A Process for Change - the development of a generic design and construction process protocol for the UK construction industry.

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Abstract

It is believed, and reaffirmed by Latham (1994), that significant savings can be made from reducing variations and confrontation, and thereby improving the performance of the design and construction process. However, in the UK construction industry, there does not exist a means by which to do this. The current perception is that flexibility is difficult within the process of construction because (inter alia) the supply chain changes for every project, and relationships are dynamic (i.e. the client on one job may be a competitor on the next). Despite this, it can be argued that the underlying design and construction process remains broadly consistent. Several existing models of the construction process (for example the RIBA Plan of Work, British Property Federation manual, Higgins & Jessop (1965), and others) confirm this.

To achieve the objectives of Latham, a consistent, integrated construction process model, which encompasses the entire supply chain is required. This paper will consider manufacturing process principles, as a starting point in the development of an improved working process for construction. In manufacturing, benefits have been achieved through matrix management by project, the application of concurrent engineering techniques and computer integrated manufacturing (CIM) systems (Mitchell, 1991), Just-in-Time and Total Quality Management. Approaches to manufacturing maintain the quality and the performance of the process via stage (or phase) reviews (proposed by Cooper, 1990) and laterly through the conduct of 'fuzzy-gate' reviews (Cooper, 1994).

The fundamental benefit of the improved design and construction process should be to optimise predictability. This could only be ensured when a truly co-operative project environment exists. The process should therefore look to facilitate teamworking and effective communication between participants.

Following the examination of comparable manufacturing approaches, and the existing processes in construction today, a draft process model for construction will then be presented. The model will be partly validated following questionnaire and interview based studies of several key participant organisations in the UK construction industry, in addition to the findings of a workshop held in February 1996. To date, work conducted by the authors in this area has developed a preliminary model which may ultimately use IT in order to facilitate a fundamental change (a re-engineering) of the design and construction process.

Keywords: process strategy, process improvement, construction innovation
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Introduction - "The Need for Change"

The UK Construction sector has, since the 1930's, voiced an apparent desire to change the way it performs its primary activity - the construction of building and civil engineering works.

A succession of Government and institutional reports have examined this activity, particularly the practice of construction management, and have commented upon the need for improvement (ibid Simon (1944), Phillips (1950), Emmerson (1962), Banwell (1964), British Property Federation (1983)). More recently, while investigating the problems of the Nigerian construction industry, Aniekwu & Okpala (1988) found that, "...in Britain,... there is a growing feeling that the contractual arrangements in her construction industry may not necessarily be the most suitable for the present-day requirements..."

The latest UK Government investigation (Latham, 1993 & 1994) reaffirms the conclusions of all the previous studies. The report focuses upon the fragmented nature of the industry as a major factor contributing to the poor communication between all parties working on a construction project.

The present day requirements of the UK construction industry may be considered threefold: There is a need to increase communication, to promote concurrency and to remove institutional barriers. The ultimate result of such action should be to ensure that taking, as Latham (1994) does, the client as our primary viewpoint, a building possesses the following qualities:-

- Value for money
- Pleasing to look at
- Free from defects upon completion
- Delivered on time
- Fitness for purpose
- Supported by worthwhile guarantees
- Reasonable running costs
- Satisfactory durability

Examples of Change from the Manufacturing Industries

In an examination of change within the manufacturing industries, Ghoshal & Bartlett (1995) report that "...in an effort to solve the problems we now see so clearly as the consequence of hierarchical structure, companies around the world have spent much of the past decade trying to adapt those structures. They have downsized by cutting out layers and laying off staff."

Ghoshal & Bartlett go on to describe how a "...strategy-structure-systems doctrine has focused their [management’s] attention on the vertical relationships of the classic hierarchical structure...” Their discussion continues in an examination of a shift in
recent years towards a realisation that within the hierarchy it is the horizontal processes that matter. “Total quality management was such a process... Likewise, reengineering showed companies how to integrate functionally separated tasks into unified horizontal work processes.”

The authors continue by defining three sub-processes that represent the current management revolution, or what we may consider to be a philosophy. Here, the entrepreneurial process, the competence-building process and the renewal process are each briefly explained/summarised:

(a) The Entrepreneurial Process - essentially this requires the role of the ‘front-line’ manager to change to one of initiation rather than implementation. The idea is to promote an “...externally oriented, opportunity seeking attitude that motivates employees to run their operations as if they owned them.” The company 3M is reported as being one company in which respect for the individual is the basis for their management practice. The organisation recognises that “mistakes will be made, but if a person is essentially right, the mistakes he or she makes are not nearly as serious in the long run as the mistakes management will make if it is dictatorial and undertakes to tell those under its authority how they must do their jobs.” The doctrine is essentially one of ‘empowerment’

(b) The Competence-Building Process - here, top management empowers the ‘front-line units’ to meet the “challenge of creating the competencies needed to pursue local opportunities.” In turn, the management structure provides a network for dissemination of successful competency building throughout the organisation. This effectively results in the business acting as “an educational institution.”

(c) The Renewal Process - this process can really be seen as a cultural doctrine, where existing practices and rules are open to question, and where conventional wisdom is challenged.

Ghoshal & Bartlett’s philosophy is supported by many other investigations. Hart (1995), for example, presents two case study summaries which could easily be reviews of a typical construction project.

“At an international engineering firm, the research and development division is, according to the many departments that rely on its services, the bane of the operation, churning out products that don’t live up to expectations and are often late and over budget. R&D employees, in turn, claim the problem is the maddeningly vague, incomplete project descriptions they receive, which rarely mention deadlines or cost limits.” (emphasis added)

“At a small direct-mail company, the sales force and production crew have practically dug trenches in the battle over who is responsible for flaws in the print materials the company produces for customers. Both sides have their arguments, but the relationship has grown so adversarial that all dialogue has ceased. The mistakes, however, continue and multiply.” (emphasis added)
In his paper, Hart presents ‘internal guarantees’ as a method, successfully implemented in each of the case companies quoted, for overcoming such problems that even TQM, reengineering, and other initiatives, cannot overcome.

Internal guarantees are effectively ‘promises’ or a “commitment by one part of an organization to deliver its products or services in a specified way and to the complete satisfaction of the internal customer or incur a meaningful penalty, monetary or otherwise.” It is emphasised that the promise must be decided upon by the employees involved - not imposed from above; and as a result, Hart argues, “Internal guarantees can and very often do lead to large scale performance improvements” by effectively inducing three trends:

- A true spirit of teamwork and partnership develops between different parts of the organization
- An environment of blameless error takes hold, wherein employees are rewarded, not punished, for identifying problems instead of sweeping them under the carpet
- Continuous dialogue and feedback begin about progress, problems and processes

There must of course be support for all guarantees offered, to allow them to work. This may mean the organisation having to provide additional resources to support the process.

Whether internal guarantees would be appropriate within a construction project environment is open to question. The temporary multi-organisational nature of projects would seem to exclude practically all means of implementing ‘internal’ guarantees. However, the implementation of internal guarantees as a form of industry standard approach to work within all organisations, may be one approach worth considering.

As a more directly comparable approach to process improvement Baxendale et al (1996) describe how the problem of work activity fragmentation has been successfully addressed, in the manufacturing industries, through the application of Simultaneous Engineering techniques. They quote Broughton (1990) who informs us that “Simultaneous engineering attempts to optimise the design of the product and manufacturing process to achieve reduced lead times, improved quality and cost by the integration of design and manufacturing activities and by maximising parallelism in working practices.”

Indeed, so successful has this technique been that Coupland (1992) reports that SE (also referred to as concurrent engineering or parallel engineering) can achieve the following process improvements:

- Reduced manufacturing lead times by 30%
- Reduced manufacturing costs over 40%
- Reduced number of engineering changes almost 100%
- Reduced design lead times by 60%
- Reduced design costs by 30%
- Reduced scrap/rework 70-80%
The key factor behind the SE philosophy is teamwork. To achieve this other process improvement techniques (for example Continuous Process Improvement, Process Data Management, Total Quality Management, and Quality Function Deployment) may be utilised.

Baxendale et al do not consider the potential barriers to a direct transfer of an SE approach to construction. For instance, the authors report that, in manufacturing, the need for manufacturing knowledge input to the process is absent. Although, they do recognise that this knowledge should be common to all team members. SE also conventionally requires the “integration of all those involved in the design and build process into one multi-disciplined project team employed by one organisation” If these concepts were to be directly applied to construction, then there is a danger that the institutional barriers to integration may prevent effective transformation.

Simultaneous Engineering would, however, appear to offer a useful insight as to how it might be possible to address the problem of fragmentation within construction.

This view is, to a degree, challenged by Schaffer & Thomson (1992) who, following an investigation into ‘activity-centred’ improvement programmes, report that from the evidence of several case studies, this type of approach gives little or no results. “In a 1991 survey of more than 300 electronics companies, sponsored by the American Electronics Association, 73% of the companies reported having a total quality program underway; but of these, 63% had failed to improve quality defects by even as much as 10%.”

Results-driven programmes are, however, more effective. It is argued that they require less ‘preparation’ (i.e. cultural change, revised training programmes); and managerial and process innovations are introduced only when needed.

In construction this approach would require that quantitative goals be identified that will drive improvements in the process. But, how, for instance, can a lessening in fragmentation, or an increase in effective communication be empirically measured? Schaffer & Thomson suggest using targets such as process turnover times, which along with the presentation of exemplar solutions may drive change.

Schaffer & Thomson believe that activity-centred programmes “suggest a tragedy in the making”; for in the long term, the expenditure of vast levels of resources will result in increasing cynicism amongst workers regarding the improvement process. In contrast, results-driven improvement processes “focus on achieving specific, measurable operational improvements within a few months.”

Both approaches share a common goal in terms of process improvement. Yet, activity-centred programmes are often large and diffused, and are consequently not keyed to specific results. Whereas, the advantage with a results-driven approach is that it identifies “specific targets and matches resources, tools and action plans to the requirements of reaching those targets.”

The relative benefits of the various improvement initiatives outlined above are certainly worth considering in the context of the UK Construction Industry. However,
there is no doubt that similar initiatives have been adopted by organisations within the industry, but in many instances they are treated as ‘fads’, and soon dissipate. In consideration of this, the level at which change is addressed should be noted.

The ‘Business System Diamond’ (PRISM, 1990) highlights what may be thought of as the four key levels;

- Business processes
- Jobs and structures
- Management and measurement systems
- Values and beliefs

Many of the techniques discussed earlier address the lower levels of change (in particular ‘values and beliefs’). At the higher levels (‘business processes’) it is the developments within technology that directly influence production. This, in combination with the relatively poor success record of the techniques applied to the lower levels of change, leads authors such as Hammer & Champy (1993) to claim that “...the answer is to radically re-design the whole process.”

The reengineering task is not a simple one. “It requires that people running companies and working in them change how they think as well as what they do. It requires that companies replace their old practices with new ones.” From the following discussion it would appear that it is to this level that one should look in order to promote improvements within the Construction Industry.

**Change within the Construction Industry**

“The procurement of any single construction project is complex in the separation of functions into discrete sub-processes, in its structures and procedures, in its proliferation of actors and activities, in the diversity of the resources employed, their sources and their mobilisation.” (Aouad et al, 1994)

This complexity of the design and construction process can be seen as the primary reason why the many Government reviews of the industry over the past 50 years have failed to instigate any significant improvements. The fragmented nature of the industry, evident if the large number of firms operating within it, and the distinct separation of the professions (in both education and practice) have, to a degree, prevented tangible change.

The adoption of various forms of procurement (Masterman, 1994) is arguably the most significant attempt that the construction industry has made to improve its services. The guidance offered by the investigations of Simon, Banwell, and Emmerson has been largely ignored. As Latham (1995) points out “...some of the recommendations of those reports were originally implemented. But other problems persisted, and do so to this day, even though the structure of the industry and the nature of many of it’s clients have changed dramatically.” Indeed, such is the industry’s poor record of improvement that Latham goes so far as to suggest that unless the current need for change is met “... a new report may be commissioned in the year 2024 to go over the same ground again!”
A Driver for Change

The Driver for Change project, currently being undertaken at the University of Salford, is concerned fundamentally with addressing the need for improvement within the current UK design and construction process.

From case studies of current projects, and interviews with widest possible range of practitioners the requirements of an improved process will be identified. The project will also investigate a manufacturing case in order to capture examples of transferable best practice.

The improvement process is being approached on two levels; one macro at which the design and construction process on each project is considered beyond it’s operational boundaries; the other (micro) at which design and construction are considered at the operational (day to day) level. The process will look to incorporate the advantages of IT to support the improved process (where appropriate). The potential of current IT as an aid to communication and the defragmentation within the industry cannot be underestimated. The project will therefore look to exploit this potential, and will develop a demonstrator system which will be developed in parallel with the improved process.

Given the limitations of the project in terms of the time available, it is likely that any proposed improvements will directed at a management, rather than production, level. At a production level the feasibility of improving the process may be doubted considering the enormity of the facilitating task required. In the longer term, production level improvements may be possible; but these will require fundamental change in standards and approaches to education and training, in addition to alterations to the various demand and supply chains associated with the industry.

Findings to date

Many attempts have been made to model (i.e. represent diagramatically) the construction procurement process. To date, however, it would appear that a single model which (1) provides an overview of the construction process in its totality, and (2) that adequately represents the process to the satisfaction of its myriad of stakeholders, has yet to be developed.

From the following reviews it can be surmised that the reason for this ‘inadequacy’ is that each of the models seeks to achieve a specific, and exclusive, objective. The conclusion that existing models of the process are deficient in that they often are relative to one perspective is supported by Lahndenpera (1996) “‘Many studies of the building process optimize partial solutions or describe the significance of individual factors in a project but their compatibility with other possible factors of success and the relevance of the solution from the viewpoint of overall optimization is not ensured - or even understood.’”
The objective of the model which has been developed from our investigations, and presented in this paper, is to represent the construction process to ultimately evince and promote tangible change/improvement, and so ensure the survival of the UK construction sector.

The following reviews provide the starting point for an assessment of the most suitable means of achieving this objective.

The ICON project (Aouad et al, 1994) as part of its wider remit, developed a “strategic level model” of the construction procurement process. The main objective of the ICON project was “to investigate the feasibility and design a prototype framework for integrated information systems” in the Construction Industry. The premise of the research was that improvements to the process could be achieved through integrating the information formats used by the participants. The model represents the information formats and flows throughout the process. This format makes it somewhat difficult to demonstrate management change. Although, through the application of the CRUD (Create, Read, Update, Delete) analysis technique, the process may be improved.

The CRUD technique allows the information flows to be grouped, presenting an opportunity to identify common ‘creators’ and ‘readers’ for example, and thus minimise unnecessary duplication within the process.

To date, the model presented by the ICON project can not be considered complete. There is little validation of the model in the field, and the model itself is limited to the three data sources used (an Architect, Quantity Surveyor and a Contractor). However, the techniques used deserve consideration.

Sanvido et al (1990), through the Computer Integrated Construction Program at Pennsylvania State University present their Integrated Building Process Model which has been designed ultimately to facilitate IT integration in construction. This model attempts to represent the “essential functions” required to manage, design, plan, construct and operate a building. Using the IDEF-0 functional modelling technique, Sanvido et al developed the model following extensive interviews with practitioners, twenty two validatory site visits, and multiple academic and industry panel reviews. The model may therefore be considered robust within the context of the American Construction Industry.

Upon closer examination, the functional breakdown of the model maintains a generic quality at its highest levels, and this, plus the methodology employed, may be transplantable to the UK industry.

However, the model seeks to use Information Technology as the primary means of improving the process. This, as will be discussed later, may be considered only partly adequate.

The “Process Plant Engineering Activity Model” (PISTEP, 1994) represents (from the viewpoint of a Plant Operator) management activities and the flows between them, found within this industry. The primary focus of the model is data management; and STEP notation is used to present the process as a model in a node tree format. The
‘nodes’ are detailed down to level of activity just above what may be considered ‘practical’ or ‘step-by-step’ notation.

The model accepts that it is not ‘complete’ in that it’s primary aim is to communicate “the main interactions between the main phases of engineering activities in the process plant life cycle.” Improvements to the process, via the deletion, combining or the concurrent performance of activities, is left solely in the remit of the user. Doing this the model ensures that it may be applied generically, “dependent upon the requirements of the task to be undertaken”.

The ICON, Sanvido and PISTEP models, focus upon the data management within a process, which may not facilitate the essential improvements required by the UK construction process. A study undertaken by the Engineering Design Centre at the University of Newcastle upon Tyne, on behalf of the Process Industries STEP Consortium (1992) found that of the problems related to the performance of the process only 16% were data management related.

As an example of a non data focused model, the RIBA Plan of Work is essentially an activity model of the building process. It is detailed from the viewpoint of the designer/architect, which (it can be argued) leaves it deficient in terms of it’s representation of the whole process. The process is however divided into five key stages- Briefing, Sketch Design, Detailed Design, Procurement and Post Procurement, which could be considered generic to any model of the construction process.

Finally, BAA’s Process Model is, like the RIBA model, activity lead. The BAA model goes beyond the simple sub-division of phases, and breaks the process down into the key sub-processes of Development Management, Evaluation and Approval, Design Management, Cost Management, Procurement Management, Health and Safety, Implementation and Control, and Commission and Handover. The model is the result of some 2 years and 15,000 man-hours of research. Each sub-process is conducted, in some form, throughout the process; and it is this grouping of activities which may be seen as ensuring the effective execution of the process. In addition, the model incorporates a ‘stage-gate’ review and approval routine between each phase (effectively ‘freezing’ the output of each phase), to control the process.

The BAA model is robustly developed. However, it’s applicability at a generic level may be questioned. The model is developed from BAA’s perspective as a client of the process (the sub-processes identified relate specifically to key functions within the BAA organisation). Consequently, the model takes little account of the improvements that could be implemented from other perspectives.

In summary, it can be seen that each of the models reviewed here represents the process at one level, or from one perspective only. This, in itself, supports our view that (to date) no model of the construction industry adequately represents the entire process.
A Direction for Change - Workshop

In a recent workshop facilitated by the authors, and attended by representatives from all areas of design and construction, what may be considered as the direction for effective change in construction began to crystallise.

A questionnaire survey undertaken during the early stage of the project had found the industry to be lacking in consensus as to what constituted the design and construction process. The workshop subsequently aimed to define this process, and to identify the potential improvements.

The workshop participants were divided into two groups. Throughout the sessions, both groups were found to have similar trains of thought. Initial discussions found the ‘contemporary’ model to be deficient in terms of its coverage of the pre-project processes. These were seen as essential in order to test the validity of a project as a scheme in itself. Currently, it was felt that, to an extent, pre-project activities were undertaken; but in terms of their effectiveness in influencing the success of the project, the current practices were inadequate. The relative skills of the participants in the process were questioned, as were the number and type of participants invited to contribute to this and other stages of the process.

The key to improving the current process was seen as twofold. First, the relative expertise of each of the participants in the process should be recognised and appropriately incorporated at the various stages of a project. Secondly, it was felt that many of the current problems associated with the industry were a result of incomplete design. For instance, the start and finish price differential on most projects was considered a result of cost plans being produced often when less than 90% of design is complete. The causes of incomplete design were many, although the briefing process was considered often poorly conducted. The inexperience of many clients, and the lack of advice given by practitioners were the fundamental reasons for this, however.

The various stages of a construction project, and particularly design, were considered re-iterative. The progressive fortification of each phase (i.e. sketch, outline, and full design - as one example) indicates a complex process, where activities often overlap. Because of the increasing specialisation of functions involved in the process, there was now a need for independent management (a role performed by interfunctional ‘brokers’ or ‘facilitators’). In design, this management role would ensure the production and approval of a clear set of project documentation at various points in the process. The many assumptions often contained within the process, and affecting decision making, should be made explicit and challenged.

The membership of each phase team should be optimised. The particular need for expert consultancy at each phase was emphasised. In the case of design, the input of a constructor consultant was considered essential, as a means of ensuring buildability and technological innovation.

The fundamental benefit of the improved process should be to optimise predictability. This could only be ensured when a truly co-operative project environment exists. The
process should therefore look to facilitate teamworking and effective communication between participants.

In order to support the improved process there were also considered some IT requirements. Fundamentally, the role of IT would be to establish and maintain a common database of all project information and data. The database contents should be standardised, and what was standard, central or core information must be identified. This would facilitate an effective referencing system, which would satisfy the varied requirements for information during the process.

Information could be classified in one respect in terms of who required it. For instance, in the production of a building involving structural steel elements, at one level cutting information would be required for production, whilst at other levels information relating to the form of the elements only would be required.

In another respect, the information on a project could be classified in terms of type. For example, all information may be coded (according to one workshop participant) as either graphical, non-graphical, or functional.

Any IT system facilitating this should enable the ‘viewing’ of the database from the variety of perspectives taken during a building project. This would require design data to be presented in either 3D, 2D, or descriptive formats; and financial information in graphical, tabular or explanatory formats.

The IT’s formatting rules would have to be held within a separate application, linked to local, national and international control bodies. This would allow the progressive updating of the controlling system. The database should be openly accessible, for viewing purposes; and the co-ordination of the database (which would most likely be a common link for multiple databases) would have to be ‘policed’ by a librarian team.

The database should allow storage of information beyond the lifespan of the construction project. This would allow a learning process to be implemented industry-wide. However, when considering this it should be appreciated that each project will be unique in at least one respect (site conditions), and that the data held by a database should maintain contextual relevance.

In summary, the workshop considered the prime objective should be to bring the fragmented parties of the process together. To do this the areas where fragmentation occurs should be identified, and where appropriate new roles may be identified.

One of the first steps to achieve this would be to ‘spend time understanding one another’.

**A Process for Change**

The findings of the workshop, together with the evidence of existing literature, have aided the development of a draft generic process model.

To facilitate discussion, the model is presented in two levels. The intention is to use the models to graphically promote (a) the concepts being developed to communicate
change, (b) the reasons for these improvements to be adopted throughout the industry and, (c) to engender a desire to contribute to improving performance.

The two draft models are complementary - one, a macro contextual model (Fig.1), provides an overview of the totality of relationships within the design and construction process between existing methods. It illustrates the regenerating process for absorbing new knowledge into the system, through inter-relating pools of knowledge informed by the realities of the construction practice.

The second model (Fig.2) is a more specific ‘micro’ analysis. The model is developed, initially, to allow an identification of the ‘bottle-necks’ within the design and construction process. From the findings of case studies, the intention is to propose a series of measures to eliminate these problem areas. A series of models will then demonstrate improvements within the process.

**The Macro Process Model - a knowledge transfer system**

The draft model presented takes as it’s four core elements, the following factors:

1) **Experience** - The experiences of most traditional design/construction systems are rarely stored or saved for future reference. However, the client, consultants and other professionals working on each project may be seen as ‘information gate keepers’. The capturing and dissemination of this experience must be seen as a key element in any future process for design and construction.

2) **Work Phases** - In a synthesis of the literature, process models, and workshop findings, the five generic phases through which a project passes may be defined as:
   - Pre-Project
   - Pre-Construction
   - Construction
   - Post-Construction
   - Post-Project

3) **Information Flow** - “Computing and Communication in the Construction Industry” (DOE & CNC, 1978) suggests three areas that information may be divided into:
   
a) Management information: information relating to design teams, contractors resources and to their use on projects, including control and monitoring; communicated mainly by office record, correspondence, programmes, networks and print-outs.

   b) Project information: client's requirements, the site, the environment, (both as proposed and executed); found in the project’s production documentation.

   c) General information: (inter alia) regulations, contract procedures, construction methods, properties of materials, ergonomics, maintenance data.

4) **Activity Targets** - measurable indicators of cost, time, quality, and other criteria.
These four elements are combined to produce a plan which demonstrates the relationship of each element to one another. The layout of the macro model represents the life cycle for construction projects - from inception to demolition - and the flows of information which occur during the cycle. The model has been adapted from the “simulation feedback model” presented by Vincent (1995).

The purpose of the macro model is to graphically communicate to the industry the cyclical processes involved in harnessing and improving the knowledge-base. Ultimately, this knowledge will then feed back into improving the performance of all aspects of the process for all construction projects.

Fig.1
Macro model description

The Macro Model (Fig. 1) is truncated down the centre by a 'spine', or interface. The 'spine' is the source of information flow and the mechanism for information manipulation to contribute to informing the process. The information flow system provides and accesses three levels of information (1) General Information, (2) Management Information, (3) Project Information. The operation of this 'spine' will most likely be best achieved using IT. The IT system will fundamentally support the improved process by maintaining a complete and updatable project database. The system will ultimately act as an auditing tool, allowing the maintenance and retrieval of historic project information, and thus facilitating continual improvements industry-wide.

To the left of the 'information spine' in the draft model is the specific project detail - with a number of phase pools indicated. The definition of the phases will be drawn from the micro model (detailed below). The 'real world' experience loop feeds both the information 'spine' and across the spine to contribute to the generic learning 'knowledge pools'.

The generic learning/knowledge 'pools' (to the right of the model) will gather together in one place, all information on selected areas of the process. The key variables for each knowledge pool have yet to be identified.

Micro Model Description

Drawing upon the influences of existing research, and data collected from questionnaires and project case studies, the micro model (Fig. 2) deals exclusively with the ‘functional’ detail of the design and construction process.

At the present time, the model is only partly defined. Subsequent interviews with practitioners will provide further detail, particularly in relation to the functional processes. However, the generic phases of the process are likely to remain consistent.

Summary & Conclusions
This paper has examined the need for, and potential approaches to change within the UK design and construction process.

This paper has examined some of the ideas and culture in mainstream manufacturing, as a driver to inform the development of a generic design and construction process protocol. From case study analysis of construction projects and the Workshop, attended by design and construction professionals, it has become evident many of the problems occurring during construction could be avoided if pre-construction planning was undertaken in greater depth and more focused; it is the front-end of the process which is the element that will require detailed analysis. In this respect, manufacturing applies well-tried product development and innovation process planning approaches to the pre-planning stage of manufacturing. The manufacturing approaches require further analysis. Not all elements are transferable, this approach learning from manufacturing will enable the design and construction industry to reengineer itself. It is also acknowledged that developments in IT (3D modelling, VR tools) will facilitate this process.

The findings to date suggest that there is scope for realistic and tangible improvements, given the examples from manufacturing industries use of Simultaneous Engineering techniques, Latham’s 30% cost reduction target may not be unfeasible. However, in order to promote such improvement, a robust and largely generic model of what constitutes the design and construction must be agreed.

The DRIVER for Change project, through which this paper has been produced, provides a clear means of achieving such improvement. With the support of several key industrial partners¹, and funding from the EPSRC’s Innovative Manufacturing Initiative, the programme of work over the next 18 months will provide a basis for demonstrating the tangible changes that are possible.

¹ Alfred McAlpine Construction, Engineering Technology, BAA plc, British Telecom, Waterman Partnership, EDM Architects, Boulton & Paul.
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