

An Information Exchange Measurement Matrix for Construction Organisations

A. N. Baldwin, A. Thorpe, and C. Carter
Department of Civil and Building Engineering
Loughborough University, Loughborough, UK.

Abstract

The successful introduction of electronic information exchange within and between construction organisations is dependent upon organisations being receptive to new technology. This is a business not a technology issue and a full understanding of organisational aspects is imperative if electronic information exchange technologies are to be successfully introduced. Moreover, unless organisations are aware of the changes required and participate positively in the process of change then new systems will not realise their full potential.

Following consultation with the IT management of leading construction contractors the critical factors relating to the successful introduction of electronic information exchange were identified. These were divided into two categories: those factors independent of the application function; and process related factors. These factors are reviewed and presented in a matrix. This is the Information Exchange Measurement Matrix a tool for organisations to determine their progress towards the successful adoption of electronic commerce. The tool is independent of the type of information exchange technology that is to be adopted. Organisations may use the matrix to establish their readiness for the introduction of new technologies. Consideration of how to move from one element of the matrix to another generates the critical factors necessary to effect such change.

Keywords: Information Exchange, Electronic Commerce, Performance Monitoring, Integration

Introduction

Since the early 1990's business process re-engineering has attracted considerable interest and has now been applied with varying degrees of success in most industries. The construction industry is no exception. Re-engineering is the fundamental re-thinking and radical re-design of business processes to achieve dramatic improvements in critical, contemporary measures of performance such as cost, quality, service and speed. (Hammer and Champy, 1993). Information Technology (IT), an important enabler of such change, and Electronic Information Exchange (also known as Electronic Commerce, Electronic Data Transfer, or simply Information Exchange), has a key role to play in process change (Baldwin et al., 1996). As with the introduction of any system the implementation of Electronic Information Exchange is not just technical enhancement but a managerial decision that involves re-engineering of organisational functions and operatives (Ahmad et al., 1995). If process re-engineering is to succeed we cannot ignore the social environment of the organisation and assume that it can manage change in isolation (Love, 1996). The importance of this is emphasised by Crook et al. (1996) who stress a more holistic approach to investigating organisation processes and the need for active user involvement in the development and implementation of new systems.



This paper describes the development and use of the Information Exchange Matrix, a tool designed for use where objectives for the implementation of electronic communication have been identified and agreed by members of the work team, and where change is seen as a continuous path to attainment. The matrix enables organisations to assess their readiness for the introduction of Electronic Information Exchange, and to monitor their progress from non-integration through to full integration with their business partners and a re-engineering of their business processes.

The Development of the Information Exchange Matrix

As part of a research project investigating the work process changes that have resulted from the introduction of EDI and other forms of Electronic Commerce, a series of interviews was held with managers of major UK construction organisations. These interviews highlighted that electronic information exchange is a business not a technology issue and that a full understanding of the organisational aspects is imperative if such technologies are to be successfully introduced into the construction organisation. From the literature review and a series of structured interviews it was possible to identify the key objectives. Some of these objectives were independent of the type of business process under consideration, others were specific to the process involved. The challenge became to identify and categorise these objectives not simply in the form of a checklist, but in a form whereby the users would be able to assess the readiness of their organisation to implement information exchange technologies, and to chart their progress from the initial steps of system integration to both integration and efficient, effective information exchange with their business partners.

A review was made of the tools and techniques developed for monitoring and control purposes by management both within and outside the construction industries. This revealed the Total Quality Measurement Matrix, a technique developed by the European Construction Institute (ECI), to provide organisations, projects, sites or sections of a project with a tool for determining their progress towards the achievement of Total Quality (ECI, 1993a). It was produced by the ECI's Total Quality Management Task Force as part of their initiative to generate a set of quality milestones appropriate to the construction industry, and covers the significant elements in a programme to achieve a Total Quality culture (ECI, 1993b). An extract from the matrix is shown in Figure 1. Within the matrix there are twelve key objectives that need to be attained before any organisation may be considered to be a Total Quality Company. The twelve objectives, which form the columns of the matrix, are not in any specific order and may be approached individually. Each column has six levels of attainment. The highest levels of each column represent 'Total Quality'.

The framework of this tool formed the basis for the Information Exchange Matrix. This was developed on an iterative basis with the charts and their elements being reviewed by both individuals and groups of experts before their formal descriptions were accepted. The Information Exchange Matrix comprises two tables: the Generic Table and the Process Specific Table. These tables contain key, specific, measurable objectives. The Generic Table (shown in Figure 2) focuses on four elements that apply across the organisation, whatever the business process: the Commitment of Senior Management; Business Performance; the Development of an IT Strategy and an IT Management Policy; and the use of Measurement and Feedback Metrics. Each of these four elements is now explained in more detail.

<i>COMMUNICATIONS</i>	<i>TEAM-WORK FOR IMPROVEMENT</i>	<i>INDEPENDENT CERTIFICATION OF QUALITY MANAGEMENT SYSTEM</i>	<i>OBJECTIVE MEASUREMENT AND FEEDBACK</i>	<i>NATURAL USE OF TQM TOOLS AND TECHNIQUES</i>
ESTABLISHED SYSTEM, FULLY IMPLEMENTED WITH EFFECTIVE FEEDBACK	IMPROVEMENT TEAM RECOMMENDATIONS ACTIONED AND RESULTS MONITORED	QMS FULLY DOCUMENTED, IMPLEMENTED AND CERTIFIED	PERFORMANCE INDICATORS AS STANDARD MANAGEMENT TOOL	USE OF TOOLS AND TECHNIQUES COMES NATURALLY TO ALL
ESTABLISHED SYSTEM, WIDELY USED WITH SOME FEEDBACK	SUCCESSFUL INTERNAL TEAMS ACTIVE	QMS FULLY DOCUMENTED AND IMPLEMENTED BUT NOT CERTIFIED	CONTINUOUS REGULAR MEASUREMENT AND ANALYSIS OF RESULTS	TOOLS AND TECHNIQUES USED BY SOME STAFF MOST OF THE TIME
SYSTEM EXISTS BUT NOT FULLY USED	INTERNAL TEAMS IDENTIFIED AND TRAINED IN TQM TOOLS AND TECHNIQUES	QMS IMPLEMENTED BUT PROBLEMS IDENTIFIED BY INTERNAL AUDITS REMAIN UNSOLVED	CO-ORDINATED MEASUREMENT AND ANALYSIS OF RESULTS	TOOLS AND TECHNIQUES USED WHEN REMINDED
POLICY EXISTS BUT SYSTEM IS DISORGANISED	IMPROVEMENT PROJECTS IDENTIFIED	PARTIAL QMS IN PLACE, CERTIFICATION NOT PLANNED	REGULAR MEASUREMENT AGAINST TARGETS	KEY STAFF HAVE TRAINING IN TOOLS AND TECHNIQUES
IMPORTANCE RECOGNISED BUT NO CO-ORDINATED POLICY EXISTS	TEAM IMPROVEMENT PROGRAMME ESTABLISHED AND BUDGET ALLOCATED	QMS PLANNED	FIRST PERFORMANCE INDICATORS IDENTIFIED	AWARE OF TOOLS AND TECHNIQUES
NO RECOGNITION OF IMPORTANCE	NONE	NO QMS	NONE	UNAWARE OF THEIR EXISTENCE

Figure 1: Extract from Total Quality Measurement Matrix

The Commitment of Senior Management is considered essential for the successful implementation of *any* type of change. It is particularly important in the introduction of IT into an organisation, and has been identified by researchers as a major obstacle to the adoption of IT by the construction industry. IT is an enabler of change not a driver for change (Hammer and Champy, 1993). Any organisation that does not monitor its Business Performance will never be in a position to fully assess the potential and impact of Information Exchange. This is more than just a question of monitoring profitability, it is essential to monitor business performance with a range of metrics and identify both changes in customer needs and changes in organisational requirements. The introduction of information technology within an organisation must be within the framework of an IT Strategy and Management System designed to meet the needs of the organisation (Earl, 1989). Without such a strategy organisations are destined to become 'shanty town systems' of which few are likely to meet their full potential, and there is a likelihood of a high level of wastage and disillusioned users. For management to be confident that new systems have achieved their anticipated business benefits it is important that there is adequate Measurement and Feedback mechanisms. Only organisations that constantly monitor the performance of their information systems are truly able to assess the impact of incremental system change.

For each of these four objectives, six levels of attainment were identified by the researchers and industry experts. These levels coincide with the progression from minimal, or no

involvement, to full participation and the recognition that high achievement within this objective is essential if the full benefits of electronic information exchange are to be realised within the organisation. For example, the 'Commitment of Senior Management' is seen to progress from 'No Interest' (Level 1), to 'Fully Committed Active Leadership' (Level 6). Business Performance ranges from Level 1: 'Unaware of Business Inefficiencies' to Level 6: the organisation 'Regularly Meets and Exceeds Business Targets'.

	COMMITMENT OF SENIOR MANAGEMENT	BUSINESS PERFORMANCE	IT TECHNOLOGY STRATEGY AND MANAGEMENT	MEASUREMENT AND FEEDBACK
<i>Level 6</i>	Fully Committed Active Leadership	Regularly Meet and Exceed Business Targets	Comprehensive Strategy Regularly Reviewed by Management	Performance Indicators Linked to Business Objectives
<i>Level 5</i>	Active Personal Involvement	Visible Improvements in Business Performance	Full Strategy Document Prepared	Performance Indicators a Standard Tool
<i>Level 4</i>	Demands Senior Management Involvement	Realignment of Business Focus	IT Needs Aligned to Business Objectives	Continuous Measurement and Analysis
<i>Level 3</i>	Encourages Specific IT Benefits	Recognise How to Improve Business Focus	IT Needs Fully Identified	Regular Measurement Against Targets
<i>Level 2</i>	Sceptical of IT benefits	Aware of Some Business Inefficiencies	IT Needs Recognised but Strategy Ill Defined	Performance Indicators Identified
<i>Level 1</i>	No Interest	Unaware of Business Inefficiencies	Non Existent	None

Figure 2: Information Exchange Measurement Matrix - Generic

The Process Specific Matrix forms a similar framework of objectives, only these are specific to the business process under consideration. This is shown in Figure 3. The objectives within this matrix are: the Commitment of a 'Process Champion'; the Process Review; Relationships with Suppliers (Internal and External); IT Awareness Education and Training; and Relationships with Customers (Internal and External). All these elements will apply irrespective of the processes or sub-processes under consideration. Each of these is now explained in more detail.

In our research senior IT managers interviewed stressed that, in addition to the commitment of senior management to change, it is necessary to obtain the commitment of a key individual within the specific application area if new systems are to be successfully introduced. This person is commonly referred to as the 'Functional Champion'. With the focus now on business processes rather than organisational functions it is more appropriate to talk in term of a 'Process Champion'. Whatever the terminology, there is a clear need for a senior manager to champion the introduction of Electronic Information Exchange within the business area under consideration. The introduction of new technology must be accompanied by an assessment of the changes required within the business processes. Those organisations that have a full understanding of their business processes and have undertaken a full Process Review will be better placed to succeed with the introduction and integration of new systems. The successful integration of systems is dependent upon Relationships with Suppliers, both Internal and External. Suppliers in this context relates to

all those on whom the supply of information is essential for the successful completion of the business activity. As with all business dealings, where suspicion and adversarial relationships exist it will be impossible for integration to be successfully achieved. The implementation of any system requires consideration of education and training needs of the users. This will require an Awareness Education and Training programme related to the specific applications to be implemented. The successful integration of systems is dependant upon Relationships with Customers both internal and external. As with suppliers, where conflicts exist it will be impossible for integration to be successfully achieved. (The Total Quality Management terminology of 'suppliers' and 'customers' from the ECI's Total Quality Matrix (ECI, 1993a) was retained as it provided a useful focus on both the receipt and delivery of information within the construction process).

	COMMITMENT OF THE 'PROCESS CHAMPION'	FUNCTIONAL PROCESS REVIEW	RELATIONSHIPS WITH SUPPLIERS (INTERNAL AND EXTERNAL)	IT AWARENESS EDUCATION AND TRAINING	RELATIONSHIPS WITH CUSTOMERS (INTERNAL AND EXTERNAL)
<i>Level 6</i>	Fully Committed Active Leadership	Reviews of the Process Linked to Business Objectives	Active Partnering Joint Improvement	Programme Fully Developed and Implemented on an Ongoing Basis	Active Partnering Joint Improvement
<i>Level 5</i>	Active Personal Involvement	Regular Reviews of the Process	Key Staff Involved in Facilitating Relationships	Formal Programme Partially Implemented	Key Staff Involved in Facilitating Relationships
<i>Level 4</i>	Demands Management Involvement	All Business Processes Modelled and Analysed	Joint Expectations Reviewed and Expressed	Budget Allocated for a Formal Programme	Joint Expectations Reviewed and Expressed
<i>Level 3</i>	Encourages Specific IT Benefits	Key Business Processes Modelled and Analysed	Recognition of Both Parties Concerns	Informal Programme Under Development	Recognition of Both Parties Concerns
<i>Level 2</i>	Sceptical of IT Benefits	Importance of Process Review Recognised and Attempts Made to Identify Processes	Activities Well Intended but Prone to Misunderstanding	Importance of IT Awareness and Education Recognised	Activities Well Intended but Prone to Misunderstanding
<i>Level 1</i>	No Interest	Aware of the Importance of the Process but no Analysis Made	Suspicious and Defensive	Minimal Training Provided	Suspicious and Defensive

Figure 3: Information Exchange Measurement Matrix - Process Specific

Again, six levels of attainment for each of the elements within the Function Specific Matrix were identified. For example, the lowest level of IT Awareness Education and Training would be the provision of the minimal training required to enable users to work with the new systems. Such training would be provided on an ad-hoc basis. At the highest level, a full IT awareness, education and training programme would be implemented.

The Validation of the Information Exchange Matrix

The first version of the Information Exchange Matrix was developed by close collaboration with a senior IT Manager within a major UK construction organisation. This enabled the matrix to be verified against their past experiences of implementing electronic information systems. The validation of the matrix was undertaken by reviewing the elements and each of the six levels within the elements with six industry representatives all of whom had extensive experience of electronic information exchange.

Using the Information Exchange Matrix

Organisations use the matrix by first agreeing how each level of each objective may be demonstrated, and then by assessing their attainment within each level. This may be achieved by an 'open' brainstorming session or by individual assessment in private. The individuals' assessments are collated, reviewed and the mode (or mean) of the levels taken as an overall view of the company's existing performance in each category. A scoring system may be adopted with each level being allocated a score on a linear scale from 0, (the lowest level) to 5 (the highest level). The total score represents the organisation's overall position.

Having established the current level within each objective the organisation should agree on the steps needed to move to the next level within each objective. This will vary from organisation to organisation for both the generic matrix and the process specific matrix. Typical steps necessary to move from one level to another are shown in Figure 4. These are not prescriptive and should be read as guidelines, each organisation determining and agreeing the behaviours and actions they consider appropriate within each objective. A review of the total points score enables the organisation's overall progress to be charted. The process for using the Information Exchange Matrix sounds simple. In practice it is anticipated that such analysis will generate considerable discussion, and many managers may find that there is a distinct difference between the level of achievement that they believe has been achieved and the level assessed by others within the organisation.

DEMONSTRATED BY THE FOLLOWING:	LEVEL	TYPICAL STEPS NECESSARY TO MOVE UP:
Programme Fully Developed and Implemented on an Ongoing Basis	6	Line Managers to Encourage and Release All Staff
Formal Programme Partially Implemented	5	Line Managers to Agree Release of Staff for Training
Budget Allocated for a Formal Programme	4	Develop Training Programme and Proposed Budget in Agreement With Staff
Informal Programme Under Development	3	Active Managers and Staff Commit to Training
Importance of IT Awareness and Education Recognised	2	Staff Request Training, or Audit of User Requirements Undertaken
Minimal Training Provided	1	

Figure 4: Typical steps necessary to move from one level to another

As with all such information, the degree to which the results from the analysis are published within an organisation is dependent upon the policy of senior management. The Information Exchange Matrix may be used by a small group of experts to plan the implementation of new systems, or publicly displayed as part of a commitment to Electronic Commerce within the organisation. Where it is publicly displayed, the ECI (1993b) recommends a colouring system is used to chart progress.

Internal and External Integration

The adoption of Electronic Information Exchange by an organisation is a commitment to integration. In the research programme undertaken by the writers to investigate work process changes (Carter et al., 1997), four levels of integration were adopted. These were taken from those identified by Back and Bell (1994). An organisation making no use of Electronic Information Exchange was termed non-integrated. Where organisations were using Electronic Information Exchange for the exchange of information internally this was termed 'Internal Integration'. Organisations exchanging information with their business partners had achieved 'External Integration'. Some organisations had radically changed, i.e. re-engineered their business processes. Electronic Information Exchange is considered essential to the success of such changes.

In viewing the Information Exchange Matrix, the levels of integration represented by Non-Integration and by Re-Engineering are at the bottom and top level of each element respectively. To identify the levels within each element represented by Internal and External Integration the attendees at an EDICON Special Interest Group Meeting were asked to indicate the levels of each element of the Generic and Function Matrix that they considered appropriate for Internal and External Integration. These results were supplemented by those obtained by questionnaire survey from members of the CITE group. (A group of UK contractors, suppliers, and Quantity Surveyors committed to the introduction of electronic commerce.) The main findings are now described.

As expected, External Integration generally requires higher achievement in each objective than Internal Integration. For example, 'Active Personal Involvement' from senior management was considered necessary for successful external integration, but internal integration depends only on 'Senior Management Involvement'. Successful External Integration requires a realignment of business focus as opposed to just an improvement in focus. IT strategy and management has to be aligned to business objectives for any integration. Measurement and feedback were not considered to be as important as other factors. The commitment of the 'Process Champion' is one category where external integration requires a considerably higher level than internal integration. Regular reviews of the functional process were deemed essential for external integration. There was general agreement on the question of IT awareness education and training with only one organisation not believing that an important requirement for integration is a formal education and training programme.

Conclusions

The successful introduction of electronic information exchange both within organisations and between organisations is dependent on organisational and human issues. These issues are more important than technological issues. New tools and techniques are needed to allow IT managers and users to monitor their progress towards the successful implementation of these technologies. The Information Exchange Matrix provides a framework for organisations to both monitor and control their level of performance, and to identify how they progress from minimum levels of information exchange to full internal and external integration. This framework is independent of the type of Information Exchange Technology adopted. It is a tool designed to be used where objectives have been identified and agreed by members of the work team, and where change is a continuous path to

attainment. The basis of the technique is applicable not only to construction organisations but also those in other industries.

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