TOWARDS THE DEVELOPMENT OF A CONCEPTUAL DESIGN MANAGEMENT MODEL FOR REMOTE SITES

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ABSTRACT

Remote and environmentally sensitive sites present unique challenges for participants involved in the design and construction process. Worldwide advances in information technology coupled with improved site accessibility and manageability has enabled the construction industry to undertake such projects with greater ease. Furthermore, research on information technology in construction has begun to focus our attentions on our increased ability to work virtually in distributed teams. These remote sites have a range of development potential as clients have varied interests including; tourism, scientific investigation and resource exploration and processing which impact upon the management of the design process. These sites pose unique challenges to the project teams and in particular for the management of project design. The conceptual design phase is often marked by an iterative and creative process, which tends to be a *sociologically oriented world* where designers respond to a range of functional, aesthetic, environmental and even spiritual concerns. Strategic decisions made during the briefing and conceptual design stage may impact upon construction logistics and sustainability. Detailed design for construction tends to be a *production oriented world.* There is a significant body of literature that addresses the application of lean thinking to improving the interface between detailed design and construction production. There is little literature that takes a holistic view of design management for remote sites. The lean design management field of research has much to contribute to the design management of these projects. The review of the literature indicated that much of the lean thinking has been primarily concerned with sequential production. However, lean thinking is based upon principles of *flow* and *value*, which is also conducive to the complex process involved in design management for *remote sites*. A conceptual model is developed that considers both the production and sociological approaches to design management, in response to the peculiar demands of the site and their project teams.

KEYWORDS

Remote sites, design management, lean design, lean production, design sociology

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INTRODUCTION

The management of design is a complex process requiring integration of a variety of disciplines. It has been well established that this is largely caused by a process that attempts to fuse various aesthetic, functional, social, political, economic and technical objectives from potentially numerous parties, with at times fundamentally conflicting objectives (London 1997). The problem of design management is further exacerbated when we acknowledge that design is often regarded as a search without a predetermined outcome whereas the design process is often about defining that predetermined outcome of performance expectation. It is a quest for innovation by the design and construction teams with each new design scenario setting new parameters and constraints, albeit in some cases only slightly altered.

The design and development process is frequently a team effort involving multiple, informed and ill-informed decision makers and is a complex natural system dependent upon initial decisions. Complex design management scenarios suggest that as areas of professional responsibility become fluid, the manner in which decisions are made by design teams becomes critical for understanding the resultant building performance (London and Ostwald 1996).

The added dimension of remote site construction increases the complexity and criticality of early decision making. The project team is required to address the traditional design problems, but also those that occur as a result of the location of the site and the team's lack of familiarity with the often uniquely social, physical, economic and sometimes spiritual criteria.

The emerging field of design management and the more focussed thinking associated with lean design management will inform the development of a model for design management for remote sites. The topic of remote sites brings with it a range of other fields that could contribute to our understanding; for example international construction, online management and procurement and sustainable development. The field of international construction has in recent years emerged as a growth area, precipitated by the growth of multinationals and lowering of trade barriers which has increased globalisation of construction (Mawhwinney 2001). However this paper is limited to lean thinking and design management fields.

CHARACTERISTICS OF REMOTE SITES

Remotely located sites are most commonly thought of as those that are on an island distant from the mainland, or simply hundreds or thousands of kilometres from major urban concentrations, such as various Pacific Islands or Antarctica. These sites are typically located within environmentally sensitive regions, due to the region being previously undeveloped or underdeveloped. Increasing global awareness of environmental issues and the emergent sustainability movement has focussed awareness, however, there is still very little evidence of research work conducted on remote site design management. Clearly most construction projects have a degree of remoteness and once we accept this notion we begin to view projects through the proxemics lens and explore difficulties associated with remoteness.

Remoteness can be based upon a continuum related to the physical distance of participants from the site:

- All project participants are initially not located adjacent to the project site, ie all design, construction and facility management actors are located in another city / urban area.
- Selected groups of project participants are initially located distant from the site, for example, the design team and project / construction management teams have their offices in other countries, regions etc, but they may move to the region or have agents in the region.
- The majority of project participants are located adjacent to the site and a selected few are located remote from the project site, for example, construction materials and components suppliers are required to transport their products to the site from other regions; or conceptual design teams win international design competitions and are located primarily in other countries or international clients commission new projects in various locations.

The majority of construction projects typically fall within the third category, however in this paper the first category of remoteness, which is the most extreme situation, is considered in detail. Within this type of remote site there are a range of types of projects and there are three predominant property markets including:

- Commercial projects, tourism, ecotourism
- Government /quasi government / ngo projects: scientific investigation, space exploration, earth evolution
- Civil infrastructure: mineral resource exploration and processing, oil/gas rigs, pipelines, dams

CONSEQUENCES OF POOR DESIGN MANAGEMENT FOR REMOTE SITES

The potential consequences of a lack of or poor design management are as follows:

- Design errors which are costly and may be irretrievable until, for example, the next accessible Antarctic summer building season (October to February).
- Rework of design or construction process(es) due to poor communication during construction. This can be caused by a lack of fulltime on site supervision or monitoring of the remote sites or regular physical interaction between participants.
- Delays in the construction project commencing because of varying levels of prioritisation in terms of providing finance, obtaining the necessary approvals or site labour
- Damage and corrosion of materials / products when mishandled or unfinished construction processes, particularly on marine, geothermal or active volcanic sites.
- Logistical errors caused by inaccurately measured or selected materials and their delivery are exacerbated

- Logistic difficulties caused by inaccurate transportation capability assumptions, particularly when, for example, all of the materials have to fit on one site specific shipment.
- Poor communication between the various stakeholders on and off site, caused perhaps by different interpretations of the issues or decisions being made remote from the site itself, and from each other, for example, lack of site supervision by construction organisation, lack of monitoring by design team or the client team
- Time delays in terms of decision making, whether in terms of the design or financial committment causes a flow on affect across all disciplines and tasks, which in the case of remote sites may mean a delay of up to twelve months, until the site becomes accessible again.

In order to understand the reasons, and the need, for good design management of remote sites, two case studies are detailed here, but only in terms of their urban proximity, regulatory frameworks, physical attributes, functionality and environmental impacts/sensitivity. These sites offer very unique challenges to those involved in the design, construction and management process. These challenges are frequently unique to the particular site and project, however, there are increasingly generic characteristics that can be strategically viewed (refer Table 1).

CASE STUDIES

The following remote site case studies were selected because of their contrasting physical attributes, and the very different developmental priorities set by the two sets of clients. The first remote location is Antarctica (the Ross Sea region and the South Pole in particular), and the second is Fraser Island, Australia. Antarctica has primarily been an exploratory investigation base for the world's scientists. Investors and entrepreneurs have also realised the increased potential and value of remote sites. Antarctica has potential for three property markets, including commercial tourist projects, government scientific bases and civil projects for minerals exploration, and is experiencing growth pressure. The number of bases across Antarctica has now increased to 26 and they range in size from 100m^2 to approximately 500m^2.

Scientific and tourism projects are organised and managed within the governance structures determined by the Antarctic Treaty, which is a unique legal agreement ensuring that all member countries work together in Antarctica for only peaceful and scientific purposes (Waterhouse 2001). There is no minerals exploration allowed currently under the CRAMRA agreement (Convention on the Regulation of Antarctic Mineral Resource Activities) and the Antarctic Treaty (1961).

Base stations have been built to support scientific activity. The first of these bases in the Antarctic Ross Sea region, (which comes under the stewardship of New Zealand), was built in 1956/7, to coincide with the 'International Geophysical Year' (IGY) and the associated British expedition. of special interest to the built environment in the Ross Sea Region is the Protocol on Environmental Protection (1991).

Currently, considerable construction and maintenance activity is taking at the South Pole of Antarctica ('Amunsden' station '), where US$200 million is being spent over a 5 year period on building a completely new scientific base station; construction began two years ago. Over the last 10 years, New Zealand and the USA have spent approximately

$US9 million on new buildings at the two Ross Island bases (Scott and McMurdo), (OPUS 1998) and several hundred thousand on the maintenance of the historic huts in the Ross Sea region and which are now a significant tourist attraction.(Waterhouse 2001).

The second case study is the 'Kingfisher Bay Resort'on Fraser Island. This island is 122 km long and is the largest sand island in the world. It lies along the eastern coast of Australia. Fraser Island is one of 14 Australian sites on the World Heritage List of which there are some 700 properties listed worldwide. It was listed in 1992 because of its unique geological, geographical and historically cultural significant features (ICOMOS 1999).

The Kingfisher Bay Resort was opened in 1992 as a fully integrated large scale ecotourist resort. It was designed to give visitors a nature based tourism experience whilst creating minimal environmental impact. The resort has various architectural design features based upon sound sustainable principles for design, construction and operation and has won 35 Australian and international awards for this commitment (ICOMOS 1999). Tourist numbers to Fraser Island have increased rapidly since 1975 and it is currently estimated to receive around 300,000 visitors a year. During 1993/1994, approximately 82,000 camper nights were recorded on the island (Australian Bureau of Statistics 1997).

The sites at Ross Sea Region Antarctica, and Fraser Island Australia, offer very unique challenges to those involved in the design, construction and management process. These challenges are frequently unique to the particular site and project, however it is proposed that there are common characteristics across all remote sites. Table 1 summarise some of the more significant of these characteristics including;

- Proximity to urban areas
- Regulatory framework
- Physical environment
- Functional, aesthetic and social aims
- Environmental impact / sensitivity

Table 1: Remote Site Comparisons (Kestle and London et al. 2002)

Site	*Proximity to major urban areas*	*Regulatory Framework*	*Physical Environment*	*Functional, aesthetic & social aims*	*Environmental Impact/Sensitivity*
Antarctic sites-Ross Sea Region *4 bases*	*Isolated. Distances to major areas:* *South America:1000km* *Australia:2500km* *NZ: 3850km* *Africa: 4000km*	***Antarctica Treaty:** 42 nations- of which 26 are the core, within the Treaty there is Protocol on Environmental Protection (Madrid Protocol 1991)* *Treaty designed for peaceful and scientific endeavours (US space program) and to protect the resources from commercial gain and to keep it a continent free from military arms. Emerging regulations governing environmental sites.(Waterhouse,2001)*	*Hostile climate, extreme cold temps, Coldest and highest continent. World's lowest temp, -89.6C. limited daylight hrs for 6 months and extended daylight hrs for other 6 months. No access during winter months due to ice, high winds, extremely low humidity, no rain* *Ancient landmass.* *2% exposed rock. Ice sheet covers majority of continent- 87% and 11% ice shelf.*	*Primarily scientific investigations- emerging Eco and Historical tourism* *Aesthetics have been of secondary importance. Little thought to the human experience and the built environment except purely on a basic human needs basis related to physical survival.* *Previous threat of mineral resources exploitation.*	***Predevelopment**:* *Largely pristine and highly sensitive* *Mature ecosystem* *Heroic Age: approx 1903-1917, explorers* ***Post development**: limited access to 6 months of the year and highly restricted access to certain sites designated as scientifically significant. Access to other locations is based upon the scientific program team leader and the nature of the program*
Fraser Island, Australia	*Adjacent to Australian landmass.* *270km north of Brisbane*	***World Heritage** listed site due to unique sand ecosystem/ dune lakes geology (world's largest sand island: complex dune systems)etc-* *Coupled with other natural and cultural significance reasons. eg fauna (rare frogs, bats and glider species, as well as marine life) and flora ('wallum heaths' are of particular evolutionary and ecological significance, complex peat swamps), and indigenous culture.* *UNESCO 1972 ICOMOS: 1999* ***Australian Burra Charter** – governed by Qld and Australian Heritage Council.*	*Subtropical, mild winters, hot and wet summers, high humidity, cyclonic zone etc* *Conditions are maritime subtropical with mean annual temperatures ranging from 14.1° C minimum to 28.8° C maximum. Rainfall is high, reaching 1,800mm on the highest dunes in the centre of Fraser Island (DASET, 1991; Sinclair and Morrison, 1990)*	*EcoTourism* *Aesthetics is critical to the resort development as is the relationship between the built environment and the total human experience.* *Threat of sand mining, mineral resources exploitation and various introduced fauna/flora species.*	***Predevelopment:*** *Pristine, evolving ecosystem and highly sensitive.* *Indigenous peoples: 1,200-2000 years ago* ***Post development:*** *Only limited by accommodation and limited restrictions on public access*

There are clear regulatory regimes that govern and restrict the development of these sites. It is interesting to note that both are governed by international law, with the Australian site being governed by the 1999 Australian Burra Charter which is a national framework endorsed by International Council of Monuments and Sites (ICOMOS) - the UNESCO advisory council on preservation of world heritage sites, of which there are 107 member nations. The climates are quite different, with Antarctica having the harshest climate in the world (coldest, driest, windiest), whilst Fraser Island is in a cyclonic zone and can be subject to extremes. These factors impact upon the design and the construction of buildings and infrastructure, particularly in that both have seasonal extremes of weather In Antarctica shelter, warmth, fail safe heating and water services are essential in such a life threatening environment. Currently the prefabricated base station buildings are permanently positioned, however, there is a trend emerging for mobile bases which will have a direct impact on design, construction and design management (Kestle et al. 2002).

The Antarctic is primarily a continent dedicated to scientific investigation (Waterhouse 2001). However, the Antarctic in recent years has emerged as a tourist destination, particularly along the Antarctic Peninsula where there are attractions including seals, penguins and pristine ecosystems. As well, there are the historical sites of the Ross Sea region which relate to the early 'heroic' explorers. Tourism in the Ross Sea region is, however, restricted to on board visitors, with only 385 tourists actually landing in the Ross Sea region in the 2000/2001 season. Fraser Island has become a world renowned ecotourist resort focussed on environmental education and ecologically responsive aesthetics, whereas the built environment in Antarctica is utilitarian and focussed on basic human survival in such a harsh climate. Both of these sites are highly sensitive environments where impact is strictly controlled.

Strategic decisions are demanded by both sites with regard to sustainability and the logistics of the construction of the project. Information technology advances are enabling greater accessibility globally in terms of telecommunication access to an increasing number of 'remote sites'. The extremes experienced on these projects distinguishes these sites from the more traditionally urban site when developing a design management model. It is useful to now consider design management literature to provide a framework for these sites and therefore a selected review of both design management and lean design management literature is undertaken.

SELECTED REVIEW OF LEAN DESIGN MANAGEMENT LITERATURE

It is well documented that 'Toyota' first introduced the concept and then the implementation of lean production (Howell 1999). There are five key lean design management principles being Value, Value Stream, Pull, Flow and Perfection (Womack and Jones 1996).

These early principles were considered further by Garnett et al. (1998), who postulated that several different *value* strategies need to occur within single projects as the client may have one definition of value, whereas the end user or the stakeholders may have others. This is not dissimilar to previous design and value management literature.

Howell and Ballard (1998), determined that: *Lean is a value seeking process that maximises value and continually redefines perfection* and that *the goals of lean thinking redefine performance against three dimensions of perfection*

(1) a uniquely custom product,

(2) *delivered instantly, and*

(3) *nothing in stores.*

This, in their view, essentially maximises value and minimises waste. This third dimension of perfection certainly has relevance for the Antarctic sites in particular, as discussed later in this paper. They further suggest that *Lean thinking forces attention on how value is generated rather than how any one activity is manage*d (Howell and Ballard 1998)

In exploring the literature on lean thinking to date, much of the research falls into the tactical category rather than being strategic and theoretical, that is until the work of researchers Koskela (1997) and Seymour (1999). Seymour (1999) suggested a proposal for implementing lean construction at the organisational level rather than just at the operational level. This work was then followed up two years later by Seymour and Rooke (2001) using an ethnomethodological approach in terms of setting up an organisational culture that established how people may perform their sitework activities in a visibly orderly manner, by changing their mindset, for instance.

Similar to findings by London's research (1997), were suggestions by Howell and Ballard (1998), that changes of the mental model needed to be made. They further suggested that lean thinking, applied at the beginning or alternatively applied midway in well run projects, revealed the weaknesses of the current systems by mapping the project value stream, and hence reinforced the power of lean thinking.

The manner in which the design process stage is handled has a significant, and often deleterious effect on all of the subsequent stages of construction project production, (Huovila 2000; Ballard 1998; Formoso (1998). These researchers recently put forward a range of propositions to minimise the problems for the production personnel, including integrating the design and construction processes, and changing mental attitudes. The separation of design and construction had long been identified as one of the key problems of construction, and that whilst design and build goes some way toward organisational integration, Huovila (2000), Ballard and Koskela (1998), and Formoso (1998), still believe that there is significant room for improvement in terms of the design process.

In lean design management, others have sought to explore not simply value as an important part of design management but other models which include conversion and flow. Further to the work of Formoso et al. (1998), Ballard and Koskela (1998), Alarcon and Freire (2000), again concluded that three distinct models -conversion, flow and value generation - comprise the process of lean design but added that the principles of lean design are generally unknown to the general public. An analysis of the application of some of the lean construction principles to design management from the point of view of design as conversion, flow and value generation was made in a paper by Tzortzopoulos and Formoso (1999). The two Brazilian case studies in their paper found some gaps in the knowledge of the application of theory in design and in particular the value generation view of design concepts and principles.

The lean design literature primarily focusses on the production approach and processes, but a few of the researchers, for example (Garnett 1999, Huovila et al. 1998) adopted a more sociological approach to lean design. The lean design principle of 'flow' is relevant from a sociological and environmental viewpoint, as it tends to be focussed on a more holistic approach for theoretical and project development work. In additon, remote sites which are frequently environmentally sensitive, may need a more holistic approach.

An ethnographic case study was made of the partial implementation of the value stream approach on a construction project by Garnett (1999), and the model created was

tested to develop a target baseline for improvement throughout the entire process. The results to date suggest that the UK construction industry is challenged by the cultural change, whilst several US companies have witnessed significant gains by employing lean thinking. Garnett (1999) believes that her research will contribute to new theory on lean thinking by taking a social constructivist methodological approach to the process work, *"through ethnographic case-based research"*.

The question of how to use lean production philosophy to promote the necessary changes in the design process is significant. The essential lean construction principles of integration and minimising design procedure conceptual changes, would increase buildability and lower the production costs of a project. (Melhado 1998).

The implications of lean thinking and production show that it is worth reflecting on how lean thinking coordinates action (Howell and Ballard, 1998). Specifying value by product to the customer shapes all actions around customer requirements and managing the work flow at the design phase of the projects. Focussing on the design phase is one of the challenges for this new discipline (lean construction). Historically in construction, specifying value has often come before design (Ballard 2000)

Lean thinking is based upon principles of *flow* and *value* within the context of a *production oriented world* and can contribute to remote site design management. Also of increasing importance, is the acceptance of a *sociological oriented worldview* of design management.

SELECTED REVIEW OF DESIGN MANAGEMENT LITERATURE

Design management from within the disciplines of the built environment is a complex process concerned with:

- Value generation
- Integration of specialist knowledge
- Critical timing of key decisions

These are now explored in more detail. Firstly design management is fundamentally concerned with value generation however understanding what constitutes value is a difficult process. The design process has become more complex and more fragmented in recent years resulting in more actors who have design knowledge that require integration (Tombesi 1997). This impacts upon a number of factors, not the least being the difficulty of the development of a shared understanding of the objectives for a project among stakeholders. This shared understanding towards identifying what is valued in the project impacts upon how critical decisions are made on design issues. This is an important point in the development of the design management field as it is the integration of those who have knowledge that can contribute to the design, construction and management, which is critical to developing and achieving value on projects.

It is suspected, though, that the process is not simple and straightforward, instead, design management is a complex social situation as value can be a socially constructed phenomenon and decision making to that end can be inherently unpredictable. Design decision making is often negotiated amongst groups and teams – it is an iterative process. The stakeholders of value can also change through the various stages of the design, construction and occupancy stages and each group of actors may differ in perspective based upon their worldview. The power to negotiate and guide design decisions and assist

with establishing building performance criteria changes at different times of the process – in many cases their voice is not heard at critical times (London 1997, 2002).

Poor integration of specialist user and producer stakeholder knowledge can have far reaching consequences, such as inappropriate synthesis of the needs analysis leading to low value generation for the client and users. In many cases identifying value is a socially constructed process between the stakeholders, who incidentally are not just design and construction teams– but are those actors who can contribute to improved design and construction building performance (London 2002)

In recent years the need for the role of design manager has become more apparent- that is a specialist who integrates and coordinates the design process. Gray and Hughes (2001) discuss design management and identify two levels of responsibility for the design and its production, the associated authority for decision-making, and responsibility for the interface with other organizations. They maintain that the task of the design manager is to ensure that the organisation of the design process is structured appropriately, to ensure that there are sufficient integrative and coordinating mechanisms for the work to progress meaningfully. They claim that a framework has to be established which keeps the focus on the tasks and objectives to achieve the value criteria set down in the initial stages.

An alternate position was taken by Green (1994) when researching in the value management field. He adopted the approach of placing value generation at the centre of the design process rather than employing outside consultants to carry out a series of value engineering critiques throughout the various development stages. This is not unlike the study conducted by London (2002) whereby she tested a design management model for the development of performance based briefing and analysed group interaction between stakeholders. The premise was that there was no need for an external chief decision maker, however there was a need for a design manager to integrate and manage knowledge that is within the stakeholder groups. The nature of complex group dynamics affects design and building performance criteria.

When there is a strict timeline for the completion of a project, for example, a restricted window of constructability and accessibility to the remote site due to climate or other reasons, the timing of the decision to proceed toward the concept design stage and financially commit to the project is absolutely critical to the subsequent design and construction stages and completion of the project on time. The resultant of delays in making key decisions can mean that the entire project becomes unviable on remote sites, particularly where accessibility is limited by seasonal weather conditions.

Ballard and Koskela (1998) suggest that there is very little literature on design management theory, and claim that the way forward for design management is to have *a management philosophy and tools that fully integrate conversion, flow and value perspectives.*

CONCEPTUAL DESIGN MANAGEMENT MODEL FOR REMOTE SITES

In developing a conceptual model for remote sites, an exploration that draws on the key concepts and principles of design management and lean design management literature, has been initiated.

One of the significant outcomes of the review of lean design management and design management literature is the important contribution of process integration to a design management model for remote sites.

This model has been set up in terms of reviewing design management 'production principles', 'sociological factors', restating the 'characteristics of remote sites', and then developing a preliminary model that identifies the key factors of design management for remote sites (refer to Figure 1).

The traditional lean design management principles of value stream, process integration, workflow and waste minimisation can be applied to remote and often hostile project sites in Antarctica. These project sites are closely aligned to lean and functional production processes, as the main priorities for the client are shelter, a strict budget, tight timelines and a process driven construction programme. The development of these sites, then, potentially fits with the 'traditional lean thinking design management model', in terms of the sequential process and flow approach. However, under the Antarctic Treaty (1961) and the related Protocol for Environmental Protection (1991), all development projects on Antarctic sites also have to fully comply with the Protocol, particularly in terms of minimising environmental impact. This means in effect that the traditional lean design management approach does not fully address all of the factors associated with remote site design management.

The more holistic approach to lean design management as explored by a few researchers over the last few years identifies additional significant design management factors. These researchers refer to the importance of and the means to achieve sustainable development. They believe that whilst traditional design and construction focusses on cost, performance and quality objectives, sustainable design and construction by comparison, focusses on value generation, minimization of resource depletion, minimization of environmental degradation and the importance of information flow management.

Clear and effective communications, whilst important on any project , become critical on remote sites. The following design management factors should therefore be included when discussing remote site projects: 'information management', 'knowledge integration', and 'timely decision making'

Information management can be considered from a sociological viewpoint. However it has a significant effect on production factors/processes, if planned or implemented ineffectively. The decisions made, and the successful implementation of those decisions, by all personnel, depend on regular and clear communications, whether verbal, digital or in the form of hardcopy documentation.

On remote sites, in particular, miscommunications can be critical to the viability and completion of the whole project, given limited physical accessibilty in many cases. Poor information management can create confused site/office personnel, resulting in mistakes requiring rework on an already tight timeline, costly overruns, lack of task completion on /off site and value degeneration from the client's and stakeholders'perspective

Given the characteristics of remote sites (refer Figure 1), the principles and concepts of 'value generation', 'knowledge integration', 'decision making' and 'process integration' become key factors of this exploratory design management model for remote sites.

Value generation refers to the value that the client and stakeholders place on the project and site. Value generation in this context is primarily concerned with the environmental protection of the site, given public accessibility to the site, and the site's global value. Value generation from the perspective of the project itself occurs mainly as

because of the manner in which the overall environmentally sensitive design approach is applied to the site.

Specialist knowledge of remote and often hostile sites is essential on these construction projects. Knowledge integration, therefore, involves in-depth pre-design briefing by and of all the specialist personnel involved on the project, and detailed pre-planning of all the construction phases.

Timely decision making refers in the main to financial and design decisions, which are critical to the successful management of the design and construction of remote site projects. These decisions are made within the context of non-negotiable windows of buildability, fixed budgetary constraints, and the need for environmentally sensitive development of these remote, pristine and often hostile sites.

Process integration, involves several aspects, ranging from construction planning methodology, logistics, and information management, to the influence that the creative design stages can have on the overall process management of the total project. Logistical planning and implementation is complex and critical for remote sites. For example, in Antarctica, where access to sites is limited to a four month window, and life threatening situations are the norm, logistical resources and their deployment have to be preplanned up to a year ahead of implementation. In response to the tight timeline and frequently adverse weather conditions, the antarctic construction projects are largely prefabricated into their various components prior to despatch to the site(s). The timing, costs and weight restrictions associated with shipping or air freighting building components, add to the complexities of the logistical aspects of a design management model for remote sites. A design management model that responds to and reflects the need for a well integrated specialist design and construction actors is essential. To achieve an integrated process, alternative and unique procurement strategies may be required.

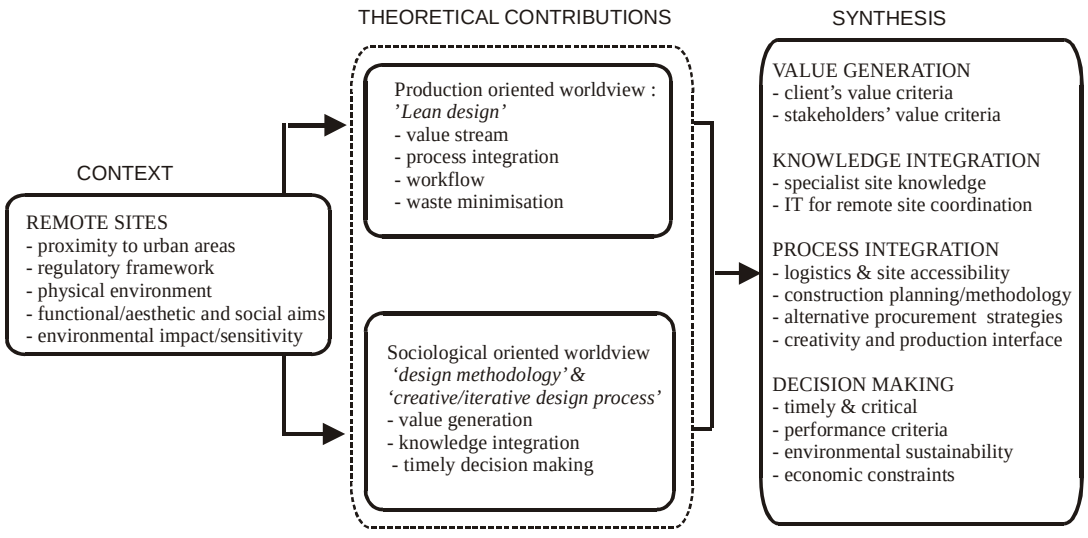

Figure 1: Exploratory Design Management Conceptual Model for Remote Sites

CONCLUSION

This paper presents two exploratory case studies to highlight the factors that need to be considered in the development of a conceptual design management model for remote

sites. The literature review, to date, indicated that much of the lean design management research has been primarily concerned with sequential production and that a few authors are exploring a more sociological design management approach. The production oriented view can assist the sociological view to develop a conceptual design management model for remote sites. Both of the investigated sites (Ross Sea region bases in Antarctica and Fraser Island, Australia) would fit the sociologically oriented holistic design management model in varying degrees, and both draw from the production oriented worldview of design management (refer Figure 1). However at this early stage of developing a conceptual model, a further literature exploration needs to be undertaken to determine the exact extent to which management of the design process for remote sites can be informed by lean thinking and a more developed model created for testing and eventual implementation.

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