The Development of a Generic Design and Construction Process

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1. Abstract

Increased globalised competition and the need to meet continuously changing customer requirements have forced the manufacturing industry to consider the way certain key activities were undertaken from a ‘process’ viewpoint. This has proven to have a number of advantages relative to the traditional functional/departmental structure of the industry.

The traditionally, fragmented construction industry can be seen to embark on the same journey as the manufacturing industry in improving co-ordination between the different parties and adopting a ‘process view’.

This paper briefly describes the research undertaken by the University of Salford, in the development of a Generic Design and Construction Process Protocol. The main principles of the Process Protocol, together with the methodology behind it.

The work undertaken so far has proven that the development of a process map is gaining momentum within the construction industry as a whole. The Latham inspired CRISP (Construction Research and Innovation Strategy Panel) community has in principle adopted the Process Protocol as a basis for its activities in terms of promoting process thinking in the construction industry.

2. Introduction

The need for improvement to the conventional design and construction process in the construction industry is well reported. Emmerson (1962), Banwell (1964), and Latham (1994) have all commented upon the need for change, and each highlight similar problem areas. Fundamentally, the need for improvement is related to the poor performance commonly associated with building projects. Typically, this performance is measured in terms of cost, time and/or quality.

Unfortunately, it is the UK Construction Industry’s response to the need for change that has perpetuated and even perhaps fostered this problem. For example, Franks (1990) and Masterman (1992) presented the evolution of the range of procurement systems currently on offer to potential construction project clients as driven ultimately by the ‘product’ view, and the need to optimise cost, time and quality. Yet, whilst many of the more recent approaches to construction procurement (i.e. Design and Build, Construction Management) apparently attempt to address ‘process issues’, such as communication, in reality they fundamentally fail.

In a survey conducted by Hibberd & Djebarni (1996), a sample of 64 respondents (representing both clients and consultants) demonstrated that contract time performance was a factor considered to be relatively insignificant, when compared to other problems commonly associated with construction projects as shown in table 2.1.

Furthermore, Morledge & Sharif (1996) reported that from a total of 215 projects surveyed, 136 (63%) were delivered later than expected “…in terms of the dates fixed by the contract or the dates given to the client for completion.”
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Table 2.1: Ranking of problems with current procurement methods (Hibberd & Djebarni, 1996)

Morledge & Sharif (1996) go on to suggest that it is the ‘expectation’ rather than the delivery which is at fault. The conventional process of generating an ‘expected’ delivery date is considered the reason for this:

“In some cases commercial, economic or political considerations can be a driver towards setting these unrealistic goals which become expectations and contract dates for lack of informed and unbiased advice. Consequently, construction performance falls short of expectations which were largely unachievable when they were established.”

A number of lessons can be learned from the manufacturing sector with regards to the implementation and practical use of a ‘process view’ within the construction industry. The area within the manufacturing sector that relates closely to construction and building works is called new product development (NPD). It concentrates in the development of an idea, need or client requirement to the final commercialisation of the product e.g. a building or a car. A number of similarities can be found between the two industries with regards to the activities used for developing new products. For example they include:

- The start of a project can be initiated internally or by direct and/or indirect contact with the customers
- The development of the product requires the participation of a number of specialists and functions such as: designers, surveyors, marketing, stress analysts etc.
- The successful construction or manufacture of a building or product can only be achieved if all external (suppliers and consultants) and internal resources are utilised and co-ordinated effectively
- The building or product is handed over to the customer/client and provisions are made for future support.

However there are a number of distinct differences, the most important of which is that in the manufacturing industry all NPD activities are co-ordinated, managed and controlled using a common framework which is the NPD process. The construction industry mainly, uses ad-hoc methods for achieving the latter and therefore reducing repeatability of process execution, resulting in the same mistakes occurring time after time.

This shift into the establishment of a consistent process for the construction industry requires a new way of thinking entailing a change of culture and working practices. Furthermore, it requires:

- a good understanding of current practices and future trends
- effective communication mechanisms of such processes, such as modelling
- agreement of participating parties

Technology can then be used to enhance integration and sharing of information. In conjunction with a process map, an IT map should enable the effective use and co-ordination of technology based on a pre-determined process framework.

This paper proposes a process map which consists of a high level process and sub-processes (Activity Zones), which support the various phases of a construction project and the appropriate information technologies.
3. **Methodology**

During the development of the Protocol a number of research methods have been used:

1. Retrospective and prospective case study analysis;
2. Review and analysis of contemporary construction processes and practices;
3. Review and analysis of concepts and practices applied within the manufacturing industries;
4. Process modelling including various modelling tools and techniques;
5. Iterative development using feedback from several industrial partners via interviews and workshop sessions and scenario building;

The results to date of some of this work will be described in subsequent sections.

4. **Principles**

As a result of the initial review of the literature, and the identification of the industry’s requirements through additional interviews with practitioners, six key principles are considered to provide the basis for an improved process.

They are drawn heavily from the manufacturing sector where process thinking and continuous improvement has been focused upon for some 30 years. In addition, many of the principles relate to recognised problem areas in construction, where significant improvements have been called for (interalia Banwell, 1964; Latham, 1994).

The six principles are as follows:

**Whole Project View**

In the construction industry the definition of a project has traditionally being synonymous to actual construction works. As such the pre-construction and post-construction activities have been sidelined and often accelerated to reach the construction stage or to move on to the ‘new job’. This has resulted in poor client requirements identification and delayed the exposure of any potential solutions to the need to any internal and external specialists.

Any contemporary attempt to define or create a ‘design and construction process’ will have to cover the whole ‘life’ of a project from recognition of a need to the operation of the finished facility. This approach ensures that all issues are considered from both a business and a technical point of view. Furthermore this approach recognises and emphasises the inter-dependency of activities throughout the duration of a project. It also focuses at the ‘front-end’ activities whereby attention is paid to the identification, definition and evaluation of client requirements in order to identify suitable solutions.

**A Consistent Process**

During the review of existing models and descriptions of the design and construction process, it was quickly established that little consistency existed. In such an environment, the problems encountered by temporary multi-organisations (TMO) working can be compounded. Luck & Newcombe (1996) support this view, describing the ‘role ambiguity’ commonly associated with construction projects.

Development of this generic Process Protocol provides the potential to establish its consistent application. Through consistency of use the scope for ambiguity should reduce. This, together with the adoption of a standard approach to performance measurement, evaluation and control, should facilitate a process of continual improvement in design and construction.

**Progressive Design Fixity**

The ‘stage-gate’ approach found in manufacturing processes (Cooper, 1994; ref. Fig.1) applies a consistent planning and review procedure throughout the Process.

Phase Reviews are conducted at the end of each Phase with the aim of reviewing the work executed in the Phase, approving progress to the next Phase, and planning the resourcing and execution of the next Phase. Cooper, in his third generation process, saw the need for ‘conditional-go’ decisions at phase gates, to accommodate aspects of concurrency. This philosophy is translated in the development of the
Protocol’s phase gates. Phase gates are classed as either soft or hard, with the ‘soft gates’ allowing the potential for concurrency in the process, whilst ensuring that the key decision points in the process are respected.

Fig. 4.1 Cooper’s comparison of stage-gate processes (Cooper, 1994)

The potential benefit of this approach is fundamentally the progressive fixing and/or approval of information throughout the Process. As Cooper (1994) states, the discipline of the Phase Review activity improved the conventional chaotic, ad-hoc approach of manufacturing to which the Construction Industry of today could be compared.

Co-ordination
Co-ordination is one area in which construction traditionally is perceived to perform poorly. This perception is supported by Banwell (1964) and Latham (1994), in addition to many other reviews of the Industry. The need for improved co-ordination was also highlighted by the interviews with senior managers undertaken during the research project.

It is therefore proposed that co-ordination of the Process Protocol is undertaken, principally, by the Process and Change Management Activity Zones. (see section 7) Appointed by the Client, the Process Manager will be delegated authority to plan and co-ordinate the participants and activities of each Phase, throughout the Process. The actions of the Process Manager are supported by the Change Manager, through which all information related to the project is passed. In this role, the Change Manager acts as the official interface between both the Activity Zones in the Process, and ultimately the Legacy Archive.

Stakeholder Involvement & Teamwork
It has been recognised in the manufacturing industries that multi-function teams, established in a development process, reduces the likelihood of costly changes and production difficulties later on in the process by enabling design and manufacturing decisions earlier in the process.

Conventionally, many building projects comprise a team of participants assembled specifically to facilitate the development of that single. Consequently, a complete project team rarely works together on more than one project, and, as Sommerville & Stocks (1996) argue, this can negatively affect the assembled “team’s” performance. In addition, many key contributors are identified and included too late in the process.

Project success relies upon the right people having the right information at the right time. Proactive resourcing of Phases through the adoption of a ‘stakeholder’ view should ensure that appropriate participants (from each of the key functions) are consulted earlier in the Process than is traditionally the case. This, in itself, will not eliminate the problems associated with TMO working. However, the active involvement of all participants, especially in the early phases of a project, may subsequently help foster a team environment and encourage appropriate and timely communication and decision making.

Feedback
In addition to the direct teamwork problems associated with TMO’s, the ability to learn from experience is also hampered by the continual formation and break-up of project teams. Both success and failure can offer important lessons for the future, yet the fragmented and competitive nature of the Construction industry prevents the benefits of shared best practice being utilised.

The Phase Review Process facilitates a means by which project experiences can be recorded, throughout the Process, thereby informing later Phases and future projects. Competitive advantage will
come from how such experiences are acted upon. (shared knowledge may not automatically reduce the competitiveness of companies working in construction.

This Process Protocol therefore proposes the creation, maintenance and use of a Legacy Archive acts as a central repository, or information-spine (Sheath et. al., 1996), for the information generated through each of the phases of the process. The subsequent increase in awareness, project to project, has the potential for reducing risk and improving performance which over time may ultimately meet Latham’s expectations.

5. Process Development

Given the apparent lack of commonality in the contemporary understanding of the design and construction process, an attempt was made to produce a model of the process which could be debated and subsequently refined towards a generic representation.

The initial model was developed based upon existing descriptions of the design and construction process (inter alia Walker, 1989; Hughes, 1991), some case study data, and reviews of other published models (inter alia RIBA, 1980; Sanvido, 1994; BAA, 1995)

The IDEF-0 (Integration Definition language 0 for Function Modelling) process modelling technique was adopted, initially, as the most appropriate means of representing this process. The IDEF-0 technique essentially represents a process as a sequence of activities, described by a verb followed by a noun. Each activity has associated inputs, outputs, controls and mechanisms. It is this technique that has been used successfully to represent processes such as Sanvido’s (1995) Integrated Building Process Model

In developing a process model using the IDEF-0 technique, an initial step is the establishment of the activities that will comprise the model. In preliminary interviews and workshop sessions with the project’s industrial partners these activities were presented for discussion in the form of an Activity Hierarchy.

However, initial reactions to this were poor, principally because such an approach did not facilitate communication of the process, either quickly or clearly.

Moreover, it was found that the industrial partners to the project, at this stage, also preferred to concentrate on the general principles of the process, in preference to the detail of the activities involved.

This preference for principles was found to have a certain congruence with other models of manufacturing processes. Cooper’s discussion of the evolution of the ‘stage-gate’ models in manufacturing (Cooper, 1994), and other (inter alia GPT (1990), Fisons) industrial models, demonstrate this. In such models the graphical representation of the process conveys it’s inherent principles. As Rosenau (1996) notes, such process models are “an effective way to show how a process works”. In their definition;

“A process map consists of an X and a Y axis, which show process sequence (or time) and process participants, respectively. The horizontal X axis illustrates time in process and the individual process activities or gates. The Y axis shows the departments or functions participating in the process...” (p.444)

Beyond this convention, there appears to be little formality in the method used to represent a process. Furthermore, it could be argued that the relative informality of the modelling process enhanced the contributions of the project’s partner representatives. Through several workshop sessions, the model was revised and deliberated by the partner representatives. As Rosenau (1996) argues, this “participative” approach to design makes any new process easier to accept and use. In an industry with a ‘need for change’ such an approach must be considered appropriate.

Thus, through a process of gradual refinement, progress was made towards an agreed version, the Process Protocol, which this paper presents.
6. The Process Protocol

The draft Process Protocol Model is presented in Fig. 6.1. Essentially, the model breaks down the design and construction process into 10 distinct phases. These 10 phases are grouped into 4 broad stages, namely Pre-Project, Pre-Construction, Construction and Post-Construction.

Pre-Project Stage
The Pre-Project Phases relate to the strategic business considerations of any potential project which aims to address a client’s need. Throughout the Pre-Project Phases the client’s need is progressively defined and assessed with the aim of:
1. Determining the need for a construction project solution, and
2. Securing outline financial authority to proceed to the Pre-Construction Phases.

In currently acknowledged models of the design and construction process (inter alia RIBA, 1980; British Property Federation, 1983; Hughes, 1991 provides a comprehensive review), and recently published client-focused guides (CIRIA, 1995), this stage of a project is given scant consideration, when compared to the latter stages. However, the models assume that when approaching the Construction Industry, clients have already established ‘the need’. Whilst there is little evidence to suggest this is not the case, it would seem reasonable to assume that the knowledge possessed by speculative building developers and consultants could assist any client in these early stages of a project. The problems associated with the translation of this need through the conventional briefing stage of design (O’Reilly, 1987) have the potential for substantial elimination via such an approach.

Pre-Construction Stage
With outline financial approval obtained, the Process progresses through to the Pre-Construction Phases where the defined client’s need is developed into an appropriate design solution. Like many conventional models of the design process, the Pre-Construction Phases develop the design through a logical sequence, with the aim of delivering approved production information. The Phase Review Process, however, adds the potential for the progressive fixing of the design, together with it’s concurrent development, within a formal, co-ordinated framework. Progressive fixity should not be confused with ‘design freeze’, although to some this may be a desired aspect of the process. The major benefit of the fixity of design is the potential for improved communication and co-ordination between the project’s participants as they pass through each Phase. Given the dynamic market conditions which influence many construction client’s decisions, the need for flexibility must be addressed by the industry.

At the end of the Pre-Construction Phases, the aim is to secure full financial authority to proceed. Only upon such authority will the Construction Phase commence, and this decision will be easier to make where the extent of the works, and it’s associated risks can be readily understood.

Construction Stage
The Construction Phase is solely concerned with the production of the project solution. It is here that the full benefits of the co-ordination and communication earlier in the Process may be fully realised. Potentially, any changes in the client’s requirements will be minimal, as the increased cost of change as the design progresses should be fully understood by the time on-site construction work begins.

The ‘hard gate’ that divides the Pre-Construction and Construction Phases should not prevent a ‘work-package’ approach to construction, and the associated delivery time benefits this brings. As with all activities in the process, where concurrency is possible, it can be accommodated. The hard and soft gates that signify Phase Reviews merely require that before such an activity is carried out, approval is granted.

Post-Construction Stage
Upon completion of the Construction Phase, the Process Protocol continues into the Post-Construction Phases which aim to continually monitor and manage the maintenance needs of the constructed facility. Again, the full involvement of facilities management specialists at the earlier stages of the process should make the enactment of such activities less problematic. The need for surveys of the completed property, for example, should be avoided as all records of the development of the facility should have been recorded by the project’s Legacy Archive.
Figure 6.1. The Generic Design and Construction Process Protocol Model
7. The Sub-Processes: ‘Activity Zones’

The earlier involvement of the project’s participants, throughout the process is a significant development of the conventional approach to building. Traditionally, a construction project’s participants are referred to by their professional or expert status. Ball (1988) demonstrates how this may be attributed to the inherent class relations associated with each of the professions and expert groups. As with all class distinctions, the effect that this basis for organisational structure in design and construction has is division.

A consequence of this traditional approach, by which even the more recent forms of contract procurement (design and build, management contracting, etc.) are included, is the poor communication and co-ordination commonly associated with construction projects.

The participants in the Process Protocol are referred to in terms of their primary responsibilities, and are represented on the Y-axis of the Process Model. It is recognised that traditionally, project to project, organisational roles and responsibilities change, resulting in ambiguity and confusion (Luck & Newcombe, 1996). By basing the enactment of the process upon the primary responsibility required, the scope for confusion is potentially reduced, and the potential for effective communication and co-ordination increased. The Process Protocol groups the participants in any project into ‘Activity Zones’. These zones are not functional but rather they are multi-functional and they represent structured sets of tasks and processes which guide and support work towards a common objective (for example to create an appropriate design solution).

A single person or firm can carry out an activity zone in small-projects but in large and complex projects, an activity zone may consist of a complex network of people and between relevant functions and/or organisations. Since they are multi-functional, membership of the ‘zones’ is determined by the specific project task and/or process. For example Design Management often has important input in the Production Management and Facilities Management activity zones, amongst others and vice-versa.

Of the activity zones associated with the model, not all will be discussed here. Most of the ‘zones’ are self-explanatory. However, the role of the Process/Change Management and Development Management activity zones will be described, as they present a significant departure from the conventional view of the design and construction process.

Development Management

The Development Management activity zone is fundamentally the client/customer for the potential project. In the Protocol scenario, it is ultimately responsible for the success or failure of the project. Representing the major stakeholder in the process, it has an important role. It is via the brief prepared by the Development Management that the client/customer’s needs are presented and ultimately interpreted. The Development Management is the only constant ‘player’ in the process. All other activity zones potentially consist of a dynamic membership, as the needs of the project develop throughout the process.

The extent to which the other participants in the process, particularly the Process Management, have authority to proceed is delegated by the Development Management. It is they who will ultimately review the work of the project’s participants and sanction progress or cessation. Development Management is responsible for creating and maintaining business focus throughout the project, which satisfies both relevant organisational and stakeholder objectives and constraints. For example, a proposed speculative office development needs to satisfy the developers objectives (say, return on capital) and constraints (say, available finance), as well as fulfilling other stakeholder considerations (say, compliance with prevailing planning concerns).

Process / Change Management

The Process and Change Management activity zones are essentially the interface between the Development Management and the other project participants. Process Management has a role independent of all other activity zones. A distinction must be made between this conventional view of a project manager and the Process Management role. Process Management, as the title suggests, is concerned with the enactment of the process, rather than the project. Key to the success of each Phase
in the process is the production of project deliverables (reports and documentation associated with each Phase). In this respect the Process Management is responsible for facilitating and co-ordinating the participants required to produce the necessary deliverables. Acting as the Development Management’s ‘agent’, it will ensure the enactment of each Phase as planned, culminating with the presentation of the deliverables at each end of Phase Review.

The Change Management function is further distinct from the Process Management zone, as this role solely concerns (as it’s name also suggests) the management of change(s) which occur during the process. As the project becomes increasingly defined as each phase is enacted, changes (or rather updates) to the information required for the development of the project will be produced. These updates will be contained within the work required to develop the deliverable documentation associated with each phase. With respect to this, the Change Management (CM) activity zone facilitates the holding, review and dissemination of all this information, as the project progresses.

It is within the Change Management function that IT potentially plays a fundamental role. Given the vast amount of information generated throughout a project’s lifecycle (Aouad et al., 1994), and the need for it’s quick and effective dissemination, IT may offer a capable solution. However, the need for judgement and discretion, especially in the earlier strategic phases of the process, will always involve the Development Management’s intervention, and this alone is likely to prohibit the use of IT as a total solution. Aouad et al., (1997) further describe the role of IT within the Process Protocol.

8. Conclusions

The paper has briefly described the development of a Design and Construction Process and the six principles upon which the Process Protocol is based.

The resulting Protocol may appear deceptively simple. However it introduces concepts which are new in a traditionally fragmented and litigation driven construction industry.

In order for any new process to be adopted, experience indicates that the key principles and underlying structure must be understood and remembered, to enable users to ‘buy-in’ Indeed in order to implement the Process Protocol significant ‘drilling down’ of sub-processes will be necessary. In addition issues of procurement systems and contracts must be addressed. This illustrates the need for further work on the levels of the sub-processes and on the implementing the process with the industry.

References


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