities fulfilment. The design and implementation of suitable management processes will commonly get insufficient attention; bearing in mind the relative impacts that strong and weak management processes may have. One major reason for this is that conventional best practice when creating management processes is typically ad hoc, non systematic and seldom is justified in terms of quantifiable outcomes. In theory therefore the use of well structured modelling methods in support of management process design can lead to sufficient competitive advantage. When developing the use of a model driven approach to design management process, this paper address the notion that management processes can be decomposed into planning, organizing, leading and controlling processes [1]. Each of these four management processes has an important role in proper management process application in manufacturing organizations. It is observed by the prime author of the paper that in manufacturing enterprises seldom is any processes of management given appropriate attention. For instance the prime and second authors have experienced a lack of planning, organizing and to some extent control processes in a number of large public sector manufacturing enterprises and in small and medium sized manufacturing enterprises in the developing industrial country of Pakistan. This weakness results in low productivity of insufficient number of these enterprises and high cost of production.

2 CASE STUDY DESCRIPTION

To exemplify benefits that can be gained by using a model driven approach to management process design, this paper consider the application of such an approach in case study manufacturing enterprise which makes various high precision products. The case study company (referred to as ‘ABC’) is a public sector make to order enterprise working in Pakistan. ABC can be categorized as medium to large enterprise as it has approximately 2500 regular employees performing different product realisation activities in different departments; namely as design, manufacturing, chemical treatment, integration, qualification and project management departments. The current **As-Is** network of processes deployed by ABC was documented using the CIMOSA (Computer Integrated Manufacturing Open System Architecture) [2]. Here four modelling templates [3]; called ‘Context Diagrams’, ‘Sub-Context Diagrams’ and ‘Interaction Diagrams’ and ‘Activity Diagrams’ are populated with case data , (see figure 1).

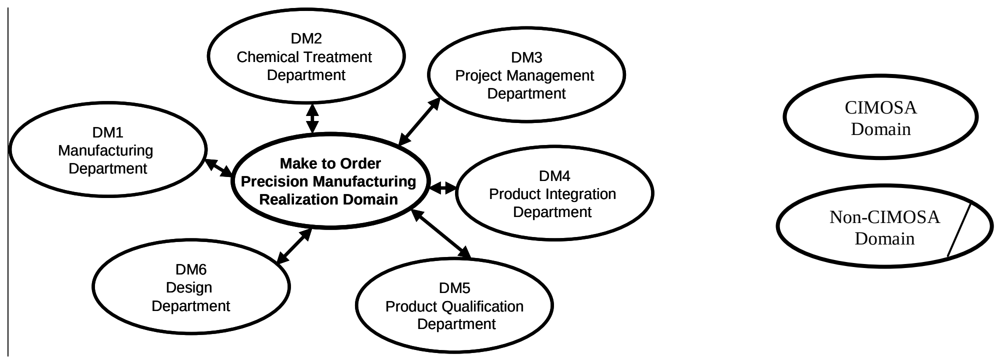

Figure 1: Context Diagram of ‘ABC’ Make to Order Precision Manufacturing Realization Domain.

The present management department (DM3 in figure 1) holds the role of coordinating management activities within other departments at three decisional levels, namely strategic, tactical and operational decision-making about product realization. In this paper DM3 focus of modelling is on using CIMOSA 'Sub-Context Diagrams' and 'Interaction Diagrams', (see figure 2 and figure 3).

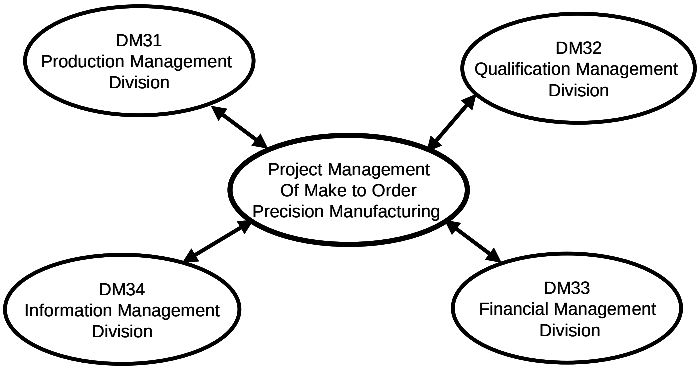

Figure 2. Sub-Context Diagram of 'ABC' Project Management Domain – DM3.

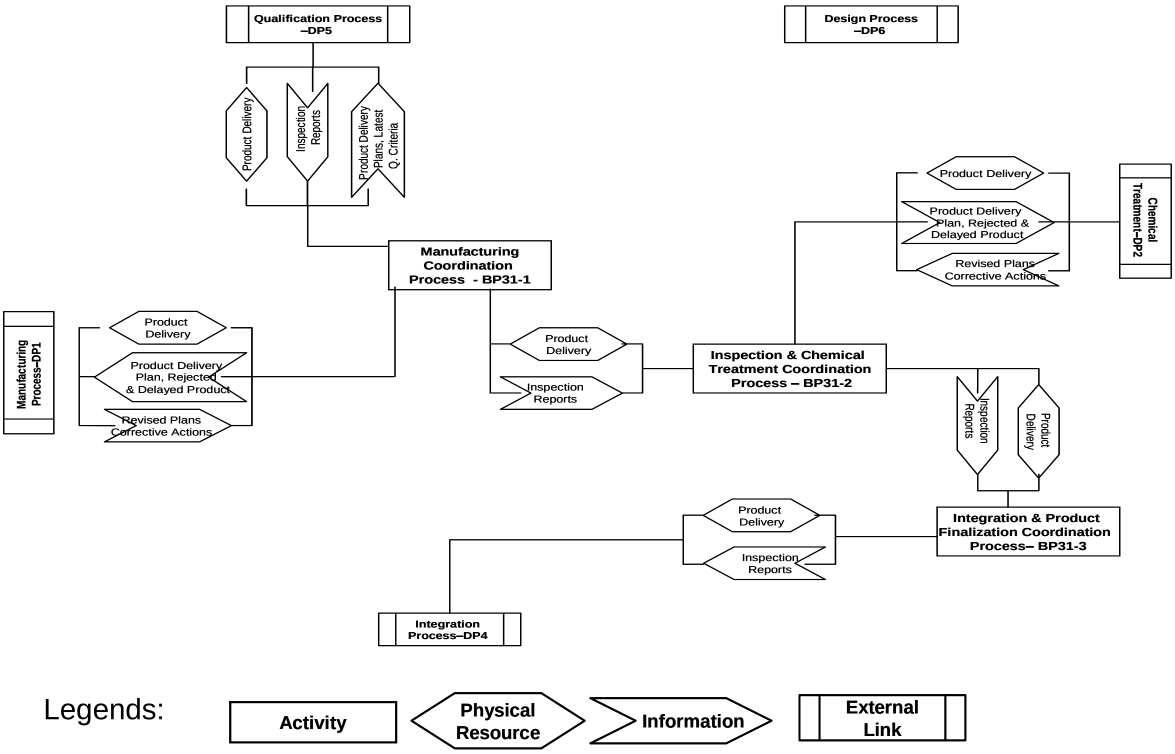

Figure 3: Interaction Diagram of 'ABC' Production Management Process – DP31.

ABC is facing significant problems because of having low productivity. Considering the above figure 3 which represent a portion of **As-Is** enterprise model of ABC, it is evident that no appropriate management controlling process is in place. For instance in this paper the effect of the management controlling process is to be tested with respect to ABC's Production Management process (see figure 4).

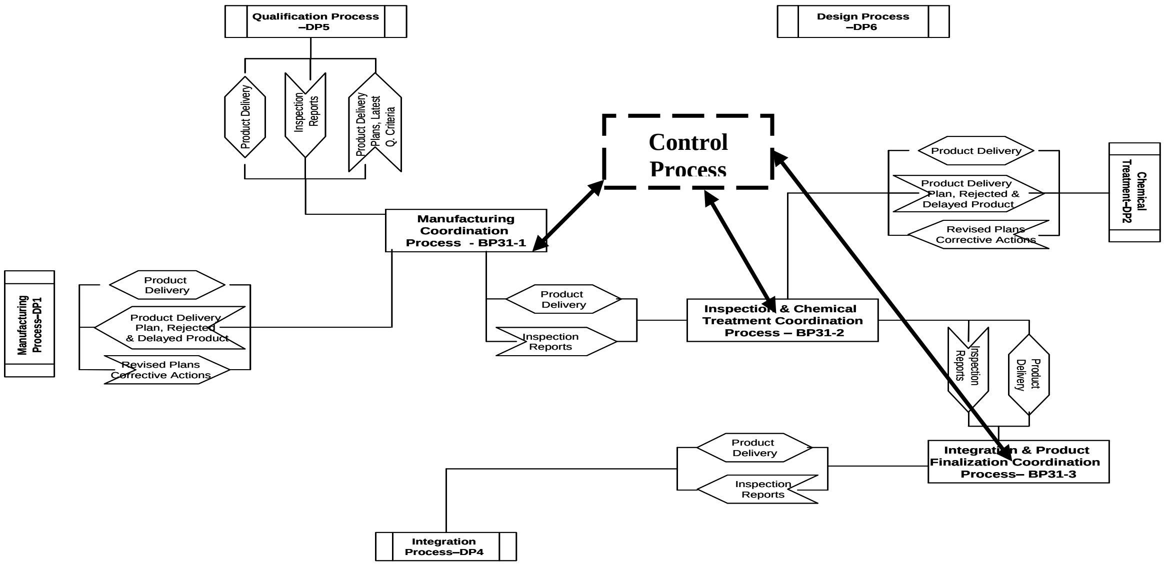

Figure 4: Application of Control Process of Management on 'ABC' Production Management Process – DP31.

ABC's Manufacturing Coordination Process (BP31-1) is taken as an example to explain the effect of the current controlling process on productivity. The Manufacturing Coordination Process is concerned primarily with coordination and transportation of mechanical products from the Mechanical Department to the Quality Department. After inspection accepted products are delivered to the Chemical Treatment Department for further processing. The configuration of ABC is such that the above-mentioned departments; manufacturing, quality and chemical treatment department are not located in the same building or shop floor. The departments are at a distance of few kilometres apart from each other. In this case timely information about the readiness of the product and a better transportation support are of vital importance. Heavy work load on the quality department specially workloads places on a costly coordinate measuring machine cause delays in communication regarding completion of work which effect the over all product completion times and hence productivity. Although the procedure for reporting and communication are in place, they were considered to be a weak control that adds delays into the production process.

To test the effect of control process application on productivity an example item called as Top Flange is considered. Top flange products are manufactured in batches of ten by the manufacturing department. The Manufacturing Coordination Process (BP31-1) is required to communicate and provide transportation support to shift these items to the quality department for inspection. After 100% inspection acceptable items in the batches of top flanges are transported to the next process stage i.e., chemical treatment processing. As mentioned in the above paragraph due to loose control the communication delays cause production delays and hence decrease productivity. This situation was tested and analyzed simulation technology. Simulation software SIMUL8 [4] is used which is a discrete event simulation tool. Initially the simulation model prepared and validated [5] replicated the 'As-Is' situation described above (see figure 5).

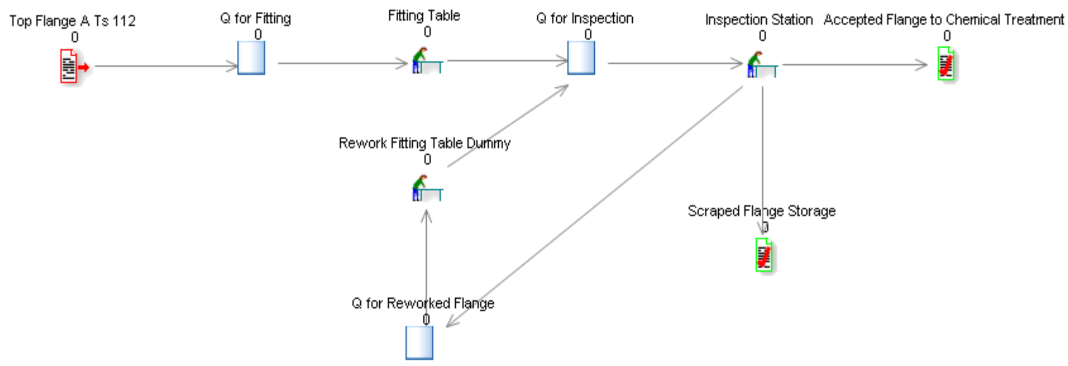

Figure 5: Application of Control Process of Management on 'ABC' Production Management Process – DP31.

Effect of using better control and communication were then tested using the same simulation model with assignment of communication delays to zero. A results comparison is arranged in table 1.

Problems / Parameters	**For Ideal System**	**For System having Lack of Control Process**
Average Time in System/job (hours)	6.35	8.45
Max. Time in System/job (hours)	8.05	12.20
Average Job Completed/week (Nos.)	6.10	4.10
Min. Job Completed/week (Nos.)	4.60	3.05

Table 1. Effect of Control Process of Management for Manufacturing Coordination Process (BP31-1) on Productivity of ABC.

The results show that due to weak communication as part of the control function significant production delays are introduced which decreases the overall productivity.

3 CONCLUSION

A systematic and unified application of CIMOSA and discrete event simulation modelling has illustrated how a selected management process has a vital impact on productivity in a case manufacturing enterprise. Better planning and organized leading to better-designed control processes can significally increase the system output. The effect of better control process on productivity for a selected group of activities is the one to give rise of case company give rise to the need to apply better control on the whole value chain. Although only a control function of a management process has been tested, each and every function of management process like planning, organizing and leading has direct impact on the productivity of any organization whether private or public. Defining performance measures of each function and testing their effects in quantitative terms is an area of future studies for the authors; as is using model driven decision making in support of systematic and quantifiable management policy selection and simulated execution.

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Appendix A-2: Research Publication 2

Model Driven Organization Design and Change

S.Rashid, S.Khalid & R.H.Weston, MSI Research Institute, Wolfson School of Mechanical and Manufacturing Engineering, Loughborough University.

ABSTRACT:

This paper describes research findings when unifying the use of CIMOSA enterprise modelling principles with those of simulation technologies. This is done by describing case study modelling of a Vehicle Parking and Valeting company currently operating at a UK airport. In this case study models of most business processes of the company are documented. Also complementary dynamic (simulation) models of key process segments have been developed. From this case study, outcomes have been new qualitative & quantitative understandings about (1) enterprise and simulation model development and validation, (2) an explicitly observed effect of lack of coordination in the case company and new understandings about the impacts of that lack, (3) the effect of untrained man power in the case company. These outcomes are useful particularly to the case company but also potentially to this business sector.

Key words: Organization Design and Change (OD&C), Enterprise Modelling(EM), Simulation Modelling(SM), Small and Medium Enterprise (SME).

1 INTRODUCTION

This paper illustrates a way of undertaking Organization Design and Change (OD&C) projects based on the combined use of enterprise and simulation modelling techniques. A case study enterprise providing vehicle parking and valeting services is modelled. The case study company (referred to as ABC) is a medium stay vehicle parking and valeting SME operating at a UK airport. ABC has 20 employees including 8 regular employees while 12 are shift employees. ABC operates 7 days a week and 24 hours a day. The customers of ABC can be categorized broadly into two. First are 15% of the total customers of ABC book their parking space directly with ABC by using a website or by calling ABC to book space and/or valeting and at this time money is debited. While others are sent by brokers (travelling service companies) which direct their customers to ABC; to which arrival and departure details are provided to ABC by fax. These brokers contribute 85% of the ABC's total customers on average. All the booking details of either the direct customers or the broker customers are uploaded in a customized data base developed in MS Access which is capable of keeping the data and retrieving it when required but is not useful enough for dealing with capacity and scheduling matters. ABC has a maximum parking capacity of 220 vehicles; while its valeting capacity 15 to 20 vehicles per day depending upon the extent of valeting required.

ABC can be referred to as a developing SME and a lot needs to be done in all the different aspects of its business processes from its strategic policy decisions through to the tactical and finally its operational decisions. For instance, ABC has not communicated its business policy to the relevant members of the staff and no well-defined and quantifiable objective and targets are set for people carrying out different functions. Role description seems to be inappropriate and the relevant training of human resource seems to be insufficient especially in the case of shift staffs, which is composed of 60% of the total. This leads to low customer service quality at the reception check in activity and increased risk of accident or vehicle break down during parking and valeting process. Considering the aspect of communication with the brokers which are the major source of business, ABC management decided that on a daily basis the brokers should be faxing the bookings for their customers for parking and valeting at ABC; but still in 20 to 25% of cases when customers arrive at ABC reception to drop off vehicles no record of their booking is available in the data of ABC. This is mainly due to the reason that no method of reconfirmation is realised between the brokers and ABC; as a consequence customers have to wait in a queue at the reception.

Keeping in view its size limitations this paper will consider only a few of the issues that ABC needs to address. To enable understanding and analysis of ABC problem issues the paper describes how complementary modelling tools and techniques have been applied in a unified fashion. Issues addressed are; a) testing the effect of broker's coordination on ABC customer service quality and system performance at reception, b) testing the effect of untrained receptionists on customer's service quality and system performance at reception.

2 ENTERPRISE MODELLING OF CASE STUDY COMPANY

To enable strategic, tactical and operational decision making of ABC CIMOSA (Computer Integrated Manufacturing Open System Architecture) [1] based modelling of

ABC was carried out using four types of graphical modelling template; called 'Context Diagram', 'Interaction Diagram', 'Structure Diagram' and 'Activity Diagram' [2]. By filling in these templates with specific ABC process data, a holistic (but static) model of ABC's different working domains [and their decomposition into Domain Processes (DPs), Business Processes (BPs) and finally in to Enterprise Activities (EAs)] was achieved. This model also documents relatively endeavouring aspects of interaction between DP's, BP's and EA's. in the form of transfers of physical, information, human or financial resources [3]. Careful construction of these diagrams 'As-Is' picture of ABC business processes that can be used in variety of ways. Figures 1and 2 show examples of CIMOSA templates created in respect of ABC.

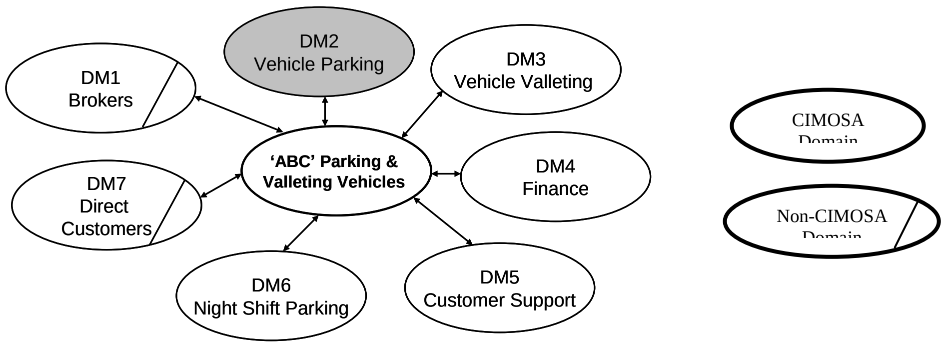

Figure 1: Context Diagram for 'ABC' Parking and Valeting Domain.

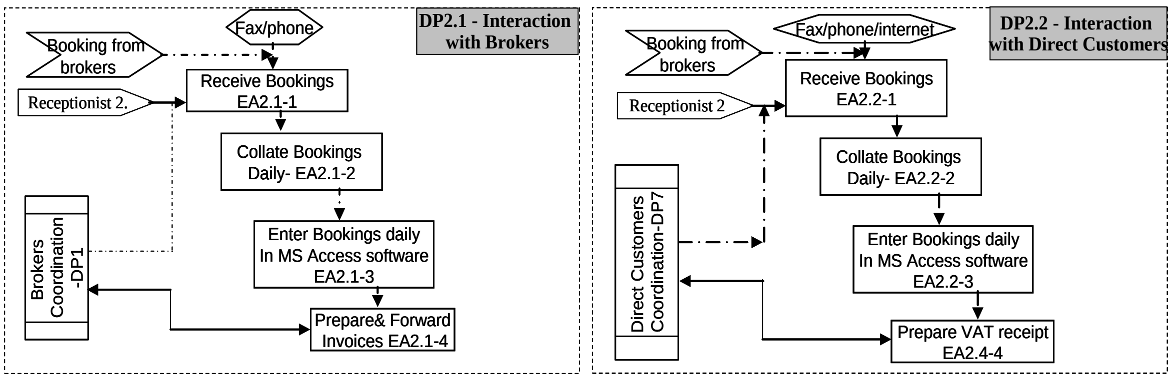

Figure 2: Activity Diagram for DP2.1 – Interaction with Brokers and DP2.2 – Interaction with Direct Customers for 'ABC'

In order to cover the scope of ABC parking and valeting the first author undertook few visits to the company to understand its business processes, their related resources and the working patterns. This took approximately 36 man-hours. There after using a Microsoft Power Point package ABC specific data is coded into the four different types of modelling diagram i.e., Context, Interaction, Structure and Activity diagrams. To construct these diagrams it took 24 man-hours approximately. So in total to develop enterprise models for ABC it took 60 man-hours. It is important to mention here that the first author undertook this enterprise static modelling project for first time hence a practitioner (or a modelling consultant) would take less time.

Based on understandings gained from these generic enterprise model of ABC a selection of activities of concern to the company were focussed on one issue of concern was about an apparent gap in information transferred between brokers and ABC's customer service personnel. The related activities were EAs that compare DP2.1 (Interaction with Brokers) and EA2.4-4 (Receive In/Outgoing Customers at Reception). A second issue of concern to ABC was to quantify effects of untrained receptionists on customer service quality for which the related activity is EA2.5-4 (Receive In/Outgoing Customers at Reception).

3 SIMULATION MODELLING OF CASE STUDY COMPANY

To analyse and predict dynamic behaviours generated by ABC processes, a computer based discrete event simulation tool called SIMUL8 was used [3]. SIMUL8 provides a simple pick and paste approach to creating a graphical and computer executable models. Different types of need to be modelled including; work entry points, work centres and work exit points when a range of attributed properties which corresponds to real conditions of ABC. To populate the model with ABC data and rules it was therefore necessary to replicate real working conditions of ABC. SIMUL8 also provides optional links to Microsoft Excel sheet data and also different checks and conditions can be applied when different simulated events occur.

Using the SIMUL8 and its particular constructs dynamic properties of selected activities i.e., DP2.1, DP2.2 and EA2.4-4 were then modelled in the form in figure 3. Actual dynamic data is then used directly in the simulation model by inputting and outputting that data via an MS Excel sheet. Also different visual logics were applied.

Generally the modelling of complex behaviours of companies will require amplifying assumptions to be made. The reasons for taking assumptions are that to avoid unnecessary complicated detail into the model, so that different stochastic behaviours of the system can still be modelled sufficiently well. In the case of ABC workflows needed simplification was made about averaging limited available data and limitation of software. In the case of ABC the time to perform customers service activities at the reception desk were assumed to have a fixed value which was decided on the basis of time observation of the real system to perform those jobs and then averaging to yield a suitable value.

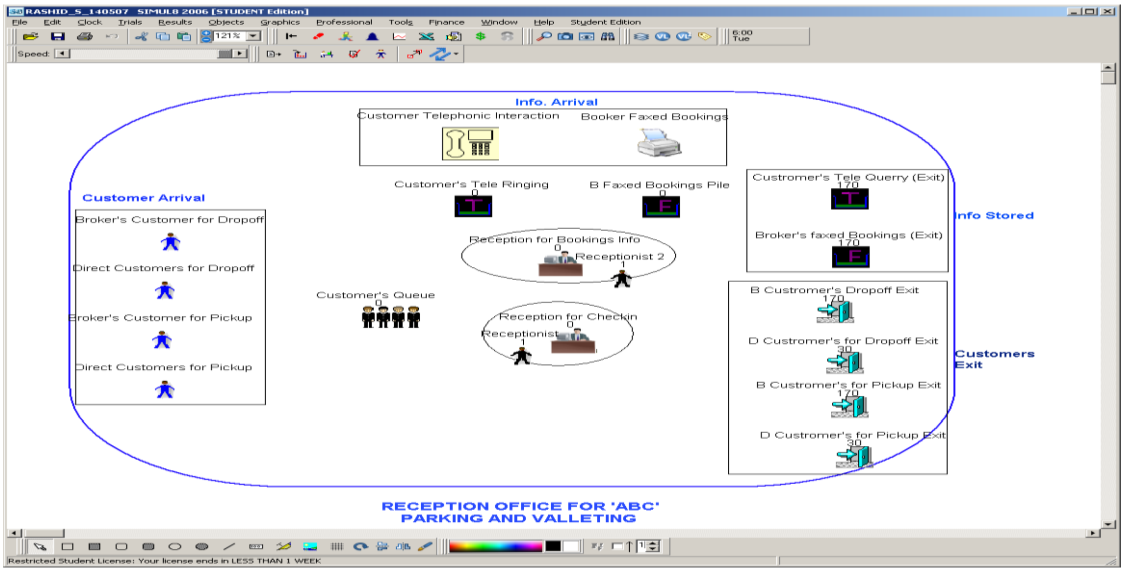

Figure 3. Simulation Model of actual ABC 'work flows' between DP2.1 – Interaction with Brokers, DP2.2 – Interaction with Direct Customers and EA2.4-4 – Receive In/Outgoing Customers at Reception for 'ABC'.

The next step undertaken was to achieve model validation. This is an extremely important step and a fundamental step before proceeding to model experimentation. The validation process also considered the validation of the set assumptions made when modelling to decide if the impact of the assumptions made would mean that the simulation results could be trusted. The validation process was done in three steps [4]. Firstly the model was checked thoroughly for each and every entity, to see whether it replicate the different rules and conditions of the real system of ABC. Secondly to consult the relevant officials performing job in the modelled system, like in this case ABCs Receptionists were consulted to verify that the As-Is simulation model replicates real system behaviours. To adhere this the model was run at slow speeds for some specific time to show the behaviour of work movement through the different entities of the system with respect to time. If it is similar to the real system behaviour then it is verified. Thirdly an important approach was to populate the model with historical data about ABC workflows through the system for which performance outcomes are already known and to test if the simulation results correspond to the real results. If the result of the real system and model are found to align then it is considered that the simulation model is validated.

From experience of creating the simulation models for ABC, it was observed that to create the first version of a simulation model of a focussed portion of the holistic enterprise model is a simple process and took less than one man-hour if modelling. But when it came to replicating real system dynamic conditions for multi entities flow under some specific work rules then it became a complex matter and also the need to make a number of simplifying assumptions arose. To minimise the assumptions made, so as to further enriching the simulation model significant further thought, effort and time was needed.

The validated simulation model of ABC was then used to undertake an analysis of prime concern to ABC. ABC had observed a coordination problem in respect to a few of its major brokers; regarding exchange of their customers booking details. For an average of 23% of customers sent by brokers to drop off their vehicle (i.e., 39 out of 170), when they arrived at reception it was found that data had not yet been faxed to ABC from the broker. It was estimated that 50% extra processing time was needed by the receptionists; because first they must call the relevant broker in order to reconfirm that the customer was in fact sent to ABC rather than to some other parking facility in the vicinity. Once that fact is confirmed then the customer is checked in. Another problem, which ABC had observed is that the training of its human resource, is problem some and the untrained staffs takes 30% extra time to perform reception activities as compared to a trained receptionist. So testing both situations was carried out by using the validated simulation model to simulate customers service quality and system performance parameters like average customers queue sizes, average customers queue times and the utilization of the receptionist. The data used is shown in figure 4 while the results from these simulations are shown in table 1.

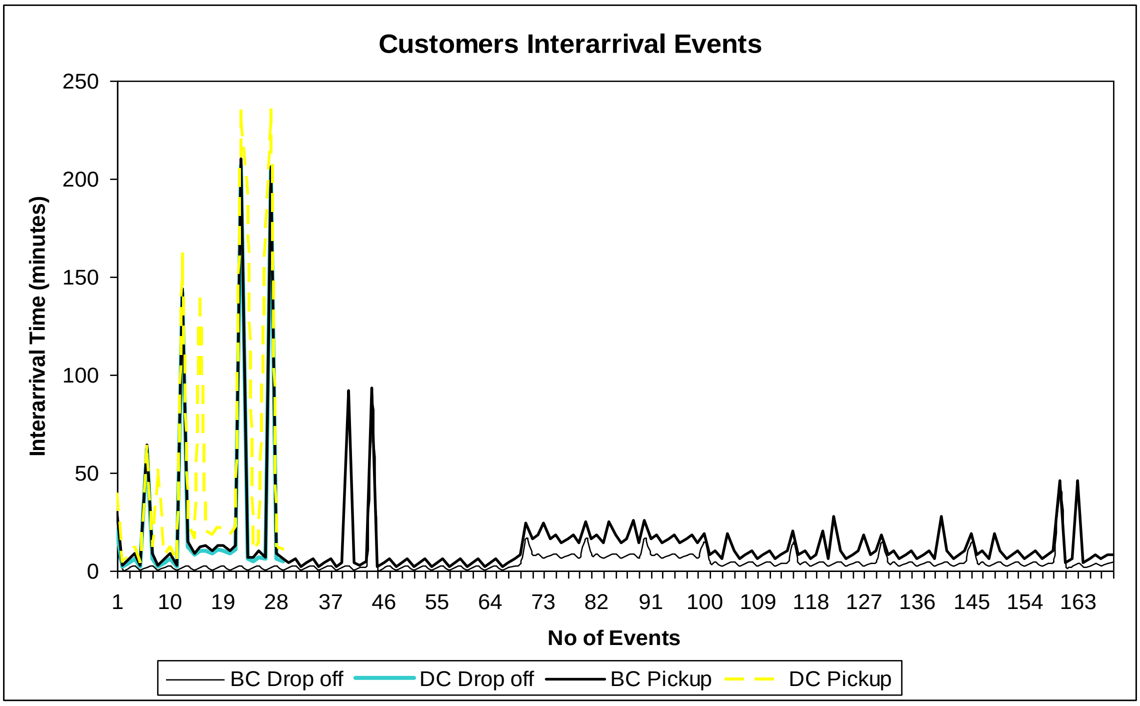

Figure 4: Customers Inter-arrival Events Data

Problems / Parameters	Ideal System	Lack of Coordination, (a)	Untrained Receptionist, (b)	Cumulative for (a) and (b)
Max. Queue Time (min.)	16.00	59.00	48.40	104.30
Max. Queue Size (nos.)	8.00	22.00	19.00	46.00
Average Queue Time (min.)	2.11	7.46	7.31	55.61
Average Queue Size (nos.)	0.49	1.69	1.58	49.34

Table 1: Effect of Brokers Coordination and Untrained Receptionist on Customers Service Quality and System Performance of ABC.

The results show that due to lack of coordination and personnel training at the customers check in reception a remarkable increase in customers waiting time in queue which lead to decrease in both customers service quality and system performance of the reception.

4 CONCLUSION

On the basis of research work related to the case company it was evident that both enterprise modelling and simulation modelling provide a practical, complimentary and feasible way of informing decisions made during engineering organization design and change projects. Though CIMOSA based enterprise modelling can be laborious it provide a static holistic view of enterprise processes which can be used in various ways as a basis for understanding specific enterprise knowledge, normally rested in many different company personnel. Simulation modelling on the other hand needs to have a well-defined focus on some aspects of the enterprise modelling. This is because dynamic (time dependent) simulations need to model all necessary states of company processes when work flows through them. However simulation models can predict portions of CIMOSA enterprise models and perform dynamic simulations for system behaviours and can inform future organization decisions based on analytical grounds.

Future work will be; a) to perform simulation modelling for the other important and interconnected activities of the case company so as to suggest improved resource utilization and better system design, b) to investigate the causal behaviour of system using causal loop modelling for better organizational design and change.

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Appendix B

Identification of Respondents for Interviews

Productivity Enhancement in ME by Management Processes Improvement using LAMP Scorecard (Doctoral Research Project)

Researcher: Khalid Shamim **Supervisor**: Professor Richard Weston
Wolfson School of Mechanical and Manufacturing Engineering, Loughborough University

Purpose: To identify the knowledgeable and experienced experts who can provide information to measure the application level of management processes (planning, organizing, leading, controlling) in this company through interviews.

1. What is your name? ………………………………………………………………………………
2. How many years of experience you have in the Planning Function? ………………...…Year (s)
3. How many years of experience you have in the Organizing Function? ……………...…Year (s)
4. How many years of experience you have in the Leading Function? ……….…………...Year (s)
5. How many years of experience you have in the Controlling Function? ……………...…Year (s)
6. What is the name of your current company? …………………………………………………………
7. What is your current position/role? …………………………………………………………………….
8. Are you the business owner of Planning Function in this company? Yes ☐ No ☐
9. If 'Yes', how many years of experience you have in the Planning Function in this company ……….Year(s)
10. Are you the business owner of Organizing Function in this company (please tick)? Yes ☐ No ☐
11. If 'Yes', how many years of experience you have in the Organizing Function in this company?……Year (s)
12. Are you the business owner of Leading Function in this company (please tick)? Yes ☐ No ☐
13. If 'Yes', how many years of experience you have in the Leading Function in this company?……….Year (s)
14. Are you the business owner of Controlling Function in this company (please tick)? Yes ☐ No ☐
15. If 'Yes', how many years of experience you have in the Controlling Function in this company?….Year (s)
16. Would you be willing to participate in the interview (please tick)? Yes ☐ No ☐
17. If 'Yes', please provide your contact number and e-mail address……………………………………

Thank you for taking the time to fill this information.

Once you have filled in the information, you can send it back via e-mail to the address:

khalid28f@yahoo.com.

Appendix C

Identification of Management Business Processes in an ME

Productivity Enhancement in ME by Management Processes Improvement using LAMP Scorecard (Doctoral Research Project)

Researcher: Khalid Shamim; **Supervisor**: Professor Richard Weston
Wolfson School of Mechanical and Manufacturing Engineering, Loughborough University

Purpose: To identify the business processes related to four management functions such as planning, organizing, leading and controlling in this company through interviews.

1. What is your name? ……………………………………………………………………………………..……

2. What is your current position/role? …………………………………………………………………………….

3. In your experience, what are the key business processes you need within the Planning Function to improve the performance?

   a. Why have you selected only these processes?
   b. Are these processes practically applied in your company?
      If YES then,
   c. How these processes are being applied in your company?
   d. Does the application of these processes require particular software/skills? If YES then please explain.
   e. Is there any mechanism for measuring the application of these business processes in your company? If YES then please explain.

4. In your experience, what are the key business processes you need within the Organizing Function to improve the performance?

   a. Why have you selected only these processes?
   b. Are these processes practically applied in your company?
      If YES then,
   c. How these processes are being applied in your company?
   d. Does the application of these processes require particular software/skills? If YES then please explain.
   e. Is there any mechanism for measuring the application of these business processes in your company? If YES then please explain.

5. In your experience, what are the key business processes you need within the Leading Function to improve the performance?

a. Why have you selected only these processes?
b. Are these processes practically applied in your company?
   If YES then,
c. How these processes are being applied in your company?
d. Does the application of these processes require particular software/skills? If YES then please explain.
e. Is there any mechanism for measuring the application of these business processes in your company? If YES then please explain.

6. In your experience, what are the key business processes you need within the Controlling Function to improve the performance?
   a. Why have you selected only these processes?
   b. Are these processes practically applied in your company?
      If YES then,
   c. How these processes are being applied in your company?
   d. Does the application of these processes require particular software/skills? If YES then please explain.
   e. Is there any mechanism for measuring the application of these business processes in your company? If YES then please explain.

Appendix D-1

Scoring of DP, BP, EA and EA Indicators in Case ME1

Domain Processes (DP)	Business Processes (BP)	Enterprise Activity (EA)	EA Indicator	No. of Respondents										
				PM1	PM2	PM3	PM4	PM5	PM6	PM7	PM8	PM9	PM10	PM11
Planning 46.15%	Time Planning 57.32%	Define Scope	Project Charter	0	0	0	1	0	0	0	1	1	0	0
			Stakeholder Register	0	1	0	0	1	1	0	0	0	1	0
			Scope Statement	1	0	1	1	1	0	1	0	1	0	1
		42.42%		33%	33%	33%	67%	67%	33%	33%	33%	67%	33%	33%
		Create WBS	WBS	1	1	1	1	1	1	1	1	1	1	1
			WBS Dictionary	0	0	1	0	0	0	0	1	0	0	0
		59.09%		50%	50%	100%	50%	50%	50%	50%	100%	50%	50%	50%
		Develop Schedule	Activity List	1	1	1	0	1	1	1	1	0	1	1
			Milestone List	0	0	0	1	1	1	1	1	1	1	1
			Activity Duration Estimate	1	0	1	1	1	0	0	0	1	1	0
			Activity Sequencing	1	1	1	0	1	1	0	1	1	0	1
		70.45%		75.00%	50.00%	75.00%	50.00%	100.00%	75.00%	50.00%	75.00%	75.00%	75.00%	75.00%
	Quality Planning 51.52%	Quality Management Planning	Quality Criteria	1	1	1	1	1	1	1	1	1	1	1
			Quality Standard Documents	0	0	0	0	1	0	0	1	0	0	1
			Quality Compliance Procedure	0	0	0	0	1	0	0	0	1	1	0
		51.52%		33.33%	33.33%	33.33%	33.33%	100.00%	33.33%	33.33%	66.67%	66.67%	66.67%	66.67%

	Risk Planning 20.45%	Risk Management Planning	List of Identified Risks	0	1	0	1	1	0	1	0	1	1	1
			List of Potential Responses	0	0	0	0	0	0	0	0	0	0	0
			Risk Breakdown Structure	0	0	0	0	1	0	0	0	0	0	0
			Risk Mitigation Plan	0	0	0	0	1	0	0	0	0	0	0
		20.45%		0.00%	25.00%	0.00%	25.00%	75.00%	0.00%	25.00%	0.00%	25.00%	25.00%	25.00%
	Resource Planning 55.30%													
		HR Planning	Activity HR Requirements	0	1	0	1	1	0	1	0	1	1	0
			Responsibility Assignment Matrix (RAM)	0	0	0	0	1	0	0	0	0	0	0
			Organizational Charts	1	1	1	1	1	1	1	1	1	1	1
			Staffing Management Plan	0	0	0	0	0	0	0	0	0	0	0
		40.91%		25.00%	50.00%	25.00%	50.00%	75.00%	25.00%	50.00%	25.00%	50.00%	50.00%	25.00%
		Budget Planning	Activity Cost Estimates	0	0	0	0	1	0	0	0	0	1	0
			Budget Plan	1	1	1	1	1	1	1	1	1	1	1
		59.09%		50.00%	50.00%	50.00%	50.00%	100.00%	50.00%	50.00%	50.00%	50.00%	100.00%	50.00%
		Procurement Planning	Make or Buy Decisions	1	1	0	1	1	1	1	1	1	1	0
			Source Selection Criteria	1	0	1	0	0	0	1	1	1	1	1
			Procurements Statements of Work	0	0	0	0	1	0	0	0	0	1	0
			Procurement Documents	1	1	1	1	1	1	1	1	1	1	1
		65.91%		75.00%	50.00%	50.00%	50.00%	75.00%	50.00%	75.00%	75.00%	75.00%	100.00%	50.00%
Organizing 86.11%	Organizing Human Resources	Acquire HR	Recruitment Manual	1	1	1	1	1	1	1	1	1	1	1
			Register for HR Acquisition Time	0	0	0	0	0	0	0	0	0	0	0
			Preventive Turnover Procedure	1	1	1	1	1	1	1	1	1	1	1

	Resources	66.67%		66.67%	66.67%	66.67%	66.67%	66.67%	66.67%	66.67%	66.67%	66.67%	66.67%	66.67%
	83.33%													
		Allocate HR	Placement Policy and Procedures	1	1	1	1	1	1	1	1	1	1	1
			Employee Turnover record	1	1	1	1	1	1	1	1	1	1	1
		100.00%		100.00 %	100.00 %	100.00 %	100.00 %	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
	Organizing Financial Resource													
		Acquire Budget	Policies to Acquire Budget	1	1	1	1	1	1	1	1	1	1	1
			Register for Budget Acquisition Time	0	0	0	0	0	0	0	0	0	0	0
	75.00%	50.00%		50.00%	50.00%	50.00%	50.00%	50.00%	50.00%	50.00%	50.00%	50.00%	50.00%	50.00%
		Allocate Budget	Disbursement Procedures	1	1	1	1	1	1	1	1	1	1	1
		100.00%		100.00 %	100.00 %	100.00 %	100.00 %	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
	Organizing Procurement													
		Inventory Management	Inventory Management Manual	1	1	1	1	1	1	1	1	1	1	1
				1	1	1	1	1	1	1	1	1	1	1
	100.00%	100.00%		100.00 %	100.00 %	100.00 %	100.00 %	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
	Communication	Information Sharing	Project Information	1	1	1	1	1	1	1	1	1	1	1
			Organizational Strategy	0	0	0	0	0	0	0	0	0	0	0
	66.67%		Organizational Rules and Regulation	1	1	1	1	1	1	1	1	1	1	1
Leading		66.67%		66.67%	66.67%	66.67%	66.67%	66.67%	66.67%	66.67%	66.67%	66.67%	66.67%	66.67%
33.33%														
		Aligning Resources Efforts	Production Review System	0	0	0	0	0	0	0	0	0	0	0
	Direction Setting		Financial Review System	0	0	0	0	0	0	0	0	0	0	0
	0.00%		Quality Review System	0	0	0	0	0	0	0	0	0	0	0

		0.00%		0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
		HR Growth and Development	Promotion Policies	1	1	1	1	1	1	1	1	1	1	1
	Motivation		Performance Appraisal Document	1	1	1	1	1	1	1	1	1	1	1
			Training and Development	0	0	0	0	0	0	0	0	0	0	0
	33.33%	66.67%		66.67%	66.67%	66.67%	66.67%	66.67%	66.67%	66.67%	66.67%	66.67%	66.67%	66.67%
		Compensatio n System	Monetary Reward and Recognition System	0	0	0	0	0	0	0	0	0	0	0
			Non-Monetary Reward and Recognition System	0	0	0	0	0	0	0	0	0	0	0
		0.00%		0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
		Time Monitoring	Time Process Flow Diagram	0	0	0	0	0	0	0	0	0	0	0
			Time Feedback report	1	1	1	1	1	1	1	1	1	1	1
		50.00%		50.00%	50.00%	50.00%	50.00%	50.00%	50.00%	50.00%	50.00%	50.00%	50.00%	50.00%
		Cost Monitoring	Cost Process Flow Diagram	0	0	0	0	0	0	0	0	0	0	0
	Monitoring			1	1	1	1	1	1	1	1	1	1	1
	Monitoring	50.00%		50.00%	50.00%	50.00%	50.00%	50.00%	50.00%	50.00%	50.00%	50.00%	50.00%	50.00%
Controlling	37.50%													
45.83%		Quality Monitoring	Quality Process Flow Diagram	0	0	0	0	0	0	0	0	0	0	0
			Quality Feedback report	1	1	1	1	1	1	1	1	1	1	1
		50.00%		50.00%	50.00%	50.00%	50.00%	50.00%	50.00%	50.00%	50.00%	50.00%	50.00%	50.00%
		Risk Monitoring	Risk Process Flow Diagram	0	0	0	0	0	0	0	0	0	0	0
			Risk Feedback report	0	0	0	0	0	0	0	0	0	0	0
		0.00%		0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%

	Progress Analysis 50.00%	Schedule Analysis	Schedule Performance Analysis Report	1	1	1	1	1	1	1	1	1	1	1
		100.00%		100.00 %	100.00 %	100.00 %	100.00 %	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
		Cost Analysis	Cost Performance Analysis Report	0	0	0	0	0	0	0	0	0	0	0
		0.00%		0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
		Quality Analysis	Quality Performance Analysis Report	1	1	1	1	1	1	1	1	1	1	1
		100.00%		100.00 %	100.00 %	100.00 %	100.00 %	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
		Risk Analysis	Risk Performance Analysis Report	0	0	0	0	0	0	0	0	0	0	0
		0.00%		0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	Corrective Action 50.00%													
		Revision of Plans	Time Management Plan Update	1	1	1	1	1	1	1	1	1	1	1
			Cost Management Plan Update	0	0	0	0	0	0	0	0	0	0	0
			Quality Management Plan Update	1	1	1	1	1	1	1	1	1	1	1
			Risk Management Plan Update	0	0	0	0	0	0	0	0	0	0	0
		50.00%		50.00%	50.00%	50.00%	50.00%	50.00%	50.00%	50.00%	50.00%	50.00%	50.00%	50.00%

Appendix D-2

Scoring of DP, BP, EA and EA Indicators in Case ME2

Domain Process (DP)	Business Process (BP)	Enterprise Activity (EA)	EA Indicator	No. of Respondents								
				PM1	PM2	PM3	PM4	PM5	PM6	PM7	PM8	PM9
	Time Planning 53.40%	Define Scope	Project Charter	1	0	0	0	0	1	0	1	0
			Stakeholder Register	0	0	0	0	0	0	0	1	0
			Scope Statement	1	1	1	1	1	0	1	0	1
		40.74%		67%	33%	33%	33%	33%	33%	33%	67%	33%
		Create WBS	WBS	1	1	1	1	1	1	1	1	1
			WBS Dictionary	0	1	0	0	0	0	0	1	0
		61.11%		50%	100%	50%	50%	50%	50%	50%	100%	50%
		Develop Schedule	Activity List	1	1	1	1	1	1	1	1	1
			Milestone List	0	0	0	1	0	0	1	1	0
			Activity Duration Estimate	0	1	0	1	0	0	0	0	0
			Activity Sequencing	1	1	1	0	1	1	0	1	1
		58.33%		50.00%	75.00%	50.00%	75.00%	50.00%	50.00%	50.00%	75.00%	50.00%
	Quality Planning 51.85%											
		Quality Management Planning	Quality Criteria	1	1	1	1	1	1	1	1	1
			Quality Standard Documents	1	0	0	0	0	1	0	1	0
			Quality Compliance Procedure	0	0	1	0	0	0	0	0	1
		51.85%		66.67%	33.33%	66.67%	33.33%	33.33%	66.67%	33.33%	66.67%	66.67%
		Risk Management	List of Identified Risks	1	0	1	0	1	0	0	1	0

	Risk Planning	Planning	List of Potential Responses	0	0	0	0	0	0	0	0	0
			Risk Breakdown Structure	0	0	0	0	1	0	0	1	0
	19.44%		Risk Mitigation Plan	0	0	0	0	0	0	0	1	0
		19.44%		25.00%	0.00%	25.00%	0.00%	50.00%	0.00%	0.00%	75.00%	0.00%
Planning												
		HR Planning	Activity HR Requirements	1	0	0	1	1	0	1	1	1
44.37%			Responsibility Assignment Matrix (RAM)	0	0	0	0	0	0	0	1	0
			Organizational Charts	1	1	1	1	1	1	1	1	1
			Staffing Management Plan	0	0	0	0	0	0	0	0	0
		44.44%		50.00%	25.00%	25.00%	50.00%	50.00%	25.00%	50.00%	75.00%	50.00%
	Resource Planning											
		Budget Planning	Activity Cost Estimates	0	0	0	0	0	0	0	1	0
	52.78%		Budget Plan	1	1	1	1	1	1	1	1	1
		55.56%		50.00%	50.00%	50.00%	50.00%	50.00%	50.00%	50.00%	100.00%	50.00%
		Procurement Planning	Make or Buy Decisions	1	0	1	1	1	1	0	1	1
			Source Selection Criteria	1	0	1	0	0	0	0	1	1
			Procurements Statements of Work	0	0	0	0	1	0	0	0	0
			Procurement Documents	1	1	1	1	1	1	1	1	1
		58.33%		75.00%	25.00%	75.00%	50.00%	75.00%	50.00%	25.00%	75.00%	75.00%
	Organizing Human Resources	Acquire HR	Recruitment Manual	1	1	1	1	1	1	1	1	1
			Register for HR Acquisition Time	0	0	0	0	0	0	0	1	0
			Preventive Turnover Procedure	1	1	1	1	1	1	1	1	1
		70.37%		66.67%	66.67%	66.67%	66.67%	66.67%	66.67%	66.67%	100.00%	66.67%
	85.19%											

Organizing 88.58%		Allocate HR	Placement Policy and Procedures	1	1	1	1	1	1	1	1	1
			Employee Turnover record	1	1	1	1	1	1	1	1	1
		100.00%		100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00 %
	Organizing Financial Resource 80.56%											
		Acquire Budget	Policies to Acquire Budget	1	1	1	1	1	1	1	1	1
			Register for Budget Acquisition Time	0	0	1	0	0	0	0	1	0
		61.11%		50.00%	50.00%	100.00%	50.00%	50.00%	50.00%	50.00%	100.00%	50.00%
		Allocate Budget	Disbursement Procedures	1	1	1	1	1	1	1	1	1
				1	1	1	1	1	1	1	1	1
		100.00%		100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00 %
	Organizing Procurement 100.00%											
		Inventory Management	Inventory Management Manual	1	1	1	1	1	1	1	1	1
				1	1	1	1	1	1	1	1	1
		100.00%		100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00 %
Leading 35.80%	Communication 74.07%	Information Sharing 74.07%	Project Information	1	1	1	1	1	1	1	1	1
			Organizational Strategy	0	0	1	0	0	0	0	1	0
			Organizational Rules and Regulation	1	1	1	1	1	1	1	1	1
				66.67%	66.67%	100.00%	66.67%	66.67%	66.67%	66.67%	100.00%	66.67%
	Direction Setting 0.00%	Aligning Resources Efforts 0.00%	Production Review System	0	0	0	0	0	0	0	0	0
			Financial Review System	0	0	0	0	0	0	0	0	0
			Quality Review System	0	0	0	0	0	0	0	0	0
				0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%

	Motivation	HR Growth and Development	Promotion Policies	1	1	1	1	1	1	1	1	1
			Performance Appraisal Document	1	1	1	1	1	1	1	1	1
			Training and Development	0	0	0	0	0	0	0	0	0
	33.33%	66.67%		66.67%	66.67%	66.67%	66.67%	66.67%	66.67%	66.67%	66.67%	66.67%
		Compensation System	Monetary Reward and Recognition System	0	0	0	0	0	0	0	0	0
			Non-Monetary Reward and Recognition System	0	0	0	0	0	0	0	0	0
		0.00%		0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	Monitoring	Time Monitoring	Time Process Flow Diagram	0	0	1	0	0	0	0	1	0
			Time Feedback report	1	1	1	1	1	1	1	1	1
		61.11%		50.00%	50.00%	100.00%	50.00%	50.00%	50.00%	50.00%	100.00%	50.00%
		Cost Monitoring	Cost Process Flow Diagram	0	0	0	0	1	0	0	1	0
			Cost Feedback report	1	1	1	1	1	1	1	1	1
		61.11%		50.00%	50.00%	50.00%	50.00%	100.00%	50.00%	50.00%	100.00%	50.00%
	48.61%											
		Quality Monitoring	Quality Process Flow Diagram	0	0	1	0	0	0	0	1	0
			Quality Feedback report	1	1	1	1	1	1	1	1	1
		61.11%		50.00%	50.00%	100.00%	50.00%	50.00%	50.00%	50.00%	100.00%	50.00%
		Risk Monitoring	Risk Process Flow Diagram	0	0	0	0	0	0	0	0	0
			Risk Feedback report	0	0	1	0	0	0	0	1	0
		11.11%		0.00%	0.00%	50.00%	0.00%	0.00%	0.00%	0.00%	50.00%	0.00%
Controlling		Schedule Analysis	Schedule Performance Analysis Report	1	1	1	1	1	1	1	1	1

53.24%		100.00%		100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00 %
	Progress Analysis	Cost Analysis	Cost Performance Analysis Report	0	0	0	0	0	0	0	0	0
		0.00%		0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	55.56%											
		Quality Analysis	Quality Performance Analysis Report	1	1	1	1	1	1	1	1	1
		100.00%		100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00 %
		Risk Analysis	Risk Performance Analysis Report	0	0	1	0	0	0	0	1	0
		22.22%		0.00%	0.00%	100.00%	0.00%	0.00%	0.00%	0.00%	100.00%	0.00%
		Revision of Plans	Time Management Plan Update	1	1	1	1	1	1	1	1	1
	Corrective Action		Cost Management Plan Update	0	0	0	0	0	0	0	0	0
			Quality Management Plan Update	1	1	1	1	1	1	1	1	1
	55.56%		Risk Management Plan Update	0	0	1	0	0	0	0	1	0
		55.56%		50.00%	50.00%	75.00%	50.00%	50.00%	50.00%	50.00%	75.00%	50.00%

Appendix D-3

Scoring of DP, BP, EA and EA Indicators in Case ME3

Domain Process (DP)	Business Process (BP)	Enterprise Activity (EA)	EA Indicator	No. of Respondents				
				PM1	PM2	PM3	PM4	PM5
	Time Planning 71.67%	Define Scope	Project Charter	1	0	1	1	0
			Stakeholder Register	0	1	0	0	1
			Scope Statement	1	0	1	1	1
		60.00%		67%	33%	67%	67%	67%
		Create WBS	WBS	1	1	1	1	1
			WBS Dictionary	1	0	1	1	0
		80.00%		100%	50%	100%	100%	50%
		Develop Schedule	Activity List	1	1	0	1	1
			Milestone List	1	0	0	1	1
			Activity Duration Estimate	1	0	1	1	1
			Activity Sequencing	1	1	1	0	1
		75.00%		100.00%	50.00%	50.00%	75.00%	100.00%
	Quality Planning 66.67%							
		Quality Management Planning	Quality Criteria	1	1	1	1	1
			Quality Standard Documents	1	0	1	0	1
			Quality Compliance Procedure	1	0	0	0	1
		66.67%		100.00%	33.33%	66.67%	33.33%	100.00%
		Risk Management	List of Identified Risks	1	1	1	1	1

	Risk Planning	Planning	List of Potential Responses	0	0	0	0	0
			Risk Breakdown Structure	1	1	0	1	1
	60.00%		Risk Mitigation Plan	0	1	0	1	1
		60.00%		50.00%	75.00%	25.00%	75.00%	75.00%
Planning								
		HR Planning	Activity HR Requirements	1	1	1	1	1
70.00%			Responsibility Assignment Matrix (RAM)	0	1	0	0	1
			Organizational Charts	1	1	1	1	1
			Staffing Management Plan	1	1	1	1	1
		85.00%		75.00%	100.00%	75.00%	75.00%	100.00%
	Resource Planning							
		Budget Planning	Activity Cost Estimates	0	1	0	1	1
	81.67%		Budget Plan	1	1	1	1	1
		80.00%		50.00%	100.00%	50.00%	100.00%	100.00%
		Procurement Planning	Make or Buy Decisions	1	1	1	1	1
			Source Selection Criteria	1	1	1	1	1
			Procurements Statements of Work	0	0	0	1	0
			Procurement Documents	1	1	1	1	1
		80.00%		75.00%	75.00%	75.00%	100.00%	75.00%
	Organizing Human Resources	Acquire HR	Recruitment Manual	1	1	1	1	1
			Register for HR Acquisition Time	0	0	0	0	0
			Preventive Turnover Procedure	1	1	1	1	1
		66.67%		66.67%	66.67%	66.67%	66.67%	66.67%
	83.33%							
		Allocate HR	Placement Policy and Procedures	1	1	1	1	1

			Employee Turnover record	1	1	1	1	1
		100.00%		100.00%	100.00%	100.00%	100.00%	100.00%
Organizing 86.11%	Organizing Financial Resource 75.00%							
		Acquire Budget	Policies to Acquire Budget	1	1	1	1	1
			Register for Budget Acquisition Time	0	0	0	0	0
		50.00%		50.00%	50.00%	50.00%	50.00%	50.00%
		Allocate Budget	Disbursement Procedures	1	1	1	1	1
		100.00%		100.00%	100.00%	100.00%	100.00%	100.00%
	Organizing Procurement							
		Inventory Management	Inventory Management Manual	1	1	1	1	1
	100.00%	100.00%		100.00%	100.00%	100.00%	100.00%	100.00%
Leading 46.67%								
	Communication 66.67%	Information Sharing	Project Information	1	1	1	1	1
			Organizational Strategy	0	0	0	0	0
			Organizational Rules and Regulation	1	1	1	1	1
		66.67%		66.67%	66.67%	66.67%	66.67%	66.67%
		Aligning Resources Efforts						
	Direction Setting 40.00%		Production Review System	1	0	1	1	0
			Financial Review System	0	0	0	0	0
			Quality Review System	1	0	1	1	0
		40.00%		66.67%	0.00%	66.67%	66.67%	0.00%
	Motivation							
		HR Growth and Development	Promotion Policies	1	1	1	1	1
			Performance Appraisal Document	1	1	1	1	1
			Training and Development	0	0	0	0	0
	33.33%	66.67%		66.67%	66.67%	66.67%	66.67%	66.67%

		Compensation System	Monetary Reward and Recognition System	0	0	0	0	0
			Non-Monetary Reward and Recognition System	0	0	0	0	0
		0.00%		0.00%	0.00%	0.00%	0.00%	0.00%
Controlling 75.00%	Monitoring 50.00%	Time Monitoring	Time Process Flow Diagram	0	0	0	0	0
			Time Feedback report	1	1	1	1	1
		50.00%		50.00%	50.00%	50.00%	50.00%	50.00%
		Cost Monitoring	Cost Process Flow Diagram	0	0	0	0	0
			Cost Feedback report	1	1	1	1	1
		50.00%		50.00%	50.00%	50.00%	50.00%	50.00%
		Quality Monitoring	Quality Process Flow Diagram	0	0	0	0	0
			Quality Feedback report	1	1	1	1	1
		50.00%		50.00%	50.00%	50.00%	50.00%	50.00%
		Risk Monitoring	Risk Process Flow Diagram	0	0	0	0	0
			Risk Feedback report	1	1	1	1	1
		50.00%		50.00%	50.00%	50.00%	50.00%	50.00%
	Progress Analysis 100.00%	Schedule Analysis	Schedule Performance Analysis Report	1	1	1	1	1
		100.00%		100.00%	100.00%	100.00%	100.00%	100.00%
		Cost Analysis	Cost Performance Analysis Report	1	1	1	1	1
		100.00%		100.00%	100.00%	100.00%	100.00%	100.00%

		Quality Analysis	Quality Performance Analysis Report	1	1	1	1	1
		100.00%		100.00%	100.00%	100.00%	100.00%	100.00%
		Risk Analysis	Risk Performance Analysis Report	1	1	1	1	1
		100.00%		100.00%	100.00%	100.00%	100.00%	100.00%
	Corrective Action	Revision of Plans	Time Management Plan Update	1	1	1	1	1
			Cost Management Plan Update	0	0	0	0	0
		75.00%	Quality Management Plan Update	1	1	1	1	1
	75.00%		Risk Management Plan Update	1	1	1	1	1
				75.00%	75.00%	75.00%	75.00%	75.00%

Appendix E

Definition of Enterprise Activities and Enterprise Activity Application Indicator

Domain Process- Planning				
Business Process	**Enterprise Activity**	**Definition (where required)**	**Enterprise Activity Indicator**	**Definition (where required)**
Time Planning	Define Scope	Define Scope is the process of developing a detailed description of the project and product.	Project Charter	The project charter documents the business needs, current understanding of the customer's needs, and the new product, service, or result that it is intended to satisfy.
			Stakeholder Register	The stakeholder register is used to identify stakeholders that can provide information on detailed project and product requirements.
			Scope Statement	The project scope statement includes the product scope description, includes the project deliverables, and defines the product user acceptance criteria.
	Create WBS	Create Work Breakdown Structure is the process of subdividing project deliverables and project work into smaller, more manageable components.	WBS	The WBS is a deliverable-oriented hierarchical decomposition of the work to be executed by the project team, to accomplish the project objectives and create the required deliverables, with each descending level of the WBS representing an increasingly detailed definition of the project work.
			WBS Dictionary	The WBS dictionary provides more detailed descriptions of the components in the WBS, including work packages, technical documentation and control accounts.
	Develop Schedule	Develop Schedule is the process of analyzing activity sequences, durations, resource requirements, and schedule constraints to create the project schedule.	Activity List	The activity list is a comprehensive list including all schedule activities required on the project.
			Milestone List	A milestone is a significant point or event in the project.
			Activity Duration Estimate	Activity duration estimates are quantitative assessments of the likely number of work periods that will be required to complete an activity.
			Activity Sequencing	Sequence Activities is the process of identifying and documenting relationships among the project activities.

Quality Planning	Quality Management Planning	It is the process of identifying the processes and activities of the performing organization that determine quality policies, objectives, and responsibilities so that the project will satisfy the needs for which it was undertaken.	Quality Criteria	The detail of parameters to be inspected to ensure the quality of product for its intended use
			Quality Standard Documents	The documents about the details of the quality standard to be followed
			Quality Compliance Procedure	The procedures and policies about quality control and assurance
Risk Planning	Risk Management Planning	The process of defining how to conduct risk management activities for a project.	List of Identified Risks	The process of determining which risks may affect the project and documenting their characteristics.
			List of Potential Responses	Potential responses to a risk may sometimes be identified during the Identify Risks process. These responses, if identified in this process, may be useful as inputs to the Plan Risk Responses process.
			Risk Breakdown Structure	The RBS is a hierarchically organized depiction of the identified project risks arranged by risk category and subcategory that identifies the various areas and causes of potential risks.
			Risk Mitigation Plan	Defines the approaches, tools, and data sources that may be used to mitigate project risks.
Resource Planning	HR Planning	The process of identifying and documenting project roles, responsibilities, and required skills, reporting relationships, and creating a staffing management plan.	Activity HR Requirements	Human resource planning uses activity resource requirements to determine the human resource needs for the project. The preliminary requirements regarding the required people and competencies for the project team members are progressively elaborated as part of the human resource planning process.
			Responsibility Assignment Matrix (RAM)	A responsibility assignment matrix (RAM) is used to illustrate the connections between work packages or activities and project team members.
			Organizational Charts	A project organization chart is a graphic display of project team members and their reporting relationships.
			Staffing Management Plan	The staffing management plan, a part of the human resources plan within the project management plan, describes when and how human resource requirements will be met.
	Budget Planning	The process of estimating the cost of individual activities needed to complete the project and	Activity Cost Estimates	The process of developing an approximation of the monetary resources needed to complete project activities.
			Budget Plan	The process of aggregating the estimated costs of individual

		aggregating these costs to develop a cost baseline.		activities or work packages to establish an authorized cost baseline.
	Procurement Planning	The process of documenting project purchasing decisions, specifying the approach, and identifying potential sellers.	Make or Buy Decisions	Make-or-buy decisions document the conclusions reached regarding what project products, services, or results will be acquired from outside the project organization, or will be performed internally by the project team.
			Source Selection Criteria	Selection criteria are often included as a part of the procurement documents. Such criteria are developed and used to rate or score seller proposals, and can be objective or subjective.
			Procurements Statements of Work	The procurement SOW describes the procurement item in sufficient detail to allow prospective sellers to determine if they are capable of providing the products, services, or results.
			Procurement Documents	Procurement documents are used to solicit proposals from prospective sellers.
		Domain Process – Organizing		
Organizing Human Resources	Acquire HR	Acquire HR is the process of confirming project team availability and obtaining the team necessary to complete project assignments.	Recruitment Manual	Policies and criteria of the organization for recruiting personnel of different categories.
			Register for HR Acquisition Time	Maintaining record of time taken to follow the procedures in acquiring HR
			Preventive Turnover Procedure	Policies to support in retaining the employees
	Allocate HR	Allocate HR is the process of allocating the team necessary to complete project assignments.	Responsibility Assignment Matrix	A responsibility assignment matrix (RAM) is used to illustrate the connections between work packages or activities and project team members.
			Placement Policy and Procedures	Rules and regulations governing the initial placement and transfer of employees in different departments
			Employee Turnover record	Maintaining record of the employees for different categories e.g. transferring, resigning, dismissal etc.
Organizing Financial Resources	Acquire Budget	Acquire Budget is the process of confirming project funds availability and obtaining the necessary to complete project assignments.	Policies to Acquire Budget	Rules, regulation and SOP's for preparing and acquiring budget
			Register for Budget Acquisition Time	Maintaining record of time taken to follow the procedures in acquiring budget

	Allocate Budget	Allocate Budget is the process of allocating the funds necessary to complete project assignments.	Disbursement Procedure	Rules, regulation and SOP's for funds distribution to different stakeholders
Organizing Procurement	Inventory Management	The process of supply of inventory to stores, its distribution to users and up keeping in stores	Inventory Management Manual	Policies and procedures for administering procurement, taking inventory on charge, issuance and maintaining store inventory record etc.
		Domain Process – Leading		
Communication	Information Sharing	The process of making relevant information available to project stakeholders as planned.	Project Information	Sharing of project information about timelines, funds, quality requirements with stakeholders
			Organizational Strategy	Sharing of overall organizational vision, goals and objectives with stakeholders
			Organizational Rules and Regulation	Sharing of overall organizational rules and regulations about HR, Admin, Procurement, Finance, Stores etc. with stakeholders
Direction Setting	Aligning Resources Efforts	The process of aligning the human and equipment efforts with the organizational goals	Production Review System	Procedures to review the progress of production
			Financial Review System	Procedures to review the progress of finances
			Quality Review System	Procedures to review the progress of quality
Motivation	HR Growth and Development	The process of raising and maintaining the competency level of HR in the organization	Promotion Policies	Policies and procedures for acknowledging the experience, skills and efforts of employees
			Performance Appraisal Document	The document to assess the performance of employees
			Training and Development	Training and development includes all activities designed to enhance the competencies of the project team members.
	Compensation System	The process of rewarding the employees based on their performance	Monetary Reward and Recognition System	The system to acknowledge the performance of employees in terms of monitory benefits
			Non-Monetary Reward and Recognition System	The system to acknowledge the performance of employees in terms of non-monitory benefits
		Domain Process – Controlling		
Monitoring	Time Monitoring	The process of getting feedback about timelines	Time Process Flow Diagram	The diagram showing the process flow of feedback about timelines
			Time Feedback report	The document to report the feedback about the actual timelines followed
	Cost Monitoring	The process of getting feedback about finances	Cost Process Flow Diagram	The diagram showing the process flow of feedback about finances

			Cost Feedback report	The document to report the feedback about the actual cost incurred
	Quality Monitoring	The process of getting feedback about quality	Quality Process Flow Diagram	The diagram showing the process flow of feedback about quality
			Quality Feedback report	The document to report the feedback about the actual quality achieved
	Risk Monitoring	Monitoring Risks is the process of implementing risk response plans, tracking identified risks, monitoring residual risks and identifying new risks throughout the project.	Risk Process Flow Diagram	The diagram showing the process flow of feedback about risks
			Risk Feedback report	The document to report the feedback about the actual risks observed
Progress Analysis	Schedule Analysis	The process of comparing the actual progress with the planned progress in terms of time, cost, quality and risk	Schedule Performance Analysis Report	The document to report about the comparison of actual and planned progress in terms of time, cost, quality and risk
	Cost Analysis		Cost Performance Analysis Report	
	Quality Analysis		Quality Performance Analysis Report	
	Risk Analysis		Risk Performance Analysis Report	
Corrective Action	Revisions of Plans	The process of making changes in plans according to the progress analysis	Time Management Plan Update	The document showing the revision in plans of time, cost, quality and risks
			Cost Management Plan Update	
			Quality Management Plan Update	
			Risk Management Plan Update	