INTERFACE OF EARLY DESIGN AND COST ADVICE IN THE BUILDING DESIGN PROCESS

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This paper reports on work that is part of a doctoral study, the aim of which is to improve the management of early stage design with particular reference to: developing the brief; the subsequent exchange of design and cost information between client and designers; and the impact of early design decisions on construction. It describes the application of information flow models to early stage design and discusses a model being developed in this research (based on IDEF0) which aims to integrate design and cost information flow. Methodologies for modelling the early stage design have thus far proved of limited usage to industry other than for the purpose of providing a generic representation of the process. If a process model is to be of value to early stage design it will be important to show the relationship between design information and the cost advice given to the client. It’s application should also have a clear effect on reducing the risk associated with providing cost advice over time. Integration of cost and design information therefore forms a significant part of the research. Techniques to combine process modelling and other methods of analysis will be investigated to ascertain their utility for managing the schematic stage of the design process. Although the initial work is based on the concept stage in design, it is believed that the schematic design stage represented here will benefit most from the application of design information analysis, as it is here that deliverables can be identified in terms of options, solutions, programmes, and estimates.

Keywords: Concept design, Design management, Design process modelling

INTRODUCTION

The Research Project

The early stage in the design of construction projects is a crucial time for both the client and the design team. It is at this time that the information provided by the client in terms of the client brief should be as accurate as possible. The design team rely on this information to be able to translate it into robust cost information. The client in turn will rely on the cost information to justify or provide sanction for a project. Blackmore (1990: 32 & 42) stated:

“The factor which most affects profitability is the incompetence of many clients in establishing their requirements and in making decisions.”

But briefing and design are an interactive process so without a strong dialogue between the design team and the client the brief will not evolve into an effective design.

This research project is sponsored by the EPSRC with help and advice being provided from a variety of industrial collaborators. The research is in the first year of a three
year project. The aim is to improve the management of the concept and schematic design stages with particular reference to developing the brief. It will:

- Investigate current briefing methods in engineering industries (including construction, manufacturing, aero / auto-motive and product design) in order to identify techniques that could improve best practice in the construction industry.
- Examine how information flow and matrix analysis techniques might assist in planning/management of the information flow (particularly the effects of changes), and to develop additional strategies.
- Investigate how designers can provide information of appropriate detail and quality for the purpose of making cost estimates for both the client and the design team.
- Identify how improved early design strategies could reduce constraints and conflicts during the construction process.

This paper addresses work concentrating on set points two and three. Our approach is to:

1. Observe the process of information exchange between client and design team, conducting interviews as well as shadowing a live project;
2. Develop an IDEF0 based information flow model for concept and schematic design using the past experiences gained by both Newton (1995) and Hassan (1996);
3. Integrate the work in 1. and 2. Above; and
4. Examine the application of the model and its integration within the cyclical process of concept design using these analytical techniques.

To help our understanding of current design practice, it was necessary to shadow and observe the process as a design team undertook their commission. Amec Design and Management, who are specialists in providing design solutions for clients needing highly engineered buildings, were able to help. They had been commissioned to provide a feasibility and front end study leading to providing +/-20% cost advice to a client wishing to expand and update an existing pharmaceutical research establishment. Both they and the client were willing to allow the project to be shadowed and form the focus of the research.

**HOW BUILDING AND DESIGN PROFESSIONALS MODEL DESIGN**

The design process in the construction industry has evolved over a long period of time from the early masons through to the great architects of the twentieth century. It was from the development of the atelier tradition and the birth of academies that institutes such as the Royal Institute of British Architects were formed. The RIBA saw a need to set out a Plan of Work (RIBA 1973) in an attempt to provide a model procedure for the methodical working of the design team. Its first edition was published in 1964. Inside the Plan of Work there are twelve stages set out to describe a logical course of action. It is then divided into four elements: this research is concentrated on parts one and two (Figure 1).
A. Inception 1. Briefing
B. Feasibility
C. Outline proposals 2. Sketch Plans
D. Scheme design
E. Detail design 3. Working Drawings
F. Production information
G. Bills of quantities
H. Tender action
J. Project planning 4. Site Operations
K. Operations on site
L. Completion
M. Feed-back

Figure 1  Table denoting RIBA Plan of Work and its stages.

Lawson (1980: 26) claimed the Plan of Work to be part of the architectural profession’s propaganda exercise to stake claim as leader of the multi-disciplinary building design team and that from it we learn more about the role of the RIBA than about the nature of the architectural design process. The Plan of Work states that it represents an outline method of working only and designers, particularly designers of highly serviced buildings, have found the Plan of Work to fall short of meeting their requirements for a process that is used to order increasingly sophisticated cost advice required by a client prior to capital sanction.

A complete picture of the design method requires both a decision sequence and a design process or morphology and there is a need to go through the process of analysis, synthesis, appraisal and decision at increasingly detailed levels of the design process. Figure 2 illustrates the point:

Figure 2  The Process Of Analysis, Synthesis, Appraisal And Decision. (adapted from Maver, 1970)

This model acknowledges that the design process is an iterative process that will be infinitely variable dependant on the solution sought. Design problems at a basic level or activity within concept or schematic design may require an input in the form of feedback from a more sophisticated level or activity further into the design process. Such inputs will have an effect on decisions already made so an appropriate allowance must be made to allow for this when modelling the process.

What is clear is that at concept stage there is a collecting together of information and decision making that will then provide the basis for proposing solutions to a client’s need. Having accepted this we can ask if it is possible to reach a single solution in providing a process model for early stage design. As there are two distinct processes
being enacted it is unlikely. What may be found are separate solutions for each that will improve both of these stages offering benefits to both the client and the design team.

In recent years there have been a variety of proposals made to improve the design process. An example is the introduction of Total Quality Management (TQM), following its successful integration into manufacturing and service industries worldwide. Most quality management programmes are process improvement orientated (Kubal 1994). TQM processes not only concentrate on the quality of the finished product or the process involved in making the product, but also aim to improve the performance of an organisation’s internal processes, the purpose being to sharpen their ability to recognise and qualify opportunities that can enhance or add value to the service they provide to their clients.

A process can be defined as the enactment of a set of purposeful tasks carried out over time, using resources and resulting in deliverables (Platt & Blockley1994). However our objective is to model design and cost information as an integrated process, using a representation that will show the flow of the data and the deliverables required to provide an accurate order of cost. Newton (1995) and Hassan (1996) showed the use of Data Flow Diagrams (DFD’s) to be a suitable method in the creation of this type of process model.

INFORMATION FLOW MODELLING

Introduction
Whilst the starting point from our earlier research was DFD’s, we chose to re-evaluate the methodologies available. This section describes the modelling device IDEF0, its use in other systems and its advantages for modelling design. IDEF0 provides the flexibility of structured functional analysis to increase the quality understanding of the information needed to be represented in a design model (Colquhoun et al 1993).

The concept and schematic design process is being modelled to identify where improvements may be made to achieve an accurate order of cost and overall improvement to the design process. In another research (Austin et al 1997) our group is investigating the potential for a system tool at the detailed design stage.

IDEF0 BASED CONCEPTUAL DESIGN MODEL

Originally developed to describe manufacturing organisation in a structured graphical form and currently used as a tool for business process re-engineering, the IDEF0 standard convention for its data flow arrows was considered to be inappropriate for our purpose. Gibson (1995) used the terms ‘decision’ and ‘decision makers’ but the concept design process is not about decisions alone. It includes recording how the collection of information is used by the different disciplines to order design. Eventually it was decided that as the process being modelled is discipline based, the model should be used to describe a discipline based process thus:

- Arrows denoting inputs would now denote interaction within disciplines.
- Arrows denoting control inputs would now denote interaction across disciplines.
- Arrows denoting mechanism inputs would now denote interaction from external sources.
Figure 3 displays these principles graphically.

![Diagram](image-url)

**Figure 3  Context Diagram for the Early Stage Design Process**

We have produced version 1 of our IDEF0 model based on Hassan’s DFD model. The hierarchical tree of activities that define individual functions within concept design are displayed in Figure 4. This provides an example of how the activities are ordered in the Concept Design Process and the activities that form part of Building Concept Design produced in Figure 5 are shown hatched.

![Hierarchical Tree](image-url)

**Figure 4  An Example of Concept Design Hierarchy**

A typical example of an IDEF0 diagram showing activities and information flow (arrows) for level one of the concept design process is shown in Figure 5:
Using the information recorded from the shadowing exercise, interactions are recorded to highlight optimum paths to reach a solution. These will be classified within their discipline as design solutions are sought. The intention is to amend and validate the information flow model using the results of the project shadowing.

CONCEPT AND SCHEMATIC DESIGN - INDUSTRIAL EXPERIENCE

A series of interviews with design professionals and user groups was planned to collect data and develop knowledge of industrial practice. An observation exercise shadowing a project was also undertaken. This was used to assess the requirements and needs of the client and respective user group members, to record how and where their criteria may or may not be met by current practice in both the concept and scheme design stages.

UNDERSTANDING EARLY STAGE DESIGN

The design process as it is undertaken by design management professionals clearly partitions the design process into two elements:

1. CONCEPT and SCHEMATIC DESIGN
2. DETAIL DESIGN

Concept and Schematic Design is that part of the design process that is covered by parts A, B C and D in the RIBA Plan of Work (Figure 1). Detail design is covered by parts E, F and G.

It is during the Concept Design Process that the client will define requirements to the design team and it is at the Schematic Design Stage that project objectives and the means of achieving them are agreed. Signore (1985) defined this as conceptual planning and conceptual development. During this combined stage we may start to
identify where to put the effort which would be robust enough to improve cost certainty and reduce conflicts during construction period.

Worthington (1995) claimed:

“There is an unease amongst well informed clients that the cost of building is excessive for the quality received.”

An often used diagram depicting opportunity to improve value for money is shown in Figure 6.

**Figure 6  Cost Over Time And The Influence On**

Time spent at design concept stage can potentially save large amounts of money because design changes during a project can be expensive. Risk may also be mitigated with time so it is important to achieve a balance when estimating for design.

Value for money in building design depends on rational decisions, which according to Connaughton & Green (1996) means ensuring that:

- The nature of the problem is fully understood.
- Decisions are made in the light of agreed objectives.
- Different options for achieving the agreed objectives are considered.
- The options and their associated risks are carefully thought out.
- Decisions are made on the basis of the best available data.
- Decisions draw on the widest possible range of expertise.

**PROFESSIONAL INTERVIEWS**

Designers and academics alike are looking to the processes used within their industry to find solutions to the increasing requirements made by clients, the sophistication of product and the risk associated with providing appropriate cost advice when estimating building design. It was important for the research that we fully understand industry requirements.

With this in mind we approached one of our industrial sponsors; Amec Design and Management and a meeting was arranged with their Projects Director to enquire about shadowing a design project from inception through to the start of detail design.

We were informed that they had just been commissioned to carry out a feasibility study on an existing drug development complex, to provide design solutions with an order of cost estimate for an expansion and improvement proposal. With the
agreement of the client we have been allowed to shadow the project from the initial team introduction meeting. Arrangements were also made to: talk with and interview the design team members about how solutions were reached within their disciplines; attend review meetings; and obtain access to documents and minutes relating to the entire process.

The first discipline interview held was with the Amec Design and Management Project Economist. In summary it was revealed that cost planners would be engaged towards the end of the initial four week fact gathering exercise to start the cost advice process.

Cost advice is used to qualify the clients budget and provide a cost certainty within given parameters. At Amec Design and Management a range of cost advice may be given: +/-20%, +/-10% through to Lump Sum. There is also a reimbursable prime cost variation offered called Guaranteed Maximum Price (GMP is an AMEC term used to describe a price capping arrangement that fits somewhere between +/-10% and Lump Sum in the ordering of cost certainty). In a management type contract no guarantee on cost is given.

At +/-20% or order of cost all that is required is a 1:100 scale plan of the building so that approximate floor area may be taken off and the functional spaces of the building assessed. The function area costs are then built up using benchmarking data combined with individual sums for specialist building components to provide the budget appropriate to this order of cost.

At +/-10% the cost certainty changes from area analysis to quantification of the building elements. This may form the basis of a bill of quantity the purpose being to identify all elements that may involve risk when providing the cost advice.

At the next stage and depending on the proposed procurement route, a decision is usually made to proceed with more detailed design work. Where the Lump Sum route is chosen, and after a period of further design work, the design is packaged together and submitted to the market for market support. Each package is reviewed technically and commercially, and the risks are assessed so that a figure can be given to the client. After negotiation a project cost is fixed and Amec Design and Management proceed with detail design. As an alternative, in a management type contract the design would be progressed and assessed against a cost plan on an ongoing basis. Each package is then let by the management contractor or construction manager. The cost plan being adjusted after prices are confirmed.

Future interviews yet to be conducted at Amec Design and Management will include: Meeting Marketing to discuss strategy, structure of the assessments used to prepare design fees, cost checks, risk evaluation and negotiations with the client. The Design Manager to discuss the team roles. And structured interviews with design team members about their specialist experience.

**PROJECT SHADOWING**

The considerable research time spent shadowing the concept and schematic stages of a new £25m research department for a pharmaceutical company has already been beneficial to the research by providing a snapshot of how a particular design specialist produces solutions for a company wishing to expand its research department. The principle steps used by the design team to assemble and present information to the client have been identified in Figure 7.
Figure 7. The Principle steps used by the design team to assemble and present deliverables:

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<table>
<thead>
<tr>
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<tbody>
<tr>
<td>1</td>
<td>Review user identified options</td>
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<tr>
<td>2</td>
<td>Data gathering and analysis</td>
</tr>
<tr>
<td>3</td>
<td>Review data on existing buildings</td>
</tr>
<tr>
<td>4</td>
<td>Review site services data</td>
</tr>
<tr>
<td>5</td>
<td>Define objectives using VM₁</td>
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<tr>
<td>6</td>
<td>Site investigation survey</td>
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<tr>
<td>7</td>
<td>Develop user brief</td>
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<tr>
<td>8</td>
<td>Adjacency/circulation analysis</td>
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<tr>
<td>9</td>
<td>Prepare optimum solution</td>
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<tr>
<td>10</td>
<td>Strategic engineering studies</td>
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<tr>
<td>11</td>
<td>Brainstorming session</td>
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<tr>
<td>12</td>
<td>Select option</td>
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<tr>
<td>13</td>
<td>Review option and test project objectives VM₂</td>
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<tr>
<td>14</td>
<td>Outline fire engineering strategy VM₂</td>
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<tr>
<td>15</td>
<td>Develop agreed layout option</td>
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<td>16</td>
<td>Prepare budget cost estimate</td>
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<tr>
<td>17</td>
<td>Structural design study</td>
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<tr>
<td>18</td>
<td>Civil design study</td>
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<tr>
<td>19</td>
<td>Mechanical design study</td>
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<tr>
<td>20</td>
<td>Electrical design study</td>
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<tr>
<td>21</td>
<td>Prepare +/-20% cost estimate</td>
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<tr>
<td>22</td>
<td>Prepare design &amp; construction programme</td>
</tr>
</tbody>
</table>

The client has provided agreement in principle to holding ‘debriefing’ at a later stage in the process. We intend to review with Head of Engineering, the person who has been responsible for procurement and who has then to defend the finished concept and schematic design to the main board of directors, opinion on the process used.

Structured interviews will be used to enquire with the Heads of Department (user group representatives) at the pharmaceutical company how they felt about the current design process and how they feel that process may be improved. It is hoped that a balancing opinion taken at this stage will assist in fine tuning the proposed model.

**CONCLUSIONS AND FURTHER WORK**

By identifying the elements within a process, a clear hierarchy of dependent tasks will evolve (Austin et al 1995). Through ordering the information dependencies diagrammatically a systems approach may then be developed. The ordering of the design process and the identifying of the respective cost stages will improve understanding which in turn can reduce risk, both of which will help achieve the objectives of the research.

The research so far has indicated that the early stage design is further separated within the concept and the schematic processes. Concept design is more iterative in a strategic sense and as such will require separate design process solutions to the schematic stage. Modelling of the concept and schematic design processes may improve the ability of design teams to estimate their costs and matrix analysis methods (Austin et al 1996) may prove beneficial in identifying deliverables and help to improve the order of magnitude estimate provided by the schematic design process.

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REFERENCES


