

# REFOCUSING COLLABORATION TECHNOLOGIES IN THE CONSTRUCTION VALUE SYSTEM

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## ABSTRACT:

*Modern construction processes rely on the contributions of diverse functional specialists working in inter-organisational teams to design, cost, procure and manage modern construction projects. In the UK the Latham report has focused attention on eliminating the adversarial nature of the construction industry. Project specific partnering is one procurement route being taken by leading client and main contracting organisations to improve the interpersonal relationships of those organisations involved in the construction process. In order to support the cultural changes recommended by Latham, the necessary communications infrastructure must be put in place. As well as a high bandwidth communications infrastructure, commonly available collaborative tools must be used to allow disparate cross-functional virtual teams to exchange information.*

*Increasingly construction work is carried out by specialists subcontractors who typically undertake 70-90% of the work. However, little attention has been given by main contractors to improve groupworking using communication and collaboration technologies between themselves and their subcontractors. This paper presents the findings of a survey conducted by a large UK design and construction organisation and Loughborough University to benchmark the current sophistication and application of information and communication technologies in UK sub contracting organisations.*

*Surprisingly little research has been conducted into the use of information and communication technologies in subcontractor organisations. Existing research has focused on the level of ICT usage among main contracting organisations and construction consultants. Whilst this research is needed, the construction process involves communication and collaboration downstream between the client, consultants and the contractor, and upstream between the contractor, suppliers and subcontractors. Future research should identify the level of ICT's up and down the construction value system, thereby examining the totality of the construction process and highlighting the opportunities for improving information flow, communications and understanding.*

## KEYWORDS

*Value System, Collaborative Working, Video Conferencing, Information Technology, Sub-contracting, Virtual Teams, Partnering.*

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## **INTRODUCTION**

The construction process can be classified into eight core processes: Project Definition; Evaluation; Design Management; Cost Management; Project Execution; Procurement; Construction Management; and Facilities Management (Betts et al, 1995). These activities have historically been conducted by three separate organisations. The client would have an architect leading a consultant team in designing the building, the clients quantity surveyor would provide costings for the project, and the main contractor would construct the building with a limited number of subcontracting specialists, both product oriented and those that are systems oriented (Latham, 1994).

## **UK ECONOMIC CLIMATE**

The UK economic recession has dramatically reduced the output of the UK construction industry. Studies indicate an annual output at £12 billion in 1996, which is a significant drop from a high in 1990 of £14.5 billion (Lynn, 1996). This has had the direct effect of increasing the competitive nature of the UK construction industry. Since 1989, there have been an estimated 500,000 job losses (Lynn, 1996; Latham, 1994). As this labour pool is essentially trained and skilled in some aspect of the construction process, many, having no alternative skills, have set up their own specialist subcontracting organisations. Despite a drop in construction related work available in the marketplace, there has been little change overall in the number of UK construction related workers, with organisations being displaced rather than disposed of. Indeed, statistics on the construction industry indicate that there are approximately 200,000 contracting organisations with 95,000 being private individuals, or one person firms (Latham, 1994).

## **CHANGING CONSTRUCTION ROLES AND RELATIONSHIPS**

The contribution of specialist contractors to the total construction process can account for up to 90% by value of the work undertaken (BRT, 1988; Ndekurigi, 1988; Gray, 1989) due in part to the fact that buildings have grown in complexity, particularly in the areas of mechanical and electrical services (Ndekurigi, 1988). As the complexity of the projects has increased, so too has the complexity of the organisational relationships. The skills required to design, procure, install and commission and maintain advances in the increasingly sophisticated technology based products, systems and processes have changed. These skills are now to be found in subcontracting organisations. This has resulted in main contracting organisations increasingly focusing on the management of sub contracts (BRT, 1988).

This increase in complexity, the over supply of specialist firms, and the declining construction output has cultivated an adversarial atmosphere due to the effects of Dutch auctioning of tenders, unfair contracts, and paid when paid clauses. In his final report of the Government/industry review of procurement and contractual arrangements in the UK construction industry, Latham gave consideration to real cost reductions of 30% together with closer collaboration through initiatives such as partnering to overcome the problems. There are many definitions of partnering with Infante (1995) suggesting that partnering is a relationship which occurs at a particular time to meet the needs of all parties concerned.

Matthews et al (1996) suggest that partnering can be defined as an activity or verb such as agreeing goals or developing a mission statement. Alternatively partnering can be defined by its attributes of trust, shared vision and long term commitments. (Matthews, 1996; Crowley, 1996). The principles of partnering, where a team is composed of multi-organisational individuals, is linked closely with the concepts of Porters value system (Porter, 1985).

## THE CONSTRUCTION VALUE SYSTEM

According to Porter and Millar, a firm can be divided into activities that make up the firm's value chain. The value accrued by these activities such as inbound logistics, operations, marketing and sales and service, can be measured by how much the client or customer is willing to pay for the product or service. Porter states that in order to create competitive advantage over its rivals, a company must either be the cost leader, or must have a different product or service offering (Porter, 1985). The changes to the construction environment are such that there is now a greater dependence by main contractors on their suppliers and subcontractors. In light of the increasing amount of work being performed by specialist firms, main contractors should focus their efforts on optimising the strengths of their upstream specialists. A typical construction project today is composed of firms along the value system as shown in figure 1, i.e., the individual value chains of the suppliers, subcontractors, consultants, the main contractor and the client. The benefits of this value system approach can be significant as the pooling of the specialist resources (the subcontractors design expertise with the main contractors management experience) can generate a synergy that can lead to the growth of the individual companies, and importantly provide the client with improved levels of service and product or building delivery. Stiles suggests that increased competitive power brought about by optimising the skill sets of the multi-organisational teams can enable firms to leapfrog jointly over larger competitors (Stiles, 1995).

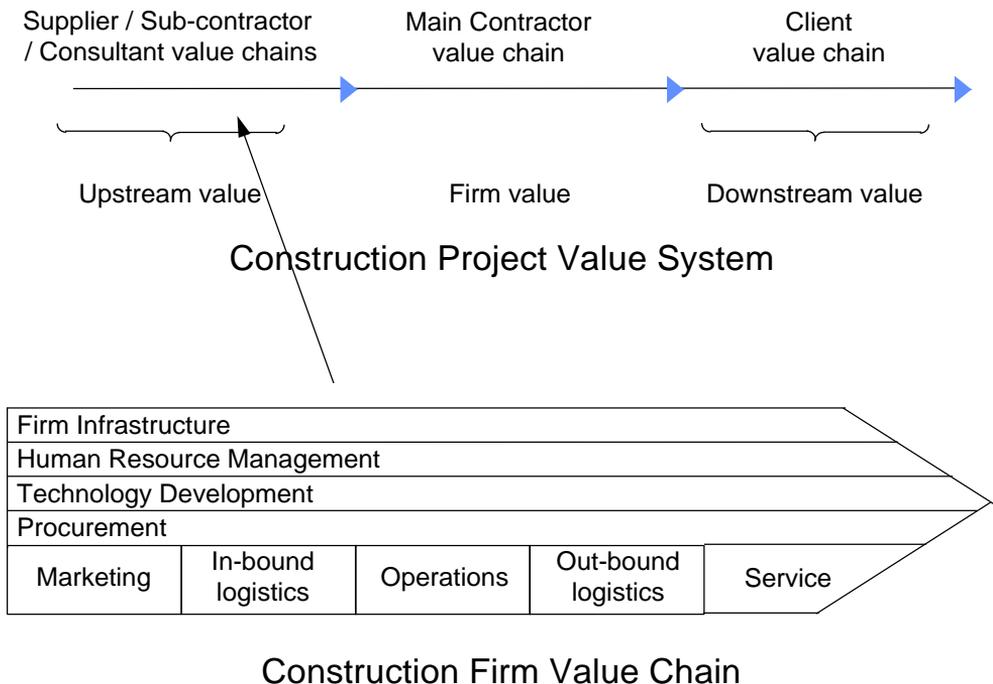


Figure 1 : Construction Project Value System. (Amended from Porter and Millar, 1985)

The value system as applied to specific projects can provide the client with an approach greater than the sum of its constituent parts. Mitchell and Singh (Mitchell, 1996) in their empirical study of the

survival of collaborating businesses provide evidence to support the notion of inter-organisational collaboration. Their study points out that despite limitations, collaboration usually appears to be superior to independent approaches. Their study focuses on the commercialisation of complex goods. We argue that a construction project can be viewed as “complex goods” with numerous components from a plethora of organisations, design input from many disparate organisations, one-off developments, and several other complex factors.

## **COMMUNICATION & COLLABORATION TECHNOLOGIES**

Information and communication technologies can support construction and in particular the partnering approach by enabling disparate multi-organisational teams distributed up and down the value system to work in an atmosphere of closer co-operation, despite the normal barriers to effective communication imposed by geographical location. Recent research has highlighted a symbiotic relationship between information exchange and partnering, with ICTs providing the catalyst for a change in attitude towards the adoption of communication and collaborative technologies (Baldwin et al. 1996).

This paper presents the findings of recent research undertaken by a leading UK design and construction organisation and Loughborough University. The overall aim of the research was to develop a greater understanding of the adversarial nature prevalent in the UK construction industry and to optimise the expertise of specialists in the future. This was achieved by taking a co-ordinated dual aspect approach to the subject. One stream of the research focused on the relationship and contractual issues, the other on communication and collaboration issues with an emphasis on the enabling power of information and communication technologies (ICTs).

### **Project Focused Teams**

The classic view of an organisations is one structured around a series of hierarchical tiers in order to provide a planning and control mechanism from supervisors over sub-ordinates. This type of command and control structure is being replaced by structures that encourage communication and co-ordination (Reich, 1987). The change in the nature of construction related activities has given rise to the removal of internal barriers and organisational layers (Humble et al, 1994) an increase in project specific teams comprising various professionals with their own functional disciplines working towards the common goals of completing a project. These functional teams often comprise professionals from other organisations upstream of the main contracting organisation (subcontractors) and downstream (clients consultants) thereby linking the whole construction value system together. Construction projects will increasingly rely on three closely related elements to provide these virtual teams with the necessary infrastructure, interface and business tools with which to communicate and collaborate among one and other. The survey findings as to the current and potential use of these three interlinked concepts is described below.

## **METHODOLOGY**

In order to encourage collaboration using the enabling power of information and communication technologies with suppliers and subcontractors, a scoping exercise was conducted. From the information provided by interviews conducted into main contractor/subcontractor relationships by Matthews and Tyler (Matthews, 1996) a target sample was established. This sample consisted of those suppliers and subcontractors who had some form of computing use. Interviews were conducted using semi-structured questionnaires to enable certain questions to be analysed statistically providing empirical data, while other questions encouraged the free expression of those interviewed adding to the richness of the data collected. These semi-open questions probed the softer, sometimes subjective management issues that faced the interviewee. Thirty five organisations

contributed to the research. The organisations comprised 15 specialist building trade subcontractors, 13 mechanical and electrical subcontractors, and 7 material suppliers. The 15 specialist building trade subcontractors chosen covered trades such as steel erection and fabrication, scaffolding, suspended ceilings, raised flooring, curtain walling, and reflected those specialists with some design input to the overall construction process.

## **THE VIRTUAL ENTERPRISE**

The value system poses potential problems to the organisations involved. Many members of the value system will be found in various geographical locations, and unless the key players set up a project specific office to co-ordinate the project, communication and collaboration must be achieved through other means. Information & communication technologies can address the geographic barriers but may alter the sense of what it feels like to be with an organisation (Sheehy, 1996). Other problems centre on the inter-operability of the information held in different organisations. In virtual teams, there can be barriers to effective communication such as insufficient security controls, differing operating practises of individual firms, the inability of application systems to exchange data meaningfully and semantic interoperability (Hardwick et al. 1996). The social and technical interaction of the team players must be pulled together in a cohesive manner. This formal and informal networking of individuals and organisations must be layered on a physical communications network.

## **NETWORK AND DIGITAL COMMUNICATIONS INFRASTRUCTURE**

In addressing the need to have systems interoperability across such a network, the survey provided details of the commonly used business systems software, the information exchange mechanism and the application of communication and collaborative technologies.

### **Software Used**

A series of questions on the type of spreadsheet, word processor, relational database and presentation package use showed that products by Microsoft dominate with spreadsheets (MS Excel: 50%, Lotus 1-2-3 :21%), word processor (MS Word: 50%, WordPerfect 5.1 for DOS :23%), relational database (MS Access :53%, Approach :18%). In the area of computer aided design, AutoCAD was the most commonly used with 69% from a sample of 29 of the 35 organisations. A variety of other software packages accounted for 17%, while Sonata, MicroStation and IBM Catia each had a 3% share. The question on project planning software yielded interesting results with Powerproject by Asta Development having a 56% share from a sample of 18 of the 35 organisations interviewed. This product is 36% ahead of its nearest rival Microsoft Project. These figures correspond to research by Bordoli who saw Powerproject take a 52% share of the total construction market (Bordoli, 1994). These figures suggest that there is indeed a certain amount of commonality in the choice and application of software packages.

### **Exchange Mechanisms**

When examining the information exchange mechanism between organisations, the subcontractors interviewed provided data to support the premise that inter-organisational communication is not being undertaken effectively. Table 1 presents the results which show that the most common exchange mechanism was the exchange of electronic information contained on a floppy disk. The results of the survey showed that only 23% of those interviewed currently had ISDN in place.

Descriptions	Build	M&E	Supp	Total	%
Computer Disks	30	59	16	105	50.24%
Modem	21	27	6	54	25.84%
Inegrated Services Digital Network (ISDN)	6	16	11	33	15.79%
Value Added Network (VAN)	6	0	6	12	5.74%
Digital Audio Tape (DAT)	5	0	0	5	2.39%
Asynchronous Transfer Mode (ATM)	0	0	0	0	0.00%
		Ranking scores		209	
			Sample		35

*Table 1 : Information Exchange Mechanisms in UK Subcontracting Organisations*

### **Networking / Communication Software**

Questions were asked to determine the penetration of network technologies into subcontracting and supplier organisations. The results of the survey showed that 60% of those interviewed had some form of communication network, the most common being Novel Netware for local area networks. This contrasts with results of a survey undertaken by O'Brien which reported 42% using some form of LAN infrastructure, mainly between PC's (O'Brien & Al-Soufi, 1994). The adoption of electronic mail systems is low with only 6 of the 35 organisations using a mail client running on these LANs (some 17%). This is lower than the projected figures by management consultants KPMG in their series of IT surveys on leading construction related firms which forecast a usage of 41% by the end of 1995 (KPMG Peat Marwick, 1987, 1990, 1993). Similar research into data communications in the UK construction industry by O'Brien and Al-Soufi showed 16% of respondents having an e-mail facility, and only 3% with links outwith their own organisation (O'Brien and Al-Soufi, 1993). The lack of information regarding the type of electronic mail client used is a further reflection of the underlying trend, that usage of communication tools is lower in subcontracting organisations than with leading contractors and consultants. What is significant is not the empirical data collected by the KPMG and O'Brien surveys, but that these surveys focus on construction related firms 'across the board', not necessarily solely on subcontracting organisations.

### **COLLABORATIVE COMPUTING**

The project organisation should allow people working on a set of related topics to better co-ordinate their efforts (Hauptman & Allen, 1987). Working towards common goals using the computer as a communication tool has been called many things such as computer mediated working, computer supported collaborative working and now more recently groupworking, using collaborative data exchange tools. The term Computer Supported Collaborative Working was not widely recognised by those interviewed with only 34% having heard of the term. Interestingly, when provided with certain options, all of those interviewed used basic CSCW techniques such as sharing files (45%) and sharing databases (50%). One organisation used redlining software to allow drawings held in a main contractors database to be annotated. None of the organisations surveyed used screen sharing technologies.

### **Videoconferencing**

Desktop video conferencing (DVC) allows face to face communication between geographically dispersed individuals or teams using the PC as the interface and broadband ISDN as the communications channel. ISDN is currently the most commonly available broadband communication channel, which uses pairs of 64Kbits/sec channels up to a maximum of 32 pairs. A typical desktop videoconferencing system will use a pair of 64Kb channels totalling 128Kbits/sec which is approximately four and a half times faster than a V.34 modem. The survey produced data on the perceived benefits of using video conferencing between organisations. Table 2 highlights the

perception that the tangible benefits will be in the reduction of travelling, whereas the second most popular option of collaborative working, provided evidence to suggest that the sometimes intangible benefits of closer co-operation will be a major benefit.

Descriptions	Building	M&E	Suppliers	Total	%
Reduced Travelling	118	107	58	283	14.66%
Collaborative Working	118	94	58	270	13.98%
Richer Information to Aid Decisions	117	100	49	266	13.78%
Project Information Quicker	115	94	40	249	12.89%
Improved Communication	88	82	50	220	11.39%
Closer Relationships	81	90	46	217	11.24%
Identify Problems in Real Time	75	61	27	163	8.44%
Improved Information Flow	66	48	27	141	7.30%
Greater Management Control	38	26	14	78	4.04%
No Benefit	15	13	16	44	2.28%
				1931	
				Sample	35

Table 2 : Perceived Benefits of DesktopVideoconferencing

Interestingly, the scores achieved between the 10 options showed relatively small increments between responses for the top 6 ranking options. In discussions with the interviewees, many pointed out the relationship of one option to another. This information was collated and a block diagram was formulated to represent the relationships. Figure 2 highlights the observation that it is DVC's synchronous nature (live/real time), as opposed to asynchronous (store and forward) which is at the heart of the interlinked relationships. The real time aspects improves the speed of the knowledge transferred which is closely related to improved information flow between the organisations. Having visual information provides richer information due to the expression of body language in the communication process. It can be argued that richer communications co-exists with collaborative working and ultimately, closer relationships through social interaction, albeit remotely.

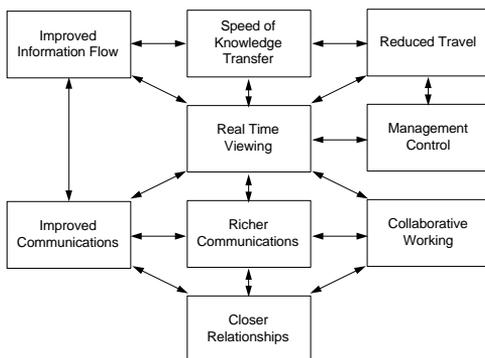


Figure 2 highlights three common themes of speed, time, and relationships. Information and communication technologies will have more than one impact in terms of value to the business according to Hammer and Mangurian who suggest the introduction of communications-intensive information systems (CIIS) will compress time, overcoming geographical restrictions and will result in a restructuring of business relationships. This is called the Impact Value Framework. (Hammer & Mangurian, 1987).

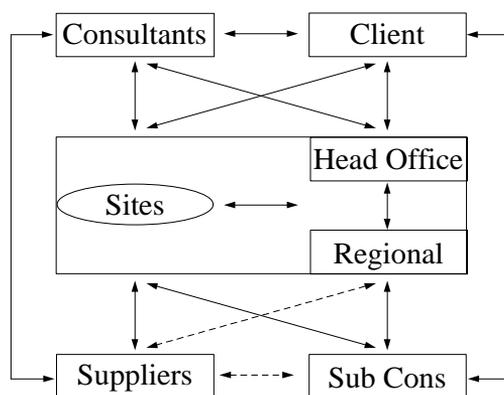
Figure 2 : Relationships Between Benefits of Using DesktopVideoconferencing

Although no organisation surveyed was using desktop video conferencing (DVC) systems, a question was asked to ascertain the potential implementation of such systems. 31% stated that they would consider installing a DVC system in the next five years, but at present there were other restrictions. Table 3 highlights the belief that there is a lack of published information regarding the application of DVC in the construction industry, either academic papers or through the media. Cost was an important factor, but many felt that if DVC became a prerequisite for working with major

industry players, then they would adopt the use of such systems. It was noted that until many large organisations invested in the equipment themselves, a critical mass of users would not be achieved.

Descriptions	Build	M&E	Supp	Total	%
Lack of Published Benefits	105	102	54	261	16.56%
Capital Cost	107	97	44	248	15.74%
Critical Mass	102	89	46	237	15.04%
Immature Technology	83	83	45	211	13.39%
Other Priorities	86	69	36	191	12.12%
Walking before Running	70	48	39	157	9.96%
Project Scope	77	53	25	155	9.84%
Conflicting Standards	30	31	14	75	4.76%
Privacy Aspects	15	13	13	41	2.60%
		Ranking scores		1576	
				Sample	35

Table 3 : Restrictions to Implementing DesktopVideoconferencing in UK Subcontracting Organisations



When asked which parties on a construction project would use DVC, various scenarios were presented. Some organisations suggested that they would use the technology internally to bring remote offices together, others focused on the relationships between specific parties on a construction project. These replies were grouped under broad headings, and a diagram was drawn to represent the potential users of video conferencing equipment. Figure 3 highlights these potential users of desktop video conferencing systems.

Figure 3 : Perceived Users of Desktop Video Conferencing Systems

## CONCLUSION

The construction industry is experiencing major forces for change from many sources. Amongst these are pressure from clients for real cost reductions whilst maintaining service and quality; structural and organisational changes brought about by the rise of the specialist sub-contractor and the realignment of main contractor functions; the experiences from other industries and initiatives (such as CRINE in the process engineering industries); and new ways of working such as alliances and partnering. Overlaying all these forces is the growing availability and capabilities ICTs.

From the findings of this survey it is clear that the specialist contractors are not currently using, or being encouraged to use, emerging collaborative technologies. These technologies will become increasingly important to enable multi-organisational virtual teams to collaborate effectively in achieving the needs of ever more demanding clients.

The use of collaborative technologies will be fostered and promoted through the use of partnering or alliancing-type arrangements where information is more freely shared than in traditional contracts. However, this improved collaboration must permeate the whole construction value system if its full benefits are to be realised.

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