SPECIFICATIONS FOR A REQUIREMENTS-CENTRED PROJECT PROCESS

John M. Kamara[1](MASCE), and Chimay J. Anumba[2](MASCE)

ABSTRACT

Clients are central to the Architecture, Engineering and Construction (AEC) industry and the adequate implementation of their requirements is vital for project success. To this end, many tools, such as the Client Requirements Processing Model (CRPM), have been developed to facilitate the capture and representation of client requirements in design. The CRPM describes how client requirements can be defined, analyzed and translated into solution-neutral specifications for design. This paper extends the philosophy of the CRPM to the entire project lifecycle and introduces the concept of a requirements-centered project process. The meaning, rationale, and specifications for such a project process, which centers on the development and management of an interactive and dynamic Project Requirements Document (PRD) are described. The paper concludes with a discussion of the potential benefits of a requirements-centered project process, and suggests areas for further research.

KEY WORDS

AEC industry, client requirements, construction project process, requirements management

INTRODUCTION

The Architecture, Engineering and Construction (AEC) industry exists to service the needs of its clients who commission and pay for the design and construction of facilities such as buildings, roads and bridges. The quality of service provided by the industry (and that of the resulting built facilities) depends on various factors which include the project organization, design quality, skills of the construction work-force, and quality of materials used. But this process begins with an understanding of the requirements of the client, and the extent to which these are incorporated into the design and construction process. The word 'client' is used in this paper to refer to the individual or organization (the 'client body') representing the owner and buyer of construction services, users of the facility and other individuals or groups ('interest groups') who influence, and are affected by the acquisition, use, operation and demolition of the proposed facility (Kamara et al. 2002). Client requirements therefore refer to the "collective wishes, perspectives and expectations of the various components of the client body" (Kamara et al. 2002).

[1] Senior Lecturer, School of Arch., Planning & Landscape, Univ. of Newcastle upon Tyne, Newcastle upon Tyne, NE1 7RU, UK, Phone +44 (0) 191 2228619, FAX +44 (0) 191 2228811, j.m.kamara@ncl.ac.uk

[2] Professor & Director, Centre for Innovative and Collaborative Engineering (CICE), Loughborough University, Loughborough LE11 3TU, UK, Phone +44(0)1509 222615, FAX +44(0)1509 223982, c.j.anumba@lboro.ac.uk

The acknowledged importance of clients to the AEC industry has, over the years, intensified calls for the construction process to be more client-oriented (Latham, 1994, Egan, 1998); and for clients to be more responsible in their dealings with the industry through a clients' charter (CCG, 2001). In support of these calls, many initiatives have been undertaken to improve "the process by which a client informs others of his or her needs, aspirations and desires..." (CIB, 1997). Examples include work by Barrett and Stanley (1999) (on defining key success factors for briefing), Blyth and Worthington (2001) (in devising ways for managing the brief for better design), and Kamara et al. (1999 and 2002) (on the use of structured techniques for the capture and processing of client requirements). Other related tools for assisting the industry to be more client-oriented include the Design Quality Indicator (DQI) (a process for evaluating design quality of buildings – CIC, 2003), and the Integration Toolkit which provides guidance on the how to assemble integrated project teams and supply chains that will better serve the interests of clients (SFC, 2003).

The Client Requirements Processing Model (CRPM) and its related software application (ClientPro) developed by Kamara et al. (2002) was designed to facilitate the definition, analysis and translation of client requirements into solution-neutral design specifications. The main stages of the CRPM are briefly described in Table 1.

Table 1: The Main Stages of the Client Requirements Processing Model

Main Stage	**Activities**	**Required Tools**
Define Client Requirements	Establish basic facts about the project and the client Identify and describe 'interest groups'. Elicit information about the end product (e.g. function, users) and associated process (e.g. acquisition) and life-cycle (e.g. operation) information.	A multi-disciplinary requirements processing team Elicitation techniques
Analyze Client Requirements	Structure and prioritize client requirements Restate client requirements into primary, secondary and tertiary requirements Determine the relative importance of 'interest groups' and prioritize tertiary requirements	Requirements processing team Decision making techniques
Translate Client Requirements	Generate design metrics & determine target values for these design attributes using relevant project, & other information Map tertiary client requirements to design metrics (DM) to determine which DM best satisfy a particular requirement; Prioritize DMs which have been matched with client requirements; Prioritized DMs and their target values constitute the solution-neutral specifications.	Requirements processing team The Quality Function Deployment (QFD) 'house of quality' matrix

In the CRPM a distinction is made between "client requirements" (as defined above) and "project requirements" – the latter refer to the mix of client requirements plus all other requirements (e.g. site conditions, environmental, regulatory, design and construction requirements) that contribute to the successful delivery of construction projects. The CRPM, focuses exclusively on client requirements, and, like other similar processes and tools for briefing, on the initial stages in the project process. While it is understandable that previous initiatives are based on research with limited scopes, the resulting outputs do not provide an explicit overview of how client requirements are managed over the lifecycle of a project. For the construction process to be truly client-oriented, it is helpful if there is continued focus on the wishes of the client throughout the course of a project.

This paper is an attempt to extend the CRPM to the entire project lifecycle with a view to developing a requirements-centered project process. It begins by describing the construction project process and the current approach to client requirements management in the AEC industry. It then outlines strategies for a requirements-centered project process and concludes with a discussion on their likely implications and makes suggestions for further research.

THE CONSTRUCTION PROJECT PROCESS

The project process is the framework for realizing the vision (or requirements) of the client. Given the definition of a project as "a unique process, consisting of a set of coordinated and controlled activities with start and finish dates …" (ISO8402 in Lockyer and Gordon, 1996), a construction project can be deemed to 'start' with the 'decision to build' (i.e. when the client decides that a construction project is required to satisfy his/her business need) and 'end' with the completion/handover of the facility in question. The 'set of coordinated and controlled activities' between this start and end points, are referred to here as the 'construction project process.' It is acknowledged that activities before the 'decision to build' and after 'completion/handover' are crucial to, and are part of a facility's life-cycle, but our focus in this paper is on the project that translates the client's vision into a physical reality.

Many models have been developed to represent the process of design and construction. These include the Royal Institution of British Architects' (RIBA) 'Plan of Work' (RIBA, 2004), the Institution of Civil Engineers' (ICE) 'Civil Engineering Procedure' (ICE, 1996), and the Generic Design and Construction Process Protocol (otherwise known as the "Process Protocol") (Cooper et al. 1998; PP, 2002). Both the RIBA Plan of Work and the ICE procedures set out the project process involving architects and civil engineers respectively, and define the nature of their involvement at specific stages during a project. The Process Protocol (PP) was designed to facilitate a whole project view, progressive design fixity, and the adoption of a consistent process by all team members (PP, 2002). The PP has nine activity zones and ten process phases (Table 2). An activity zone is "a structured set of sub-processes involving tasks which guide and support work towards a common objective" (PP, 2002). Process phases relate to phases in the overall project beginning with "demonstrating the need" (phase 0) up to "operation and maintenance" (phase 9). These phase can however be grouped into "Pre-Project" (Phases 0, 1, 2 and 3), "Pre-Construction" (Phases 4, 5 and 6), "Construction" (Phases 7 and 8), and "Post Completion" (Phase 9) (Table 2). The scope of our analysis, as indicated above, is on the "Pre-Construction" and "Construction" phases.

Table 2: Overview of the Process Protocol (adapted from PP, 2002)

Activity Zones	Process Phases (0-9)									
	0	1	2	3	4	5	6	7	8	9
	Pre-Project				Pre-Construction			Construction		PC*
Development Management	Demonstrating the Need	Conception of Need	Outline Feasibility	Substantive Feasibility/Outline Financial Authority(FA)	Outline Conceptual Design	Full Conceptual Design	Coordinated Design/Procurement/Full FA	Production Information	Construction	Operation and Maintenance
Project Management										
Resource Management										
Design Management										
Production Management										
Facilities Management										
Health/Safety Management										
Process Management										
Change Management										

*Post-Completion

A requirements-oriented (or 'requirements-led' – Higgins (2005)) project process can be defined as a process where there is explicit (forwards and backwards) traceability to the requirements of the client, where every action can be traced back to the original wishes of the client. The ultimate goal is that the final output truly represents the wishes of the client. A 'requirements-oriented' project can also refer to a process that is 'requirements-driven'; that is, each activity is driven by the requirements for executing it in a way that enhances quality and satisfies the wishes of the client. For example, design will be driven by 'design requirements' (e.g. adequate information and time to develop solutions), construction will be driven by 'construction requirements' (e.g. clear specifications and schedules, adequate float between activities, etc.). This underscores a customer-driven approach where recipients of information and/or resources are the 'customers' of those providing that information or resource. All the parties involved in a project therefore become a network of customers and suppliers. Again, the ultimate goal of a requirements-driven process is client satisfaction and the delivery of excellent value-for-money for the client.

In this paper, our focus is on the explicit traceability of client requirements throughout the project lifecycle. The proposition is that while there are many established and emerging processes and practices that invariably deliver client requirements (and can be described as 'client-oriented'), more systematic and explicit mechanisms are required to ensure that there is continued focus on the requirements of the client. This focus on a requirements-oriented

project process is a response to previous calls (e.g. by Egan, 1998) for the AEC industry to be more client-focused in its attitudes and practices. This obviously suggests that although construction projects usually lead to completed facilities, the processes adopted are not necessarily 'client-focused' (or in the best interests of clients). Previous initiatives in process management improvement in the industry (e.g. Process Protocol (PP, 2002) and Integration Toolkit (SFC, 2003)) also reinforce the need for projects to be more client-oriented. However, in acknowledgement that current practices in the industry do contribute to the delivery of client requirements, the next section reviews and assesses existing mechanisms for, and related research on, the management of client requirements in the AEC industry. This provides the context for our specifications for a requirements-oriented project process.

MANAGING CLIENT REQUIREMENTS IN CONSTRUCTION PROJECTS

There are many activities and (established) practices in the AEC industry that ultimately deliver the facility commissioned by a client. For simplicity, these are discussed under 'procurement and contract strategies' and 'project management'. Emerging practices for effective project delivery and related research are also discussed.

PROCUREMENT AND CONTRACT STRATEGIES

Procurement is "the total process of procuring construction work from the client's initial idea to his occupying the finished asset" (Ferry 1991). This incorporates the idea of a project (as defined above) but can include many other activities (e.g. all the phases of the Process Protocol in Table 2 above.). The procurement of constructed work is usually closely associated with the contracts that the client enters into between him/herself and various parties involved in the design and construction of a facility. The most commonly used procurement method is the 'traditional method' where design is separated from construction. The client engages a designer (or a team of consultants) to translate his/her requirements into a design; a contractor is then selected (usually through competitive tendering) to construct the works, with the designer acting as consultant to ensure that it is built according to their specifications. Contracts define the legal obligations and rights of the parties involved, the apportioning of risk, the basis for payment and for resolving disputes. There are many standard forms of contracts that define different relationships in the procurement of projects, and their use has become established industry practice. Procurement and contract strategies provide the legal framework (and structure) for the temporary multi-disciplinary organization that is responsible for actualizing and enforcing compliance with the client's wishes.

PROJECT MANAGEMENT

Project management (PM) is defined as "the overall planning, co-ordination and control of a project from inception to completion aimed at meeting a client's requirements in order to produce a functionally and financially viable project that will be completed on time within authorized cost and to the required quality standards" (CIOB, 1998:3). The PM role is a relatively recent addition to the construction process and it seeks to separate the management functions of a project from the design and execution functions. It is an attempt to provide a holistic (or integrated) oversight over the entire project to ensure that there is effective

coordination of all the parties involved in the project. As the CIOB definition suggests, the PM function can include contract management, time and cost management, resource management, risk management and quality management. Regular feedback through project meetings is used to monitor progress, deal with problems, and ensure that all project activities result in a completed facility that meets the expectations of the client.

EMERGING PRACTICES AND RELATED RESEARCH

The improvement of the construction process has been a major feature of construction research since the early 1990s. This was fuelled by the realisation that the fragmentation of the industry and established practices (especially the traditional method of procurement mentioned above) led to inefficiencies and encouraged an adversarial culture in the industry to the disadvantage of both the industry (under-achievement in meeting its own needs) and its clients (poor value for money for their investment in construction) (Howard et al. 1989; Winter, 1989; Latham, 1994; Atkin and Pothecary, 1994; Egan, 1998). Research therefore focused on developing alternative procurement strategies (e.g. through the revival of management-oriented procurement strategies – Ashworth, 1991; Ndekugri and Turner, 1994), using information and communication technologies (ICT) to foster integration (Howard et al. 1989; Sanvido and Madeiros, 1990; Evbuomwan and Anumba, 1996), and the adoption of a wide range of concepts and techniques such as Total Quality Management (TQM), Just-In-Time (JIT), Lean Construction, Partnering, and Concurrent Engineering (Kamara et al. 1996). The Process Protocol and Integration Toolkit mentioned above are examples of the outcomes of these research efforts. Another example is project partnering, which is "a management approach used by two or more organisations to achieve specific business objectives by maximising the effectiveness of each participant's resources' (Bennett and Jayes, 1988). A number of contract types have been developed to assist in the implementation of a partnered approach to procurement (Perform21, 2005). Alongside these efforts in process improvements were those that focused on improved briefing practices such as the initiatives cited above. Other examples include the use of information technology (IT) in briefing process (Rezgui et al. 2003), and the concept of dynamic brief development, which links the brief development to project change orders (Othman et al. 2004).

CURRENT APPROACHES AND CLIENT REQUIREMENTS

The reviews in the previous section show that much has been (and is being) done to improve the project process to the benefit of both clients and the industry. It is true that an efficient, integrated project process can deliver best value for clients and will therefore provide client satisfaction. But because client requirements are 'embedded' in the various documents and processes involved, there is a risk that client requirements become subsumed in other project requirements; exclusive focus on client requirements cannot be guaranteed.

Another concern is that, contrary to the trend over the last decade for the industry to become more 'client-oriented', there are now calls for this to be reversed. In their book "*Why is construction so backward?* Woudhuysen and Abley (2004) recommend that one of the ways to reverse 'backwardness' in the industry is through "asserting the independence of architects from unbridled client power and partnership fudge [in reference to partnering]." To

avoid such a return to the situation where designers designed for posterity without due consideration of clients' wishes, a requirements-oriented process is required.

Integrated processes such as the PP and Integration Toolkit provide (to some extent) a framework for a requirements-oriented process. For example, in the PP (Table 2), the activity zone, "development management," is responsible for creating and maintaining business focus throughout the project (PP, 2002). The Integration Toolkit also makes provision for the incorporation of various tools in the development of an integrated project team (or supply chain) (SFC, 2003). This paper is a first step towards a requirements-oriented project process tool, within the framework for a client-oriented integrated project process.

A REQUIREMENTS-CENTERED PROJECT PROCESS

The main goal of a requirements-centered project process is to ensure continued and explicit focus on the clients' requirements during the course of a project. The following are suggestions of how this can be achieved.

DEVELOPMENT OF A PROJECT REQUIREMENTS DOCUMENT

A first step is the development of a Project Requirements Document (PRD) (akin to the idea of an 'Integrated Building Model') which has at its core, the client requirements. This is a separate document with the ability to link (or integrate) it other project documents as required. The key features of the PRD include the following:

- It contains information the client's wishes for the *end product* (e.g. functions and attributes about the facility) and the *process* (e.g. client's preferred level of involvement in procurement, and strategy for operation and use) to bring this about.
- It includes information on all other requirements (e.g. site and regulatory requirements) and the interrelationships between different types of requirements, with a particular emphasis on how other project requirements either enhance or hinder the achievement of client requirements. The relationship between the *process* and the *end product* should also be established (i.e. how a particular process can lead to the desired outcome). The established relationships between the different sources of information in the PRD should facilitate the planning and execution of various aspects of the project (e.g. design, project management).
- The development of the PRD should involve key project stakeholders (an extension of the Requirements Processing Team in Table 1), and should be an evolving and dynamic document. It should also allow different end-users of this information to be able to retrieve information that is relevant to their needs, but which has a link to the 'original' (or current) PRD.
- To allow the automatic exchange (or linking) of PRD information with other project documents and/or applications (e.g. CAD systems for design);
- Allow the continued development and modification of the PRD during the course of the project and facilities for collaborative decision-making on priorities and trade-offs within the PRD.

The realization of a PRD requires the use of Web-based systems, building information models and other technologies (e.g. data mining and intelligent agents for creating relationships between the information, XML for customized representation of representation, etc.) as it is best implemented within a computing environment.

SYSTEMATIC MAPPING AND TRACEABILITY OF REQUIREMENTS

In the CRPM, one of the central ideas was a structured process for translating client business needs into design specifications through systematic mapping of client requirements to design metrics (Table 1). This idea is now extended over the life of a project as illustrated in Figure 1, which is a modification of the Quality Function Deployment (QFD) process (Kamara et al. 2002). The project phases used in the PP (Table 2) have been used, with the 'Pre-Construction' phase split into two (into 'Requirements Specification" and "Design and Construction Planning"). The "Post-Construction" phase has been omitted since this is beyond the scope of this paper. From Figure 1, systematic mapping involves the association of "client's business need" to "strategic requirements"; from "strategic requirements" to "design specifications", etc. It is acknowledged that Figure 1 is a simplistic representation of what is otherwise a very iterative (and usually non-linear) process. We are also aware that 'mapping' is done in projects (albeit implicitly), but what is illustrated here is a process which, when combined with the idea of a PRD, ensures explicit focus on client requirements.

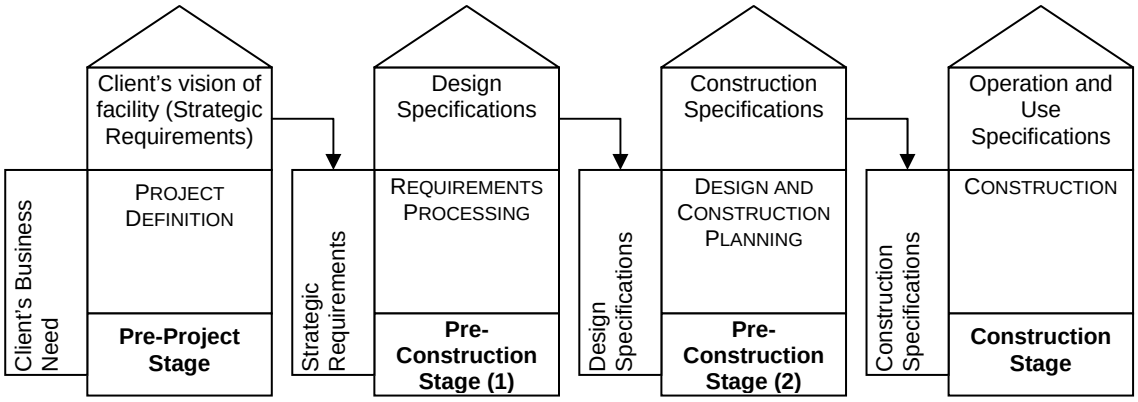

Figure 1: Systematic Mapping of Client Requirements in a Project

IMPLEMENTATION WITHIN EXISTING PROJECT PROCESSES

In order not to re-invent the wheel, the specified requirements-oriented project process should be implemented within established integrated frameworks. For example, although different terminology has been used in Figure 1, the process specified can be easily integrated (subject to further development) with the PP phases with some activity roles (e.g. Development Management) modified to manage the development and management of the PRD. If using the Integration Toolkit to put together an integrated project team (IPT), the PRD (and its associated processes for its development and management) can serve as a specific tool to assist an IPT to achieve its goal of delivering best value for the client.

DISCUSSION AND CONCLUSIONS

In this paper, we have set out to specify a strategy for a requirements-centered project process. This strategy seeks to build on previous work on the capture and representation of client requirements which was formulated into a Client Requirements Processing Model (CRPM). The key elements involve the development and management of a Project Requirements Document (PRD) and the systematic and progressive mapping of client requirements over the lifecycle of the project. The PRD is a separate but 'linkable' document which should allow integration with other project documents, models and/or applications, the systematic mapping of client requirements to project activities, and therefore retain focus on client requirements. This is in direct contrast to current practice where client requirements are 'embedded' in other project documents making the traceability of requirements (especially when there are changes) difficult, if not impossible. It should be pointed out that although the specification is for a "Project Requirements Document," this does not militate against our emphasis on "Client Requirements". It is, however, an acknowledgement that client requirements are implemented within the context of other project requirements (i.e. site conditions, regulatory requirements, etc.). The key to maintaining focus on client requirements (as specified above) is the relationships between the different types of requirements and how they enhance or inhibit the realization of the client's wishes. Another feature of the PRD is the heavy reliance on Information and Communication Technology (ICT). Although advances in Web-based systems and intelligent data mining techniques should make this feasible, further research is clearly needed to bring this to reality. Such research includes: an investigation into the kind of relationships between different project requirements that will inform the subsequent stages of a project, the information (representation format and content) needs of various users of the PRD information, and ways in which data relationships in the PRD can be created in a meaningful way.

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