THE DEVELOPMENT OF A PROCESS MAP FOR THE CONSTRUCTION SECTOR.

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Abstract
The construction industry has witnessed serious efforts in the last few years through the consideration of the adoption of new procurement systems and production/manufacturing philosophies. However, process maps which can help organisations map their processes into some meaningful structure are still lacking. The product (building) is still the main focus in construction. In the manufacturing industry, most large organisations have process maps which can assist them in ensuring the delivery of products on time, within budget and to the right quality while capturing the best process practices. In construction, there had been some efforts to devise process maps such as the RIBA plan of work in the UK. This paper presents a process map based on principles used in the manufacturing industry. Knowledge was elicited from experts through a series of workshops and case studies. The results of some of these case studies, which have been used to assess the practicality of implementing this process map on real life projects, are presented. Finally, the IT required to support and enable the effective implementation of the process map is briefly described.
Keywords: Process map, manufacturing, IT support, case studies.

1. Introduction

The last few years have witnessed little effort in the development of process maps and protocols in the UK construction sector. The Construct IT Centre of Excellence in the UK has proposed a process map that enables the adoption of IT by the construction sector [1]. Also, work on agile construction at Bath University (http://www.bath.ac.uk) has been progressing in this area. The work presented here is related to the development of a

process protocol at Salford University (http://www.salford.ac.uk/gdcpp). A process protocol can be defined as a way in which the processes involved in the designing and constructing of a structure are re-arranged so as to produce a more efficient, effective and economical way of undertaking the design and construction of projects. Tangible benefits can be realised through wastage reduction, shortening the duration of projects or improving communication methods and channels. Research has shown that some large construction organisations in the UK have started to develop process maps and protocols to improve their businesses (see for example [2]). In the manufacturing sector, most large organisations have been using such maps and protocols, which have delivered significant business benefits. The historical linear, sequential, relationship between design and construction activities is a frequently cited contributor to many problems including buildability issues. It is a clear priority that the design and construction phases are to be better integrated - in both the context of a common managerial approach and enhanced communication (including the content of that communication). Since this could not be achieved at the (post-design) operational level alone, it would have to be achieved using a strategic management level which spanned the design and construction phases. There is also a need to consider revising the duration and entry point of professional involvement in the process in relation to the life cycle of the product. In addition, it is essential to adopt techniques that reduce the number of interfaces by relying on the idea of prototyping, which is mainly used in manufacturing. It is also of great importance to make use of legacy archives that contain libraries of cases of previous projects avoiding to re-invent the wheel every time we start a new project.

This paper starts by presenting an improved design and construction model. It then highlights the major developments in the manufacturing sector within the area of new product development. The IT and process map is then described. Following this, a generic design and construction process protocol is presented and some case studies are described.

2. The construction process

Figure 1 presents a simplified model for the design and construction process encapsulating many of the aforementioned concepts. This model will ultimately become useful to the industry provided that process maps that support these concepts become more available. This is described later in this paper. It is essential to rely on legacy archives when dealing with construction projects. Legacy archives will enable and facilitate most of the processes within a construction project including strategic planning and facilities management. Prototypes of the intended building can be produced more quickly and accurately removing many of the interfaces existing in the current process. Time and cost simulation models can also be quickly produced. This is how the manufacturing industry has benefited from the idea of prototyping and the use of legacy archives. In another section of this paper, a more detailed model is presented based on the ideas presented here. Figure 1 demonstrates how the whole life cycle of a construction project can be linked to the business requirements phase provided that legacy archives are used as the central knowledge repository model. Facilities management feed into business requirements

which may lead to a concept quickly prototyped and constructed through the availability of similar electronic prototypes. The idea presented here relates to a model developed by Bacon [3].

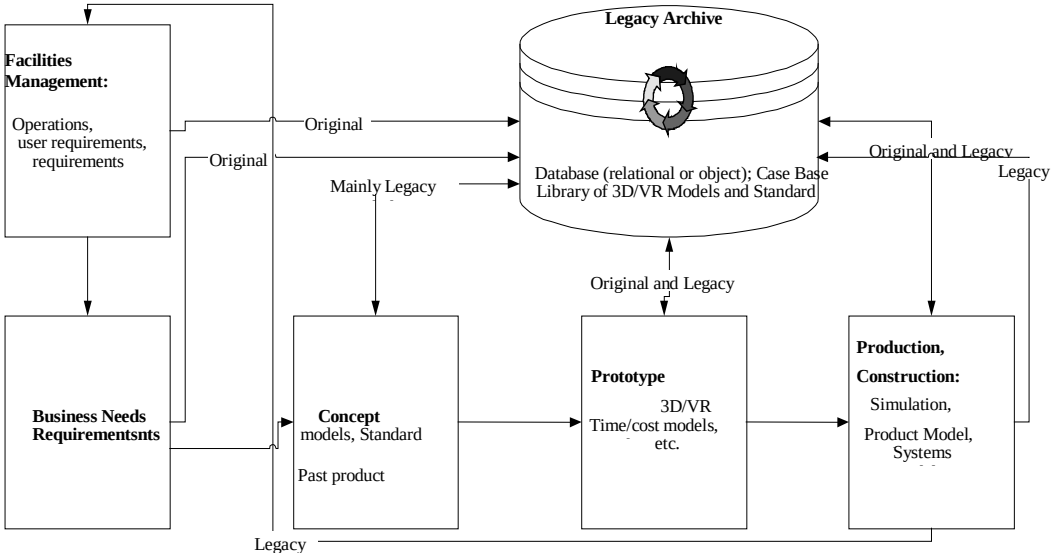

Fig. 1. A model of the construction process

3. Process in manufacturing

A review of the manufacturing research field and in particular the field of New Product Development (NPD) research, indicated distinct differences in the involvement of designer and assembler in the NPD process, and corresponding differences in perception of the terms of reference for *process* and process involvement. In the New Product Development (NPD) sector, it appeared to be more conventional for product developers to be involved in the early stage of a client's exploration of a new product [4]. This is sometimes referred to as the Requirements Capture phase, which is characterised by a consultative involvement of the potential product developer(s) before the decision to proceed with the product is finalised. A further issue arising from the review of NPD processes was the use of an explicit stage/ gate process approach, whereby decisions on the project progression were scheduled for a number of prescribable decision points. Scope for the concurrent process planning and professional input were included in such process philosophies, which in turn led to scope for the projects to be systematically conceived, developed, and revised whilst retaining the option to vary or cease the process within the prescribed process management protocol [5]. In NPD, this was reported as allowing flexibility of product and operational processes, and to support the innovation step, within a generic set of strategic management principles [6]. In addition the potential introduction of 'fuzzy' gates within the process could further facilitate reduced development times and ease the natural progression of a projects lifecycle [6]. This approach became a key parameter for the Process Protocol.

The NPD process approach also commonly involves the product developer in the review of products after their completion, which allows subsequent versions to be improved. It was therefore clear that for some sectors of the manufacturing industry, involvement of the various stakeholders was more intense, interactive, and relevant for a larger proportion of the product life cycle. If translated to construction, this appeared to offer extra scope for a pre and post-production consultancy and evaluation role, and also to allow for the construction industry to generate and use feedback in improving the product and their own production process.

4. IT and process

IT, process management, and communication are inter-dependent [7] [8]. There is an associated emergent need to integrate and communicate information between the various members of the project team and to define the terms and content of communicated information. This will be particularly challenging in the early stages of the process where information and the brief in general are unstructured. The model presented in Figure 1 will ensure that IT is used properly and efficiently. For integration and communication to happen and to retain control of information there are a number of technical and product-oriented support provisions which are required, and also a requirement for a process convention for originating, handling, storing and communicating information (including the legal ownership issues) [8]. Data to support this are also crucial. This information would better support the management process if it included the process decisions and operation as well as the production and design data, especially if it was integrated at all levels process. Clearly a co-maturation of the process and Construction IT is required [8] [9] [10].

5. The process protocol

The process protocol described here is an EPSRC (Engineering and Physical Sciences Research Council) funded project under the IMI (Innovative Manufacturing Initiative) ‘Construction as a Manufacturing Process’ initiative. A wide spectrum of collaborating companies from the construction industry including, clients, contractors, sub contractors, architects, suppliers etc. were involved in undertaking this project. The main aim of this project was to develop a Generic Design and Construction Process Protocol for the construction industry by considering the lessons learnt through a number of decades in manufacturing New Product Development (NPD). This was achieved by comprehensive reviews of the construction and manufacturing industries, interactive workshops with the project industrial partners, case studies in the manufacturing and construction industry and other research and data collection tools and techniques. 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 and many of the

principles relate to recognised problem areas in construction [11] [12]. The six principles are as follows [13] [14] [15]: *Whole Project View, Consistent Process,* ***Progressive Design Fixity,*** *Co-ordination, Stakeholder Involvement & Teamwork, and Feedback.*

6. The Process Protocol Elements

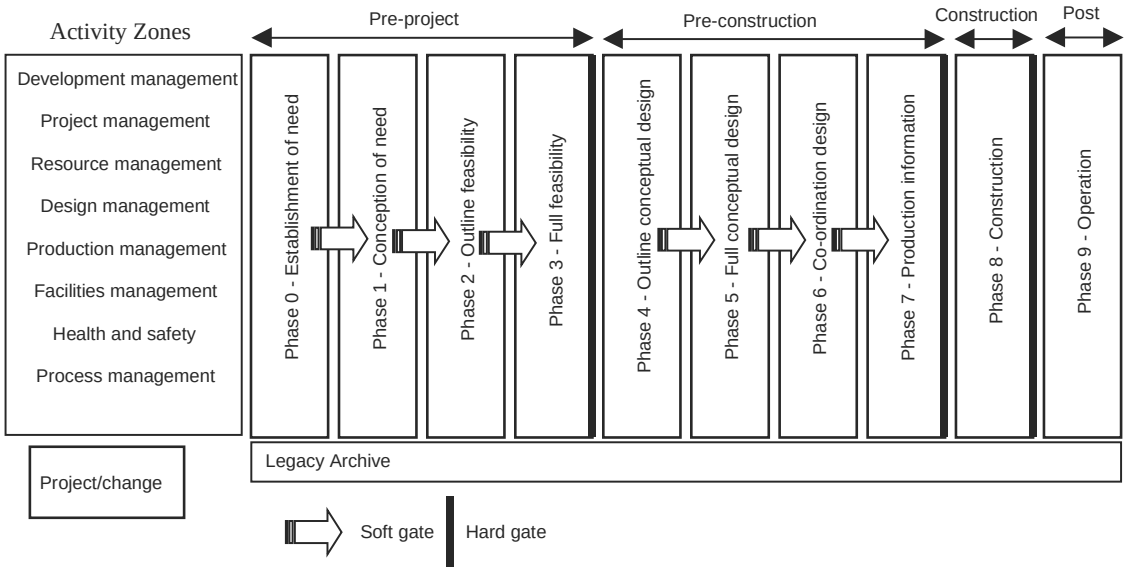

Fig. 2. The Process Protocol

The Process Protocol Model is presented in figure 2. Essentially, the model breaks down the design and construction process into 10 distinct phases. These 10 phases are grouped into 4 broad stages: Pre-Project, Pre-Construction, Construction and Post-Construction.

6.1. 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 a) determining the need for a construction project solution, and b) securing outline financial authority to proceed to the Pre-Construction Phases.

In currently acknowledged models of the design and construction process [16] [17] ([18] provides a comprehensive review), and recently published client-focused guides this stage of a project is given scant consideration, when compared to the latter stages. 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 have the potential for substantial elimination via such an approach.

6.2. 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. 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 its associated risks can be readily understood.

6.3. 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. The hard and soft gates that signify Phase Reviews merely require that before such an activity is carried out, approval is granted.

6.4. 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.

7. Case studies

A traditional case study approach was used, with University of Salford researchers entering industrial partners' organisations openly in the role of investigators, for the express purpose of learning more about their activities with respect to the design and construction processes being practiced [14] [19]. Two case studies are presented in this paper. For the sake of confidentiality, the companies will be referred to as A & B. The

research team acknowledge that the case study approach can be rightly criticised on the basis of lack of measurability – because the data gathered are generally based on perceptions and subjective interpretations of the individual University of Salford researchers, therefore often making quantification and the manageable summary of findings very problematic and ambiguous. In response to these methodological weaknesses, the research team triangulated the data collection process as much as possible, by carrying out interviews, using questionnaires and presenting and debating the findings at Workshops. Further, the research team does not view the findings from the case study as being in anyway definitive; rather, it views the case studies as being a starting point for further, more in-depth, research. This section presents the main findings for two case studies.

7.1. Company A (Manufacturing)

The Process Protocol has been developed primarily by transferring principles and philosophies applied in the manufacturing industry for new product development (NPD). As part of this project one of the main objectives of the research is the analysis and adaptation of best practice in process management from both the construction and manufacturing industry. Company A is a large manufacturing organisation which attempted to use a manufacturing process (phase review, stage/gate) in a construction project. The construction context is presented for the refurbishment of a number of buildings in a proposed site. It was clearly shown that the process could prove to be a constraint when not implemented adequately. Such pitfalls can be attributed to poor training and lack of process and project matching i.e. project deliverables different from process deliverables and duplication of project work to facilitate the production of process deliverables. The project has identified the need for effective 'stakeholder' identification and capturing of their requirements at the early stages of the project, forming part of a short-term (project specific) communications strategy. The benefits of using a phase review process can only be realised by teamwork between project members and with the effective participation and integration of all attributes of the process e.g. assessors. Company A have made use of most of the technologies identified within the IT map supporting the process protocol (The IT map is not described in this paper). In addition, it has been found that the inter-site communications and software applications were facilitated by the provision of an 'all-in-one' computer network. Considering the size of the project team in this particular case study, the complexity and size of the work that needed to be carried out it was decided from the beginning of the project that network facilities would need to be utilised. A 'shared' area in the network was allocated to include main documents and information that will be needed by a number of members from the project team. Also, to enable fast and accurate communications the email addresses of all members (wherever applicable) were distributed to the project team. Video conferencing facilities were also used to eliminate long travelling periods (more than 2 hours between two sites) for short meetings.

Areas for improvement through the adoption of the process protocol can include:

- The process needs to be customised to the project in-hand, and only then it facilitates better control by the project team

- Its applicability depends on the size and complexity of the project. If the project is big and complex then the process provides a structured formal review mechanism
- For small projects traditional project management should be adequate
- The documentation is very big because the project is not accurately related to the process. Thus, duplication and extra amount of paperwork is produced. The deliverables should be part of normal working practices. The phase review plans should be more in line with project plans
- Training: more training and in particular using hypothetical situations; more time for training prior to the commencement of the project
- The stakeholders and their needs should be identified at the beginning of the project and not at a later stage.

This case study proves that the use of process maps by manufacturing firms has achieved some advancement. However, the overall perception about the usefulness of such maps needs to be improved. The next case study will address these issues within a construction industry context.

7.2. Company B (Construction)

Unlike the previous case study, this retrospective case study examines the development of a stadium by a construction organisation. It is widely known that construction is behind that of manufacturing in the use of process maps. The overall observations from examining this case study are addressed below. First a summary of areas for improvement will be examined which resulted from the identification of current malpractice. These include: a) the informal appointment of consultants; b) lack of definition; lack of co-ordination; c) the "fluid" nature of the project; and d) lack of formality and control

The potential advantages of the Process Protocol in relation to the issues noted from this case study are:

- A focus on front end of the process in terms of requirements capture in addition to financial approval.
- Specific deliverables highlight the link between past, present and future activity.
- The Phase Review process induces a continual checking and approval procedure. Whilst this may be seen as an unwanted stop-start procedure, the managed and explicit nature of this process eliminates the 'surprise' element which induces risk.
- The identification and prioritization of 'stakeholders' allows the clear identification of 'your client'.
- Feedback – the legacy archive of the process protocol.
- Independent co-ordination via the Process Manager provides a single point of control, which may help continuity.
- Roles and responsibilities are clearly defined.

This case study has highlighted various issues concerning the management process as enacted on one construction project. Of the issues highlighted the following were found to be particularly relevant to and supportive of the principles and potential benefits of the Process Protocol:

- The need to appreciate stakeholder involvement

- The need to control the ‘front-end’ of the process
- The need to formally identify ‘the need’
- The need for feedback (from previous projects)
- The need for effective change management

Company B have also been using most of the information technologies identified within the IT map. In particular 3D modelling tools have been used to produce a graphical representation of the buildings involved in the case study. The use of 3D models was mainly for marketing/fund gathering. The electronic and disk-based transfer of information was also adopted practice by some of the participants of the case study project. The benefits associated with the use of IT within this particular case study have been highlighted as follows:

- The archiving and retrieval of project information;
- Rapid communications;
- Effective co-ordination;
- The visualisation of client’s requirements; and
- The visualisation of structural and spatial requirements.

The expense of the latest technology appears to be main barrier to the full exploitation of these benefits.

In comparing companies A and B, it is evident that the manufacturing company has more process focus in performing its activities. The construction industry will need to learn from manufacturing of how to build up a better perception for processes which will result in improvement in productivity and performance. Many of the problems associated with current practices can potentially be resolved by adopting the process protocol described in this paper.

8. Conclusions

This paper presents an improved process model that supports the life cycle of construction projects. The experiences from the manufacturing sector have been found to be extremely useful in devising the process model. IT that enables such a model will need to be developed according to the process needs. It is concluded that Process and IT maps are helpful in identifying strategic as well as process and IT requirements. A more holistic picture of the design and construction process can be realised through the synchronization of process and IT capabilities. The use of case studies to test the practical implementation of the process model is essential as many of the process problems are identified during the implementation phase. The full results of the research project presented in this paper can be found in [14][19][20].

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