Manufacturing as a reference for rethinking construction
design management

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ABSTRACT
Design changes due to lack of constructability, cost overruns, delays and dissatisfied clients are but a few problems experienced in construction due to poor management of the design processes. Increased problems, challenges, demands and continuous criticism of the architectural profession has led to increased demand for research into the improvement of design processes.

The aims of this research were to determine the adequacy of design management processes used by Eastern Cape (EC) architectural companies and compare these with the design management processes used in manufacturing in order to establish practices, theories, principles, technologies and deliverables that can be transferred from the manufacturing into the construction to improve efficiency of architectural design management.

The quantitative research approach was implemented for this research, the questionnaire was designed to acquire primary, factual and attitudinal data from EC architectural companies and secondary data were acquired through a literature review.

The results revealed that design management processes, continuous improvement philosophies, lean principles, and Information and Communication Technology (ICT) used by EC architectural companies are not similar to those used in manufacturing.

Therefore EC architectural companies could increase their efficiency by adopting some of the design management processes, ICT, continuous improvement philosophies and lean principles originating from the manufacturing industry.

Keywords: Design management, construction, manufacturing, architectural profession, process improvement.
ACKNOWLEDGEMENTS

I would like to take this opportunity to thank all persons and organisations that contributed towards the successful completion of this research. In particular the assistance of the following is acknowledged:

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Border-Kei Institute of Architects and Eastern Cape Institute of Architects for providing valuable information that contributed to the success of this research.

All the architectural companies that participated in this research, without which this document would not have been possible.
DEDICATION

This research paper is dedicated to my parents Enoch Makalima Sidloyi and Nozitulele Sidloyi, who instilled in me from an early age the importance of education.
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<table>
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<tr>
<th>Abbreviation</th>
<th>Full Form</th>
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<tr>
<td>3D</td>
<td>3 Dimensional</td>
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<tr>
<td>ANG</td>
<td>Activity Network Graphs</td>
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<td>BKIA</td>
<td>Border-Kei Institute of Architects</td>
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<td>BPR</td>
<td>Business Process Re-engineering</td>
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<td>CAD</td>
<td>Computer Aided Design</td>
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<td>CAE</td>
<td>Computer Aided Engineering</td>
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<td>CAI</td>
<td>Computer Aided Inspection</td>
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<tr>
<td>CAM</td>
<td>Computer Aided Manufacturing</td>
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<td>CAPE</td>
<td>Computer Aided Production Engineering</td>
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<tr>
<td>CAQ</td>
<td>Computer Aided Quality</td>
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<td>CE</td>
<td>Concurrent Engineering</td>
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<tr>
<td>CFD</td>
<td>Computational Fluid Dynamics</td>
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<td>CI</td>
<td>Continuous Improvement</td>
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<td>CIDB</td>
<td>Construction Industry Development Board</td>
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<td>CIOB</td>
<td>Chartered Institute of Building</td>
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<td>CM</td>
<td>Construction Manager</td>
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<tr>
<td>CSIR</td>
<td>Council for Scientific and Industrial Research</td>
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<tr>
<td>DTA</td>
<td>Dimensional Tolerance Analysis</td>
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<td>EC</td>
<td>Eastern Cape</td>
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<td>ECIA</td>
<td>Eastern Cape Institute of Architects</td>
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<tr>
<td>FEA</td>
<td>Finite Element Analysis</td>
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<td>ICT</td>
<td>Information and Communication Technology</td>
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<td>IDS</td>
<td>Integrated Databases</td>
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<td>IVT</td>
<td>Innovative Technologies</td>
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<td>JIT</td>
<td>Just In Time</td>
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<td>KBE</td>
<td>Knowledge-Based Engineering</td>
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<td>LP</td>
<td>Lean Production</td>
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<td>LRC</td>
<td>Linear responsibility chart</td>
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<td>MPM</td>
<td>Manufacturing Process Management</td>
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<td>MES</td>
<td>Mechanical Event Simulation</td>
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<td>NDT</td>
<td>Non-Destructive Testing</td>
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<td>NPD</td>
<td>New Product Development</td>
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<td>Acronym</td>
<td>Full Form</td>
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<td>OLAP</td>
<td>On-Line Analytical Processing</td>
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<tr>
<td>OMT</td>
<td>Operation and Manufacturing Technologies</td>
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<td>PDCA</td>
<td>Plan-Do-Check-Act</td>
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<tr>
<td>PEP</td>
<td>Project Execution Plan</td>
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<td>RIBA</td>
<td>Royal Institute of British Architects</td>
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<td>RPW</td>
<td>RIBA Plan of Work</td>
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<td>SACAP</td>
<td>South African Council for the Architectural Profession</td>
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<td>SAIA</td>
<td>South African Institute of Architects</td>
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<tr>
<td>TQM</td>
<td>Total Quality Management</td>
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<td>VM</td>
<td>Value Management</td>
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<td>VR</td>
<td>Virtual Reality</td>
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<td>WBS</td>
<td>Work Breakdown Structure</td>
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<td>World Wide Web</td>
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DEFINITION OF TERMS

Architect
According to Simpson and Weiner (1989:30), an architect is a person who designs buildings and supervises their construction.

Architecture
The art, science or practice of designing buildings, in which human requirements and construction materials are related so as to furnish practical use as well as an aesthetic solution (Columbia 2004:589).

Artefacts
According to Dym and Little (2004:6), artefacts are human-made objects or devices.

Budget
A detailed, time-phased estimate of the costs of all resources required to perform a project (Portny 2001:312).

Client
The individual or organisation commissioning the building project and directly employing the designer, the project manager and the works contractor (Gray and Hughes 2001:165).
Convergent thinking
According to Dym and Little (2004:101), convergent thinking is the narrowing down of alternatives to focus on the 'best' alternative.

Construction
Collier (2001:284) defines it as the design and production of construction work.

Co-ordination
A fundamental feature of planning and day-to-day project relations. Depends upon openness of intent, anticipation, sharing of information (Allinson 1997:184).

Creativity
According to Sternberg (1988:118), creativity refers to the potential to produce novel ideas that are task-appropriate and high in quality.

Design
According to Simpson and Weiner (1989:120), design is a plan or drawing produced to show the look and function or workings of something before it is built or made.

Designer
A person who provides skilful and economic designs for work and acts as an independent coordinator on behalf of the client; usually a professional
engineer or architect who performs the design functions (Gray and Hughes 2001:166).

**Design management**

An outcome of business realising that design is important to added value (Allinson 1997:184). The term also refers to any set of managerial techniques which aim to realise the potential of design as some form of socio-economic benefit.

**Divergent thinking**

According to Dym and Little (2004:101), divergent thinking refers to the expansion of design alternatives.

**Efficiency**

The proportion of time spent on project work on a project, as opposed to organisational tasks not related to the specific project (Portny 2001:313).

**Inception**

This is a term used by architects to describe when a project begins (Allinson 1997:186).

**Life-cycle**

Management

Simpson and Weiner (1989:430) describe management as a process of managing.

Model

A miniature representation of something (Dym and Little 2004:113).

Process

A series of steps by which a particular function is routinely performed (Portny 2001:316).

Procurement

A word referring to a process of acquisition, usually used with reference to project goals (Allinson 1997:187).

Productivity

The results produced per unit of time spent working on an activity (Portny 2001:316).

Progress

A measure of achievement along a path from inception to the goal of project completion (Allinson 1997:187).
**Project**

A work assignment that has specific outcomes, definite start and end dates, and established resource budget (Portny 2001:316).

**Project management**

Process of guiding a project from its beginning through performance to its closure. Includes planning, organising and controlling (Ibid).

**Project manager**

The person, ultimately responsible for the successful completion of a project (Ibid:317).

**Prototype**

First full-scale and usually functional form of a new type or design of artefact (Dym and Little 2004:113)

**Risk**

The possibility that something will go wrong and threaten the plan (Allinson 1997:188).

**Specification**

According to Dym and Little (2004:6), artefacts are precise descriptions of the properties of the objects being designed.
CHAPTER 1

THE PROBLEM AND ITS SETTING

1.1 INTRODUCTION

Cull (2004) reported that the South Africa construction industry would be required to double its output over the next 10 years, according to a status report compiled by the Construction Industry Development Board (CIDB). Hodgson noted in CIDB (2004) that, over the past two years, just over half of all projects were completed on time, within budget and relatively defect free. The increased pressure on the construction industry to improve its practices and continuous criticism of its less than optimum performance has led to research on improvement of processes and efficiency.

The Egan report (1998) suggested that there are significant inefficiencies in the construction process and that there is potential for a systematised and integrated project process in which wastage can be reduced and both quality and efficiency improved. There are many practitioners and academics who believe that the construction industry has much to learn from manufacturing. Howell (1998) suggested that this learning could be a two-way process: manufacturing could learn from construction in areas of project based management and construction could learn from manufacturing’s developing and developed solutions.
Egan (1998) noted that clients needed better value from their projects and construction companies needed reasonable profits to assure their long-term futures, and that the need for improvement in construction is clear. The Egan report recommended that the building industry could change, by rethinking the fundamentals of its delivery processes; and offered clues as to how some of the problems might be overcome by transferring practices from the manufacturing industry to achieve continuous improvement on its performance and products.

The architectural profession is an integral part of the construction industry’s supply–chain, and some inefficiencies experienced by the construction industry are directly or indirectly influenced by poor management of design processes. The increased pressure on the construction industry to improve its practices, increased workload and demand for better quality, coupled with numerous problems facing the architectural profession, have forced architectural practices to reconsider its service delivery processes. Allinson (1993:164) stated that “getting a project from A to B is dependent upon an inextricably bound union of design and management”. Therefore contemporary architectural practice has a need to reconcile issues of management, design and professionalism. RIBA (2005) noted that the success of the architectural profession and its practitioners relied partly on their approach to the future as they are well placed to take advantage of future opportunities and emphasised the need to act proactively.
1.1.1 The construction industry

The South African (SA) construction industry has been frequently criticised for its less than optimal performance by several institutional and governmental reports such as Bruce (2003), Gasa et al. (2003) and Gymahl et al. (2003). These reports concluded that the fragmented nature of the industry, lack of co-ordination and communication between parties, and lack of customer focus are inhibiting the construction industry’s performance. The reasons for the construction industry’s poor performance are: firstly, the use of outdated industrial processes; and secondly, the industry has not kept pace with innovations and developments as compared with other industries. The above point is substantiated by Hindle (then CIOB president) in an interview with Janse van Vuuren (2003:2), stating that “business models and processes of construction have not evolved to meet today’s needs”. Egan (1998:18) asserted that “due to the fragmented nature of the construction industry, very little work has gone into process modelling”.

The construction industry’s poor performance is not unique to SA, but is a global problem. Egan (1998) commented on the state of the construction industry globally and concludes that construction projects are unpredictable in terms of delivery time, cost, profitability and quality. Egan’s point was substantiated by Hindle, claiming “everyone thinks of construction as the process that most often results in pain, extra money, late delivery and poor quality”. According to Langford and
Murray (2004: 34), the inefficiency of the construction industry has tended to be a way of life.

Pheng and Tan (1998) concluded that process improvement in the construction industry may well be a significant strategy for getting the right product to the right market at the right time, cost and quality. The above point is further justified by Kagioglou et al. (2005:3) stating that “process has been identified by the construction industry as an important issue to address”. These authors concluded that “in order to deliver a construction product on time, on cost and on highest quality, it is critical to manage the construction process and problems effectively”. Kagioglou et al. (2005) suggested that the construction industry could learn from manufacturing’s developed and developing solutions to improve its competitiveness and further suggested that the construction industry should look to manufacturing for reference on how to manage the design and development process.

1.1.2 The architect

The architectural profession is caught between accusations of gross managerial inefficiency and art-less aesthetic inadequacy. As noted by Allinson (1993), the architectural profession has been criticised and viewed as restrictively self-interested, economically marginal, and sometimes inexpert and frequently art-less. This is evident in architects’ sayings “I don’t intend to build in order to have clients, but intend to have clients in order to build". 
Globally, the architectural profession is at a critical point regarding its future due to the continual erosion of its status and responsibilities. The theme of the architects’ changing role in the built environment has been a central concern of the profession. As noted in the RIBA journal (2000), large sections of the profession have suffered economically as a result of the increasing marginalisation of the architect’s role in the past 15 years. As stated in Gray and Hughes (2001:6) “the rise of construction managers and then project managers as recognised disciplines in the construction process has accelerated the decline of architects’ role”. The above statement is substantiated by Cairns (1992:14) claiming that “the architect has allowed, through lack of interest, and subsequently been forced through lack of knowledge, some of his roles in the fields of construction and project management to be assumed by others, losing control over their correct integration into the overall architectural process”. Another reason that the architect’s role is being taken over by other professions is that the architects have failed to satisfy the clients. The above point is substantiated by RIBA (1992:12) stating that “their dissatisfaction would appear to have arisen as architects moved away from being responsible for programme and financial control (the areas of most concern to clients) toward pure design”. The other reason is that clients and architects have different perceptions of quality in construction. RIBA (1992:13) states that “Architects tend to interpret quality in terms of the finished product while clients increasingly see it in terms of control of the design and the construction process”.
The architectural profession has been noted for its introverted perspective and for lack of interest in interdisciplinary working. The stereotypical social class system that positions architects alongside doctors, lawyers and other members of the middle class professional elite, has contributed to the introverted perspectives of the architectural profession. RIBA (2005:12) stated that “the profession’s introverted perspective is instigated during education; architects are not educated to meet industry and wider market needs”. Loxton (2004) noted that the design professionals produced by the education system did not know enough about construction processes and produced designs that were unworkable and too costly. RIBA (2005:12) concluded by stating that “the quality and quantity of graduates completing professional architectural education and entering practices appears to be falling, largely because they are not equipped with skills needed for modern industry”.

Gorb (2003:2) stated that “what designers need to learn, and this is the most important thing, is the language of the business world. Only by learning that language can designers effectively voice the arguments for design”. Gorb’s statement is substantiated by Allinson (1993:160) insisting that “architects must learn the language and lessons of business”. Allinson (1993) concluded by recommending that architects should avoid the implications that “design is a wild card” and that project management is “misguided consultant-bashing by philistine”. Langford and Murray (2004: 23) concluded by recommending that “the
architect needs to regain his role so that he can facilitate effective performance of the temporary and multi-organisational team”. As Gorb (2003:12) puts it, “designers are not there to design, but to run the business world”.

1.1.3 The client

Under-achievement in construction projects is evident in the growing dissatisfaction with construction among both private and public sector clients. Clients have too often been disappointed by the results of the way promising designs have been delivered as buildings often over budget, late and with too many defects. Egan (1998:7) reported that "projects are widely seen as unpredictable in terms of delivery on time, within budget and to the standard of quality expected”.

New ways of procurement and management have excluded the architect as a project leader. According to Langford and Murray (2004), clients have become more sophisticated, more demanding and are prepared to take design and construction consultancy services from a wide range of providers. Clients also consider design development and construction stages as a wild card; it is during these stages that projects are most likely to go wrong. Clients hold architects responsible for a high proportion of building faults and process delays that result from poor communication, inadequate information, inadequate reviews, lack of technical expertise, inadequate feedback and late information. Clients have therefore looked at ways to minimise their risks,
particularly those caused by the failure of architects to manage their tasks.

Bennet and Gray (1994:15) pointed out that “construction projects have increased in complexity placing greater emphasis on the management and co-ordination of specialist designers and contractors”. The complexity is brought about by two factors: firstly, the clients are demanding sophisticated buildings and are stretching the boundaries of design and construction. Secondly, design continues to grow in complexity because of the dramatic increase in specialised knowledge. The increase in specialised knowledge has given rise to design processes which consist of the continual exchange and refinement of information and knowledge. Clients are focusing on other processes which come before and after the design stage. RIBA (2005) noted that clients are interested in the insight into core business needs and how buildings might meet them and in the management of the delivery of the building. RIBA (2005:46) concluded by stating that “to give real value to clients, we need to integrate and be fully integrated into the whole process”. RIBA (2000:35) asserted that “unless architects act as an integral part of the building industry, they will cease to have a significant role in the shaping of the built environment”.

Contemporary architectural practice thus has to cope with increasingly demanding clients and complex design processes. Egan (1998:8) concluded that “construction often fails to meet the needs of the
modern businesses that must be competitive in the international markets, and rarely provide best value for clients and tax payers”. Clients want greater value from their building by achieving a clearer focus on meeting functional business needs.

1.2 THE STATEMENT OF THE PROBLEM

Main problem

Allinson (1993) states that the design management processes in the construction industry are not clearly defined while Langford and Murray (2004) are of the opinion that the design management processes in construction are not as efficient as in manufacturing. Taking the above statements into consideration, this research seeks to determine the adequacy of design management processes used by architectural companies in the Eastern Cape (EC) construction industry and compare this with the design management processes used in manufacturing.

1.2.1 Sub-problem 1

To determine the adequacy of existing design management processes used by architectural firms in the EC.

1.2.2 Sub-problem 2

To determine whether EC architectural companies use similar design management processes as used in manufacturing.
1.2.3 Sub-problem 3
To determine whether EC architectural companies use similar continuous improvement philosophies and lean production principles as used in manufacturing.

1.2.4 Sub-problem 4
To determine whether EC architectural companies are using Information and Communication Technology (ICT) for the effective management of design processes, as used in manufacturing.

1.3 THE HYPOTHESES

1.3.1 Hypothesis 1
The inadequacy of existing design management processes has contributed to the construction industry’s poor performance.

1.3.2 Hypothesis 2
EC architectural companies have not adapted manufacturing’s developed and developing design management processes to improve efficiency.

1.3.3 Hypothesis 3
EC architectural companies have not adapted manufacturing's continuous improvement philosophies and lean production principles to improve project delivery processes.
1.3.4 Hypothesis 4

EC architectural companies lag behind the manufacturing industry in adopting ICT for the efficient management of design processes.

1.4 THE DELIMITATIONS

a) The study will be limited to the profession of architecture as regulated by the South African Council for the Architectural Profession (SACAP).

b) The investigation will be limited to architectural companies in the Eastern Cape Province of South Africa.

1.5 SPECIFIC OBJECTIVES

The objectives of the research are to:

a) Determine the adequacy of current design management processes used by EC architectural companies.

b) Determine whether EC architectural companies use similar design management processes, continuous improvement philosophies, lean production principles and ICT as used in the manufacturing industry.

c) Determine design management processes that can be adapted from the manufacturing industry to improve project and service delivery in the construction industry.
1.6 THE ASSUMPTIONS

The following assumptions were made with respect to the problem statement and sub-problems:

a) It is assumed that the manufacturing industry’s design management processes are more efficient than in the construction industry.

b) It is assumed that architectural practitioners can learn from manufacturing industry’s design management processes.

c) It is assumed that technology influences the architectural and construction industry.

1.7 THE IMPORTANCE OF THE STUDY

A core theme of the Egan (1998) report, was the need to integrate the construction process to benefit the clients, delivering greater value to clients by focusing attention on the need to meet functional business needs within a tighter budget. The increasing workload and expectations of clients and changes in the professional role of the architects and the social positions have challenged the architect to re-engage with other professionals in the construction team and stake his claim as a manager of the overall construction process. Langford and Murray (2004:338) stated that “RIBA is encouraging its members to gain formal project management qualifications”. It is therefore important
for architects to be more effective in the contemporary project management environment.

It is believed that a more efficient design management process will lead to better co-ordination, better communication, better information flow and a good team spirit. Effective and efficient design management which is integrated with the construction process can minimise the risks endemic to projects and offer clients and the professional team reasonable certainty and predictability.

1.8 THE OUTLINE OF THE STUDY

This treatise will be divided into five chapters: chapter 1 will be an introduction to the research; chapter 2 will consist of a literature review into construction and manufacturing design management processes; chapter 3 will focus on outlining an appropriate research methodology for research into given problem; chapter 4 will outline the results from questionnaire, presentation and analysis of results; and chapter 5 will discuss conclusions and recommendations.
CHAPTER 2

REVIEW OF THE RELATED LITERATURE

2.1 INTRODUCTION

Certain construction practitioners, such as Ball (1988) believed that in the past the construction industry was unique and that principles from manufacturing could not be adopted because of this uniqueness. Those beliefs were later dismissed by Egan (1998) who pointed out that some of the problems in construction might be overcome by transferring established practices from the manufacturing industry. This view has been affirmed by a number of authors like Langford and Murray (2004) and Kagioglou et al. (2005).

Egan (1998) suggested that 80% of inputs (electrical, mechanical and services) into buildings were repeated and that design and construction processes could be continuously improved on. Egan (1998:18) concluded by stating that “The parallel is not with building cars on the production line; it is with designing and planning the production of a new car model”. Kagioglou et al. (2005) reported that, in a study they had conducted, although design was responsible for only 5% of the product's cost, it determined 75% of manufacturing costs and 80% of product quality performance. They concluded that for the Ford Automotive Company, 70% of all production savings resulted from improvements in design.
According to Kagioglou et al. (2000), there are two areas in which construction could benefit from manufacturing:

*The project process:* This related to the design and construction processes. It considered the development of a solution from a need identified in the market place to the implementation of the solution and the whole life cycle of the product.

*The operational/production process:* The second related to the actual production of products. There are a number of effective philosophies (continuous improvement and lean production) and ICT utilisation which have increased productivity in manufacturing.

This literature review will examine the adequacy of existing design management processes in construction and manufacturing’s project and production processes with specific reference to design management.
2.2 LITERATURE REVIEW

The literature review has been conducted according to the sub-problems. These sub-problems have been broken down into related areas of research as shown below:

<table>
<thead>
<tr>
<th>Sub-problem</th>
<th>Research area</th>
</tr>
</thead>
<tbody>
<tr>
<td>To determine the adequacy of existing design management processes used by architectural companies in the Eastern Cape (EC).</td>
<td>1. Review of design management processes in construction.</td>
</tr>
<tr>
<td>To determine whether EC architectural companies use similar design management processes as used in manufacturing.</td>
<td>1. Management of design and creativity in manufacturing.</td>
</tr>
<tr>
<td></td>
<td>2. Product development in manufacturing.</td>
</tr>
<tr>
<td>To determine whether EC architects use similar continuous improvement philosophies and lean production principles as used in manufacturing.</td>
<td>1. Process improvement in manufacturing.</td>
</tr>
<tr>
<td></td>
<td>2. Lean production.</td>
</tr>
<tr>
<td>To determine whether EC architects are using Information and Communication Technology (ICT) for effective management of design as used in manufacturing.</td>
<td>1. Use of Information and Communication Technology (ICT) in manufacturing.</td>
</tr>
</tbody>
</table>

2.2.1 Review of design management processes in construction

This section will identify existing design management processes in construction and problems identified with these processes.
2.2.1.1 Design management process protocols used in construction

The British RIBA Plan of Work and the South African Institute of Architects (SAIA) Work stages are widely recognised design management protocols in construction. This section will discuss the two protocols.

a) RIBA Plan of Work (RPW)

According to RIBA (2001), the RPW was originally published in 1964 as a standard method of operation for design and construction of buildings. It was updated in 2000 and Kagioglou et al. (2005) noted that the RPW was widely accepted as the operational model throughout the building industry. Langford and Murray (2004:1) substantiated the view of Kagioglou et al. (2005:22) by stating that “The RIBA Plan of Work still provides a valuable set of guidelines from which architects can develop a project and determine how their responsibilities fit into the work of others in the construction team”. The RPW has 11 sequential steps representing a logical sequence of events that should ensure that sound and timely decisions are made during the course of the project. RIBA (2001) recommended that all decisions set out or implied, should be taken into account or reviewed. RIBA (2005) suggested that the RPW needed only slight adjustments depending upon the size and complexity of the project.
The project progresses from inception to completion in a linear fashion, requiring the completion of one stage before proceeding to the next. The structure of the RPW is under attack from various authors such as Egan (1998) and Kagioglou et al. (2005). These authors urged that the construction process is not linear and they concluded that the RPW contributed to the problems of fragmentation and poor communication in the construction industry.

b) SAIA Work Stages protocol

The formation of the SAIA Work Stages protocols was intended for identification of the architect’s services and to structure fees.
The SAIA Work Stages resemble the RPW and the fees are structured according to five work stages as follows:

<table>
<thead>
<tr>
<th>Work Stages</th>
<th>Description</th>
<th>Proportion of fee</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Appraisal and definition of project</td>
<td>5%</td>
</tr>
<tr>
<td>2</td>
<td>Design concept</td>
<td>15%</td>
</tr>
<tr>
<td>3</td>
<td>Design development</td>
<td>15%</td>
</tr>
<tr>
<td>4</td>
<td>Technical documentation</td>
<td>40%</td>
</tr>
<tr>
<td>5</td>
<td>Contract administration and inspection</td>
<td>25%</td>
</tr>
</tbody>
</table>

Work stage 1: The first part of the process includes the identification of the client’s requirements and possible constraints on development. The second part includes the identification of procedures, organisational structures and range of consultants to be engaged for the project.

Work stage 2: This process consists of preparation of conceptual design proposal, estimation of costs and review of procurement routes.

Work stage 3: The first part consists of preparation of detailed design proposal and obtaining developmental approvals from municipal authorities. The second part consists of all components and elements of the project.

Work stage 4: The first part of the process consists of preparation of production information to enable tendering. The second part consists of preparation of further production information required under the building contract.

Work stage 5: The first part consists of administration of the building contract from tendering through to after practical
completion. The second part consists of inspection of construction work up to after practical completion.

Source: South African Institute of Architects (1999:7)

The SAIA Work Stages were designed from an architect’s point of view and for administration of fees. This has restricted their application to joint contracts. The SAIA Work Stages protocol is less defined than the RPW, and is therefore more ambiguous and has more shortcomings.

2.2.1.2 Problems identified in existing design management processes

A number of factors identified by Kagioglou et al. (2005) and Allinson (1993) as problems or contributory factors in poor management of design in construction include the following: variation in design and construction processes; fragmented nature of the industry; and IT and design processes. These problems are discussed below:

a) Variation in design and construction processes

According to Kagioglou et al. (2005), there exists no standard project process that is succinctly followed in construction and Allinson (1993) maintains that design management processes in construction are not clearly defined. The reasons for the above situation are: the changes in supply-chain for every project; the dynamic nature of the relationships between the project teams;
one-of-a-kind products; on-site production; and the fragmented nature of the industry. Therefore it is difficult for professionals to organise themselves into working-team environments, when their roles vary from project to project.

b) Fragmented nature of the industry

The traditional building process refers to the practice whereby a perceived need for a new facility leads a building client to approach an architect/engineer to initiate the process of design, procurement and construction of a building to meet his/her specific needs. The process is designed on the assumption that design and construction are sequential and independent of each other. Therefore the processes are carried out by two separate groups of disciplines, namely: the design group and the construction group. The principle function of the design group is to prepare the design specifications for the work, as well as other technical and contractual documents. The construction group is responsible for the physical construction of the project.

The two groups do not work concurrently; the design group is usually isolated from the realities of the issues facing production as each group is expected to play a specific and limited role during each phase, thus contributing to poor communication and buildability problems.
New procurement routes have emerged to ease some of the problems and these routes are outlined below:

*Construction management*: The Construction Manager (CM) is employed alongside the design team as the project is initiated. He defines and manages the work packages to allow construction to commence before the design of the project is completed.

*Management contract*: The management contractor is appointed early, and is responsible for all construction work and providing advice to the design team.

*Design and manage*: This method is similar to the management contract but with this method the contractor is responsible for management and production of detailed design.

*Design and build*: The contractor is responsible for both design and construction of the project for a lump sum price.

*Develop and construct*: The client appoints a designer to prepare the concept design before the contractor assumes the responsibility for the completion of the detailed design and construction.

Source: Langford and Murray (2004:26)

c) **IT and design process**

Kagioglou et al. (2005) concluded that the management of IT in construction has rarely been considered within a process
context. These authors further stated that “Both IT and process have been frequently treated separately without any apparent links and/or interfaces”. The RPW and the SAIA Work Stages have done little in considering IT as an integral part of the process.

To date IT has been used as a support tool rather than a driver/enabler in the design and construction process. Hart (2003) concluded that the construction industry as a whole, including design and construction, did not have a cutting edge reputation in terms of technology use.

2.2.1.3 Problems identified with pre-project phases of the design process

Pre-project is defined as consisting of those phases that occur before the decision is made by the client to proceed with construction. Some of the problems identified with this phase were: poor management of the briefing of the client; existing design processes; poor assessment of process performance; and lack of risk assessment. These problems are briefly discussed below:

a) Poor management of briefing of client

Authors like Kagioglou et al. (2005), Langford and Murray (2004), and Dym and Little (2004), concluded that the early stages of the life of a project were poorly handled by the construction consultants. There were also problems identified
with communication interfaces between the clients and designers. The problems in the briefing stages are made worse by the lack of involvement of appropriate expertise in the conceptual phases. These problems could lead to poor co-ordination in design and project planning phases.

b) Existing design management process protocols

Kagioglou et al. (2005) identified problems of inconsistency, linearity and the sequential nature of the existing design management process protocols. These protocols were responsible for problems in the co-ordination of production information and poor communication of the project team.

c) Poor assessment of process performance

Kagioglou et al. (2005) concluded that one-of-a-kind projects tended to limit feedback potentials and focused reviews on product feedback and not on process feedback. The implication of this statement is that the construction industry focuses its efforts on resolving individual project problems without creating managerial systems which could help minimise and overcome these problems.

d) Lack of risk assessment

Langford and Murray (2004) and Kagioglou et al. (2005) identified the lack of follow on risk assessment between design
phases as a factor in compounding problems in the design process. These authors also identified that many of the risk assessments were done by individuals rather than by all stakeholders.

2.2.2 Management of design and creativity in manufacturing

This literature review now investigates design and creativity management techniques and processes used in manufacturing.

2.2.2.1 Defining design and design management

The word design is derived from Latin designare, which according to De Mozota (2003:2) translates to both “design” and “to draw”. De Mozota (2003) concluded that the etymological analysis of the word led to the following equation: Design = Intention + Drawing. The equation clarifies that design is both an intention and a plan.

There are many definitions of design and the most relevant for this research is by Dym and Little (2004:4). They define design as “a systematic, intelligent generation and evaluation of specification for artefacts whose form and function achieve stated objectives and satisfy specified constraints”. Therefore from the definition, it can be concluded that design solutions result from the systematic and intelligent generation of solutions. The above statement raises the controversial question of whether design is a science or art.
Design can contribute in many ways but in essence, it is about linking user needs with form and function to create something attractive. Design has a strategic potential in the following areas:

- Design for aesthetic style, image and fashion status.
- Design for function – engines and other industrial machinery.
- Design for manufacturability – creative thinking on how the product will be effectively and efficiently manufactured.
- Design for sustainability – for reuse and recycling.
- Design for reliability and quality in use.

Design Management refers to the movement which first became consolidated in the 1970s and 1980s in Great Britain, Europe and America and which focused on the management of design resources in corporate business. With the recognition that design was an important resource that needed to be championed and managed at all levels within a corporation, a number of initiatives arose which brought attention to the nature and importance of design management.

Gorb (2003:1) defined design management as “the effective deployment by line managers of the design resources available to a company in order to help the company achieve its objectives”. Therefore, design management is a planned implementation of design in a company to help the company achieve its objectives. De Mozota (2003:67) defined design management as “an approach
whereby organisations make design-relevant decisions in a market and customer-oriented way as well as optimizing design-relevant processes”. Therefore, design management acts as an interface between management and design; and functions as a link between technology, design, design thinking and management.

There is no denying that design is a creative process and that the techniques of design require the logical character of a scientific approach. De Mozota (2003) compares design with management and concludes that there are similarities in problem solving activities, systematic activities and co-ordination activities.

2.2.2.2 Design as a process

The design process is prescriptive, beginning with the client’s needs and ending when the final design is documented for the client. Designers suggest what the world might look like and therefore their jobs are futuristic. De Mozota (2003) noted that the design process is experimental and concluded that it is ideational.
De Mozota (2003) asserted that the design process has four essential characteristics, which she names the four Cs:

*Creativity:* This involves the designer having to create something that has not existed before.

*Complexity:* Design is complex because it involves discussions on a large number of parameters.
Compromise: Design requires balancing multiple and conflicting requirements such as cost, performance, aesthetics, etc.

Choice: The Designer is required to make choices between many possible solutions to problems at all levels.

According to De Mozota (2003), there are three types of design processes:

The analytical design process: This process is used when the outcome is a modification of something already existing. Therefore it is used when there is little uncertainty about the outcome.

Iterative design process: This process is best suitable for medium risk projects such as radical improvements and adopted innovations.

The visionary design process: This process is best used when design problems cannot be defined.

The application of these processes is governed by the degree of freedom given to the designer in the design brief and degree of risk taken by the organisation.

2.2.2.3 Design as a creative process

The subject of creativity covers an entire field of psychology and has numerous definitions. One example of such a definition is that
of Sternberg (2001:118), who states that “creativity refers to the potential to produce novel ideas that are task orientated”. Therefore creativity is goal-directed and designed to serve a known purpose. According to Sternberg (2001:119), there are three basic components which are necessary for creativity.

a) **Domain relevant skills**
   
   These are skills, competencies and talents which are applicable to domains in which the designer is working. In other words, the designer will have to draw on his knowledge and experience in order to solve a problem.

b) **Intrinsic task motivation**
   
   This refers to an internally driven involvement in the given creative task. These motivations are formed in the design schools and by exposure to inspirational objects and places.

c) **Creative relevant processes**
   
   This refers to personality characteristics, cognition styles and working habits which promote creativity.

Sternberg (2001) examined the creative process and discovered that it was reiterative. He concluded that the creative process was characterised by five conditions, where boundaries were sometimes blurred, namely:
**Preparation:** This takes place when project tasks have been analysed and necessary data gathered. The designer then looks for patterns, trends, ideas tried out and assumptions questioned.

**Frustration:** Sternberg (2001:119) states that “frustration is a personal issue to be resolved by the designer in being creative, through learning and management of the creativity”. Frustration occurs when the problem appears to be unsolvable.

**Incubation:** Incubation occurs when the insolvable problem is left to the sub-conscious mind to solve. This happens when the designer realises that the solution cannot be forced.

**Insight:** This is the stage where the sub-conscious and conscious minds reveal the creative solution.

**Working out:** This stage involves transformation and realisation of the insight.

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2.2.2.4 Management of the creative process in manufacturing

De Mozota (2003:14) asserted that “whether analytical, iteration or visionary, the design process follows similar phases”. She concluded that the phases were identical, irrespective of design discipline or project. She also stated that the creative process has five phases and they are investigation, research, exploration, development, realisation and evaluation.
Table 3: Five stages of the creative process

<table>
<thead>
<tr>
<th>Phases</th>
<th>Objectives</th>
<th>Visual outputs</th>
</tr>
</thead>
<tbody>
<tr>
<td>0. Investigation</td>
<td>Idea</td>
<td>Brief</td>
</tr>
<tr>
<td>1. Research</td>
<td>Concept</td>
<td>Visual concept</td>
</tr>
<tr>
<td>2. Exploration</td>
<td>Choice of style</td>
<td>Roughs of ideas, sketches</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Roughs of presentation</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Reduced scale model</td>
</tr>
<tr>
<td>3. Development</td>
<td>Prototype</td>
<td>Technical drawings</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Functional model</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3F mock-up for visual correctness and working</td>
</tr>
<tr>
<td></td>
<td></td>
<td>capabilities</td>
</tr>
<tr>
<td>4. Realisation</td>
<td>Test</td>
<td>Documentation of execution</td>
</tr>
<tr>
<td>5. Evaluation</td>
<td>Production</td>
<td>Illustration of the product</td>
</tr>
</tbody>
</table>

Source: De Mozota (2003:14)

**a) Phase 0: Investigation**

The starting point of the design phase is the identification by the client of a need to be met. The aim of this phase is to understand the client’s needs and to widen the field of investigation in order to identify the problems that can be solved by the design.

**b) Phase 1: Research**

This phase involves the identification, study and use of already existing information to better understand the problem and possible solutions. Dym and Little (2004) asserted that
information can be acquired by use of the following methods: literature review, user surveys and questionnaires, focus groups and informal or formal interviews, which will now be discussed briefly:

**Literature review**: Designers use the literature review to gain more understanding of the nature of the design problem, potential users and the client.

**User surveys and questionnaires**: These focus on identifying the user’s understanding of the problem and possible solutions. The survey and questionnaires will help the designer to clarify and better understand the problem.

**Focus groups**: Allow the designer to observe the response of the selected users to a potential problem.

**Informal or formal interviews**: These interviews are ways of gaining information from the client and potential users by means of structured and unstructured questionnaires.

c) **Phase 2: Exploration**

After the understanding of the problem, the designer employs his creativity to conceptualise the solution to the problem. According to Dym and Little (2004), design is a goal orientated activity which combines divergent and convergent thinking. These authors describe three intuitive methods that encourage divergent thinking in order to enhance collective creativity.
These methods are the 6-3-5 method, C-sketch method and the gallery method:

6-3-5 method: Six design team members write an initial list of three design ideas expressed in keywords and phrases. The six individual lists are circulated to each member five times for written comments and annotations. Verbal communication is not allowed during the circulation process. When all team members have commented, the design ideas are listed, discussed and evaluated. The disadvantages are that the method is time consuming and impractical as all members have to comment on the same piece of paper. The main advantage is that a large number of design ideas can be generated.

C-Sketch method: This method is similar to the 6-3-5 method. It starts with a single sketch from each team member; the sketches are circulated to each member for annotations and modifications. Discussions or communication are not allowed during the circulation of the sketches. When all members have commented on each sketch, a common visualisation medium is used to list, discuss, evaluate and record the design ideas. The disadvantages are: crowding of the sketches because of the annotations; and the circulation of the sketches is time consuming. Dym and Little (2004) noted that the advantage
is that the C-Sketch method is especially effective in mechanical device design.

*The Gallery method:* In this method, group members develop their own initial ideas in a given time. The sketches are then posted on a wall for questions, critique and suggestions. There are no ways of predicting how many cycles of individual idea generation and group discussions will be needed for a design. The advantage of this method is that the sketches and ideas can be developed quickly through open group discussion.

The exploration phase ends with the selection of the “best” design from the generated alternatives. The selection is facilitated by the diagnosis of various solutions in relation to specific criteria of value which are defined by the clients. Gray and Hughes (2001:98) stated that “for successful projects, these criteria need to be established, hence the need for value management”. They defined value management as “a structured approach to define what value means to clients in meeting a perceived need to establish a clear consensus about project objectives and how they can be achieved”. The values are represented by certain objectives that the design has to satisfy in order to be successful. Gray and Hughes (2001) recommended the value hierarchy and the value tree methods
for determining the value of the objectives. These two methods will be briefly discussed below:

*Value hierarchy:* In this method, the primary objectives are broken into their sub-objectives. The sub-objectives can be further subdivided if necessary.

![Value hierarchy diagram](image)

**Figure 3: Value hierarchy**

*Value tree:* The value tree is a process of weighting the objectives and sub-objectives of the value hierarchy in order to prioritise between all conflicting demands. The weights are arrived on by group consensus.

Dym and Little (2004) suggested that two selection methods can be used to evaluate alternatives, namely the numerical evaluation matrix and the weighted checkmarks chart.
Numerical evaluation matrix: The matrix is presented in a chart that shows objectives, constraints and calculated weights.

Table 4: Numerical evaluation matrix

<table>
<thead>
<tr>
<th>Constraints and objectives</th>
<th>Weight (%)</th>
<th>Concept 1</th>
<th>Concept 2</th>
<th>Concept 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constraint 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Constraint 2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Constraint 3</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Objective 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Objective 2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Objective 3</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TOTALS</td>
<td>100</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: Dym and Little (2004:111)

Weighted checkmarks chart: The objectives are marked as high, medium or low in priority. The objectives with high priorities are given three checks, medium are given two checks and low are given one check. If design alternatives satisfactorily meet the objectives, they are given the appropriate check and finally the checks are added up. The advantages of this method are the ease of use and the clients can easily understand them. The disadvantage is its lack of detailed definition.

These selective methods are subjective but their essential characteristic is that decisions are a consensus view of team members. The quality of the assessment will firstly depend on how well the initial objectives are defined and secondly on the
expertise of the project members. The objectives and weighting are decided by the client.

d) Phase 3: Development

Once the design has been chosen, it must be represented in three-dimensional actualisation. The designer can build either a prototype or model.

*Prototypes:* These are working models of the designed product. They are intended to demonstrate to the designer that the product will function as designed. Therefore, they are tested in the same operating environment in which they will function as final products.

*Models:* They are a miniature representation of the product or process and they may be paper, computer or physical models. Models are intended to be used as studies for designers to better understand the behaviours that are being studied. Therefore models are tested in controlled environments.

The designer compiles technical plans of the pre-test prototype or model. From these drawings, the designer will verify technical constraints in assembling the product. After testing, a final model is adopted and the creative process ends.

e) Phase 4: Realisation
The designer has to create documents for the execution and a plan that defines the material used, surface treatment, colour of the product, etc. This is a complex and time-consuming phase as it requires assembling and management of the construction team.

**f) Phase 5: Evaluation**

According to De Mozota (2003), tests are launched in three different directions, namely: technical control, calculation test and marketing calculation.

*Technical control*: Tests for conformity, use, security and durability.

*Calculation test*: This is the preparation of production programmes.

*Marketing evaluations*: These are evaluations of appropriateness of design solution to brand value, target market and market share objectives.

2.2.2.5 **Management of the design process in manufacturing**

This section will explore techniques and tools that are used by design teams in manufacturing to plan, organise design activities and monitor progress. Dym and Little (2004) noted that management consists of four functions:

*Planning*: The project leader has to determine the scope, schedule and spending of the project.
**Organising:** This is determining the responsibilities of personnel for the activities of the project.

**Leading:** The project leader has to motivate, divide the work fairly and monitor the levels of work produced.

**Controlling:** This is setting of meaningful goals and tracking the progress against them.

---

a) **Tools to manage scope**

*Work breakdown structure (WBS):* This is the listing of all the tasks needed to complete the project, organised in such a way as to help the design team understand how the tasks fit into the overall design project. The WBS can be confused with other organisational charts such as an organisational chart for completing a project or a flow chart showing relationships amongst tasks.
Linear responsibility chart (LRC): Once the tasks have been identified in the WBS, the LRC can be used to list the tasks to be managed and match them to project participants. The LRC uses a matrix format to match each task to a team
member. The disadvantage of the LRC is that it makes the sharing of responsibilities for the project difficult and the advantage is that the workload can be distributed fairly.

b) **Schedule and time management tools**

Dym and Little (2004) noted that there are three scheduling tools used in project management, namely: team calendar, an activity network and the Gantt chart.

*Team calendar:* An agreement by the team to assign the resources and time necessary to meet deadlines shown on a calendar.

*Activity network graphs (ANG):* Graphs the activities and events of the project, and shows them in a logical order in which they must be performed. In ANG, it is essential to understand the logical relationships that exist in design projects. Dym and Little (2004) asserted that three relationships exist, namely: finish-to-start precedence, one activity must be finished before the start of the next; finish-to-finish precedence, when two activities are executed simultaneously but the successor task cannot be completed before the prior activity is completed; and start-to-start precedence, where one activity cannot be started until another is started.

*Gantt charts:* Longitudinal bar graph that maps various design activities against time-line. The Gantt chart is more
readable and much easier to create as compared to the activity network graph.

c) Tools for monitoring and controlling of the budget

Dym and Little (2004) noted that the Percentage-Complete Matrix is a tool that can be used to monitor and control projects.

*Percentage-Complete Matrix (PCM):* The PCM uses information in the WBS and the budget to determine the overall status of the project. Dym and Little (2004:174) stated that “this method is best suitable to uses where there is a clear method of calculating progress”.

2.2.3 Product development in manufacturing

The need to consider manufacturing as a reference point to overcome some problems in construction has already been clarified in the introduction. This literature review uses the product development process in manufacturing as a reference point for defining and understanding design processes in construction. Kagioglou et al. (2005) reported that manufacturing has been modelling and improving its processes and Egan (1998) supports this drive and suggests that the construction industry could similarly improve its performance by modelling and improving its processes.
2.2.3.1 New Product Development (NPD) activities

It is evident that, in order to obtain the benefits of design, the design process has to be structured in a systematic fashion and in manufacturing, design processes have been broken down into activities. The way in which NPD activities are performed is subject to different circumstances in terms of timescales, complexity, etc. Kagioglou et al. (2005) claimed that the number of stages range from six to thirteen. NPD activities can be separated into three main categories: pre-development activities, development activities and post-development activities. They listed the activities as follows:

a) Pre-development activities

This is the most important activity, as decisions made at this point will set the pattern for all subsequent activities. The first activity in the NPD process is the establishment of the need, followed by preliminary market, technical, financial, and production assessment. However, Kagioglou et al. (2005) found that many companies faced problems in the translation stage; this resulted in the final product not being quite what the customer wanted. The deliverables of the pre-development activities can be outlined as follows:

   Stakeholder list: Identifies all the stakeholders who could have an influence on the project, including stakeholders who care about the outcome of the project, and critical information sources. Assesses the nature of stakeholders’
impact and thus determines what types of information they need to receive during the project.

Statement of need: Assesses and establishes the need for the building in terms of function, timing and priorities. This deliverable provides the project team with an indication of the client’s reasons for the potential project.

Business case: Considers the risks, costs and benefits associated with any proposed solution from perspectives related to finance, service and customers.

Business plan: Provides specific details on the scope, governance, budget, resources, work plan and milestones of the project. Defines the project and quality management processes to be used throughout the project.

Project execution plan (PEP): Developed to expand on the Project Business Plan by specifying the day-to-day (operational) management procedures and control plans. The PEP enables those completing tasks in the project to deliver the expected results, as per the agreed Project Business Plan.

Terms of reference: The terms of reference is an accurate description of what the project aims to achieve. The report contains the description of the purpose, aims and deliverables; it states parameters (timescale, budgets, scope and authority).
Performance management report: A report that measures effective performance of the project. The measurements applied to the project include financial, technical, human resource, material handling, and IT utilisation.

Communication strategy: A communication strategy report indicates the means of communication of the project team. The report includes use of CAD, e-mail, intranet, extranet, etc.

Procurement plan: The plan includes procurement of services, product, finance and programme.

Project brief: A document that identifies the scope of the project and the proposed solution. The project brief remains a ‘live’ document for most part of the project.

Design brief: A specific purpose document outlining different project solutions before the performance of the feasibility studies. Information in the project brief forms part of the updated business case.

Value management: A strategy of examining the whole project to ensure that it can be delivered in the most economical way. Three value management techniques are used namely: the value hierarchy, the value tree and the decision matrix.

Risk management plan: A plan that identifies and prioritises risks; a contingency plan included to overcome or minimise the risks. Source: Kagioglou et al. (2005:86)
b) Development activities

This activity relates to the physical development of the product and process. Therefore the design team has the task of creating the product and process in order to sell the product at a profit. The deliverables of the pre-development activities can be outlined as follows:

*Concept design plan:* This document includes the results of the feasibility studies and identifies proposed project solutions, timescales, life cycle costing and resources necessary to carry out the project.

*Outline concept design:* This includes the final site for construction of project solution and informs business case with regard to: form, function, speciality equipment and programme for proposed solution.

*Full concept design:* Identifies major elements of the proposed solution and is detailed to include: plans, elevations, specifications, cost plans, programme, special studies and reports.

*Value engineering:* Gray and Hughes (2001) referred to value engineering as a systematic approach that seeks to enhance value by eliminating unnecessary costs while maintaining function. An alternate design team undertakes to critically review the proposed concept designs.

*Prototype and testing:* Production of mock-up, model or some other preliminary version of final design which can be
explored, tested, evaluated and used to promote discussions and development.

*Product model:* Refers to the construction of a physical model of the product so that its performance and functionality can be tested.

*Testing and validation:* The product is tested in-house and by customers. Kagioglou et al. (2005) noted that the manufacturing process is tested in a limited trial, or pilot production. These tests will prove the production process and determine production costs.

*Cost plan:* Kagioglou et al. (2005:87) defined the cost plan as a “Presentation of the potential and actual costs of the product such as cost/benefit analysis and cash flow requirements”. Source: Kagioglou et al. (2005:87)

c) Post-development activities

These activities are related to the final launch of the product into the market place and marketing approach.

*Maintenance plan:* This is the consideration of the maintenance of the finished product and examination of components to determine design life.

*Support and extension:* After sale support is tailored to meet customer requirements, including field failure analysis, product upgrades, repair, and engineering change management.
Post-project review report: Captures information and knowledge on the successes and failures of the product and process, so that future projects can benefit from the lessons.

Source: Kagioglou et al. (2005:87)

2.2.3.2 NPD models

This section will review NPD models used in manufacturing and identify their advantages and disadvantages. NPD models are classified into three categories: sequential, stage-gate and overlapping.

a) Sequential approach

This approach is also known as the serial approach because the product development proceeds in a logical step-by-step fashion. The development can only proceed once all requirements of the previous stage are satisfied; the outputs of the previous phase form the inputs of the next phase. Cooper (2006) reported that this approach isolates design activities from testing, manufacturing, quality and service. This results in what is termed the “over the wall” approach; when finished, the design is thrown over the wall to be picked up by the next group. Kagioglou et al. (2005) identified the following limitations of this approach:

There is a lack of collaboration between design and production teams.
Omissions and/or mistakes made in previous phases will be carried over to next phases, probably resulting in an obsolete product.

The passing of design from one department to another results in long lead times, increased development costs and lack of information flow.

Kagioglou et al. (2005) identified the following advantages of this approach:

- It offers high staff utilisation in departments.
- It functions well where there is a high level of innovation required and when there is a lead designer who conceives the idea and passes it down.

Cooper (2006) noted that this approach is suitable for big projects where personnel communication will be limited between team members.
Figure 5: Sequential NPD process

Source: Kagioglou et al. (2005:10)

b) Stage gate process

Kagioglou et al. (2005:12) stated that “A stage gate process is a conceptual and operational road map for moving a new product from idea to launch”. The stage gate approach breaks the innovative process into predetermined set of gates. Each gate represents a number of activities that need to be performed and
information that needs to be gathered to progress to the next gate. These gates serve as quality control and check points in the processes. Kagioglou et al. (2005:12) stated that “Each stage costs more than the preceding one and the strategy is based on incremental commitment; as uncertainty decreases, expenditure increases and the risk is managed. They also identified the following advantages of the stage gate process:

- Reduces product development time.
- Produces marketable products.
- Optimises internal resources by eliminating projects that are not promising.

Cooper (2006) identified six limitations of the stage gate process:

- Projects are slowed down at each gate until all tasks are completed.
- Projects have to go through each stage and gate even when it would be quicker to bypass.
- Activities cannot be overlapped.
- The process takes too long to learn.
- The process does not lead to process prioritisation, as there are multiple projects.
- The system tends to be bureaucratic, making the process slow.
c) The development funnel

Cross-functional teams are involved in the development of a product using the development funnel; the approach is customer and market focused. The first phase in this process represents the conceptual development of large numbers of potential products/processes. Screen 1 represents an evaluation point, similar to the go/kill gates in the Stage Gate process. A review of the product and process is used to select those products that will be fully developed. According to Kagioglou et al. (2005), procedures, phases and rules can be streamlined and made adaptable to the design firm’s requirements. A major disadvantage of this process is that it requires high resource allocation for conceptual development because of the large number of projects.
2.2.3.3 Differences between design management process protocols used in construction and NPD models used in manufacturing

There are distinct differences between manufacturing NPD models and construction design management process protocols. These differences are summarised below:

a) In NPD, product developers (designers and assemblers) are consultatively involved in the clients’ exploration and conceptualisation phase of a new product. In construction design management processes, only the designers are involved in the
exploration and conceptualisation phase and this approach results in buildability problems during the construction phase. Kagioglou et al. (2005:24) noted that the outcome of not considering product constructability of a product during conceptual phases has affected quality, efficiency and speed of development.

b) NPD processes utilise the stage gate process approach whereby each gate represents a number of activities that need to be preformed and information that needs to be gathered to progress to the next phase. In construction design management there are no stage gates and projects proceed to the next phase before all deliverables of the previous phase are met.

c) The NPD approach involves the review of products after their completion by product developers (designer and assembler). This approach allows subsequent versions to be improved on the basis of knowledge gathered through a post-project review. In construction design management, a post-project review is not carried out by all developers and knowledge is not captured and reused.
2.2.4 **Process improvement in manufacturing**

This section will explore methods used by the manufacturing industry to improve its processes. According to Kagioglou et al. (2005), Oakland (1995), and Thompson and Strickland (2004), process improvement is usually achieved by: management and continuous improvement of existing processes, designing and redesigning of new processes, and concurrent engineering. The first method aims to optimise and continuously improve the operational processes within an organisation and the second and third methods change the organisational structures. These methods are briefly discussed below:

**a) Management and continuous improvement of existing processes**

Continuous Improvement (CI) originated from the field of quality management and is sometimes referred to as continuous quality improvement, business improvement or process improvement. CI is concerned with the continuous improvement of organisational processes. Kagioglou et al. (2005:32) defined it as “An incremental change process that focuses on performing existing tasks more effectively” and that “CI adopts the stance that creating a development process is never complete”. Improvement only occurs if attempts are made to learn from new information generated by the process itself rather than the product.
Oakland (1995:15) stated that the CI process is commonly associated with the Plan-Do-Check-Act (PDCA) cycle. He defined the PDCA cycles as follows:

*Plan:* In this phase, problems or opportunity for improvement are identified and a plan developed to implement the changes.

*Do:* The plan is implemented and any changes to it are documented.

*Check:* The revised processes are analysed to see if goals have been met.

*Act:* If the goal is achieved, the results are standardised and documented. If the goals are not achieved, the reason for failure is documented.

**Figure 8: PDCA cycle**

Source: Kagioglou et al. (2005:32)
Oakland concluded that each phase of the cycle played an important role in sustaining the ongoing improvements and that the PDCA cycle could be repeated. He also stated that a 10% to 15% performance improvement could be achieved by using CI.

b) Business Process Re-engineering (BPR)

BPR is a strategic management theory and it differs from CI in that it deals with break-through improvements as opposed to gradual change. Thompson and Strickland (2004:376) defined BPR as “A process to reduce fragmentation across traditional departmental lines and cut out bureaucratic overheads”. Hammer and Champy (1993:45) defined BPR as “The fundamental rethinking and radical redesign of business processes to achieve dramatic improvements in critical, contemporary measures of performance, such as cost, quality, service and speed”. Therefore, in essence, BPR is the ability to rethink the organisation as a set of processes oriented to enlighten the end user and that all available technologies are harnessed to drive the effectiveness of new processes.

Thompson and Strickland (2004) recommended that BPR be implemented as follows:

A flow chart for all the business processes should be developed.

The process should be structured.
It should be determined which parts of the processes could be automated.

The process should then be re-engineered and then re-organised.

Thompson and Strickland (2004) and Kagioglou et al. (2005) concluded that when BPR is implemented properly, it can produce dramatic results.

c) Concurrent Engineering (CE)

CE is a NPD process where designers, manufacturers and specialists concerned with product life-cycle work together in the design so that they are collectively and concurrently designing the product together. Dym and Little (2004:181) stated that "Such teams are concerned with understanding and optimising the product development for the entire life of the product". Kagioglou et al. (2005) concluded that the CE delivered new products more efficiently and decreased development time and costs.

2.2.5 Lean Production (LP)

This section will review principles and concepts of lean production and the implications of lean production for construction practice are considered.
2.2.5.1 Origins of LP
Adams et al. (1999:766) noted that LP evolved from the Toyota production system and these authors defined LP as “A way of thinking where all employees continuously look for ways to improve the process with the philosophy of eliminating non-value added activities”. Koskela (1997:2) defined LP as “A systematic approach to identify and eliminate non-value added activities through continuous improvement”. Therefore LP is the process for compressing time to obtain greater productivity, shorter delivery times, lower costs, improved quality and increased customer satisfaction.

2.2.5.2 Conceptual framework
According to Koskela (1997), there are two aspects in all production systems, namely: conversions and flows. Conversions are characterised by value added activities and flows are characterised by time, cost and value. Koskela (1997) concluded that in order to improve production, conversions and flows have to be considered. Non-value adding activities should be reduced or eliminated, and value adding activities should be made more efficient.
2.2.5.3 **Principles of LP**

According to Koskela (1997), LP principles are as follows:

- Reduction of non-value-adding activities.
- Increased value through consideration of customer requirements.
- Reduction of variability.
- Reduction of cycle times.
- Simplification by minimising number of steps, parts and linkage.
- Increased output flexibility.
- Increased process transparency.
- Focused control on the complete process.
Integration of continuous improvement into process.

Balanced improvement between flow and conversion.

Benchmarking.

Koskela (1997) concluded that the principles above can be applied to physical production and information production. He further stated that the principles could be applied to mass production and one-of-a-kind products. Therefore the implication of the above statement is that the core principles of LP can be applied to other industries.

2.2.5.4 Methodologies

Koskela (1997) noted that the most important methodologies for lean manufacturing are as follows:

*Just In Time (JIT):* An inventory strategy implemented to improve the return on investment of a business by reducing in-process inventory and its associated costs.

*Total Quality Management (TQM):* A management strategy aimed at embedding awareness of quality in all organisational processes.

*Process re-engineering:* The fundamental rethinking and radical redesign of business processes to achieve dramatic improvements in critical contemporary measures of performance, such as cost, quality, service, and speed.

*Value based management:* A management approach that governs the mindset and actions in an organisation.
Visual management: A management system that visualises the problem points according to priority and status.

Total productivity maintenance: Total productivity maintenance aims at maximizing equipment effectiveness and uptime throughout the entire life of the equipment.

2.2.5.5 LP in construction

Koskela (1997:3) stated that “LP was effective in car manufacturing” and, according to him the manufacturing industry is using less of everything: half manufacturing space, half human efforts in factory, half product development time, and half investments in tools. The point is not that constructing buildings can be like making cars, but that the construction industry can change itself by rethinking the fundamentals of its delivery processes. The starting point is to recognize that only a small fraction of the total time and effort in any organisation adds value to the client/customer. By clearly defining value for a product or service from the customer’s/client’s perspective, all non-value adding activities can be removed. In construction, few projects are provided by one organisation; therefore waste removal has to be pursued throughout the value stream. Removing wasted time and effort represents the biggest opportunity for performance improvement in construction.
2.2.6 Use of Information and Communication Technology (ICT) in manufacturing

This literature review will explore ICT use in manufacturing.

2.2.6.1 ICT and the manufacturing process

It is acknowledged by authors like Kagioglou et al. (2005) and Sun and Howard (2004) that improved processes in manufacturing have been realised by significant ICT support. According to Kagioglou et al. (2005), the improvement was achieved by viewing ICT and processes the following ways:

There was a distinction between process and ICT alignment, this resulted in the process becoming the driver and ICT the enabler.

Manufacturing considered the co-mutualisation of ICT and processes, this was achieved by synchronising ICT and process development.

Bessant and Nelly (2000) urged that the use of Computer Aided Design (CAD) tools made innovative processes more accurate and efficient. These authors indicated that in manufacturing processes, ICT use is seen as enabling innovation; Operation and Manufacturing Technologies (OMT) as implementing innovation; and Innovative Technologies (IvT) as creating innovation.
Kagioglou et al. (2005) asserted that there are four dimensions of ICT involvement in manufacturing, namely simulation, integration, communication and visualisation:

a) Simulation

Bessant and Nelly (2000) noted that there are two areas in which ICT is used for simulation, namely project simulation and computer analysis.

*Project simulation:* Refers to the use of a computer model to simulate the proposed design’s performance under a defined set of conditions. An example is the wind tunnel used by automobile designers.

*Computer analysis:* Refers to the development of a computer based model which consists of applications of various analytical techniques. According to Dym and Little (2004: 31), these applications include finite element analysis,
integrated circuit modelling, facilitation mode analysis, critical analysis, etc. Examples of computer analysis are the computer generated crash tests for automobile designers.

b) Integration

Kagioglou et al. (2005) noted that the development of frameworks and Integrated Databases (IDS) has been an area of intense activity in manufacturing. According to these authors the main objective of the IDS is the sharing and processing of information in an acceptable information framework. Kagioglou et al. (2005:45) claimed that the IDS should provide the following:

Knowledge capture facilities: These can be document and drawing software to record information and project activities.

Knowledge development facilities: This refers to the use of data mining or On-Line Analytical Processing (OLAP) techniques to analyse project information patterns.

Knowledge sharing facilities: Such as messaging services, E-mail notifications, etc.

Knowledge utilisation facilities: This refers to the search tools for document and information retrieval.

c) Communication

According to Kagioglou et al. (2005:46), the four most used ICT communication and collaborative tools are:
Internet and the World Wide Web (WWW): These tools have allowed for sharing of project data online using web browsing software.

Extranet: Kagioglou et al. (2005:46) stated that “This tool has been a solution for improving co-ordination, communication and collaboration in manufacturing”. It enables members of the project team to communicate with each other and share project information via the internet in a controlled and secure way.

Intranet: This tool allows the project team members within one building to collaborate in a locally based network.

E-mail: A fast and convenient means of one-way written communication. It can be used for transferring a variety of data.

d) Visualisation

Sun and Howard (2004) asserted that visualisation is a wide topic covering a variety of techniques and devices. These authors stated that the two mostly used visualisation techniques are the Virtual Reality (VR) and 3-Dimensional CAD (3D), these will be briefly discussed below:

Virtual Reality (VR): Sun and Howard (2004:68) stated that “The main objective of VR is to mimic the real world, so that the virtual model looks real, sounds real, feels real and
responds realistically to user’s actions”. VR is popular at early conceptual design stages.

3-Dimensional CAD (3D): Refers to the creation of a three-dimensional model on a computer. The model provides information on Bills of Quantities, geometry and structural properties and cost analysis.

2.2.6.2 Creative process phases and corresponding ICT

Sun and Howard (2004) noted that many software solutions have been developed to organise and integrate different phases of the creative process. Kagioglou et al. (2005:41) further stated that “One of the aims of the use of ICT in manufacturing is to collect knowledge that can be re-used for projects and co-ordinate simultaneous concurrent developments of products”. The creative phases have already been discussed and this section will describe the ICT use in each phase.

a) Investigation and research phase (0-1)

The tasks in this phase are carried out using standard office software packages, and research and collaborative tools.

b) Exploration and development phases (2-3)

The main tool used for design and development is CAD. This can be simple 2D Drawing / Drafting or 3D Parametric Feature Based Solid/Surface Modelling. According to Kagioglou et al.
Such software includes technology such as Hybrid Modelling, Reverse Engineering, Knowledge-Based Engineering (KBE), Non-destructive Testing (NDT) and Assembly construction. Simulation, validation and optimisation tasks are carried out using Computer-aided Engineering (CAE) software either integrated in the CAD package or stand-alone. Kagioglou et al. (2005:47) noted that these are used to perform tasks such as: Stress analysis, Finite Element Analysis (FEA); Kinematics; Computational Fluid Dynamics (CFD); and Mechanical Event Simulation (MES). Computer-aided Quality (CAQ) is used for tasks such as Dimensional Tolerance Analysis (DTA).

c) Realisation phase (4)

Once the design of the product's components is complete, then methods of manufacturing need to be defined. Kagioglou et al. (2005:47) stated that the following ICT can be used for defining methods of manufacturing: CAD tasks such as tool design; creation of machining instructions for the product's parts as well as tools to manufacture those parts, using integrated or separate Computer-aided Manufacturing (CAM) software. These authors further stated that “This will also involve analysis tools for process simulation for operations such as casting, moulding, and die-press forming”. Kagioglou et al. (2005) noted that once the manufacturing method has been identified, Manufacturing Process Management (MPM) comes into play. This involves
Computer-aided Production Engineering (CAPE) or production planning tools for carrying out factory, plant and facility layout and production simulation. Once components are manufactured their geometrical form and size can be checked against the original CAD data with the use of Computer Aided Inspection (CAI) equipment and software.

d) Evaluation phase (5)

According to Kagioglou et al. (2005), appropriate evaluation software is used for technical control and calculation tests. Sales product configuration and marketing documentation work will be taking place. These authors further stated that “This could include transferring engineering data to a web based sales configurator and other Desktop Publishing systems”.

2.3 SUMMARY

The literature review shows that much research has been conducted on construction’s design management and manufacturing’s design management processes. It is therefore necessary to carry out a study on the extent to which EC architectural companies have adopted manufacturing industries’ developed and developing solutions to improve efficiency. This would assess existing design management processes used by architectural companies and compare them with those used in manufacturing.
CHAPTER 3

RESEARCH METHODOLOGY

3.1 INTRODUCTION

This chapter will focus on outlining an appropriate research methodology for research into the given problem. The methodology that was used needed to be sympathetic to the problem being investigated so the descriptive method was chosen for the acquisition of data. Walliman (2001:185) defined a descriptive survey as “A method of research that looks with intense accuracy at the phenomena of the moment and then describes precisely what the researcher sees”. The adoption of this method was highly influenced by the procedures followed in the literature review.

3.2 DATA COLLECTION PROCEDURES

The data for this research were collected using primary and secondary sources. The questionnaire was designed to acquire primary, factual and attitudinal data from EC architectural companies; and was use to determine the acceptance or rejection of the hypotheses. Secondary data used in this study were acquired through a literature review of international and national publications which included conference papers, reports, journals, articles and the Internet. Secondary data were utilised to establish criteria and theories against which empirical research of the primary data was measured.
3.3 RESEARCH METHODOLOGY

The quantitative research approach was implemented for this research project as it supported deductive reasoning. Mouton and Marais (1992:156) defined the quantitative approach as “Fundamentally more formalised and explicitly controlled, with a range which is more exactly defined, and in terms of the methods used, is found to be close to physical sciences”. The research process is set out as follows:

Identification of target population within delimited area

Questionnaire design

Questionnaire administration

Bias

Treatment of data for each sub-problem in terms of data needed; where the data were located and how the data were secured.

3.3.1 Target population

The survey was conducted in the EC amongst professional architectural companies registered with the SAIA. SAIA has two architectural institutions for the EC, namely the Border-Kei Institute of Architects (BKIA) and the Eastern Cape Institute of Architects (ECIA). The questionnaires were administered to all architectural companies represented by these two institutes.
3.3.2 Questionnaire design

The questionnaire was divided into two parts and contained 29 questions. It was designed to gather information on:

a) Section 1

Demographic information about respondents and their organisations.

b) Section 2

A general assessment aimed at identifying:

Adequacy of current design management processes used by EC architectural companies.

Similarities in design management processes, continuous improvement philosophies, lean production principles and ICT
used by EC architectural companies and in manufacturing industry.

3.3.2.1 Testing of questionnaire

The questionnaire was quality tested by the research supervisor for precision of expression, question duplication, objectivity, suitability to problem situation; and probability of favourable reception and return. Walliman (2001) recommended that questions should be pre-tested on a small population and he referred to this as pilot studying. In accordance with the above recommendation a draft questionnaire was sent to a seven architects to obtain their comments, to test whether there were any items that they had difficulty in understanding and to determine the time it takes to complete the questionnaire. The pilot study indicated that the architects took 15 minutes to complete the questionnaire and they recommended that the “Unsure” option should be included in some questions.

3.3.2.2 Response rate

The following procedures were followed to improve the response rate and to stimulate interest in the research:

A brief courteous and thoughtfully structured letter was sent to respondents describing the potential value of the study and inviting them to co-operate by completing the questionnaire (Appendix A).
The questionnaire was kept as brief, simple and as courteous as possible in order to ensure a favourable response rate (Appendix C).

Respondents were assured of anonymity and confidentiality of their information.

Respondents were able to answer the questionnaire on-line so that they did not have to go through the trouble of e-mailing and faxing (figure 11&12).

A PDF copy of the questionnaire could be downloaded from the website so that it would be useful for respondents who were more comfortable with faxing questionnaires instead of replying online.

Respondents were offered the summary of the results of the survey if they wished to receive it.

A log containing all EC architectural companies’ contact details was drafted and companies that replied to the questionnaire were ticked off.

A reminder letter was sent after four weeks to all companies that did not reply to the questionnaire (Appendix B).
3.3.3 Sampling

For the purposes of this study, 24 architectural companies were randomly selected from the 81 companies registered with BKIA and ECIA. The sample was chosen by the process known as randomisation; Walliman (2001:201) refers to randomisation as “Selecting a sample from the whole population in such a way that the characteristics of each of the units of the sample approximate the characteristics of the total population”. Therefore the composition of the sample is derived from 1:3 proportion of the population and the sizes of companies of the sample vary from small to medium (there are no large companies in the EC according to the SAIA classification in table 6).
Walliman (2001) urged that in probability sampling, the researcher should specify in advance that each segment of the population will be represented in the sample, so the researcher considered the above sample as sufficient for the survey.

### 3.3.4 Questionnaire administration

A covering letter was sent to the BKIA and the ECIA, the institutes then distributed the letter to the various architectural companies. The covering letter contained a hyper-link (http://www.onshow24-7.co.za/Questionnaire/) which directed respondents to the web-site that contained the questionnaire. Respondents could complete the questionnaire in two ways:

- They could complete and submit the questionnaire online without having to e-mail it back.
- They could download at the website a PDF questionnaire that could be completed and returned by fax.

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Table 6: Classification of companies

Table 7: Sample population

Source: South African Institute of Architects (2005:3)
The online questionnaire method was motivated by the following reasons:

The BKIA and ECIA confirmed that all institute member companies have Internet and e-mail access, so that the population would be properly represented.

An online questionnaire is far more cost effective and convenient for data collection as compared with traditional data collection methods.

Online questionnaires can be completed and submitted faster than offline questionnaires.

3.3.5 Bias

“Data in descriptive survey research are particularly susceptible to distortion through the introduction of bias through the research design” Walliman (2001:213). This author defined bias as “Any influence, condition, or set of conditions that singly or together distort the data from what may have been obtained under conditions of pure chance”. Therefore bias is inherent in all research and attacks the integrity of the facts and it is sometimes difficult for the researcher to detect.

The researcher made every effort to eliminate the likelihood of biased data although the possibility of biased data is acknowledged.
3.3.6 **Verification of respondents**

The following measures were taken to ensure authenticity of responses:

The questionnaire was administered through the BKIA and ECIA institutes and they only distributed the questionnaires to member companies.

Questions for identification of respondents were included at the end of the survey so that respondents could be identified and verified.

A list of all BKIA and ECIA member companies was used to double check the names of companies that responded.

3.3.7 **The treatment of data**

Walliman (2001) noted that survey research ultimately aims to solve problems and the survey must obtain data that can be analysed and interpreted to get information for strategic decision-making. Data for this research were analysed using simple descriptive statistics, namely frequency and percentages in Excel software. From these data various charts were extracted and used to assist with analysis in Chapter 4.

3.3.7.1 **Specific treatment of sub-problem 1**

(To determine the adequacy of existing design management processes used by architectural companies in the EC.)
a) **Data needed**

In order to make a comparative study of the adequacy of design management processes used by EC architectural companies, it was important to compile a literature review on:

- Existing design management process protocols used by architects nationally and internationally.
- Problems identified in existing design management processes.
- Problems identified with the pre-project phase of design process.

b) **Where the data were located**

Primary data were gathered from architectural companies within the delimited area as previously identified. Secondary data were obtained from a literature review.

c) **How the data were secured**

Relevant questions for this sub-problem were formulated, which formed part of the questionnaire that was circulated to identify architectural companies in the EC.

3.3.7.2 **Specific treatment of sub-problem 2**

(To determine whether EC architectural companies use similar design management processes as used in manufacturing.)
a) **Data needed**

The required information included primary data relating to design management processes used by EC architectural companies. Secondary data relating to management of design, creativity and product development in manufacturing.

b) **Where the data was located**

Primary data was gathered from architectural companies within the delimited area as previously identified and secondary data was obtained from literature review.

c) **How the data were secured**

Relevant questions for this sub-problem were formulated, which formed part of the questionnaire that was circulated to identify architectural companies in the EC.

3.3.7.3 **Specific treatment of sub-problem 3**

(To determine whether EC architectural companies use similar continuous improvement philosophies and lean production principles as used in manufacturing.)

a) **Data needed**

The required information included primary data relating to continuous improvement philosophies used by EC architectural companies and secondary data relating utilisation to process
improvement philosophies and lean production principles in manufacturing.

b) Where the data were located

Primary data were gathered from architectural companies within the delimited area as previously identified. Secondary data were obtained from a literature review.

c) How the data were secured

Relevant questions for this sub-problem were formulated, which formed part of the questionnaire that was circulated to identify architectural companies in the EC.

3.3.7.4 Specific treatment of sub-problem 4

(To determine whether EC architectural companies are using information and communication technology (ICT) for the effective management of design processes, as used in manufacturing.)

a) Data needed

The required information included primary data relating to use of ICT by EC architectural companies for managing design processes and secondary data relating to ICT use in manufacturing for management of design processes.
b) Where the data were located

Primary data were gathered from architectural companies within the delimited area as previously identified. Secondary data were obtained from a literature review.

c) How the data were secured

Relevant questions for this sub-problem were formulated, which formed part of the questionnaire that was circulated to identify architectural companies in the EC.

3.4 SUMMARY

The literature review provided the information for compilation of the questionnaire that was sent to EC architectural companies. Results of the analysis of collected data will be discussed and presented in Chapter 4; and these data will be used to test the hypotheses.
CHAPTER 4
RESULTS, DATA ANALYSIS AND INTERPRETATION

4.1 INTRODUCTION

This chapter will outline the results from responses to the questionnaire, the data analysis and the interpretation. The chapter will be presented in the following sequential format:

a) Sub-problem 1

Related questions: 2.1, 2.3

b) Sub-problem 2

Related questions: 2.5-2.15

c) Sub-problem 3

Related questions: 2.2, 2.16-2.21, 2.23-2.24

d) Sub-problem 4

Related questions: 2.4, 2.22

The research is differentiated by the various sizes of architectural companies as categorised in Table 6 and Table 8 shows that a 100% response rate was achieved.
4.2 DEMOGRAPHIC BREAKDOWN

The demographical data collected include the average years for which companies have been practising, the total number of employees and scale of operations.

4.2.1 Average age of companies

An important set of data concerns the average ages of companies in each institute and category. Table 9 and Graph 1 illustrate the comparative breakdown in ages of companies in the two institutions and categories. It can be noted that the average age of small companies is 8 years and 21 years for medium sized companies. This is a good indication of the high level of experience of EC companies.

Table 9: Average age of companies

<table>
<thead>
<tr>
<th>Classification</th>
<th>Years</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small</td>
<td>8</td>
</tr>
<tr>
<td>Medium</td>
<td>21</td>
</tr>
<tr>
<td>Average all</td>
<td>15</td>
</tr>
</tbody>
</table>
4.2.2 Average number of employees

Table 10 and Graph 2 illustrate the breakdown of the average number of employees employed by companies in two designated groups. One of the most striking features is the number of architectural companies in the EC (81 according to Table 5) and most of these companies fall in the small and medium category.

Table 10: Average number of employees

<table>
<thead>
<tr>
<th>Classification</th>
<th>Employees</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small</td>
<td>5</td>
</tr>
<tr>
<td>Medium</td>
<td>13</td>
</tr>
<tr>
<td>Average all</td>
<td>9</td>
</tr>
</tbody>
</table>
4.2.3 Scale of operations

Table 11: Scale of operations

<table>
<thead>
<tr>
<th>Scale of operation:</th>
<th>Classification</th>
<th>Total</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Small</td>
<td>Medium</td>
<td></td>
</tr>
<tr>
<td>Local</td>
<td>12</td>
<td>4</td>
<td>16</td>
</tr>
<tr>
<td>National</td>
<td>0</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td>International</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

 Altogether 66% of the companies indicated that they operated locally while 34% indicated that they operated nationally. The results revealed that a high number of companies operate locally which may result in high levels of competitiveness. The competitiveness will demand that EC companies become increasingly competitive through efficiency and effective adoption of new innovations and technologies. There is currently no company that is operating internationally, and this suggests that EC architectural companies have not recognised and exploited the opportunities created by globalisation.
4.3 SUB-PROBLEM 1

To determine the adequacy of existing design management processes used by architectural companies in the EC.

4.3.1 Design management process protocol used by EC architectural companies

Table 12: Design management process protocol used

<table>
<thead>
<tr>
<th>Protocols</th>
<th>Classification</th>
<th>Total</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Small</td>
<td>Medium</td>
<td></td>
</tr>
<tr>
<td>RIBA Plan of Work</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>South African Institute of Architects Work Stages</td>
<td>12</td>
<td>12</td>
<td>24</td>
</tr>
<tr>
<td>Other</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

All 24 of the architectural companies surveyed from both institutions indicated that they used the SAIA Work Stages protocol for management of the design process. This is due to the fact that all members of the SAIA are required to use the South African Institute of Architects Work Stages protocol.
4.3.2 Responses to problems identified with existing design management processes and pre-project phases

Table 13: Problems with existing design management processes and pre-project phases

<table>
<thead>
<tr>
<th>Problems:</th>
<th>Unsure</th>
<th>Classification</th>
<th>Average all</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Rating: 1 = Small extent, 3 = Neutral, 5 = Large extent)</td>
<td></td>
<td>Small</td>
<td>Medium</td>
<td></td>
</tr>
<tr>
<td>Lack of involvement of appropriate expertise in the conceptual phases</td>
<td>0</td>
<td>2.17</td>
<td>2.17</td>
<td>2.17</td>
</tr>
<tr>
<td>Poor co-ordination of information in design and project planning phases.</td>
<td>0</td>
<td>2.09</td>
<td>2.17</td>
<td>2.13</td>
</tr>
<tr>
<td>Poor design management process definition and control.</td>
<td>0</td>
<td>2.59</td>
<td>2.33</td>
<td>2.46</td>
</tr>
<tr>
<td>Poor management of briefing stage by architects.</td>
<td>0</td>
<td>1.75</td>
<td>2.09</td>
<td>1.92</td>
</tr>
<tr>
<td>Incorrect information and mistakes regarding the nature of client’s problem statement.</td>
<td>0</td>
<td>2.83</td>
<td>2.59</td>
<td>2.71</td>
</tr>
<tr>
<td>Poor co-ordination of design information between design consultants.</td>
<td>0</td>
<td>2.50</td>
<td>2.50</td>
<td>2.50</td>
</tr>
<tr>
<td>Poor assessment of process performance between design phases.</td>
<td>0</td>
<td>3.09</td>
<td>2.75</td>
<td>2.92</td>
</tr>
<tr>
<td>Lack of risk assessment between design phases.</td>
<td>0</td>
<td>4.17</td>
<td>4.42</td>
<td>4.23</td>
</tr>
<tr>
<td>Poor communication between design consultants and construction team.</td>
<td>0</td>
<td>2.42</td>
<td>2.58</td>
<td>2.50</td>
</tr>
<tr>
<td>Design changes and buildability problems during construction.</td>
<td>0</td>
<td>2.59</td>
<td>2.83</td>
<td>2.71</td>
</tr>
<tr>
<td>The final building not satisfying client requirements.</td>
<td>0</td>
<td>2.42</td>
<td>2.00</td>
<td>2.22</td>
</tr>
</tbody>
</table>

Table 13 reflects respondents’ ratings of problems with existing design management processes and pre-project phases in terms of an average
rating ranging between 1 (small extent) and 5 (large extent). It is notable that problems ranked second to ninth have an average rating of less than 3, which indicates that in general the respondents do not concur with the various problem statements. The lowest rating problem statement is “Poor management of briefing stage by architects” with an average rating of 1.92 and the highest ranking problem statement is “Lack of risk assessment between design phases” with an average rating of 4.23. The response regarding the management of the briefing stage does not reflect the findings of the literature review as respondents indicated that they did not manage the briefing stage poorly. The lack of risk assessment reflects the findings of the literature review and indicates that EC architectural companies do not identify, assess and mitigate risks during design. Usually these risks emerge later in the project and they adversely affect the project time, cost and quality parameters.

4.3.3 Summary and interpretation

All the architectural companies surveyed indicated that they used the SAIA Work Stages protocol for management of the design process. Graph 3 illustrates a general summary of the respondents’ rating of problems with existing design management processes and pre-project phases. The respondents indicated that they acknowledge 1 of 11 problems as making a large contribution to the inadequacy of existing design management processes and pre-project phases.
Graph 3: Summary of responses to problems with existing design management processes and pre-project phases

Summary of responses to problems with existing design management processes and pre-project phases

1. The final building not satisfying client requirements.
2. Design changes and buildability problems during construction.
3. Poor communication between design consultants and construction team.
4. Lack of risk assessment between design phases.
5. Lack of quality control during the design phase.
6. Poor assessment of process performance between design phases.
7. Poor co-ordination of design information between design consultants.
8. Incorrect information and mistakes regarding the nature of client's problem statement.
9. Poor management of briefing stage by architects.
10. Lack of involvement of appropriate expertise in the conceptual phases.
11. Poor design management process definition and control.
12. Poor co-ordination of information in design and project planning phases.

Average rating scale: 1-5
4.3.4 Testing of hypothesis 1

*Hypothesis 1*: The inadequacy of existing design management processes has contributed to the construction industry’s poor performance.

Based on the responses and summary in sections 4.3.2 and 4.3.3, the respondents perceived that the existing design management processes are adequate as they only acknowledged 1 of 11 problem statements. The results and analysis of the survey therefore reject the hypothesis.

4.4 SUB-PROBLEM 2

To determine whether EC architectural companies use similar design management processes as used in manufacturing.

4.4.1 Responses to project appraisal stage of design processes

<table>
<thead>
<tr>
<th>Methods</th>
<th>Classification</th>
<th>Total</th>
<th>Average %</th>
<th>Ranking</th>
</tr>
</thead>
<tbody>
<tr>
<td>Literature review</td>
<td>4</td>
<td>7</td>
<td>11</td>
<td>46</td>
</tr>
<tr>
<td>User surveys and questionnaires</td>
<td>3</td>
<td>6</td>
<td>9</td>
<td>38</td>
</tr>
<tr>
<td>Focus groups</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Informal or formal interviews</td>
<td>12</td>
<td>12</td>
<td>24</td>
<td>100</td>
</tr>
<tr>
<td>None</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Other</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Table 14 lists the methods used in manufacturing during project appraisal and responses indicating as to which ones are used by EC architectural companies. The main method used is the interview (formal and informal) as all respondents indicated that they use it and
the literature review is the second most used method followed by user surveys and questionnaires. No respondents indicated that they used the focus group and other methods. It can be noted that the literature reviews, user surveys and questionnaires are more frequently used by the medium sized companies as compared with small companies. This could be due to the fact that medium sized companies work on larger projects which require research.

It can be concluded on the basis of the responses to questions regarding methods used during the project appraisal stage of design processes that EC architectural companies use at least one of the design methods used in manufacturing.

4.4.2 Responses to project definition stage of design processes

Table 15: Methods of establishing clients' value criteria

<table>
<thead>
<tr>
<th>Methods</th>
<th>Classification</th>
<th>Total</th>
<th>Average all %</th>
<th>Ranking</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Small</td>
<td>Medium</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Value hierarchy</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Value tree</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>None</td>
<td>12</td>
<td>12</td>
<td>24</td>
<td>100</td>
</tr>
<tr>
<td>Other</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>12</td>
<td>12</td>
<td>24</td>
<td>100</td>
</tr>
</tbody>
</table>

Table 15 lists the methods used in manufacturing for establishing clients' value criteria and responses indicating which ones are used by EC architectural companies. None of the respondents from both classifications indicated that they used the value hierarchy and value tree, showing that they did not utilise any method to establish clients' value criteria. The findings indicate that EC architectural companies do
not have an approach for establishing clients’ value criteria. This could be due to the problem with the architectural briefing format (written words supplemented with drawings) which does not provide analytical tools and recording methodologies that are important in helping with the articulation and prioritisation of client’s and designer’s values.

Table 16 lists the tools used in manufacturing for management of scope and responses indicating which ones are used by EC architectural companies. Altogether 46% of respondents indicated that they used the Linear Responsibility Chart while 13% used the Work Breakdown Structure. An important finding was that 41% of the respondents did not use any scope management tools. The lack of definition of scope usually occurs during the briefing stages, as architects focus their attention on design related problems and they overlook project management processes. The lack of definition and management of scope results in the final product not being quite what the client wanted and this causes rework and additional effort which will have cost and time implications.

Table 16: Project management tools used for management of scope during project definition stage

<table>
<thead>
<tr>
<th>Tools</th>
<th>Classification</th>
<th>Total</th>
<th>Average %</th>
<th>Ranking</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Small</td>
<td>Medium</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Work Breakdown Structure</td>
<td>0</td>
<td>3</td>
<td>3</td>
<td>13</td>
</tr>
<tr>
<td>Linear Responsibility Chart</td>
<td>6</td>
<td>5</td>
<td>11</td>
<td>46</td>
</tr>
<tr>
<td>None</td>
<td>6</td>
<td>4</td>
<td>10</td>
<td>41</td>
</tr>
<tr>
<td>Other</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>12</td>
<td>12</td>
<td>24</td>
<td>100</td>
</tr>
</tbody>
</table>
Table 17 lists the tools used in manufacturing for scheduling and time management, and responses indicating which ones are used by EC architectural companies. Some 54% of respondents indicated that they used the Team Calendar and 38% used the Gantt Charts. None of the respondents from both classifications indicated that they used the Activity Network Graphs and 8% indicated that they did not use any scheduling tools. This finding indicated that the majority (92%) of EC architectural companies do use schedule and time management tools.

<table>
<thead>
<tr>
<th>Tools Classification</th>
<th>Small</th>
<th>Medium</th>
<th>Total</th>
<th>Average %</th>
<th>Ranking</th>
</tr>
</thead>
<tbody>
<tr>
<td>Team Calendar</td>
<td>7</td>
<td>6</td>
<td>13</td>
<td>54</td>
<td>1</td>
</tr>
<tr>
<td>Activity Network Graphs</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>Gantt Charts</td>
<td>5</td>
<td>4</td>
<td>9</td>
<td>38</td>
<td>2</td>
</tr>
<tr>
<td>None</td>
<td>0</td>
<td>2</td>
<td>2</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>12</td>
<td>12</td>
<td>24</td>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>

Tables 15-17 list tools and methods used in manufacturing during project definition stages. From these tables, the following summary can be deduced:

Respondents do not use any method for establishing clients’ value criteria (Table 15).

Altogether 59% of respondents indicated that they use scope management tools (Table 16).

Some 92% of respondents indicated that they use schedule and time management tools (Table 17).
Therefore it can be concluded based on the summary that EC architectural companies use similar tools and methods (with the exception of value criteria) as used in manufacturing during project definition stages.

### 4.4.3 Responses to documents/deliverables produced during appraisal and definition stages

Table 18: Documents/deliverables produced during appraisal and definition stages

<table>
<thead>
<tr>
<th>Documents/deliverables</th>
<th>Classification</th>
<th>Total</th>
<th>Average all %</th>
<th>Ranking</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Small</td>
<td>Medium</td>
<td>19</td>
<td>79</td>
</tr>
<tr>
<td>Stakeholder list</td>
<td>9</td>
<td>10</td>
<td>79</td>
<td>19</td>
</tr>
<tr>
<td>Statement of need</td>
<td>4</td>
<td>3</td>
<td>29</td>
<td>7</td>
</tr>
<tr>
<td>Business case</td>
<td>6</td>
<td>6</td>
<td>50</td>
<td>12</td>
</tr>
<tr>
<td>Business plan</td>
<td>4</td>
<td>5</td>
<td>38</td>
<td>9</td>
</tr>
<tr>
<td>Project execution plan</td>
<td>3</td>
<td>4</td>
<td>29</td>
<td>7</td>
</tr>
<tr>
<td>Terms of reference</td>
<td>6</td>
<td>10</td>
<td>67</td>
<td>16</td>
</tr>
<tr>
<td>Performance management report</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Communication strategy</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Procurement plan</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Project brief</td>
<td>11</td>
<td>9</td>
<td>83</td>
<td>20</td>
</tr>
<tr>
<td>Design brief</td>
<td>12</td>
<td>12</td>
<td>100</td>
<td>24</td>
</tr>
<tr>
<td>Value management</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Risk management plan</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Other</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Table 18 lists the documents/deliverables used in manufacturing during the appraisal and definition stages, and responses indicating which ones are used by EC architectural companies. The majority of respondents indicated that they produced the design brief (100%), project brief (83%), stakeholder list (79%) and terms of reference (67%). Some 50% indicated that they produced business case and the
least produced were business plan (38%), statement of need (29%) and the project execution plan (29%). No respondents indicated that they produced performance management reports, communication strategy, procurement plan, value management and risk management plan. The findings suggest that architectural companies focus more on the documents/deliverables needed for production of the designs as indicated by the most produced deliverables and that they ignore deliverables needed for communication, process definition, process management and measure. Therefore architectural companies do not produce documents and deliverables needed for effective management of the design process and this often results in the final products not being delivered on time, at the right cost and quality.

4.4.4 Responses to concept exploration and development stages of design processes

Table 19: Methods used for conceptualisation of design solutions

<table>
<thead>
<tr>
<th>Methods</th>
<th>Classification</th>
<th>Total</th>
<th>Average all %</th>
<th>Ranking</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Small</td>
<td>Medium</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6-3-5 method</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>C-Sketch method</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>The Gallery method</td>
<td>3</td>
<td>10</td>
<td>13</td>
<td>54</td>
</tr>
<tr>
<td>Other (individual criticism)</td>
<td>12</td>
<td>10</td>
<td>22</td>
<td>92</td>
</tr>
</tbody>
</table>

(Some companies indicated that they used more than one method)

Table 19 indicates that no respondents use the 6-3-5 and C-Sketch methods for conceptualisation of design solutions. Altogether 54% of respondents indicated that they used the Gallery method and the most used method is the ‘individual criticism’. The individual criticism method
is similar to the Gallery method, the only difference with the individual criticism method is that feed-back is given by an individual instead of a group. The reason for the popularity of the individual criticism method is that it is easier to implement and less time consuming as compared with other methods.

Table 20: Methods used for evaluating concept designs

<table>
<thead>
<tr>
<th>Methods</th>
<th>Classification</th>
<th>Total</th>
<th>Average</th>
<th>Ranking</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>SmallMedium</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Numerical evaluation matrix</td>
<td>00</td>
<td>0</td>
<td>0</td>
<td>2=</td>
</tr>
<tr>
<td>Weighted checkmarks chart</td>
<td>00</td>
<td>0</td>
<td>0</td>
<td>2=</td>
</tr>
<tr>
<td>None</td>
<td>1212</td>
<td>24</td>
<td>100</td>
<td>1</td>
</tr>
<tr>
<td>Other</td>
<td>00</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>1212</td>
<td>24</td>
<td>100</td>
<td></td>
</tr>
</tbody>
</table>

Table 20 indicates methods used in manufacturing for evaluation and selection of concept sketches. No respondents indicated that they used the Numerical evaluation matrix and the Weighted checkmarks chart methods for evaluating concept designs. As these methods require weighted value criteria and objectives, and as already noted EC architectural companies do not establish value criteria and objectives. Further, it can be noted that all respondents indicated that they did not use any method for evaluating concept designs. This is due to the fact that Architects and clients usually choose a design they ‘like’ most without any use of a formal evaluation method.
Table 21 indicates responses to methods used for representation of three dimensional actualisation of proposed design solutions. The most used method is 2D renderings; this could be due to the fact that this is the easiest and less time consuming method of presentation. The second most used method is the 3 Dimensional CAD (54%) followed by the Scale models (46%). It can be noted that medium sized companies use the scale models more than small companies, and this could be due to the fact that medium sized companies work on bigger projects which have greater presentation requirements. No company indicated that they used prototypes as most building systems are standardised and therefore there is no need for prototyping. No company indicated that they used Virtual Reality, this could be for economic reasons as Virtual Reality is very expensive.

Table 22 indicates that the most used tool by respondents for monitoring and controlling projects is the QS estimates (75%) and 42% of respondents indicated that they used the Percentage-Complete Matrix. The Percentage-Complete Matrix is an easier tool for managing
project costs for smaller projects but in much more complex projects
the architects rely on the QS estimates.

Table 22: Project management tools used to monitor and control the project budget

<table>
<thead>
<tr>
<th>Tools</th>
<th>Classification</th>
<th>Total</th>
<th>Average</th>
<th>Ranking</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Small</td>
<td>Medium</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Percentage-Complete Matrix</td>
<td>6</td>
<td>4</td>
<td>10</td>
<td>42</td>
</tr>
<tr>
<td>None</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Other: QS estimates</td>
<td>8</td>
<td>10</td>
<td>18</td>
<td>75</td>
</tr>
</tbody>
</table>

(Some companies indicated that they used more than one method)

Tables 19-22 list tools and methods used in manufacturing during concept exploration and development stages of design processes and respondents’ indications. From these tables, the following summary can be deduced:

Respondents use the more economical methods (Gallery method and individual criticism) for conceptualisation of design solutions (Table 19).

Respondents indicated that they do not use any method for evaluating of concept designs (Table 20).

Respondents indicated that they used 2D CAD renderings (100%), 3 Dimensional CAD (54%) and scale models (46%) for actualisation of design solutions (Table 21).

Respondents indicated that they used the Percentage-Complete Matrix (42%) and QS estimates (75%) for monitoring and controlling project budget.
Therefore, it can be concluded that EC architectural companies use similar (with the exception of evaluation methods) methods and tools as in manufacturing during the concept exploration and development stages of design processes.

4.4.5 Responses to documents/deliverables produced between design concept and technical documentation stages

Table 23: Documents/deliverables produced between design concept and technical documentation stages

<table>
<thead>
<tr>
<th>Documents/deliverables</th>
<th>Classification</th>
<th>Total</th>
<th>Average %</th>
<th>Ranking</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Small</td>
<td>Medium</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Concept design plan</td>
<td>1</td>
<td>3</td>
<td>4</td>
<td>17</td>
</tr>
<tr>
<td>Outline concept design</td>
<td>3</td>
<td>5</td>
<td>8</td>
<td>33</td>
</tr>
<tr>
<td>Full concept design</td>
<td>12</td>
<td>12</td>
<td>24</td>
<td>100</td>
</tr>
<tr>
<td>Value engineering</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Technical drawings</td>
<td>12</td>
<td>12</td>
<td>24</td>
<td>100</td>
</tr>
<tr>
<td>Prototype and testing</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Cost plan</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Other</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

(Some companies indicated that they used more than one method)

Table 23 lists the documents/deliverables used in manufacturing during the appraisal and definition stages, and responses indicating which ones are used by EC architectural companies. The majority of respondents indicated that they produced the full concept design (100%) and technical drawings (100%). The above documents are the standard set of documentation that architects need to produce for design development, contract procurement and construction. Altogether 33% of respondents indicated that they produced the outline concept design and 17% indicated that they produce the concept design plan. These two sets of documentation are produced during the
feasibility study and most projects undertaken in architectural companies do not require feasibility studies. No respondents indicated that they produce Value Engineering (VE) because it requires an articulation and prioritisation of client’s and designer’s values. No respondent indicated that they produced Prototype and as already indicated most building systems are standard. No respondents indicated that they produced cost plans as costing on architectural projects are performed by the QS.

### 4.4.6 Responses to activities/documents produced after completion of the project

Table 24 lists the activities/documents produced in manufacturing after completion of projects, and responses indicating which ones are used by EC architectural companies. Altogether 38% of respondents indicated that they produce a Post-project review and 17% indicated that they produce a maintenance plan, therefore the combined total percentage of respondents who produce activities/documents after project completion is 55%. Some 45% of respondents indicated that they did not produce any activities/documents with the majority being smaller companies.

<table>
<thead>
<tr>
<th>Activities/documents</th>
<th>Classification</th>
<th>Total</th>
<th>Average</th>
<th>Ranking</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Small</td>
<td>Medium</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maintenance plan</td>
<td>1</td>
<td>3</td>
<td>4</td>
<td>17</td>
</tr>
<tr>
<td>Post-project review</td>
<td>4</td>
<td>5</td>
<td>9</td>
<td>38</td>
</tr>
<tr>
<td>None</td>
<td>7</td>
<td>4</td>
<td>11</td>
<td>45</td>
</tr>
<tr>
<td>Other</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>12</td>
<td>12</td>
<td>24</td>
<td>100</td>
</tr>
</tbody>
</table>

Table 24 lists the activities/documents produced in manufacturing after completion of projects, and responses indicating which ones are used by EC architectural companies. Altogether 38% of respondents indicated that they produce a Post-project review and 17% indicated that they produce a maintenance plan, therefore the combined total percentage of respondents who produce activities/documents after project completion is 55%. Some 45% of respondents indicated that they did not produce any activities/documents with the majority being smaller companies.
It can be concluded on the basis of the 55% of respondents indicating that they produce deliverables/documents after completion of the projects, that EC architectural companies are producing similar deliverables/documents as produced in manufacturing after completion of projects.

4.4.7 Summary and interpretation

Tables 14-24 list tools, methods, deliverables and documents used and produced in manufacturing during various stages of design management. Respondents indicated which tools, methods, deliverables and documents were used and produced in their architectural companies. The tables and the responses made it possible to determine the similarities between design management processes used in manufacturing and those used by EC architectural companies. The following summary lists the similarities and difference between manufacturing and architectural design management processes:

EC architectural companies use similar tools and methods (with the exception of value criteria) as used in manufacturing during project definition stages.

EC architectural companies use similar (with the exception of evaluation methods) methods and tools as in manufacturing during the concept exploration and development stages of design processes.
EC architectural companies are producing similar deliverables/documents as produced in manufacturing after completion of projects.

EC architectural companies do not produce deliverables/documents needed for effective management of scope, time, cost, quality, value, communication, risk and procurement. This is different compared with manufacturing as they focus on effective management, control and performance measure of the design process.

Therefore, based on the above summary, it can be determined that EC architectural companies produce similar deliverables/documents as in manufacturing for management of the creative processes and that they do not produce similar deliverables/documents for management of design processes.

### 4.4.8 Testing of hypothesis 2

*Hypothesis 2*: EC architectural companies have not adapted manufacturing’s developed and developing design management processes to improve efficiency.

The summary in section 4.4.7 noted that there are similarities between manufacturing and architectural design management in management of the creative processes and differences in the management of design processes. Further, section 2.2.3.3 of the literature review noted the
differences between manufacturing NPD models and construction
design management process protocols. Therefore based on the
differences between design management processes and design
management protocols, it can be concluded that EC architectural
companies have not adapted manufacturing’s design management
processes to improve efficiency. Hypothesis 2 is therefore supported.

4.5 SUB-PROBLEM 3

To determine whether EC architectural companies use similar
continuous improvement philosophies and lean production
principles as used in manufacturing

4.5.1 Responses to rethinking of service delivery processes

Table 25: Increasing efficiency in architectural companies by rethinking of service
delivery processes

<table>
<thead>
<tr>
<th>Classification</th>
<th>Small</th>
<th>Medium</th>
<th>Total</th>
<th>Average</th>
<th>Ranking</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>9</td>
<td>7</td>
<td>16</td>
<td>66%</td>
<td>1</td>
</tr>
<tr>
<td>No</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>13%</td>
<td>3</td>
</tr>
<tr>
<td>Unsure</td>
<td>2</td>
<td>3</td>
<td>5</td>
<td>21%</td>
<td>2</td>
</tr>
<tr>
<td>Total</td>
<td>12</td>
<td>12</td>
<td>24</td>
<td>100</td>
<td></td>
</tr>
</tbody>
</table>

Table 25 indicates that the majority of respondents (66%) are of the
opinion that architectural companies can become more efficient by
rethinking their service delivery processes, while 13% indicated that
they will not and 21% were unsure. In order to increase efficiency, the
architectural companies will need to focus their service delivery
processes on satisfying client requirements and delivering buildings on costs, time and quality.

4.5.2 Responses to process improvement philosophies and lean principles

Table 26 lists philosophies and principles used in manufacturing for process improvement and responses indicating which ones are used by EC architectural companies. Altogether 50% of respondents indicated that they implement the continuous improvement philosophy, and the other 50% indicated that they did not implement any improvement philosophy or lean principles. No respondents indicated that they implemented Business Process Re-engineering, Concurrent Engineering and Lean Production principles. These findings indicate that there is a great scope for improvement in EC architectural companies if they adopted the process improvements and philosophies from manufacturing. The EC architectural companies will not only make

<table>
<thead>
<tr>
<th>Philosophies and principles</th>
<th>Classification</th>
<th>Total</th>
<th>Average</th>
<th>Ranking</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Small</td>
<td>Medium</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Continuous improvement</td>
<td>6</td>
<td>6</td>
<td>12</td>
<td>50</td>
</tr>
<tr>
<td>Business Process Re-engineering</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Concurrent Engineering</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Lean Production</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>None</td>
<td>6</td>
<td>6</td>
<td>12</td>
<td>50</td>
</tr>
<tr>
<td>Other</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>12</td>
<td>12</td>
<td>24</td>
<td>100</td>
</tr>
</tbody>
</table>

Table 26 lists philosophies and principles used in manufacturing for process improvement and responses indicating which ones are used by EC architectural companies. Altogether 50% of respondents indicated that they implement the continuous improvement philosophy, and the other 50% indicated that they did not implement any improvement philosophy or lean principles. No respondents indicated that they implemented Business Process Re-engineering, Concurrent Engineering and Lean Production principles. These findings indicate that there is a great scope for improvement in EC architectural companies if they adopted the process improvements and philosophies from manufacturing. The EC architectural companies will not only make
dramatic initial increases in efficiency and quality, but they will obtain the greatest value through sustained improvements.

4.5.3 Responses to investment in research and development

Table 27 indicates that 67% of respondents indicated that they invested 0% of their annual business volume in research and development, while 33% indicated that they invested 0.1-0.5% and no respondents invested more that 0.6%. The findings indicate that there is a lack of investment in research and development, and this has contributed to the lack of innovation, strategic thinking and efficiency in the architectural profession. Investment in research and development is important for the profession as its success will depend on its ability to match its supply side to future demands for quality services and products.
4.5.4 Responses to the extent to which process improvement is addressed at board meetings

Table 28: The extent to which process improvement is addressed at board meetings. (Rating: 1 = Never, 3 = Neutral, 5 = Always)

<table>
<thead>
<tr>
<th>Unsure</th>
<th>Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small</td>
<td>0</td>
</tr>
<tr>
<td>Medium</td>
<td>0</td>
</tr>
<tr>
<td>Average all</td>
<td>0</td>
</tr>
</tbody>
</table>

Table 28 indicates the extent to which process improvement is addressed at board meetings in terms of ratings ranging between 1 (Never) and 5 (Always). It is notable that all the ratings are below the midpoint rating of 3, which indicates that in general the respondents do not address process improvement regularly during board meetings. The smaller sized companies rated very lowly (1.67) as compared with medium sized companies (2.41), with an average from both classifications of 2.04. This finding indicates that managers of the companies are not committed to improving processes within their organisations. Therefore an opportunity exists for managers of companies to improve process performance by creating and maintaining a culture of process improvement. This culture will in turn influence the actions and behaviours of employees, which will lead to both improved process performance and organisational competitiveness.
4.5.5 Responses to the extent to which companies “benchmark”

Table 29: The extent to which companies “benchmark” other design practices or industries to gain a competitive advantage.
(Rating: 1 = Never, 3 = Neutral, 5 = Always)

<table>
<thead>
<tr>
<th></th>
<th>Unsure</th>
<th>Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small</td>
<td>0</td>
<td>2.42</td>
</tr>
<tr>
<td>Medium</td>
<td>0</td>
<td>2.50</td>
</tr>
<tr>
<td>Average all</td>
<td>0</td>
<td>2.46</td>
</tr>
</tbody>
</table>

Table 29 indicates the extent to which companies “benchmark” other design practices or industries to gain a competitive advantage, in terms of ratings ranging between 1 (Never) and 5 (Always). It is notable that the average rating is 2.46 which is below the midpoint rating of 3, which indicates that in general the respondents “seldom” benchmark other practices or industries. This finding indicates that the respondents do not know how their performance measures up to their competitors and to “world class” standards.

4.5.6 Responses to the extent to which employees are encouraged to make suggestions to improve office processes

Table 30: The extent to which employees are encouraged to make suggestions to improve office processes.

<table>
<thead>
<tr>
<th>Classification</th>
<th>Total</th>
<th>Average</th>
<th>Ranking</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Small</td>
<td>Medium</td>
<td>all</td>
</tr>
<tr>
<td>Yes</td>
<td>2</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>No</td>
<td>3</td>
<td>7</td>
<td>10</td>
</tr>
<tr>
<td>Somewhat</td>
<td>7</td>
<td>3</td>
<td>10</td>
</tr>
<tr>
<td>Unsure</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>12</td>
<td>12</td>
<td>24</td>
</tr>
</tbody>
</table>
Table 30 shows that 42% of respondents indicated that they do not encourage employees to make suggestions about improvements of office processes. Some 16% of respondents indicated that they encourage employees and 42% indicated that they “somewhat” encourage employees, therefore the combined average of respondents that encourage their employees to improve office processes is 58%. The finding indicates that the majority of respondents (58%) have recognised the contribution that employees make to improvements of office processes and innovation.

### 4.5.7 Responses to reward system for motivation of employees

Table 31 revealed that no respondents indicated that there was a reward system in place to motivate their employees and that 58% of respondents indicated that there was no reward system. Altogether 42% of respondents indicated that the question did not apply to them as they indicated in the previous question that they do not encourage employees to improve office processes. A reward system reflects managers’ commitment to improvement of office processes and it can

<table>
<thead>
<tr>
<th>Classification</th>
<th>Total</th>
<th>Average all %</th>
<th>Ranking</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>No</td>
<td>9</td>
<td>14</td>
<td>58</td>
</tr>
<tr>
<td>Not applicable</td>
<td>3</td>
<td>10</td>
<td>42</td>
</tr>
<tr>
<td>Total</td>
<td>12</td>
<td>24</td>
<td>100</td>
</tr>
</tbody>
</table>

Table 31: Reward system for motivation of employees for improving office processes.
therefore be concluded that the managers are not committed to process improvement.

4.5.8 Responses to identification and elimination of non-value adding activities

Table 32: The extent to which companies identify and eliminate non-value adding activities in delivery processes.
(Rating: 1 = Never, 3 = Neutral, 5 = Always)

<table>
<thead>
<tr>
<th></th>
<th>Unsure</th>
<th>Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small</td>
<td>0</td>
<td>2.17</td>
</tr>
<tr>
<td>Medium</td>
<td>0</td>
<td>2.92</td>
</tr>
<tr>
<td>Unsure</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Average all</td>
<td>0</td>
<td>2.54</td>
</tr>
</tbody>
</table>

Table 32 indicates the extent to which companies identify and eliminate non-value adding activities in delivery processes in terms of a rating ranging between 1 (Never) and 5 (Always). It is notable that the rating of small companies is 2.17 which is much less than the rating of 2.92 from medium size companies. The differences in ratings could be due to the fact that medium sized companies have better infrastructure, time and resources which can be spent on identifying and eliminating non-value adding activities. The average rating is 2.54 which is below the midpoint rating of 3, which indicates that in general the respondents “seldom” identify and eliminate non-value adding activities in delivery processes. This finding shows that the respondents have not systematically researched the clients’ needs and that they have not stream-lined their processes to cater to these needs. The EC architectural companies can become more efficient by focusing on
clients’ needs and eliminating the activities that do not add value to clients.

4.5.9 Responses to transfer of processes from other industries

Table 33: The extent to which companies transfer processes from other industries. (Rating: 1 = Never, 3 = Neutral, 5 = Always)

<table>
<thead>
<tr>
<th></th>
<th>Unsure</th>
<th>Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small</td>
<td>0</td>
<td>1.75</td>
</tr>
<tr>
<td>Medium</td>
<td>0</td>
<td>1.84</td>
</tr>
<tr>
<td>Unsure</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Average all</td>
<td>0</td>
<td>1.8</td>
</tr>
</tbody>
</table>

Table 33 indicates the extent to which companies transfer processes from other industries in terms of a rating ranging between 1 (Never) and 5 (Always). It is noted that the average rating is 1.8 which is below the midpoint rating of 3 and this indicates that the companies “seldom” transfer processes from other industries. As already stated, the manufacturing industry has been a constant reference point and source of innovation for the construction industry for many decades. It is believed that EC architectural companies could improve efficiency and competitiveness if they transferred processes from manufacturing.

4.5.10 Summary and interpretation

Tables 25-33 and Graph 4 list process improvement philosophies and lean production principles used in manufacturing and respondents indicated which were used in their architectural companies. The tables and the responses made it possible to determine the similarities between philosophies and principles used in manufacturing and those
used by EC architectural companies. The following summary lists the similarities and differences:

Altogether 66% of respondents indicated that architectural companies can become more efficient by rethinking their service delivery processes (Table 25).

Fifty percent of respondents indicated that they implemented one philosophy (Continuous Improvement) from four that are implemented in manufacturing and the other 50% of respondents indicated that they did not implement any process improvement philosophy and lean production principle (Table 26).

Approximately 67% of respondents indicated that they invested 0%, and 33% indicated that they invested between 0.1-0.5% of their annual business volume in research and development. (Table 27)

Respondents indicated that process improvement is not adequately addressed in board meetings (Table 28).

Respondents indicated that they are not adequately benchmarking other design practices and industries (Table 29).

The majority of respondents (58%) indicated that they are encouraging employees to make suggestions to improve office processes and 58% of respondents indicated that they are not rewarding employees for improvement of office processes (Tables 30-31).

Respondents indicated that they are not adequately identifying and eliminating non-value adding activities (Table 32).
Respondents indicated that they are not adequately transferring processes from other industries (Table 33).

Therefore it can be concluded by taking the above summaries into consideration that EC architectural companies are not using similar continuous improvement philosophies and principles as used in manufacturing.
4.5.11 Testing of hypothesis 3

Hypothesis 3: EC architectural companies have not adapted manufacturing's continuous improvement philosophies and lean production principles to improve project delivery processes.

Based on the summary in section 4.5.10, it can be concluded that the majority of EC architectural companies are not using similar continuous improvement philosophies and lean production principles as used in manufacturing. Hypothesis 3 is therefore supported.

4.6 SUB-PROBLEM 4

To determine whether EC architectural companies are using Information and Communication Technology (ICT) for the effective management of design processes, as used in manufacturing

4.6.1 Responses to ICT and collaborative tools used by companies

Table 34: ICT and collaborative tools used by companies

<table>
<thead>
<tr>
<th>ICT and collaborative tools</th>
<th>Classification</th>
<th>Total</th>
<th>Average all %</th>
<th>Ranking</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Small</td>
<td>Medium</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Internet</td>
<td>12</td>
<td>12</td>
<td>24</td>
<td>100</td>
</tr>
<tr>
<td>Extranet</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Intranet</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>E-mail</td>
<td>12</td>
<td>12</td>
<td>24</td>
<td>100</td>
</tr>
<tr>
<td>Other:</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

(Some companies indicated that they used more than one method)

Table 34 lists ICT and collaborative tools used in manufacturing and responses indicating which ones are used by EC architectural companies. It is noted that the most utilised ICT and collaborative tools
are the internet and e-mail with 100% indication from respondents from both classifications, while no respondents (0%) indicated that they used the extranet and intranet. It can be concluded that EC architectural companies are using standard ICT and collaborative tools, and that they are not exploring available technologies that could enhance communication and professional collaboration.

4.6.2 Responses to ICT utilisation for project management

![Graph 5: Summary of responses to ICT utilisation for project management](image)

Graph 5: Summary of responses to ICT utilisation for project management
Table 35: ICT utilisation for project management

<table>
<thead>
<tr>
<th>Statements</th>
<th>Unsure</th>
<th>Classification</th>
<th>Average</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Rating: 1 = Strongly disagree, 3 = Neutral, 5 = Strongly agree)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Every new project brought into the company is assessed and new technologies are implemented so as to handle the project as efficiently as possible.</td>
<td>0</td>
<td>2.84</td>
<td>2.56</td>
<td>2.7</td>
</tr>
<tr>
<td>Management are aware of the current trends and technologies in project control, collaboration, CAD and management.</td>
<td>0</td>
<td>2.50</td>
<td>2.50</td>
<td>2.50</td>
</tr>
<tr>
<td>There is an extranet set up to assist with communication and sharing between professionals involved in a project.</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Once projects are completed, their success or failure is assessed and documented for future reference.</td>
<td>0</td>
<td>2.67</td>
<td>2.42</td>
<td>2.55</td>
</tr>
</tbody>
</table>

Graph 5 and Table 35 indicate respondents’ ratings of statements on ICT utilisation for project management in terms of ratings ranging between 1 (strongly disagree) and 5 (strongly agree). It is notable that all ratings are below the midpoint rating of 3, which indicates that in general EC architectural companies are not utilising ICT effectively for project management. Based on responses to statements, the following conclusions can be deduced:

EC architectural companies are not adequately identifying and implementing ICT according to the needs of each project.
EC managers are not really aware of current trends and technologies in project control, collaboration, CAD and management.

EC architectural companies are using standard ICT (e-mail and internet) and are not exploring available ICT for effective communication and collaboration. It can be noted that EC architectural companies are not using extranets for project control.

EC architectural companies do not adequately undertake the post-project review of projects.

4.6.3 Summary and interpretation

Tables 34-35 and Graph 5 list ICT tools and statements about ICT utilisation for project management in manufacturing, and respondents indicated which were used in their architectural companies. The tables and the responses made it possible to determine the similarities between ICT used in manufacturing and that used by EC architectural companies. The findings indicated that EC architectural companies are using standard ICT and that they are not utilising ICT effectively for project management.
4.6.4 Testing of hypothesis 4

Hypothesis 4: EC architectural companies lag behind the manufacturing industry in adopting ICT for the efficient management of design processes.

Based on the summary in section 4.6.3, it can be concluded that EC architectural companies are not using ICT for effective management of design processes as used in manufacturing. The hypothesis is therefore supported.

4.7 SUMMARY

This chapter presented the findings on the adequacy of design management processes used by architectural companies in the EC construction industry and compared these with the design management processes used in manufacturing. The chapter opened with respondents’ response rate, proceeded with discussions on findings pertaining to sub-problems and tested the hypotheses. The implications of the results, recommendations and possible future research will be discussed in Chapter 5.
CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

5.1 INTRODUCTION

This chapter will discuss conclusions and recommendations arising from an examination of the relevant literature and the findings derived from respondents who participated in the study.

5.2 CONCLUSION

The results indicated that architectural companies in the EC use the SAIA Work Stages protocol for management of the design process. EC respondents indicated that the SAIA Work Stages protocol was adequate for their design processes as it contributed to a limited extent to 10 of 11 problems identified by the literature review. However, the SAIA Work Stage Protocol contributed to a lack of risk between design phases. The researcher found that there is inconsistency in the way the SAIA protocol is implemented; this is due to the fact that the SAIA does not stipulate a definite set of deliverables in its phases. The inconsistency is made worse by the utilisation of temporary multi-organisational teams for each project, this making it difficult for professionals to organise themselves into team a working environment due to variations in their roles and responsibilities. The inconsistency has resulted in difficulties in performance measurement, control and attempts at continual improvement in design processes.
The results also showed that design management processes used by EC architectural companies at various stages are not similar to those used in manufacturing and it has already been established that productivity in construction lags behind that of manufacturing. Therefore EC architectural companies could increase their efficiency by adopting some of the design management processes, theories and deliverables used in the manufacturing industry.

The results revealed that EC architectural companies are not using similar continuous improvement philosophies and lean principles as used in manufacturing and that the majority of EC architectural companies do not implement any continuous improvement philosophy. EC architectural companies can therefore improve by considering continuous improvement and lean practices originating from manufacturing.

The results also indicated that EC architectural companies are not utilising ICT for simulation, integration, visualisation and communication of design projects. Therefore more effective utilisation of ICT during design management processes will result in improved communication and collaboration that will ensure design constructability and clear communication through ICT tools.
5.3 RECOMMENDATIONS

1. **Risk allocation and management:** The allocation of risk by stakeholders at pre-project phases is essential for minimisation of design changes, buildability problems and overall efficiency of design and construction processes. A risk management plan document should be utilised by stakeholders and this document should be a “live document” throughout the design and construction stages. The risk management plan document should be assessed at every stage gate in the design and construction processes.

2. **Benchmarking other design practices and industries:** Companies should use benchmarking as a tool for performance measure of their competitors and other industries, in order to achieve “world class” process improvement and innovations.

3. **Consistent process deliverables for SAIA protocol:** It is important that all architectural companies are operating on a consistent process with standard deliverables. This standardisation of processes and deliverables should not only apply to architects, but to all team members involved in the design and construction stages to achieve repeatability and hence manageability. This will mean linking professional capabilities and processes involved across all construction phases to a consistent process. Another important factor will be to have a standard method of presenting project information so that it can be easily reviewed by all stakeholders. Through consistent utilisation of standard processes and deliverables together with standard approaches to performance measurement, evaluation and control, the
SAIA protocol will be more effective and will facilitate a process of continual improvement in the design and construction processes.

4. **Value Management (VM):** EC architectural companies should implement the VM approach for defining what value means to the client and for establishing clear project objectives. VM will also ensure that expectations will be delivered in the most economical way.

5. **Assessment of process performance:** There is a need for a consistent process to be in place which would make it easier for performance to be assessed. Process performance should be assessed by a Phase Review Board similar to one utilised in manufacturing NPD. The role of the Phase Review Board will be to: assess phase progress; determine whether the project should proceed to the next phase; and assess potential risks that might occur during processes.

6. **Consistent project teams:** It is clear that the creation, management and consistency of project teams between projects must be given considerable attention in order to enable consistency, continuous improvement and knowledge transfer benefits for the design and construction processes.

7. **Stakeholder involvement:** The involvement of stakeholders, whether client or end user, in the appraisal stage in manufacturing has reduced the likelihood of changes by enabling correct decisions to be made earlier in the design process. This approach should also be applied in the SAIA protocol.
8. *Early involvement of suppliers and contractors:* In manufacturing NDP processes, suppliers, contractors and sub-contractors are involved in the exploration and conceptual phases of design management and this allows them to contribute to the design processes and improve manufacturability. This approach should also be utilised in the SAIA protocol so that contractors can contribute to: design processes, value engineering, sharing of innovative solutions; and consideration of resources (machinery, labour and materials) during conceptualisation phases. This approach will assist in overcoming the linear sequential relationship between design and construction, and will contribute to delivering efficiency and quality.

9. *Transferring of deliverables/documents from manufacturing:* The SAIA protocol should incorporate some of the manufacturing industry’s design management deliverables/documents as highlighted in section 2.2.2.4 and 2.2.2.5 to improve its design management processes.

10. *Stage-gate approach:* The stage-gate approach in manufacturing NPD is used for progressive fixing and/or approval of information throughout the design process. This approach could be applied in the SAIA protocol for phase review, design fixity, change management, and for improvement of project delivery time, cost and quality.

11. *Post-project review:* The manufacturing NPD approach facilitates the recording, updating and utilisation of post-project review information for continual improvement of products. This approach could be incorporated in the SAIA protocol.
12. *Utilisation of continuous improvement philosophies and lean principles:*  
EC architectural companies should implement continuous improvement philosophies and lean principles to reduce development time and increase quality of products.

13. *ICT utilisation:* EC architectural companies should utilise ICT, as highlighted in section 2.2.6.1 and 2.2.6.2, for effective management of the design process. The design team should strive to utilise compatible ICT applications in order to eliminate problems experienced during information exchange. Managers of companies should be aware of current ICT trends and technologies in order to raise their organisation’s ICT utilisation.

5.4 **RECOMMENDATION FOR FURTHER STUDIES**

The following research areas have been highlighted for further studies:

1. Research to develop an improved SAIA design management process protocol, using manufacturing principles as reference point, which will consider the whole life cycle of construction projects whilst integrating participation under a common framework.

2. Research on how lean principles, as applied in manufacturing, can be applied to construction design management to improve performance.
REFERENCES


**WEBIOGRAPHY**

Jansen Van Vuuren, R. 2003. *CIOB SA* 


APPENDIX A: COVERING LETTER

3 The Paddock
Saar Avenue
Lorraine
Port Elizabeth
Cell: 073 377 5307
Fax: 086 626 9345
E-mail: xabisosidloyi162@hotmail.com
30 July 2007

The Managing Director or Associate

Dear Sir/Madam

Design management research questionnaire

The architectural profession is currently faced with challenges of changing roles, clients demanding more for less, and continual erosion of status and responsibilities. Various authors such as Allison (1993), Kagioglou et al. (2005), RIBA (1992) and RIBA (2005) noted that the profession has been criticised and viewed as restrictively self-interested, economically marginal and sometimes inexpert and frequently artless. Increased challenges, demands and continuous criticism of the profession have led to research into the improvement of processes and efficiency. Authors such as Le Corbusier (1945) suggested that the profession should learn from the Ford Corporation, Latham (1994) suggested using manufacturing as a reference point for overcoming some of constructions problems, and Egan (1994) in his Rethinking of Construction report recommended process modelling as a way to improve efficiency.

I am conducting a survey to obtain data on the adequacy of existing design management processes and to determine whether Eastern Cape (EC) architectural firms use similar design management processes as used in manufacturing. For this purpose EC architectural firms are invited to participate in the survey by completing a questionnaire which would take no more than fifteen minutes of your time. All data obtained will be treated in the strictest confidence and a summary of the research results will be made available to participants at their request.

The questionnaire can be accessed and answered on-line at the following website http://www.onshow24-7.co.za/Questionnaire/. If you are more comfortable with faxing or e-mailing, you will be able to download a PDF questionnaire from the website which you can fax or e-mail back to me.

It would be gladly appreciated if all responses could be received before 27 August 2007. Thank you for the courtesy of your assistance.

Very sincerely yours

Xabiso Sidloyi
Pr. Arch (SA)
(Researcher)

Dr F Buys
(Supervisor)
APPENDIX B: REMINDER LETTER

3 The Paddock
Saar Avenue
Lorraine
Port Elizabeth
Cell: 073 377 5307
Fax: 086 626 9345
E-mail: xabisosidloyi162@hotmail.com
27 August 2007

The Managing Director or Associate

Dear Sir/Madam

Design management research questionnaire

All of us are busier these days and most of us have a hard time keeping abreast of those obligations which are essential and required. We know how little extras sometimes receive our best intentions, but we also know that in reality none of us have the time which we would desire to fulfil those intentions.

From the questionnaire which reached you on 30 July 2007, I have had no reply. Perhaps you mislaid the questionnaire or it may not have reached your e-mail. In any event, I will reattach the website link (http://www.onshow24-7.co.za/Questionnaire/). I am sure you will try to find fifteen minutes somewhere in your busy schedule to complete and submit the questionnaire online. Most of the questionnaires have been submitted and would like to have all submissions.

Thank you, I will appreciate your kindness.

Very sincerely yours

__________________________  ______________________
Xabiso Sidloyi                  Dr F Buys
Pr. Arch (SA)                    (Supervisor)
(Researcher)
APPENDIX C: QUESTIONNAIRE

PART 1: DEMOGRAPHICS

1. Name of company

2. For how many years has the company been practising?

3. What is the total number of employees employed by the company?

4. Scale of operation (Please tick most appropriate box)

   - Local
   - National
   - International

PART 2: GENERAL ASSESSMENT

1. Which design management protocol is used in your company? (Please tick most appropriate box)
   - RIBA Plan of Work
   - South African Institute of Architects Work Stages
   - Other: Please specify:

2. Do you think architectural companies can become more efficient by rethinking their service delivery processes?
   - Yes
   - No
   - Unsure
3. Please rate to what extent the design management protocol used in your company has contributed to the following problems (1=small extent, 3=Neutral, 5=large extent).

<table>
<thead>
<tr>
<th>Problems:</th>
<th>Small extent</th>
<th>Neutral extent</th>
<th>Large extent</th>
<th>Unsure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lack of involvement of appropriate expertise in the conceptual phases</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Poor co-ordination of information in design and project planning phases.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Poor design management process definition and control.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Poor management of briefing stage by architects.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Incorrect information and mistakes regarding the nature of client’s problem statement.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Poor co-ordination of design information between design consultants.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Poor assessment of process performance between design phases.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lack of risk assessment between design phases.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Poor communication between design consultants and construction team.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Design changes and buildability problems during construction.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>The final building not satisfying client requirements.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other: Please specify:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

4. Which of the following IT communication and collaborative tools are used in your company?

- Internet
- Extranet
- Intranet
- E-mail
- Other: Please specify:

5. During project appraisal stage, which method(s) are used by your company to better understand clients’ problems and possible solutions?

- Literature review
- User surveys and questionnaires
- Focus groups
- Informal or formal interviews
- None
- Other: Please specify:
6. During project definition stage, which method(s) are used by your company to establish clients’ value criteria?

<table>
<thead>
<tr>
<th>Method</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Value hierarchy</td>
<td></td>
</tr>
<tr>
<td>Value tree</td>
<td></td>
</tr>
<tr>
<td>None</td>
<td></td>
</tr>
<tr>
<td>Other: Please specify:</td>
<td></td>
</tr>
</tbody>
</table>

7. During project definition stage, which project management tool(s) are used by your company to manage scope of project? (Please tick most appropriate box)

<table>
<thead>
<tr>
<th>Tool</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Work Breakdown Structure</td>
<td></td>
</tr>
<tr>
<td>Linear Responsibility Chart</td>
<td></td>
</tr>
<tr>
<td>None</td>
<td></td>
</tr>
<tr>
<td>Other: Please specify:</td>
<td></td>
</tr>
</tbody>
</table>

8. During project definition stage, which project management tool is used by your company for scheduling and time management of projects? (Please tick most appropriate box)

<table>
<thead>
<tr>
<th>Tool</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Team Calendar</td>
<td></td>
</tr>
<tr>
<td>Activity Network Graphs</td>
<td></td>
</tr>
<tr>
<td>Gantt Charts</td>
<td></td>
</tr>
<tr>
<td>None</td>
<td></td>
</tr>
<tr>
<td>Other: Please specify:</td>
<td></td>
</tr>
</tbody>
</table>

9. Which of the following documents/deliverables are produced by your company during project appraisal and definition?

<table>
<thead>
<tr>
<th>Document/Deliverable</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Stakeholder list</td>
<td></td>
</tr>
<tr>
<td>Statement of need</td>
<td></td>
</tr>
<tr>
<td>Business case</td>
<td></td>
</tr>
<tr>
<td>Business plan</td>
<td></td>
</tr>
<tr>
<td>Project execution plan</td>
<td></td>
</tr>
<tr>
<td>Terms of reference</td>
<td></td>
</tr>
<tr>
<td>Performance management report</td>
<td></td>
</tr>
<tr>
<td>Communication strategy</td>
<td></td>
</tr>
<tr>
<td>Procurement plan</td>
<td></td>
</tr>
<tr>
<td>Project brief</td>
<td></td>
</tr>
<tr>
<td>Design brief</td>
<td></td>
</tr>
<tr>
<td>Value management</td>
<td></td>
</tr>
<tr>
<td>Risk management plan</td>
<td></td>
</tr>
<tr>
<td>Other: Please specify:</td>
<td></td>
</tr>
</tbody>
</table>

10. During concept exploration phase, which method(s) are used by your company to conceptualise design solutions? (Please tick most appropriate box)

<table>
<thead>
<tr>
<th>Method</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>6-3-5 method</td>
<td></td>
</tr>
<tr>
<td>C-Sketch method</td>
<td></td>
</tr>
<tr>
<td>The Gallery method</td>
<td></td>
</tr>
<tr>
<td>Other: Please specify:</td>
<td></td>
</tr>
</tbody>
</table>
11. During design concept evaluation phase, which method(s) are used by your company to evaluate concept designs? (Please tick most appropriate box)
- Numerical evaluation matrix
- Weighted checkmarks chart
- None
- Other: Please specify:

12. During design development stage, which method(s) are used by your company to represent three dimensional actualisation of proposed design solution? (Please tick most appropriate box)
(Prototypes = Working models of design solution tested in operating environment in which they will function as final products).
- Prototypes
- Scale models
- Virtual Reality
- 3 Dimensional CAD
- Other: Please specify:

13. During the design phase, which project management tool(s) are used by your company to monitor and control project budget? (Please tick most appropriate box)
- Percentage-Complete Matrix
- None
- Other: Please specify:

14. Between design concept and technical documentation stages, which activities/deliverables/documents are produced by your company?
- Concept design plan
- Outline concept design
- Full concept design
- Value engineering
- Prototype and testing
- Cost plan
- Other: Please specify:

15. After completion of the project, which activities/documents are produced by your company?
- Maintenance plan
- Post-project review
- Other: Please specify:

16. Which process improvement philosophies and principles are implemented in your company?
- Continuous improvement
- Business process re-engineering
- Concurrent engineering
- Lean production
- Other: Please specify:
17. Please indicate the approximate percentage of annual business volume your company invests in research and development.

<table>
<thead>
<tr>
<th>Percentage</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>0 %</td>
<td></td>
</tr>
<tr>
<td>0.1 – 0.5 %</td>
<td></td>
</tr>
<tr>
<td>0.6 - 1%</td>
<td></td>
</tr>
<tr>
<td>1.1 – 5 %</td>
<td></td>
</tr>
<tr>
<td>More than 5% (Please state):</td>
<td></td>
</tr>
</tbody>
</table>

18. Please state how often process improvement is addressed at board meetings (1=Never, 5=Always)?

<table>
<thead>
<tr>
<th>Frequency</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Never</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Unsure</td>
<td></td>
</tr>
</tbody>
</table>

19. Please state the extent to which your company “benchmarks” other design practices or industries either locally or internationally to gain a competitive advantage (1=Never, 5=Always).

(Benchmarking = the process of identifying practices or processes from organisations anywhere in the world to help improve your own processes or practices)

<table>
<thead>
<tr>
<th>Frequency</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Never</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Unsure</td>
<td></td>
</tr>
</tbody>
</table>

20. Are employees encouraged to make suggestions to improve office processes?

<table>
<thead>
<tr>
<th>Encouragement</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>No</td>
<td></td>
</tr>
<tr>
<td>Somewhat</td>
<td></td>
</tr>
<tr>
<td>Unsure</td>
<td></td>
</tr>
</tbody>
</table>

21. If yes, please state if there is a reward system in place to motivate employees for this.

<table>
<thead>
<tr>
<th>Reward System</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>No</td>
<td></td>
</tr>
<tr>
<td>Not applicable</td>
<td></td>
</tr>
</tbody>
</table>
22. Please rate between “strongly disagree” [1] and "strongly agree" [5]

<table>
<thead>
<tr>
<th>Strongly disagree</th>
<th>Neutral</th>
<th>Strongly agree</th>
<th>Unsure</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
</tbody>
</table>

- Every new project brought into the company is assessed and new technologies are implemented so as to handle the project as efficiently as possible.
- Management are aware of the current trends and technologies in project control, collaboration, CAD and management.
- There is an extranet set up to assist with communication and sharing between professionals involved in a project.
- Once projects are completed, their successor failure is assessed and documented for future reference.

23. Please state the extent to which your company identifies and eliminates non-value adding activities in delivery processes. (1=Never, 5=Always).

<table>
<thead>
<tr>
<th>Never</th>
<th>Always</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
</tr>
</tbody>
</table>

24. Please state the extent to which your company transfers processes from other industries. (1=Never, 5=Always).

<table>
<thead>
<tr>
<th>Never</th>
<th>Always</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
</tr>
</tbody>
</table>

25. Would you like to receive a summary of the research results?
- Yes
- No

THANK YOU FOR YOUR CONTRIBUTION TO EFFORTS DIRECTED TOWARDS IMPROVING THE PERFORMANCE OF THE ARCHITECTURAL INDUSTRY IN THE EASTERN CAPE.

Designation of person completing the form:

Name:__________________________

Contact details:_____________________
Tel:__________________________
Fax:__________________________
E-mail:__________________________