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How Would the Management of Design Projects Change into the Future?

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Abstract
The design phase of an engineering and construction project is often described as the knowledge phase of the project delivery. This is because it relies heavily on the knowledge input of various design and engineering specialists and the output from that phase is typically information. Collaboration of these specialists making a team often presents considerable challenges. Where members making up the team are geographically remote from each other, this often results in a heightening of the potential challenges associated with such teamwork. The possibilities of remote working through virtual environments made available by IT and other technological solutions equally give rise to new ways of interaction for project teams.
The authors outline how these emerging developments will help to shape the current challenges of delivering design projects into the future. A framework of the possible transition to a future state of design-work environment, which captures the elements of people, organisation, process and information, is presented and discussed. The authors focus on the scenarios of the possible future state to provide lessons for the AEC sector both at industry and academic levels.

Keywords
Design, Organisation, Construction, Aerospace, Project Management

1. Introduction

Projects in construction and engineering involve several stages which collectively can be categorised under pre-production, production and post-production phases (Cooper, 1994; Gregory and Deasley, 2003;). The design aspect of any such project forms part of the pre-production phase, and is often described as the knowledge phase for the project delivery (Wootton et.al, 2003). Typically, the design aspect entails reconciling the knowledge inputs of various design and engineering specialists as well as other non-technical stakeholders (Lazarus, 2001; Vossoughi, 1998). The output of the design aspect of projects is typically *information* represented in graphical or descriptive form (Anderson and Tucker, 1994). McCaffer and Edum-Fotwe (2003) aptly described the processes involved in the design activity within projects as *information transactions*. Viewed from such a perspective of information transaction, design reflects the degree of flux that the ICT sector is exposed to. This presents a strategic issue for design and project organisations, who have to be able to manage their future viability within such an environment of milieu. This paper is based on the *Telegenesis* project which focuses on how design would evolve over the next

two decades in distributed project environments for low volume complex products (Edum-Fotwe et al., 2004). It addresses design from the standpoint of the aerospace and Architectural and Engineering Construction – AEC sectors, where low volume complex products are the norm, and there is considerable similarity in the nature of the sector as well as project structures.

The outcome from the study provides some insights on and suggestions for potential innovation and improvement in the use of, and management of design operating in distributed environments. The authors outline how these emerging developments will help to shape the current challenges of delivering design projects into the future. A framework of the possible transition to a future state of design-work environment, which captures the elements of people, organisation, process and information, is presented and discussed. The authors focus on the scenarios of the possible future state to provide lessons for the AEC sector both at industry and academic levels. The subsequent sections of the paper provide a brief overview of the *Telegenesis* project, and a consideration of sector context to illustrate the wider applicability of the issues the reflected by the transition into the future. This is followed by a consideration of future design, and results from the analysis of future changes to design projects. The paper ends with a brief discussion of the lessons for construction.

2. Telegenesis

The *Telegenesis* term represents the concept of 'giving naissance at a distance'. This reflects the essence of distributed working that is becoming the norm in design environments, whereby key actors collaborate from disparate locations to bring about a complex product. Further details on the objectives and scope of the TELEGENESIS project, as well as the Reports for the five Tasks making up the project, can be obtained from the Offices of Innovative Manufacturing Research Centre (IMRC) at Loughborough University or the project website (www.telegenesis.org).

This paper concentrates on providing some insights on how the current state of design for complex products will evolve into the future against the backdrop of the principal *drivers of change* in the aerospace and construction sectors. These drivers reflect *technical* (including both Information and Communication Technologies – ICT and non-ICT technologies as well as processes), *organisational* (including business, globalisation, regulatory frameworks and design work environment), and *human requirements* (including skills and knowledge acquisition, socio-cultural factors and team structures). The essential aspect of providing such a futures lookout is rooted in the development of a *transitional framework* and a simple accompanying *evaluation system* to enable design organisations as well as sectors to assess their state of development towards the projected futures (Edum-Fotwe et al., 2004).

3. Sector Contexts

Gregory and Deasley (2003) describe aerospace as a sector that has developed from an industry with dozens of companies, each capable of carrying out the design and manufacture of a complete aircraft project, to a global industry where a small number of major companies frequently rely on international co-operation for major projects. Engineering principles relies on an appreciation of the overall product life cycle, to improve efficiency. Distributed design is increasingly prevalent, both for combining the capabilities of different geographic locations within the company and their partners and also for interacting with the suppliers of major components such as engines and avionics. ICT tools are essential to the aerospace industry, with 3D Modelling being the norm. Modelling, simulation and supporting analyses have advanced rapidly in recent years and will continue to get more sophisticated as they are developed to tackle the ever-increasing complexity of design tasks undertaken to satisfy the conflicting requirements of performance, affordability and sustainability. There are increasing pressures arising from 'people' issues affecting the culture of

distributed teams. Methods of team working and team selection will continue to develop, and training will need to keep pace with this for maximum effectiveness.

The AEC sector has witnessed a gradual transition over the past four decades from an overbearing focus on the production to a situation whereby increasing attention is given to the delivery of the pre-production aspect of the project (McCaffer and Edum-Fotwe, 2003). This has been driven in part by the quality agendas of the last two decades, and growing competition within the sector. The pre-production phase of the project is dominated by business case development, the design and associated project management, and naturally lends itself to a distributed approach to delivering a solution. This is because the output from the pre-production phase is not localised as is the case for the fixed site-based production phase. At the production phase the operations involve the utilisation of large stocks of natural resources, the processing and incorporation of which affects the natural environment, often adversely. The need for a sustainable approach for the utilisation of these resources in the past two decades has given rise to a sustainable construction agenda (Technology Foresight Panel on Construction, 1995). In such an environment there has been a growing realisation of the need for management of human capital as it relates to the design as well as the methods that by which the design solution is delivered (Latham, 1994; Egan, 2002). The development effort addresses not only the technical aspects of design know-how, but also the influence that ICT is playing to transform organisations and production activity. ICT tools are extensively exploited to support many design tasks. The delivery of AEC projects have up until now been based on a functional specialisation. A consequence of this functionally driven delivery has been the distribution of work packages in AEC on the basis of functional specialisation, resulting in a less optimal solution for the whole project, as architects, and engineers optimise their solutions in isolation. To achieve effective integration for the design solution, options outside the design task would have to be contemplated, since most designers are *programmed* to perform a particular function in a specific way (McCaffer and Edum-Fotwe, 2003).
Historically design outside AEC, such as in product design, was an almost invisible function in the development process of new products. The benefits of good design have been emphasised by successive governments in the UK, and are now recognised by trade bodies and many others as a critical aspect of business. Design remains a largely in-house function for global business such as the motor industry, but is invariably out-sourced to specialised consultancies who operate on a worldwide scale and who must interact with a complex network of other designers and suppliers.

4. Design: the emerging future

The survival and future success of all design organisations depends upon how effectively they can anticipate and respond to unexpected and foreseeable change (De Bono, 1992; Lazarus, 2001). To be able to anticipate such futures, designers and managers of the design activity in projects require appropriate scenarios of the future to enable them rehearse how they would cope with the change it imposes and so plan for it more effectively (Cramer, 2005). The subsequent sections address the scenario issues that were employed in exploring how design would change into the future.

4.1 Scenario Issues

There are a number of issues and influencing conditions within the aerospace and AEC sectors. These issues have contributed to what design and the related organisations currently look like and how they will evolve over the next two decades. They can be summarised as follows:

- Increasing cost, time, and quality (reliability)
- Increasing client demand for physical and financial risk protection
- New and emerging codes, standards, and regulations with implications for design
- Increasing costs for workforce protection, both at national and international level
- Accelerating demand for technology innovation (small scale, automated, intelligent, integrated)

4.2 Scenario Assumptions

The scenario assumptions address four key areas of product/process, demand and supply (clients and delivery organisations), technology, and design work environment and are projected to a period of twenty year horizon. An initial list of 120 issues and assumptions were subsequently refined to thirty –two firm scenario assumptions. These scenario assumptions were combined to produce the transitional framework (see Figure 1) on how design in aerospace, construction and product design sectors would progress over the next two decades.

5. Design Transitions 2003- 2020

The exercise to establish the possible futures of the design activity in projects involved a series workshops that relied on the use of the Delphi technique to prioritise the principal factors that should form part of a framework to provide a chain scenario from the current context to the a 2020 horizon. Figure 1 presents the transitional framework that emerged from the exercise. The transitional framework was developed by using the data collected from the workshops attended by cross-sector industry representatives (Edum-Fotwe and Thorpe, 2003). The purpose of the framework is to serve the futures requirements of design communities across in aerospace and AEC sectors.

The framework presents a 2020 horizon scenario of design that is characterised by designers that operate as self-directed multifunctional teams that respond to their own training needs as well as the demands of the market place and projects. The processes for design will involve distributed teams that are self managed and well driven towards the project needs, with the design solution being considered from a whole-life ownership perspective. Design teams would form and disband in rapid and flexible fashion, with reduced face to face interaction between various specialists. The technological infrastructure that supports them would reflect grid computing, with complete interoperability between different systems that are intuitive and readily customisable. The design know-how itself would be widely shared, and be readily accessible. In its current form the transitional framework is aimed at:

- enabling organisations to position themselves
- provoking discussion and to generate more specific scenarios
- assist in generating technology requirements and strategies for change
- assist directly or indirectly in benchmarking design development.

The key to making use of the transitional framework is that acting in only one of these elements or transition states alone is not enough to improve design development at organisational or sector level. The different elements presented within the framework should be seen as mutually reinforcing. Achieving sustained progression in design would therefore require a comprehensive strategy based on addressing all the different elements.

6. Lessons for design in AEC projects

While there are examples of design practices within AEC sector that reflect stage scenes for each change element across the framework, the majority of practices associated with the design aspect of projects are typified by the scenes in stage one. Transition towards stage four requires a critical mass which currently does not exist for construction. For example, the major constraints in achieving full deployment of current technological solutions in design are more socio-cultural than technical possibilities. The construction sector is more fragmented and dominated by complex, and a multiplicity of contractual arrangements. This feature of the AEC sector has often militated against the full exploitation of the principles and protocols required for operating in distributed environments. The use of dispersed, cross-functional development teams - typified by distributed design teams - involves a wide range of business, technical, social and

knowledge-based challenges in the dispersed work. Understanding and appreciating these challenges are fundamental to the competitiveness of distributed design organisations. There is the need for research to assist in the maturation of current technologies in design environments both from technical as well as socio-economic standpoints.

7. Conclusion

The authors have presented some of the results from a foresight project that explored alternative scenarios of chain developments that could transform the current scene of the design activities in projects for the construction sector.

Issue	Stage 1 (2003)	→Stage 2 (2010)	→Stage 3 (2015)	→Stage 4 (2020)
A. People: Education Training Skills	Individual organisational training based on functional specialism and legalisation. Teams skills poorly specified and underdeveloped	Multi-organisational training for multi-skills, cultural awareness and technology integration. Improved team working skills.	Clearly understood training needs for distributed design and ICT-facilitated, integrated teams Developed distributed design teams skills.	Self-directed, multi-functional team training, reactive to demand or project.
B. Process: Product development	(Product) development focus. Issues of whole life recognised but not fully realised.	Whole life cycle focus partially implemented, driven by government and market developments (e.g. PFI, PPP, etc.)	Whole life ownership and service delivery approach tested and commonly implemented.	Whole-life ownership and service delivery focus are standard.
C. Process: Process development	Company-focused, high-level processes	Project-aligned processes facilitated by technology	Supply network focused and aligned processes.	Self-generated, managed and distributed processes driven by development and team needs.
D. Organisation: Collaboration	Supply chain management. Informal networking. Informal team formations.	*Networks* – Aligned companies harnessing synergies between technical specialists	Rationalised global supply networks, sharing risk and reward in product development, which is service delivery driven.	Global-clustered organisations that design, make and service products
E. Organisation: Design Teams	Informal team formations Face-to-face communication dominant in distributed design.	Face-to-face still required. Increased ICT support for distributed teams	Speed and flexibility incorporated into team formation. Sophisticated ICT communication supplemented by face-to-face where necessary	Rapid and flexible formation of design teams within a forma framework is the standard approach. Sophisticated technology minimise face-to-face interaction.
F. Technology	Discrete functional tools	Wireless computing as standard Ease of use, common standards and integration are priority for users.	Intuitive, human-centred, interoperable systems available	Integrated grid computing. Complete interoperability. Intuitive, intelligent and customisable systems.
G. Design knowledge	Management of design knowledge is inconsistent, but requirement is recognised. Knowledge management systems embryonic	Design knowledge requirements better understood. Increased ICT support and competence building for design knowledge management	Design knowledge tailored for use by appropriately skilled design teams. Movement towards design knowledge systems.	Intuitive design knowledge management systems Easily accessible and tailored to needs.

Figure 1. Transitional Framework for Design Futures in Aerospace and AEC Sectors

This is presented as the transition framework. It can be appreciated that the influence of ICT tools is fostering a shift in the way designers will work into the future. Whilst their current skills would still be relevant in the emerging work environment, additional skills and know-how become apparent. These additional skills are predominantly human and social oriented. The essence of design will remain as information and knowledge transaction. However, the medium in which this transaction will transpire as well as the conversion processes associated with the transaction will continue

to be driven by available technologies and commercial competition. The skills for ensuring effective management of knowledge in these emerging team environments are still evolving but are predominantly "soft" in nature. The results of the analysis presented a number of issues that need addressing to ensure that designers can be effective in possible future work environments. Notable is the need for migrating from 2D to 3D as the medium for design and underscores the enormity of the challenge of making the transition form ICT support to ICT medium in design.

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