

# MEASURING INFORMATION INTEGRATION IN PROJECT TEAMS

Measuring Information Integration

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## Abstract

Integrated project information is the goal for many clients and their project teams. In theory, the aim is to use IT to support a seamless electronic process in which data are entered once and where no manual intervention interrupts the flows across the different life stages. In practice, IT has been used largely to reinforce existing work patterns that fragment the team's efforts. So far, IT has delivered limited benefits. A study of integrated project information has been completed on 11 building projects across four European countries. Degrees of integration of project information have been measured and used to derive some measure of the extent to which project teams are bound together by the use of IT. This paper summarises the 11 case studies, by revealing the extent to which IT has been successfully applied to support integration. The findings provide pointers to the future application of IT by project teams. In this regard, the active interest of the client in the project and its IT infrastructure is emphasised.

Keywords: IT, integration, project information, project teams, process models.

## 1 Introduction

The use of IT on 11 construction projects has been studied to establish the type of IT being used and the degree to which information was integrated. This refers to the extent to which the exchange of information between project participants occurs seamlessly without any re-keying of data. The combined value of the projects studied exceeds 2 billion Euros.



This paper describes the findings from the 11 project case studies and provides clues to the more effective use of IT at the project level, where the client's objectives must be satisfied by the combined efforts of human resources, materials, mechanical assistance and IT support.

## **2 Project life stages**

All stages in the building life cycle were considered – see below. Comparison was made on the basis of this structure, taking account of different procurement strategies, and the extent to which information flow was IT enabled. All 11 projects were believed to reflect at least good use of IT. The following stages were covered.

1. Inception
2. Briefing
3. Feasibility
4. Concept design
5. Scheme design
6. Detail design
7. Tender documentation
8. Estimating and tendering
9. Evaluation of tenders
10. Off-site fabrication/prefabrication
11. Delivery/logistics
12. Production/assembly
13. Testing, commissioning and hand-over
14. Operations/facilities management
15. Re-use/demolition

## **3 Method of study**

The study was loosely based on benchmarking methodology (Leibfried and McNair 1994) and relied principally on interviews with key project participants. It was agreed that all information flows reported by them should be regarded as necessary to the projects in question, but that detailed recording of the information was outside the scope of this study.

Project co-ordinators were interviewed in order to obtain a complete (or as near complete) picture of the information flows, their frequency and the kind of IT being used. Each project was visited, on average for two days: first, to get the general impression of information flows and IT use, and second, to make detailed notes and to refine the analysis. Further days were spent in preparing and validating the resultant functional models.

Interviews began by considering the extent to which the list of generic stages applied to the project. The technique used to assist in the analysis and the subsequent presentation of the 11 project process models is IDEFØ. This is used to document activities, their relationships and their associated inputs, controls, outputs and mechanisms (ICOMs). This was supported by computer software: originally Ai0win, but subsequently BPwin. Both are based on the US IDEFØ Federal Information Processing Standard for function modelling.

The basic notation of IDEFØ has however been modified for the purpose of this study to aid clarity in the analysis and presentation of information. Input and outputs are

shown As-Is, that is, as the actual flows into and out of activities in the way they occur in reality. Controls and mechanisms have, on the other hand, been simplified so that the various participants, organisations and authorities that have any bearing on the projects (and hence the process) are represented as controls; mechanisms remain to cover mostly IT elements and other tools.

## **4 The projects**

Six of the 11 projects are briefly described below.

### **4.1 Out-of-town shopping mall**

This is one of the largest building projects currently being undertaken in northern Europe and is being procured under a modified design and build arrangement. The architect was novated to the construction manager during the latter stages of design. It is a fast track project, with a large body of design staff and has faced a lot of pressure, not least in surviving a difficult planning application. Local sensitivities have been a major factor and constraint for what is said to be the last project of its kind in the region.

### **4.2 Speculative housing**

Innovations in practice, as well as in the use of IT, are reflected in this case study, the design and construction of a medium sized housing project. A striking feature of this project is that of a single source of responsibility under the control of a developer-builder. The adoption of an innovative procurement method took the place of practices that were long considered in need of change. A good example of this was where management of the supply chain had to be completely overhauled. Suppliers became partners in the process and, as part of the new working relationship, were given electronic access to the project database. This innovation enabled the project team to eliminate many non-value added activities that otherwise characterise much of traditional procurement.

### **4.3 Office complex**

Built to support the client's expansion into financial services. The design commission was won in competition for a scheme that, subsequently, changed significantly. Although the client could be regarded as informed or expert, that appears to be true only in the case of its core business. The client was inexperienced and unsure of requirements. This necessitated a close interaction between the design team and the client. Changes very late in the day were a feature of this project. The architect was novated to a management contractor during the later stages of design.

### **4.4 Public-private partnership detention centre**

That was the first of its kind involving the use of several innovative approaches. Major projects can create many challenges. Complexity and a novel form of procurement were just two challenges facing the project team on this large building project for a public-private partnership. Added to this was a diverse and culturally

varied project team. The result was a challenging project. Perhaps for these reasons, effort was concentrated more on integrating people into effective teams than achieving the highest practical use of IT.

#### **4.5 Manufacturing facility**

This is a major project with a *hands on* client and is based on a management contract. Very high levels of services were required, with extensive clean room technology. The project commenced in November 1996 and suffered a slight setback through the current economic problems in Southeast Asia. Work on the site was, in fact, suspended between during the first quarter of 1998. Completion is scheduled for early 1999. The project is welcomed locally as it is expected to provide high levels of employment within the area.

#### **4.6 Headquarters building, car park and related facilities**

For a car manufacturer which is let as four separate contracts. The headquarters building, a 40,000m<sup>2</sup> development, was the subject of an internationally invited design competition. Considerable effort was expended during the competition phase, which provided the basis for the subsequent design commission. The client novated the contract to a developer, with the intention of leasing back the development on completion. The contractor that took on the design and build contract re-let the consultancy contracts, although the developer retained the original consultants in an advisory role. The project reflected a very demanding brief and client and one where the physical location of the project was bound to cause some difficulties. Procedures were highly detailed and somewhat complex. The design commission was a joint venture with partners from two countries.

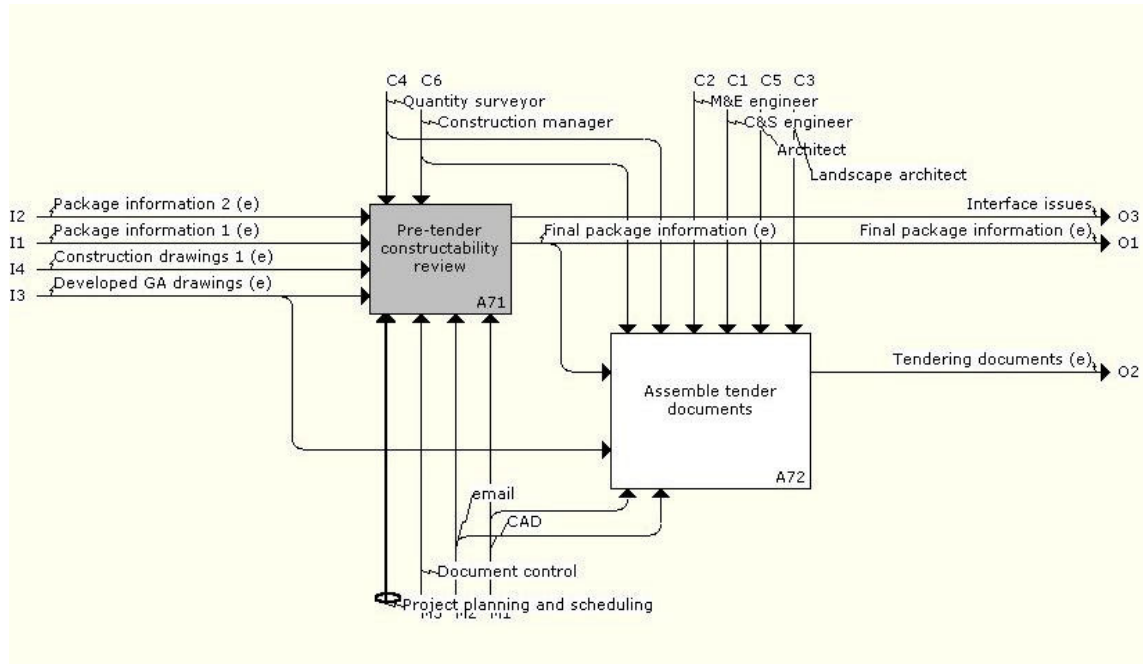
### **5 The projects' use of IT**

#### **5.1 Out-of-town shopping mall**

This project's greatest achievement is probably its control over a large and intensive work programme, involving a large number of people and organisations. The construction manager's use of an in house developed system of information, cost and change management ensured that information flows were controlled and directed to those who needed them. This was an information management application on a large scale, with impressive savings demonstrated in the use of IT over traditional means for communication and the transmission of drawings etc. No organisation was allowed to fall outside the IT sphere or regime. This meant that even the smallest of contractors and specialists had to fall into line and enable information flow to be fully electronic. There could be some criticism of the narrow focus of this IT supported process; whatever it is, the word focus is highly pertinent. IT was used to get on top of a large problem and reduce it to more manageable proportions.

On the downside, the project suffered from what appeared to be too protracted a design phase, where information was developed very incrementally and where some input (especially those in relation to constructability) occurred late in the day. The

impression was of a project trying hard to keep up. IT made sure that, at the very least, the process stuck to the schedule.



**Fig. 1: Constructability studies are vital, but should not be too late in the process (The letter (e) after the name of a flow indicates that it was electronic)**

## 5.2 Speculative housing

This project exemplified the concept of integration through a re-engineered process that used significant IT to achieve lower production costs against demanding time-scales. The project team was able to report substantial reductions in programme time when compared with more traditional procurement, including its own previous work.

In overall terms, this developer-builder claimed a near 50% reduction in time spent on design today, compared with earlier projects. Particular gains arose from the ability to make changes to the design once only and an ability to communicate them rapidly to those affected. CAD was a key technology for this developer-builder and one that was used to build object-oriented models embodying information about the process. The intention was that these could ultimately be evolved into product models serving the wider needs of the project team, manufacturers, suppliers, the client and end users.

During the project's design, checks for consistency in detailing and clash avoidance – especially in the area of engineering services – also meant that prefabricated components could be manufactured in the belief that few problems would arise on site. This latter aspect was important since the time spent on site had been compressed to the point where there could be little tolerance for delays caused by errors and inconsistencies. Bringing manufacturers and major suppliers into the project during the earliest of stages helped to co-ordinate work to the extent that the team adopted the goal of zero errors in component delivery and assembly. Comparison of the use of IT against the earlier manual

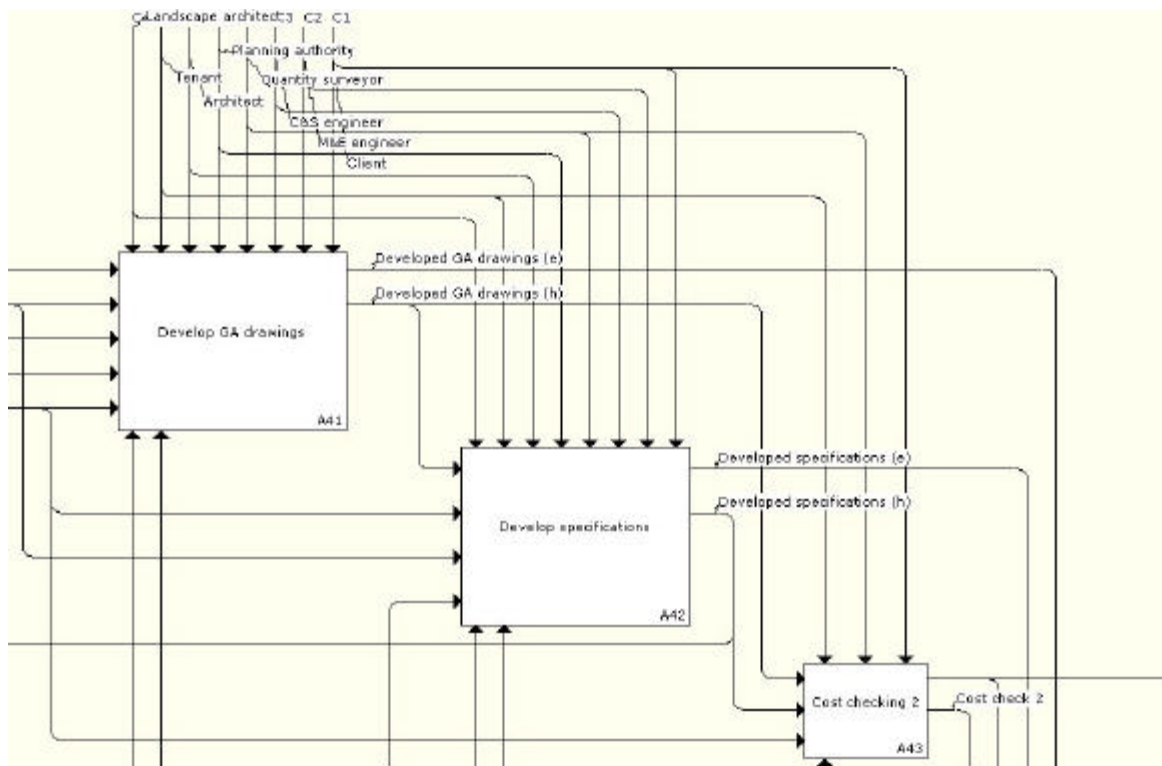
process showed that quality, reliability, accessibility and re-usability of information was significantly better.

In many respects, this project has moved a long way towards the ideal of making construction more like a manufacturing process. By applying IT to a re-engineered process, this developer-builder was able to progress towards the goal of integrating project information, which, under more traditional procurement forms, would have been very difficult. The developer-builder is intent on extracting further gains, as part of a culture of continuous improvement, on top of an already significant payback.

### 5.3 Office complex

The client relied heavily on the architect's traditional plan of work and the IT tools that supported it. A lack of real pressure for IT use by the client and 'constructor' meant that more reliance was placed upon the architect's own preferences in regard to the use of IT. This did not necessarily imply a great or innovative use of the technology. Indeed, there are elements of the process where streamlining of working practices could have been achieved had the client and rest of the project team been more IT aware. IT use supported the control of documentation generally and the production of design information in particular.

The client was heavily involved in many changes to the design. However, the absence of a quantity surveyor, as part of the design 'loop', meant that progress in evolving, developing and refining the design was hindered and was not always as planned.



**Fig. 2: Quantity surveying cost checking function hindered the free flow of information**

#### **5.4 Public-private partnership detention centre**

IT was present in many forms – desk top PCs, email and database management – though there was little linking and sharing of information. That said, the project was viewed as a success, against a tight time-scale, strict budgetary control and a very demanding client. The nature of the project, in particular its intended use, meant that security was an important factor weighing on the project team. The imposition of rigorous procedures, designed to ensure confidentiality and security on what was also a politically sensitive project, meant that IT was felt to present too great a risk for the project team.

Limited electronic exchange did take place between parties, for instance amongst the designers and with the client body, but even these did not amount to a significant attempt to integrate information on a project wide basis. The demands of the project were probably thought to be enough without having to cope with the uncertainty of IT. Even so, the opportunity to enforce better communications between the various actors through, for example, projects wide email and drawing exchanges was passed up. Project team members were acutely aware of the penalty for failure on the project and so anything that was unproven was unlikely to be adopted. Given that the project was the first to bring the consortium together, there was probably no obvious basis upon which to implement an information management strategy.

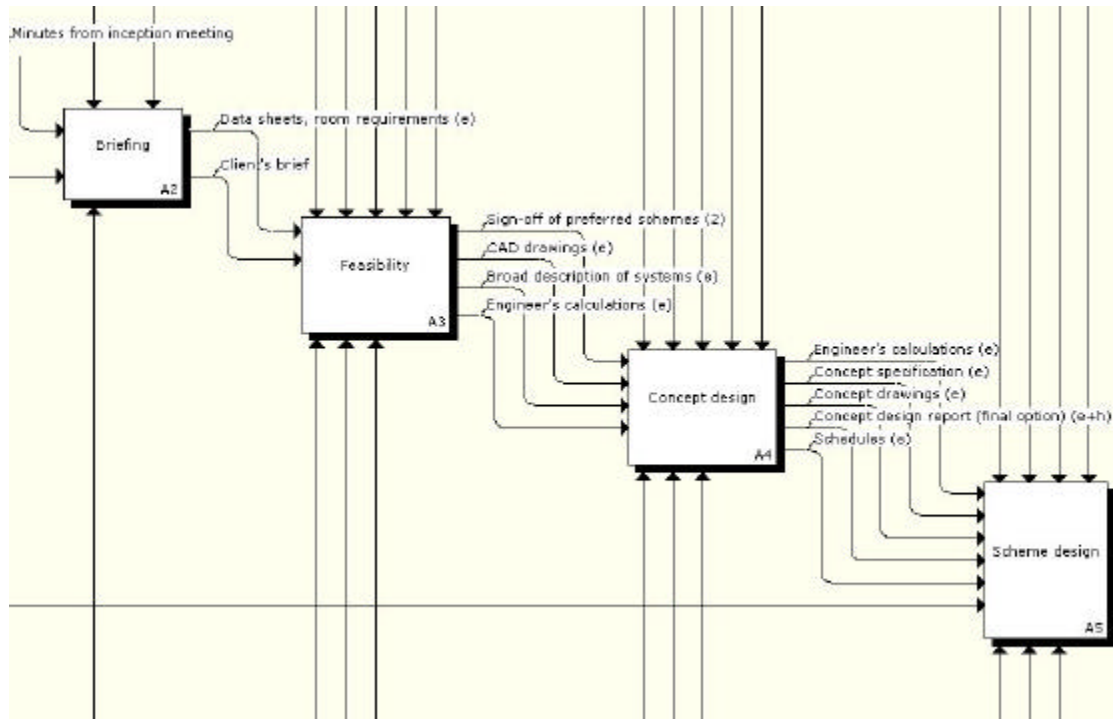
IT was used in many different ways, but most was in supporting the disparate working practices of the various participants. As a means for exchanging information, IT was rejected for the reasons given above. The co-location of project team members helped team building, but did not necessarily make for an efficient process. Meeting deadlines and working within budgets are not conclusive proof of an efficient and cost-effective process. Concentrating attention through the actions of project personnel may not represent the most efficient use of human resources, but it can get the job done. The fundamental issue is therefore one of whether or not IT is necessary for integrating the project team. On the face of it, there is no evidence to support this proposition. However, there is no evidence either that efforts to integrate project information would have compromised time, quality or security.

#### **5.5 Manufacturing facility**

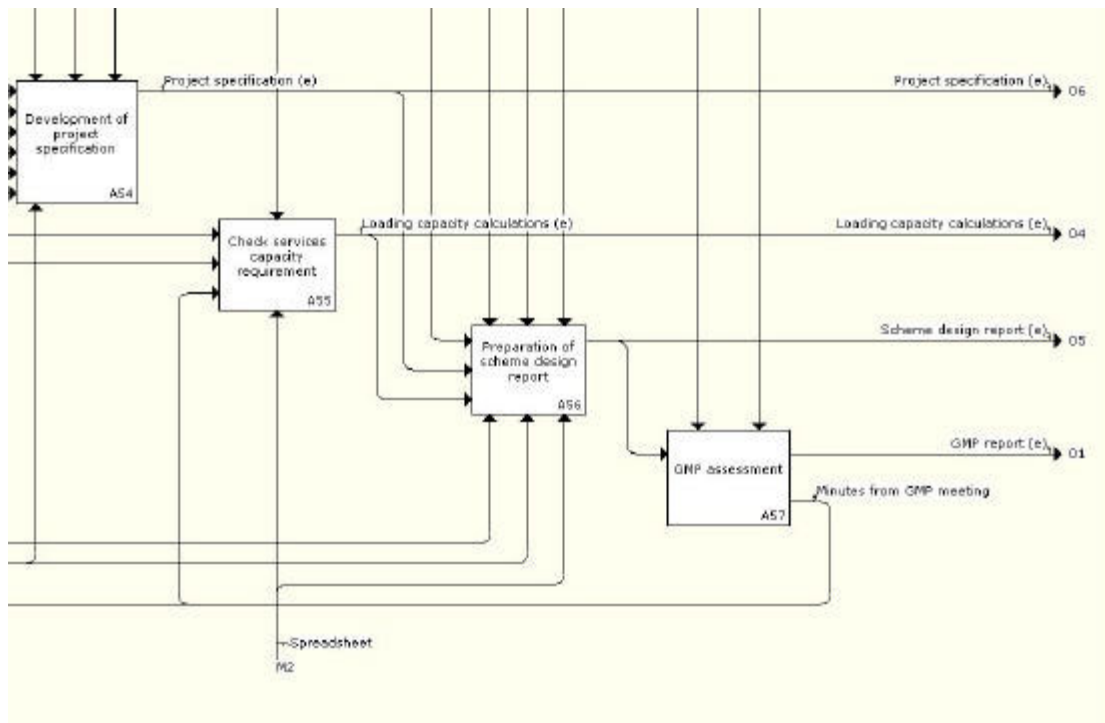
Activities on this project were planned with IT in mind. All drawings were produced on CAD and all documents shared electronically between members of the design team. The client's retained architect, management contractor and the designer each maintained their own servers and LANs for security purposes. All operated with up to date versions of office automation tools and CAD software to ensure compatibility. Limited access was available to areas of all three servers to ease distribution of information. Drawings and specifications were uploaded to the management contractor's server for onward distribution to suppliers and trades contractors (typically on disk). There was, similarly, a transfer area on the design architect's server where drawings were uploaded for distribution. Hard copy documents were still provided in addition to electronic versions.

Internet email was essential to ensuring connectivity with the client (in Southeast Asia) and other consultants located elsewhere in the world. The architect maintained

connectivity with head office through an ISDN link to the WAN. Security of data was paramount.



**Fig. 3: A strong degree of information integration between stages**



**Fig. 4: Even at a very detailed level there can be good integration**



## 5.6 Headquarters building, car park and related facilities

The project office was based in one country, using the software and CAD facilities available there, and the project was sited in another country. ISDN links were established to the site in order to exchange data with the local design partner and other members of the design team. This was also used to send drawings to a print shop near the site. Data exchange was accomplished by internet email and attachments through the ISDN connection. Internal email in the main design office was automatically forwarded to the external system if the project manager was at the site.

90% of the design and electronic document generation on the project took place at the design office, which had both space and resources. The site office was, on the other hand, very small during the initial phases of the project and connectivity was maintained through a modem link to a laptop computer. Later, the site was connected to a LAN in a new office in the same town as the site.

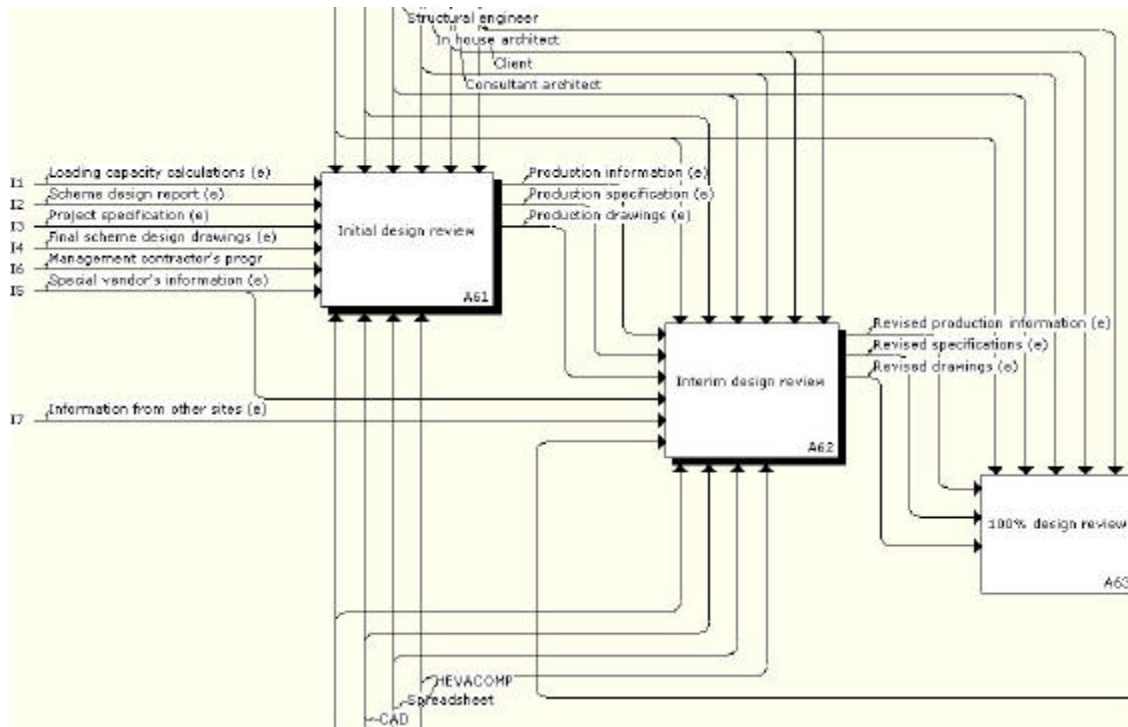


Fig. 5: Focused involvement of the client and team in design reviews

## 6 Degrees of integration of project information

Of the 11 projects, the six featured in this paper have their integration index given below, together with a grading. A figure of 1.00 would indicate total integration.

**Table 1: Degrees of integration of project information for the six case study projects**

<b>Project</b>	<b>Index</b>	<b>Grading</b>
1	0.70	Strong degree of integration
2	0.82	High degree of integration
3	0.55	Moderate degree of integration
4	0.22	Low degree of integration
5	0.70	Strong degree of integration
6	0.35	Modest degree of integration

## 7 Main findings

1. IT is being used to counteract the problems caused by a lack of integrated project-based work in this fragmented industry, by supporting the electronic exchange of project information. IT is also being used to support innovative methods of building procurement and technology procurement – the highest degree of project information integration is where there is a tendency towards a single source of responsibility for the project.
2. There is strong evidence to support the view that integrating project information is greater when there is a physical distance between project participants, for instance when they are located in different regions. Efforts to effect better communications are helped by the use of IT. Conversely, use is generally lower where project teams are co-located – this working arrangement has benefits for teambuilding, but tends to militate against co-ordination of information and can succeed in building paper bureaucracies.
3. The extent of IT use and, therefore, the degree of integration is influenced by the extent to which the client and ‘constructor’ see IT as an important factor in achieving project success. Everyone in the value chain must be connected through IT. This is borne out by all projects to a greater or lesser extent. However, the out-of-town shopping mall illustrates what can happen when the ‘constructor’ ensures that everyone is locked into the system. Even the smallest firm is part of the IT regime: no one is allowed to hinder the smooth, electronic flow of information. Significant time and cost savings were demonstrated from this approach to IT use.
4. Individual project team members may well be prepared to use IT as much as possible, but use or commitment can vary significantly. Each actor must be willing to drive forward the use of IT, if the client is to benefit fully. Where the client appears not to be overly concerned about the need for IT, the resultant desire for the project team to use IT appears less pronounced than might otherwise be the case. In a similar way to the position in 3 above, the client can be instrumental in ensuring that IT is taken very

seriously. In the case of the manufacturing facility project, the client appears to have driven the process hard and that has meant a serious commitment to IT by everyone.

5. Quantity surveyors, acting as the client's primary consultant on cost, are singled out for not being properly integrated into the process. There is a case for appointing only those QSs who can interface electronically with other members of the project team – most notably the designers. There is considerable potential for delays and bottlenecks because QSs are still requiring paper based information. Their physical dislocation from the rest of the design team means that they cannot contribute efficiently to the evolving design. It is a classic case of reaction, as opposed to pro-action. A number of projects show that the QS can be left outside the loop of close interaction between the design disciplines. One reason for this is that the external QS is not employed in a way that actively supports such interaction. The consequence is that the QS exercises a limited role.
6. Design is largely a process of progressive and iterative development of information and detail used to describe the building – the traditional distinctions between the different stages have become blurred. There is good reason to question the several traditional stages that constitute 'development of the design'. Collapsing three traditional stages (concept, scheme and detailed design) into two needs to be examined. Most project teams tend to operate in a somewhat traditional manner. Procedures are geared to a plan of work that seems at odds with some of the objectives and demands of the projects on which it applies. When interviewing project co-ordinators, it became clear that their thinking was often framed in terms of the established plan of work. The implications are that innovative methods might be shoehorned into an inappropriate plan of work. What could appear to be complicated and carefully detailed procedural elements within the models might well be more a consequence of an ineffective plan than an efficient problem-solving function. In this respect, IT has limited potential to streamline and improve the efficiency of the process.
7. Many examples of best practice exist and are noted mostly by the seamlessness that results from an IT-enabled process. There is, however, real danger in that what appears to be a good use of IT might be little more than the reinforcement of a practice that adds little value for the client. As implied in 6 above, faster information is not necessarily better information.

## **8 Conclusions**

The research reflected in this paper is based on the detailed analysis of 11 construction projects. From this analysis, it has been possible to develop an impression of how IT is actually being used and the organisational support and dynamics that enable or frustrate its deployment. Useful, yet simple, lessons can be learned by clients and constructors in stimulating greater application of IT in order to realise savings in cost and time. Before then, there needs to be some refocusing and realignment of the roles and responsibilities of certain participants in the process. In other words, real gains in productivity through IT may not necessarily come from more sophisticated IT, but from

participants who are able to apply proven tools and techniques, many of which are low cost.

## **9 Acknowledgements**

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