Chapter 1: Introduction and overview

This chapter provides a brief introduction to the impact of the knowledge-age drivers on the product development processes. This suggests that the construction industry need to be improved in general and architectural briefing and design specifically if it is to remain competitive. It identifies the fact that, although there are similarities between product development and architectural design, there are also significant and problematic differences. Realistic Artificial Intelligence in a *post-modern* form brought new opportunities to improve architectural design activities.

The advent of the information age and a knowledge economy brought a necessity for global competitiveness and a need for product innovation (TechnoSolve 1998:1).

The Global drivers of the new marketplace are (Agility Forum 1997):

- Ubiquitous availability and distribution of information.
- Accelerating pace of change in technology.
- Rapidly expanding technology access.
- Globalisation of markets and business competition.
- Global wage and job skills shift.
- Environmental responsibility and resource limitations.
- Increasing customer expectations.

The Next Generation Manufacturing Company (NGM) will succeed through the integrated performance of people, business processes and technology. Of the NGM imperatives identified *Rapid Product/ Process Realisation* is the aspect that is most relevant to the present study.

This challenges firms to:

- Address smaller market segments, with an increased variety of products.
- Increase the frequency of product introductions.
- Compress the lead-time for product development.
- Shorten product life cycles.
- Increase product complexity.
- Distribute product development and production activities across a network of firms instead of within a single integrated firm. (TechnoSolve 1998:1).

These challenges imply the need to design and develop families of products by networks of firms on compressed development schedules, which in turn implies increasingly more knowledge from the designer regarding the life cycle costs of a product at the conception of the design problem, where few decisions have been made and little cost committed to production. Designers are under increasing pressure to apply upstream design techniques to improve quality, whilst decreasing downstream costs. *" Problems experienced downstream are symptoms of neglect upstream. Upstream problems can only be solved upstream. The ability to influence a system's characteristics diminishes very rapidly as the system proceeds from one phase of its life cycle to the next."* (Sparrius 1998:1-2) (Figure 1).

In order to implement these challenges, companies, especially in the manufacturing industry, are re-engineering their business processes to survive in the new knowledge economy. Traditional manufacturing development processes are more and more re-engineered towards a concurrent engineering model, tailor made for the requirements of the information age. To accommodate business shifts and an ever-changing social environment, it is important to emphasise the importance of a holistic perspective in these re-engineering exercises. Re-engineering should include setting up an integrated organisation information environment, an organisational Information Ecology (Davenport 1997:4).

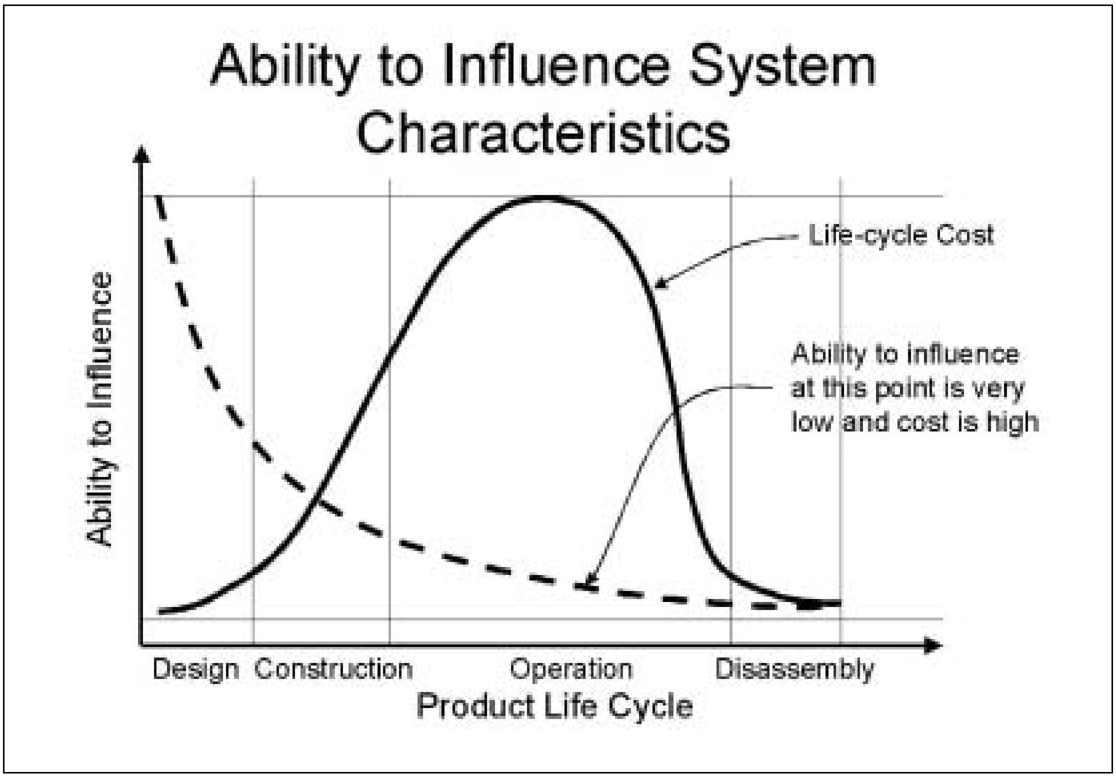

Figure 1: Ability to influence system characteristics (Sparrius 1998: 1.1)

Simultaneously to the abovementioned, the advent of *Post-Modern Artificial Intelligence* (AI) brought new opportunities in the design field. According to Riesbeck (1996:374) AI is the search for answers to the eternal question: Why are computers so stupid? Riesbeck (1996:377) indicates that the problem of AI is to describe and build components that reduce the stupidity of the systems in which they function. The goal should be the improvement of how systems function through the development of intelligent components to those systems. For example, one does not want an automated designer. One wants a design support facility that is not stupid. One requires one that knows concepts, not keywords, that will be able to retrieve relevant design information when the designer is designing a new departure lounge of an airport. In *Post-Modern AI* , AI becomes an invisible part of the overall system.

Although architectural practitioners have not traditionally been seen as being in the business of manufacturing products, research publications (Pugh 1996), (Anumba *et al.* 1997:8) indicate strong similarities between the building construction industry and the manufacturing industry. Not only are both industries in the business of designing and building physical objects (products or artefacts) to satisfy specific client (customer) requirements in a specific environment, but they are also following similar design-build processes. However there are also significant and problematic differences.

Architectural design tasks take place in an open world (Hinrichs 1991:5). An open world denotes any problem-solving situation in which the reasoner's knowledge is incomplete or inconsistent. A design problem solver's knowledge can be incomplete in several ways (Hinrichs 1991:5):

- *Open categories*. An open category is one for which membership cannot be determined from lack of knowledge of membership. The set of primary colours is a closed set.

However the set of possible solutions for a particular architectural design problem is open.

- *Incomplete domain theories*. In architecture the designer's theory of his domain is incomplete. He may not know or be able to retrieve all the causal relationships and facts relevant to a given problem. Reasoning processes that demand theorem proving are not possible.
- *Under-specified problems*: Design problems that are under-specified have solution criteria that are incomplete. This means that the class of solutions forms an open category. If a problem is under-specified the solution needs to be satisfactory rather than absolutely correct. To determine when an architectural design solution is adequate is critical.

According to Hinrichs (1991:15-16) the generation of plausible solutions for a design problem is not simply tedious, it is downright problematic. The generation of a solution is difficult for the following reasons:

- *The design problem spaces are not enumerable*. As with irrational numbers, there is no function that permits a designer to generate the next possible design. Because the problems are ill structured in this way, the designer must supply his own structure in terms of a vocabulary of categories of designs and design components. The content and organisation of this design knowledge is critical for the task of generation. This indicates the necessity for a convenient, flexible and structured language to express designs in.

- *Design constraints are not constructive*. The constraints of a design problem do not directly suggest solutions. Constraints on most design problems rule out an infinite number of possible designs and possibly still permit infinitely many. Due to this the designer needs some kind of associative mechanism to identify members of the categories.

- *Categories in the design vocabulary are fuzzy and subjective*. Design problems are not described by necessary and sufficient conditions, but by experience and expectations. The design solutions of today is contextually, functionally and normatively characterised by designs we have known from the past. This strongly indicates that creative designs should be generated from experience and not deductive rules. This seems to question one of the basic antihistoric tenets of modernism.

- *Problems may be barely decomposable*. While it is sometimes possible to break problems into smaller subproblems, these subproblems tend to be highly inter-constrained. Design time and search can be reduced by using entire plausible solutions that are already internally consistent. These designs can be modified when required. If it is not possible to solve the design problem at this higher level of granularity then the problem can be decomposed. Consequently, the design problem solver should be able to retrieve possible solutions in large design knowledge fragments or cases.

- *Design occurs in multiple problem-spaces*. Because it is sometimes necessary to decompose a problem the designer must work at different granularities or problem spaces, such as the design of a door or an entire airport. All indications are that electronic design knowledge should be hierarchically organised rather than relationally.

Over the last twelve years the author built up considerable experience in the design, programming and implementation of Facilities Management (FM) systems that integrates the long-term strategic and short-term operational maintenance. Most of the present FM systems essentially only handle the operational part of the building life cycle. The integration of processes and information between all the important stages of the life cycle of structures is presently not well understood. The National Health Facilities Audits undertaken since 1996 brought the opportunity to implement quantification of observed phenomena. The condition and suitability of every government hospital in the RSA were analysed and quantified in the form of coloured grid, bar graphs and block plans (Conradie 1996). Recent movements and requirements both locally and abroad indicate that FM will increasingly begin to cover the entire life cycle of the building to ensure informed holistic and appropriate decisions. There is also an increased realisation that decisions taken during the briefing and design phase significantly influences the subsequent phases. Unfortunately these decisions sometimes have to be taken with very little software support or the lack of structured design information.

Attempts were made to represent the properties of objects and to modelling and visualise their forms. Design solutions were synthesised and their specific performances evaluated (Carrara *et al.* 1994).

1. Key performance requirements of an Information Age development process (an information management process, integrated with a structured development process) are:

- An integrated life cycle process.
- A concurrent multimedia environment.
- Life cycle requirement validation.
- Storing of structured design knowledge.
- Ad-hoc queries and reports.

2. The architecture for the proposed Information Age process should be designed as part of an organisational Information Ecology, one that *"emphasises an organisation's entire information environment. It addresses all of a firm's values and beliefs about information (culture); how people actually use information and what they do with it (behaviour and work processes); the pitfalls that can interfere with information sharing (policies); and what information systems are already in place (yes, finally technology)."* (Davenport 1997:4).

The above mentioned already suggests that the improvement of architectural briefing and design is not a trivial matter. The successful solution will be an appropriate synthesis of many different techniques. The subsequent chapters will study well-established techniques from the world of manufacturing, the characteristics of design and Artificial Intelligence (AI) in an attempt to understand the characteristics of the early phases of architectural design better and to discover if a significant improvement can possibly be made.