Electronic data interchange in the construction industry

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ELECTRONIC DATA INTERCHANGE IN THE CONSTRUCTION INDUSTRY

by

Tony Lewis

A Doctoral Thesis submitted in partial fulfillment of the requirements for the award of

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June 1998

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Glossary of terms

ANSI X.12 - American national EDI standards.
ASC X12 - Standards committee X12 accredited by the American National Standards Institute (ANSI) and comprising government and industry members meeting for the purpose of creating national EDI standards for submission to ANSI for subsequent approval and dissemination, and/or for the submission to the UN/ECE for approval and submission of UN/EDIFACT international standards.
ASCII - American Standard Code for International Interchange. Each code indicates a single character, number or symbol as a seven-bit code with an eighth bit used for parity. The term is used to describe simple forms of character-file transmission and storage.
CAD - Computer Aided Design.
CCITT - Comite Consultatif International Telegraphique et Telephonique, a group responsible for the establishment of international telecommunications standards.
CEC - Commission of the European Economic Community, the governing body of the European Community.
CEN - Comite European de Normalisation. European Committee for Standardisation, the standardisation committee of Europe.
Data element - A unit of data which, in a certain context, is considered indivisible.
Data element directory - A listing of identified, named and described data element attributes.
Data element tag - A unique identifier for a data element in a data directory.
De facto standard - A preferred format which has informally become a standard simply by its adoption by a majority of users.
DISA - Data Interchange Standards Association, the secretariat of the ASC X12 committee, which also serves as the secretariat for the pan-American EDIFACT board.
EDI - Electronic Data Interchange.
EDMD - The UN EDIFACT Data Messages Directory.
EDSD - The EDIFACT UNSM Standard Segments Directory.
Electronic data exchange - Generic term to describe all methods of exchanging data by electronic means.
Electronic mail - Communicated text and attached files which require human interpretation to identify and act upon its contents.
IE Interchange Agreement - A document which defines the conditions of data exchange between trading parties.
ISO - International Organisation for Standardisation
JIT - Just In Time, a system where incoming material arrives at the right time and place within the process in which it is to be used.
Message - A set of EDI information to be processed as a whole (roughly the equivalent of a document).
MFE - Multi Format Exchange.
Modem - A device for the modulation and demodulation of a data-carrying signal between a computer and a telephone link.
Protocol Segment - The mechanism that enable systems on a network to communicate.

SITPRO - Simplification of Trade Procedures Board.
SME - Small or medium-sized company or organisation.
STEP - The standard for the Exchange of Product Model data.
Syntax - The definition of basic concepts used for structuring data and the means of encoding this data.
Tag - A unique EDIFACT reference which is used to identify a data element.
UN/ECE - United Nations Economic Commission for Europe.
UN/EDIFACT - United Nations rules for Electronic Data Interchange for Administration, Commerce and Transport.
UNTDDED - The United Nations Trade Data Elements Directory.
UNTDID - United Nations Trade Data Interchange Directory.
VADS - Value Added Data Service. An EDI mailbox systems to enable interworking between a number of organisations which exchange information. This term can be used interchangeably with term VAN.
VAN - Value Added Network.
Abstract

The aim of this research is to improve the efficiency of the construction process through the application of electronic data interchange (EDI). This thesis describes the development and application of EDI messages. The messages described are targeted to provide a means for transferring construction specific information during the construction process.

The definition of electronic data interchange and its technical issues are first described. The nature of EDI, replacing paper based communication with electronic messages, impacts on the way in which business is conducted, and also has far reaching legal implications due to the reliance of many legal systems on paper documents and signatures. The business and legal implications are therefore discussed in detail.

The application of EDI in the construction industry is investigated by means of a literature review. This work is furthered by a longitudinal study of the construction industry's application of EDI, which consisted of two surveys at a five year interval.

A model of the information flows within the traditional construction process is developed to assist in the identification of information flows suitable for EDI. A methodology for message development was produced. The methodology was then applied to develop a description data model that could be utilised in the existing bill of quantity and trading cycle messages.

The bill of quantity message set was at a stage ready for trial. To determine the issues related to implementation specifically in the construction industry a trial implementation of this message set was undertaken. The official implementation undertaken by EDICON is described. Software was also developed to undertake the trial. This software was tested and proved the message set developed was suitable for the transfer of bill of quantity related information during a construction project.

The factors causing the failure of the implementation of the bill of quantities message set are discussed. A number of these factors are considered valid for all construction project information flows. Finally, the use of shared project models to re-engineer construction information tasks is recommended as a means of achieving significant benefit from electronic data exchange in the construction process.
Chapter 1
Introduction

1.1 Construction industry

1.1.1 Background
The economy of the UK has been through a cycle of growth, recession then recovery in the period between the mid 1980s and the current day. The construction industry had to respond to these economic changes, and it is these responses that have moulded the structure of today's industry. During the mid to late 1980s the economic growth of the country provided excessive work for the industry which was highly profitable. Profits were maximised by undertaking high volumes of work and efficiency was not a significant factor, the industry at large having the reputation of not completing projects on time (World Bank 1990).

The recession of early 1990’s exposed the inefficiencies of many construction companies, which then failed. The reduction in work and more importantly the reduction in profitable work led most companies to seek to improve efficiency to remain profitable. This was achieved by increasing the use of sub-contractors to control costs and reduce risks. The use of sub-contractors had also increased during the 1980’s due to the more specialised nature of the work undertaken, particularly with the increase in mechanical and electrical services requirements. Indeed, specialist contractors accounted for up to 90% by value of work undertaken (BRT 1988, Ndekugri 1988, Gray 1989). This resulted in the main contracting organisations increasingly focusing on their sub contracts (BRT 1988). The increase in use of sub-contractors is reflected by the fact that of the 200 000 contracting organisations in the UK 95 000 are one person companies (Jamieson et al 1996). The formation of many small companies to fulfill the sub-contracts has compounded the fragmented nature of the industry and introduced more complex communication chains.

A fragmented industry is one in which no firm has a significant market share such that it can influence the market. Fragmentation is widespread in construction and it is a characteristic which permeates every aspect of the industry (Krippachne et al 1992; Ahmad et al 1995; O’Brien, 1996). Fragmentation in the construction industry is due to the small number and large size of the projects, in conjunction with the geographical spread of these projects with the limitations this incurs due to transport costs. Porter (1980) states that industries that are fragmented are difficult to consolidate as the economics of this situation are difficult to change. Assuming the
The fragmented nature of the construction industry will remain, the industry will have no dominant member to provide guidance to the industry as a whole.

The construction industry's production network is an ACR-type relationship (Arm's length Contractual Relations) (Grilo et al 1996). ACR type relationships are those which occur in a competitive free market, where adversarial, short-term relations are the norm (Sako 1992). The result of an industry with no individual dominant member to guide it's development and short term adversarial relationships is significant inefficiency in the industry's processes. The growth of the global market place therefore places the UK construction industry under threat from overseas construction organisations.

The lack of a single dominant member in the industry has resulted in the formation of different groups to provide guidance to the industry. However, such groups have little impact on the major construction companies which remain driven by their need to operate successfully in an industry with an ACR type production network.

The fragmented nature of the industry is a major impediment to efficient processes. However, if the effect of fragmentation can be reduced by better communications between the parties involved then the efficiency of the industry as a whole can be improved.

The problems of interdisciplinary communication and data exchange have been highlighted over the past 25 years by numerous individuals and organisations (Higgin and Jessop 1965; Bishop and Allsop 1969; Ndekugri and McCaffer 1988; Thorpe et al 1994). Ndekugri and McCaffer (1988) also identified typical data flow problems in construction, data provided by one value adding process is rarely in a format suitable for subsequent down stream processes. For example, a planner will throw away information from an estimator and start again. Ndekugri and McCaffer (1988) see the solution through integration where any data created can be utilised by any other function. If information is managed well it is estimated that savings in construction costs of 25% could be achieved (NCE 1991). This scale of improvement in information processes would contribute significantly to the 30% improvement in construction processes called for by the Latham report (Latham 1994).

1.1.2 Application of IT in the Construction Industry
The highly profitable years of the mid to late 1980's resulted in an increased spend on IT, but with little planning. The use of IT to achieve competitive advantage was popularised during the
1980's (Edwards 1994). The objective of IT implementation was considered as a means to improve the efficiency of individual processes. Contracting organisations implemented estimating and planning systems. Consulting organisations and architects implemented design suites and Computer Aided Design (CAD) systems.

Whilst minor concessions were made to share data between a few CAD systems, there was no method of transferring data from a CAD system to an estimating system to a planning system. The systems implemented therefore largely operated on a standalone basis, with little consideration being given to life cycle data of the project. In this respect the construction industry differed greatly from other more forward looking industries. IT is considered a support tool in construction, whilst in financial services it is used to drive business and create new opportunities (Hollingworth 1992). IT is also given a different emphasis by the different organisations in the construction industry, consultants placing more importance on the technology than contractors, with 1.5% and 0.5% respectively (Al-Soufi 1994), of their turnover being invested in IT.

It has been estimated that IT performance per pound will improve by over 20% per year for the next 10 years (Edwards 1994). Such improvements cannot be achieved if IT systems continue to be implemented on a standalone basis. The improvement in the performance of hardware can only provide a limited benefit and the interaction of the systems involved in all construction processes must be considered.

The concept of business re-engineering was being popularised in the early 1990s (Edwards 1994). The re-engineering of business involves the redesign and or rationalisation of the processes which form a system, to optimise the operation of the system. The application of business re-engineering to construction provides a significant opportunity for improving the efficiency of the construction process, thus assisting the UK construction industry in the global market place.

The major disciplines involved in the construction process all use IT tools to improve the efficiency of their processes, eg. estimating systems, CAD, etc. EDI is a technology which can be used to exchange information between the IT systems used by each of the disciplines and therefore provide integration between the disciplines, thus providing a solution to the problems identified by Ndekugri and McCaffer (1988). Furthermore, the use of EDI as a means of data exchange in a construction process system which has been re-engineered, would provide greater
overall efficiency benefits. However, the practicality of re-engineering the construction process is far from simple and requires the participation of all parties, which is extremely problematical in such a fragmented industry.

The fragmented and project based nature of the construction industry dictates that the parties with which a company deals are varied and change regularly. This state of flux is unavoidable, and the constant creation and termination of communication with companies leads to a very simple and inefficient communication infrastructure. The short term nature of the relations provide no incentive to invest in more efficient, but relatively expensive, technologies. EDI provides a common structure that can be used to communicate widely. The use of EDI with common standards by construction organisations would allow the rapid creation and termination of relationships whilst providing a very efficient means of communication. The implementation of EDI would therefore provide significant efficiency benefits to the industry.

EDI can be realistically applied to achieve two objectives: the integration of disciplines within the construction process, by improving information flow between existing systems; and the reduction of the effects of fragmentation by providing more efficient communications between the different parties in the construction process.

1.1.3 Development of Electronic Communications Technologies

Electronic communication technologies have been adopted by the construction industry for a number of specific tasks. In the 1970s the telex was the only means of electronic communications utilised in the construction industry. This technology was used to transfer messages between parties quickly whilst maintaining a record of the message. The 1980s saw the widespread adoption of the fax in all industries, in 1983 10% of the construction industry used fax, by 1989 95% of the industry used fax (KPMG 1987; KPMG 1990). The cheap and flexible nature of this technology led to its success and hence made the telex redundant. The use of e-mail is now making a similar impact in the industry.

Electronic communication technologies have also been used to disseminate information throughout the industry. For example, the RICS provides a Building Cost Information Service (BCIS) which is a central database of price information supplied by subscribing members, which is shared to provide benefit to all members (Betts et al 1991). Whilst such technology has been superseded by the internet is does provide a rare example of the industry willing to work together to provide mutual benefit.
1.1.4 Application of EDI in the Construction Industry

Electronic Data Interchange, EDI, is the electronic exchange of structured data between computer systems. This form of information exchange is key to efficient information exchange between the computer systems of trading companies, as it removes the need for manual intervention and facilitates automatic processing of data.

The feasibility of a computer network establishing a “paperless clearing house for handling trading cycle information” was presented more than 25 years ago (Kaufman 1966). However, few applications of EDI emerged until the 1980s as the ANSI X.12 and Tradacoms standards became available in the USA and UK respectively. During the late 1980s the benefits of a common standard were recognised and the EDIFACT standard was developed, based largely upon the Tradacoms and ANSI X.12 standards. The United Nations adopted this standard and promoted its use throughout the world. The western European EDIFACT board was formed to co-ordinate development in the EU. The USA also recognised the importance of the standard and pledged to develop EDIFACT messages in conjunction with ANSI X.12 messages (Genilloud 1990).

It is estimated that 70% of all computer input is output from another computer (Harris 1992). If the data is printed and manually entered, which is often the case, a significant amount of data re-handling is required which is open to error due to the manual entry of the data. The benefits of EDI are clearly demonstrated by the example of its impact on the transfer of trading cycle information.

The business case for EDI was identified early in the UK. In 1984 it was estimated that 3.2 billion trading cycle documents were sent each year and each document cost approximately £10 to process. £24 billion of this process cost was associated with personnel and paper handling (ISTEL 1984). EDI can be used to automatically send and receive these documents, therefore eliminating the need for paper handling, manual data entry and document checking, hence greatly reducing personnel requirements. The data transfer is also of a higher integrity as errors are eliminated. Al-Soufi (1994) suggested a 60% cost reduction is possible if EDI is used instead of paper for trading cycle information. Such cost reductions based upon the automation of transactions are available for large volumes of documents. EDI however, can be used to achieve indirect benefit, for example as a means of achieving a corporate strategy, or providing close trading relationships with a particular supplier.

The obvious benefits of EDI have led to its implementation in a number of industries, including retail, manufacturing and banking. The use of EDI in Europe lags behind that of North America,
however, between 50% and 65% of all EDI users in the EU are UK companies (Bartel 1992; Bamfield 1994). Robson (1994) reported that the number of EDI users had reached 1100 by the end of 1994 in the UK. The use of EDI in the UK is largely due to the success of the Tradacoms standard. The differential of EDI use between the US and the EU is likely to change. In 1991 the predicted growth of EDI was 23% per year in the manufacturing and service sectors in the US (EDI Research Inc. 1991) and 40% in Europe (Kutten et al 1991). This indicates that the gap should have reduced between the two economies. However, Akintoye (1997) reported that only 20% of the top companies in the UK (5% of the commercial base) are actually involved in EDI transactions.

There is very little application of EDI in the construction industry. EDICON was formed in the late 1980s to promote the use of EDI in the industry. As part of their work EDICON made a number of messages available to the construction community that could be used to transfer trading cycle information. EDICON also had the objective of providing messages for information flows which are specific to the construction industry. The reasons why EDI had not been adopted in the UK construction industry were identified by Strassman (1990) as: structure and nature of UK construction industry; the scale and complexity of data flows in construction; the economic recession; conflicting standards of data transfer; the availability of agreed message formats; security concerns; and legal issues (Strassman 1990). Whilst a number of these issues were outside the control of EDICON, the group endeavoured to promote EDIFACT and thus provided a common standard and set of messages for information transfer in the industry.

The prevailing climate in the industry was promising in the early 1990s. A realistic view was provided by the Building on IT 2000 project which stated that while economics, structure and organisational behavior can all act as restraints, EDI will either come of age or fail (Building on IT2000). The use of EDI was envisaged as growing with CICA and KPMG (1990; 1993) forecasting that 15% of the construction industry would be using EDI by 1995, which was supported by other experts (CERCI 1991).

The optimistic climate toward the application of EDI and its potential to provide a significant benefit, led this research to investigate EDI as a means of integrating the disciplines that are involved in the construction process and to reduce the effects of fragmentation identified in section 1.1.1. This would then hopefully lead to a more effective construction process.
1.2 Aim and Objectives

Against this background, the main aim of this research is to “review the role of EDI in the construction industry and develop tools to assist in its application to improve the efficiency of the construction process”.

This main aim can be divided into the following objectives.

1. To examine EDI and its application in the construction industry.
2. To develop tools to assist in the development of EDI messages.
3. To develop and implement EDI messages to determine the effectiveness of the tools developed and the suitability of the technology to the industry.

The second objective was divided into the following sub-objectives:

(i) develop tools to identify information flows suitable for transfer by EDI; and
(ii) develop a generic methodology that can be used to develop an electronic message.

The third objective was divided into the following sub-objectives:

(i) undertake the development of a message as defined by the methodology;
(ii) analyse the message to be implemented, to determine the scope of initial implementation; and
(iii) undertake a trial implementation defined by this scope.

1.3 Methodology

To achieve the first objective defined in section 1.2 the following tasks were undertaken.

i) A review of EDI and its technical components.

A brief investigation of EDI was undertaken to provide a basic understanding of the subject. The technical components of EDI were investigated to develop an understanding of the technical issues involved in implementing and operating the technology. This investigation took the form of a review of technical literature as this method is both rigorous and time effective.
ii) A detailed review of EDI standards for both technical and commercial data.

The selection EDI standards was identified as crucial by the investigation of technical components. EDI standards were investigated by means of a literature review to identify the standard most suitable for the exchange of both technical and commercial data in the construction industry.

iii) An investigation of the business impact of EDI, both potential and observed.

The implementation of EDI impacts on the business in which it operates. If this technology is to become the dominant means of communication in the industry it is essential to develop an understanding of the potential impact on business. The impact was investigated by means of a review of literature that either describes observations of the effect of the impact or postulates possible impact that has not yet been realised.

iv) An investigation of the legal impact of EDI, in the framework of the UK legal system operating within the European Union.

The use of electronic trading technologies was not expressly accounted for in traditional law, which considers the paper document. The impact on the legal status of electronic trade is investigated, by means of a literature review, to determine how the law is adapting and its likely status once these technologies have become widely established.

v) A review of literature to investigate issues relating to the application of EDI in the construction industry.

The implementation of electronic exchange or any technology is driven by the benefit it can afford. It is essential that the benefits afforded by EDI are significant for the technology to succeed. The issues which determine the benefit available are investigated. First, the use of EDI in construction is compared with other industries by means of a matrix analysis of case studies. This is used to identify key criteria of the successful use of EDI. Further issues are then identified by means of a review of previous electronic exchange research. Finally, the means by which electronic exchange can be implemented in construction is postulated based upon this review.

vi) A longitudinal study of the application of EDI in the construction industry was undertaken over a five year period.

The purpose of the study was to identify: the status and application of EDI; the perceived benefits; the message formats considered most beneficial; and the EDI standard considered most likely to be adopted by the industry. The study comprised two similar questionnaire surveys of the same industry sample. These two surveys are analysed and compared to identify change in the industry.
To achieve the second objective defined in section 1.2 the following tasks were undertaken.

(i) **Identify system modelling tools suitable for representing construction information flows.**

To identify information flows which are suitable for EDI it is first necessary to examine the flows which form the traditional construction process. This process and its components are known, therefore a hard systems modelling approach was adopted in preference to a soft systems approach which is utilised to model unknown processes. Hard systems modelling tools were investigated to select the tools suitable for modelling the information flows which form the construction process.

(ii) **Create a data flow model which represents the external information flows during the construction process.**

To aid the identification of information flows suitable for EDI a data flow diagram representing information exchange between construction parties was developed. The model is structured on the five stages of the traditional construction process as defined by RIBA(1973).

(iii) **Select an information flow best suited to conversion to an EDI message.**

A single information flow was selected for development into an EDI message. To select this flow, first all flows suitable for EDI were identified. The flows for which messages have been developed were eliminated. Finally, a single message was selected based upon criteria identified from the study of EDI in the industry.

(iv) **Develop a generic methodology that can be used to create EDI messages.**

A generic methodology was developed to provide a guide by which messages can be developed for the industry. This methodology was developed by interviewing industry experts and referring to other message development literature.

To achieve the third objective defined in section 1.2 the following tasks were undertaken.

(i) **Undertake the development of a message as defined by the methodology.**

The development of a message was undertaken to test and validate the methodology developed. The development of the selected message was undertaken using the methodology prescribed, under the guidance of an industry working party which ensured the relevance and applicability of the message developed.

(ii) **Analyse the message to be implemented, to determine the scope of initial implementation.**

The message to be implemented was analysed to gain understanding of the message and to define the scope of trial implementation. This analysis was undertaken by the deconstruction of the message into its component sections and segments. The purpose and structure of each section and segment is then described.
Undertake a trial implementation defined by this scope. The bill of quantities message set was tested to determine whether it can be utilised successfully with current systems and to identify implementation issues. To test a message set the applications with which it communicates are first identified. Translation software was developed for these applications. The EDI systems were then tested using sample bill of quantities documents. Finally, the trial system was demonstrated to EDICON and the software vendor for evaluation.

1.4 Main findings

EDI is technically possible and can provide significant benefit. The selection of EDI standards should be made on an industry basis to facilitate information exchange. The standards best suited to the construction industry are currently the EDIFACT standard for commercial data exchange and DXF for technical data exchange.

EDI impacts on business in two ways, by improving efficiency of the business processes and by affecting the way in which business operates to maximise these benefits. If EDI is used to achieve re-engineering then the benefits can be maximised. EDI can be beneficial to the whole business. EDI is currently being used by industries for high volume trading processes as this application provides obvious benefit. The advent of the internet is opening electronic trading to a wider community and will therefore nullify a number of the short term benefits of EDI which result from closed markets.

The two key legal issues relating to EDI are those of contract and evidence. The use of computer data as evidence has been recognised in the Civil Evidence Bill. The formation of contracts is less well defined. No jurisprudence currently exists regarding the formation of contracts using electronic data exchange. Electronic trading can be achieved, without compromising the business operation of a company, if both parties agree at the outset of trading that EDI may be used to form contracts. This is best achieved by implementing an interchange agreement between the two parties.

The success of EDI in any industry is dependent on two factors. If there is a high volume of data exchange or EDI is used to achieve re-engineering then EDI can be successful. If neither of these factors exist EDI cannot provide sufficient benefit, therefore a business case cannot be made for the technology.
The investigation of the low level of use in the construction industry revealed the following factors that inhibit the use of EDI: industry structure; complexity of data flows; reluctance to invest; and the lack of a business case for electronic exchange in construction.

The use of EDI in construction requires re-engineering of existing processes to succeed due to the low volume of data exchanged. The integration of information activities was identified by Bjork (1997) as a means of re-engineering the industry. The use of a shared data resource in the form of a shared project model is one way of integrating the industry's information activities. Three initiatives were investigated which utilise STEP technology to provide a shared project model: IAI; RoadRobot; and VEGA. The concept of partnering was investigated and this concluded that partnering may provide a means of driving the implementation of electronic exchange.

The study of EDI in construction was undertaken by means of a five year study, comprising two questionnaire surveys the first in 1992 the second in 1997. This study indicated that the potential application of EDI predicted in 1992 was not realised. The application of electronic exchange has also shifted to technical information during the study, due probably to the expansion in the use of CAD. Interest in EDIFACT has dropped, being replaced by the more practical approach of CITE. However, the need to improve awareness of electronic exchange technologies in the industry remained consistent throughout the study.

An information flow model of the construction process was developed as a tool to identify information flows which are suited to EDI. This model identified the specification message as the next priority for message development.

A message development methodology was developed as a tool to improve the efficiency of the process of EDI message development. The methodology developed comprised two parts: data analysis; and message design. The data analysis consists of the development of a data model which provides the functionality of data exchange required. This stage is generic and therefore can be applied to any EDI standard. The message design stage is the conversion of the data model produced into an actual EDI message. This stage is specific to the standard used.

The development of a data model for the description part of a specification message was undertaken. This work identified that: the development of EDI messages is currently time consuming; the data model must provide the functionality required by all parties; the data model
produced can be generalised and over complicated; and thorough testing of a data model is essential.

The official implementation of the bill of quantities message set undertaken by EDICON failed. The trial of the bill of quantities message set proved the technical competence of the CONITT and CONTEN messages. The exercise also indicate that the integration of the messages with existing software is not inherently problematical.

The bill of quantity message set whilst providing an excellent technical solution to the problem of electronic data exchange of the document, proved to be the downfall of EDI as the solution was too complicated for the conservative and practical members of the construction industry. It can be argued that the necessarily complicated nature of the message led people to believe all messages are over complicated. Investment in EDI was continually deferred due to the lack of a clear business case, with little apparent benefit available from the application of the technology.

The approach now being adopted through the CITE initiative may be more successful, due to the reduction of investment required, whilst retaining all the high profile benefits available, particularly in the case of the bill of quantity message set.

If the current CITE initiative succeeds it will be due not only to its more pragmatic approach, but more significantly to the more healthy nature of the construction industry in the mid to late 90's. Companies are now more willing to invest in technology that will provide a benefit. CITE provides the simplest, cheapest and best suited method of using electronic means for communication in the construction industry to date. It could be argued that if this initiative fails it is because the industry simply isn't ready to use such techniques. Alternatively the benefits of trading electronically may have been so diluted by the lack of integration of the technology that it does not provide significant benefit. The solutions provided by CITE merely offer operational benefit. The use of EDI can be justified for the exchange of high volumes of data on efficiency improvements alone, however for the exchange of low volumes of data, as in the case of project information, it is essential to re-engineer the processes of construction to provide significant benefit.

The use of a shared project model to integrate the information activities of the construction process is one means of re-engineering that could provide significant benefit to the industry. Several projects have been initiated to develop STEP based technologies to implement such
models. These models must include a means of storing and distributing commercial project information, which is best contained in EDI messages. The VEGA project has recognised this requirement and includes EXPRESS meta-models to store EDIFACT messages. Shared project models represent an effective means of achieving the maximum benefit from EDI technology and indicate that the work that has been undertaken to develop EDIFACT messages has not been wasted. Indeed further work is essential to fully implement shared project models.

Finally, the emergence of the internet as an easily accessible means of communication, will facilitate the use of electronic communication techniques in the majority of companies that form the construction industry. The internet can be used to exchange EDI messages directly, or as a means to access and update a shared project model. This technology will therefore enhance the application of EDI in the industry and may prove to be a significant factor in its success.

The main contribution to knowledge made by this research was a result of the following tasks: a longitudinal study of EDI in the construction industry; the development of an information flow model of the construction process; the development of a methodology for message development; the development of a description data model; and the trial of the bill of quantities message set. The longitudinal study provides a report of the current status of EDI, as well as an indication of the future of the technology in the industry. The information flow model and message development methodology are two tools which can be used to assist in the development of future EDI messages for the industry. The development of a description data model validated the tools developed, and the model produced can be utilised in existing and future messages. Finally, the trial of the bill of quantities message set proves that there are no technical barriers to the implementation of EDI in the construction industry.

1.5 Guide to thesis

The thesis consists of nine chapters. A brief description of each chapter is presented below to summarise the thesis. Also a diagrammatical interpretation of the thesis is presented in figure 1.1.

Chapter 1 This chapter explains the background to the research, the aim and the main objectives. The methodology applied to achieve the aim of the research, the main findings and the guide to this thesis are also presented.
Chapter 2  This chapter defines EDI and provides a comparison to other electronic communication techniques. The technical components of EDI are then described, including a study of the majority of EDI standards currently available.

Chapter 3  The implementation of EDI is undertaken to achieve either a competitive advantage or strategic objective. EDI, however, provides not only short term effect but medium and long term impacts. The implications of EDI in both business and legal terms are discussed in this chapter.

Chapter 4  This chapter presents a study of EDI in the construction industry. The study consists of two parts: a literature review; and a survey of the UK construction industry. The literature review is a study of the issues pertinent to the success of EDI technologies in the industry. The survey was a longitudinal study, consisting of two surveys with a five year interval, of the application and perception of EDI in the UK construction industry.

Chapter 5  This chapter investigates system modelling techniques available. Based upon this investigation a method of modelling the traditional construction process is identified. The selected method, data flow diagram is then applied to produce the model presented. The model is utilised to identify which information flows would be suitable for conversion from a traditional communication method to an electronic communication technique.

Chapter 6  A methodology was developed which can be used to produce an electronic message. This methodology comprises two stages: data analysis and message design. Data analysis is generic and can be applied to the development of any electronic message. Message design is the conversion of the data model produced by data analysis into an actual message, and is therefore standard specific. An example for an EDIFACT message is described. This chapter describes the application of this process to develop a description data model.

Chapter 7  The structure and content of the key messages in the bill of quantity message set is analysed. The key messages selected are those required during the tender stage of the traditional construction process.

Chapter 8  The implementation of the bill of quantities message set is described. The findings of this exercise are discussed in detail with recommendations on how such an exercise would be ideally undertaken.
Chapter 9  This chapter presents the conclusions of the research and the main recommendations for further research.

Figure 1.1 - Schematic guide to thesis
Chapter 2
Electronic Data Interchange, technical issues

2.1 Introduction

Electronic Data Interchange is a technology that provides services which are commonly accepted, but which are not commonly understood. People are willing to accept that funds can be transferred to their bank account, but have little understanding of how this occurs. It is generally difficult to visualise the transfer of an electronic message, whilst it is easy to visualise the transfer of cash or a cheque, as they have some physical form.

The first objective of this chapter is to define EDI. The key differences between EDI and other electronic exchange technologies are identified and the terminology used for each type is defined. The concepts of EDI are briefly investigated to provide a simple understanding of the reasons which have resulted in its use. This is followed by an explanation of the mechanics of EDI by means of a technical overview of its components. This explanation identifies two key areas, electronic data interchange standards and electronic data interchange messages. The standards provide the syntax used to define the structure of the messages. The messages are the means by which the information is conveyed. The message used is peculiar to the type of information flow transferred, therefore a message is required for each information flow type that is to be transferred.

To further the utilisation of EDI in the construction industry it is necessary to select standards which are common to all companies trading within the industry. It is also necessary to select standards which can be used for communications with companies outside the construction industry. To identify the EDI standards suitable for the construction industry an investigation of standards available for commercial and graphical information was undertaken and an appropriate standard proposed for each.

2.2 Definition of EDI

Electronic Data Interchange, or EDI, has been defined as:

“The electronic transfer from computer to computer of commercial or administrative transactions using an agreed standard to structure the transaction or message data”

(UN/EDIFACT, 1984)
"The electronic exchange of structured and normalised data between computer applications of parties involved in a (trade) transaction" (Hofman, 1987)

"the transfer of structured data, by agreed message standards, from computer to computer, by electronic means" (Donington, 1990)

"communication system that allows direct computer to computer exchange of standard business format information" (Gibson and Bell, 1990)

"the transfer of structured data, in an agreed format, from computer to computer, by electronic means" (Naughton 1990)

"computer to computer communication of standardised electronic transactions between sites" (Snapp 1990)

"computer to computer communication with data structured in accordance with an agreed format - assembled in a particular sequence and wrapped in an electronic envelope" (Knutton 1991)

"the interchange of standard formatted business data from computer to computer and application to application" (Harris 1992)

The key concept in all these definitions is that of a standard information structure. The standardised structural nature of an EDI message allows the recipient to recognise the individual data elements and to implement automatic data processing techniques on the data received. The ability to process information received automatically sets EDI apart from other electronic data transfer techniques, such as fax and electronic mail, and offers many potential benefits to both sending and receiving parties.

**Definition of EDI terms**

EDI has been identified as only one form of electronic data exchange. Baldwin et al (1995) also identified multi format exchange(MFE) and information exchange(IE). MFE is the name given to electronic data interchange where additional data is appended to the message by either embedding the data or attaching the data by another linked transmission. This technology can be used to send technical data encapsulated in a commercial data standard, for example a DXF file can be embedded
in an EDIFACT message. The need for MFE has been identified by EDICON (see section 2.6) which has identified a series of formats for combination with EDI messages, including: Tagged Image File Format(TIFF); Graphics Interchange Format(GIF); Encapsulated Postscript(EPS); Hewlett-Packard Graphic Language(HPGL); Drawing Exchange Format(DXF); and the Standard for the Exchange of Product model data(STEP) (EDICON 1995). IE is a term often used in the UK to describe all forms of electronic information exchange. The alternative to this term in the USA is Electronic Data Management(EDM) which is used to describe the emerging technologies for electronic data management (Bell et al 1994).

This research refers either specifically to EDI, or alternatively the term electronic data exchange is used when referring to all forms of structured data exchange.

2.3 Why EDI developed

2.3.1 The inception of EDI

Traditionally companies and organisations have conducted their business using paper as a means of information transfer (Shaw 1993). Coins, seals and paper documents have been used as records of trading having taken place.

The explosion of business and the immense volumes of paper produced to record the millions of commercial transaction led industries to seek a more efficient means of transferring data (DISA 1993). The widespread use of computers for commercial applications and the availability of communication methods in the 1970's provided the tools required to develop such a solution.

The use of EDI was first considered by the North American road haulage industry which set up the Transportation Data Coordinating Committee (TDCC) in 1968. The first TDCC standards were published in 1975 (Anonymous 1995).

The general trend towards the application of EDI for general commercial application started in the USA in 1979 with the formation of Accredited Standards committee (Anonymous 1995) and has grown rapidly, the UK followed shortly after and has experienced similar growth (SITPRO 1993a). The United Nations also recognised the importance of EDI and developed and published a set of rules in 1981 known as 'Guidelines for Trade Data Interchange' (GTDI) (Anonymous 1995). The development of EDI in the USA and the UK is described further in section 2.8.0.
2.3.2 Benefits of EDI

The adoption of EDI is driven entirely by the benefits it provides. The manual processing of large volumes of paperwork is expensive and prone to problems. Such processing includes printing, photocopying, filing and retrieval. The electronic alternative to each of these tasks is significantly faster and less open to error, hence the automation of processing facilitated by automatic entry of data into a computer system provides a significant cost benefit. To give an indication of the scale of savings achieved by EDI, Texas Instruments in the US, achieved savings of $50 million dollars a year by introducing EDI (Williams 1997).

Benefits can be divided into hard and soft categories. Hard benefits are those which are tangible, and therefore can be easily quantified. Soft benefits are non-tangible and therefore cannot be easily quantified. The benefits of EDI are well reported (Nottage 1988)(Davidson 1991)(Harris 1992)(O'Brien and Al-Soufi 1993)(Adcock 1996). These are presented below in their respective category.

**Hard benefits**

The hard benefits of EDI are:

- Reduction in staff resources required as no re-keying of data;
- Elimination of errors caused by data re-keying;
- Reduction in paper handling costs;
- Reduction in postal costs;
- Delivery of message much speedier than mail;
- EDI imposes discipline on its users, hence details are not omitted; and
- Cost savings through process re-engineering (indirect hard benefit).

**Soft benefits**

The soft benefits of EDI are:

- A means of complying with a corporate strategy;
- A method of building closer relationships with trading partners (short term); and
- Maintaining customer base.

**What benefits drive the adoption of EDI**

The hard benefits, such as improved accuracy and reduction in labour requirements do provide a significant benefit. However, the largest benefits are achieved by the use of business process re-engineering (Hendry 1993). This is the use of EDI to facilitate a change in how processes are
undertaken. EDI has provided the means by which benefit can be drawn from the integration of existing computer systems. An example being the integration of the stock control and purchasing systems allowing the automatic ordering of stock as it is required using EDI. An excellent example of the application of EDI to achieve process re-engineering is "Just-In-Time" manufacture. The benefits of "Just-In-Time" manufacturing are discussed in section 3.2.2.

The soft benefit of maintaining a customer base has in some cases been the sole driving force behind EDI as several companies have required suppliers to trade electronically, or lose their business. In these cases EDI has been used to force trading partners to work in a particular way to suit the client (Adcock 1996). As major manufacturing companies such as Volkswagen, (Williams 1997), and General Motors, (Sadhwani 1987)(Takac 1993), force all suppliers to trade using EDI the suppliers concerned will be in a privileged position as they will have developed a closer trading relationship with the client. This will only apply in the short term however as the scale of the component supply required by a major manufacturer will mean the majority of suppliers will be willing to accept the cost of implementing EDI to undertake trade. The result will be a return to more traditional commercial factors being used to select the supplier.

Factors to be considered in a cost/benefit analysis of EDI

A cost/benefit analysis provides a means of determining if the implementation of EDI would provide a financial advantage. Hendry (1993) identified the costs and benefits associated with EDI shown in table 2.1.

<table>
<thead>
<tr>
<th>Savings</th>
<th>Costs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Postage and Paper</td>
<td>Initial capital cost</td>
</tr>
<tr>
<td>Inventory reductions</td>
<td>Maintenance</td>
</tr>
<tr>
<td>Better utilisation of resources (through reduced delays)</td>
<td>Communications</td>
</tr>
<tr>
<td>Reduced errors</td>
<td>Training</td>
</tr>
<tr>
<td>Lower transaction costs</td>
<td>Consultancy</td>
</tr>
<tr>
<td>Possible manpower savings</td>
<td></td>
</tr>
<tr>
<td>Telephone costs</td>
<td></td>
</tr>
</tbody>
</table>

Table 2.1 - Costs and benefits of EDI

It is essential that all the costs and benefits resulting from the implementation of EDI are considered, otherwise the analysis is invalid. The implementation of EDI should be backed by a clear business
case, which can incorporate a cost/benefit analysis. However, such an analysis does not form a business case alone, business and operational strategies should also be considered as these can incorporate the less tangible factors.

2.4 Components of EDI - a technical overview

This section describes the key functional components required to achieve electronic data interchange between computer systems. The components described are:

- EDI standards;
- structured message format;
- communication networks;
- communication software; and
- translation software.

The relationship of these components is presented by means of a diagram in figure 2.1.

![Diagram of EDI components](image)

**Figure 2.1 - Components required to achieve EDI**

2.4.1 EDI standards

"The standards for EDI set out the rules for writing and sending EDI messages"

(Naughton, 1990)
EDI standards provide the rules of syntax from which neutral file structures can be developed. The prevalent EDI standards of today are ANSI X.12, Tradacoms, EDIFACT and industry specific solutions such as CITE for commercial text data, and DXF, IGES and STEP for graphical and product model data. Many of the standards available are described in detail in sections 2.8.0 and 2.9.0.

The neutral file structures produced using the EDI standards are known as messages.

2.4.2 A structured message format
A message, or neutral file structure, is required for every type of document transferred by EDI. For example an invoice, purchase order, and a delivery note each require a specific structure, or message, in which the data in the document can be slotted. The message must be consistent for each document using a particular EDI standard. For example, the EDIFACT invoice message used by all parties must be consistent for data to be transferred between many computer systems successfully.

Structure of a message
A typical message begins with a header and ends with a trailer. The header may contain details of the message sender and receiver, whilst the trailer may contain controls to be used as a check of message integrity. The central part of a message can be of any structure, and is dependent on the purpose of the message. A message is made up of segments which represent particular information types, eg. address, references etc. Data elements are the components of a segment. Data elements relate to items of data, eg. a date, a value, a name.

2.4.3 Communication network
To transfer EDI messages between computer systems requires a means of electronic communication. There are six communication methods available for the transfer of an EDI message:

- exchange of storage media;
- private leased line;
- telephone network (PSTN);
- data network (PSDN, ISDN);
- value added network; and
- the internet.
Exchange of storage media
The physical exchange of storage media, tape, disk or CD, is the simplest means of transferring data. It is suitable for transferring large complicated files, such as CAD files, on an infrequent basis.

This method negates the speed benefits of EDI as the storage media is either posted or sent by courier. Also the storage media is open to damage during transit.

Private leased line
The implementation of a network of private data lines is costly. However, it provides secure and reliable service. This technology is commonly used for wide area networks as it provides inherent data security. The high cost of this service dictates that it is only suitable for EDI if there is a high volume of traffic. Since the early 1990's frame switched relay connections have become available. These provide four times the data transfer rate, or bandwidth, of a traditional private leased line. Also the bandwidth can be upgraded on request. The additional facilities provide a great deal of flexibility, but incur an additional cost in proportion to the additional bandwidth available.

Telephone network (Public Switched Telephone Network)
The use of modems allows the national/international telephone network to be used to transfer data. This option has low initial costs and the cost of transferring the data is identical to that of making a telephone call.

The disadvantages of this solution are: slow speed of data transfer; frequent interference; the telephone circuit can handle only one transmission at a time; and a long connection time at the start of each telephone call.

These disadvantages result in a high cost if large volumes of data are transferred regularly over a long distance. However, this option provides a low-cost method of undertaking a trial of EDI, thus allowing companies to ascertain the suitability of EDI to their operations without excessive financial commitment.

The advent of digital cellular networks has provided a mobile means of connecting to a PSTN. These methods, whilst convenient, provide limited bandwidth, typically 9,600 baud, and are therefore only suitable for text based terminal emulation connections.
Public switched data network (PSDN, ISDN)
These are networks specifically designed to carry data. To achieve a connection with another party a number is dialed, in the same way as a PSTN. The advantage of this option over the telephone networks are: low error rate; faster data exchange; faster connection time; simultaneous transmission capabilities; and network spoofing capabilities. PSDN therefore provides a more efficient solution than PSTN for the transfer of high data volumes of long distances. However for low data volumes over short distances PSTN is the most cost efficient option. The most common data network used in the UK is known as ISDN, which has a data transmission rate of 64Kb/s (single ISDN).

Value added network (VAN) / Value added data service (VAD)
A VAN is an electronic mailing service. This mailing service can be used for any type of electronic message, but provides many practical advantages to the EDI user. These advantages include: not having to synchronise transmissions between traders; one connection point to trade with many different parties; and proof of message transfer. The use of a VAN/VAD to distribute a message to a number of trading partners is represented in figure 2.2. The disadvantage of a VAN is that it is a closed network of traders, if your key trading partners do not belong to your VAN trading is impossible. However, in recent years the major VAN suppliers in the UK have successfully linked their systems (Heppell 1997) allowing for larger trading groups, without having to join several VAN's.

A user must connect to the VAN using either a PSTN, ISDN or leased line link. The services provided by a VAN supplier do vary. Naughton (1990) identified the following services as common to VAN suppliers:

24 hour, 7 days a week availability;
the storing, filing and forwarding of EDI messages;
the checking and correction of messages to ensure a successful passage through the network;
mailboxes for transmitted messages and acknowledgments of receipt;
data security, with immediate copies of the message taken and separately stored and strict protocols to prevent unauthorised access or movements of data; and
varying levels of additional support to implement EDI, for example consultancy and training.
Users are charged an initial joining fee plus annual standing charges. These charges may include some data storage and on-line time. However, these items may be charged separately.

![Diagram of EDI message distribution]

Figure 2.2 - Use of a VAD/VAN to distribute an EDI message

**The Internet**

The internet is a network of servers which span the globe. This network is accessed by connecting to a server on the network. This can be achieved by setting up an internet server, many companies now provide an internet server registration service, alternatively a connection can be made to the server of an internet service provider. The connection to an internet server can be made by any method of remote server connection, including: PSTN, PSDN or leased line. If an internet server is local to your operations a local area network can be used.

The performance of data transfer over the internet is dependent on the activity on the internet and to a lesser extent the bandwidth of your connection and that of the host which you are connecting. Typically data transfer speeds of up to 60Kbytes/sec are the maximum which can be expected.
Security is also a major consideration due to the open nature of the network. The secure exchange of confidential messages can be achieved using encryption techniques, such as a public/private key system.

2.4.4 Communication software

Communication software provides an efficient means of transferring data over the communications network. Communication software provides two features: a means of checking and compressing an EDI message; and a means of physically transferring data over the communication network.

The function of checking and compressing an EDI message requires knowledge of the standard used. Communication software is therefore developed to support the majority of EDI standards in use.

The function of physically transferring data over the communication network requires the use of a protocol. A communications protocol can provide additional facilities such as additional compression and error checking. A communication protocol which has come to the fore in recent years is X.400.

X.400

X.400 is a means of communicating data using a communication wire that includes a number of features over and above the delivery and receipt of information. Included in the specification of X.400 is: the ability to store and forward data (mail-boxing); the ability to provide origin authentication; incorporate password controls; and data encryption (Robson 1994).

X.435 is the standard specifically developed for the transfer of EDI messages. The features provided by X.435 over those provided by X.400 are:

- standard EDI message handling;
- mixing EDI and non-EDI messages;
- improved message notification providing end-to-end acknowledgment;
- forwarding of a message together with the responsibility to provide notification to the originator of the message; and
- improved security (Barrett 1994).
The features of X.400 and X.435 are such that they can provide an alternative to VAN services (Robson 1994).

2.4.5 Translation software

The purpose of EDI translation software is to convert data from the application specific data format into the EDI format. Furthermore, this software must also convert incoming data from an EDI format into the application specific format. A translator is required for each relationship between an EDI message format and an application. For example, if an accounting application sends and receives both invoice and purchase order messages two translators are required.

Translation software can be developed by a company in-house to specifically meet its own requirement. Alternatively, a commercial package can be purchased which can be configured to undertake the translation tasks required. The commercial option is usually favourable due to the high cost of developing and supporting systems in-house.

2.5 Trade associations

Trade associations have been formed to develop trading groups for their relevant industries. Whilst some of these groups were formed specifically for EDI many others existed previously. These groups were formed to consider the topic of trade data exchange generally and to promote the adoption of EDI as it became available.

Trade associations exist for many industrial sectors. Associations that currently exist to facilitate EDI:

- Article Numbering Association (retail industry)
- Association for Payment Clearing Services (banking)
- British Paper and Board Industry Federation (process industry)
- Society of Motor Manufacturers and Traders (Automotive manufacturing)
- Simplification of International Trade Procedures (SITPRO)
- EDICON (construction)
- EDIFICE (electronics)
- ODETTE (motor trading)
- CEFIC (chemical)
- EDI Association (international trade and transport)
- RINET (reinsurance)
2.6 EDICON

History of EDICON
In November 1986 a small group started meeting to discuss the application of EDI to the construction industry. This group consisted of representatives from the design, contracting, information and computing services aspects of construction. The group identified the pressing need for much more efficient communication between the separate parts of the industry and between individual companies. The group also concluded that the development of an EDI system would not only be feasible but was essential for the future health of the industry (Sanders 1988).

This group formed the EDI association known as EDICON, which is a non-profit making company limited by guarantee called Electronic Data Interchange (Construction) Ltd. The launch meeting of this group was held on 26 March 1987. The attendees were invited to join the community and assist in bringing the benefits of EDI to the construction industry. There were 8 founding members of EDICON. The membership grew rapidly to 100 organisations by 1990 (Knowles 1990). The membership has since stabilised around this number.

Since EDICON was formed, similar organisations have been created in France, Sweden, Denmark and other European countries (Knowles 1990). The development of the EDI association in construction indicates the interest in the application of EDI within the construction industry prevalent in the late 1980s. However, this interest had to be converted into systems implementation for EDI to have an impact on the efficiency of the industry as a whole.

Purpose of EDICON
The “mission statement” of EDICON is to bring the benefits of EDI to the UK construction industry. This is to be achieved by promoting and coordinating the application of EDI in the industry. A major part of this work is to ensure suitable EDI messages are available to the industry for the transfer of information. EDICON as a group supports all EDI standards, but has adopted the EDIFACT standard. All messages developed or provided by EDICON are based on this standard.
EDICONs policy is to adopt, wherever possible, those standards developed by other EDI communities and ratified by the UNECE and EDIFACT. This is demonstrated by EDICONs use of existing EDIFACT messages for trade data flow, including invoice and purchase order messages. Clearly there are information flows which are specific to the industry, and it is the development of messages for these which EDICON concentrates its efforts (Al-Soufi 1994). This work has resulted in the full ratification of a message set for exchange of bill of quantities information (Adcock 1996).

EDICON works closely with EDIBUILD, the European construction EDI group, and MD5 the construction industry group on the Western European EDIFACT Board. This collaboration provides a means of coordinating effort, which yielded some 54 EDI message standards for the construction industry by 1994 (EDICON 1994).

Messages available through EDICON

The following messages, developed specifically for the construction industry, are currently available through EDICON.

Accepted standards (status 2)

<table>
<thead>
<tr>
<th>Message</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>CONITT</td>
<td>Invitation to tender</td>
</tr>
<tr>
<td>CONTEN</td>
<td>Tender</td>
</tr>
<tr>
<td>CONEST</td>
<td>Establishment of contract</td>
</tr>
<tr>
<td>CONQVA</td>
<td>Quantity valuation</td>
</tr>
<tr>
<td>COMPVA</td>
<td>Payment valuation</td>
</tr>
<tr>
<td>CONDPV</td>
<td>Direct payment valuation</td>
</tr>
</tbody>
</table>

Under review (status 1 or 0)

<table>
<thead>
<tr>
<th>Message</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>CONWQD</td>
<td>Work item quantity determination</td>
</tr>
<tr>
<td>CONAPW</td>
<td>Advice on pending work</td>
</tr>
<tr>
<td>CONRPW</td>
<td>Response on pending work</td>
</tr>
<tr>
<td>PROTAP</td>
<td>Project task planning</td>
</tr>
<tr>
<td>CONDRO</td>
<td>Drawing organisation</td>
</tr>
<tr>
<td>CONDRA</td>
<td>Drawing administration</td>
</tr>
</tbody>
</table>

(Akintoye 1997)
2.7 Data exchange standards for the construction industry

The construction process, from inception to handover, requires a large amount of information to be transferred between the many parties involved. Traditionally the information flows take various forms including paper based documents, faxes and telephone conversations.

The advent of computers to aid accounting, estimating and design has had little impact on the methods of information transfer. A study of site communications undertaken in 1996 indicated that whilst technologies such as e-mail and internet connection were viewed as beneficial, very few (approximately 10%) had access to these information transfer methods (Murray and Thorpe 1996). The information produced by computer systems is still transferred between parties by traditional means, which requires the manual re-entry of data into each system. This is not only expensive in terms of labour resources but can also lead to erroneous data. A number of sectors, including the retail, automotive and transport industries have identified this inefficiency and as a result have adopted EDI. These industries have adopted standards which have been identified as suitable for their requirements.

Exchange standards used for electronic communication must suit the information which is being transferred. Two groups of exchange standards have evolved: one for commercial text information; and one for graphical information.

The IGES and DXF standards have been developed for the transfer of CAD (graphical) information. The EDIFACT, ANSI X12 and TRADACOMS standards have been developed for the transfer of textual and numerical commercial information. The construction industry has the need to transfer both commercial and graphical information.

The following sections describe data exchange standards in each group and discuss their suitability for the UK construction industry.

2.7.1 The case for EDI standards

In its most elementary form, EDI can take place between two companies, using data format conventions agreed between the two parties. This approach can be applied to any number of company pairs, creating a number of partnerships all with their own data format conventions. However, with the number of conversions (C) between partners (P) growing at the rate of $C=P(P-1)$,
it becomes more practical for the groups to agree on standardised, or neutral, message formats. (Ovum 1990)

The advantages of using pre-defined syntax rules is summarised below.

a) Media
Data is structured in the same way whether it is interchanged via magnetic media or a telecommunications link. The syntax rules help minimise the cost of changing from one medium to another in inter-organisation exchange, and the cost to a single organisation of sending or receiving data via several different types of media.

b) Machine
Incompatibilities of record size and character representation between different makes of computer are avoided. No reprogramming costs need be incurred by existing members of an interchange application when a new member, who has a different make of computer joins.

c) System independence
The rules are not influenced by the constraints of any particular system design, such as batch, on-line, file/record design or retrieval techniques, communications techniques, etc.

d) Flexibility
The rules allow a great deal of flexibility in the design and structuring of messages. Changing message specifications should be less costly with data structured using the syntax rules than with conventional records. Using table-driven programs makes changes particularly easy to effect.

e) Efficiency
The rules allow data to be transmitted in an economical manner. This can be important over telecommunications links.

f) Intelligibility
By using special character data separators and alpha segment codes the syntax rules make messages relatively easy to interpret, and thus aid tasks such as investigating errors. (Fenton 1989)
It should be noted that the majority of EDI standards require a low level compatibility between systems, which is the use of the 7 bit representation of characters as defined by the ASCII system.

2.7.2 Categorisation of EDI standards
EDI standards can be divided in two groups, those for commercial information and those for graphical and technical information. The following sections describes the EDI standards which are commonly used today and presents these standards in one of the two groupings defined above.

2.8 Commercial standards

2.8.1 Basic components of a commercial standard
EDI standards consist of a number of components which are the 'information building blocks'. These components range from the smallest constituent particles to the complete 'envelope' structures which enable electronic communications.

The basic components of an EDI standard are detailed below.

(a) Data elements - the smallest individual item of information, from which segments are built.
(b) Data segments - a grouping of related data elements which form a single 'object' or 'entity'. These are the building blocks of EDI messages.
(c) Message - A group of segments structured to model a particular business transaction.
(d) Functional group - A group of messages of the same type.
(e) Interchange - A complete EDI transfer, consisting of an 'envelope' which contains any number of messages and functional groups.
(f) Syntax rules - The 'grammar' which is used in the structuring of data elements and segments into meaningful messages.
2.8.2 The evolution of commercial standards

EDI was first developed by users in groups representing their various industries (e.g., purchasing, transportation and financial applications) (Fisher 1991). Each group defined a set of data format conventions, which permitted the free flow of data between parties in their industry. For example the WINS (warehouse industry standards), UCS (grocery and related industry) and TDCC (transportation data coordinating system) standards which are utilised in the USA.

However, many companies do not confine their trading to their own industry, for example a building contractor will deal with suppliers from many industries. These companies which do not trade within a specific industry, but on a pan-industry level, had to adopt a number of standards to trade with all their partners. The need to trade on a pan-industry level led to the gradual development of generic EDI standards which could cater for a number of industries (Fisher 1991). Two major proponents of EDI emerged, the American Standards Institute who developed ANSI X12 and Sitpro, the UK's simpler trade procedures board, who originally developed the UN/TDI syntax rules.

2.8.3 ANSI X12

The history of ANSI X12

In 1968 Ed Guilbert formed the Transportation Data Coordinating Committee. The objective of this committee was to "convince business executives that it is better to do business via computer than on paper". The TDCC established four ground rules, which are still valid for EDI:

- it must provide generalised interface data standards and formats that will be responsive to users' needs for inter company computer-to-computer transactions;
- interface capability must be insensitive to internal computer equipment and programs of the interchange parties;
- EDI should leave to the using parties the selection of the option of communication speeds and services; and
- it should have a capability of providing documents, when required, as a by-product of integrated database transactions.

(Schatz 1988)

The TDCC set about convincing industry to apply the rules it developed. Task forces were formed of shipper and rail, shipper and motor, shippers/forwarders and ocean carriers, shippers/forwarders and airlines, shippers/carriers and banks. These task forces devised common coding between
industries to make electronic trading possible. The first EDI documentation was published in 1975 by the TDCC for Rail Transportation Industry Applications (Anonymous 1995).

In the 1960's other industry groups initiated the development of EDI standards for purchasing, transport and finance (DISA 1993). The early EDI standards were developed by user groups within industries, hence the standards produced could only support data exchange within their native industry (Fisher 1991). However, a few, including those developed by the TDCC, were industry independent.

The sectoral initiatives flourished creating a situation of incompatibility between user groups. This situation highlighted the benefits of standards which are not industry specific. To facilitate a common means of communication between these user groups the Accredited Standards committee (ASC) X12 of the American National Standards Institute was formed. The objective of the committee was to develop a national generic standard. This standard has become known as ANSI X12. In the late 1970's ASC X12 began the development of it's first national standard for electronic data interchange (Fisher 1991). The first ANSI X12 message standard was published in 1981, by 1983 there were five standards, by 1989 this had risen to 32 standards and by 1992 there were 168 draft standards for trial use, with over 100 under development (Ovum 1990)(DISA 1993). These standards include most of the standards required by the transportation and retail industries.

The ANSI X12 standard

In North America the ANSI X12 standard, developed by the American National Standards Institute, has been widely adopted.

The X12 standard is actually made up of four parts: the X12.3 data element directory; the ANSI X12.5 interchange control structures, the EDI equivalent to an 'envelope'; the X12.6 application control structures, or the formal description of the EDI architecture; and the X12.2 segment directory, which defines segments (Fisher 1991).

Example ANSI X12 message standards are listed below.

- Invoice
- Request for quotation
- Response for request for quotation
- Planning schedule/release
The DISA (Data Interchange Standards Association) have been selected by ANSI as the nonprofit making secretariat to oversee the daily business activities of ANSI ASC 12. However, the development and updating of messages is undertaken by the 10 ANSI X12 sub committees which have the following areas of concern:

X12C - Communications and control;
X12D - Education and implementation;
X12E - Product data;
X12F - Finance;
X12G - Government;
X12H - Materials management;
X12I - Transportation;
X12J - Technical assessment; and
X12K - Industry standards transition.

2.8.4 UN/TDI

History of UN/TDI
In 1976 SITPRO was formed to develop a generic syntax required to affect trade data interchange in the European market (Mills 1989).

In 1978 Sitpro published a document called “Computers in International Trade and Transport” which detailed a system of syntax rules. These rules were adopted by the United Nations and became UN/TDI (United Nations guidelines for Trade Data Interchange) (VANGUARD 1989).
UN/TDI standards
The UN/TDI syntax rules form the basis on which most European EDI user communities have built their message standards, sometimes in conjunction with the UN/TDED (United Nations Trade Data Element Dictionary) which was published in the late 1970's.

UN/TDI based standards include:

- DACOM, Sweden, 130 users;
- GENCOD, France, 50 users;
- SEDAS, Germany, 300 users;
- TRANSCOM, Holland, 70 users;
- TRADACOMS, UK, 2000 users; and
- ODETTIE, Automotive industry, 800 users.

Tradacoms and Odette are probably the two major European standards based on the UN/TDI syntax (Ovum 1990).

Tradacoms
The Tradacoms (Trading Data Communications) standard was developed by the ANA (Article Numbering Association) in response to UK user demand for an electronic data exchange standard that can convey a range of common commercial transactions.

The ANA was considered the ideal base for the development of an EDI standard as it was experienced with standard product numbering, having developed the EAN coding system, and comprising a membership of over 6000 companies from a wide range of trades and industries. The link between coding and EDI that the ANA provided was considered to be very important, since ultimately in order to have an electronic message which can be automatically processed, descriptions have to be replaced by codes.

The pressure for rapid results was great while the standard was under development. This caused the scope of the multi-industry standard to be limited to national trade. "It was felt that the threat of imposition of unilaterally developed standards made it unwise to attempt the complex job of defining and reconciling distinctive features of the various national economies" (VANGUARD 1989).
Established in 1980, TRADACOMS includes a wide range of messages, and is used by over 2000 companies throughout industry and commerce (Naughton 1990). Examples of Tradacoms messages are listed below.

- Orders (Simple and Complex)
- Picking Instructions
- Delivery Notification
- Delivery Confirmation
- Invoices
- Credit Notes
- Statement/Remittance Advice
- Stock Snapshots
- Stock Adjustments
- Availability Reports

The widespread use of the Tradacoms standard can be attributed to the following factors.

- It was the first standard available in the UK.
- The very strong user demand for an electronic data exchange standard when it was launched.
- The standards allow the use of EAN codes.
- The standards are simple as they are only relevant to UK trade.
- The standards are widely advertised and properly supported by the ANA.

Odette

In contrast to the multi-industry national nature of the Tradacoms standards the Odette (Organisation for Data Exchange by Tele-Transmission in Europe) standards were developed for a single industry for international trade.

Odette was produced by a grouping of European automobile manufacturers and suppliers for the automotive industry. The users of Odette, in Europe, include the major car manufacturers FIAT and General Motors. However, many of the suppliers to the automotive industry also supply many other manufacturing companies, which has led to the adoption of the standard by the manufacturing industry. The European acceptance of the standard, in particular the invoice message, makes Odette
attractive to other industries who wish to trade internationally. The process and energy industries have adopted the standard for this reason.

2.8.5 Harmonisation of message standards
To facilitate trade on a global basis a common standard should be adopted. This was recognised by the United Nations. On November 21, 1985 the United Nations formed JEDI (Joint Electronic Data Interchange) which was a group consisting of both American and European EDI experts. The purpose of JEDI was to facilitate the building of EDI standards which would be valid for trade across international boundaries. However, in practical terms the objective was to bridge the differences between the UN/TDI and ANSI X12 standards (Fenton 1989).

The JEDI project received full support from the European Commission at the first full meeting of both the American and European groups, which has held in March 1986. Work on a new syntax commenced in June 1986. The new syntax was given the acronym of EDIFACT (Electronic Data Interchange For Administration Commerce and Transport).

2.8.6 EDIFACT
The EDIFACT syntax rules are based upon ANSI X12 and UN/TDI. This was considered the most suitable method of achieving the objective of bridging the differences between these earlier standards. Hence, EDIFACT is a superset of ANSI X12 and UN/TDI (VANGUARD 1988). The use of a syntax system which incorporates features common to existing syntax systems creates an exchange standard which is recognisable to current users, and hence more easily acceptable.

In March 1987 UN/ECE approved the EDIFACT syntax approximately 18 months after development commenced. They also appointed three regional boards to develop organisational support. The regional boards formed were for: North America; western Europe; and eastern Europe. The number of regional boards had expanded to five by 1992 (Sitpro 1993a), and currently there are six regional EDIFACT boards for: Africa; Asia; Australia/New Zealand; central and eastern Europe; North and South America; and western Europe (Anonymous 1995).

The EDIFACT syntax was adopted by the International Standards Organisation (ISO) in September 1987 and is referred to as ISO 9735. The EDIFACT syntax has been adopted by a number of international organisations including: CEN (The European Community standards body); the United Nations; and the European Union.
Nations; the EEC; and Odette. The standards are also supported by the American national standards institute and the Article Numbering Association, of the UK.

The production of EDIFACT messages commenced in 1987 and the first message, the invoice, was approved in the September of the same year. The number of EDIFACT message continues to grow, indicating the increasing support of the standard. In 1995 there were 101 EDIFACT messages at status 1 or above (UN 1995), this had risen to 125 messages by 1996 (UN 1996) and then risen again to 161 messages by the end of 1997 (UN 1997).

Examples of EDIFACT messages currently available are listed below.

- Invoice
- Purchase order
- Credit advice
- Debit advice
- Arrival advice
- Payment order
- Customs cargo message
- Customs declaration message
- Booking confirmation

The EDIFACT syntax has been adopted for the development of EDI messages by a number of industries including: Customs (on a worldwide basis); banking and insurance; transport; tourism; and construction (VANGUARD 1989).

**UN support of EDIFACT**

The United Nations support EDIFACT by means of the trade facilitation working party which coordinates the updating and development of messages throughout the world. The structure of the EDIFACT organisation and how it relates to the United Nations is shown in figure 2.3. The local rapporteur for the UK is that of the Western European EDIFACT board. The Western European EDIFACT board consists of three categories of working group; support groups, message development groups and special interest groups.
The support groups include the following:

- Awareness;
- Codes;
- Procedures and documentation;
- Technical assessment and Maintenance.

Message development groups exist for each industrial sector including transport, finance, construction, insurance etc.

The special interest groups are concerned with areas not covered by the first two groups, but are still regarded as significant to the development of EDIFACT. These areas include information modelling, UNSM, United Nations Standard Message, user implementation guidelines and security (SITPRO 1993a).

To enable the work of the support, message development and special interest groups the EDIFACT board liaises with standards bodies, trade associations and industry.

**The adoption of EDIFACT**

The United States and the United Kingdom agreed to harmonise their national standards (ANSI X12 and Tradacoms, a UN/TFI based standard, respectively) with EDIFACT. This does not mean X12 and Tradacoms will be dispensed with, rather the three standards will co-exist with increasing levels of compatibility between them (Donington 1990).

However, the adoption of EDIFACT is not proven successful merely by it's selection by the organisations which developed and support the earlier EDI standards. The success of any EDI standard is dependent on it's adoption by trading companies.

The selection of an EDI standard by a company which is new to EDI is not made freely but is determined by the user groups with which the company wishes to electronically trade. Many existing user groups have adopted national standards, such as Tradacoms and ANSI X12, therefore new companies joining these groups will adopt the relevant standard. This will create an inertia which will maintain the use of ANSI X12 and Tradacoms for several years.

Many user groups are now recognising the need for international trade within their industry and have therefore adopted an international standard. An example of this is provided by Odette which
has produced a set of messages that are suitable for international trade. These messages are utilised by both motor and manufacturing industries for trade in Europe (see section 2.8.4).

**Figure 2.3 - United Nations EDIFACT structure**
As the ODETTE messages have proven popular in the manufacturing industry it follows that EDIFACT, which will provide a recognised set of international trade messages, will be equally popular. However, EDIFACT will have the advantage of being suitable for pan-industry trade.

To achieve the widespread adoption of EDIFACT two obstacles need to be overcome:

a) the lack of awareness of EDIFACT; and

b) the lack of suitable messages for each industrial sector.

To help overcome these problems the TEDIS project was initiated. The TEDIS project, which was financed by the EU, worked in conjunction with the western European EDIFACT board to promote EDIFACT in a number of industrial sectors. TEDIS also assisted the work of the message development groups of the western European EDIFACT board. TEDIS funded projects to aid the development of messages in the following sectors: trade; transport; finance; construction; tourism; insurance; statistics; health care; social administration and employment (TEDIS 1993).

It is not expected that the EDIFACT standards or syntax will supersede standards based on UN/UNTDI or ANSI X12, which have a large, established and growing user base. Nevertheless, there is growing support for the evolution of EDIFACT standards as the ultimate solution for international EDI.

2.8.7 Migration from UN/UNTDI and ANSI X12 standards to EDIFACT

The main objective of EDIFACT is to standardise the electronic transfer of commercial data on an international basis. To achieve this objective all companies which have existing EDI systems will have to migrate from their existing standards to the EDIFACT standard.

The need for migration from existing standards was recognised at the outset of the JEDI project, and in order to aid this process EDIFACT was based upon the most popular existing standards, ANSI X12 and UN/UNTDI.

Migration support

To facilitate the process of migration, advice is available from a number of organisations. These include the UN/EDIFACT local rapporteur (see figure 2.3), SITPRO (the simpler trade procedures board) and TEDIS (1993).
The United Nations state, in section 11 of the UN/EDIFACT Syntax Implementation Guidelines, that users seeking advice on migration to UN/EDIFACT from any other interchange standard should refer to their local EDIFACT Rapporteur's Advisory Team (RT).

However, Sitpro have published migration guidelines in their EDIFACT service manual, these were developed by the RT for the European Union and EFTA countries. This document relates specifically to the migration from UN/ECE Trade Data Interchange syntax and its related message structuring requirements, to the syntax and message structuring of EDIFACT. Migration support forms part of the TEDIS programme. The TEDIS programme recognises that many companies will have invested heavily in their own standards, so provides financial support in addition to advice to assist the migration to the EDIFACT standard (Parfett 1993).

**Halt of migration to EDIFACT in USA**

Donington's view (1990) of the coexistence of standards rather than replacement has proven to be true in the USA. The scale of investment in the ANSI X.12 standard has resulted in a vote to halt the migration to EDIFACT indefinitely in the USA. The ANSI X.12 and EDIFACT standards are both to be utilised and adopted as national standards in the USA (Fitch 1995)(Electronic Trader 1995).

2.8.8 **Comparison of commercial data exchange standards**

(a) Tradacoms and Odette - The European viewpoint

The advantages of Tradacoms and Odette are:
- they are well established;
- a wide range of messages is available;
- Tradacoms can prepare and agree messages in a matter of months;
- straightforward standards manuals; and
- widely used, especially Tradacoms.

(Naughton 1990)

(b) ANSI X12 - The American viewpoint

The advantages of ANSI X12 are:
- it is widely established in a large proportion of American industries; and
- a wide range of messages are available.
The advantages and disadvantages of EDIFACT remain unchanged regardless of your viewpoint. The points below therefore refer both to the European and American viewpoints.

The advantages of EDIFACT are:
• it is designed for international trade;
• it is totally non-proprietary;
• the generic rules of EDIFACT will allow any type of message to be created or information to be contained in that message; and
• EDIFACT standards and messages are guaranteed not to be superseded. The amount of time and effort being expended to arrive at international agreements ensures good results.

The disadvantages of EDIFACT are:
• it is not as well established, with few users having practical experience; and
• the agreement of some messages is proceeding slowly.

(Naughton 1990)

The disadvantages of EDIFACT will diminish with time as it becomes more widely adopted. The first indications of a broadening in acceptance of the EDIFACT standard have been shown by the ANA and Odette who are now involved in development of messages which conform to the EDIFACT syntax.

2.8.9 CITE (Construction Industry Trading Electronically) initiative

CITE is a collaborative electronic trading initiative for the UK construction industry. CITE provides both common standards for the exchange of data and practical support for the implementation of electronic exchange (CITE 1997).

The CITE Initiative was established in 1994 and formally launched in April 1995. The initiative was formed by companies from three sectors of the construction industry: 8 UK contractors; 7 material suppliers; and 5 quantity surveyors. The number of members increased from the 20 founding members to 50 by 1995 (Watson 1995), many of which are also members of EDICON.
CITE objectives

The initiative was founded on three objectives (Adcock 1996):

- to achieve operational use of electronic data exchange within the construction industry;
- to act together to secure the benefits; and
- to enable all companies, regardless of their size or data exchange experience to become involved.

The approach of the CITE initiative is fundamentally different to that of EDICON, in that that CITE has a more pragmatic attitude to electronic data exchange. The key CITE objective is to secure the benefits of electronic data exchange in the construction industry. To this end CITE provides practical support to assist companies in achieving electronic data exchange whereas EDICON merely provided a method of trading electronically using EDIFACT, with little practical assistance.

CITE has formulated standards for the transfer of Invoices and Bills of Quantities. The Invoice message being based upon the EDIFACT 1992 INVOICE message, whilst the Bill of Quantities message is a column structured ASCII file representation of a Bill (Adcock 1996). These diverse solutions to each message indicate the pragmatic approach of CITE. The EDIFACT Invoice message is simple and hence easy to implement, whereas the EDIFACT Bill of Quantities suite of messages are more complicated and do not lend themselves to integration with existing software.

CITE has collaborated with software houses to assist the development of interfaces that comply with these standards. Interlock, a software company, has made software available at low cost, which allows companies to create, read and manipulate electronic bills produced in the simple CITE format.

Collaboration with EDICON

The work of CITE has been interpreted as a new community spirit to promote electronic trading in construction instead of the traditional “big stick” approach where a dominant party drives adoption (FT 1995). This may be due to the lack of dominant parties in the industry, therefore CITE was born out of the need for an alternative approach. The concept of a community spirit has been realised also in the collaboration between CITE and EDICON, the first joint annual conference between EDICON and CITE was held in 1997 (EDICON 1997). This co-operation also confirms EDICON’s view of supporting all electronic trading standards in the industry, regardless of the fact
that the CITE group shunned the EDIFACT messages developed for bill of quantity information developed by EDICON (Baldwin et al 1995b).

Success of CITE
The success of the CITE initiative is measured by the accomplishment of its objectives. The key objective of CITE is to achieve the operational use of electronic data exchange in the construction industry. The use of the CITE bill of quantities messages was reported in a questionnaire survey undertaken by Akintoye (1997), where only 2 out of the 26 contractors who responded used the standard. This survey indicated that CITE has not provided the solution to electronic data exchange in construction. This view has been affirmed by a recent CITE initiative presentation where only 4 out of the 40 attendees, all of whom were interested in CITE, actually used the standard (Watson 1998). One of the four users, a representative of a quantity surveying practice, admitted that whilst they supply bills of quantities in electronic format they are all returned as a paper document.

Future of CITE
CITE has provided a practical means of exchanging certain construction information electronically. However, the group has failed to maintain the momentum of message development achieved during the first two years of the formation of CITE. If the CITE initiative does not provide messages for the exchange of the majority of construction information it will not be able to provide a means of integrating the key information tasks in the construction process. This is essential to maximise the benefit of electronic exchange technologies. Also, without the commitment to produce a comprehensive message set for construction information it is questionable whether the initiative can meet the electronic data exchange requirements of the industry.

2.8.10 Selection of a commercial standard for the UK construction industry
Information flows used in the construction industry can be placed in one of two categories: trading cycle; or project cycle information. Trading cycle information flows are those which are required to undertake the trading process, i.e. the purchasing/selling of goods. Project cycle information flows are those which contain data specific to the construction project or facilitate the construction process, these include all flows excluding the trading cycle flows. The trading cycle and project cycle are described further in chapter 5. The commercial standard selected for the industry must be suitable for supporting both these types of data flow.

EDICON as an organisation has adopted EDIFACT as the exchange standard it promotes for use within construction companies. Any construction company planning to use EDI in the UK should
join the EDICON group as it provides not only support for several EDIFACT and CITE messages but also an invaluable number of contacts who have experience in using and implementing EDI through its affiliation with the Electronic Commerce Association (ECA) a pan industry EDI group.

The use of Tradacoms remains greater than that of EDIFACT in the UK, 84% of EDI trading companies compared with 32% (Barry 1995). However, the EDIFACT standard is best suited for EDI applications in the construction industry because of the following.

- EDICON and EDIBUILD support EDIFACT.
- Currently there are a complete set of trading cycle, and a few project cycle messages available in EDIFACT.
- The increase in international trade will require an international electronic trading standard.
- EDIFACT is enjoying a continuing increase in support (UN 1995; UN 1996; UN 1997).

2.9 Technical data exchange standards

Computer aided design (CAD) has always taken advantage of the most advanced computer developments, with many packages available to designers on various hardware platforms. The diversity of platforms created an environment of systems with incompatible file formats, which resulted in drawing transfer only being possible between identical systems. This shortfall was quickly recognised and led to the development of data exchange standards for graphical information, examples of which include IGES, DXF and SET.

The graphic exchange standards proved to be suitable for the transfer of CAD drawings. However, these standards are limited to transferring graphical data with limited annotation. As computer systems become more deeply involved in the design process, the need is increasingly for data exchange that is able to convey a complete set of design information which relates to the drawings. The transfer of a complete set of design information is not possible using traditional CAD data exchange standards. This shortfall has led to the concept of product models and product model transfer protocols.

“A product model is a formal description of an engineering artifact that is independent of a specific representation and is able to support the information needs of a range of engineering activities.” (Watson 1990)
A product model would be created during the design process of the product and would constitute a detailed and on-going specification for the life cycle of the product.

2.9.1 Graphical data exchange standards

Graphic exchange standards have been developed on a national, international and application specific basis. The applications specific standards cannot be described as neutral formats, however, the use of such standards is beneficial in many cases. These standards therefore warrant consideration when a data exchange standard is being selected.

Both neutral and application specific graphic data exchange standards are described in detail in the following section.

IGES

IGES (Initial Graphics Exchange Specification) was the first standard neutral format for storing the data generated by CAD systems (Anonymous 1997).

IGES has gained worldwide acclaim as the most popular method of transferring Computer Aided Design (CAD) data between systems. (Mayer 1987) IGES was developed in 1979 under the leadership of the National Bureau of Standards (NBS), in the USA, whose objective was to facilitate the transfer of product definition data between different CAD systems.

Version 1.0 of IGES was published in 1980, as part of an ANSI standard. It provided entities able to convey graphical two and three dimensional information and supported limited annotation, including standard dimensioning. IGES 1.0 does not provide a means for transferring complete information about 3-D solid models. Transfer is by means of ASCII files in 80 character records.

An expanding community of IGES researchers emerged whose work resulted in the publishing of Version 2.0 in 1982. The modifications and additions to version 1.0 included:

- Finite element data modelling;
- electronic printed wiring board product data;
- and binary file format (resulting in smaller files).
Version 3.0 was launched in April 1986. The modifications and additions to version 2.0 included (Owen 1987):

- a mechanism for further reducing the file size called "Compressed ASCII";
- external file referencing mechanism to store libraries of standard symbols and components; and
- extended finite element modelling capabilities.

Version 4 was launched in 1988, and was the first version to incorporate solid model descriptions by the use of constructive solid geometry (CSG).

Version 5 is the latest version of IGES, and incorporates another form of solid model description known as boundary representation (Kroszynski et al 1989).

**Disadvantages of IGES**

The five versions of IGES have created a "non-standard" standard, as one company who has adopted the IGES 1.0 standard will not be able to directly communicate with a company which has adopted the IGES 4.0 standard. The compatibility of the various versions of IGES is hindered by the three different methods of data encoding; 80 character ASCII, binary file format and compressed ASCII.

The major problem with IGES, however, is that CAD vendors have been selective with their implementation of the standard. This has resulted in creation of many translators that do not support all the entities defined in a particular version of the standard (Watson 1990).

Data transfer between two new IGES systems does not work immediately, there is a period of debugging required. However, the problems encountered are well known to the vendors, who supply the CAD systems, resulting in short debugging periods.

In spite of these problems IGES remains the most widely adopted neutral file data exchange standard, with over 30 CAD vendors supporting the standard by 1987 (Mayer 1987) and every high end CAD vendor supporting the IGES standards by 1994 (Curran 1994). However STEP is now increasing in popularity (Baumgartner 1998). Also IGES to STEP translators have been developed, using application protocol 202 as the destination standard (see section 2.9.2), to ease
the migration between the two standards (Bhandarkar et al. 1997). These factors indicate that the IGES standard does not have a long term future.

**VDA-FS**

VDA-FS (Verband des Automobilindustrie Flachen-Schnittstelle) is a method of transferring free-form surface data used by the members of the Associations of German Car Manufacturers. This standard only deals with essential elements allowing a simple interface, thus permitting the transition to national and international standards.

VDA-FS 1.0 is supported by several CAD vendors and has become a national standard in Germany. VDA-FS 2.0 has been developed further to include topology and neighbourhood relationships.

**PDDI**

PDDI (Product Definition Data Interface) is a research project funded by the United States Air Force ICAM Project. It has a similar specification to IGES, but also includes more manufacturing information, such as machined, turned and sheet metal features, tolerances, geometric tolerances and datum positions. It was the first specification to mention “product data”.

**CAD*I**

This European Esprit project was initiated in 1984 and defines a specification for the transfer of surface, solid and finite element modelling data. The results of this work have been channelled into the development of STEP.

**SET**

SET (STandard d'Echange et de Transfert) was developed by Aerospatiale in France, with file structure and size as primary considerations. It was used to transfer data between companies during the European Airbus project, and gained momentum from other companies such as Renault and Peugeot (Owen 1987).

**DXF (a non-neutral file format)**

AutoCAD has become the predominant CAD system in the UK construction industry with 4960 companies using the system in 1991. The number of users is still growing, this is shown by the 48% increase in users between 1990 and 1991. The standard has also proven successful on a wider scale with 118 000 users in Europe and 400 000 worldwide (CICA 1991).
AutoCAD supports its own data exchange format which is known as DXF (Data Exchange Format). Owing to the popularity of AutoCAD and the lack of more predominant standards, DXF has become a de facto exchange standard in the UK and is recommended by the National Economic Development Office (NEDO) (Howard 1991). Many other CAD systems have been equipped with DXF translators in order to allow the exchange of data with AutoCAD systems, these include ANSYS, INTERGRAPH, MEDUSA and MOSS. This popularity has led to the standard being the de-facto standard for all PC based CAD data exchange (Curran 1994).

Technically DXF is limited to the entities supported by AutoCAD, which can lead to the loss of data when translating from other systems which support different entities. In addition, Howard (1991) states that DXF is only effective for two-dimensional unstructured data. Despite these limitations DXF has been widely adopted in the UK construction industry, this is largely due to the widespread adoption of AutoCAD in the industry. The large DXF user base has forced suppliers of other CAD platforms to provide fully compatible systems, thus overcoming the majority of incompatibility difficulties.

2.9.2 Product modelling standards

After the introduction of computer applications in order to support the process of design, production and maintenance of products, it was soon realised that different applications were not able to exchange data. This was even worse for applications dealing with the same product but describing different aspects, for example a geometrical description and a finite element description.

The inefficiency of this situation led to the consideration of a complete, neutral and standardised description of a product, a product model, which would enable all technical applications to exchange meaningful information with each other.

The development of the current product data exchange initiatives evolved from the earlier graphic data exchange initiatives, this is shown in figure 2.4 (Watson 1990).

PDES (Product Data Exchange Specification)
PDES is an American initiative undertaken by the NBS (National Bureau of Standards) the objective of which is to develop a neutral exchange medium capable of completely representing product data (Wix and McClelland 1986).
The objectives of PDES can be summarised as (Wilson 1987):

- establish a definition of what information constitutes a complete computer-interpretable definition of a product;
- gain acceptance of the information definition in a standard specification; and
- accelerate implementation of technologies pertinent to the delivery and interpretation of such product definition information in a heterogeneous computer environment.

It is evident that PDES and the ISO STEP standard are striving for the same objective. It is also apparent that to have two exchange formats defeats the whole objective of a standard. This has been recognised and the PDES group are now working in accordance with STEP. While the combined initiative is known as STEP it is still referred to as PDES in the USA.
The PDES project now has the function of supporting the development and implementation of STEP while ensuring the requirements of US industry are incorporated into STEP (King and Norman 1992).

STEP (Standard for Exchange of Product data)
The principal objective of the STEP development initiative is identified as the “creation of a standard that enables the capture of information comprising a computerised product model in a neutral form without loss of completeness and integrity throughout the life cycle of the product” (Wix 1989).

STEP was initiated in 1984 by ISO (International Standards Organisation) and is guided by sub committee TC184/SC4. The STEP standard is referred to as ISO 10303. Within ten years of the start of the initiative approximately 12 of the standards parts had been adopted by ISO as draft international standards (Curran 1994).

As well as the overall goal, there is a series of individual goals for STEP indicated in the preliminary design document (Wix 1989).

- **Exchange completeness**
STEP must be able to handle 100% of product data generated from the user point of view and the data should be able to be read into any other system which supports STEP without loss of data.

- **Archiving**
There must be no loss of completeness or integrity of data over time.

- **Extensibility**
It must be possible to add further extensions to STEP without invalidating previous implementations.

- **Testability**
All additions or modifications to STEP must be tested before acceptance.

- **Efficiency**
The facilities within STEP and the file structure must as efficient as possible for processing communication and data storage.

- **Compatibility**
STEP must be developed to be compatible with other relevant standards and facilities to migrate from representations in other specifications (eg. IGES) will be provided.
• **Minimum entity set**

The intention is to make the size of the common entity set within STEP as small as possible and to avoid uncontrolled extensions to the standard.

• **User definition**

There will be a mechanism for user-defined temporary additions to STEP.

• **Computer independence**

The STEP data exchange file is intended to be independent of any specific computer function, eg. programming language, operating system, hardware, etc.

• **Subsets**

Recognising that it is unlikely that no single system will support the full STEP standard, it is intended that well defined subsets or implementation levels will form part of the standard.

### Technical aspects of STEP

In order to understand STEP some knowledge of product models is required. A product model may be regarded as a representation of a real structure or object, for example a building or a bridge, in a manner which allows its characteristics to be observed without having to build it (Wix 1989). In CAD, a computerised product model is used, in place of current paper drawings and scaled down models. The data describing the product may be continuously updated, accessed and exchanged by organisations undertaking product maintenance. Even demolition may require access to a product model, particularly for potentially dangerous structures such as nuclear reactors. This concept is important in construction applications where long life cycles exist.

Figure 2.5 illustrates the technologies employed in STEP. These technologies can be related to three levels: application; logical; and physical.

**Application level**

At the application level, specific data models are developed which are applicable to particular segments of industry. Formal data modelling techniques are used (either IDEF1X or NIAM) to identify the data entities and their relationships. Both techniques are graphically based, making the models accessible to practising engineers.

**Logical level**

At the logical level, the component models created at the application level are converted into EXPRESS. The converted component models are then merged to form the integrated product model, also known as the unified model. EXPRESS is the data definition language which is used
for formalising the standard. The definition of EXPRESS is itself a part of the standard. EXPRESS has a model which is quite close to a frame. One object can, for instance, be an attribute to another object, which can lead to nested class definitions (Bjork 1991).

**Physical level**
The integrated product model that is represented in EXPRESS is finally used to generate the specification for the STEP exchange file format, which is the physical interpretation of the unified model. Watson explained how the EXPRESS definition of the unified model could be used to create STEP translators.

"it also provides the input to PARSERS, which can be used to build the STEP translators needed at the physical level to export and import STEP files between particular CAD systems" (Watson 1990).

![Figure 2.5 - The Technologies Employed in STEP](image-url)
Application Protocols
The application protocols available are the tangible product of the work of the STEP initiative. An application protocol is a unique set of entities chosen for a specific product, process, or industry. For example, application protocols have been tailored to the automotive, aerospace, and shipbuilding industries. As the standards become more mature and more features are supported, the population of products that can be covered with this approach will increase significantly (Qiao 1993). The commercial implementation of the application protocols is therefore essential to the success of STEP.

The first application protocols to be supported by CAD products are: AP203, configuration control of 3D designs; and AP214, Core Data for Automotive Mechanical Design Processes. Other application protocols which are approaching the stability required to be incorporated in a commercial product include:

- AP202 Associative Drafting;
- AP210 Design and Manufacturing of Printed-Circuit Assemblies;
- AP209 Composite and Metallic Structural Analysis & Related Design;
- AP215 Ship Arrangement;
- AP216 Ship Model Forms;
- AP217 Ship Piping;
- AP218 Ship Structures;
- AP221 Functional Data & Schematic Representation for Process Plants; and
- AP227 Plant Spatial Configuration.
(Mattei 1995; Baumgartner 1998).

The support of these application protocols has spread and now includes a number of major CAD/CAM suppliers. The following vendors support both the AP203 and AP214 application protocols: Ansys; Autodesk; Camax; Computervision; Dassault Systems; EDS/Unigraphics; Intergraph; and Parametric Technology Corporation (Mattei 1995). The support of these vendors means that STEP translators can be used on the majority of hardware platforms including: Hewlett-Packard, Sun, Silicon Graphics, RS/6000, 32-bit Intel, DEC Alpha and DEC VMS platforms (Baumgartner 1998).
Application of STEP in construction

Application of the STEP standard occurred during the mid 1990s. A number of initiatives have succeeded in utilising the technology or proposing means of utilising the technology to achieve benefit in both manufacturing and construction processes. These initiatives include International Alliance for Interoperability (IAI) (Zelly 1996), CIM-Steel (CIM-Steel 1997) and the VEGA project (Debras et al 1997). IAI is an on-going initiative that seeks to utilise STEP as a means of integrating construction industry information tasks, VEGA is a short-term project to integrate construction information, whilst CIM-steel utilises STEP to integrate the manufacturing of steel components with construction projects. The CIM-Steel project whilst having a less esoteric objective, has been implemented, unlike IAI which is still merely an initiative to determine means of applying the technology. All three initiatives are described in more detail in chapter 4.

2.9.3 Selection of a technical data exchange standard for the construction industry

The STEP concept of product modelling provides a sound solution for the technical data exchange requirements of the industry. This theoretical strength is now being supported by the IAI initiative through application of the technology. The VEGA and CIM-Steel projects also utilise STEP technology. These projects indicate that STEP will be fundamental in the integration of information tasks in the construction process.

These initiatives are yet to be implemented throughout the industry. In the meantime existing graphic exchange standards should be considered for use by construction organisations. The two predominant exchange standards in the UK are IGES and DXF.

The IGES standard, while being the most popular neutral format, is not widely used in the construction industry. This is largely because of the predominance of AutoCAD within the industry, which has led to the adoption of DXF as a de-facto standard. This standard is supported by a large number of CAD systems, other than its parent AutoCAD system. IGES is also supported by a number of CAD systems. However, IGES has been implemented with varying levels of completeness by CAD vendors, resulting in a situation where it is necessary to de-bug translation software when dealing with another system using IGES.

The National Economic Development Council endorsed the DXF standard for the transfer of 2-D CAD drawings. The recognition of DXF as a standard, it's popularity and ease of implementation suggest that the DXF standard is currently the best suited to the UK construction industry.
2.10 Summary

The following conclusions were drawn from a brief investigation of EDI:

- the key concept in all definitions of EDI is that of a standard information structure, which allows the automatic processing of the data transferred;
- for simplicity, only the terms EDI and electronic data exchange would be used in this research; and
- EDI can provide a number of tangible and non-tangible benefits, making the overall benefit difficult to quantify.

The technical components required to undertake EDI are well defined. There are also a number of options available for each component to suit the application of EDI, depending on the scale of the system, the number of trading partners, the volume of data exchanged and the security required. The importance of EDI standards and message formats, is central to EDI adoption. The development of standards for commercial and technical data exchange is shown in figure 2.6.

Electronic drawing exchange is common with many companies transferring drawings on disk using the DXF standard. This standard has been adopted by the UK construction industry, thus virtually excluding all other graphical exchange standards from practical use. Other standards including the more comprehensive neutral drawing exchange standard IGES, are perceived as having little or no advantages over the DXF standard and therefore no initiative has arisen for their adoption. The future of technical data exchange is with the STEP standards which will provide a true international pan-industry method of technical data transfer. However, the STEP projects currently underway do not yet provide a practical solution to construction technical data exchange. Also many of these projects require the re-engineering of information tasks, such change is always slow to be adopted in the industry. In the meantime the DXF standard provides the best solution to graphical data exchange for the UK construction industry.

The adoption of electronic data exchange for commercial data is being championed by the EDICON group. The EDICON group has adopted the EDIFACT standard and recommends it's adoption by construction related companies. EDICON has published message manuals for trading cycle messages (eg. purchase order, invoice, etc.) and continues to develop messages particular to the construction industry (eg. bill of quantities).
EDIFACT's advantage over existing data exchange standards is that it is suitable for international trade and is truly generic, thus allowing any type of message to be created for any country. EDIFACT also has the benefit of being supported by the United Nations.

Due to well established user groups, existing data exchange standards will remain for some time. However, EDIFACT is the first international pan-industry standard, and has been adopted by many national and international organisations. The adoption of EDIFACT by EDICON and EDIBUILD, the UK and European construction EDI groups, necessitates its selection for EDI message design in the construction industry.

It is interesting to note that the solution accepted by industry for drawing exchange was DXF is a simple readily available standard, which are the same qualities possessed by the standards currently being championed by the CITE initiative. It appears that the "technically correct" standards, i.e. generic, have as yet proven to be too complicated to be accepted by the construction industry.
Chapter 3
Business and legal impact of EDI

3.1 Introduction

Electronic data interchange is a technology which provides an alternative method of transferring information to traditional paper documents. The use of a different medium to transfer information impacts on the business processes that utilise the information and the legal status of the information transferred.

EDI impacts on business in two ways: by improving the efficiency of the business; and affecting how the business operates. The impact on business is investigated by means of a literature review. First the impact of EDI in four common applications is investigated. These applications are: trading; just in time manufacture; tracking goods in transit; and banking. All EDI applications require business drivers, the common drivers of EDI are discussed. This discussion identifies the focus on short term impact by business. The short, medium and long term impact of EDI is described. Short and medium term impacts include the use of EDI to form trading relationships, the use of EDI as a barrier to form closed markets, whilst the long term impact if for EDI to form part of a business philosophy and is therefore fully integrated with other systems. The role of both internal and external integration is then investigated. The long term effect of EDI is not certain nor is it's relationship with the growth of the internet. However, the potential of this and the possible impact on employment are discussed.

The legal implication of electronic document transfer centre on the two key legal issues of contract, (is a contract formed by the transfer of an electronic document) and evidence, (is a document which is created and stored electronically considered as admissible in court). The use of trading internationally also raises questions over these legal issues in all countries, not just the UK or the EU. These issues are investigated and discussed in section 3.3 of this chapter.

3.2 Business impact of EDI

The implementation of EDI will affect any business, however, the nature of this impact will vary depending on the nature of the implementation. The financial benefits of integration require a number of IT technologies to be utilised. If EDI is implemented as a standalone solution it can provide the driving force for integration. Alternatively, if a company considers workflow and the
integration of systems as a whole, EDI merely provides a solution to information flow, be it internal or external to the organisation. The benefits realised by the use of EDI to achieve integration is the direct impact of EDI on an organisation. Indirect implications can also be attributed to EDI, such as changes in trading relationships.

EDI is utilised for different applications in different industries. The impact of EDI in the applications of: trading; just in time manufacture; tracking of goods; and banking, are discussed in this section. The drivers of implementation are then identified and defined followed by the short, medium and long term impact of EDI. The need to integrate EDI with existing systems, the use of EDI to achieve better integration and the need for business re-engineering is investigated as a means of achieving maximum benefit from EDI. Finally the impact of the internet on EDI and hence business is discussed.

3.2.1 Trading

How EDI is used for trading

The trading cycle consists of a series of information flows between the client and supplier of goods. These information flows are represented in Figure 3.1.

![Figure 3.1 - The trading cycle](image)

Traditionally the information flows represented above were undertaken using the mail to exchange the paper documents. The application of EDI to the trading cycle replaces these flows with EDI messages. There are, for example, EDI messages for an invoice, a purchase order, and a request for quotation.
Impact of EDI for trading

Trading was one of the first applications of EDI, with Boots receiving 15% of its invoices electronically by 1972. However, EDI was not established as a legal transaction in England and Wales until the Finance act of 1980 (Bamfield 1994). The speed of EDI is one of its primary benefits with the transmittal of an EDI order being faster than either post or fax. EDI can also cope with much higher volumes of transactions. However, the major benefits of EDI result from the integration of the customers stock control system to an EDI ordering system. In this way the stock control system can automatically order stock as it is required. Similarly a supplier can link their stock control system to the EDI system so the level of stock can be updated as goods are sold. Indeed, EDI reduces inventory level, improves cash flow and streamlines a companies operations (Dearing 1990). EDI also promotes closer ties between the trading partners and the quick response to its customers provides a competitive advantage for its users (Mohr 1990).

The adoption of EDI has impact on the personnel, with a need for retraining buying staff. Such impact is short term. The main impact of EDI is on the purchasing procedures. EDI results in more efficient purchasing procedures with a reduction in vendor monitoring, the introduction of automatic ordering and simplified order approval processes (Banerjee, 1995). Banerjee also concluded, from an empirical investigation of the impact of EDI, that the adoption of EDI by a company is not sufficient to achieve significant benefit. It is necessary to encourage all trading partners to adopt EDI to maximise the number of transactions undertaken by EDI.

The use of EDI for trading facilitates the automation of financial and ordering activities, i.e. internal integration. However, it is also necessary to consider the integration with external trading parties. Such external integration is essential to maximise the operational efficiency benefit of EDI.

3.2.2 Just in time manufacturing

How EDI is used to achieve just in time manufacturing

Just In Time Manufacturing is a method of reducing stock by ensuring delivery of components from suppliers is made on an as-required basis. A decrease in stock greatly reduces overheads in terms of storage costs and in terms of capital invested in stock, which is effectively depreciating.

To achieve JIT manufacturing the link between suppliers and customers becomes essential. Once stock levels and lead times drop below two weeks fast, accurate communication becomes vital and the post is no longer sufficiently reliable. An alternative method of communication is therefore
required (Nottage 1988). The alternatives are: Fax; electronic mail; and EDI. Only, EDI however removes the need for the re-keying of data into the supplier and customers computer systems. The inaccuracy of the manual re-keying and the time taken all result in a need for a larger stock. EDI is therefore often selected to enhance the communication between supplier and customer.

A construction application of JIT used to minimise the material inventory on site would be practical. Direct EDI links between a site and its suppliers would provide exact timing, quantity and type of delivery to the supplier, and would also provide instant notification of any rescheduling of deliveries required. Such benefits are attractive, but require a great deal of trust between supplier and contractor, (Akintoye, 1994). It could be considered that such a level of trust is not currently possible in the aggressive construction market place.

**Impact of EDI used to achieve just in time manufacturing**

Just in time manufacturing practices require frequent deliveries, in this situation EDI can help reduce costs and enable better monitoring of the suppliers (Bannerjee and Golhar 1993). The benefits provided by EDI in a Just In Time application consist of the benefits achieved by trading by EDI as described in the previous section, plus the benefit of being able to operate in a Just In Time environment reliably and effectively. The benefits of the alliance of EDI and JIT are illustrated by Navistar, a company based in Chicago, who operate with some materials arriving only four hours before they are required for processing, a system only possible by means of EDI. Navistar achieved an inventory reduction of $80 million within one year of implementation (Stix 1986).

The saving of JIT manufacture are increased as delivery-to-use lead times are reduced. The only means of achieving very short storage periods, is to maintain very strict control of the supply of components, ensuring the status, location and condition of the order is known at all times. Such timely and accurate control can only be achieved by the use of EDI (Sadhwani 1987). It is therefore not unreasonable to state that EDI is required to achieve reliable and effective JIT operations. The dependence of JIT on EDI has resulted in EDI becoming of strategic importance, rather than a cost cutting exercise (Stanton 1989).

**3.2.3 Tracking goods in transit**

**How EDI is used to track goods in transit**

Companies which deal with the transport of goods handle large volumes of goods which can be anywhere in the world. The use of EDI to indicate which goods are in a particular load, then to
monitor the progress of a load, has been adopted by several transport companies. For example, P&O utilises EDI in its container shipment business (Willmott 1995).

**Impact of using EDI for tracking of goods in transit**

The ability to track goods in transit allows strict control of the supply chain. This allows transport companies to provide good customer service. It must be remembered that EDI is an enabler, and that information is central to the efficient management of logistics (Christopher 1992). EDI therefore provides information to the transport company, allowing timely decisions to be made to maintain the highest level of customer service.

The potential benefits of goods tracking are illustrated by the example of Excel logistics, who by installing an in-cab vehicle tracking system achieved the following benefits: 5% reduction in fuel costs; reduced accident damage; improved utilisation of load space; reduction in stolen trucks due to remote GPS tracking; reduction in tachograph analysis costs; and better service to customer as driver can make credit checks, sales, etc. from his cab (Hammant 1995).

### 3.2.4 Banking

**How EDI is used for funds transfer**

The transfer of funds is simply replaced by the transfer of simple EDI messages. These messages include information which describe the sum of monies and the parties between which the sum is to be transferred. These messages, although simple, are required to be very secure. BACS, Bankers Automated Clearing Service is the most popular form of electronic funds transfer in the UK. BACS uses a number of passwords to authorise the transfer of funds, thus allowing payment for goods, or most commonly payment to employees.

**The impact of electronic funds transfer**

The benefits of electronic funds transfer are achieved through the reduction of administrative costs to process the ever increasing number of transactions. Electronic funds transfer was one of the first applications of EDI and it was developed out of necessity to allow the banks to provide a relatively inexpensive services to its clients. The example of BACS is described in detail in appendix A.

### 3.2.5 Business drivers for the adoption of EDI

The feasibility of using a computer network as a paperless clearing house for handling trading cycle information was presented more than 30 years ago (Kaufman 1966). While computer and
communications technologies have been utilised for this purpose, it has not yet replaced the traditional paper based trading methods of many industries.

EDI is the technology central to achieve a paperless clearing house. Keen (1990) argues that the economics of EDI are so compelling that no firm can ignore the competitive opportunity today. He concludes that EDI is one of the “must” do applications in the 1990s. The promotion of EDI on the basis of economic advantages is common (Al-Soufi 1994; Willmot 1995; Sanders 1988). However, if the technology provides such a compelling financial advantage why do companies still use existing paper based trading methods? Indeed, does EDI provide a financial advantage in all applications? The question of EDI adoption must therefore involve a more complex argument than that of financial advantage. The drivers of EDI are investigated below to determine the potential impact of EDI on business and explain the pattern of adoption among the different industries.

The decision to adopt EDI is not a technical issue. The technology has been available for many years. Indeed Galliers et al (1995) stated that EDI should not be viewed simply as a technological infrastructure, but as a technology which may enable an organisation taking a strategic view to derive competitive advantage from utilising it as part of a process of business re-engineering. In this statement Galliers also identifies two of the key business drivers for the adoption of EDI: strategic benefit and competitive advantage. Other business drivers include: the economics of EDI; differentiation; and a necessity to trade. Adcock (1996) identified a number of EDI drivers and considered the stages after implementation at which they would be achieved. Adcocks view of EDI drivers is shown in figure 3.2.

Definition of drivers

Strategic benefit is the use of EDI to achieve a specific company objective, which itself provides significant benefit. An example of the use of EDI to achieve a strategic benefit is Just in Time manufacture.

Economic advantage of EDI is the reduction of costs achieved from the operational advantages of EDI, including speedier transfer of information, reduced errors and less manpower required to undertake processing and data entry. To provide an indication of the benefit this provides, it has been estimated that 70% of all computer input is the output from another computer (Harris 1992).
Differentiation is the ability to provide a service which is either different or in addition to those supplied by your competitors. An example of differentiation afforded by EDI is the reduced time between order and delivery of an item ordered using EDI.

Competitive advantage is the use of the cost reduction and efficiency benefits of EDI to provide services which are more attractive than your competitors.

Client pressure is a common driver for the adoption of EDI where implementation is undertaken on the request of a major customer to keep their trade. An example of this in the manufacturing industry is General Motors (US) which requires its parts suppliers to trade using EDI (Takac 1993). Client pressure to adopt EDI has also been reported in the UK (Baker 1991).

![Figure 3.2 - EDI business drivers, defined by Adcock (1996)]
3.2.6 Short/Medium term impact of EDI

The simplest and best known impact of EDI is the increase in speed and accuracy of transmissions it provides (Hansen and Hill 1989; Monckza and Carter 1989). However, these direct impacts are well known, and hence are simply predicted. The impact of EDI is usually also the driver for its implementation. For example, early implementations were based on its use to gain competitive advantage (TEDIS 1994). However, there are impacts which were not initially identified but have come to light through experience of implementation. The impact of EDI in the short to medium term is described below.

Impact of competitive advantage, strategic advantage and differentiation

The use of EDI to gain competitive advantage, strategic advantage or differentiation within a marketplace is a strong argument for its implementation. The ability to provide a more efficient service or indeed a service which the competition cannot provide is attractive to companies operating in fiercely competitive markets, for example retail companies.

Competitive advantage, strategic advantage and differentiation related benefits accrue to companies which implement the technology first. These benefits will be eroded as competitors respond and implement EDI themselves. However, the benefits to an industry on an industry wide basis will remain.

An example of competitive advantage providing significant benefit is the retail industry. Sales increases of 20% to 40% have been reported by users implementing EDI. This is achieved through the elimination of out of stock items, and the ability to tailor the inventory to customer demands. These sales benefits are only achieved by those who implement EDI first. As soon as competitors can provide the same service the sales benefit is nullified (Davies 1989).

Early implementors of EDI stress its potential as a strategic information technology, used to gain advantage over competitors. This benefit is now understood to be short term and current rhetoric of EDI increasingly views it within the concept of "partnership" between trading partners (TEDIS 1994).

Forming of trading partnerships

The initial implementation of EDI within industries is typically between a small number (two or three) of companies, which trade regularly. These small trading groups quickly form a good trading relationship due to the team effort involved which provides a feeling of friendship between the individual employees involved and the companies as a whole. Also the economic and operational
advantages of trading within the EDI community ensure the attraction of keeping trade within that group. These two factors result in the formation of close partnerships between companies.

EDI as a Barrier
The objective of improving efficiency and reducing costs is a common objective of implementing EDI. To produce the most efficient systems, utilising EDI, integration between the systems of different companies should be implemented (Baldwin et al 1996). However, such integration forms a barrier to other trading companies making it difficult to join the trading group. The potential impact of EDI as a barrier to entry will be increased by the development of more complex inter-organisational linkages requiring greater investment in equipment (TEDIS 1994). Furthermore, the barriers created are equally valid in the arena of a trading group, as the equipment required in that group may be expensive. This situation could seriously disadvantage SMEs particularly those lacking an IT infrastructure (TEDIS 1994).

Change in markets
The benefits accrued by companies operating within an EDI trading group, or partnership, will be attractive to other companies who will wish to join the trading group. Alternatively, the use of EDI may be driven by an existing dominant trading partner. EDI adoption will therefore become a prerequisite for successfully competing in some markets (Benjamin et al 1990).

Trade within a group would be competitive, however, the reduced size of the trading group due to the barrier of EDI will increase market share of the companies involved.

The operational advantages of EDI and the investments required to build electronic trading networks means that EDI will impact upon the nature of competition in markets. The key issue is whether or not communities will be open to late entrants at an equitable cost (TEDIS 1994).

3.2.7 Long term impact of EDI
Although the short to medium term impact of EDI on business can be observed in industries, the long term implications in industry cannot be identified until all sectors which will ultimately adopt EDI have mature systems in place. The identification of long term benefits is therefore open to interpretation, however, potential implications can be identified with the use of reasonable arguments based upon current knowledge. It must also be noted that the long term implications of EDI are the most significant as it is under these that industries will operate for the longest period. This view is held by Banerjee(1995) and Dearing(1990). Banerjee (1995) states that most of the
literature on the impact of EDI is anecdotal or consists of illustrations of the technical details of the product. He goes on to note that where empirical evidence exists it is often proprietary and not in the public domain. As a result of this situation he concludes that the long term implications of EDI are still unclear. Dearing(1990) identified the importance of the long term strategic benefits of EDI and also noted the difficulty in measuring this impact.

A Business Philosophy
The best means of implementing EDI is to integrate it with other related systems. The encompassing of EDI in business practice is the key to its success. Indeed, EDI is treated as a philosophy by many organisations where the operations are integrated across organisational functions in order to realise its full benefits. In such cases EDI is not a communications tool but a vehicle for implementing a business philosophy (Banerjee 1995). Examples of this philosophy include JIT and banking implementations, which are among the most successful.

Assuming the benefits of EDI are recognised, it will become an integral part of industry. The use of EDI will then become part of business philosophy, thus affecting the way in which people work. This represents the most significant long term impact of EDI.

Trading in an open market
One of the key difficulties of EDI, within an immature trading community, is that it creates trading barriers. Assuming these barriers can be removed by cheap, open, secure and easy to use communications technologies the result will be a utopian electronic market place in which all companies can easily trade. This is not a wild assumption as earlier indicators point to the internet, and it’s related technologies, providing such a technological basis for open trade.

However, one of the commonly stated impacts of EDI is partnership between companies. The TEDIS(1994) project put forward the view of partnership and the benefits it provides, however the utopia of open and efficient trade within a market place is contrary to the philosophy of partnership. It is highly likely therefore that the good trading relationships initiated by EDI could quickly disappear as the technology matures. Partnerships should therefore be regarded as a short term benefit. The TEDIS project also noted that the utopia of a truly open EDI trading community will nullify any competitive advantage that EDI previously provided (TEDIS 1994).

The long term impacts of EDI appear to invalidate many of the drivers identified by companies who implement EDI systems. The question is what is the long term benefit of EDI in a utopian open
electronic market place. To answer this the operational benefits of EDI, which provide more efficient trade and hence reduced costs, must be considered.

EDI will ultimately reduce the cost of negotiating and consummating deals, within an electronic market place (Bannerjee 1995). EDI is also expected to speed up document flow in international trade and as a result may standardise and simplify trade procedures and documents for international trading partners (Jansens and Cuyvers, 1991). Assuming that trade is competitive within a market place it is reasonable to assume that these cost benefits will be passed on to the customer. The long term benefit of EDI is therefore a more efficient industry in which the customer benefits from reduced cost.

3.2.8 EDI a means of integration

The impact of EDI on any industry is dependent on the application of the technology. In industries using EDI for trade it can merely provide more efficient purchasing and sales systems, whereas a company wishing to adopt just in time manufacture EDI is essential to minimise the lead time of component supply.

Regardless of the application the benefits of EDI are not achieved unless the EDI systems are integrated with the companies existing systems. Integration can be achieved on different levels, for example integration could mean the development of an interface between existing systems and an EDI system, alternatively integration could mean the re-engineering of all the systems involved to suit EDI. These two alternatives have significantly different impacts on the business involved. The adoption of EDI is not always entered into voluntarily by a company, but it is often the result of direct customer pressure (Shatz, 1988). Companies which are forced into using EDI are less likely to fully integrate their existing systems, but are likely to implement an interface with their existing systems. The forced implementation of EDI is therefore likely to result in reduced benefit over self driven implementation.

Why full integration not interface?

The interface between EDI communication software and a company’s internal systems is necessary to avoid manual re-entry of data. The benefit of an automatic interface by means of electronic manipulation of the information is therefore clear. However, the benefit of re-engineering internal systems to operate more effectively with the new communications is less clear, as is the re-engineering of systems that operate over company boundaries. The re-engineering of these systems can be referred to as internal and external integration respectively.
Internal integration

Internal integration is simply the integration of the EDI system, and the functionality which it provides with the company systems. A simple interface to existing systems does not allow these systems to utilise the operational benefits afforded by EDI, for example the speedier transfer of information.

External integration

External integration is the integration of the EDI system and other systems within a company with systems external to that company. This is achieved by predetermining the processes which occur between the two companies and developing systems internal to each company which will allow interaction using EDI in the most efficient means possible.

Business Re-engineering

Business re-engineering is the identification of processes which the organisation needs to have in place to meet strategic objectives. Once these processes are identified Business process redesign is applied. Business process redesign is the abandonment of old processes and the development of completely new processes, instead of patching up what already exists (Myllymaki 1997). The new processes developed are designed to best fit the planned operational situation. In the case of EDI, Business process redesign would result in processes best suited to the exchange of information using EDI, instead of paper documents.

In the case of EDI being used for trade between companies Business re-engineering would result with external integration. Business re-engineering would identify the need for processes which integrate the customer ordering process with the order fulfillment process, so that they are performed as one process. The use of EDI to enable the re-engineering of processes in trading companies is depicted in figure 3.3. EDI would therefore not just form an interface but a means of integration (Edwards 1994).

Whilst business re-engineering is considered to provide the greatest benefit, there is little guidance as to the scale of benefits which can be achieved. This is reflected by the fact that between 50 and 70% of organisations that undertake re-engineering efforts do not achieve the dramatic results they intended (Edwards 1994).
Quantification of integration benefits

The integration of systems within an organisation provides benefit over no integration. Similarly, the integration of systems between a company's systems and systems of external companies would provide benefit over internal integration. Whilst these assumptions are derived from an understanding of the benefit integration can achieve it is difficult to quantify this benefit. Indeed, a report produced by CICA (1995) focused on the problems of identifying the business benefits of information technology to the construction industry. Baldwin et al (1996) used data flow diagrams to model the construction estimating and tendering processes in the three stages of electronic commerce: non-integrated; internal integration; and external integration. A simulation model was produced using simulation software from the data flow models. The results of this work showed that internal integration provides a 10% reduction in cost over non-integration, whilst external integration provides a 40% reduction.

Figure 3.3 - The use of EDI with process re-engineering to integrate trading processes

One of the effects of the adoption of EDI is the increase in internal integration of systems (Banerjee 1995). However, EDI itself is a means of transferring data externally and it is this external integration that provides the greatest benefit. It should be noted that internal integration must be in place for the benefits of external integration to be achieved.
3.2.9 Impact of the internet

The internet and the technologies associated with its GUI browsers, provide a means of exchanging data with a very large and rapidly increasing group of companies and individuals. The internet provides access to the largest user base in the world. The HTML language utilised by the web browsers to encapsulate the information can therefore be argued as providing the closest to truly open systems that has currently been achieved.

This enormous community, or perhaps the term society is more appropriate, can exchange information simply, be it text or image. The concept of the internet providing a platform for exchange with few rules attached have allowed for diverse applications to be implemented using the technology, from viewing live images and listening to live radio stations to simply reading through information on the latest cricket scores and even administering an NT network or updating a remote corporate database. The use of add-ins, a technology which allows specific interfaces to be installed in a browser, facilitates these diverse applications.

The flexibility of the internet is in direct contrast to the rigidity of the concept of EDI. However, it must be remembered that the two technologies are somewhat different. EDI provides a means of incorporating meaning in the data transferred, whilst the internet is an open platform on which a variety of data can be exchanged.

Winters (1997) suggests that the high degree of structure in EDI caused it to have limited impact. The lack of a simple and open means of communication is surely a more rational reason for the limited success of EDI. The internet provides an open trading community. This would be expensive to achieve using any means of direct communications topology, no matter what form of communications technology is utilised, eg. modem, ISDN, or VAN.

The internet should renew interest in EDI technologies as it provides the open market allowing communication with any number of trading partners at little cost. However, the issue of security must be suitably addressed with any internet-based trading system.

Encryption can be used to provide secure internet information exchange. Such a system is utilised by the Microsoft NT4.0 internet administration system (Microsoft 1997). The system uses the 2 key system, which consists of a public and a private key. The public key is known to all, whilst the private key is only known by the recipient. Information can be sent by anybody, but only read by the designated recipient, ensuring secure data transfer.
E-commerce (Electronic commerce)

E-commerce is the concept of putting the supply chain of a company onto the internet. The benefits of E-commerce are to automate business processes and relieve staff of routine paperwork. Whilst the concept of E-commerce has been popularised, the uptake of the technology is slow. One of the reasons for the slow uptake is the lack of standards available to implement such trade (Youett 1998). The need for standards is currently being addressed by the development of web forms which facilitate the exchange of EDI messages over the internet.

Electronic web forms allow the web browser to be used to send and receive EDI transactions with an EDI proficient hub. The hub is implemented by a company that wishes to trade electronically with its suppliers and/or customers, which requires significant investment. However, once a hub is in place there is minimal investment required for other companies to enter into electronic trade with the hub company. Web forms therefore allow hub companies to easily form electronic trading relationships with small organisations.

TradeWeb is a third party solution for Web forms which is operated by General Electric. The number of users of TradeWeb had risen to 1800 by February 1998, increasing at a rate of almost 400 a month (Willmott 1998). The Chrysler Corporation uses TradeWeb and has committed to making all transactions paperless by the year 2000 (Robson 1997). TradeWeb hubs have also been formed outside the US, proving the system provides an international solution.

A number of web form initiatives are either in development or are undergoing trials (Willmott 1998). These include: FreightNet; TradeUK; SITPRO's aligned document series; and 'Simple EDI'. FreightNet is an initiative to develop a web form system for the air freight community. TradeUK is the web site for British exporters, supported by the government, which will be adopting E-commerce for purchasing and the processing of shipping documents using web forms. SITPRO is going to make its aligned document series, use in international trade and export, available on an electronic forms site. The Article Number Association has developed 'Simple EDI' messages that concentrate on minimum levels of information. These messages are designed to be used with web forms.

The internet is also used by bespoke systems to undertake trade (News Item 1997). However, the use of web forms is currently the most likely means of trade developing on the internet. The success of web forms may therefore have significant impact on the utilisation of EDI for trading purposes.
3.2.10 Impact of EDI on Employment

The automation of data entry and checking, a direct impact of EDI, may result in job losses as personnel will not be required for these tasks. The scale of these losses is, however, difficult to determine. EDI is relatively well developed in the transport sector. The COST 320 study (TEDIS 1994) was a study of companies which utilise EDI in the transport sector and part of the survey related to the employment issues of EDI.

The results of this survey provide an interesting insight into the employment impact of EDI. EDI did result in the reduction of clerical staff, but only in 13% of the companies surveyed. Indeed, 10% employed additional staff. 20% of respondents admitted to planning for reductions in staff in the future, while 16% claimed that turnover had increased, without an increase in staff.

A surprising result was that 61% of respondents did not believe that EDI leads to job losses, whilst 26% did. Of the companies exchanging in excess of 10,000 messages per month 33% admitted a reduction in staff, whilst 20% claimed that EDI would not affect staff levels.

However implemented, either by reducing staff and maintaining turnover, or increasing turnover and maintaining staff levels, it is clear that EDI allows the more efficient use of staff in relation to turnover. It is interesting to postulate what proportion of the 61% who believed EDI did not result in job losses, had the objective of using EDI to increase turnover. Clearly the objective of the implementation will determine whether or not job losses occur.

3.2.11 Conclusion

The use of EDI can impact on business in two ways: by providing benefits, both short and long term to the companies utilising the technology; and by a change in the methods of work utilised by the companies.

The adoption of EDI by a company is not sufficient to achieve significant benefit, it is necessary to encourage all trading partners to adopt EDI to maximise the number of transactions undertaken by EDI. To achieve the maximum operational benefit from EDI it is essential that it is integrated with existing systems. Ideally EDI itself is used to integrate systems both internal and external to the organisation. Regardless of the level of integration the organisations which benefit most from EDI implementation are those which incorporate EDI into their overall strategy (Holland et al 1992). The inclusion of EDI in such a strategy requires commitment to the technology. It is only where such commitment exists that EDI can succeed, because the implementation of EDI systems poses a
number of difficulties. The COST320 study (TEDIS 1994), identified the main implementation problems as follows: technical start up problems (57%); interfacing EDI software and in-house systems (36%); organisation/procedural start-up problems (33%).

The need for commitment supports the view of O'Callaghan (1992) who reported that expected efficiency and service gains make EDI adoption more likely, while anticipated system incompatibility makes the adoption less likely.

The decision to adopt EDI in an industry is finely balanced and is currently being decided by significant operational benefits. Hence EDI is currently having the greatest impact on industries dealing with high volume trading cycle processes. However, the development of the internet will provide an accessible method of trading electronically which will make EDI open to a far greater number of companies. This will not only impact on the number of people trading electronically but will also open electronic trading markets, leading to the utopian situation of a truly open EDI trading community. Such a community will nullify any competitive advantage, and will simply achieve reduced costs, hence the long term impact of EDI will be a reduction in cost to the customer (TEDIS 1994).

3.3 Legal Implications of EDI

The application of EDI to undertake trade with another party has many legal implications, including: admissibility of computer records as evidence; contract formation and performance using electronic messages; liability; and dispute resolution. The areas of admissibility of computer evidence and contract law when using electronic messages have proven to be of great legal interest as traditional laws formulated with only consideration of paper documents do not accommodate electronic messaging technologies.

An investigation of the legal issues involved in a trading partnership is presented in this section. The issues of contract formation and performance using electronic messages, and the use of computer records as evidence are described separately. The issues of liability and dispute resolution are incorporated in the section regarding trading agreements.

The effect of electronic trade is an emerging legal issue. An investigation of electronic trade law therefore cannot identify the solution to the issues involved. The conclusions drawn in this section only represent the findings of the literature review undertaken as part of this research.
3.3.1 EDI Contracts

The components of a contract
To determine the problems of using EDI to transfer contractual information it is necessary to consider the ingredients which form a contract. The minimum requirements for a legally binding contract are:

i) An intention to enter into legal relations.
ii) The making of an offer.
iii) Acceptance of the offer.
iv) Communication of the acceptance.
v) Some kind of consideration, (except for contracts made under seal)

(Millard 1989).

Application of the concepts of a legal contract to EDI

Intention to enter into legal relations
The automatic ordering of goods by stock control systems raises the question of whether it is legally acceptable for a computer to make an offer. Contract law involves an intention to be bound by a contract. Johnson argues that if an offer is created automatically by a computer, can that computer be described as having the intention to make a contract (Johnson 1995). A computer cannot have the intention of doing anything, as it does not have a conscience. However, it could be argued that the parties entering into a trading relationship, where it is understood that orders are created automatically, and the criteria which triggers an order are defined, would have the intention to make an offer when the criteria are met (Johnson 1993).

The making of an offer
An offer can be made and accepted automatically if the rates for the items involved are predetermined. It can be argued that this is no different to normal operating practice, where standard rate are agreed and items are requested as required.

The use of electronic means to communicate either an offer or an acceptance does not raise any difficulties under current law. It is reasonable to regard EDI simply as an effective means of communicating information. Under contract law offers and acceptances can be made orally, in writing or by conduct (Millard 1989). The function of communication is the important issue with regards to contract law, the means of the communication is irrelevant.
Acceptance of the offer

The same theory applied to the making of an offer automatically can be applied to acceptance. If the items involved are at pre agreed rates there is no difference to normal operations.

Communication of the acceptance

The same theory applies to communication of acceptance as to the communication of an offer. However, problems do arise with different methods of communication in determining where and when a contract is made (Millard 1989).

Some kind of consideration

A consideration is generally regarded as a benefit to the person making the offer. The transfer of the benefit would be undertaken by another system not related to the EDI system which is used to form the contract, therefore the consideration is not an issue affected by EDI. Although, the consideration may be transferred using EFT, however, the legality of the contract depends on the transfer of a consideration and not by the means by which the transfer was achieved.

Is Electronic Trading within the Scope of Current Law?

If each item which forms a contract is considered individually, there appears few major legal obstacles to trading electronically. The two areas of uncertainty are the issue of intent, which could be ignored depending on your interpretation of the law, and the time and location at which a contract is made. The second raises the most significant issues, particularly when considering trade across national borders, as it is the law of the country in which the contract is made that applies.

These basic questions, whilst not challenging the fundamental principles of contract law, are very important when considering the application of electronic transfer in the real world. In the USA the conclusion reached by the American Bar Association from evaluating commercial practices using EDI was that existing rules in the Uniform Commercial Code and common law were inadequate for assuring the legal enforceability of any contract formed with the use of electronic media (ABA 1990).

Recently, UNICTRAL (United Nations Commission on International Trade Law) has set out model law for electronic commerce. This document includes a section relating to the formation and validity of contracts, which states that the validity of a contract should not be affected by being formed by means of a data message (UNICTRAL 1996). Whilst this document is not considered
law in any domain, it is an indicator to the acceptance of electronic methods as means of forming contracts.

In 1996 a document titled "The Principles of European Contract Law" was published by the Commission on European contract law. This document outlines the fundamental requirements of the conclusion of a contract. These are:

- the parties intend to be legally bound; and
- the parties reach a significant agreement without any further requirement.

The document qualifies these principles by stating that for the contract to be concluded there is not a need for the transactions to be evidenced in writing or to comply with any requirement as to form. The contract may be proved by any means (CECL 1996).

There appears to be agreement between the views of the United Nations and the European Law Commission, that the method by which trading takes place does not affect the validity of the contract.

**Number of Trading Parties**

The number of parties trading has a significance to the legal situation. During the early days of EDI an 'EDI trader' may have had one or two trading partners. The settling of disputes within such a small community would not be difficult as the relationship would have been developed closely between the two companies involved. However, in an open EDI market where trading is undertaken between many companies, the close trading relationships would become lost, and legal disputes would therefore be more likely. It is for the situation of 'open trading' that legal issues become more relevant. It can be argued that a situation of open trading is yet to exist as all the case studies, reported in chapter 4, involve close relationships between supplier and customer. There may be many suppliers, but only one customer in the trading groups described. If there are many customers and many suppliers in a trading group, the legal problems will become more apparent. This is because there would no longer be a dominant member to define the terms of trade.

**Where and when is a contract made?**

In most cases it is of little importance when a contract is made, however, in particular cases it is necessary to establish the exact time at which a contract commenced. For example, the scale of damages for breach of a contractual obligation may depend on the time which has elapsed since the
relevant obligation came into effect (Millard, 1989). Also the timing and location of the electronic transfer of funds is critical, particularly when taxation is considered (Voroegop, 1990).

In verbal negotiations the acceptance of a contract is communicated immediately, as the decision is made. Problems arise where parties use a non-instantaneous means of communication, such as a postal service.

A contract is generally considered to be in effect as soon as the acceptance of the offer has been communicated. In the case of postal communications the date of posting of the notification of acceptance is regarded as the starting point of the contract, regardless of whether or not it reaches the intended recipient.

The case of a postal service being used to notify the acceptance of a contract is a special one, as by its nature it causes a delay between the first party sending the acceptance and the second party receiving the acceptance. It may be argued therefore that this is similar to using a VADS system to deliver an EDI message which communicates the notification of the acceptance of a contract. However, not all EDI messages are sent via VADS and more importantly there is a fundamental difference between the case of EDI and that of a postal service, which is timing. As in a postal service there may be a delay between the sending and receiving of a message. However, if the recipient is connected to the VADS, at the time of the sending of the message he/she may receive the message instantaneously.

It has not been legally established whether acceptance occurs when a message arrives in the recipient's mailbox on the network supplier's computer, when it is retrieved by the recipient's computer, when it is translated and accepted by the recipient's order processing system or when it is read by a human (Johnson 1995; Napier 1992).

Instantaneous methods of data transfer have been in use for many years now, in the form of the telephone and telex. A precedence for the use of telex for the communication of contract acceptance was set during 1955 in Entores Ltd. v. Miles Far East corporation (Millard 1989). In the court of appeal, Denning LJ stated that:

"the rule about instantaneous communication between the parties is different from the rule about the post. The contract is only complete when the acceptance is received by the offerer: and the contract is made at the place where the acceptance is received."
Birkett LJ added that:

"so far as telex messages are concerned, though the dispatch and receipt of a message is not completely instantaneous, the parties are to all intents and purposes in each other's presence just as if they were in telephonic communication, and I can see no reason for departing from the general rule that there is no binding contract until notice of the acceptance is received by the offerer."

More recently the House of Lords agreed to reconsider the rule established by the Court of Appeal in Entores. The rule was in essence reaffirmed.

3.3.2 Evidential Issues of EDI

The use of EDI poses three legal problems areas with regards to evidence, which are admissibility, authentication and form. Each of these is discussed individually in the following sections.

Admissibility

The question of admissibility is not limited to EDI but is equally applicable to all areas of computing. All forms of modern computers store data in a digital format, usually on magnetic read/write media such as disk or tape. The question is whether information stored on these types of storage media is admissible as evidence in the same way as information on paper is admissible.

The current law statutes refer not to actual pieces of paper as evidence but to documents. The solution therefore lies in the definition of a document. The UK civil evidence act of 1968 defines a "document" as "any disc, tape, soundtrack or other device in which...... data (not being visual images) are embodied so as to be capable, with or without the aid of some other equipment, of being reproduced therefrom"

(Civil Evidence Act, 1968).

The above extract appears to indicate that it is acceptable for computer stored data to be admissible as evidence in British courts.

The information stored by a computer, be it on disk or tape, is subject to the same laws as evidence which takes a more traditional form. Evidence can be divided into two distinct categories, real evidence and hearsay.
Hearsay

"The hearsay rule operates to exclude assertions made by persons other than the witness who is testifying as evidence of the truth of that which was asserted"

(Tapper 1989).

The hearsay rule was formed due to the nature of common law tradition, whereby a party proves his case by calling witnesses who state their personal knowledge of events. The accuracy of the witness's account can then be challenged by cross examination. However, a party without first hand knowledge of the events he/she describes, or similarly a document, cannot be cross examined. The veracity of the evidence therefore cannot be challenged. Evidence such as this is categorised as hearsay and is generally excluded.

Is computer recorded evidence admissible considering the hearsay rule?

A computer record cannot be cross examined, therefore applying the hearsay rule leads to the conclusion that computer records would be excluded as evidence. However, if a computer is used as a recording device, where no human intervention is involved, as is the case for a data logger, the evidence may be considered as real evidence and thus negate the hearsay rule. The basis of this view was laid in a case having little to do with computers. In The Statue of Liberty (Tapper 1989) a collision occurred in the Thames estuary between two vessels, each of which blamed the other. The estuary was monitored continuously by radar, and a wholly automatic cinematographic record was maintained of the radar traces. The submission of the film as evidence was resisted on the basis that it was hearsay. If a human being had been watching the estuary and had dictated the course of events into a tape recorder, the recording would be considered as hearsay. It was argued that the film was susceptible to a similar objection. However, Simon P. rejected this argument by regarding the film as equivalent to a direct oral testimony, and hence it was considered as real evidence.

"Where machines have replaced human beings, it makes no sense to insist upon rules devised to cater for human beings but rather as Simon P. said, 'the law is bound these days to take cognisance of the fact that mechanical means replace human effort"

(Tapper 1989).

The automatic recording of information as described in the case of The Statue of Liberty is analogous to the automatic recording of electronic data transmissions as undertaken by a data logger. It can therefore reasonable to assume that evidence stored on an automatic data log would be admissible in court.
Recent modifications to hearsay evidence

The hearsay rule has proven difficult to understand and explain, and can result in evidence which is relevant being excluded (Law Commission 1993).

This situation was first outlined by the law commissions report in 1993, which went on to recommend the abolition of the hearsay rule. This report resulted in the repeal of part 1 of the civil evidence act by means of a Civil Evidence Bill.

In the Civil Evidence Bill hearsay is defined as:

"a statement made otherwise than by a person while giving oral evidence in the proceedings which is tendered as evidence of matters stated" (Civil Evidence Bill 1995).

The bill states that evidence which is otherwise admissible should not be excluded because it is hearsay. However, the bill does require that if hearsay evidence is to be presented in a case the opposing side should be given fair notice.

The result of the bill is that the existing rules of admissibility of computer generated evidence, defined in the civil evidence act 1968, are out of date, these provisions have therefore been dropped (Lord Chancellor 1995).

Authentication

The question of authentication is the proof that a party was involved in an exchange of contract documents, eg. did the party place the order.

In the case of an EDI system data regularly flows into the computer at any time without human intervention. This leads to the situation where there are no human witnesses to the transfer of data. It is therefore essential that there is some form of log to record all data exchanges. The UNCID rules (drafted by the international chamber of commerce) specify that a trade data log is vital both in connection with the evidential and audit requirements. The trade data log may itself be in electronic format (Crawley 1991).

If a data log is used to record the transactions which have occurred the question of authentication becomes one of admissibility.
Traditionally documents which are admissible in court take the form of a paper document. Such paper documents are quite secure as any alterations or forgeries can often be detected by expert examination. However, since computer records are often stored on read-write media they can be altered without leaving any trace of alteration (Bradgate 1989).

The inherent fallible nature of computer records leads to the question of whether such records should ever be considered as authentic evidence. The reliability of computer recorded evidence depends almost entirely on the security of the computer system on which the records are stored. If a computer record can be proven to originate from a computer system with an acceptable level of security and a log of data exchange, then it would appear logical to assume that the record is reliable evidence.

The security aspects of EDI are closely linked to the legal aspects of EDI, as security is essential in proving the identification of the parties, and also the confirmation of integrity of the message and error detection (Johnson 1993).

Section 5 (2) of the Civil Evidence Act concurs with this view by stating the following:

"in order for computer evidence to be admissible a certificate should be supplied stating that the system was functioning correctly when the evidential record was generated, stating that the machine was used regularly for processing information of that type, that it was working properly, that the message was the sort of message normally processed on that machine and that there is no reason to doubt that the machine is not working properly. Such certification would normally be provided by the holder of the data log and therefore the independence of the data logger must be firmly established" (Civil Evidence Act 1968).

Whilst the rules on the admissibility of computer evidence in the civil evidence act 1968 have been dropped (Lord Chancellor 1995), this statement does provide guidance as to the interpretation of the current civil evidence bill which only considers hearsay evidence as admissible when there is no other reason to consider it inadmissible (Civil Evidence Bill 1995).

**Form of Evidence**

The form of evidence presented in a court is governed by the best evidence rule. The best evidence rule requires that no evidence which indicates the existence of better evidence should be admitted, unless a satisfactory explanation of the absence of the better evidence is given (Bradgate 1989).
In the case of computer stored information the form of the evidence as physically stored is unintelligible to human beings, therefore an alternative form of representation has to be made.

The two options for presenting computer recorded evidence are:

- to submit the evidence in computer readable form, for example on magnetic disk or tape. This can then be presented by using a computer system; or

- to present the evidence in the form of a human readable printout.

The Civil Evidence Bill does allow the admissibility of computer stored data (Civil Evidence Bill 1995). Also the UNICTRAL model law of electronic commerce states that the form of evidence should not be considered a reason for exclusion.

The Issue of Writing and Signature

The concept of legal documents being of a paper form is tied to the concept of writing in traditional law. However, writing cannot exist in the traditional sense when electronic documents are considered. Similarly, it is not possible for a signature to be written.

Electronic Signatures

Electronic signatures cannot exist in the form which has traditionally been recognised on paper. Any image of a signature is easily copied and hence it's authenticity would always be suspect. The purpose of a signature is for the authentication of the originator of the document. One of the most secure means of ensuring message authentication is the use of cryptographic techniques (Walden 1992).

There are two methods of cryptology, symmetric cryptology and asymmetric cryptology. Symmetric cryptology uses a common key to both code and decode the message. This method is secure in terms of the parties involved, but there can be no proof as to who sent a message. This would cause problems if a trading dispute occurred between the two parties. Asymmetric cryptology is more secure as it uses a “one way” mathematical formula. These system have two code keys, one to encode the message and another to decode the message. The system is most beneficial when the encryption key is made public, and the decoding key is held only by the party.
wishing to receive messages. Anyone wishing to send a message can be sure only the desired person will be able to decode the message (Nilson 1993).

The use of cryptology does provide a secure means of authentication, but does it replace a signature, indeed can the input of a password be considered as a signature (Bell and Gibson 1990). The UNICTRAL model law on electronic commerce does not require a signature as long as the means by which the communication was made can be deemed as reliable (UNICTRAL 1996). However, as this document does not constitute law, it is necessary to amend the law, as long as the techniques adopted provide equal or better security than that afforded by a hand written signature (Johnson 1993).

Writing

The need for contract documents to be recorded in writing has been eroded. The United Kingdom Bills of Exchange act 1882, defines writing as meaning “in hand written form, typed or printed” (Johnson 1993). This definition appears very narrow when compared with the definition in the Copyright, designs and patents Act 1988. This states that writing includes “any form of notation or code, whether by hand or otherwise and regardless of the method by which or medium by which, it is recorded” (Millard 1989). However, both definitions are relevant to the technologies available in their day. The increased acceptance of electronic trading has resulted in the most recent published documents to fully accept electronic messages as writing.

The UNICTRAL model law states that when there is a requirement for writing this requirement is met by a data message, if the information is accessible so as to be usable for subsequent reference (UNICTRAL 1996). Furthermore the principles of European contract law stipulate that a contract can be concluded without being evidenced in writing (CECL 1996).

Is computer data admissible as Evidence in Court?

The UK Civil Evidence Bill has introduced a flexible system whereby all documents and copy documents, including computer records can be admitted as evidence in civil proceedings (Civil Evidence Bill 1995). This removes any questions regarding the form of evidence, and the admissibility of computer records. Assuming there is no other reason to discount the evidence. The question of authentication relies on admissibility and security to prove the identification of the parties involved.
The notion of best evidence will still apply, therefore computer stored data will only be submitted as evidence when it is the primary record of the relevant information. The admissibility of computer data will still be scrutinised and the system from which it is retrieved will have to be proven to be operating reliably. A "best practice" method of working should therefore be considered to provide an assurance of the security of the system. To achieve best practice in terms of an EDI trading relationship the use of a trading agreement is strongly recommended (Johnson 1993), where the responsibilities of each party are defined for the trading relationship. The storage of data on archive media, such as recordable CD, has a code of best practice to be used to maximise the integrity of the data stored, which may have to be produced as evidence (BSI 1996). The use of "best practice" whilst advisable, does not provide satisfactory legal security for many applications. This argument is demonstrated by the recommendation of the creation of a microfiche copy of all data stored on CD-R for legal purposes by the Institute of Chartered Accountants (Shohet et al 1996).

3.3.3 Contracts Between Parties Involved in the Trading Process

Interchange Agreements
Interchange agreements are commonly considered as the solution to all the legal problems of EDI, with most authors merely citing their existence and not venturing any deeper into the legal issues of electronic trading (NEDC 1992; Hendry 1993). This however, is far from the truth. An interchange agreement is developed to provide an agreement between the two trading parties with respect to their conduct in undertaking EDI, and their obligations to act in accordance with the terms of their underlying commercial contract is not within the scope of the agreement (Adcock 1996).

The use of interchange agreements is strongly recommended, however, as an agreement displays a willingness on behalf of both parties to enter into contract and to maintain good business practice (Johnson 1993). The latter of these aspects is particularly important when considering the admissibility of a transmission log as evidence if a legal dispute arises.

Several standard interchange agreements have been drafted, which can be used to form the basis of an interchange agreement. These standard agreements have been developed for different industry groups, however, the majority are based upon the Uniform rules of conduct for interchange of trade data by tele-transmission (UNCID 1987; Thomsen 1989).
A standard interchange agreement for electronic trading has been developed by the UK EDI association, a copy of this agreement is presented in appendix B. This agreement addresses the following issues:

security of data;
authenticity of messages;
integrity of message;
confirmation of receipt of messages;
storage of data;
intermediaries;
term and termination;
interpretation of the user manual;
force majeure;
invalidity and severability;
notices;
amendments in writing; and
disputes and law (SITPRO 1993a).

These issues directly relate to the communication process involved in the trading relationship. However, there are two issues in which the purpose of an interchange agreement could be easily confused: liability; and dispute resolution.

**Liability**

There are two different areas of liability where electronic trading is concerned: the liability where a contractual agreement is broken; and liability where the obligations of electronic trading are not met. The former is not an issue related to the means by which trading is undertaken, but is governed by an underlying trading contract (Thomsen 1989) and therefore is excluded from any interchange agreement.

If a party fails to meet the obligations set in an agreement and damage is caused as a result, liability for the damage to a party falls upon the party whose breach of the agreement caused the damage to occur. Unless that concept of liability requires further clarification it is left out of an interchange agreement (Adcock 1996). It is therefore common for there to be no reference to liability in an interchange agreement.
Dispute Resolution
The resolution of disputes between parties would mainly consist of disputes with relation to the trading contract, not the means by which trading took place. Only in the instance of the failure of an electronic transfer would an issue arise that would be considered in the scope of the interchange agreement. In this instance the interchange agreement could be used as a means of resolving the dispute.

Contracts with Value Added Network Providers
A third party, a value added network provider, is often involved in the trading process. However, there is a separate contract between each trading party and the network provider. This contract is usually designed to minimise the liability of the network provider as to the loss of information on its network (Mosteshar 1989). This is reasonable as the network provider cannot be aware of the value of the data which it is handling, and therefore cannot make any additional provision for its integrity where required.

The contract with the network provider should include the following requirements:

- the conveyance of the message in the correct format and protocol;
- the safeguard against corruption of the message;
- securing that the message is conveyed to the recipient;
- preserving the confidentiality and security of the message;
- the customer should maintain the right to audit the operations of the network provider; and
- the network provider should not monitor the volume, direction, type or details of the customers data.

(Marcella and Chan 1995; Mosteshar 1989)

3.3.4 Conclusion
The first uses of EDI were between a small groups of companies, which developed very strong trading relationships. Any dispute or problem with the electronic trading could be resolved by means of a telephone call. This close relationship allowed companies to trade without legal concern within these small groups. This feeling of security and the uncertain nature of the legality of EDI resulted in many EDI partners ignoring the issue, and trading without signed, sealed agreements that specify what is expected from each party (Johnson 1993).
This situation is changing slowly as EDI trading groups become more open, with the ability to trade with any number of suppliers. The feeling of trust is lost between the parties, therefore the need for legal protection when entering into a trading relationship has become necessary (Johnson 1993).

**Legality of trading electronically**

To form a contract properly it is necessary to match the buyers acceptance to the seller's offer. Parties must be sure the offer was not modified or revoked prior to acceptance, and the parties must have the authority to create binding obligations. These problems have been dealt with by jurisprudence for paper documents. No jurisprudence exists for electronic formation of contracts, as to date there has not been a single case involving EDI (Marcella 1993)(Holt 1998). The dispute of contracts will be determined by courts which apply the laws of contract formation and performance to new technology (Crawley 1990). It could then be argued that the problems of contract law with regards to EDI will be addressed in time.

It is possible to achieve electronic trading, without compromising the business operations of a company, if both parties agree at the outset of trading that EDI may be used to form contracts and the terms of contract and the intention of both parties is discussed and agreed at the outset (Crawley 1990). This method of forming trading relationships, with the use of an interchange agreement as a guide, would then place the companies involved in a reasonable position if a dispute arises. This position is strengthened by the statement of Lord Wilberforce, in which he recommended the use of best practice for operations utilising electronic communication methods (Millard 1989).

**International Trade**

International trade poses further questions, with the many different legal systems none of which address electronic trade. However, the global nature of electronic transfer do provide the vehicle to create a commonality between legal system throughout countries which trade electronically. Indeed, there appears to be some commonality between the approach to EDI contract law between the legal bodies of the US and the UK (Sarson 1993).

Recently, UNICTRAL (United Nations Commission on International Trade Law) has set out model law for electronic commerce. This document includes sections relating to: the formation and validity of contracts; admissibility of data messages; concepts of writing and signature; and time and place of dispatch and receipt (UNICTRAL 1996). The inevitability of international trade using EDI has also resulted in a Model Agreement For the International Commercial Use of Electronic Data Interchange developed by the United Nations Economic Commission for Europe (Ritter 1995).
These documents indicate that the use of international trade, far from further confusing the legal issues of EDI, is providing direction to an achievable solution.

3.4 Summary

This chapter investigates both the business and legal impact of EDI by means of a literature review. The investigation of the business impact identified the following points.

- The application of EDI identified that business focuses on the short and medium term impacts of EDI when considering its use.
- Operational benefit is the predominant business driver for EDI.
- The short and medium term impacts of EDI are: use to gain competitive advantage, strategic advantage and differentiation; forming of trading relationships; use of EDI as a trade barrier; and a change in trading markets.
- The long term impacts of EDI are: incorporation of EDI in business philosophy; trading in open markets.
- To achieve significant benefit it is necessary to encourage all trading partners to adopt EDI to maximise the number of transactions.
- To maximise operational benefit of EDI it is essential that EDI is integrated with the systems with which it interacts, both internal and external.
- The internet will provide an easier means of adopting EDI.
- The internet will not only increase the number of companies trading electronically but will also open electronic trading markets. This will accelerate the evolution of EDI to point where the long term impacts of EDI must be considered.
- There is little evidence that EDI will have a significant effect on employment.

The investigation of the legal impact of EDI identified the following points.
- No jurisprudence exists for the electronic formation of contracts.
- The dispute of contracts will be determined by courts which apply the laws of contract formation and performance to new technology.
- The problems of contract law with regards to EDI will be addressed in time.
- Electronic trading can be achieved, without compromising the business operation of a company, if both parties agree at the outset of trading that EDI may be used to form contracts. This is best achieved by implementing an interchange agreement between the two parties.
• International trade poses further questions, with many different legal systems to be considered.
• There appears to be a commonality between the approach to electronic trade law of US and UK legal bodies.
• The UN has produced a model law for electronic commerce.
• International trade, far from confusing the legal issues of EDI, is providing direction to an achievable legal solution.
Chapter 4
Investigating the application of EDI in construction

4.1 Introduction

This chapter describes an investigation of the issues which are pertinent to the application of EDI in the construction industry. This investigation has been undertaken by means of a review of recent information technology research literature to ensure the conclusions drawn are both relevant and representative of the current situation in the industry. The starting point of this review is an analysis of case studies of EDI implementation in construction and a number of other industries. Construction is recognised as being conservative and hence follows other industries in terms of technology implementation. The analysis of the case studies is summarised in the form of a matrix which is used to determine the key differences between EDI implementation in construction and other industries. In particular factors which are key to the success of EDI are investigated.

Having identified the key issues of implementation, the use of electronic data exchange is investigated. This is followed by an investigation into the limited application of the technology and the key issues that require addressing. The benefits of EDI afforded through re-engineering are identified as a key element and are described and quantified. This clarifies that re-engineering by the integration of information activities is essential for the industry, thus leading to the investigation of the technical solutions which would realise this objective. Finally the role of partnering in promoting the application of electronic exchange is discussed.

The second part of this chapter describes a five year longitudinal study of EDI in the UK construction industry. This study comprised two questionnaire surveys undertaken during 1992 and 1997. The objective of this study was to determine:

- the current status of EDI in the industry;
- the purpose of EDI applications;
- the reasons why EDI has or has not been implemented;
- the perceived benefits of EDI and whether or not they have been achieved;
- the percentage of UK companies who are implementing or considering the use of EDI;
- the message formats which are considered most beneficial to the industry; and
- the EDI standard which is considered the most likely to be adopted by the industry.
The conclusions of the two surveys are compared to determine the change in the application of EDI, and the change in the industries perception of EDI over the five year period. The conclusions of other studies of electronic exchange in construction are also reported, and used for comparison with the conclusions of this study.

4.2 Investigation of EDI application issues in construction

4.2.1 A comparison of the application of EDI in construction and other industries
The application of EDI in construction is not as common as in many other industries. To determine how EDI can be more successfully utilised in the industry a comparison can be made with other industries which have achieved successful implementations.

To compare the use of EDI in construction with other industries published case studies were analysed. It was not possible to collate and analyse every EDI application, therefore case studies which represent typical examples were selected from a number of industries. Each case study was reviewed then summarised. The summaries produced are presented in appendix A.

The following case studies were reviewed.

Construction
Wavin Building Products (Adcock 1996).

Retail
Tesco (O'Reilly 1993).
Price Chopper (Withington 1990).

Pharmaceutical
AAH (ET 1993)

Logistics/transport
Safeway (Moore 1989)
Utilities
Oil industry (Howard 1991)
Eastern Electricity (Willmot 1995a; Willmot 1995b)

Manufacturing
Black and Decker (Harris 1992)

Automotive
General Motors (Takac 1993).
Rover Group (Classe 1991).

Banking
Royal Bank of Canada (Takac 1993).

Selection of criteria
To determine a means by which the industry can utilise EDI successfully, the factors which are critical to successful implementation need to be identified. To identify these key factors a number of factors which are known to affect EDI implementation were selected for analysis. The factors selected were: volume of transactions; type of transaction; EDI standard used; who was the driving force behind adoption; reasons for implementation; and the benefits realised after implementation.

Volume
The volume of transactions determines the actual benefit achieved from the improvements in efficiency provided by EDI. The frequency of use was divided into two levels, low, for less than 100 transactions per month, and, high, for 100 and more transactions per month.

Type of transaction
EDI can be used for two main information groups, trading cycle and industry specific information. The use of EDI for industry specific information has not been as common as that for trading cycle information. This situation may be due to the applicability of the technology to trading cycle information.
EDI standards used
The use of common standards had been promoted by ECA (previously EDIA) and the UN. The use of common standards, however, may or may not be necessary to successfully adopt EDI. To provide an indication to the importance of the standard used, the standards used in each case study were classified as one of the following: Tradacoms; EDIFACT; or other.

Driving force
The adoption of EDI may be driven by either the client or the supplier in any situation. It would be reasonable to assume that a client would have greater effect over its suppliers than vice versa. The majority of successful implementations should therefore be client driven. To examine this theory each case study was categorised as either client or supplier driven.

Reasons for implementation
The following reasons for implementation were identified: as part of a business strategy; as a means to achieve re-engineering; due to customer pressure; to improve customer service and relations; to improve efficiency; and as a trial study of the technology.

Benefits realised
The following benefits were identified: improvement in efficiency of transactions and related processes; improvement in accuracy of data; the timely availability of information; the facilitation of re-engineering; and improved customer service and relations. The benefit categories are similar to the reasons for implementation, but differ in that they represent what was achieved, and not what was originally anticipated.

Matrix of EDI application factors
The matrix of case studies analysed by the factors identified is presented in figure 4.1. An additional column has been included which indicates whether the system implemented is still in use and is therefore successful.
<table>
<thead>
<tr>
<th>Volume</th>
<th>Type</th>
<th>Standard</th>
<th>Driven By</th>
<th>Reasons for Implementation</th>
<th>Benefits</th>
<th>Use</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 4.1 - Matrix of EDI application factors
Analysis of matrix

The following conclusions can be drawn from analysis of the matrix.

- The two key factors for success are high data volumes and the use of EDI to achieve re-engineering.
- The implementation of EDI must form part of a business strategy otherwise implementation is unlikely unless the volume of transactions is very high, and the efficiency benefits are therefore obvious.
- The EDI standard employed has little effect on the success of an EDI application.
- EDI implementation is largely client driven.
- The successful applications of EDI in construction are similar in nature to those of other industries. They concentrate on the exchange of high volumes of trading cycle information.

To achieve significant benefit for the application of EDI the construction industry must consider the two types of information flow separately. The implementation of EDI for trading cycle would be successful based on transaction efficiency and accuracy improvements alone. The benefits of integration with related systems would provide further benefit. The implementation of EDI for industry specific information requires a different approach. Analysis of the matrix indicates that low volume of industry specific transactions would mean the implementation would fail on the basis of efficiency accuracy improvements alone. To achieve significant benefit from the application of EDI for this type of information process re-engineering would be required. Whilst not indicated by this analysis, such re-engineering may take the form of data sharing by means of a project model.

4.2.2 Use of electronic data exchange in the construction industry

The use of electronic exchange technologies was popularised during the late 1980’s and early 1990’s in construction. The increased use of CAD to produce drawings, the development of STEP and the formation of the EDICON organisation provided a platform for developing awareness and commitment to electronic exchange and gave direction for further developments of the technologies to achieve greater business benefit.

The forecast for the implementation of such technologies was very positive during this period (KPMG 1993). However, the application of these technologies has been limited and has emerged more slowly in construction than in other industries.
Industry representatives have identified the need to share or exchange information quickly within their own organisations using the latest communications technologies (CSM 1993). However, research has indicated that few construction organisations are currently using electronic exchange on a regular basis either internally or with business partners (Baldwin et al 1995).

Use of EDI
The use of EDI, the technology primarily promoted by EDICON within the industry, has failed to become a mainstream means of business information exchange. Forecasts made by KPMG (1990), KPMG (1993) and CERCI (1991) reported that some 15% of the industry would be using EDI by 1995. However, Baldwin et al (1995) reported that the level of implementation was far less than this figure by 1995.

EDICON viewed the evolution of EDI as providing a means of better communication in the industry between the disciplines using a set of messages developed for industry specific applications. Whilst the development and ratification of the bill of quantities message set, the most significant development of an industry message was completed, it’s use has not proceeded beyond the test stage.

The early use of EDI in construction was for trading cycle information. The survey undertaken by O’Brien and Al-Soufi (1994) indicated that this was still the case, with no practical implementation of industry specific EDI. This situation was confirmed by a survey of CITE members which showed that the application of EDI is concentrated between builders merchants and their suppliers (Baldwin et al 1995b). The current situation was reported by Akintoye (1997), who noted the use of the CITE bill of quantities message exchange, but only for pilot projects. This survey also indicated that the number of contractors using EDI had not risen since the survey undertaken by O’Brien and Al-Soufi (1994). The use of EDI is still concentrated on the exchange of trading cycle information.

Use of graphic/product information data exchange
CAD systems have been in use by construction companies for the past decade. By 1993 CAD was in use by 89% of consultants, 92% of architects and 71% of building services engineers (KPMG 1993). Since the widespread implementation of CAD in the late 1980s, electronic drawings have been exchanged. This has been undertaken mainly using DXF, the standard created by Autodesk for its AutoCAD product. The COMPOSITE site communications survey reported that 30% of construction sites have CAD systems (Murray and Thorpe 1996). However,
the exchange of drawings was largely undertaken by post on a magnetic media as less than 10% of sites utilised e-mail. Years of CAD experience has led people to believe a neutral file format is the solution to data exchange (Wix and Bloomfield 1997). The most widely used neutral standard was IGES in the late 1980s (Shaw 1990). This has been replaced by STEP, a product modelling standard. Several research projects have sought to implement STEP in the industry. These include: ATLAS, CIM-STEEL, COMBI, COMBINE and the work of Bjork (1991). CIM-Steel is a system which integrates the steel design and manufacture process. CIM-Steel uses CIM-Steel Integration Standards to provide an open standard for the exchange of product data which addresses all types of steel frames (Watson 1994). Projects are designed using the CAD preparation program Steelfab, a list of details and bolts is then made available immediately allowing the preparation for fabrication (CIM Steel 1997). This successful example of the application of STEP provides an indication of the level of integration that can be achieved, but is the product of many man years of effort and considerable cost.

Use of electronic mail

Electronic mail is means of exchanging simple text messages and electronic documents between individuals or groups. This technology provides an open platform for the exchange of unstructured information and is commonly used within many companies for internal and external communication, largely replacing the internal memorandum.

The use of electronic mail was forecast to be used in 41% of companies by 1995 (KPMG 1993), similar levels of use were forecast by KPMG (1987, 1990). These figures have been achieved, but the systems used by these companies mainly provide only internal communication, with only 3% of organisations utilising an external electronic mail connection by 1994 (O’Brien 1994). However, by 1996 over 10% of site professionals had access to external e-mail (Murray and Thorpe 1996). This situation means it is still not possible for electronic mail to replace paper as the primary means of inter-disciplinary information exchange during a construction project. However, the use of e-mail is increasing rapidly due to it’s low cost and simplicity.

4.2.3 What is limiting the implementation of electronic exchange technologies?

The application of electronic exchange in the industry is limited. There is no single reason for this situation, however it is possible to identify a number of reasons which together have limited the implementation of electronic exchange technologies. These reasons can be divided into three groups: issues related to the industry; issues related to electronic exchange; and the business case for electronic exchange.
Industry issues
The construction industry has a reputation of being conservative in nature and therefore less willing to adopt new technologies. To accept this theory as the reason for the reluctance to adopt electronic exchange is over simplifying the situation, and a more detailed analysis is required.

Industry structure
The industry operates using "arms length contractual relationships", an ACR production network, which does not encourage unnecessary risk. An industry operating using this type of network requires a dominant party to force the use of electronic exchange. The lack of a dominant party in the construction industry makes it difficult to warrant the investment required. The structure of the industry causing a reluctance to invest in electronic exchange has been recognised for several years (Strassman 1990; Baldwin et al 1993). Also, Betts et al (1995) identified the production network as hindering the possible benefits of electronic exchange. This is due to the short term nature of relationships and ever changing project partners which greatly reduces efficiency, as communication links have to be continually terminated and reformed with many parties all using different IT systems. As environmental pressure does not lead to improving inter-firm coordination, firms are not willing to make the required amount and type of investments (Grilo et al 1996).

The industry was hit by recession during the early to mid 1990s. Studies indicate that annual output dropped from £14.5bn in 1990 to £12bn in 1996 (Lynn 1996). The recession has placed additional economic factors on the industry which has exacerbated the effect of the production network, by increasing competition through the reduction in available work.

Complexity of data flows between disciplines
The information flow between the parties involved in the construction process consists of many types, occurring many times and at sporadic intervals. The information flow whilst being inefficient in it’s current form does achieve the objective of disseminating information to the correct parties. The problems of interdisciplinary communication and data exchange have been highlighted over the past 25 years by numerous individuals and organisations (Higgin and Jessop 1965; Bishop and Allsop 1969; Ndégkugri and McCaffer 1988). However, to replace these flow with electronic alternatives is a risk and has been cited as a reason for concern when considering the adoption of such techniques (Baldwin et al 1993; Strassman 1990).
In addition to these considerations there is also a general uncertainty over the applicability of electronic exchange technologies (Baldwin et al 1993). Electronic messages may well replace paper-based documents, but it is argued that their use would provide little benefit, yet require significant investment.

Reluctance to invest
To implement electronic exchange technologies a significant investment is required. Research has frequently stated that there are problems associated with justification procedures for the purchase of high technology equipment (Wilner et al 1992; Geisler and Hoang 1992; Sriram and Banerjee 1994; Emmelhainz 1991). This indicates that the industry is conservative with respect to investment in IT, which includes electronic exchange technologies. This situation, however, must be considered in the light of the two dominant factors: industry structure; and the nature of the information flows involved. Grilo (1996) summarised the situation well by stating that construction production networks do not have electronic interaction because the investment of tangible and intangible assets is considerable and firms are not willing to invest.

Grilo (1996) also identified that the deployment of electronic links would require investment in long-term, collaborative and trustful relationships. The need for such relationships is in direct contradiction with the structure of the construction industry. The ACR type production network, which currently forms the industry’s structure, must therefore be considered a major stumbling block to electronic exchange in construction.

Electronic data exchange issues
The application of electronic exchange techniques to information flow using current systems can be problematical. This is due to the transitory nature of today’s systems with respect to information exchange. Most systems are capable of utilising electronic methods but they are optimised for paper-based transactions.

Early research identified the following concerns when considering electronic exchange of documents (Strassman 1990; Baldwin et al 1993).

- the need for universal standards
- the availability of message formats
- security concerns
- legal issues
The use of many standards within a market place does not permit free trade, this remains one of the cornerstones of the philosophy behind the current data exchange standards EDIFACT and STEP. The need for suitable message formats was seen as a significant stumbling block, as they are necessary to utilise a standard. However, as a new message is required it will be developed by the interested party. The number of message formats available is therefore determined by the requirement of trading communities and therefore is itself an indicator of the level of use of electronic exchange.

The legal system is still adjusting to the concept of electronic exchange. There is also great concern over the transfer of commercially sensitive information over electronic networks. These topics are discussed in detail in chapter 3.

Whilst the items identified above are valid additional concerns have been identified which relate to concerns of practical implementation.
- most users prefer paper-based documentation
- the high cost of communications for large volumes of data
- lack of available translators for proprietary application software

(Baldwin et al 1995)

The common link between these problems is that they are a result of a period of transition. These problems will disappear as electronic exchange becomes established, and they therefore do not warrant particular consideration.

Business case for electronic exchange
Back et al (1994) and Baldwin et al (1995) identified that there is a difficulty in justifying electronic exchange technology in the terms of business benefits. This situation is compounded by the fact the based on experience in other industries, the costs of EDI come earlier and the benefit come later (Baldwin et al 1993). It is very difficult to justify significant expenditure to a company executive when the benefit is uncertain and it is not likely to be obtained until a significant period after implementation. In fact such a proposal should be regarded as high risk.

The problem facing the development of the business case is that the benefit is not largely achieved in a tangible form, through increased efficiency of transfer and processing of large volumes of documents, but is achieved through the availability of improved information quality. The benefit of
improved information quality is intangible and hence highly subjective, also the data required to estimate benefits are not always available (Back and Bell 1995).

There is no firm business case for the use of information exchange technologies in the construction industry. No matter how good a technology is, it will only be used if it can demonstrate a real benefit to the industry (Wix and Bloomfield 1997).

Betts et al (1995), confirmed that the poor business case for electronic exchange is affecting the adoption of the technology by reporting that main contractors and suppliers do not foresee major benefits from improving inter-organisation co-ordination through IT.

The lack of a business case represents the most significant obstacle to the implementation of electronic exchange. Whilst the evidence available suggests that there is a significant benefit which can be obtained there is still not enough hard evidence of financial and time benefit. This is needed to convince industry to continue to support the development of the required technology and the standards which would provide the benefit (Wix and Bloomfield 1997).

4.2.4 Key requirements for implementation

Technical issues

The technical components required to undertake electronic exchange of information are described in chapter 2. The three elements required to implement EDI successfully as identified by CII (1993) are: a transmission network; translation software; and communications software. The transmission network is the physical system used to transfer information. Translation software undertakes the conversion between the EDI message format and the application. Communication software manages the physical transfer of the data. Two of its key functions are to compress and decompress the EDI message format to minimise the volume of data transfer, and to provide error checking of the data transferred.

The physical system for transfer selected must allow access to all parties to be incorporated in the trading group. The selection of communications software must support both the EDI message standard utilised and the physical communication network. Both these considerations are simple to resolve.
The key considerations for implementation are:

the selection of an EDI standard and message format; and

the development of application level translation software.

The selection of the EDI standard used is crucial. It must be selected to suit the information transferred (commercial or technical) and the trading group (national or international, industry specific or pan industry). Once the standard is selected the message formats must also be agreed between the trading parties (NEDO 1992). Implementation of translation software to provide application level compatibility with the EDI system requires development of existing systems or major investment in replacing these systems. Whilst these issues were significant they have become less so due to the technical development of EDI which has been widely publicised (Coomber et al 1990; Langan 1990; Parfett 1992).

Management issues

The implementation of electronic exchange technologies has a business impact in terms of organisational and process change. It has long been recognised that to achieve the maximum benefit from these technologies it is necessary to modify the process with which the information exchange interacts (Dyer 1992). For example, to achieve benefit from the electronic receipt of an un-priced bill of quantities by a contractor the electronic document must be fed directly into the estimating system, not manually entered as would have been the case with the paper based document. Hence this process has changed. Whilst this example is simple it indicates the scale of the change necessary if all processes are modified to optimise the efficacy of electronically exchanged documents. Indeed significant process change has occurred in other industries which have implemented electronic exchange, including the automotive industry (Classe 1991) and the retail industry (O'Reilly 1993), with both of these examples realising significant efficiency benefits.

The need for process modification, or process re-engineering, has been recognised within construction industry research. Carter et al (1996) added the viewpoint that the work practices that would require change are considered ‘sacred’ in the construction industry and in doing so reflected the reluctance to change. The re-engineering of processes in the industry may therefore prove more difficult than has been the case in other industries.

Process and organisational change requires careful management, it is not something which can be driven or implemented by an IT department, which is commonly viewed as a support department.
Such change must be part of a business strategy with a measurable objective and must be driven by management. The need for the implementation of electronic exchange to be part of a business strategy is clearly reflected by the case study matrix presented earlier in this chapter.

The successful introduction of electronic information exchange within and between construction organisations is also dependent on organisations being receptive to new technology (Baldwin et al 1997). In the case of the construction industry the resistance such a strategy may receive dictates that it must be driven by senior management. These views were largely agreed by Wix and Bloomfield (1997) and Ahmad et al (1995), both reporting that the management issues involved in undertaking the implementation of such technologies are far greater than the technical issues.

4.2.5 Benefits available to industry

Benefits of electronic exchange
Industries other than construction have experience of EDI and its benefits. The benefits which are most widely reported are: reduction in paper and manual labour; the reduction of errors in documents; speedier and better levels of service (Baldwin et al 1993). Such benefits are available to any industry and become more significant with greater volumes of information exchange of a similar type. However, the construction industry transfers sporadic and disparate information. These benefits are therefore harder to accrue.

The benefits available to the industry are through improvements in key processes. These processes include: design; estimating; planning; construction; and maintenance.

The increased use of CAD to speed the design process during the 1980s and 1990s has led to significant efficiency improvements through the exchange of electronic drawing documents between parties. Such benefits are maintained throughout the life of the project, as the reduction in draughting time required is just as applicable when maintenance work is being undertaken as when design modifications are made. For example, savings of 25 to 40 percent were reported by the British library from the use of CAD data exchange, for maintenance work to the library (Wix and Bloomfield 1997).

The use of STEP for product models assists the design stage further by improving the efficiency of the actual design work. Design time savings of 75% have been reported from use of product model data input directly into design system to undertake air-conditioning load calculations,
when compared to manual take off and manual data entry (Wix and Bloomfield 1997). Such claims may only be true for specific cases and types of design work, however, Van Tienhoven (1994), reported that design reductions of 10-35% can be achieved by standards-based approaches.

It is clear that the design process would benefit from electronic exchange related technologies, however, the remaining processes would also benefit from the improvement in quality and availability of information. Ideally there should be a smooth flow of information from design to estimating and planning then to construction and finally to maintenance. To achieve this availability of information throughout the construction process a project model is required which is available to all parties involved. This approach of data sharing between disciplines would provide significant benefit in process efficiency as all parties would be working with compatible data. Also other benefits would be realised, for example clash detection which greatly reduces the need for redesign during the construction phase (Wix and Bloomfield 1997).

The concept of data sharing using a project model also provides quality of information. Whilst this benefit is significant and desirable to construction professional as it greatly reduces error and wasted effort, it is difficult to quantify. To make an estimate of this benefit a form of risk analysis would have to be applied.

**How benefits are achieved**

The Latham report called for a 30% improvement in building construction processes. A part of this improvement could be achieved through the application of electronic exchange technologies. Whilst there are few indicators as to the contribution which could be made as a percentage of the construction process as a whole Wix and Bloomfield (1997) indicated that a contribution of 3 to 5% could result from the widespread adoption of a mature technology such a product modelling.

To achieve adoption at such a wide level there needs to be standards available to facilitate the transfer of information specific to the industry. This view is concurred by Thorpe et al(1994). Also the industry needs to be organised in a way to allow it to exchange information effectively. Therefore to fully achieve the benefits of electronic commerce it will be necessary to change work practices long held sacred in the construction industry (Carter et al 1996).
4.2.6 Quantification of benefits to industry

The implementation of electronic exchange is often based upon benefits which are tangible and hence easy to measure and understand. This is clearly portrayed by the case study matrix presented earlier in this chapter. However, there are known to be significant benefits available from integrating this technology with existing systems internally, and further improvements from external integration and re-engineering of processes. These benefits are more difficult to quantify and hence difficult to use as justification for the significant operational change and capital expenditure required to implement these technologies. The cost benefit analysis of an electronic exchange project should include consideration of the projected gain achieved through re-engineering enabled by IT (Ahmad et al 1996), otherwise electronic exchange projects may never be funded as their most significant benefit is being overlooked.

CIRIA(1995) undertook a series of case studies of organisations in the construction industry with the objective of identifying how these organisation quantify the benefits of an IT project. The Case studies were of two building contractors, 2 civil engineering contractors and three consulting organisations. This work identified the possible cost and possible benefits, shown in table 4.1, which should be considered when undertaking a cost benefit analysis of an IT project.

<table>
<thead>
<tr>
<th>Possible costs</th>
<th>Possible benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quoted costs of hardware and software (dependent on breadth of definition of IT)</td>
<td>Savings from fewer staff, less office space, less administrative support.</td>
</tr>
<tr>
<td>Costs of additional staff/staff upgrading</td>
<td>Cheaper operational costs leading to either greater profit margins or larger turnover from competitive pricing or a combination of the two.</td>
</tr>
<tr>
<td>Costs of additional offices, support</td>
<td>Improved company image with clients and public compared to competitors.</td>
</tr>
<tr>
<td>Training - immediate users as well as medium and long term</td>
<td>Better staff morale from elimination of mundane activities</td>
</tr>
<tr>
<td>Maintenance of new hardware and software support, cost of consumables</td>
<td>Income from new services offered to clients</td>
</tr>
<tr>
<td>Exchange of data from existing systems (manual or computer based)</td>
<td>Better information (more consistent, more accurate, more precise, generated more quickly, etc.) allowing better business decisions to be made</td>
</tr>
<tr>
<td>Maintenance of archive material</td>
<td></td>
</tr>
<tr>
<td>Finance of any borrowing or lost opportunity cost of capital</td>
<td></td>
</tr>
</tbody>
</table>

Table 4.1 - Possible costs and benefits of an IT project

The work of CIRIA(1995) provides a list of costs and benefits to be considered, however, as reported by Carter et al(1996) in the previous section it is necessary to modify work practices to achieve the full benefit of electronic exchange. The less tangible benefits of re-engineering and
integration are essential to the success of electronic exchange and therefore must be quantified to facilitate the implementation decision.

Two research groups have sought to quantify the benefits achieved through the use of integration and re-engineering. Each group considered a process native to the industry and applied modelling techniques to determine the comparative benefits of non-integrated and integrated applications of electronic exchange.

Back and Bell (1995) modelled materials management. This group identified that a total process improvement of 68% in terms of cycle time savings could be achieved through the adoption of EDI and bar-code technology. However, external integration of the technology yielded 52% process costs savings per cycle when compared to the non-integrated model. Re-engineering provided yet further cost reductions. The simulation showed that 80% process savings in cycle time and 75% total savings in process cycle cost are achievable if re-engineering is employed (Back and Bell 1995).

Carter et al (1996) modelled the estimating and tendering stages of the construction process. This research identified that cost savings in the order of 40% can be made by externally integrating the estimating and tendering process. However, the same modelling indicated that cost savings of only 10% are realised by the internal integration of the process (Carter et al 1996).

This research indicates that the integration is essential to achieve the benefit of electronic exchange technologies. A means of achieving a construction industry which is willing to operate in an integrated manner is therefore essential.

4.2.7 Integration of Construction

Ndekugri and McCaffer (1988) recognised the need for integration in construction due to the incompatibility of data produced by each value adding process. For example, data produced by an estimator is not in a format suitable for use by the planner, which results in an inefficient method of operation between disciplines. Market expansion, global competition, a renewed demand for quality and productivity and increased IT capabilities are making the issue of integration of various stages of the construction process more critical than ever (Betts et al 1991; Schimming 1993). The focus of this attention is to achieve increased productivity and improved quality of construction (Betts et al 1991). This has been recognised and traditionally fragmented
construction organisations are now searching for new ways to integrate both inter- and intra-organisational functions (Nam and Tatum 1992).

The fundamental challenge for computer integrated construction research is to develop techniques facilitating the efficient creation and management of information throughout the construction process.

Bjork(1997) identified three types of integration that are required in the construction process: integration of material process activities; integration of information process activities and organisational integration. The integration of material process provides significant benefit (see Back and Bell 1995), which include reduced transport costs, smaller inventories, improved quality assurance. The integration of information activities means making reuse and exchange of information between the numerous construction parties (nodes) more efficient. The main objective is to minimise the time and resources spent on information retrieval and communication (Bjork 1997). These two types of integration involve: communications; information retrieval; and information distribution. All these functions are well supported by IT tools. Hence, the application of electronic exchange in conjunction with other IT technologies can be applied to these two methods of achieving integration in construction.

The integration of material process whilst providing significant benefit is achieved through relationships between contractor and supplier. This type of integration will not therefore benefit the industry as a whole. The integration of information process activities, such as design, estimating, planning and construction provide the means by which the integration of the major construction disciplines can be achieved.

Shared data resources
The integration of information process activities requires a common communication channel. A shared data resource provides such a channel by acting as a repository for all information relating to a project.

The benefits of a shared data resources are that it allows automatic exchange of data between diverse systems of hardware and software and project information is accurate and readily available. The accuracy and timeliness of information is extremely beneficial as it is a crucial factor in the decision making process (Ahmad 1995).
The exchange of information between construction parties is shown in Figure 4.2. The information flows required to exchange information between parties if a shared project model is implemented is shown in Figure 4.3.

**Figure 4.2** - Representation of information flow between construction professionals

**Figure 4.3** - Representation of information flow between construction professionals utilising a shared project model
**Impact of a shared data resource**

The implementation of a shared data resource would promote integration of operations and functions within and among various construction organisations (Ahmad 1995). Management processes, communication channels and organisational structures would have to be redefined and redesigned to comply with integration requirements and the responsibility of maintaining the shared data resource accurately.

The use of a shared data resource requires good relationships between parties due to the reliance on the information stored in the data resource. Inaccurate or untimely information leaves all parties susceptible to loss. A shared data resource is therefore dependent on fostering good working relationships within a project. Such relationships can be achieved through collaboration approaches, such as partnering, which fosters an atmosphere of team working within a project.

**Technology required for a shared data resource**

The concept of a shared data resource has been widely accepted and is being developed in the form of shared project models. These models are being developed by the International Alliance of Interoperability (IAI). The vision of IAI is “enabling interoperability in the AEC/FM Industry”. The Mission of IAI is “to define and publish specification for the Industry Foundation Classes (IFC) as a basis for information sharing through the project life cycle, globally, across disciplines and technical applications” (IAI 1997).

The development of the shared project model is an ongoing effort which will evolve over the next several releases of the IFC specifications. The current release contains the beginnings of the overall shared project model with initial development of the Architectural, HVAC, Facilities Management and Cost Estimating models (IAI 1997).

The approach of IAI using STEP based technology is recognised as a realistic means of achieving integration in construction (Wix 1997). However, other existing formats for information should not be overlooked. STEP is suited to storing product information, which forms a large part of construction information. However, for commercial information standards such as EDIFACT are far better suited. For example, several man years of work was invested in the development of the bill of quantities EDIFACT standard. This standard represents a very comprehensive, secure and internationally recognised means of storing bill of quantities information, there is no need to replicate this work. The objectives of IAI should therefore incorporate several electronic exchange formats applying the standard relevant to the information involved.
Other projects with the objective of integrating applications for construction utilising STEP technologies are the RoadRobot Project and the VEGA project. The RoadRobot Project (Goncalves et al 1996) is a four year ESPRIT III European project started in 1992, with seven partners coming from different countries and areas of expertise. The projects objective is to develop a generic control architecture to fit the requirements of the construction industry and perform its validation. The validation of the work is being undertaken by implementation on a project using an operator assisted mobile road robot for heavy duty civil engineering application. The main deliverable of this project was a STEP base Integration Platform (SIP) toolkit. This toolkit was developed to integrate existing industry applications and tools. The transfer of information was undertaken by E-mail Data Interchange, working in batch mode between different sites. The information was transferred using the STEP neutral format to synchronise geographically separate systems. This project is successful as the SIP toolkit developed is being used in integration tasks (Goncalves et al 1995).

The objective of the VEGA project is to harmonise STEP, SGML and EDIFACT information standards for the support of integrated and distributed construction project information systems (Debras et al 1997). This project builds upon a CORBA(Common Object Broker Architecture) based middleware layer allowing the distribution of STEP SDAI(Standardised Application Protocol Interface) models. The Distributed Information Service addresses the integration and distribution of project information systems on two levels. First, the conceptual level elaborates on STEP EXPRESS product data models to support SGML(Standard Generalised Mark-up Language ISO 8879) documents and EDIFACT messages by means of EXPRESS meta-models. The implementation level is concerned with the development of dedicated converters supporting translation of SGML documents and EDIFACT messages to the STEP format. This project also aims to utilise client server applications over the internet as a means of providing remote access for all participants involved in a construction project. The global view of the VEGA platform is portrayed in figure 4.4.

**Proposed implementation of a shared project model**

The concept of a shared project is sound but little work has been undertaken to determine how such a model would operate in the construction process. It must be realised that the total process will largely not change. It will still comprise: a feasibility study; a design stage; a tender stage; a construction stage; and a handover stage.

The parties involved in each stage differ, and the availability of data in the project model should therefore vary accordingly. Project team members will only be able to access relevant information.
The management and security of a shared project model would therefore be critical.

![Diagram of a global view of the VEGA platform]

**Figure 4.4** - A global view of the VEGA platform

The management of data in the project model would broadly operate as described below.

*Design stage* - Up to date project drawings, the specification and bill of quantities which are under development are available. These are only available to the design team.

*Tender stage* - Project drawings bill and specification information will be available to a group of selected contractors to allow them to submit tenders. The documents available to the contractors would be stored separately to the working documents which were created by the design team. This would allow work to continue by the design team if necessary.

*Construction stage* - Drawing and bill information would be open to all project team members. At this point the selected contractor would be allowed access to the up to date working drawings.

*Handover* - All information in the project model is archived and handed to the client. This information will be used for the management and further development of the item constructed.

### 4.2.8 Partnering

Achieving the objective set by Latham requires more than just the implementation of IT technologies. Ahmad et al (1995) concludes that whilst IT technologies can assist integration they cannot solve all construction problems. Indeed to achieve the improvements in efficiency of 30%
significant operational changes need to be made. The concept of partnering is currently seen as being one of the means of improving efficiency in a construction project.

Partnering has been defined:

- as a relationship which occurs at a particular time to meet the needs of all parties concerned (Infante 1995);

- as an activity or verb such as agreeing goals or developing a mission statement (Matthews 1996); and

- by its attributes of trust, shared vision and long term commitments. (Matthews 1996; Crowley 1996).

Partnering is a means of removing the negative aspects of the construction industries ACR production network by effectively forming teams that work together with the success of the project providing mutual benefit. To maximise the benefit construction companies have sought to determine how partnering is best used, covering such issues as: suitable project type; roles of key personnel; contractual arrangements; and implications for the supply chain (ECI 1995). The effect of the implementation of electronic exchange in a partnering project has also been investigated. A case study of the use of electronic exchange in a partnering project identified the following benefits:

- reduced data handling;
- improved quality of data;
- improved communication between alliance partners; and
- reduced risk of project delay (Baldwin et al 1996).

The use of IT in a partnering project therefore provides benefit. Indeed Ahmad et al (1996) claimed that enhanced communication enabled by IT will make joint venturing and partnering truly effective in the construction industry. Given the lack of enthusiasm for electronic exchange amongst major construction organisations, partnering may therefore be seen as a catalyst for a change in attitude towards electronic exchange (Baldwin et al 1996).

The dependence of partnering on IT is mirrored by the dependence of IT on partnering. The dependence of IT based construction integration techniques using a shared project model
described above, identified the need for team working. Such an atmosphere can be achieved through the establishment of partnering.

The successful application of partnering and electronic exchange to achieve integration appear to be interdependent. It is therefore reasonable to argue that for: partnering; integration; or electronic exchange to be successful the others will be inevitable. The question is therefore not if, but when, the implementation of electronic exchange technologies will occur.

4.3 **STUDY OF THE EDI IN THE CONSTRUCTION INDUSTRY**

4.3.1 **Introduction**
This section describes a five year study of the status of EDI in the UK construction industry. The study comprised 2 questionnaire surveys held at a five year interval, the first of which was undertaken in 1992. The purpose of the surveys was to determine: the use of EDI in the industry; the plans to implement EDI; and the views of industry professionals of EDI. The results of the two surveys were then analysed to determine the change in status of EDI and to ascertain if the predictions of the first survey were realised.

4.3.2 **Survey Objectives**
The questionnaires were designed to obtain the following information:

- the current status of EDI in the industry;
- the purpose of EDI applications;
- the reasons why EDI has or has not been implemented;
- the perceived benefits of EDI and whether or not they have been achieved;
- the percentage of UK companies who are implementing or considering the use of EDI;
- the message formats which are considered most beneficial to the industry; and
- the EDI standard which is considered the most likely to be adopted by the industry.

In addition the second questionnaire was designed to obtain the following information:

- the view of professionals of the future of EDI in construction; and
- the factors which inhibit the adoption of EDI.
The following section explains the survey methodology and the reason for adopting the mailed questionnaire technique.

4.3.3 Data collection technique
There are two primary methods which have been widely used for data collection. These are; mailed questionnaire and interview (Berelson 1964; Babbie 1973; Brevker et al 1984; Welbank 1987). In this study the mailed questionnaire technique was adopted to obtain representative information and a high response rate.

The mailed questionnaire technique is a self completion form which is designed by the researcher to gather information from individuals located in different areas of the country.

The mailed questionnaire technique was adopted for the following reasons:
- to enable a large number of domain experts throughout the UK to be sampled and to gather information which would have been otherwise difficult to obtain;
- so that responses were available quickly;
- it is a cost efficient method of data collection for the size of the sample; and
- the questionnaire was short and the amount of information required was limited.

4.3.4 Survey planning

Sampling
The sample of construction related companies used in the two surveys was collected by reference to the contractor file 1992, the consultants file 1992 and the Building and Construction Index 1992. The sample was selected by applying a stratified sampling technique (Fellowes and Liu 1997). This included weighting between the disciplines based upon their involvement in the construction process. Contractors have the largest weighting followed by consultants, the remainder having an equal weighting. The sample collected for the first survey was also used for the second survey to provide comparable results.

Design of questionnaire
The design of the questionnaires used for this study was established using the procedures recommended by Fowler(1993); and Prescott(1993). These recommendations include:
(i) the questionnaire must be clear, unambiguous and easy to answer;
(ii) the questionnaire should be attractively spaced and uncluttered;
(iii) the questionnaire should use short sentences and be brief;
(iv) the questionnaire should be written in simple language;
(v) the questions should be ranked in order of importance;
(vi) biased terms should be avoided in order to get a real view from the respondents;
(vii) the questionnaire must be designed to enable easy analysis; and
(viii) the questionnaire should be self-explanatory.

The two types of questions used in this study are described below.
• Open questions (those for which space is provided for the respondents to write their replies).
• Closed questions (those for which a list of acceptable answers is provided to the respondents).
  In some cases a space is provided for respondents to record an answer which does not fit any of
  the preset options.

A copy of the questionnaire is included in appendix C.

Layout of questionnaire
The layout of the questionnaire was carefully considered in order to achieve its objectives. The
approaches used are listed below:
• the important questions to respondents were asked first to gain their interest;
• the questionnaire clearly indicated how to record the answer to each question;
• enough space was allowed for respondents to express their views and record their comments;
• an instruction was included where necessary on where to go next;
• a brief definition was given to some questions where it was necessary;
• questions were consistent in style; and
• questions with similar content were kept together.

Covering sheet
A cover sheet was prepared and enclosed with each questionnaire to provide the respondents with:
• a brief introduction about the research;
• the objectives of the research;
• the confidentiality of the information provided;
• an affirmation that a summary of the survey result analysis would be returned if requested;
• the name and phone number of the person who should be contacted if there was any difficulty
  or queries about the questionnaire.
Testing the questionnaire
Pilot testing is a method used to test the validity of the draft questionnaire by sending the
questionnaire to a small sample and interviewing the respondents once the questionnaires had been
completed.

The pilot testing was conducted to check the following:

- the format of the questionnaire;
- the order of the questionnaire;
- the flow from one question to the next;
- any difficulties in understanding the questions;
- the interest areas of the respondents; and
- the time required to answer the questions.

Survey follow-up
A follow up letter was prepared and posted with a further copy of the questionnaire and a stamped
return envelope to companies who did not respond in the first instance. The purpose of this letter
was to remind the recipients of the importance of their responses and to increase the percentage of
responses.

4.4 The first survey (1992)

4.4.1 The companies surveyed
To ensure the survey produced results which are representative of the construction industry
companies from all major disciplines were sent questionnaires. Questionnaires were circulated to
construction related companies in the proportions shown in table 4.2.

The grouping of “Construction related companies”, in table 4.2 refers to companies that cannot be
placed in the other listed groups, but are involved in construction, eg. material suppliers.

The total number of questionnaires posted was 138. The number of completed questionnaires that
were returned was 56, a return rate of 41%. This return rate compares favourably with similar
surveys.
Table 4.2 - Proportions in which questionnaires were circulated (Sent) and returned (Ret.)

<table>
<thead>
<tr>
<th>Discipline</th>
<th>Sent</th>
<th>Ret.</th>
<th>Discipline</th>
<th>Sent</th>
<th>Ret.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Consultants</td>
<td>20%</td>
<td>21.4%</td>
<td>Contractors</td>
<td>45%</td>
<td>46.4%</td>
</tr>
<tr>
<td>Quantity Surveyors</td>
<td>8%</td>
<td>7.1%</td>
<td>Clients</td>
<td>7%</td>
<td>5.4%</td>
</tr>
<tr>
<td>Architects</td>
<td>8%</td>
<td>8.9%</td>
<td>Design and Build</td>
<td>6%</td>
<td>5.4%</td>
</tr>
<tr>
<td>Construction related</td>
<td>6%</td>
<td>5.4%</td>
<td>companies</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The 56 returned questionnaires can be divided into their respective professional groups, as presented in table 4.2. This shows that the majority of questionnaires were returned by contractors.

A company's perception of EDI may be affected by company size. For example, larger companies may have more interest in EDI as they can afford the implementation costs of a trial system, while these costs may be considered as prohibitive to smaller companies. The questionnaire was posted to companies of varying sizes to minimise the affect of company size in the survey results.

The size of a company can be assessed by two characteristics: the gross turnover; and the number of personnel employed. These characteristics are represented in figures 4.5 and 4.6. These figures show that the companies who returned questionnaires are diverse in size.

![Figure 4.5 - Turnover of companies surveyed](image-url)
EDICON and CITE are associations which are pioneering the development of EDI within the British construction industry. The membership consists of a group of subscribing construction related companies who wish to keep up to date with the latest developments in EDI. The companies in these groups will be more aware of the opportunities offered by EDI, because of their interest in the subject. To provide balanced results the survey sample consisted of both EDICON/CITE members and non-members.

The data collected from the survey is analysed in the following sections.

4.4.2 EDI plans
Few construction companies were using EDI, however many companies had plans for implementation. The time scale of these plans determines the time at which the construction industry reaches an EDI "critical mass". The "critical mass" can be defined as the number of companies, using EDI, that are required to force other companies to adopt EDI, to remain competitive. The attainment of the "critical mass" would therefore cause the rapid adoption of EDI throughout the construction industry.

The questionnaire defined four times scales for the implementation of EDI. These were: immediate; within one year; within five years; and after five years. The time scales of planned EDI implementation for the surveyed companies are shown in figure 4.7. The graph in figure 4.7 shows that no companies claimed to have plans to implement EDI after five years. This concurs with the theory that construction companies do not plan more than five years ahead.
The main division depicted by the graph is that between those companies with and without plans for EDI. 75% of the surveyed companies were either using EDI or planned to use it within five years. This indicated that EDI would be likely to reach its required critical mass within five years, forcing companies who had no implementation plans, to adopt EDI or become uncompetitive.

![Planned implementation of EDI](image)

**Figure 4.7** - Timescale in which surveyed companies intend to implement EDI

Although 21% of companies planned to implement EDI within a year, a greater number were aiming for implementation within five years. This was probably due to the economic climate which forced companies to be more cautious with new investments, such as EDI.

### 4.4.3 Data exchange standards

There are a number of data exchange standards available to EDI users. These standards are suited to specific EDI applications, for example BACS is specifically designed for the transfer of banking information.

The questionnaire asked each respondent to select the data exchange standard which they considered the most likely to be adopted by the construction industry.

The results are shown in Figure 4.8. The high proportion of "don't know" responses highlighted the lack of EDI knowledge in the industry. The results of this question therefore could not provide an indication of which data exchange standard was most likely to be adopted.
3 respondents selected the TRADACOMS or ANSI ASC.X12 standards, 12 respondents selected the EDIFACT data exchange standard. The EDIFACT standard has been adopted by the United Nations and is used by EDICON and EDIBUILD, the European construction industry EDI group.

4.4.4 Message formats

To implement an EDI system each document, to be transferred, has to have a suitable standard message format. The standard message format is designed using a data exchange standard. The construction industry EDI group EDICON has selected the EDIFACT standard for messages. This is discussed in more detail in chapter 2.

The development of message formats is a time consuming process. It can several years to develop a message. The bill of quantities message took 5 years (Lewis 1993). The messages to be developed for the construction industry must therefore be selected with care. The messages developed must not only provide a benefit to the parties involved, but must be considered useful by the construction industry, thus promoting the further use of EDI.
The plans for implementation of each respondent included details of the areas in which they wished to apply EDI. The number of companies who planned to use each message type was calculated and the results are shown in Figure 4.9.

![Figure 4.9](image)

**Figure 4.9** - Messages planned to be transmitted by EDI

The bill of quantities message was the most popular. The second most requested messages was the group of trading cycle messages, the third was the specification message and the fourth was a message standard for CAD data. The remaining message formats had less than 50% of the interest afforded to the bill of quantities message.

The demand for the bill of quantities message was recognised by EDICON who developed a suite of suitable EDIFACT messages. The electronic transfer of trading cycle and CAD data is also required by other industries, hence much work has been undertaken in these areas. There are EDIFACT messages available for trading cycle data which are available to construction companies.
through EDICON. The IGES standard was created to address the electronic transfer of CAD data, but this has been superseded by the PDES (Product Data Exchange Specification) and ISO STEP (Standard for the Exchange of Product Data) initiatives.

The remaining message in the top four required by the construction industry, defined by this survey, was that for specification information. A message for specification had not been developed at this time, therefore the development of such a message, using the EDIFACT standard, was identified as the next priority.

### 4.4.5 Users of EDI (1992)

The main division between the respondents of this survey is between EDI users and non users. The total number of replies to the questionnaire was 56, yet only nine of these were from companies currently using EDI. The low number of EDI users surveyed meant that few firm conclusions could be drawn regarding the nature of the use of EDI in the construction industry. However, the results may be used as an indication to the industry's future use of EDI.

#### Trading partners

To determine the scale on which a company uses EDI, the number of electronic trading partners with which the company trades was considered.

The bar graph in figure 4.10 show the frequency of surveyed companies with: 1 to 4; 5 to 10; and 11 plus trading partners. As figure 4.10 shows the majority of companies only dealt with between 1 and 4 trading partners electronically. This indicates that the companies surveyed used EDI for one purpose, such as banking or they are using EDI on a trial basis.

The number of trading partners with which a company deals electronically can be regarded as an indication of the company's commitment to EDI. As figure 4.10 shows, only two companies had 11 or more trading partners and only 4 had 5 or more.

The results shown in figure 4.10 do not represent a construction industry which is committed to EDI.
No of electronic trading partners

Figure 4.10 - The number of electronic trading partners

Message formats
The disciplines of the trading partners with which a company trades determines the message which the company uses. For example, if a contractor deals electronically with one of its suppliers the data exchanged will take the form of trading cycle messages.

Figure 4.11 shows the number of companies surveyed who dealt with each type of trading partner. The most common EDI trading partners of the surveyed companies, as shown in figure 4.11, were banks and suppliers. This concurs with the message used by the surveyed companies, the majority of which were for transferring trading cycle and banking information.

Data exchange standards
The wide scale adoption of the EDIFACT standard had not occurred in the construction industry. This was largely due to the small numbers of EDI users within the industry, as indicated by this survey. Figure 4.12 shows the exchange standards used by the surveyed companies.

EDIFACT was the most commonly used standard by the surveyed companies, as shown in figure 4.12. This does not indicate the adoption of EDIFACT by the construction industry as only four of the 56 surveyed companies used EDIFACT.

A small number of the surveyed companies used standards such as ANSI ASC X12 and TRADACOMS, as well as, or instead of, EDIFACT. The reason for this was that companies with which construction companies traded may have had established EDI systems, that used older style
standards. Construction companies had adopted these “old style” standards to aid the trading process.

![Figure 4.11 - Electronic trading partners](image1)

![Figure 4.12 - The data exchange standards currently used](image2)

Figure 4.11 - Electronic trading partners

Figure 4.12 - The data exchange standards currently used
4.4.6 Conclusions - first survey

The purpose of the first survey was to determine: the use of EDI in the industry; the plans to implement EDI; and the views of industry professionals of EDI. The results of the first objective proved to be inconclusive due to the lack of respondents who used an EDI system. The only conclusion which could be drawn from these results was that very few companies in the construction industry used EDI.

14% of the companies surveyed used EDI. However, an additional 61% had plans to implement EDI within 5 years. This indicated that EDI would reach its “critical mass” within 5 years, resulting in the rapid adoption of the technology by other construction organisations.

The data exchange standard which respondents considered the most likely to be adopted by the construction industry was EDIFACT. However, 61% of the respondents did not know which exchange standard was likely to be adopted. This indicated a lack of knowledge regarding data exchange standards among respondents, which was due to the lack of EDI experience in the industry.

The plans of the surveyed companies, regarding the implementation and use of EDI, provided an indication of the EDI messages the industry wanted. The messages in most demand were for the bill of quantities and trading cycle information. These had already been developed using the EDIFACT standard. A message for specification information was the third placed message. The development of this message was therefore identified as the next priority for development.

4.5 The second survey (1997)

4.5.1 The companies surveyed

The total number of questionnaires circulated was 180. The number of questionnaires that were returned was 52, a return rate of 29%. This is 12% lower than that of the first survey, and may be a reflection of the reduction in interest of EDI.

The same companies which were sent a questionnaire for the first survey were included in the second survey, with approximately 40 additional questionnaires sent out to maintain the number of responses. The cross section of the professional groups sent questionnaires was consistent between the two surveys.
The discipline cross section of the companies which returned the questionnaire is shown in Table 4.3. The proportion of questionnaires returned from each discipline remained similar to that of the first survey.

<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>21.4%</td>
<td>17.3%</td>
<td>Consultants</td>
<td>46.4%</td>
<td>48.1%</td>
<td>Contractors</td>
</tr>
<tr>
<td>7.1%</td>
<td>5.8%</td>
<td>Quantity Surveyors</td>
<td>5.4%</td>
<td>5.8%</td>
<td>Clients</td>
</tr>
<tr>
<td>8.9%</td>
<td>11.5%</td>
<td>Architects</td>
<td>5.4%</td>
<td>5.8%</td>
<td>Design and Build</td>
</tr>
<tr>
<td>5.4%</td>
<td>5.8%</td>
<td>Construction related companies</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 4.3 - Proportions in which questionnaires were returned for the two surveys

The size of the companies responding can be measured by turnover and number of employees. The companies responding are similar to that of the first survey. The only significant deviation being the increase in companies with a turnover indicating a medium size company, £101 million to £1000 million.

4.5.2 EDI plans

The timescale of EDI implementation plans of the surveyed companies is shown in figure 4.13.

The inspection of the two graphs depicting the plans for implementation of EDI within the surveyed companies shows a distinct similarity between the results of the two surveys. The majority of companies claim to be implementing the technology within five years, as in the first survey, yet if the claims made by companies in the first survey were true there would be a significantly larger EDI user group reported by the second survey. The claim of implementation within five years indicates that the companies are interested, but not enough to invest in a current project, which would be implemented within a year.

4.5.3 Data exchange standards

The data exchange standard considered the most likely to be adopted by the construction industry was CITE in the second survey, second was EDIFACT. This is the only significant change between the first and second survey. The majority of respondents did not know which standard would be adopted, as in the first survey. This could be due to either little knowledge of EDI, or the uncertainty of the future of EDI. This data is shown in figure 4.14.
Figure 4.13 - The timescale in which the surveyed companies plan to implement EDI

Figure 4.14 - The data exchange standards most likely to be adopted by the construction industry

4.5.4 Message formats
The message format considered the most beneficial to the construction industry in the first survey was used to select the specification message for development and the bill of quantity messages for
trial. The results of the second survey (see figure 4.15), however, indicate that the trading cycle messages are those which are considered most beneficial. These messages were available at the time of the first survey. This swing in opinion indicates that resources should be targeted at the pragmatic implementation of such messages within the industry. This result therefore substantiates the pragmatic approach of CITE in the implementation of the trading cycle messages, in addition to the bill of quantities message.

![Figure 4.15 - Messages planned to be transmitted by EDI](image)

**Figure 4.15 - Messages planned to be transmitted by EDI**

### 4.5.5 Users of EDI (1997)

The total number of companies surveyed was 52, yet only 8 were current users of EDI. The percentage of EDI users surveyed is very similar to that in the original survey, and the companies included in this second survey are a superset of the original companies surveyed. This suggests that there has been no increase in the adoption of EDI during the five-year period between the surveys.

**Trading partners**

To determine the scale of EDI activity a company undertakes, the number of electronic trading partners with which the company trades was requested in the survey. The number of partners with which the EDI capable companies surveyed trade is shown in figure 4.16. The total number of EDI users surveyed limits the conclusions which can be drawn from the results. However, there appears to be an increase in the number of trading partners, which whilst not significant, does indicate an increase in the utilisation of EDI in companies that already use the technology. This is an indicator
that the companies which use EDI are beginning to realise the benefits, necessary for expansion to be considered.

Figure 4.16 - The number of electronic trading partners

Message formats

The discipline of the companies with which the EDI capable companies trade is shown in figure 4.17. This graph shows that there has been a change from the predominant exchange of banking and supply information to project related information. The most common trading partners reported in the second survey included consultants, architects, design and build companies and contractors.

Figure 4.17 - Electronic trading partners

Data exchange standards

The data exchange standards used for electronic data exchange provide a direct indicator as to the type of information commonly exchanged. Surprisingly the use of EDIFACT has dropped since the first survey, and the use of DXF a non generic CAD data exchange standard has become dominant (see figure 4.18). Also the use of the CITE standards is new to the second survey. However, due to the small sample no significant conclusions can be drawn from these results.
4.5.6 The perceived future of EDI

Two questions were added to the second survey to provide an insight to the future of EDI in the construction industry and to provide an indicator as to why the use of EDI has not significantly increased in the five year period between the two surveys.

The first question asked the respondents to give their view as to the future of EDI in the construction industry by rating it's future on a scale of 1 to 10, a lost cause to definite success. The results of this question are shown in figure 4.19. The graph shows the majority of respondents did not commit to either a positive or negative response to the future of EDI, by giving an answer of 5. However, it is promising that more respondents provided an answer of greater than 5 than less than 5.

The second question asked the respondents to select from the answers shown in figure 4.20 the factors which are inhibiting the use of EDI in the construction industry. The economic climate is not considered the greatest inhibitor, which indicates a positive feeling within the industry since the end of the recession of the early 1990's. The three factors that were significant are: the dislike of change; the lack of benefits; and the lack of awareness. These three factors are best overcome by education of the industry as a whole as to the advantages of electronic trading. This indicates that
there is a need for the CITE and EDICON organisations to improve their profile within the industry to aid the success of electronic trading.

Figure 4.19 - Rating of the future of EDI in the construction industry

Figure 4.20 - Factors inhibiting EDI in UK construction industry

4.5.7 Conclusions - second survey

The purpose of the second survey was the same as the first survey, which was to determine: the use of EDI in the industry; the plans to implement EDI; and the views of industry professionals of EDI. In addition to this purpose the second survey was also used to determine if the findings of the first survey would still be valid five years later, and to provide an insight into the future of EDI in the construction industry.
The growth of EDI predicted by the EDI plans reported by the first survey (see figure 4.7) has not been realised. This is indicated by no significant increase in the percentage of EDI users from the survey sample. This in turn means that the survey results from the EDI user group, whilst indicating a change to more pragmatic EDI solutions, eg. DXF and CITE, are not significant due to the small survey sample.

The first survey identified the bill of quantity and specification messages as the most beneficial messages. These messages were therefore selected for trial and development respectively. The message formats now considered most beneficial are those used for trading cycle information. This change could be due to the realisation of the industry that trading cycle information represents the highest volume data transfers. This indicates a more pragmatic approach to the technology, thus reinforcing the approach of the CITE initiative.

The surveys indicate that the future of EDI is still uncertain, with the majority of respondents unwilling to deviate from a non committal response when questioned on their view of this issue. However, the factors inhibiting EDI identified by the respondents can all be resolved by an increase in EDI education, thus suggesting the need to put greater effort into promoting EDI by EDICON and CITE organisations.

4.6 Construction EDI survey findings of other research studies

Gibson and Bell - A survey of EDI software and Case study of EDI Application

Gibson and Bell (1990) undertook a survey of PC software packages and described a case study of EDI implementation. The survey consisted a review of vendor literature and an examination of representative PC software packages. This review yielded the following points.

- Translation software packages are simple to configure for use with a trading cycle related application.
- EDI software is generally capable of supporting multiple EDI standards, including ANSI X.12, UCS, WINS and EDIFACT.
- Software provides a number of management tools including tools for: tracking of ingoing and outgoing documents; file management; printing; report generation; document purging; standard template design; and database maintenance.

This survey therefore indicates that there is little technical difficulty with implementing EDI with trading cycle related applications.
The case study presented is of Construction Industry Institute (CII), the US construction industry group, members implementation of EDI for transmitting purchasing related information. The system consisted of a PC running translation software which interrogates a mainframe and transfers new or modified records. The system was initially implemented to transmit purchase orders, but was later modified to include EDI invoicing and fund transfer.

The following conclusions were drawn from the case study.

- A PC is recommended as a means of establishing an initial system.
- A manual purchasing time cycle of 23 days was reduced to 8 days.
- Processing cost savings of $389 000 had been achieved.

The work of Gibson and Bell (1990) concentrated largely on the technical aspects and tangible benefits of EDI implementation, as these areas were regarded as of greatest interest at the time. However, this work did yield a few pointers as to the importance of management issues, in particular the identification of the need for top management support to achieve a successful EDI implementation.

O'Brien and Al-Soufi - A survey of communications technologies

O'Brien and Al-Soufi undertook a survey of communications technologies applied in the construction industry. In particular this work concentrates on the communications technologies which O'Brien and Al-Soufi (1993) had identified earlier as having the effect of bringing trading partners closer together and altering business relationships and methods of working.

The following information was concluded from the survey.

- PC/DOS computers are prevalent in the industry
- 50% of respondents utilised a Local Area Network.
- The majority of data exchange internally is financial in nature.
- There appears little attempt to alter methods of working, by introducing new practices or re-engineering processes.
- 6% of companies used EDI to exchange information between companies.
- The majority of data exchange between organisations is financial in nature.
- There is minimal use of communications technology to support construction processes.
• 16% of respondents had an e-mail facility with only 3% having an external connection.
• The lack of use of e-mail was credited to economic considerations.
• EDI is spreading through the industry through a process of exposure to the technology, coming from trading collaborators or direct competitors.
• EDI is still in its formative stages in the industry.
• EDI is primarily used to support ordering and accounting processes.
• The quality of software available and the difficulty to integrate with existing system was noted from respondents.
• EDI is seen to be a particularly expensive technology.
• EDI is primarily used by building materials manufacturers and suppliers.

The survey undertaken by O'Brien and Al-Soufi is clearly more comprehensive than that of Gibson and Bell, and more importantly this second survey considers the management aspects of electronic exchange in more detail. These conclusions also indicate the low level of EDI implementation and the concentration on the exchange of financial/trading cycle related information by manufacturing/supply organisations in the industry. The total lack of application of EDI to construction processes with no consideration of process re-engineering is also symptomatic of the application of EDI being in its formative stages in the industry.

Murray and Thorpe - Site communications survey
Murray and Thorpe (1996) undertook a study of site communications as part of the COMPOSITE(COmmunication by computer between Main Participating Organisations on SITE) project which formed part of a study co-funded by the DoE and 6 industry partners. The study consisted two parts: a questionnaire survey; and a survey by interview.

The following conclusions were drawn from this study.
• Suppliers and sub contractors account for 90% of all communication with the main contractor on site.
• Quantity surveyors and planners are biggest users of computers on site.
• Most communication is paper-based, second to verbal. Electronic communication is low and largely undertaken by disk transfer.
• General correspondence was identified as an area with the greatest potential for improvement through the application of IT. Other site documentation, originated
from project managers, quantity surveyors and site planners was identified as offering the least potential benefit. These results indicated a lack of education of respondents in the possible applications of IT.

- Volume and feedback of site information were identified as major problem areas. The exchange and awareness of information was also identified as a problem by the main contractor's site team.
- Use of e-mail on site is very low.
- Those using e-mail felt it had not reduced time spent communicating with other members of the project team when compared to traditional methods.
- Both questionnaire and interview respondents were apprehensive about e-mail, particularly due to loss of face to face contact and computer illiteracy.
- ISDN is little used, 50% of sites have modems and 30% had access to remote sources of data.
- 90% of sites state that IT equipment is purchased as a site decision, not as a company strategic decision.
- 87% of sites felt IT had not been fully exploited with e-mail and internet access being selected as the most popular evolving technologies.
- The need for IT training before new technologies are implemented was identified.

This study concentrated on site communications, but is clearly more contemporary than that of O'Brien and Al-Soufi with the use of the internet being considered, though not for purposes of construction integration. This study indicates that there is still little use of electronic exchange on site. Significantly, the implementation of IT on site is not occurring as part of a company strategy. This situation needs to change, otherwise it would not be possible to implement a company wide electronic communications strategy.

**Akintoye - Construction industry EDI survey**

Akintoye(1997) undertook a questionnaire survey of main contractors, sub-contractors and building materials' suppliers and manufacturers. The objective of this survey was to determine: the scale of EDI use; the function of EDI use; reasons for implementation; benefits of EDI; barriers to use of EDI; and the industry's view of EDI.
The following conclusions were drawn from this study.

- 30% of all respondents use EDI.
- 62% of material manufacturers and 40% of builders merchants use EDI.
- 8% (2 respondents) of main contractors and 11% (1 respondents) sub contractor use EDI.
- 13 contractors, 2 sub-contractors, 6 material manufacturers and 3 builders merchants claimed to be either implementing EDI or undertaking a pilot project. These potential users are included in the EDI function statistics below.
- 67% of EDI users exchange invoice information.
- 48% of EDI users exchange purchase order information.
- 18% of EDI users exchange bill of quantities information using CITE standard.
- Main contractors are the only group using bill of quantities exchange.
- Sub-contractors, material manufacturers and builders merchants only use EDI for trading cycle information exchange.
- Reasons for adoption, in order of influence: competitive advantage; customer pressure; competitors; and supplier pressure.
- Benefits of EDI in order of importance: enhanced customer/supplier relations; reduced operational costs; reduced paperwork; competitive advantage; and improved cash flow.
- Barriers to EDI use, in order of effect: lack of awareness; proliferations of SME’s; cost; lack of messages standards; and separations of design and construction processes.
- Reasons for not implementing EDI, information gathered from respondents who do not use EDI, in order of importance: no customer/supplier demand; current systems are inadequate; no worthwhile benefit; it is not suited to the construction industry; and cost.
- General comments were reported regarding the lack of support from EDICON and the CITE initiative has 'gone quiet'.

This survey clearly indicates that the majority of EDI users in the industry are material manufacturers and builders merchants, using the technology for the exchange of trading cycle messages. The response from main contractors and sub contractors is negligible (3 respondents), whilst the reported use of the CITE standards is mainly for pilot applications of the technology. The reported benefits show customer relations and reduce operational costs as the major responses,
which again is indicative of using the technology for high volume, trading cycle message exchange. The barriers to use and reasons for not implementing EDI centre on the lack of awareness and lack of perceivable benefit. However, the affect of the industry’s structure is also reflected, with responses stating that the proliferation of SMEs is a barrier to EDI and that the technology simply does not suit the industry. Finally, the lack of support from EDICON and CITE is noted, which indicates a reduction in implementation drive from these organisations.

4.7 Summary

The analysis of case studies to compare the application of EDI in construction and other industries identified three key conclusions.

• The two key factors for success are high data volumes and the use of EDI to achieve re-engineering.
• EDI implementation is largely driven by clients.
• The successful applications of EDI in construction are similar in nature to those of other industries. They concentrate on the exchange of high volumes of trading cycle information.

The construction industry must consider two types of information exchange. Implementation of EDI for trading cycle information based on transaction efficiency and accuracy improvements alone. The implementation of EDI for industry specific information would require re-engineering to be successful.

The use of electronic exchange has not increased as predicted in the early 1990s. EDI in particular has not taken hold in the industry. The transfer of technical information has increased largely due to the expansion of CAD, and e-mail, whilst expanding, is mainly being used for internal communication.

To determine why the use of electronic exchange is low three areas, which have an impact on implementation, were investigated. These areas were: industry issues; electronic data exchange issues; and business case. The following factors were identified as a possible cause.
• **Industry issues**
  Industry structure
  Complexity of data flows
  Reluctance to invest
• **Electronic data exchange issues**
  need for standards and message formats
  need for application translators
  security concerns
  legal issues
  high cost of communications
  most users prefer paper-based documentation
• **Business case**
  There is no clear business for electronic exchange in construction

The electronic data exchange issues would be the result of the transition to electronic exchange and would therefore not be long term problems. Industry issues and the lack of a business case however require more detailed consideration. The fragmented nature and complexity of the data flows are significant inhibitors which are compounded by the unwillingness to invest in new technologies, particularly such technologies which do not have a clear business case to support their implementation.

The key technical and management implementation issues were investigated to identify any additional items which require attention to succeed. The technical issues of implementation are straightforward. However, the implementation of electronic exchange requires two areas to be considered: process and organisational change; and the need for staff to be receptive. These two issues require an electronic exchange project to be driven by senior management to succeed.

The benefits of electronic exchange were investigated, both tangible and non-tangible. To achieve these benefits it was concluded that it is necessary to change work practices in the industry. This concurs with the conclusion from the case study matrix which identified re-engineering as one of the key requirements for success in the industry.

The success of EDI in construction is dependent on re-engineering. The benefit that this would afford needs to be quantified. The work of Back and Bell (1995) and Carter et al (1996) indicated
that cost savings in the range of 40% to 75% are achievable through re-engineering indicating that these benefits would be significant.

The integration of information activities was identified by Bjork(1997) as a means of re-engineering the industry. The use of a shared data resource in the form of a shared project model is one way of integrating the industries information activities. Three initiatives were investigated which utilise STEP technology to provide a shared project model: IAI; RoadRobot; and VEGA. The VEGA project is in one respect more complete than the other two as it incorporate EXPRESS meta models to allow the storage of SGML documents and EDIFACT messages in the project model. This initiative also recognises the need to provide access to the project model for all participants in a construction project, it is proposed that this is achieved by means of internet client-server applications. The use of such a project model is transposed onto the traditional construction process and a tentative application of such a model is presented.

Finally the concept of partnering was investigated and it was concluded that partnering may provide the best opportunity to drive the implementation of electronic exchange.

Five year study of EDI in construction

The five year study of EDI in the construction industry identified the following points.

1992 survey
- EDI was little used in 1992 (9 respondents).
- 75% of companies either used EDI or planned to implement it within five years, hence critical mass of EDI should be reached.
- EDIFACT considered most suitable EDI standard.
- Lack of knowledge of EDI identified.
- The three messages considered most useful: bill of quantities; trading cycle; and specification.
- EDIFACT standard most commonly used.

1997 survey
- EDI little used in 1997 (8 respondents)
- 70% of companies either used EDI or planned to implement it within five years.
- CITE considered most suitable EDI standard.
• Lack of knowledge of EDI re-affirmed.
• Message considered most useful: trading cycle; and bill of quantities.
• DXF standard most commonly used.
• Non-committal response from industry as to the future of EDI.
• The inhibitors for implementation identified: dislike of change; lack of benefits; and lack of awareness.

Other surveys
• Other surveys (Gibson and Bell 1990; O'Brien and Al-Soufi 1994; Murray and Thorpe 1996; Akintoye 1997) all indicated that EDI is little used in construction.
• The surveys of other researchers also showed a shift from a concentration on technical issues (Gibson and Bell 1990) to the concentration on management and business issues (O'Brien and Al-Soufi 1994; Murray and Thorpe 1996; Akintoye 1997).
• Use of EDI is concentrated on the exchange of trading cycle information (O'Brien and Al-Soufi 1994; Akintoye 1997)

This study clearly indicates that the potential application predicted in 1992 was not realised. The application of electronic exchange has also shifted to technical information, probably due to the expansion in the use of CAD. Interest in EDIFACT has dropped, being replaced by the more practical approach of CITE. However, there is still a significant requirement to improve awareness of electronic exchange technologies in the industry.
Chapter 5
Application of data modelling techniques to the construction process

5.1 Introduction

To facilitate the development of a new EDI message format for any industry it is necessary to identify the complete set of information flows within the industry that are suitable for transfer by EDI. Once this set of information flows has been identified a single flow can be selected for development by applying further criteria. To aid the identification of a complete set of information flows modelling techniques can be applied to the process in question.

This chapter presents an information flow model of the traditional construction process. In the first part of this chapter information modelling tools and techniques are investigated, by means of a literature review. A modelling technique is then selected to model the construction process. The modelling technique selected is the Data Flow Diagram, this technique is described in detail.

A Data Flow Diagram of the information flows in the traditional construction process, as defined by the RIBA, is presented. The information flow model produced was the result of the synthesis of existing construction process literature, examples of which include McCaffer and Pasquire (1987) and NEDO (1990). Once a flow model has been developed it must be validated. The model of the construction process was validated by circulating it to members of the construction industry for comment. The model was then reviewed and modified in accordance with these comments. This process of development was repeated until the industry representatives involved agreed the model accurately represented the traditional construction process.

The Data Flow Diagram of the construction process allows the easy interpretation of all information flows. The model is used to identify the different flow types which occur during the construction process. In particular information flows suitable for EDI are identified. A single flow was then selected for development, using criteria formulated from the study of EDI in construction presented in chapter 4.
5.2 Methods for modelling information flow

5.2.1 Hard and Soft System Modelling Techniques

System modelling can be undertaken using either a hard systems or soft systems approach. The hard systems approach is used to model well understood systems or processes (Nesan 1997). However, often systems and their processes are difficult to define. In these cases a soft systems approach is adopted. Wilson (1984) described soft systems methodology as “a seven stage process of analysis which uses the concept of a human activity as a means of getting from finding out about the situation to taking action to improve the situation”. The seven stages are described below, and illustrated in figure 5.1.

1. Problem situation unstructured
2. Problem situation expressed
3. Root definition of relevant systems
4. Conceptual models
5. Real world systems and comparison
6. Feasible and desirable changes
7. Action to improve.

(Checkland 1981)

Figure 5.1 - Soft Systems Methodology Model (Checkland 1981)
The processes and information flows in the system which is known as the traditional construction process can be defined. A hard systems approach was therefore selected for the modelling of information flows that occur during the construction process.

There are many hard system methods of representing information flow in the form of a model, all of which have been developed from the methods of structured design.

Structured design is an approach to the design process that produces a hierarchical system model. The structured design process is undertaken in a top-down manner. The term top-down means a system is considered firstly from a high level in which each module is being described simply. The modules in the high level model are then considered individually and defined in more detail by a separate model. This produces a hierarchy of models which represent the system at a number of levels of detail. This approach produces systems which are both maintainable and provable.

5.2.2 The purpose of system modelling tools

Why system modelling tools were developed
Clear, understandable models play an important role in designing complex information systems and developing computer software.

“one of the reasons building and maintaining software systems is so expensive and error prone is the difficulty we have in clearly communicating our ideas to one another.”
(Martin and McClure 1985)

The purpose of system models therefore is a means of communication between information system developers, for example software engineers. The focus of a systems analyst or programmer is to be able to communicate the systems content to the user, hence models have to be easily understandable.

Yourdon (1989) states that system models are built for three reasons:
1. To focus on important system features while downplaying less important features.
2. To discuss changes and corrections to the user's requirements at a low cost and with minimal risk.
3. To verify that we understand the user's environment and that it is documented in such a way that systems designers and programmers can build the system.
Who uses system modelling tools

The study and analysis of the flow of information forms the basis of the work of a systems analyst. The role of a systems analyst can be summarised as follows:

“A systems analyst studies the problems and needs of an organisation to determine how people, methods, tasks, and computer technology can best accomplish improvements for the business. When computer technology is used, the systems analyst is responsible for the efficient capture of data from its business source, the flow of that data to the computer, the processing and storage of that data by the computer, and the flow of useful and timely information back to business users” (Whitten et al 1986).

The techniques utilised by systems analysts, and software engineers, for their work can be given the title of structured systems analysis. Structured analysis is not only used by systems analysts, it can be used by anybody to model any system. Thus the tools developed for systems analysis can be utilised for the modelling of construction process information flows.

Criteria of a good system modelling tool

Yourdon (1989) stated that any modelling tool should have the following attributes:

- It should be graphical, with appropriate supporting textual detail.
- It should allow the system to be viewed in a top-down, partitioned fashion.
- It should have minimal redundancy.

The graphical nature of modelling tools is required to allow easy interpretation of the model. The structure of the model represents the structure of the system. Text is used to describe each element in the model.

A model designed in a top-down structure uses a hierarchy of models to describe the system. The ‘top’ model portrays the complete system in a small number of modules which are described simply. Further models are used to describe each of these models in more detail. There can be any number of levels of hierarchy, depending on the complexity of the system. The top-down design of a model ensures it is both provable and easily maintainable. It is therefore desirable to use a modelling tool which is based upon the top-down philosophy to incorporate these qualities in the model developed.
Redundancy is the repetition of information in a model. The second, third and fourth occurrences of information in a model add no further value to the model as a whole, they are therefore considered redundant. Redundancy becomes a problem when a model is modified. If a piece of information is altered all the occurrences of that information must also be altered. If there is just one occurrence of each piece of information there is no problem. However, if there are a number of occurrences it is easy to forget to alter one. This would create an inconsistency in the model, making it both confusing and incorrect. A good system modelling tool should therefore encourage the minimisation of redundancy in the models created.

A list of system modelling tools
Structured systems analysis includes many system modelling tools, these include: action diagrams; Bachman diagrams; data flow diagrams; decision tables; decision trees; entity-relationship diagrams; Ferstl diagrams; flowcharts; functional decomposition; Hamilton-Zeldin diagrams; HIPO diagrams; Hoss charts; IDEFO diagrams; Jackson data structure diagrams; SADT diagrams; PAD diagrams; state-transition diagrams; structure charts; system flowcharts; and Warnier-Orr diagrams. For further details of these methods see: De Marco (1978); Gane and Sarson (1979); Newton(1995); and Hassan (1996).

5.2.3 System modelling tools
The system modelling tools which were considered for use in this research are describe in this section.

System flow chart
A system flow chart portrays a sequence of activities, the respective controlling mechanisms and the involvement of the parties in the process (Nesan 1997). A flowchart is divided into a number of columns which relate to the party responsible for a process. An activity is represented by an rectangular box, a decision is represented by a diamond shape box, terminators are represented by flat ovals and connectors are represented by circles. An example of a system flow chart is shown in figure 5.2.

Data flow diagram
Data flow diagrams are used to model the flow of data through a system between system bodies and processes. The model describes the system from the point of view of the data and therefore shows the transformation of the data resulting from the processes in the system. Ensuring a system undertakes the processing as required by the user is very important, hence models
displaying this information have to be accurate and clear. A Data flow diagram incorporates the three aspects required of a model which portrays system processes. These are: the functions the system must perform; the transformations the system must carry out on the information; and the information sources and results destinations.

![A system flowchart](image)

**Figure 5.2 - A system flowchart**

**Entity relationship diagram**

Entity relationship diagrams are used to model stored data. For example, they are used to design relational databases. The entity relationship diagram portrays each set or group of data in the system as an object and details their inter-relationships. An entity is any object or event about which someone chooses to collect data. An entity may be a place, a thing, or an event. Relationships are associations between entities. There are one to one, one to many and many to many relationships. An example of an entity relationship diagram is shown in figure 5.3.

**State transition diagram**

State transition diagrams are used to model time-dependent behaviour. Figure 5.4 is an example of a state transition diagram.
Structure chart

The structure chart is the tool used for designing a modular, top-down system model structure. A structure chart is simply a diagram consisting of boxes, which represent the systems modules, connected by arrows. The positioning of the modules and the direction of the arrows indicate the hierarchy of the system (see figure 5.5). The module on the first level controls the modules to which it is connected on the second level. Similarly the modules on the second level control the modules on the third level to which they are connected. Additional smaller arrows are placed along side the main arrows to indicate that something is passed down to the lower module or back to the upper module.

Figure 5.3 - An entity relationship diagram

Figure 5.4 - A state transition diagram
Structure Analysis and Design Technique (SADT)/IDEFO

SADT is a graphical technique to aid systems description which was originally developed to describe a system from any environment (Marca and McGowan 1988). IDEF0 is a standardised version of SADT produced by the US Department of defence.

A SADT diagram contains boxes and arrows, the boxes represent activities and the arrows the interfaces between them. The arrows can represent either inputs, outputs, controls or mechanisms. Each activity box can represent another SADT diagram, thus allowing a hierarchy of diagrams. To keep the diagrams readable and succinct they are limited to a total of six boxes.

An SADT diagram is produced by functionally decomposing systems and producing a hierarchy of diagrams, from the most general to the most specific (Newton 1995). A set of diagrams is therefore required to describe a complete system. A generic example of a SADT diagram is shown in figure 5.6 to show the function of each arrow connected to an activity box.

5.2.4 Selection of the system modelling tool

The application of system modelling tools to the research

The system modelling tool selected must be suitable to portray the information flows between parties which occur during the construction process.

Attributes that determine the model to be used

To select a system modelling tool first it is necessary to determine the scope of the information which is to be modelled. Second the target audience of the model must be selected, this will determine the information detail and attributes to be included in the model. These two factors will determine the system modelling tool to be utilised.

Identification of these attributes for the research model

The model for this research is required to represent the information flows that occur during the construction process. The information flows to be considered are those which occur between parties involved in the process, flows which are internal to a party are not included. For example, the movement of contract documents within a contracting organisation. The modelling tool selected must therefore be capable of portraying the flow of data between entities. This requirement excludes: system flow charts, which do not effectively portray the information flows amongst entities (Nesan 1997); entity relationship diagrams, which do not portray data flow; state
transition diagrams which focus on system states and processes; and structure charts, which portray the structure of the components of a system.

The model will be passed to industry representatives for comment, and therefore must be easy to interpret by these representatives. The ease of interpretation of a model is key to its usability. The use of SADT diagrams would result in a very large number of diagrams, due to the scale of the system being modelled. The model produced would therefore be difficult to interpret. Also it is difficult to portray dialog between parties, which is common during the construction process, using SADT diagrams (Hassan 1996). This further excludes the SADT modelling tool.

Figure 5.5 - Structure chart

Figure 5.6 - An SADT/IDEF0 diagram
System modelling tool selected

The data flow diagram (DFD) was selected as the tool best suited to the modelling of the construction process. The first reason for this selection is that the data flow diagram is a hard systems modelling tool, which are used to model systems that are well understood, such as the construction process. The second reason is that data flow diagrams are used to represent the flow of data between entities, which is analogous to the exchange of information between construction parties. The final reason for selecting the data flow diagram is that it provides documentation of a system from the point of view of the data. As data populates the whole system, the model produced would provide an overview of the system under consideration, which is easy to interpret. This point is affirmed by Gane and Sarson (1979) who state:

"The Data Flow Diagram is documentation of a situation from the point of view of the data. This turns out to be a more useful viewpoint than that of any of the people or systems that process the data, because the data itself sees the big picture."

5.2.5 Components of a Data Flow Diagram

A Data Flow Diagram (DFD) is formed from four basic components, these are the data flow, the process, the data store and the data source/sink. Each of these components is described in more detail in the following paragraphs.

The process

The first component is the process, this can also be referred to as a bubble, a function, or a transformation. The process represents a transformation of one or more inputs into one or more outputs.

There are three graphical methods of representing a process, the most common is the circle (or bubble) as adopted by Yourdon and De Marco, the second is an oval (or a rectangle with rounded corners) as suggested by Gane and Sarson, and the third is a rectangle which is used in SADT (Structured Analysis Design Technique) based DFD's. See figure 5.7.

The process is named or described with a single word, phrase or simple sentence which describes what the process does. Alternatively the name may be a reference to the person or group of people who undertake the process.
Figure 5.7 - Three methods of representing a process

The data flow

A data flow is represented by an arrow between two entities which can be a process, a source/destination or a store. The arrow not only represents a flow of data but also the direction of the flow. Flows can either be referred to as an input or an output flow depending upon the frame of reference, see figure 5.8.

Figure 5.8 - An input Flow and output Flow

A data flow may also represent a dialogue between two entities, this takes the form of a double headed arrow. A dialogue is a convenient packaging of two data flows (eg. an inquiry and response) on the same flow (Yourdon 1989). In the case of a dialogue, each data flow is named. Each name is placed at the arrow head which represents the data flow, see figure 5.9.

Data flows can diverge or converge in a DFD. In the case of a diverging flow duplicate copies of the data flow are sent to each recipient. Conversely, in the case of a converging data flow the
source data flows are joined together to form one data flow which contains all the data in the source flows.

![Diagram of a dialogue flow](image)

**Figure 5.9 - A dialogue flow**

**The data store**
The data store, as the name suggests, stores the data received from the input data flows attached to it. The store is given a name which describes the data which it holds. Typically, the name chosen to identify the store is the plural of the data that are carried by the flows into and out of the store (Yourdon 1989).

There are three recognised graphical representations of a data store, each of which is associated with a graphical modelling convention. Figures 5.10 parts (a),(b) and (c) show data stores as represented by the Yourdon, Gane and Sarson, and De Marco conventions respectively.

**The data source/sink**
The final component of a DFD is the data source/sink, which can also be referred to as an external entity. A data source/sink represents entities that pass data to, or receive data from, the system. These entities are also external to the system which is being modelled, for example a data source/sink may represent another system which is modelled by a separate DFD.

![Three methods of representing a store](image)

**Figure 5.10 - Three methods of representing a store**

The graphical representation of a data source/sink is a rectangle, this is the case for the Yourdon, Gane and Sarson, and De Marco conventions (see figure 5.11).
5.3 An information flow model of the construction process

5.3.1 Scope of the construction process model
To create an information flow model of the construction process the scope of the model must first be defined. The purpose of the model is to assist the identification of information flows in the construction industry. The construction process identified in this work is that defined by the RIBA(1973) as the traditional construction process.

Information flows exist between the various companies involved in the construction process. Information also flows between the various work groups and individuals within each of these companies. The consideration of the information flows both internal and external to each organisation involved in the construction process would create a 'complete' model of the process.

The 'complete' model of the construction process would be complex. This model would also include many assumptions and compromises. Compromises would have to be made because of the varied nature of construction projects and operational differences between companies. For example, one contractor may undertake procurement of materials from it's sites while another may undertake procurement centrally from it's head office. The 'complete' model of the process would also be so large that it would be difficult to interpret. The 'complete' model does therefore not provide a suitable means of representing the construction process. A means of reducing the information considered and hence simplifying the model is required.

To simplify the model it's purpose must be considered, which is to aid the identification of information flows that could be replaced by an EDI message. The model should therefore only represent the information flows that are external to the organisations/parties involved in the construction process.

5.3.2 Structure of the external information flow model
The traditional construction process consists of a number of stages. These stages are well defined and documented in the RIBA's plan of work (RIBA 1973). The process model has been divided
into parts that represent these distinct stages. However, the stages were selected to suit the portrayal of the process model, hence the model doesn't strictly follow the RIBA plan of work.

The process model is divided into the following stages to represent the construction process.

<table>
<thead>
<tr>
<th>Stage</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inception and Feasibility</td>
<td>This consists the original commission by the client, followed by the production of a feasibility report for the client.</td>
</tr>
<tr>
<td>Design stage</td>
<td>The design process consists of the development from a general outline specification, through the scheme design to the production of the tender drawings, specifications and bills of quantities.</td>
</tr>
<tr>
<td>Tender stage</td>
<td>This stage portrays the tender process, the result of which is the selection of the main contractor.</td>
</tr>
<tr>
<td>Site Operations stage</td>
<td>This stage represents all information flows resulting from site operations.</td>
</tr>
<tr>
<td>Handover</td>
<td>The handover stage consists of the production of defects lists, so that the contract is obligated to complete unfinished or inadequate work. The submission of the final accounts and payments signify the completion of the project. It must be noted that monies withheld for a maintenance period are not shown in this model.</td>
</tr>
</tbody>
</table>

5.3.3 **Definitions of sources/sinks depicted in the process model**

The flow model of the construction process includes a number of information sources and sinks. These sources/sinks have been given descriptive names to aid their identification. However, a few of the sources/sinks require a more detailed description than that provided by their title. These are listed, with a complete definition, below.
PQS  
- Professional Quantity Surveyor  

CLIENT'S REPRESENTATIVE  
- This party is appointed by the client to ensure the project is completed satisfactorily whilst maintaining the client's interests. In projects which consist of a large building element the architect usually acts as the client's representative. Similarly, if a project consists of a large mechanical element, structural element, or electrical element the relevant consulting engineer is usually appointed as the client's representative.

STATUTORY BODIES  
- These include the companies which provide the statutory undertakings: water; electricity; and gas.

CONSULTANTS (DESIGN CONSULTANTS)  
- These entities represent the consulting engineers. These may include: structural; drainage; mechanical; and electrical engineers.

SPECIALIST CONTRACTORS  
- These entities represent sub-contractors which specialise in a certain field. These parties can be a useful source of information regarding their particular discipline, eg. mechanical engineering contractor.

5.3.4 Model of the construction process  
The model produced is divided into the sections defined earlier in this chapter. The process model is based on the traditional tender based form of contract. Other forms of procurement, eg. design and build, are not represented by this model.

A number of simplifications were made to the model during the production of the process model. For example, there are a number of separate consultants involved in a project but all of these are grouped under the general title of 'consultants'. The simplification of the process model has the
benefit of increasing the ease of interpretation, which is of fundamental importance to good data model design.

The Gane and Sarson data flow diagram conventions were used to produce the information flow model of the construction process.
Figure 5.12 - Inception and feasibility study

**Inception and feasibility study (see figure 5.12)**

**Flow**

<table>
<thead>
<tr>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Commission</td>
</tr>
<tr>
<td>Client to client’s representative.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Commission</td>
</tr>
<tr>
<td>Client’s representative to PQS.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Request for quote * (T)</td>
</tr>
<tr>
<td>Request for quotation from manufacturer/contractor.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quote * (T)</td>
</tr>
<tr>
<td>Quotation from manufacturer/contractor.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost report</td>
</tr>
<tr>
<td>Report of costs produced by PQS.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feasibility report</td>
</tr>
<tr>
<td>Feasibility report produced by client’s representative.</td>
</tr>
</tbody>
</table>
Figure 5.13 - Design stage
### Design stage (see figure 5.13)

<table>
<thead>
<tr>
<th>Flow</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Design co-ordination</td>
<td>Letters, faxes, memos and architects drawings.</td>
</tr>
<tr>
<td>Quotes and advice</td>
<td>Quotations and advice provided by manufacturers and specialist contractors.</td>
</tr>
<tr>
<td>Building regulations*</td>
<td>Regulations enforced by the local authorities.</td>
</tr>
<tr>
<td>Planning approval*</td>
<td>Documents submitted to request planning approval.</td>
</tr>
<tr>
<td>General outline specification*</td>
<td>General project specification, this will not necessarily form any part of a</td>
</tr>
<tr>
<td></td>
<td>detailed specification at the end of the design process.</td>
</tr>
<tr>
<td>Liaise to produce scheme design</td>
<td>Communications between consultant, quantity surveyor and client's representative to produce the scheme design.</td>
</tr>
<tr>
<td>Scheme drawing</td>
<td>CAD</td>
</tr>
<tr>
<td>Specification*</td>
<td>Specification of project components.</td>
</tr>
<tr>
<td>Costs*</td>
<td>Outline costs.</td>
</tr>
<tr>
<td>Product data*(P)</td>
<td>Information on the latest products. STEP product models are currently being developed.</td>
</tr>
<tr>
<td>Technical advice</td>
<td>Advice with respect to particular products and their use.</td>
</tr>
<tr>
<td>Project drawings</td>
<td>Detailed drawings. Separate items for each discipline, eg. mechanical, structural and electrical.</td>
</tr>
</tbody>
</table>

162
<table>
<thead>
<tr>
<th>Task</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project specification*</td>
<td>Detailed specification. Separate items for each discipline.</td>
</tr>
<tr>
<td>Outline project specification*</td>
<td>Outline specification for project, including relationships between specifications produced by consultants.</td>
</tr>
<tr>
<td>Request for quote*(T)</td>
<td>Request for quotation from manufacturer, distributor or contractor.</td>
</tr>
<tr>
<td>Quotation*(T)</td>
<td>Quotation from manufacturer, distributor or contractor.</td>
</tr>
<tr>
<td>Liaise to produce design</td>
<td>Telephone calls, letters and passing of documents relevant to the design. eg. partial specifications and drawings.</td>
</tr>
</tbody>
</table>
Figure 5.14 - Tender Stage
<table>
<thead>
<tr>
<th>Flow</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Invitation to tender *</td>
<td>Invitation to submit a tender.</td>
</tr>
<tr>
<td>Tender documents *</td>
<td>Specifications, drawings and bills of quantities.</td>
</tr>
<tr>
<td>Request for quote *(T)</td>
<td>Request for quotation from distributors or manufacturers.</td>
</tr>
<tr>
<td>Quotation * (T)</td>
<td>Quotation from distributors or manufacturers.</td>
</tr>
<tr>
<td>Specific product details *(P)</td>
<td>Phone calls, faxes and literature.</td>
</tr>
<tr>
<td>Tender reports *</td>
<td>Reports on submitted tenders to assist evaluation.</td>
</tr>
<tr>
<td>Discuss</td>
<td>Meetings and phone calls, agreed by letter.</td>
</tr>
<tr>
<td>Negotiation</td>
<td>Meetings and phone calls, agreed by letter.</td>
</tr>
<tr>
<td>Contract documents *</td>
<td>Conditions of contract, bills of quantities, specifications and drawings.</td>
</tr>
<tr>
<td>Invitation to tender *</td>
<td>To sub-contractors and suppliers.</td>
</tr>
<tr>
<td>Tender prices *</td>
<td>Prices for tender items.</td>
</tr>
<tr>
<td>Orders with contract documents *</td>
<td>Contract with suppliers and sub-contractors.</td>
</tr>
</tbody>
</table>
Figure 5.15 - Site Operations Stage
Site operations stage (see figure 5.15)

<table>
<thead>
<tr>
<th>Flow</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Request for quote * (T)</td>
<td>Request for quotation from distributors or manufacturers.</td>
</tr>
<tr>
<td>Quotation * (T)</td>
<td>Quotation from distributors or manufacturers.</td>
</tr>
<tr>
<td>Order * (T)</td>
<td>Purchase order to distributor or manufacturer.</td>
</tr>
<tr>
<td>Invoice * (T)</td>
<td>Invoice from distributor or manufacturer.</td>
</tr>
<tr>
<td>Payment * (T)</td>
<td>Payment to distributor or manufacturer.</td>
</tr>
<tr>
<td>Monthly valuations * (T)</td>
<td>Valuation of work completed each month.</td>
</tr>
<tr>
<td>Claims *</td>
<td>Report of claims for additional payments.</td>
</tr>
<tr>
<td>Variations *</td>
<td>Variations to work specified.</td>
</tr>
<tr>
<td>Financial implications *</td>
<td>Relating to variations.</td>
</tr>
<tr>
<td>Valuation certificate *</td>
<td>Certificate detailing value of work carried out by the contractor.</td>
</tr>
<tr>
<td>Programme of progress *</td>
<td>Regular progress reports. Also updating of programme as project progresses.</td>
</tr>
<tr>
<td>Drawing revisions</td>
<td>CAD.</td>
</tr>
<tr>
<td>Quality control and test data *</td>
<td>Test data may be in many forms depending on the testing company.</td>
</tr>
<tr>
<td>Topic</td>
<td>Description</td>
</tr>
<tr>
<td>-------------------------------</td>
<td>---------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Design</td>
<td>Design information may be sketches, CAD, faxes, letter or verbal by telephone.</td>
</tr>
<tr>
<td>Variations *</td>
<td>Variations to work specified.</td>
</tr>
<tr>
<td>Site instructions *</td>
<td>Instruction to undertake work not specified in original contract documents.</td>
</tr>
<tr>
<td>As-built drawings</td>
<td>Drawings detailing project as it was built.</td>
</tr>
<tr>
<td>Owners manual</td>
<td>A document produced by the contractor, often made up from suppliers and manufacturers catalogues.</td>
</tr>
<tr>
<td>Information is passed to the relevant consultant for action</td>
<td>This may result in communications between the consultant and the contractor.</td>
</tr>
<tr>
<td>Regular reports *</td>
<td>To keep client informed of progress.</td>
</tr>
<tr>
<td>Building control</td>
<td>Local authorities ensure the project is “acceptable”.</td>
</tr>
<tr>
<td>Variations *</td>
<td>Between main and sub-contractors.</td>
</tr>
<tr>
<td>Claims *</td>
<td>Between main and sub-contractors.</td>
</tr>
<tr>
<td>Drawing revisions, instructions and programmes</td>
<td>Between main and sub-contractors.</td>
</tr>
<tr>
<td>Technical advice</td>
<td>Between consultants and specialist contractors.</td>
</tr>
</tbody>
</table>
Figure 5.16 - Handover Stage

Handover (see figure 5.16)

Flow | Description
---|---
Defects lists * | Any outstanding work at handover.
Final account * | Account of all work carried out and monies due, including variations.
Make payment * | Payment of funds in accordance with contract.
5.3.5 Data flow types

The data flows in the construction process can be categorised into three types. These types are: trading cycle data flows; product data flows; and project cycle data flows.

Trading cycle data flows

The trading cycle is the process by which products or services are bought and sold, or traded.

The trading cycle consists of the following data flows:

- request for quotation;
- quotation;
- purchase order;
- invoice; and
- payment.

There are also a number of other flows which may occur during the process, but these are not commonly used.

The data flows in the trading cycle are similar for trade in all industries. Industries such as retail and manufacturing have recognised the potential of trading electronically both in terms of improved business processes and cost reductions. These industries have developed EDI messages for the trading cycle data flows. Trading cycle messages have been developed using the ANSI X12, Tradacoms and EDIFACT standards. The messages developed using the EDIFACT standard have been adopted by EDICON for use by the construction industry. The general nature of the trading cycle process and the thorough development of these EDIFACT messages resulted in the need for very little or no modification to make the messages suitable for the construction industry. These messages have been ratified by the United Nations and are available to the construction industry for all trading cycle data flows. Examples of these messages include PORDER (Purchase order message), INVOIC (Invoice message), and REQ (Request for quote message).

Product data flows

Product data flows represent flows of product information. For example, product information from a supplier to a customer. Product information can take many forms including: technical specifications; drawings; photographs; and general descriptions. Catalogues and pamphlets
produced by a supplier do not conform to a standard format, their layout and content is totally at the discretion of the supplier.

The volume of information required to describe a product and the lack of standardisation in product information currently available has hindered the transfer of product information by electronic data interchange methods. This complex issue is currently being addressed by the STEP and IAI initiatives. These initiatives have the objective of producing standard product models to facilitate the electronic transfer of product information (see chapter 2). The task of producing the many complex product models required for the construction industry is in progress. The transfer of product data using EDI technologies, for all construction related products, is possible, but the commitment required by suppliers and customers currently outweighs the benefit.

**Project cycle data flows**

Project data flows are flow types which are specific to construction industry projects. These flows are the information flows in the construction process other than those included in the product data or trading cycle groups.

Project cycle data includes a wide range of information that can be divided into two groups: CAD or technical data; and construction management information in the form of text.

**Technical data**

Drawings are used to convey the majority of construction information. Hence, the efficient storage and transfer of this information is vital to the construction process. Traditionally drawings were produced by hand, however, the majority of tender drawings are now produced using Computer Aided Design (CAD) applications. In 1991, the construction industry accounted for approximately 50% of all CAD usage in the UK, with a total of 15,984 users (CICA 1991) and by 1993 the use of CAD had reached saturation in the industry with 89% of consultants, 92% of architects and 71% of building services engineers using the technology (KPMG 1993).

Computer Aided Design has proven to be one of the leading areas of computer implementation in the construction industry. The past decade has seen the introduction of many CAD systems and the emergence of the AutoCAD system as the de facto standard for the construction industry.

The popularity of the AutoCAD package has resulted in its DXF data exchange standard being the most commonly used in the UK (Howard 1991)(Chevin 1990). Many other CAD packages support
the DXF standard, thus allowing the majority of CAD users to exchange data electronically. The transfer of drawing data using the DXF standard has proven very popular and has provided users with an indication of the benefits afforded by electronic data interchange.

The DXF standard has proven to be a successful method for drawing data exchange in the construction industry. However, the DXF standard should not be accepted as an EDI standard for the following reasons.

1/ The DXF standard is a standard developed for a particular application and therefore its capabilities are limited by the functionality of this application.

2/ AutoCAD is not as popular in industries other than construction or in countries other than the UK.

3/ The DXF standard is not an internationally accepted graphical data exchange standard.

The STEP/IGES/IAI standards, developed over the past decade, are the currently accepted generic graphical data exchange standards. These are described in detail in chapter 2.

Construction management data

The information transferred to manage a construction project takes the form of textual information. Examples of this type of information flow include: the bill of quantities; the invitation to tender; the specification; and site instructions.

Construction management information flows are specific to the construction industry. The specific nature of this type of information flow means the construction industry has to develop suitable EDI messages for these information flows. The conservative nature of the construction industry has resulted in slow progress in the development of such EDI messages.

The EDICON group initiated the development of EDI messages for the construction industry. The group first concentrated on trading cycle message. This work has been completed. EDICON also developed some messages for construction specific data, including the bill of quantities messages set. The process of producing EDI messages for construction specific information does involve a significant amount of work as other industries do not provide assistance. The development of these
messages is therefore a slow process. The CITE initiative provides a means of avoiding this long development process, by developing simple yet practical message solutions for the industry. However, it must be remembered the CITE messages do not provide a long term solution as their development is far less rigourous and they are not accepted for international application.

5.3.6 Data flows suitable for electronic data interchange

The production, viewing and interpretation of the information flow model identified that for an information flow to be theoretically suitable for EDI, it must have certain characteristics in common with EDI message flows.

The characteristics which must be the same are described below.

1/ Each flow must be one-way. A series of one way flows can be combined to form a flow which can be produced by either party involved.

2/ The flow must be well defined in both structure and content.

The one way nature of the flows does not demand that a response is produced to any flow. The term one way indicates that the structure and content of the information flows is not produced interactively, as is the case with a two-way “conversation”.

An EDI message is designed to a fixed set of criteria. These criteria determine the structure and content, whether optional or mandatory, of the message. The fixed nature of an EDI message therefore does not lend it's use to interactive or “conversational” information flows.

The information flows suitable for EDI are identified in the notes for each part of the process model. Each flows which is considered suitable for EDI using the criteria defined above is marked with an asterisk.

The suffix (T) denotes the information flow is part of the Trading cycle. The suffix (P) denotes the information flow contains product data.

5.3.7 Priority of the development of construction messages

An inspection of the data flow model (figures 5.12 to 5.16) and its notes shows that the majority of information flows that occur during the construction process are suitable for transfer by electronic
data interchange. The development of new standards and messages to facilitate the electronic transfer of information flows is a time consuming process, therefore it is important to ensure the information flows which will benefit most from EDI have suitable standards and messages developed first.

To determine the priority of development the different types of information flow identified will be considered. The information flows for trading cycle data, product data and Drawing data have standards to facilitate EDI developed or currently under development: EDIFACT messages are available for trading cycle information; IGES/STEP standards are available for drawing data; and the STEP/IAI standard is currently being developed to facilitate the transfer of product data.

The information flows which have been placed in the construction management group have had the least resources invested in the development of suitable EDI messages. This group of messages can also provide significant benefit and is key to the industry wide adoption of EDI in construction. For these reasons an information flow from this group was selected for development into an EDI message.

The first survey of EDI use in the industry (see chapter 4) was used to determine which construction management information flow should be developed. The result of this survey showed that the five messages considered most beneficial, in order of priority, were:

- bill of quantities;
- trading cycle;
- specification;
- CAD; and
- design information.

EDICON have published EDIFACT messages for bill of quantities related information flows and all the trading cycle information flows. The development of an EDI message for specification information flows was therefore selected as the next priority.

5.4 Summary

This chapter presents an information flow model of the traditional construction process which was developed to identify information flows that could utilise EDI.
First an investigation of system modelling techniques identified the Data Flow Diagram selected as the best suited to modelling the information flows of the construction process. The data flow diagram (DFD) was selected for the following reasons:

- the DFD is a hard systems modelling tool, which are used to model systems that are well understood, such as the construction process;
- the DFD is used to represent the flow of data between entities, which is analogous to the exchange of information between construction parties; and
- a DFD provides documentation of a system from the point of view of the data, as data populates the whole system, this provides an overview of the system under consideration.

The information flow model was then developed and validated.

Information flow types identified in the construction process by the model were: trading cycle; product data; and project cycle. Where project cycle flows comprise technical data and construction management data.

Information flows were identified as suitable for EDI if they complied with the following criteria: each flow must be one-way, a series of one way flows can be combined to form a flow which can be produced by either party involved; and the flow must be well defined in both structure and content.

This analysis of information flows indicated that the majority of flows could utilise EDI technology.

The specification information flow was selected as the next priority for EDI message development. This selection was made because of the following reasons:

- EDI message development for construction management information flows is poorly resourced compared to other information flows types.
- The first survey (see chapter 4) identified the specification information flow as the most beneficial if exchanged using EDI, excluding information flows for which messages have already been developed.
Chapter 6
Investigation of the message development process

6.1 Introduction

The development of an EDI message should be undertaken in a logical manner. However, there are no development guidelines which describe the process from beginning to end. The design of EDIFACT messages within the UK is undertaken using guidelines set out by SITPRO (Simpler Trade Procedures Board) in their publication entitled "Guidelines to message design" (SITPRO 1993b). However, these guidelines only address the design of messages and not the development of their content and structure. The message design guidelines are also general and therefore cannot be applied directly to every industry. Each group involved in message development therefore has to evolve a method of working appropriate to their own particular requirements.

The first part of this chapter describes a message development process which has been formulated from the experience of message developers in the EDICON organisation with additional information being elicited from the SITPRO publication. The development of the methodology described was undertaken by active investigation of the process. First, a series of interviews were held with Peter Vice of EDICON who imparted his view of the process. Peter has several years experience of message design both in the EDICON group and working with MD5, the construction section of the West European EDIFACT Board. The notes taken during these interviews were used to develop a draft methodology. This methodology was then reviewed with the assistance of members of EDICON. Modifications were identified and incorporated in the document. Several review cycles were undertaken until the methodology reflected the development process.

The analysis of the first survey presented in chapter 4 and the information flow model of the construction process presented in chapter 5 identified the specification data flow as the next priority for message development in the UK construction industry. The EDIFACT EDI standard was selected in chapter 2 as the best suited to the transfer of construction related commercial information.

The second part of this chapter describes the development of a description data model, the main component of a specification message, as a means of testing and validating the methodology. The
author adopted an action research style (Fellows and Liu 1997) by undertaking the development of the data model.

A description data model was selected for development as it could be incorporated in not only a specification message but in invoice, purchase order and bill of quantities messages. The data model produced was reviewed by an industry working party, and finally validated by codifying sample specifications.

6.2 Message development process

The message development process consists of two stages: Data Analysis; and Message design.

The purpose of the data analysis stage is to create a standard data model which represents the original documents. This is undertaken by dissecting many examples of the current document used for the traditional transfer of the data under consideration. The data model which is developed provides a method of examining the data involved in the manual exchange that is independent of any existing format. Message design consists of using the developed data model as the basis from which the equivalent EDI message is created. The EDI message can either be a direct conversion of the data model or alternatively the data model can merely be used as a point of reference from which the message can evolve. The standard used for the EDI message has no impact on the data analysis stage of the process. However, the message design stage is dependent on the EDI standard employed.

The two stages, of the message development process, are described in detail in the following sections.

6.3 Data analysis

The objective of the data analysis stage is to produce a data model of the documentation that is currently transferred. The data model can then be used to aid the design of the EDI message.

1. The first stage of the message design process is to form an industry-led message development team. The members of this team are needed throughout the design process, to provide experienced views on current practice and the practical use of the message in the industry.
These contacts can also be a source of sample documents of the type the message is to address. It is necessary to have large quantities and a wide variety of sample documents, to ensure that the majority of possible variations that occur in the industry are accounted for in the data model.

2. Once the sample documents have been collated, a team of people must be organised to analyse the data within the documents. This team should consist of people from the industry as well as people who can think logically and possess analytical skills, for example people with an information technology background.

The team members from industry are required to ensure that the data model produced represents the actual practices of the industry. For the purposes of this research they will be referred to as the industry team. Those team members who undertake the data analysis will be referred to as the data analysis team.

3. The data analysis team undertakes the first stage of the data analysis which is to inspect the sample documents. Every item of data on each document is analysed. For example the title page of the document may consist of the company name and address, project title and the date.

Each item of data is given a data type, a status, a character type, a character length and the maximum number of repetitions. The meanings of these item details are explained in the following paragraphs, with suitable examples employed as necessary.

The data type of an item is a description of the data stored within the item. For example a data type could be the delivery address or a product identification number of a piece of equipment.

The data model and message will be of a generic form. Hence not every data item is required for every message. Some data items, however, are necessary in the information flow to make it understandable to the receiving party or legally acceptable. This leads to the concept of mandatory and conditional data items. To denote whether an item is mandatory or conditional the item is given a status, which is either a “M” for mandatory or a “C” for conditional.

A data item can consist of one of three character types, depending on the data contained in the item. The three character types are numeric, alphabetic and alphanumeric. These are denoted by “n”, “a” and “an” respectively.
The length of a data item can vary, however, each item is given a maximum number of characters, as this aids data processing. If there is insufficient space within a data item, a second identical item should be used. For example 5 data items can be used to store up to 5 different quantities.

If it is necessary to repeat a data item then the maximum permissible number of repetitions should be noted next to the item within the data model. If only one occurrence of an item is necessary then a repetition of one should be noted.

The process of identifying every item of data is time consuming and must be carried out for each sample document. However, the majority of data types in each document are repeated in all similar documents. Once the first document has been analysed the majority of the data analysis for all other documents has therefore been carried out. The analyst must be thorough as a data item that is repeated could contain more or different character types, which must be accounted for in the model.

4. The data items that form the document should be grouped together to produce a logical model. This will make the model more understandable and will also aid data processing. For example the Buyers details can be grouped together. This group could include their company name, address, telephone number, Buyer department, employee name, telephone number, Buyer's correspondence contact department, name and telephone number. An example of a group of data items can be seen in figure 6.1.

<table>
<thead>
<tr>
<th>Reference</th>
<th>Price Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unit price</td>
<td></td>
</tr>
<tr>
<td>Price type</td>
<td></td>
</tr>
<tr>
<td>Measure unit</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>C</th>
<th>M</th>
<th>n..15</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>C</td>
<td>an..2</td>
</tr>
<tr>
<td>C</td>
<td></td>
<td>an..3</td>
</tr>
</tbody>
</table>

Figure 6.1 - An example of a group of items

The grouping of items may be carried out on more than one level, i.e. a group of items can be contained within another group of items.

An example of this occurs within the former design of the purchase order message. Each ordered item is given an item line which is a group of information relevant to that order. This includes
package details, transport details and scheduling details. Some of the data items within the line item are in fact groups of items themselves. For example the transport details group contains location identification and date/time references.

In the data model a group of items will usually require some of the details that a single item requires. Additional data is therefore needed to distinguish a group of items from a single item. The details that a group of data requires are a group type, a status and a maximum number of repetitions.

The type, or title, of a group of items describes the type of data items within the group. For example a group may have the title of Reference Price Information, which would include unit price, price type and measure unit specifier data items.

A group of items is given a mandatory or conditional status based on the same basis as for individual items. The items contained within a group, however, are given a mandatory or conditional status depending on whether they are necessary for the group, rather than the message as a whole.

An individual item can be repetitive, similarly a group of items can also be repetitive. A maximum number of repetitions should therefore be noted for each group, within the data model.

The grouping of the data is best undertaken in parallel with the analysis of the data, step 3. If steps 3 and 4 are carried out separately, time is wasted as the details of each item have to be relearned so that the analyst can group them. This is not necessary if the data is grouped as it is analysed.

5. The sample documents originally collated have a format in which the data they contain is presented. The data model, similarly, must have a format, or structure, so that when a computer receives a message it can be processed.

The form of the message should portray the document in a logical manner, so that it is easily understood. It should, however, be noted that the form of the message will not necessarily be that of the original paper document. The message should be in a form that aids data processing within computer applications, which usually leads to a more abstract form.
A purchase order can be used as an example of the form of a message. The purchase order is divided into three main sections, into which the data items and groups of data fit. These sections are described below:

i) The first section is the header which contains all the buyer, supplier, delivery and distributor data.

ii) The body is the main section which contains the data for each item ordered, such as its description, quantity and unit price.

iii) The tail section contains data regarding the totals of the order, including the total monetary amount, any bonus or trading discounts and the reference to the payment terms.

This type of format can be regarded as a data picture, (see figure 6.2), and can be used as a template in which to fit the information items. A data picture such as this can be developed for any data model and hence provide a format for the complete message.

![Diagram of an EDI message format](image)

**Figure 6.2 - Example data picture of an EDI message**

6. Once the formulation of the data picture is complete it is a simple task to place each data item or group into its relevant position. When this task is complete the resulting document can be regarded as the first draft of the data model.

7. The draft data model must then be passed on to the industry team who can evaluate the model's structure and contents.
The industry team are likely to make many comments and criticisms regarding the data model. This is because the people involved in the development up to this stage are not necessarily experienced in the practical use of the document.

The input from the industry is of great importance because these people are in effect the "customers", as they will ultimately be using the message, for real projects. The comments and criticisms from industry should be understood and relevant modifications to the model should be made accordingly. The process of message design is therefore seen as an iterative process that, over a series of revisions, produces the optimum message design from both a data processing viewpoint and the viewpoint of industry practitioners.

6.4 Considerations during the data analysis process

During the data analysis stage it is essential to maintain a strong reference point for the document. This allows a full understanding of it's purpose within the industry as well as how it is related to other documents and processes.

It is also important to ensure that every member of the data analysis team has the same perception of the document, otherwise misunderstandings and confusion will occur during the analysis process. To ensure this a diagram can be used to portray the documents position within the industry's cycle.

An example of this is the bill of quantities message. To maintain a reference point a data flow diagram was used to demonstrate how the document fits into the construction project cycle (see figure 6.3). During the tendering stage of the project the bills of quantity document is passed between the PQS/CLIENT and the TENDERER on the Request For Tender. Sections of the document are also used to request quotes from suppliers and sub contractors.

While undertaking the data analysis process, the uses of the document by different parties should be considered. The members of the design team can place themselves in various industrial roles to determine the requirements placed on the document by each position in industry. The requirements defined by this role playing can then be used to develop the data model, ensuring that it is suitable for the industry.
6.5 Message design

The completion of the data analysis stage results in the production of a data model of the document that is required to be transferred by EDI.

The next stage of the message development process is that of message design, which consists of converting the data model into an EDI message. The message design process is specific to the EDI standard used. This section describes the message design process for the EDIFACT standard. This standard was selected as it is the EDI standard selected in chapter 2 as the most suitable for the exchange of commercial construction industry information and it is similar to several other standards including Tradacoms and ANSI X.12.

There are three stages to the message design process which are: data element selection; data segment selection; and message structuring. It is preferable to undertake these processes simultaneously, as if they are undertaken separately a re-acquaintance period is required each time the message designer returns to a different part of the message.

Figure 6.3 - Project cycle information flows
Components of an EDIFACT message

An EDIFACT message is built from Data Elements and Data Segments, as described below.

An EDIFACT message can be defined as the whole document, which is made up of sections. The sections, or lines, of the message are known as Data Segments. The Data Segments are made up of several data items, which are known as Data Elements. A Data Element may contain a code, which identifies, for example, the units of another data element. Such codes are usually selected from a standard directory which is included in the EDIFACT Standard Segments Directory (EDSD).

Design process

At this stage the message designer should have a list of data items, groups and sub groups that fit into the form of a data model. The data model can now be converted into an EDIFACT standard message.

1. Data elements

The first step of converting the data model into an EDIFACT message is to identify the data elements which are required to satisfy the function of the message. The data elements selected may not relate directly to individual data items as described in the data model, but the whole set of data elements must describe and fulfill the function of the data model. Each data element is assigned a unique EDIFACT reference, known as a tag (SITPRO 1993a).

A simple data element can have three forms:

i) Where the element requires no form of qualification. An example of which, in tag (a unique EDIFACT reference number) , name and format order, is:

1296 Contract Number AN..17

(AN..17 means an alphanumeric variable of up to 17 characters)

ii) Where it requires qualification - a qualified data element could be:

3884 Communication Number AN..25
On its own, "Communication Number" has no specific meaning, for example, it could be a FAX number, telephone number, etc. In order to identify its function, a qualifier is associated with it.

iii) Where it gives another Data Element a more precise meaning - a qualifier. An example of a qualifier could be :-

3887 Communication Number Qualifier AN.3

(SITPRO 1993a)

A United Nations Rapporteur's Advisory and Support Team (RT) exists in each area, which has an EDIFACT database available. This database contains current directories covering Universal Standard Messages, and directories which specify approved standards for code sets, data elements, data segments, and messages. The data element directory stored in this database should be used to identify the data elements required for the data model.

As the data elements are identified for the message, each should be checked against the UNTDED Data Element Directory and its code sets to determine its standard format and representation.

The process of data element selection, although simple, is considerably time consuming requiring many man months of effort. However, the time involved is reduced as the message designer becomes familiar with the element directory and the technique of matching EDIFACT elements to information items.

The matching of data elements to data items and groups leads to the modification of the data model to match the EDIFACT standard. This occurs because the standard elements used to create an EDIFACT message will not exactly match the data items or groups in the model. Ideally this should not compromise the information stored within the message.

If there is a requirement for a data element or code which is not specified in either the EDIFACT database or the UNTDED Data Element Directory, a request can be channelled through the local RT to create a new element or code. The inclusion of a new element or code inevitably delays the validation process of the message by the United Nations, but is unavoidable particularly when creating messages for new areas of industry.
**Composite data elements**

Composite data elements are groups of conceptually linked items of data. There are five typical uses of composite data elements and these are detailed below. Please note that tags are not shown in the following examples.

i) Data element and Qualifier.

   \textit{eg.}
   
   DATE/TIME
   
   Date/time qualifier (Qualifying the remainder of the composite data element)
   
   Date
   Time
   Time Zone

ii) Code and clear representation of a data element.

   \textit{eg.}
   
   DEPARTMENT IDENTIFICATION
   
   Department code
   Department name

iii) Multiple iterations of the same data element in a series.

   \textit{eg.}
   
   NAME AND ADDRESS ITEM NUMBER GROUP
   
   Address Item Number
   Address Item Number
   Address Item Number
   Address Item Number

iv) Small groups of conceptually related component elements having a close inter-relationship.

   \textit{eg.}
   
   LOCATION
   
   Location - coded
   Code List Identifier
   Location - clear text
   Sub-Location
v) Mandatory data, where the inclusion of one, two or more of the components will meet the mandatory requirement at the group level.

eg.

GROUP (Mandatory)

Component 1  (Conditional)
Component 2  (Conditional)
Component 3  (Conditional)

(At least one of the components must be present)

The mandatory and conditional status of the group and it's elements can be in any combination, to account for different data element requirements.

Codes

Codes are used in data elements, for example to indicate the units of a value stored in the following element. There is a list of standard codes held by the local RT secretariat, which are suitable for the majority of requirements. If, however, a suitable code list does not exist one should be defined in conjunction with the local RT. It is preferable for existing internationally codes to be utilised (e.g. ISO, IATA etc.). If this is not possible it is necessary to define a new code list.

Once a new code list has been defined it is the responsibility of the local RT to co-ordinate the adoption of the new list with other RT's.

2. Data segments

In addition to the selection of data elements the message designer must select the data segments to be used. A data segment is formed from a series of data elements, and represents a line of information in an EDIFACT message. A simple segment conveys the information it contains by means of a three letter tag. The components of an example data segment are shown below.

<table>
<thead>
<tr>
<th>Segment tag</th>
<th>CNT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Function of segment</td>
<td>Specifies Container Details</td>
</tr>
<tr>
<td>Data elements in segment</td>
<td>CONTAINER NUMBER; SIZE AND TYPE; MOVEMENT DETAILS; etc.</td>
</tr>
</tbody>
</table>
A qualified segment is a segment that requires a qualifier to define its function. The components of an example qualified data segment are shown below.

<table>
<thead>
<tr>
<th>Segment tag</th>
<th>Function of segment</th>
<th>Data Elements in segment</th>
</tr>
</thead>
<tbody>
<tr>
<td>NAD</td>
<td>To specify any number of name and address details.</td>
<td>NAME AND ADDRESS SEGMENT QUALIFIER;</td>
</tr>
<tr>
<td></td>
<td>(according to the value of the segment qualifier)</td>
<td>PARTY IDENTIFICATION; NAME AND ADDRESS; etc.</td>
</tr>
</tbody>
</table>

The segment qualifier is placed directly after the segment tag, as the first data element in the segment, and is separated by the data element separator. In the actual EDIFACT message the qualifier of a segment tag would be shown:

'QSC+Q+......'

QSC - Qualified Segment code
Q - Qualifier
+ - Separator.

Selection of data segments
The selection of data segments occurs in parallel with the selection of data elements, as the logical groupings of certain data elements form the data segments.

It is preferable to select all the data segments for the message from the UNSM Standard Segments Directory, which is attainable from the local RT. Standard user data segments can be described as those having common functions, required for use across a broad spectrum of industry, administrative and transport applications (SITPRO 1993b). The use of standard user data segments reduces the time required to design a message and allows conformity on a pan-industry and international basis.

The data segments must also have either a mandatory or conditional status, as had the data items in the original data model. The data model should be used to determine the status of each segment.
Non-standard data segments
If the message requires a segment that is not listed in the standard segment directory two courses of action may be taken.

The first is the modification of existing segments. It is acceptable to omit data elements in data segments, if the element are removed from the end of the segment. It is not possible to remove elements from the middle of a segment. Alternatively, if there is not a suitable qualification for a standard segment, which otherwise could be used, it is possible to request additional qualifiers to the standard list. The two techniques of modification described above should be undertaken in conjunction with the local RT.

If it is not possible to modify an existing segment it is necessary to define an application oriented segment. This, however, is more time consuming and must also be undertaken in conjunction with the local RT.

3. Message structure
Every EDIFACT message must conform to a simple structure consisting of a start segment, the central user defined section and the last segment. The first and last segments of an EDIFACT message are mandatory service segments. The first segment is called the UNH, or message header, segment, which details the message type and version, and the last segment is called the UNT segment, or message trailer segment, which indicates the end of the message.

The structure of the central user defined section is entirely dependent on the information being transferred, and therefore its design is an important stage of the message development process.

The data model defined by the data analysis process can be used as the basis of the message structure. The structure, however, is also affected by the standard segments and data elements used to represent the information stored in the data model. The processes of data segment selection and message structuring are intrinsically linked, and should therefore be undertaken in parallel.

The easiest way to design the message structure is to use a diagrammatic format. The type of diagram best suited for the purpose of message structure design is known as a branching diagram.
Branching diagrams

A branching diagram is used to show the structure of the message in such a way that it can be easily understood. An example of a branching diagram is shown in figure 6.4. This shows the header section of the purchase order message.

A branching diagram portrays the order in which data from the EDIFACT message is processed. The order of processing is identical to the order in which the message is read, as described below.

A branching diagram is read by starting from the top left hand corner. You proceed by reading to the right. If a vertical group of segments is encountered you read downwards. Once all the segments within a vertical group have been read the reader should proceed, from the top of the vertical group, to the right. The arrows on the example, in figure 6.5, demonstrate the order in which it should be read.

The diagram is divided into a number of levels. The segments or segment groups that are in level 0 only occur once within any message, if a segment or segment group occurs more than once it must appear on level 1 or below.

Figure 6.4 - Branching diagram

The example diagram shows a grouping of segments, group number 1. The group is given a status, "C" in this case, and a maximum number of occurrences. The group title segment occurs on the same level as the group header. All component segments must appear on a level below the group header.
Figure 6.5 - How to read a branching diagram

The boxes that represent each segment consist of the segment title, the segment status and the maximum number of occurrences of the segment, see figure 6.6.

Similarly to the data items in the data model, the data segments in the message must also have a status of either mandatory or conditional. The status of a segment is determined by the status of the data items it represents in the data model, or by the configuration of EDIFACT segments in the message. A segment is given a status “C” for conditional, or “M” for mandatory.

Groups of segments can be defined, see figure 6.5, that are either mandatory or conditional, and their components are given a status dependent on their requirement to the group, rather than to the message as a whole.

The number following the status of a segment determines the maximum number of occurrences of the segment. A segment marked, M 1, must occur once in the message. A segment marked, C 1, may occur in the message, but only once.
The form of an EDIFACT message

An EDIFACT message is not transmitted in the form of a branching diagram, but in the form of an ASCII file. A simple syntax is used to separate the data elements and segments. It is convention that each segment is placed on a new line, segments are separated by an apostrophe, "'". Single data elements in a segment are separated by a plus, " + ", and composite data elements in a segment are separated by a colon, " : ".

The repetition of segments is shown either explicitly or implicitly, only one of these forms can be present in any message. The implicit method of repetition is the preferred technique, an example of which is shown in figure 6.7.

```
UNH+......data.....'
AAA+......data.....'
BBB+......data.....'
CCC+......data.....'
DDD+......data.....'
CCC+......data.....'
DDD+......data.....'
DDD+......data.....'
EEE+......data.....'
FFF+......data.....'
FFF+......data.....'
UNT+......data.....'
```

Figure 6.7 - Example of implicitly portrayed segment and segment group repetition
The UNH and UNT segments, in figure 6.7, indicate the start and end of the message, with the AAA to FFF segments representing the user-defined section of the message. CCC is an example of a segment group, it contains two DDD segments, and occurs twice in the message.

It is not necessary to transform the branching diagram into an actual message format, as this form of message will only exists within a computer, and is therefore not relevant to the message development process.

4. Documentation
The final stage of message design is to provide documentation so that the design can be easily understood by the users of the message. The minimum documentation that should be produced consists of the following:

i) A document which details the applications of the message within the relevant industry.

ii) A document which details all segments in the message.

6.6 Development of a description data model

The specification message was identified as the next priority for development in chapter 5. This decision was based upon the first survey presented in chapter 4 and the information flow model presented in chapter 5.

The development of a message, or part message, consists two parts, data analysis and message design. The first part, data analysis, determines the functionality of the message. A data model is the result of the first stage of the message development process. As this stage is the least well defined, the knowledge acquired through an actual data modelling exercise would help in the validation of the data analysis stage described earlier in this chapter. The second stage of message development, message design, is the process of converting a data model into an EDI message. During this stage of the process no value is added to the message. The exercise of converting the data model produced into an actual EDI message would therefore be of little benefit. These reasons in addition to the limited time available to undertake the work, determined that only the data analysis stage of message development would be undertaken.
The development of a specification message was considered over a number of months and discussed with EDICON representatives. The result of these discussions was the modification of the objective to a smaller, but more significant subject area, the development of a structured description data model. The development of a description data model was selected as it is an essential building block of a specification message and could also be utilised in the EDIFACT bill of quantities message group and the EDIFACT trading cycle message group.

6.6.1 Structured description data modelling working party

A working party was formed to provide guidance in the development of a description data model. The working party was selected from a number of parties interested in the application of EDI in the construction industry. The working party comprised two EDICON representatives, five industry representatives and three construction related academics. The EDICON representatives had several years experience of data analysis, and therefore were ideal to guide the process. The industry representatives were selected to provide the practical knowledge of how a specification is used. The academics provide a different viewpoint of the use of specifications and undertook the administrative tasks of the working party.

The structured description working party comprised the following members.

Peter Vice                John Laing/EDICON
Charles Rogers            EDICON
Geoffrey Ashworth         Monk Dunstone Associates
Phil Oliver               Trafalgar House Construction
Ivan Dickason             COSTAIN Construction Division
Mike James                Miller Group
Andrew Kirby              George Corderoy and Company
Derek Lavelle             University of Northumbria
Tony Thorpe               Loughborough University
Tony Lewis                Loughborough University

Scope of project

The working party defined the scope of the project as the development of a description data model for bill of quantities, specification, and trading cycle message types. However, the specification messages was selected as the basis from which the model was developed.
The project was confined to the structuring of product or item descriptions. Process and service descriptions, which are common in specifications, were deemed too complex to be considered by the working party.

Limiting the project to the construction domain was considered inappropriate during the early stages of data modelling. The model should therefore be considered as generic. This view is reinforced by the nature of the construction which comprises diverse engineering disciplines including: civil; building; mechanical; and electrical.

**6.6.2 Plan of action**

A provisional schedule of work was produced based upon the methodology presented in the first part of this chapter. The schedule of work was as follows.

1. Identify sample document required.
2. Collect sample documents. (6 weeks)
3. Analyse sample documents. (9 weeks)
   - identify data items
   - group data items
   - structure model
4. Present draft data model to working party for review.
5. Detailed Analysis. (14 weeks)
   - further develop data model
   - incorporate criticism from working party.
6. Present data model to working party.

This plan of action was presented to the working party and agreed. The members of the working party that represent Loughborough University were identified as the data analysis team.

**6.6.3 Development of the first data model**

**Collection of sample documents**

A large number, approximately 50, specifications were collected from the members of the working party.
Initial analysis of descriptions
The data analysis team then studied the specifications collected and divided each one into the many item descriptions, of which it consisted. A large proportion of the item descriptions were studied by the data analysis team for a period of two weeks. An example of the analysis of an item description (see figure 6.8) is described briefly in the next section.

Example analysis of an item description
The description of a boiler from a specification is shown in figure 6.8. The data content of this description is discussed in the following paragraphs.

The data as portrayed in the boiler section is poorly organised and does not purely contain boiler information, but also includes data relevant to flue design and items which are supplementary to the boiler itself. Information is also incorporated that does not specify an object but describes modes of operation, installation details or processes. This information is not relevant to the data model and should therefore be stripped from the data under consideration.

The redundant data must be included in a specification as a whole to fulfill its function. It may therefore be necessary to develop a purely text specification to supplement the object description specification. Alternatively the data model may prove to be only suitable for trading cycle applications such as invoices and purchase orders, in which objects are considered.

Generic description data model
The analysis of many descriptions resulted in the following conclusions.

1. Descriptions of items currently have no standard form.
2. The concept of an object, with any number of attributes, forming the basis of a description data model appears reasonable. This concept was originally proposed by a working party member.
3. An object may be related to any number of other objects. These relationships are hierarchical, for example one object may form part of another.
RAF Lakenheath - Replace Heating in Elementary School
Boiler House 52

Objects: boilers, flues, pressurisation unit, MTHW circulating pumps, primary summer pumps, domestic hot water pumps, water treatment and dosing plant, calorifiers.

Information in Boiler Section of Specification

Boiler Data

- Constructed to BS 855.
- Thermal design to BS 2790 (1986).
- Position as indicated on drawing LAK 89/52/HB1/1.
- Manufactured by Babcock Robey Ltd. tel: 021 5523311, 3 nr. model AYT4/325 oil fired shell type reverse flame boilers, or equivalent.
- Fully modulating control with all necessary pre-wired control and Limit thermostats.
- Rated capacity 950kw.
- Working temperature 100°C flow, 80°C return.
- System static head 8m.
- High temperature safety limit +5°C of the set point.
- Control thermostat 100°C.
- Electrical supply 415V, 3 phase, 50Hz.
- Fuel type 35 second oil, class D.
- Rated fuel consumption 1021/h.
- Turn down ratio 4:1.
- Burner equipment shall conform to BS799.
- 150 mm dia pressure guage (0-7 bar) complete with syphon and cock.
- 150 mm dia thermometer guage fitted in the water flow (0-150°C).
- 125 mm twin safety valve.
- 32 mm drain valve.
- Modulating immersion control thermostat.
- Immersion high limit thermostat.

Name plate giving:
- maker's name;
- series and type;
- serial number;
- rated output;
- design pressure; and
- date of manufacture.

Plate bearing a distinct and visible number for each boiler.
The controls should be accessible from the boiler front.
Mild steel flue connections, all joining materials to be heat resistant.
Flue connections shall be top mounted, to discharge vertically, through the boiler house roof.
Fully automatic burners incorporating oil pressure indicators and controlled by the modulating sequencing controller.
Electric ignition with safety devices complying to BS 799 Part3, to be arranged to attempt one automatic restart before locking out.
Warning of lock-out shall be given by an audible alarm fitted outside the boiler house.
Each boiler to be fitted with a preset over-riding limiting device in the flow outlet before the boiler outlet valve to shut down the burner in event of excess temperature. The temp setting to allow normal set point temp of boiler under boost conditions. Thermostat to be provided with a locking device, or screwed cover to prevent unauthorised interference. Hand reset with indicator light labelled "High temperature cut-out".
The boiler should be suitable for a mean operating pressure of 3.5 bar.

Figure 6.8 - Sample item description from a specification
The concept of an object having a number of attributes is portrayed in the entity relationship diagram in figure 6.9.

To develop the entity relationship model into a detailed model the coding structure defined by the CI/SfB was employed. CI/SfB is a method of describing a complete construction project. The coding structure defined in CI/SfB is related to the concept of objects with attributes.

```
  OBJECT  1  N  ATTRIBUTE
```

Figure 6.9 - An object with N attributes

**Description data model using CI/SfB**

CI/SfB is a method of describing a complete construction project. The structure of the CI/SfB codes is detailed below.

Table 0  -  Environment (physical)
Table 1  -  Elements
Table 2  -  Constructions, forms (object level)
Table 3  -  Materials
Table 4  -  Activities, requirements

Using the CI/SfB coding an object would require 3 levels of coding. These level numbers refer to the table numbers defined above.

level 2 -  Object
level 3 -  Materials
level 4 -  Requirements

Structure of fields for the codes in each CI/SfB table.

Table 0  -  n..3
Table 1  -  n..2[,]n1
Table 2  -  a1             (uppercase alphabetic character)
Table 3  -  a1n1
Table 4  -  a1n1           (uppercase alphabetic character)
If a data model was based on the five Tables of C/SfB the following information would be required. The table numbers (in brackets) identify which table are relevant to each group of information.

Object group : identify object;
(Tables 0,1,2) individual object code; and
object description.

Attribute group : identify attribute;
(Tables 3,4) attribute description;
attribute unit; and
attribute value.

The use of the C/SfB structure resulted in a detailed data model, shown in figure 6.10.

Object group
level 0 n..3
level 1 n..2[.]n1
level 2 a1 (uppercase alpha character)
object reference an..17
object description an..35

Attribute group
level 3 a1n1
level 4 a1n1 (uppercase alpha character)
attribute description an..35
attribute unit an..3
attribute value n..17

Figure 6.10 - Generic data model based on C/SfB code structure

The data model shown in figure 6.10 is specific to the C/SfB code structure. The next stage is to generalise the model so that it can accommodate any reasonable coding structure.

The generalisation of the model consisted the adoption of alphanumeric fields and the increase in number of data fields, so that larger coding structures with any type of coding could be accommodated.
Increase in numbers of fields

The model includes three level codes to define the object and two level codes to define the attribute, the number of these fields is defined by CI/SfB. The number of these fields was increased to 5, for both objects and attributes.

Consideration of objects and their relationships

An object description is still required to provide a general view of the object, the free text field was therefore modified to a repeatable field so that a text description of an object could be comprehensive.

The CI/SfB object references were deemed unnecessary as the structure of an EDIFACT message would identify the object which is being described. However, it must be possible to portray the relationships between objects (eg. ancillary equipment on a boiler), the object identification fields allow such relationships to be described.

Generic data model

The consideration of object relationships resulted in the production of two generic data models to be presented to the working party for consideration. The first does not incorporate object relationships, whilst the second does.

The data models are shown figure 6.11. The data models are portrayed in the format used by EDICON and SITPRO to publish the data models which form EDIFACT messages (SITPRO 1993a).

Proposed attributes

An attribute list is required to allow the testing or use of the data model described in section 6.8.4. The data analysis team therefore commenced the compilation of a preliminary attribute list.
Initially the data analysis team considered the purpose of object attributes and compiled a list they considered to be relevant to the description of an object. The following attributes were identified by the data analysis team:

- function;
- performance;
- size;
- colour;

**Figure 6.11 - Modified generic data model**
finish;
composition;
mass;
quality;
location;
production time;
availability; and
price.

The selection of these attributes was determined by the experiences of the data analysis team. To provide an objective view the attributes defined in existing coding schemes were considered.

**Existing coding systems**
Several coding schemes were collected and studied, each of which included several hundred attributes. Sources included CI/SfB, EPIC and ISO 6241. The ISO technical report identified the concept of attribute groups. This document identified 8 attribute groups for an object: performance; function; shape; location; material; price; production time; and other.

The attribute groups in the ISO report provided the starting point of the development of a complete set of attributes. The attributes in the sample coding schemes and the experience of the data analysis team were amalgamated to form the attribute list shown in figure 6.12.

**6.6.4 Development of the revised data model**
The data model and attribute list produced by the data analysis team were reviewed by the working party. The comments from the review formed the basis of the modifications undertaken to produce the revised data model.

The following modifications were undertaken as a result of the review of the data model.

**Modification of scope of project**
The term description was confined to the definition of a product. Process and service descriptions are not considered due to the complexity such work would entail. As a means of emphasising this the term 'Object' was replaced with the term 'Product'.
The limiting of the project to the construction industry was considered inappropriate, as the data model is envisaged as being generic. Initial work has revealed that the use of industry specific sets of attributes will account for the varying requirements of other industry groups.

Generic data model structure
The data model produced was considered too abstract and hence unreadable by the lay-man. To improve the presentation of the data model a graphical version of the generic structure of the data model was produced (see figure 6.13). Also a set of empty tables were produced to indicate how data would be stored in the model (see figure 6.14).

Attributes
The list of attributes received significant criticism. In particular the lack of definition of attributes confused their purpose.

In an attempt to clarify the definitions of the attributes to be used in the data model the data analysis team decided to utilise a set of existing attribute group headings. The headings defined in the CIB master list were selected as they are applicable to the construction industry and provide detailed definitions. Also these group headings are already known in the construction industry and therefore would make the concept of the data model more acceptable to the industry representatives in the working party.

CIB Master list
The CIB Master list is an agreed list of headings for the arrangement and presentation of information used in design, construction, operation, maintenance and repair of buildings and building services, and in documents associated with the supply of construction products and services, their manufacturers and suppliers.

The CIB Master list was prepared by George Atkinson, under the auspices of CIB working commission W57 (Building documentation and information transfer) in consultation with Charles Rogers.

The CIB Master list consists of two levels of heading, general headings and sub headings, each heading is clearly defined by a text description, thus clarifying the purpose of the associated attributes. The headings in the CIB list are not as detailed as required for the definition of
construction attributes, but provide a recognised level platform from which a complete set of attributes can be developed.

Product identification
As the CIB Master list provides a means of identifying an attribute, a code list is also required to identify the product. The analysis of the Cl/SfB code lists indicated that tables 0 and 1 provide a means of identifying a product. These code lists were therefore adopted for the preliminary model.

6.6.5 Validation of the description data model
To determine if the data model consisting of products with attributes is valid a trial conversion exercise was instigated within the working party.

The sets of attribute codes from the CIB master list, and product codes from Cl/SfB tables 0 and 1 were used. However, any reasonable code lists could be utilised in a similar manner. The structure of the data model itself was under scrutiny during this exercise.

The following items were distributed to each member of the working party: the new graphical representations of the data model; sets of blank product and attribute tables; a description of how to convert description to the data model form; and a number of descriptions selected from the sample specifications.

The blank product and attribute tables were then completed by each working party member for a number of sample descriptions and returned to the data analysis team with comments.

How to use description data model
The data model is portrayed by figures 6.13 and 6.14. Figure 6.13 details the structure of the description model, showing a product to have a number of attributes. Related attributes may be grouped, for example output, consumption, heat retention and brittleness can be grouped together under the heading of performance attributes. Figure 6.14 shows the contents of a 'product' and an 'attribute'. 'Products' and 'attributes' both include an identification code and a text description, which allows recognition by both a person and a computer. The 'attribute' also contains a unit specifier and a data field. The data field is used to store the information relating to the attribute, for example if the attribute is COLOUR then BLUE may be stored in the data field. Indicating the product is the colour blue. The unit specifier is used when the attribute data consists of a value.
**ATTRIBUTE GROUPS**

<table>
<thead>
<tr>
<th>Performance</th>
<th>Function</th>
<th>Description</th>
<th>Location</th>
<th>Material</th>
<th>Operation</th>
<th>Price</th>
<th>Production</th>
<th>Other</th>
</tr>
</thead>
</table>

**PERFORMANCE ATTRIBUTES**

<table>
<thead>
<tr>
<th>Mechanics</th>
<th>of solids;</th>
<th>of fluids;</th>
<th>strength;</th>
<th>loads, forces;</th>
<th>adhesion;</th>
<th>vibration;</th>
<th>deformation, stability.</th>
</tr>
</thead>
</table>

Fire, explosion
Matter
Thermal
Visual/optical
Acoustic
Electrical
Magnetic
Radiation
Energy
Safety in use
Hygienic properties
Suitability
Durability
Economics

**DESCRIPTION ATTRIBUTES**

<table>
<thead>
<tr>
<th>Shape</th>
<th>Size</th>
<th>Appearance</th>
</tr>
</thead>
</table>

Size:
- height;
- length;
- width;
- volume;
- area; and
- weight/mass.

Appearance:
- colour;
- texture/pattern;
- opacity; and
- smell, aural, taste.

**LOCATION ATTRIBUTES**

<table>
<thead>
<tr>
<th>Site</th>
<th>Site situation</th>
<th>Relative situation</th>
</tr>
</thead>
</table>

Site:
- (eg. the site is borehamwood, north London)

Site situation:
- (eg. the wall that is situated to the east of the site)

Relative situation:
- (eg. a window in the east wall)

**MATERIAL ATTRIBUTES**

Generic material type (eg. metal)
Particular form of type (eg. mild steel)
Composition
Properties

**FUNCTION ATTRIBUTES**

<table>
<thead>
<tr>
<th>Transport</th>
<th>Industry</th>
<th>Office, commerce</th>
<th>Medical care</th>
<th>Recreation</th>
<th>Culture</th>
<th>Housing</th>
<th>Circulation</th>
<th>Catering</th>
<th>Hygiene</th>
<th>Cleaning, maintenance</th>
<th>Storage</th>
<th>Service</th>
</tr>
</thead>
</table>

**PRICE ATTRIBUTES**

<table>
<thead>
<tr>
<th>Production costs</th>
<th>Storage costs</th>
<th>Transport costs</th>
<th>Buying price</th>
<th>Selling price</th>
<th>Tax prices</th>
<th>Maintenance costs</th>
<th>Operation costs</th>
</tr>
</thead>
</table>

**PRODUCTION ATTRIBUTES**

<table>
<thead>
<tr>
<th>Production time</th>
<th>availability</th>
</tr>
</thead>
</table>

**Figure 6.12** - Proposed attribute groups for description data model
For example, a flow attribute could have the unit m$^3$/s, and the value 6.2 in the data field. This represents a flow of 6.2m$^3$/s.

![Diagram](image)

**Figure 6.13 - Structure of the description data model**

Appendix D consists of a page from a mechanical services specification with an alternative version of the same page in the form of the description data model.

The description data model representation of the mechanical services descriptions is in the form of completed product and attribute tables. The use of identification codes in the product and attribute tables is described below.

**Identification codes**

Two sets of identification codes are used in the example, one for product identification and one for attribute identification.

**Product identification**

The Cl/SfB table 0 and 1 codes are used for product identification. The table 0 codes define the type building or works the project consists of, eg. a school, and the table 1 codes define the element within the building or works in which the product can be classed.
For example, a medium temperature hot water circulation pump in an elementary school would be coded as follows.

Table 0 code 712 - primary school
Table 1 code 56 - space heating
4 - central heating with hot water distribution

The CI/SfB list of codes and their definitions are detailed in appendix E. The description item of the product (see figure 6.14) is used to describe the product in detail. Figure 6.15 shows an example of a product stored in the data model form.

The CIB Master list codes are used for attribute identification. The CIB codes have two levels of detail, which take the form of headings and sub headings. The definition of the CIB Master list headings and sub headings are detailed in appendix F.
The use of these headings is best explained by example. A pump flow rate of 22 l/s is a performance attribute, the heading of performance is therefore selected, which is represented by the number 4. A flow rate is a capacity value, hence the sub heading titled "Active: capacity, output, consumption" is selected, which is represented by the number 1. The description section of the attribute is used to describe the attribute in detail. Figure 6.16 shows an example of an attribute stored in the data model form.

<table>
<thead>
<tr>
<th>Identification code</th>
<th>Description</th>
<th>Unit</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 2 3 4 5</td>
<td>Water flow rate</td>
<td>l/s</td>
<td>22</td>
</tr>
</tbody>
</table>

Figure 6.16 - Example of an attribute in data model form

Conclusions of description data model testing

Four working party members completed the conversion of a description to the data model structure using the blank product and attribute tables supplied. All of the working party members who attempted the exercise had little difficulty in undertaking the process of conversion.

Different working party members completed the product and attribute tables with different text descriptions for the same items. However, there was a commonality between the completed product/attribute codes for the same items.

These results suggest that the proposed data model and coding system provide a reasonable preliminary method of structuring product descriptions.

An example of a completed product and attributes table with the associated original description is shown in appendix D.

6.7 Summary

The development of EDI messages for the construction industry has progressed slowly. The trading cycle messages available were copied in part or whole from other industries. The bill of quantities group of messages was the first to be developed specifically for the construction
industry. The rate of development of messages needs to be increased. To achieve this the method of development must be formalised.

The first part of this chapter describes a standard method of developing an EDI message. The process consists of two stages: data analysis; and message design. The data analysis stage comprises the production of a data model which represents the traditional transfer document. The message design stage is the conversion of a data model into an EDI standard.

The methodology described was developed from a series of interviews with an experienced message developer. This means of eliciting knowledge, whilst successfully producing a formal means of message development, does result in a methodology which was largely derived from the experience of an individual. Whilst the methodology was reviewed by other message developers, it must be recognised that it represents the view of a small group. The methodology therefore does not present an ideal means of message development, but provides a starting point from which improved methods can be derived.

The objective of producing a message development methodology was to achieve a reduction in the time required to develop a message. To determine if the methodology meets this objective it must be validated.

The validation of the message development process is presented in the second part of this chapter. A specification message was identified in chapter 5 as the next priority for development. To start the development of a specification message the development of a description data model was undertaken.

A working party consisting both industry and academic members was formed to guide the development of the data model. In particular the working party reviewed the data model produced and took part in the validation of the completed model.

The successful production of a data model validated the message development methodology. The data model was produced in approximately two months. This indicates the speed of message development can be improved by the employment of standard development techniques. However, it is realised that a far greater time is required to complete the comprehensive testing required to produce a workable EDI message.
Chapter 7  
The analysis of the bill of quantities message set

7.1 Introduction

The bill of quantities message set was selected for trial implementation to investigate the issues involved. The selection of the bill of quantities message set for trial was based upon previous research, industry opinion and timing. The first survey presented in chapter 4 reported that industry considered the electronic exchange of bill of quantities information as providing the greatest benefit. The analysis of information flows presented in chapter 5 identified the bill of quantities information flow to be suitable for EDI. The need for a bill of quantity message set had previously been recognised by EDICON which has developed a set of EDIFACT messages. These messages were at a stage ready for trial during this research.

The selected message group consists of six messages; CONITT; CONTEN; CONEST; CONPVA; CONQVA; CONDPV. For the purpose of the tendering process only the CONITT (Invitation to tender) and CONTEN(priced tender) messages are required. This chapter analyses the key components of these message required to undertake the tendering process, thus providing the minimum structure and content required to undertake a meaningful trial.

The benefits and disadvantages of the minimum application of the bill of quantities message set is discussed followed by the value added benefits available from the use of all the messages and the additional functionality incorporated in their design.

7.2 Selection of bill of quantity messages for trial

The first survey of EDI use in the industry (see chapter 4) was used to determine the construction management information flows which were considered to provide benefit when using EDI. The result of this survey showed that the five messages considered most beneficial, in order of priority, were:

- bill of quantities;
- trading cycle;
- specification;
- CAD; and
- design information.
The analysis of information flows presented in chapter 5 identified the bill of quantities information flow to be suitable for EDI.

EDICON had previously identified the requirement for a bill of quantity set of EDI messages. To address this requirement EDICON undertook the development of a set of suitable EDIFACT messages. The development of the bill of quantity messages commenced in the late 1980s. The messages developed were granted level 1 accreditation in 1991. Level 1 accreditation indicates the messages are suitable for trials. This set of messages is now level 2 accredited, indicating it is stable and is suitable for use (UN 1997).

7.3 Bill of quantity messages

The Bill of Quantity message group consists of the following six EDIFACT messages.

- **CONITT** - Construction - Invitation to Tender
- **CONTEN** - Construction - Tender
- **CONEST** - Construction - Establishment of Contract
- **CONPVA** - Construction - Payment Valuation
- **CONQVA** - Construction - Quantity Valuation
- **CONDPV** - Construction - Direct Payment Valuation

(EDIA 1994)

**CONITT**

At the pre-construction stage of a project, the client appoints a contractor using the tender process. The first step in the tender process is to issue an invitation to tender. The invitation to tender includes an unpriced bill of quantity. The CONITT message facilitates the transfer of an unpriced bill from the client to the contractors which are tendering for the project.

**CONTEN**

Following the receipt of an invitation to tender a main contractor, or sub contractor, will submit a priced bill of quantities, which is a commercial offer to execute the work therein. The CONTEN message facilitates the transfer of a priced bill of quantity between a contractor and client.
CONEST
The bill of quantity is a key contract document which is exchanged and amended during the life of a project. The CONEST message should be used to establish all approved amendments to the original contractual bill of quantity.

CONPVA
The CONPVA message should be used between a contractor and the client’s representative, during the process of approving the value and payment for work completed.

CONQVA
The CONQVA message should be used by a contractor to submit progress details to the client’s representative. This message could also be used for parts of the project which have been subcontracted to other parties. In these cases the exchange would be between the subcontractor and the party who subcontracted the work.

CONDPV
The CONDPV message is an instruction sent by the contractor to the party responsible for payments, to pay the subcontractors for work completed.

7.4 Selection of CONITT and CONTEN for trials

The two flows which form the tender process are the transfer of an unpriced bill of quantity to a tendering contractor and the return of the priced bill to the professional quantity surveyor. The CONITT and CONTEN messages equate to these message flows. The CONITT and CONTEN messages are also used to transfer parts of the bill to and from subcontractors and suppliers. The exchange of bill of quantities information during the tender cycle, with each flow tagged with the associated EDIFACT message, is portrayed in figure 7.1.

Figure 7.1 - Exchange of bill of quantities information during the tender cycle
CONITT and CONTEN are key messages in the bill of quantities set. The structure of the CONITT and CONTEN messages is described in sections 7.5 to 7.8. The structure and content of the messages described in the following sections is not representative of the complete messages. Instead only the parts of the messages necessary to undertake the trial of the CONITT and CONTEN messages is included. The omission of parts of the messages is a practical measure as the messages were developed to meet the requirements of countries other than the UK and also included added functionality to meet potential future requirements. The information included relates approximately to the information currently transferred in bill of quantities documents.

Facilities omitted from the CONITT and CONTEN messages include the alternative index and sub items. The alternative index could be included to provide an alternative means of referencing items and hence gives added value to the information stored in the bill. Sub items also allow additional information to be added to a bill item, such information could include position of an item or colour of an item.

7.5 CONITT - structure

The CONITT message consists the following sections:

- Message Header;
- Project Details;
- Index;
- Group Details;
- Item Details; and
- Message Trailer.

The general structure of an EDIFACT message is portrayed in figure 7.2. The structure of the CONITT message and how this maps to the generic structure of an EDIFACT message is shown in figure 7.3.
Figure 7.2 - General structure of an EDIFACT message

7.6 CONITT - content

7.6.1 Message header

Function
The message header identifies the start of a message. Other information stored in the message header include the message type, eg. CONITT, and a message reference number.

Segments
UNH
The message header consists of one segment - the UNH segment. The UNH segment consists of seven data items: a message reference number; a message type; a message version number; message release number; a controlling agency; a sequence of transfers code; and a first and last transfer code. The message reference number stores a number, which can be used to identify the message. The message type identifies the type of EDIFACT message. For example, 'CONITT' denotes the
message is the construction invitation to tender message. The message version and release numbers are used to identify the version of the message used. The controlling agency is set to 'UN' identifying the United Nations as the controlling agency of the message. The sequence and first and last transfers are used for message transfer control. If the message is a one off transfer the sequence is set to '1' and the first and last transfer is set to 'F' denoting the final transfer.

**General EDIFACT message structure**

**CONITT message**

![Diagram of message structure]

**Figure 7.3 - Structure of the CONITT message**

**7.6.2 Project details**

**Function**
The function of the project header is to define the message type and identify the project to which the bill of quantity relates. Information relating to the document is stored to facilitate the control of the document, this includes the date of document issue and authorisation passwords. Information relating to the project as a whole is also stored in this section, this includes the form of tender, eg. JCT 80, and a general text description of the project.
Segments

BGM
The BGM segment is used to store a document name code to identify the document, eg. 208 = unpriced bill, and a reference number which is assigned by the originator of the message. This reference number can be used to uniquely identify the document.

RFF
The RFF segment is assigned a reference qualifier of 'AEP' and a reference number which is used to relate a CONITT and CONTEN message.

DTM
The DTM segment stores the date when the document was issued. A qualifier of '137' is assigned to this segment to indicate the date type. A second qualifier is used to identify the date format, eg. a date qualifier of '101' indicates a date format of 'YYMMDD'.

AUT
The first AUT segment is used to store the sender's password.

AUT
The second AUT segment is used to store the authorised sender's name.

AGR
The first AGR segment has a qualifier 'FOT'. This indicates that the segment contains form of tender information. The form of tender is stored in natural language in the segment.

AGR
The second AGR segment has a qualifier 'ODW'. This indicates that the segment contains a text description of the type of contract. The title of the project can be stored in this segment, eg. 'Folkenchurch - Factory and Offices'.

7.6.3 Index

Function
The index defines the structure of the bill of quantity contained within the message. The structure is defined for each message to suite the original structure and content of the bill. The ability to define
the structure for each bill allows the transfer of any bill regardless of the method of measurement employed. For example, the CONITT message can be used to transfer both SMM6 and SMM7 bill of quantity.

Index structure

The index is made of repeating sets of the segments described below. Each set of segments describes an index structure heading or an index heading. Following the definition of the index in the message an alternative index can be described. The alternative index is also repeating sets of the same segments, but with an identifier indicating that the information relates to the alternative index.

Both the index and alternative index consist of two sections: definition; and content. The definition section defines the structure of the index itself, by assigning a title to each level of the index. The number of index levels is not defined by the message, the number of index levels can be varied depending on the content of the bill of quantities. For example, 3 index levels prove satisfactory for an SMM7 bill of quantities. The content section defines the index descriptions and assigns the index codes to each description. These codes are then used in the item detail section to assign items to the index.

Segments

IND

The IND segment is the index segment. This segment is used to identify the function of the following index entry and to what it relates. In the case of the CONITT message the index always relates to a project, therefore a qualifier of 'PJT' is assigned to this segment. The second data item in the segment indicates whether the following entry is an index structure definition or the content of the index.

RCS

The RCS segment contains three data items: a sector qualifier; a condition identifier and an action request code. The sector qualifier is set to '1' to indicate the construction sector. The condition identifier is required by the EDIFACT standard, and is set to the value 'DUMMY' as it is not required for the EDIFACT message. The action request code defines action that should be undertaken with the following index entry, eg. '1' denotes the entry should be added to the existing index. If index information has not yet been sent for this bill a code of '1' is also used.
GIS
The GIS segment contains 1 data item, a processing code. This code identifies the index level of the following index entry. For example, 2 relates to level 2 of the index.

BII
The BII segment contains an index qualifier plus data items which define the index level codes to which the description in the following index entry relates. The index qualifier is set to 'INX' for the bill index, and 'ALT' for the alternative index. The number of data items following the index qualifier indicates the level of the index structure heading or the index heading defined in the IMD segment.

IMD
The IMD segment contains the index entry information, and consists four data items: an item description type code; item characteristic code; item description identifier; and the item description. The item description type code is set to 'B' for all entries in the CONITT message. This indicates a code or text description. The item characteristic code indicates the type of information. For example, 'IXH' is used for this segment in the index header to denote an index related entry. The item description identifier indicates the line number of this IMD segment. If the description entry stored is long a number of IMD segments may be required. An identifier of 'A' indicates it is the first IMD segment, 'B' indicates the second IMD segments, this series continues. The item description itself is a text description.

7.6.4 Group details

Function
The group information facility can be used to store information regarding any section of the project defined in the index. The group detail section can also be used to store project information. In this instance the BII segment used to identify the section does not include any index reference codes. The contents of the group detail section below are described as they would be used to store project information.

Segments
BII
The BII segment only uses an index qualifier data item which is set to 'INX' denoting the following data items relate to the index. The following items identify a section of the project using the index.
To record project information in the groups section only the index qualifier data item is completed. The lack of an index reference indicates that the information in the following segments relates to the entire project.

**RCS**

The RCS segment for group information is used in the same way as the index.

**GIS**

The GIS segment consists one data item, the processing indicator.

**NAD**

The first NAD segment in the group detail section consists a party identifier and six name and address data items. The party identifier is set to 'EL' denoting the following name and address information relates to the group.

**LOC**

The LOC segment consists three data items: the place location qualifier; the place location identifier; and the place/location. This segment is used to store the location of the group, or in this instance the project.

**DTM**

The DTM segment in the group section consists three data items: the date qualifier; the date; and the date format qualifier. The date qualifier indicates the meaning of the date. In the case of project information this segment is used to store the deadline for tender submission. This is indicated by the qualifier '286'. The date is the value, the format of the value is defined by the date format qualifier. For example, the qualifier '101' indicates the date is portrayed in the order Year/Month/Day and the format YY/MM/DD.

**RFF**

In the project details group there are three RFF segments used in the order: sending software identity; the identity of author; and the standard method of measurement used. In these instances the RFF segment consists two data items: the reference qualifier; and the reference.
GIS
This segment is used to indicate whether the bill described in the message varies from the method of measurement denoted in the previous RFF segment. This segment consists a single data item, which stores either the value 'YES' or the value 'NO'.

FTX
The FTX segment, which stores free text, is used in the section to store a narrative of amendments to the standard method of measurement described in the above RFF segment. This segment consists three data items: a text subject qualifier, set to 'SMM' denoting standard method of measurement; a text function, set to the value 'I'; and the narrative.

CUX
The CUX, or currency, segment identifies the currency in which the item rates should be submitted. This segment consists two data items: the currency details qualifier; and the currency. The currency for UK bills is set to the value 'GBP' denoting the use of Great Britain Pounds.

NAD
There can be several NAD, or name and address, segments at this point. These segments are used to store the names and addresses of the various parties involved in the project. A qualifier is used to identify which party a name and address relates. For example, 'CLI' denotes the client.

UNS
The UNS segment denotes the end of a message section. In this instance the segment denotes the end of information relating to the bill information and the start of the bill items themselves. This segment consists one data item which is set to the value 'D' which indicates the start of the detail section of the message.

7.6.5 Item details

Function
The item detail section contains the bill information.

Structure
The item detail section consists of repeating sets of the following segments, each set representing an item entry. Once all items have been described the item detail section ends.
Within each repeating set the LIN and first IMD segments may repeat several times to define the headings above an item. Each item is assigned an index reference, the item may be further defined by the use of headings which are assigned levels below that of the index. An item is also assigned a level which is one level lower than the lowest level heading to which it relates. The headings for a previous item remain pertinent to the next item, only the headings at levels which have changed need be redefined for the next item.

Segments

BII
The BII segment in the item details section consists an index qualifier plus a number of fields to describe the index reference for the item. The index qualifier is set to 'IDX' denoting the contents of the segment refer to an index. The index reference consists of a number of data items relating to the index defined in the index section.

RCS
The RCS segment in the item details section consists three data items: a sector qualifier; a condition identifier; and an action request code. The sector qualifier is set to 'I' denoting a construction related item. The condition identifier is required by the EDIFACT standard, and is set to the value 'DUMMY' as it is not required for the CONITT message. The action request code defines action that should be undertaken with the following item. 'I' denotes the item should be added to the bill, '2' denotes the item should be deleted from the bill, '3' denotes the item is being modified in the bill, '4' denotes no action should be undertaken on the item in the bill.

GIS
The GIS segment in the item detail section is used to define the item type. The segment consists two data items: a processing indicator; and a code list qualifier. The processing indicator is set to 'IT' denoting a code list qualifier relating to an item. The code list qualifier is set to either 'WI' denoting a work item, or 'SI' denoting a standard item, or 'SII' denoting a sub item.

LIN
The LIN segment is used to identify the level of the description in the following IMD segment. The segment consists two data items: a line item number indicating the level of the description; and a action request code which indicates the action to be undertaken with the description in the following IMD segment. The codes 1 to 4 are the same as in the previous RCS segment for this data item.
IMD
This IMD segment is used to store a test description. The description may relate to a specific item or may be a heading. This segment consists four data items: item description type; an item characteristic code; and item description identifier and an item description. The segment is used in the same way as in the index, except the item characteristic code is set to either 'HEA' when the description is a heading, or 'DES' when the description is an item description.

This IMD segment may be repeated with the LIN segment several times to convey the correct headings before an item description LIN and IMD segment is used.

QTY
The QTY segment stores the quantity of the item. This segment consists three data items: a quantity qualifier; a quantity; and a measure unit qualifier. The quantity qualifier indicates the status of the quantity, eg. '99' denotes an estimated value. The quantity is a numeric value. The measure unit qualifier indicates the unit of measure, for example 'MTQ' denotes the cubic metre.

GIS
The first GIS segment in the item detail section is used to describe the source of the quantity. This GIS segment consists two data items: a process indicator; and a code list qualifier. The process indicator is set to 'QSO' denoting the code list qualifier relates to the source of the quantity. The code list qualifier is used to describe the source of the quantity. '1' denotes a contractors item, '2' denotes a new item, '3' denotes a take off item, and '4' denotes a bill of quantity item.

GIS
The second GIS segment is used to describe the status of the quantity. This GIS segment consists two data items: a process indicator; and a code list qualifier. The process indicator is set to 'QST' denoting the code list qualifier relates to the status of the quantity. The code list qualifier is used to describe the status of the quantity. '1' denotes an agreed quantity, '2' denotes a provisional quantity, '3' denotes a disputed quantity.

IMD
The second IMD segment in the item detail section is used to store an item description for the alternative index. This IMD segment is used in the same way as the other in the item detail section. The exception being the item characteristic data item is set to 'ALT' to denote an alternative index description.
7.6.6 Message trailer

Function
The trailer section of the message not only indicates the end of the message, but also provides controls which can be used to ensure the complete message is received correctly.

Segments
CNT
The CNT segment consists two data items: a control qualifier; and a control value. The control qualifier is set to 'QT' to indicate the control value is equal to the sum of the item quantities stored in the message. The control value is used to store the sum of the item quantities in the message.

UNT
The UNT segment consists two data items. The first is used to store the number of segments in the message. The second is used to store a message reference number.

7.7 CONTEN - structure

The CONITT and CONTEN messages share the same data model. The difference between the two messages is their purpose. The differences portrayed in this chapter between the two messages is therefore the result of the practical application of the messages requiring the use of different parts of the whole data model. The CONITT message includes project information, index structure, and complete descriptions of each item in the bill. The CONTEN message simply identifies itself as relating to the originating CONITT message and includes the tendered rate for each item. The CONTEN message can include all the information in the originating CONITT message, but this provides no benefit.

The CONTEN message consists the following sections:
- Message Header;
- Project Details;
- Group Details;
- Item Details; and
- Message Trailer.
The structure of the CONITT message and how this maps to the generic structure of an EDIFACT message is shown in figure 7.4.

7.8 CONTEN - content

7.8.1 Message header

Function
The message header denotes the start of the message. The header is also used to store the type of message, eg. CONTEN, and a unique message reference.

Segments
UNH
As for the CONITT message, the message header consists of one segment - the UNH segment. The UNH segment consists seven data items: a message reference number; a message type; a message version number; message release number; a controlling agency; a sequence of transfers code; and a first and last transfer code. These data items are used in the same way as for the CONITT message. The key difference is the message type is set to 'CONTEN' instead of CONITT.

Figure 7.4 - Structure of the CONITT message
7.8.2 Project details

Function
The content of the project detail section in a CONTEN message is largely identical to that in the related CONITT message. The key differences are a different document name code in the BGM segment and the absence of the final two AGR segments.

Segments

BGM
The BGM segment is used to store a document name code to identify the document, in this instance the code '209' is used indicating a CONTEN message. Also a unique document reference number can be stored which is assigned by the originator of the message.

RFF
The RFF segment is assigned a reference qualifier of 'AEP' and a reference number which is used to relate a CONITT and CONTEN message.

DTM
The DTM segment stores the date when the document was issued. A qualifier of '137' is assigned to this segment to indicate the date type. A second qualifier is used to indicate the date format, eg. a date qualifier of '101' indicates a date format of 'YYMMDD'.

AUT
The first AUT segment is used to store the senders password.

AUT
The second AUT segment is used to store the authorised senders name.

7.8.3 Group details
The group detail section is used in the same way as the CONITT message, in that information on any part of the project can be stored in this section. However, to mimic the current bill of quantity, the segments below describe the use of the section for project information only.
Segments
The first four segments: BII; RCS; GIS; and DTM are used in the same way as the corresponding segments in the group detail section of the CONITI message.

ARD
The ARD segment is used to store the monetary function, this segment is required before any MOA segment. A value of 'XXX' can be assigned if no purpose is required of this facility.

MOA
The MOA segment is used to store the total tendered value of all the items in the message. This segment consists of three data items: the monetary amount type qualifier; the monetary amount; and the currency code. The type qualifier is set to 'TEN' in this instance to signify a tender sum. The monetary amount is a value which includes two decimal places, although the decimal point is not shown. The currency code is set to 'GBP' indicating Great Britain Pounds.

NAD
This name and address segment is used to store the name and address of the contractor submitting the priced tender. To indicate this the party qualifier is set to the value 'EN'.

CTA
The CTA segment stores the name of the contact in the submitting contractor. This segment consists of two data items in this instance: the contact function code, which is set to 'IC' denoting an internal contact; and the contact name.

COM
The COM segment can be used several times at this point. This segment is used to store communication contacts, for example telephone numbers and electronic mail addresses. This segment consists of two data items: the communication number; and the communication channel qualifier. The qualifier is set to: 'TE' to denote a telephone number; 'FX' to denote a fax number; or 'EM' to denote an electronic mail address.

UNS
The UNS segment denotes the end of a message section. In this instance the segment denotes the end of information relating to the bill information and the start of the bill items themselves. This
segment consists one data item which is set to the value 'D' which indicates the start of the detail section of the message.

7.8.4 Item details

Function
The Item detail section of the CONTEN message is used to store the quantity, rate and value of each bill item. The group of segment described below is repeated for each bill item.

BII
This BII segment is used to identify the item to which the information in the following segments relates. This segment consists: an index structure qualifier, set to 'IDX' denoting an index reference; a number of index references, the number depending on the number of defined index levels; and the item number. The item number typically consists the original bill of quantity page number and the item letter.

RCS
This RCS segment is used to store an item action request and the sector to which the item relates. The segment consists three data items: a subject identification qualifier; a condition identification; and a action request code. The subject identification qualifier is set to '1', denoting the construction industry. The condition identification data item is defined as mandatory by the EDIFACT standard but is not required for this message. It is therefore set to the value 'DUMMY'. The action request code is set to the value '1' for items for which rates have not yet been returned. The action request codes include: 1, add; 2, delete; 3, change; and 4, no action.

GIS
The GIS segment is used to define the item type. This segment consists two data items: a process indicator; and the code list qualifier. The process indicator is set to 'IT' denoting an item. The code list qualifier can be set to one of three values: 'WI' denoting work item; 'SI' denoting standard item; and 'SUI' denoting sub item. The value suitable for use with a traditional bill item is that for a work item.

QTY
This segment is used to store the quantity of the item. This QTY segment consists three data items: a quantity qualifier; a quantity; and a measure unit qualifier. In the case of a priced tender the
quantity qualifier would be set to '99' denoting an estimated value. The quantity is stored with two
decimal places included. The decimal place is not shown. The measure unit qualifier stores the unit
of measure, eg. MTQ' means Cubic Metres.

PRI
This PRI segment is used to store the unit rate for the item. This segment consists four data items:
a price qualifier; a price; a price type; and a measure unit qualifier. In the instance of a priced
tender the data items would be set as follows. The price qualifier is set to 'TEN' denoting tendered
rate. The price is stored including two decimal places. The price type is set to 'PU' denoting the rate
is per unit. The measure unit qualifier is set to the measure unit to which the rate relates.

GIS
Three GIS segments can be included at this point to store either: rate source; rate status; or rate
qualifier information. These GIS segments consist two data items: a processing indicator and a code
list qualifier. The processing indicator indicates which of the three functions the segment serves.
The code list qualifier is used to store the rate information code. An example suitable for a priced
tender is a processing indicator 'RSO' denoting the rates source, with a code list qualifier of '1'
denoting a contractors item.

ARD
This ARD segment is use to store the function of the following monetary value. This segment
consists one data item, the monetary function code, which can be set to one of the following: 1,
denoting amount to date; 2, denoting amount to complete; 3, denoting amount this period; 4,
denoting total amount.

MOA
The MOA segment store the monetary value of the bill item. This segment consists three data
items: a monetary amount type qualifier; a monetary amount; and a currency code. In the case of a
priced tender the type qualifier should be set to 'TEN' denoting a tendered value. The monetary
amount include two decimal places. The currency code should be set to 'GBP', denoting Great
British Pounds.
7.8.5 Message trailer

Function
The function of the message trailer, as for the CONITIT and all messages is to indicate the end of the message and provide controls which can be used to ensure the complete message is received correctly.

Segments
The segments are used in the same way as for the CONITIT message.

7.9 Advantages and disadvantages of the bill of quantity message set

7.9.1 Advantages of EDI bill of quantities message set
The content of the CONITIT and CONTEN messages described above is that necessary to undertake a tender cycle. A tender cycle consists of the transfer an unpriced bill to the tendering contractor who applies rates to the bill, then returns the priced tender. This is the simplest scenario in which the bill of quantities messages can be applied, and was selected for the EDICON trial. The benefits that can be achieved for this scenario must therefore be investigated to identify criteria which can be analysed during a trial.

The benefits achieved by using EDI for the process described above would include: speed of information exchange; speed and accuracy of data input to contractors estimating system; speed and accuracy of data input to client’s tender evaluation system.

Speed of information exchange
The reduced time required to transfer the bill of quantities both from the client’s representative to the contractor, and then return it, would add to the time available for the contractor to prepare an estimate. Considering the documents will take a day to be posted, a total of two additional days will be available to the contractor. The additional time if only used to check an estimate is of significant benefit to reduce the number of errors.

Direct data entry
The direct entry of bill of quantities information into the contractors estimating system, provides a reduction in the time required to enter the data and also to check the data entered. It is common for a bill of quantities to be scanned, and using optical character recognition converted to ASCII text,
which can then be entered into the majority of commercially available estimating systems, for example CCS, ICEMate and Techsonix. Such scanned documents require checking, as it is vital that no errors in the output of the optical character recognition software are transferred into the estimate. The time required to check a scanned bill of quantities for a medium sized project of approximately £10m can be two days. Whilst this process may be undertaken by a junior member of staff, the reduction in time to undertake the input of the bill is significant. The time benefit made available to the client is beneficial but less significant, as the speed of input of data to their systems does not have a direct impact on a limited time resource, as in the case of the contractor.

**Additional benefits**

In addition to the benefits afforded by the simplest scenario, the use of the full set of messages and their full functionality can provide additional benefits.

The use of subcontractors requires the passing of sections of the bill of quantities document between main contractor and sub-contractor for purposes of costing and valuation. This functionality is also possible using the CONITT and CONTEN messages, by simply creating the message from the relevant sections of the bill.

The **Bill messages can also provide functionality over that provided by the bill of quantities document.** The use of additional information data elements allows the transfer of more detailed information for each bill item including location information and referencing. The use of groups, an alternative index, and alternative index groups provide very flexible indexing structures for items. This ensure the data can be analysed by whatever criteria required.

**Benefits of the EDIFACT standard**

The use of the EDIFACT standard for the development of the bill of quantity messages provides many advantages over other standards. The international adoption of the standard through its promotion by the United Nations ensures that any messages developed using EDIFACT will be available to the largest group of users possible. The EDIFACT standard is described in detail in chapter 2.

The bill of quantity message set has been developed with the international perspective in mind. The data analysis process used to develop the messages, similar to that described in chapter 6, has resulted in a very flexible group of messages. These messages can be utilised in countries which do not have a document known as a bill of quantities, but do transfer quantity and valuation...
information. This flexibility is demonstrated by the trial of the bill of quantity messaged set undertaken by the Charente district department of public works in France (see case study in appendix A) (Lorigne 1993).

7.9.2 Disadvantages of EDI bill of quantities message set
The disadvantages of the use of bill of the bill of quantity message set include the following issues: complexity of messages; low frequency of information transfer; significance of data entry benefits; alternative solutions available; other applications; implementation issues; and the timing of the launch of the message group.

Complexity
The design of the bill of quantity messages has produced a set of six messages which fulfil the function of transferring quantity and valuation information throughout the life cycle of a construction project. These messages have been developed to be used in the construction industries of many countries. The international compatibility of a message is vital for any UN/EDIFACT message. In addition the message development process has identified a number of additional facilities which may provide useful to the efficiency of the construction process. Flexibility and the inclusion of added functionality has resulted in a set of messages which are over engineered if applied to simply replace the bill of quantities. Whilst the content of the message can be adjusted according to the application to provide a relatively streamline method of communicating bill of quantity information, the entire message provides a daunting mechanism by which to transfer such information. It would not therefore be unreasonable for construction professionals to consider the message group to be over complicated, and thus hinder implementation.

Low frequency of information exchange
The matrix analysis of EDI case studies presented in section 4.2.1 identified the two key factors for the successful use of EDI as: high data volumes; and the use of EDI to achieve re-engineering. The use of the bill of quantities messages does not in itself represent re-engineering. The benefits of EDI must therefore be achieved by improvements in efficiency, through the transfer of high volumes of data. The messages used during the tender process, CONITT and CONTEN, would only be transferred once, for each tendering contractor. The CONEST message would only be transferred once to establish the contract between the clients representative and the contractor. The progress and valuation messages would be transferred at most once a month during the project between the quantity surveyor, contractor and sub contractors. The frequency of data transfer is therefore very
low during a project. The bill of quantities message set therefore cannot provide significant
efficiency benefits to the parties involved.

Data entry benefits
The bill of quantity message group does eliminate data re-entry, which has associated efficiency and
error reduction benefits. However, due to the low frequency of information transfers these benefits
are minimal. The ability to directly enter an unpriced bill of quantities into an estimating system,
for example, does provide time and cost savings. However, this saving would only be achieved
once for each project, so provides only a small cost saving.

Alternative solutions
The benefit of direct data entry provided by EDI can also be achieved by the use of an ASCII file to
transfer bill information. The standard structuring of such ASCII files using a the simple means
provided by the CITE initiative remove the need to check through such ASCII file imports, which
was previously necessary. This further negates the benefit of the EDIFACT messages.

Other applications
The bill of quantity message group provides the first construction specific EDI messages available.
This, however, does not necessarily make this message set the best suited for implementation in an
organisation which does not currently use EDI. For example, contractors would achieve greater
benefit from using EDI for procurement from their major suppliers. However, very few use EDI for
this purpose. It is therefore unlikely that a significant number are going to invest in the transfer of
less frequent, less beneficial document transfers, such as the bill of quantity message set.

Implementation issues
The use of EDI requires the implementation of EDI communication software and translation
software for each application that is either a source or sink for information transferred. The
implementation is not problematical for main contractors and client's representatives as these
companies have a turnover significant enough to establish such communications. The issues of
implementation for the simplest scenario of using the messages for the tendering stage of a project is
not problematical because only three messages are used and these messages are only transferred
between the tendering contractors and the client's representative.

The issues of implementation become more of a hindrance when considering the implementation of
the full message set for transfer of bill of quantity information to the sub contractors and the transfer
of progress and valuation information transfer. Sub-contractors deal with many contractors and have much smaller turnover, these companies therefore do not have the resources for EDI implementation. A possible means by which these companies could be made EDI compliant is for the key parties in a project, ie. the contractor and client, to supply the sub contractors with the equipment they require to undertake EDI transactions. Such a solution would not allow for integration of EDI into the sub-contractors existing systems, so would compromise the benefits from the sub-contractors viewpoint. A sub-contractor may however be willing to participate to establish a good working relationship and hopefully ensure repeat work.

Timing of availability

The bill of quantity message group was released for trial during the early 1990's. At this time the construction industry was experiencing a deep recession, therefore money was difficult to justify for IT infrastructure. The use of EDI was not promoted as cost saving and was therefore not sufficiently attractive to construction companies.

7.10 Summary

This chapter first describes the selection of the bill of quantities messages set for trial. This message set was selected for trial by research and availability. The first survey reported in chapter 4 and the information flow model showed that this message set was suitable for EDI and was considered the most beneficial by industry. In addition, EDICON had developed a bill of quantities message set using the EDIFACT standard. This message set was ready for trial at the time of this research.

To undertake a trial of a message the scope must be defined. The use of the CONITT and CONTEN messages was identified as the minimum requirement to undertake a trial tender cycle. The structure and content of the CONITT and CONTEN messages were investigated to develop an understanding of these messages and to identify a way in which the messages can be implemented.

The advantages and disadvantages discussed in the final section of this chapter indicate that whilst the bill of quantity messages do provide some benefit, it is difficult to identify a party which realises enough benefit to encourage them to promote the adoption of this EDI message set. The number of disadvantage also appears to be significant. This balance of advantages and disadvantages proved to be a factor in the ultimate failure of the bill of quantities message set.
Chapter 8
Implementation of the bill of quantity message set

8.1 Introduction

The development of EDI messages and their implementation are two separate disciplines. The failure of either results in the failure of the message. The success of a message can be measured by two criteria: the popularity of the message within its target user group/industry; and the ability of the message to fulfil its design requirement. The second of these criteria can be fulfilled by sound development, however it is a poor criteria as little is achieved by the development unless the message is used. The first criteria, that of popularity is dependent on both a successful development and a successful implementation. A message will not be popular if it does not fulfil its design requirement as it will not be of use, similarly it will not be popular if it is implemented poorly, as no one will know of its capabilities, or how to use the message correctly.

This chapter describes the first pilot implementation of the bill of quantity EDIFACT messages in the UK. The first section describes the formal implementation of the CONITT and CONTEN messages organised by EDICON. The second section describes the development of software to trial the CONITT and CONTEN messages. The third section describes the current status of the bill of quantity message set and discusses the means of achieving successful implementation in the industry.

Formal implementation of CONITT and CONTEN messages

EDICON undertook a two stage implementation plan. An implementation steering committee was formed and three functional working parties identified. Two of these working parties were formed, the third was not formed as it was not necessary to consider support and maintenance issues, the function of the working party, early in the implementation process. The objectives and achievements of these working parties in considering the technical issues and practical issues of implementing the CONITT and CONTEN messages are described in sections 8.2.1 to 8.2.5. The working parties reached a point were it was considered no further meaningful work could be undertaken without the trial of the messages.

The trial of the messages constitutes the second stage of implementation. The objectives and structure of the trials is described, in sections 8.2.6 to 8.2.8.
Trial of CONITT and CONTEN messages

The EDICON trial of the CONITT and CONTEN required the development of software to provide an interface for a bill of quantity preparation package to produce a CONITT message and to receive a CONTEN message. A similar interface was also required for an estimating package so that it could receive a CONITT message and produce a CONTEN message. The mapping of data from a bill of quantities to a CONITT message which must be undertaken by such an interface is presented in figure 8.1.

To facilitate the trial a software package was developed that provides an interface for a bill of quantity package and includes a program which imports a CONITT messages, allows the application of rates to the bill of quantity described in the CONITT message, and produces a CONTEN message.

The development, testing and demonstration of this software is described, including the knowledge elicited from these processes, in section 8.3.

![Diagram of CONITT Message Format](image.png)

**Figure 8.1 - Mapping of bill of quantities data into a CONITT message**
Current status of bill of quantities messages
The current status of the bill of quantities messages in the UK construction industry is discussed. The failure of the formal implementation of the messages is first described, followed by the identification of the possible causes of this failure.

A means of successfully implementing the bill of quantities message set is then investigated. This investigation draws on the review of previous work presented in chapter 4 and the advantages and disadvantages of the message set identified in chapter 7. This concludes with the identification of a means of implementing the message set that provides significantly greater business benefit than methods previously utilised.

8.2 EDICON implementation

8.2.1 Implementation working parties
The completion of the development and ratification, by the western European EDIFACT board, of the bill of quantities messages was achieved by July 1992 (Lewis 1993). Once the set of messages had been developed EDICON focused its attention on the implementation of the bill of quantities messages. To implement the bill of quantities messages EDICON identified 3 working parties consisting of interested representatives from construction related companies. Working party 1 considered the impact of EDI on working procedures, working party 2 considered matching EDI messages to working practice and working party considered support and maintenance. To obtain information for this research the author joined both of these working parties.

Working party 1 produced a code of procedure document, which describes how the messages should be used. The Code of Procedure for the exchange of the CONITT and CONTEN messages is presented in appendix G. Working party 2 investigated the structure and content of the CONITT and CONTEN messages and produced simple guidelines for the development of a coding structure. Following six months of investigation both working parties recommended a trial of the messages to further understand the issues of implementation.

8.2.2 EDICON trial of CONITT and CONTEN messages
The objectives of the trial were defined as follows.

To test if the standard works
To identify software implications
To identify procedures and rules required to achieve exchange
The bill messages at this stage were stable, but not fixed. Any necessary modifications identified by the trial could therefore be incorporated in the message. The scope of the trial is presented diagrammatically in figure 8.2. The trial was envisaged as being undertaken by several groups. These groups each would identify themselves as a producer of un-priced bills and receiver of priced bills, or a tenderer who receive un-priced bills and applies prices. Once established groups could then undertake the process of exchanging an un-priced Bill, applying rates, and exchanging a priced Bill. Though several parties expressed an interest in the trial of the CONITT and CONTEN messages, none, except Loughborough University, were willing to expend resources on the trials. Due to the lack of substantial trials the working parties did not undertake any further work. A more detailed description of the official EDICON implementation is in Appendix J.

8.3 Trial of CONITT and CONTEN messages

8.3.1 Introduction
A trial of the bill of quantities message set was undertaken as part of this research. Two industry partners were selected to assist with the trial. These partners were from a quantity surveying practice and a contracting organisation.

![Diagram of the trial process](image)

**Figure 8.2 - Scope of trial**
To undertake a trial each party must adopt one of three roles: a party which originates the bill; a party who prices the bill; or a software developer who provides the translation software which provides the EDIFACT interface for the applications of the first two parties. As part of the research it was decided to develop the translation software necessary to undertake the trial.

The scope of the trial identified in chapter 7 was to carry out the tender cycle using the CONITT and CONTEN messages. To undertake the tender cycle the following processes must occur.

1. Transfer of un-priced bill to tenderer, using the CONITT message.
2. Pricing of bill.
3. Transfer of priced bill back to creator of un-priced bill, using the CONTEN message.

A simple 3 page paper copy of a bill was selected for use in the trial. This bill was selected because it included the use of several levels of heading and varied content, thus rigorously testing both the message format and software developed.

The first stage of the process is the creation of the bill of quantities. This is commonly undertaken using a bill of quantities preparation package. The industry partners assisting in the trial used the CATO bill preparation system. The CATO system was also selected because it is a commercially available system, thus allowing more than one party to use the translation software. CATO is supplied by Elstree computing. Elstree supplied a CATO license, the software and complete documentation.

Selection of hardware platform
Elstree computing's CATO the bill of quantity preparation package selected for the trial operates on an IBM-compatible personal computer using Microsoft DOS version 5.0. An IBM personal computer using Microsoft DOS version 5.0 was selected as the development platform for the software required to facilitate the trial. This selection eliminates the need to transfer data between different hardware platforms thus avoiding unnecessary complication.

Selection of development language
The following criteria were identified as pertinent to the selection of a software development language.
• Knowledge of researcher
• Good file handling
• Good text handling
• Acceptable performance of language

The consideration of the above resulted in the selection of the 'C' programming language for the development of the EDI software.

8.3.2 Software development

The purpose of the EDI software is to facilitate the following:

• transfer of a bill of quantity from a professional quantity surveyor to a tendering contractor;
• application of rates to bill of quantity by the tendering contractor; and
• transfer of the rates from the tendering contractor to the professional quantity surveyor.

To achieve this objective three software programs were developed. The first, 'CATO', is for use by the PQS. This program converts the bill of quantity export file from ECL's CATO BQ preparation package into an EDIFACT CONITT message, ready for transfer to the contractor. The second program, 'RATES' used by the contractor, converts a CONITT message into a format viewable by a user and allows the user to apply a rate to each item in the BQ. Once all the rates have been applied the BQ, including rates, is converted into an EDIFACT CONTEN message for transfer back to the PQS. The third program, CINTER, used by the PQS, converts an EDIFACT CONTEN message into the CATO in-house file format structured data file, facilitating seamless input to the originating ECL CATO system.

8.3.3 Development methodology

A functional specification was developed for each of the three programs, which constituted the EDI translation software package.

A summary of these specifications, defining the function of each program, is presented in the following sections.
**CATO**

1. Identify information required in the CONITT message.
2. Identify information in ASCII export file that is required in the CONITT message.
3. Provide means for manual data entry of data required by CONITT message, which is not included in ASCII export file.
4. Use the structure of headings in the ASCII export file to create the index for the CONITT message.
5. Map data from ASCII file and manually entered data into CONITT message.

**RATES**

1. Read in data from CONITT messages, convert to a readable ASCII file format.
2. Display ASCII file on screen, allowing entry of a rate for each item in turn.
3. Convert ASCII file with rates to CONTEN format (only include item reference and rate in message, description is superfluous)

**CINTER**

1. Read in data from CONTEN message.
2. Extract bill reference, item reference and rate data and write to file in CATO in-house file format.

**8.3.4 EDI software produced**

The 'C' language was used to develop the 'CATO', 'RATES' and 'CINTER' programs. The 'C' source code produced is presented in appendix H. The programs developed were compiled from a set of source code modules. This strategy allowed the development of common functions, thus providing consistency between the applications whilst simplifying maintenance.

A flowchart portraying the process of using the 'CATO', 'RATES' and 'CINTER' programs is shown in figure 8.3.
Bill of Quantities (BQ) Enter BQ information

Export BQ from ECLs CATO

ASCII BQ

Load ASCII file into CATO

Enter additional information

Export CONITT message

CONITT

Load CONITT file into RATES

Add rates using BQ rates input screen

Export CONTEN message

CONTEN

Load CONTEN file into CINTER

ECLs CATO in-house file format

Export file in ECLs CATO in-house file format

STOP

Figure 8.3 - Flowchart depicting the use of 'CATO', 'RATES' and 'CINTER' programs
8.3.5 Testing of the EDI software

Two bills of quantities were obtained to be used to trial the messages. These bills of quantities were given the reference bill no.3 and bill no.4, and were produced by the Wellington Row partnership. Bill no.3 is made up of the items required for the foundations of an administration block. Bill no.4 is made up of the items required for the foundations of a library building. This bill is included in appendix I. The three modules of the EDI software were developed in the following order: CATO; RATES; and CINTER. As each module was completed it was tested with both trial bills of quantities.

Once all three modules were completed they were tested again as a whole with both trial bills of quantities no.s 3 and 4. An example of one of these bills with the associated CONITT file, CONTEN file and CATO in-house file produced is presented in appendix I.

The limitation of the test bills of quantities to the foundation construction phase does not indicate that the software is limited to this area. This is because the software developed interprets the structure of the bill of quantity not the content. A further five bills of quantities were tested once the EDI software was complete to validate the development phase.

Testing process

The testing process mirrors the use of the software, however, there are additional stages to check the validity of the output of each stage of the process.

The testing process of the EDI software for a bill of quantity was undertaken as follows.

1/ Enter a sample BQ into Elstree's CATO BQ preparation software, as directed in literature supplied by ECL.

2/ Export the entered BQ using the ASCII file export utility in the CATO software.

3/ Check integrity of the exported ASCII file, ensuring all data entered into CATO is included in the ASCII file. (Although ECL's CATO software was not developed as part of this research, its operation must be checked to ensure any errors encountered later in the testing process are a result of the newly developed software).

4/ Execute CATO program, select bill of quantity ASCII file for conversion.

5/ Enter information which is required by CONITT message, but is additional to that included in the bill of quantity exported by ECL's CATO software.

6/ The CATO program then exports the CONITT message to an ASCII formatted file. Terminate CATO program. Check the integrity of the CONITT message file. Ensure all
data entered either manually or from the original bill of quantity is included. Also ensure a suitable index structure has been created and that all data is referenced according to this index structure.

7/ Execute RATES program. Select the CONITIT ASCII file to which rates are to be applied. The RATES program then converts the CONITIT file into a user readable format, similar in format to a traditional bill of quantity, which is stored as an ASCII format file on the PC's local fixed disk drive.

8/ Terminate the rates program and check the integrity of the ASCII file produce using a text editor. Ensure all information is included and all items are under the correct headings and in the correct order (Note: during normal operation of the RATES software it is not necessary to terminate the program at this point, termination is undertaken to allow integrity checking of the ASCII working file created).

9/ Execute the RATES program once more and select the option to add rates to the bill of quantity. The BQ is then presented on screen and scrolled to each item in turn, allowing the application of rates.

10/ Once a rate has been applied to every item in the bill, the option to export a CONTEN file is selected. This option converts the BQ file, including rates, into a CONTEN file. Terminate the RATES program.

11/ The integrity of the CONTEN file is then checked using an ASCII text editor. Ensure each item reference is included with a rate. Also ensure the index system in the CONTEN file is the same as in the associated CONITIT file produced earlier in the testing process.

12/ Execute the CINTER program, select the CONTEN file to be entered back into the ECL CATO software. The CINTER program converts the CONTEN file into the CATO in-house file format, then automatically terminates.

13/ The integrity of the CATO in-house file is then checked using an ASCII text editor. Ensure every item from the original bill is included in this file. Also ensure this file complies with the CATO in-house file format.

Results of testing
The software package was developed in three modules: CATO; RATES; and CINTER. As each module was developed it was debugged, ensuring it performed to its specification requirements, as prescribed by the development methodology (see section 8.3.3).
Once all three modules had been completed they were tested as a whole using the testing process described in the previous section. The first test of the software proved successful, using both bill numbers 3 and 4. No additional modification was required to any of the software modules.

The method of debugging each module as it was completed proved successful in eliminating the need for debugging during the final testing process. The elimination of debugging during the final testing process, shows that each module performed to its prescribed specification and operated in conjunction with each of the other modules. Thus validating the development methodology.

8.3.6 Demonstration of software to EDICON and Elstree computing

Once the testing process of the software was completed an external viewpoint was required to validate the software package. To this end representatives of EDICON and ECL, the company which supplied the bill of quantity preparation package, were invited to a demonstration of its operation.

A meeting was held at ECL’s Mill Hill offices to demonstrate the software, which was attended by eight members of EDICON and ECL.

The demonstration used two notebook personal computers one, the BQ preparation PC, incorporating ASCII export files from ECL’s CATO software, the CATO software module and the CINTER software module. The other, the rate addition PC, incorporating the RATES software module.

The demonstration consisted the testing process described earlier in this chapter, with manually entered data being provided by representatives from EDICON and ECL, to prove the authenticity of the CONITT and CONTEN messages produced.

The EDIFACT messages were passed between the BQ preparation PC and the rate addition PC using newly formatted 3 1/2” floppy diskettes.

Comments made on software

1. Manual data entry should be avoided in conversion software. This should be incorporated in ECL’s BQ preparation software, CATO.
2. The RATES module only allows the addition of rates. CATO already produce a software program which allows the addition of rates to a bill manually, without the use of an EDI message.

3. An interface with an estimating package would be the next step.

4. The CINTER module produces an in-house formatted file for CATO. ECL's CATO would have to be modified to facilitate the import of this file.

5. The programs demonstrated are suitable for the EDICON trial of the CONITT and CONTEN messages.

8.3.7 Conclusions of software development project

The objective of the software development process was to develop a software package which would facilitate the trial of the CONITT and CONTEN messages, complying with the trial guidelines set by EDICON, thus enabling further work to be undertaken by the working parties.

The software developed comprised three modules: CATO; RATES; and CINTER, each of which was developed to a specification using a predetermined development methodology. The development of the software package was also time bound. The time constraints were imposed at the outset of the project to ensure the software was complete within 6 months of the trial initiation meeting, held at RICS on 1st April 1993. A time limit of 6 months for software development was selected to ensure the software was available to be included in the formal EDICON trial of the CONITT and CONTEN messages.

The objective of developing a software package to facilitate the trial of the CONITT and CONTEN message was achieved. The testing process proved that the software package facilitated the transfer of CONITT and CONTEN messages created from the test bills provided by EDICON.

The software provides an interface for ECL's CATO software to the CONITT and CONTEN messages. However, due to the time bound nature of the project an interface for an estimating package was not developed. As an alternative for the trials a single software module was developed to import the CONITT message, allow the application of rates, and produce a CONTEN message. The development of an interface for an estimating package would be essential to the commercial application of the CONITT and CONTEN messages.

The successful testing of the software, with no debugging required when the three modules were tested together, was the result of a sound development methodology in conjunction with a good
performance specification for each module. The successful performance of the software during the demonstration to EDICON and ECL representatives proved the testing of the software to be sufficient.

The demonstration of the software to representatives from EDICON, who initiated the EDICON trial resulted in its acceptance as suitable for the formal trials of the CONITT and CONTEN messages. The software development project achieved its objectives and was therefore successful.

Lessons learned from software development
The software development described in this chapter include the following features which assisted the development process.

1. objective setting
2. performance specification for each module
3. development methodology for each module
4. planning of software modules
5. time bound project

These features form part of the structured systems development methodology, known as SSADM.

The features identified can also be related to the key points of any objective. Objectives should be:
Specific;
Measurable;
Agreed;
Realistic; and
Time bound (Insight 1994).

8.4 Current status of bill of quantities messages

8.4.1 Application of bill of quantities messages in UK construction industry
The official EDICON trial of the CONITT and CONTEN messages did not prove successful. The lack of success was not a result of any shortcomings in the messages themselves, as proven by the testing and demonstration of the software described in this chapter, but by the failing of the parties attending the trial initiation and technical briefing meetings to invest any resources in the trial.
Indeed, the only trial of the CONITT and CONTEN messages was that undertaken using the software described in this chapter during the testing and demonstration of the software.

The reason for the unwillingness of companies to commit resources to the trial is uncertain. However, there are several factors that together may have caused the failure of the trial, these factors are described below.

- The recession in the construction industry coincided with the trial
- Transfer of bill of quantity information by EDI is not critical to the operation of construction companies.
- Savings afforded by transfer of bill of quantity are negligible compared to the cost of a contract, as the bill of quantity is only transferred twice during the tender stage.
- If a construction company is the first with EDI capability, with whom does it transfer bill of quantity documents with?
- Transfer of ASCII text files, exported from bill of quantity preparation software and imported directly into estimating software provides many of the advantages of EDI to a contractor.

The result of the failure of the CONITT and CONTEN trials is that no EDIFACT messages are used to transfer bill of quantity documents in the UK construction industry.

8.4.2 Achieving implementation of the bill of quantities message set

The adoption of any technology must be supported by a clear business case. This is the case in construction where no matter how good a technology is, it will only be used if it can demonstrate a real benefit to the industry (Wix and Bloomfield 1997).

The use of electronic exchange must therefore provide significant benefit. The benefits reported in chapter 7 include: speed of information exchange; speed and accuracy of data input to contractors estimating system; speed and accuracy of data input to client's tender evaluation system. These benefits whilst tangible equate only to minor operational benefit. This minimal benefit is compounded by the fact that reports indicate that there is generally a difficulty in justifying electronic exchange technology in the terms of business benefits (Back et al 1994; Baldwin et al 1995).

The lack of significant benefits to all parties stems from the fact that the implementation of the bill of quantity messages, to directly replace the bill of quantities, does not comply with either of the
two implementation criteria identified in chapter 4. The analysis of case studies presented in chapter 4 identified that one of two criteria must be met for an EDI application to be successful. These criteria are:

the use of EDI provides operational efficiency improvements in a high volume data exchange scenario; and

the application of EDI facilitates re-engineering that provides significant benefit.

The six bill of quantities message types, each of which are transferred a few times over a long period, do not constitute a high volume of data exchange. Also the use of EDI messages to replace the existing exchange of documents does not provide any benefit through re-engineering. These arguments also hold true for the exchange of bill of quantities information using the CITE standard. Whilst, this standard provides a simpler means of exchanging the data, it still cannot achieve significant benefit through operational improvements alone. A means of re-engineering is therefore required to achieve the adoption of electronic exchange technologies.

The use of a shared data resource in the form of a project model, for construction projects provides a means of process re-engineering. A number of projects have been initiated to investigate the potential of shared project models, including the VEGA project and IAI. These projects are reported in detail in chapter 4. These project models integrate the information tasks which occur during the construction process and in doing so may provide a significant benefit to all parties in the construction process. Such a system would require bill data to be stored in the project model, and thus a means of storing, retrieving and updating this information would be required. The bill of quantities message set would be ideally suited to these tasks.

The electronic exchange of other project cycle information flows, identified by the information flow model in chapter 5, are also of low volume, therefore to warrant further development of EDI standards the re-engineering of the information tasks in the construction process is essential. However, once a means of re-engineering is implemented, for example in the form of a shared project model, such messages would be essential. This has been realised by the VEGA project team who have incorporate an EDIFACT interface in their STEP based system to facilitate such information exchange (Goncalves et al 1996).
8.5 Summary

This chapter first describes the attempted implementation of the bill of quantities message set in the industry guided by EDICON. The formal approach of EDICON consisted of the use of working parties to ensure the application of the message meets industry requirements. The working parties developed an understanding of the messages and produced a code of practice for their use. The need for a trial of the messages was identified by the working parties. A significant number of parties were interested in the trial of the messages. However, few resources were available to undertake the trial, which subsequently failed.

The trial of the message was undertaken as part of this research in collaboration with industry representatives. The scope of the trial was set to undertake the tender processes, as defined in the information flow model in chapter 5, for a bill of quantities message using the CONITT and CONTEN messages. Bill of quantities preparation software, the CATO system, and the hardware platform were selected for the trial.

The development of the trial system proved that the bill of quantities message set is suitable for undertaking the tender process and also proved that translation software can be produced for existing software products. The process of development emphasised the need for rigorous planning and validation of EDI systems to ensure their reliable operation.

Finally, the investigation of the implementation of the bill of quantities message set identified the lack of significant business benefit as the key reason for the failure. The investigation of implementation issues undertaken in chapter 4 identified the need for re-engineering to achieve significant benefit from the electronic exchange of information in low volumes. All project cycle information flows identified in the information flow model in chapter 5 are low volume. It is therefore necessary to re-engineer the information tasks in the construction process to achieve significant benefit from the electronic exchange of project cycle information. The use of a shared data resource, in the form of a project model, as a means of re-engineering has been identified and is currently being developed in a number of initiatives including IAI and the VEGA project. These approaches are the only means currently in development that can be used to successfully implement the electronic exchange of bill of quantities documents in the construction industry.
Chapter 9
Conclusions and recommendations for further research

9.1 Introduction

This research has concentrated on the application of EDI to the information flows which occur during the traditional construction process. The aim of this research was to review the role of EDI in the construction industry and develop tools to assist in its application to improve the efficiency of the construction process. To meet this need the aim was divided into the following objectives, as stated in section 1.2:

1. To examine EDI and its application in the construction industry.
2. To develop tools to assist in the development of EDI messages.
3. To develop and implement EDI messages to determine the effectiveness of the tools developed and the suitability of the technology to the industry.

The main conclusions drawn from this research in relation to these objectives are described in this chapter.

9.2 Research tasks

To achieve each of the objectives a set of tasks were identified (see section 1.3).

To achieve the first objective the following tasks were undertaken:

- a review of EDI and its technical components;
- a detailed review of EDI standards for both technical and commercial data;
- an investigation of the business impact of EDI, both potential and observed;
- an investigation of the legal impact of EDI, in the framework of the UK legal system operating within the European Union;
- a review of literature to investigate issues relating to the application of EDI in the construction industry; and
- a longitudinal study of the application of EDI in the construction industry over a five year period.
To achieve the second objective the following tasks were undertaken:

- identify system modelling tools suitable for representing construction information flows;
- create a data flow model which represents the external information flows during the construction process;
- select an information flow best suited to conversion to an EDI message; and
- develop a generic methodology that can be used to create EDI messages.

To achieve the third objective the following tasks were undertaken:

- undertake the development of a message as defined by the methodology;
- analyse the message to be implemented, to determine the scope of initial implementation; and
- undertake a trial implementation defined by this scope.

9.3 Main conclusions

This section describes the main conclusions drawn from this research classified by the main objectives and their related tasks.

9.3.1 Examination of EDI and it’s application in the construction industry

Review of EDI and its technical components

The following conclusions were drawn from a brief investigation of EDI and a review of it’s technical components:

- the key concept in all definitions of EDI is that of a standard information structure, which allows the automatic processing of the data transferred;
- for simplicity, only the terms EDI and electronic data exchange would be used in this research;
- EDI can provide a number of tangible and non-tangible benefits, making the overall benefit difficult to quantify;
- the technical components required to undertake EDI are well defined, with a number of options available for each component to suit the application.
Review of EDI standards for both technical and commercial data

The review of EDI standards resulted in the selection of EDIFACT for the exchange of commercial information and the selection of DXF for the exchange of graphical/technical information.

EDIFACT's advantage over existing data exchange standards is that it is suitable for international trade and is truly generic, thus allowing any type of message to be created for any country. EDIFACT also has the benefit of being supported by the United Nations. The adoption of EDIFACT by EDICON and EDIBUILD, the UK and European construction EDI groups, necessitates its selection for EDI message design in the construction industry. The CITE standards provide an alternative to EDIFACT, however, this set of standards were developed specifically for the UK construction industry and are therefore not suitable for international trade. Also CITE lacks the commitment to develop a comprehensive construction message set, which indicates that the initiative may not be able to fulfill the electronic data exchange requirements of the industry.

The DXF standard has been adopted by the UK construction industry, thus virtually excluding all other graphical exchange standards from practical use. The future of technical data exchange is with the STEP standards which will provide a true international pan-industry method of technical data transfer. However, the STEP projects currently underway do not yet provide a practical solution to construction technical data exchange.

Investigation of the business impact of EDI, both potential and observed

EDI impacts on business in two ways, by improving the efficiency of the business, and affecting how the business operates to maximise these benefits.

To achieve the maximum operational benefit from EDI it is essential that it is integrated with existing systems, ideally EDI itself is used to integrate systems both internal and external to the organisation. Regardless of the level of integration the organisations which benefit most from EDI implementation are those which incorporate EDI into their overall strategy (Holland et al 1992). The inclusion of EDI in such a strategy requires commitment to the technology. It is only where such commitment exists that EDI can succeed, as the implementation of EDI systems includes a number of difficulties. The COST320 study (TEDIS 1994), identified the main implementation problems as follows: technical start up problems (57%); interfacing EDI software and in-house systems(36%); organisation/procedural start-up problems (33%).
The need for commitment concurs with the view of O'Callaghan (1992) who reports that expected efficiency and service gains make EDI adoption more likely, while anticipated system incompatibility makes this adoption less likely.

The decision to adopt in an industry is finely balanced and is currently being decided by the measurable operational benefits. Hence EDI is currently having the greatest impact on industries dealing with high volume trading cycle processes. However, the development of the internet will provide an accessible method of trading electronically which will make EDI open to a far greater number of companies. This will not only impact on the number of people trading electronically but will also open electronic trading markets, leading to the utopian situation of a truly open EDI trading community. Such a community will nullify any competitive advantage, and will simply achieve reduced costs, hence the long term impact of EDI will be a reduction in cost to the customer (TEDIS 1994).

**Investigation of the legal impact of EDI, in the framework of the UK legal system operating within the European Union**

The legal implication of electronic document transfer centre on the two key legal issues of contract, is a contract formed by the transfer of an electronic document, and evidence, is a document which is created and stored electronically considered as admissible in court. These issues must be resolved to determine if trade can be undertaken in a legally secure manner by electronic means. The use of trading internationally also raises question over these legal issues in all countries, not just the UK or the EU.

The investigation of legal issues undertaken resulted in the following conclusions.

- No jurisprudence exists for the electronic formation of contracts.
- The dispute of contracts will be determined by courts which apply the laws of contract formation and performance to new technology.
- Electronic trading can be achieved, without compromising the business operation of a company, if both parties agree at the outset of trading that EDI may be used to form contracts. This is best achieved by implementing an interchange agreement between the two parties.
- International trade poses further questions, with many different legal systems to be considered, however, far from confusing the legal issues of EDI, this is providing direction to an achievable legal solution.
Investigation of issues relating to the application of EDI in the construction industry

An analysis of case studies was undertaken to compare the use of EDI in construction to other industries and to identify the key success factors of EDI utilisation. The three conclusions from this analysis were as follows.

- The two key factors for success are high data volumes and the use of EDI to achieve re-engineering.
- EDI implementation is largely driven by clients.
- The successful applications of EDI in construction are similar in nature to those of other industries. These applications concentrate on the exchange of high volumes of trading cycle information.

An investigation of the low volume of EDI use in the construction industry identified the following factors:

- industry issues;
- electronic data exchange issues; and
- business case.

The electronic data exchange issues would be the result of the transition to electronic exchange and would therefore not be long term problems. Industry issues and the lack of a business case however require more detailed consideration. The fragmented nature and complexity of the data flows are significant inhibitors which are compounded by the unwillingness to invest in new technologies, particularly such technologies which do not have a clear business case to support their implementation.

An investigation of the key technical and management implementation issues identified there to be few technical issues. However, the implementation of electronic exchange requires two areas to be considered: process and organisational change; and the need for staff to be receptive. These two issues dictate that the successful implementation of electronic data exchange requires the project to be driven by senior management.

The investigation of the benefits of electronic exchange, both tangible and non-tangible, concluded that to achieve these benefits it is necessary to change work practices in the industry. This concurs
with the conclusion from the case study matrix which identified re-engineering as one of the key requirements for success in the industry.

The success of EDI in construction is dependent on re-engineering. The benefit that this would afford needs to be quantified. The simulation of data transfer through EDI by Back and Bell (1995) and Carter et al (1996) indicated that cost savings in the range of 40% to 75% are achievable through re-engineering indicating that these benefits would be significant.

The integration of information activities was identified by Bjork (1997) as a means of re-engineering the industry. The use of a shared data resource in the form of a shared project model is one way of integrating the industries information activities. Three initiatives were investigated which utilise STEP technology to provide a shared project model: IAI; RoadRobot; and VEGA. The VEGA project is in one respect more complete than the other two as it incorporates EXPRESS meta-models to allow the storage of SGML documents and EDIFACT messages in the project model. This initiative also recognises the need to provide access to the project model for all participants in a construction project, it is proposed that this is achieved by means of internet client-server applications. The use of such a project model is transposed onto the traditional construction process and a tentative application of such a model is presented.

Finally, the investigation of partnering concluded that this practice provides a current opportunity to drive the implementation of electronic exchange.

**Longitudinal study of the application of EDI in the construction industry**

A longitudinal study of the use of EDI was undertaken by means of two surveys of the same industry sample at a five year interval. The study also provided an indication of the industry’s view of EDI at each point in time. The first survey was also used collate views regarding the potential applications of EDI to provide information to assist the selection of an information flow suitable for message development. A total of 138 questionnaires were issued to construction related companies in 1992. 56 responses were received, a return rate of 41%. A total of 180 questionnaires were issued to construction related companies in 1997. 52 responses were received, a return rate of 29%.

The main conclusions drawn from this study were as follows.
1992 survey
- EDI was little used in 1992 (9 respondents).
- 75% of companies either used EDI or planned to implement it within five years, hence critical mass of EDI should be reached.
- EDIFACT considered most suitable EDI standard.
- Lack of knowledge of EDI identified.
- The three messages considered most useful: bill of quantities; trading cycle; and specification.
- EDIFACT standard most commonly used.

1997 survey
- EDI little used in 1997 (8 respondents)
- 70% of companies either used EDI or planned to implement it within five years.
- CITE considered most suitable EDI standard.
- Lack of knowledge of EDI re-affirmed.
- Message considered most useful: trading cycle; and bill of quantities.
- DXF standard most commonly used.
- Non-committal response from industry as to the future of EDI.
- The inhibitors for implementation identified: dislike of change; lack of benefits; and lack of awareness.

This study clearly indicates that the potential application predicted in 1992 was not realised. The application of electronic exchange has also shifted to technical information, probably due to the expansion in the use of CAD. Interest in EDIFACT has dropped, being replaced by the more practical approach of CITE. However, there is still a significant requirement to improve awareness of electronic exchange technologies in the industry.

9.3.2 The development of tools to assist in the development of EDI messages

Identification of system modelling tools to represent construction information flows
To identify the information flows that occur during the construction process, which would be suitable for EDI, it is first necessary to identify all the information flows that form the process.
This can be achieved by modelling the information flows which form the process. System modelling tools were investigated to identify which best suited the task.

The data flow diagram (DFD) was selected as the tool best suited to the modelling of the construction process for the following reasons:

- the DFD is a hard systems modelling tool, which are used to model systems that are well understood, such as the construction process;
- the DFD is used to represent the flow of data between entities, which is analogous to the exchange of information between construction parties; and
- a DFD provides documentation of a system from the point of view of the data, as data populates the whole system, this provides an overview of the system under consideration.

**Production of a data flow model which represents the external information flows during the construction process**

The information flows identified were tagged as suitable and not-suitable for EDI based upon the following criteria: the flow must be unidirectional; and the flow must be well defined in both structure and content. The flows suitable were then grouped into project specific, trading cycle and product information.

**Selection of an information flow for EDI message development**

The specification information flow was selected as the next priority for EDI message development. This selection was made because of the following reasons.

- EDI message development for construction management information flows is poorly resourced compared to other information flows types.
- The first survey (see chapter 4) identified the specification information flow as the most beneficial if exchanged using EDI. Excluding information flows for which messages have already been developed.

**Development of a message development methodology**

The development of EDI messages for the construction industry has progressed slowly and the rate of development needs to be increased. To achieve this the method of development must be formalised. A message development methodology was therefore developed. This methodology consists two parts. The data analysis stage and the message design stage. The data analysis stage
is the production of a data model based upon the documents which form the existing information flow and the additional requirements of the message. This stage is generic and can be applied to the development of a message using any EDI standard. The second stage, message design, is the conversion of the data model into an actual message using the syntax and components that form the message as governed by the EDI standard. This stage is therefore dependent on the EDI standard employed.

The methodology was produced represents the view of a small group, it therefore may not present an ideal means of message development, but it does provide a starting point from which improved methods can be derived.

The objective of producing a message development methodology was to achieve a reduction in the time required to develop a message. The methodology was validated to determine that this objective was met.

9.3.3 The development and implementation of EDI messages

Development of a description data model

The message development methodology was validated by developing a data model for a description. The data analysis stage was successfully undertaken to produce a data model that can be used to store descriptive information relating to an object.

The development of the data model highlighted the following issues:

- the development of messages is extremely time consuming, as the message must provide the functionality required by all parties;
- the data model and hence messages produced must provide the functionality required by all parties;
- the resulting data model can be generalised and over complicated;
- thorough testing of a developed data model is essential; and
- the time taken to develop data models and messages could be greatly reduced.

The research suggests that a modular technique may be suited to EDI message development. The example of the data description model, provides an example of data analysis that can be utilised for a number of messages. The use of such development techniques may provide means to
reduce the development cycles of new messages. This methodology is not new, and is commonly used by software developers in the form of function libraries and rapid application development tools.

**Analysis of the bill of quantity message set**

The bill of quantities message set was selected for trial for the following reasons:

- the first survey reported that industry considered the electronic exchange of bill of quantities information as providing the greatest benefit;
- the analysis of the information flow model identified the bill of quantities information flow as suitable for EDI; and
- EDICON had developed an EDIFACT bill of quantities message set which was at a stage ready for trial during this research.

The bill of quantity message set comprises: CONITT; CONTEN; CONEST; CONPVA; CONQVA; and CONDPV. These messages are utilised for the transfer of different information flows. The trial of the message set must be rigorous, but realistic. The tender process was selected to demonstrate the validity of the messages.

The analysis of the message set showed that only the CONITT and CONTEN messages would be required to undertake a meaningful trial. The level of redundancy in the messages themselves is also high. Only a moderate percentage of the segments that fit within the overall structure of each message are required to mimic the existing information flows. These messages represent a complication of the industry’s requirements. It is not suggested that the messages be simplified, however, a reduced version of the messages must also be made available to provide a perceivably simpler solution, which is fully compatible with a more comprehensive utilisation of the message set.

The following advantages and disadvantages of the bill of quantities message set were identified.

- The reduced time required, to transfer the bill of quantity both from the client's representative to the contractor and then return it, would add to the time available for the contractor to prepare an estimate

- The speed and accuracy of direct data entry into the contractor's estimating system, provides a reduction in time required for the actual data entry and also for the checking of data.
• In addition to the benefits afforded by the simplest scenario, the use of the full set of messages and their full functionality can provide additional benefits. These include added functionality and the ability to use the CONITT and CONTEN messages to transfer partial bill of quantities information between the main contractor and sub-contractors.

• Advantages of the EDIFACT standard, including international standardisation. The benefits of EDIFACT messages are describe in detail in chapter 2.

• The messages may appear over complicated to the industry and hence hinder implementation. The complexity is required for international compatibility and to provide added functionality.

• The number of messages exchanged using the bill of quantities message set is low during the project life cycle. This does not fit the ideal application of EDI which is a high frequency of similar data flows. The operational efficiency benefits to the parties involved will be minimal.

• The ability to directly enter an un-priced bill of quantities into an estimating system does provide time and cost savings, but as this only occurs once for each project and as it is undertaken by junior members of staff, it is not excessively costly.

• The CITE initiative provides a simpler alternative to the EDIFACT messages.

**Trial implementation**

A trial implementation of the CONITT and CONTEN messages was undertaken as part of this research in collaboration with industry representatives. To undertake the trial a suite of 'C' software was developed for use with the CATO bill of quantities preparation system.

The software suite developed was validated by the exchange of a number of bills of quantities. The system was demonstrated to representatives from EDICON and Elstree Computing Ltd, and was deemed by these parties as suitable for the trial of the CONITT and CONTEN messages. The software development project proved that the EDIFACT bill of quantities message set can be used with current construction systems.
The success of the software project was due to the following key features of the development process.

1. clear objective setting
2. performance specification for each module
3. development methodology for each module
4. planning of software modules
5. time bound project

Two working parties were formed to implement the message set. These working parties investigate the following implementation issues: the impact of EDI on working procedures; and matching EDI messages to working practice. The result of this work was the production of a code of procedure for the exchange of CONITT and CONTEN messages as part of the tender process.

The working parties concluded that a trial was required to assist in the identification of further issues that should be discussed regarding the implementation of the CONITT and CONTEN messages.

The success of the trial system developed indicates that there are few technical issues to overcome to facilitate the implementation of the message set. The other procedural issues can also be seen as easily resolved by means of the code of procedure. The implementation of EDI therefore has few difficulties, other reasons for the failure of the messages set must therefore be sort.

Issues identified by this research related to the failure of the implementation of the bill of quantity message set are describe below.

- The benefits and disadvantages identified in chapter 7 indicate that whilst the bill of quantities message set does provide benefit, it is difficult to identify a party which benefits enough to encourage them to promote the adoption of these EDI messages.

- The lack of significant benefits to all parties stems from the fact that the bill of quantity message set does not comply with the key criteria of an effective EDI message, ie. the high volume transfer of information in a standard format.
• The perceived complexity of the bill of quantity message set may inhibit its implementation.

• The implementation of the complete bill of quantities message set would require all sub contractors to become EDI complaint. This would involve implementing EDI in tens of small companies for each project, to achieve the transfer only a small volume of messages. The cost of implementing the necessary systems in all sub-contractors involved in a project would be prohibitive, whilst providing minimal benefit.

• The lack of notable benefit to the contracting parties and the structure of the construction industry dictates that for the bill of quantity message group to become widespread throughout the industry the technology must be promoted by the client by making its use a contractual obligation. No clients took the step of contractual obligation to aid the implementation of the message set.

• The lack of a champion of EDI who has the authority to impose the use of EDI, has resulted in no company needing to use the technology to survive. The lack of a champion is due to the fragmented nature of the industry, which is a feature of the industry that is not likely to change.

• During the early 1990s the industry was in recession. The result of this is for construction companies to be come entirely cost-led. The implementation of EDI a technology which incurs a significant initial cost and requires other parties to comply to achieve any benefit is not a high priority during a period of recession.

The investigation of the implementation of the bill of quantities message set identified the lack of significant business benefit as the key reason for the failure. The investigation of implementation issues, undertaken in chapter 4, identified the need for re-engineering to achieve significant benefit from the electronic exchange of information in low volumes. All project cycle information flows identified in the information flow model in chapter 5 are low volume. It is therefore necessary to re-engineer the information tasks in the construction process to achieve significant benefit from the electronic exchange of project cycle information. The use of a shared data resource, in the form of a project model, as a means of re-engineering has been identified and is currently being developed in a number of initiatives including IAI and the VEGA project. These approaches are the only means currently in development that can be used to successfully implement the electronic exchange of bill of quantities documents in the construction industry.
9.4 Analysis of conclusions

The main aim of this research is to "review the role of EDI in the construction industry and develop new tools to assist in its application to improve the efficiency of construction process". The need to improve the efficiency of the construction process was identified by Latham(1994). The need to improve efficiency is borne out of two factors, the current inefficient nature of a fragmented industry and the need to compete in what is becoming an international market.

It is estimated that the efficient management of information would yield savings in construction costs of 25% (NCE 1991). This would make a significant contribution to the cost savings being sought by the industry in response to the Latham report. Currently, the data provided by one value adding process is rarely in a format suitable for subsequent downstream processes, Ndekugri and McCaffer (1988) see the solution through integration where any data created can be utilised by any other function.

EDI is a technology which can be used to integrate the IT systems used by each of the disciplines and therefore improve the information interface between the disciplines. EDI technology could therefore be employed to improve the management of information during the construction process.

The barriers to implementation of EDI identified by Strassman(1990) were: structure and nature of UK construction industry; the scale and complexity of data flows in construction; the economic recession; conflicting standards of data transfer; the availability of agreed message formats; security concerns; and legal issues.

This research has identified that the technical issues of EDI do not form a barrier to its implementation. The need for common standards and message formats is the only issue that requires significant consideration. The legal issues, similarly, also do not present a barrier, as long as reasonable precautions are implemented, for example by using an electronic data interchange agreement. The two main issues identified by this research that form a barrier to the implementation of EDI in construction are: the need to identify a clear business case for the technology; and the fragmented nature of the construction industry.

The business case for EDI is defined by the benefit it can afford. EDI can afford significant benefit in one of two ways: by improving the efficiency of a high volume of transactions; or by using EDI to facilitate re-engineering which itself provides operational benefit. Information
exchange in construction consists a large number of complex and sporadic data flows. This is shown by the information flow model of the construction process presented in chapter 5.

The bill of quantities message set was proved to be capable of integration with existing systems and to be technically correct by the trial undertaken in this research. The implementation of the bill of quantities message failed for a number of reasons identified in chapters 7 and 8, however, the most significant of these was the lack of benefit. The implementation of the bill of quantities message set could not provide significant benefit through improved transaction efficiency due to the low volume of exchange. Also the message set was not used to facilitate re-engineering that itself would provide benefit. The solution for bill of quantities exchange provided by the CITE initiative also fails to meet either of these criteria, it would therefore also be difficult to develop a business case for the implementation of these standards. This is reflected by the study reported in chapter 4 and the survey undertaken by Akintoye(1997) which reported only a minimal application of the CITE standards in the industry. This situation has been recently affirmed at a CITE initiative presentation were only 4 of the 40 attendees, all of which were interested in CITE, used the standards (Watson 1998).

The current information processes in the construction industry are of low volumes, therefore re-engineering is required to obtain the benefit required to substantiate the implementation of EDI. The use of a shared project model to manage project data has been proposed as a means to re-engineer information tasks in the construction process. Such a model would require the use of EDI technologies to populate and retrieve data from the model. Current initiatives developing shared project models include: IAI; VEGA; and the RoadRobot project. These initiatives are largely STEP based, but the VEGA project has identified the need to store commercial information also and includes EDIFACT meta-models to achieve this.

There are still a number of EDI messages to be developed before such project models could be implemented. The information flow diagram of the construction process and the message development methodology provide two tools which can be utilised to develop these messages.

If the benefits of improved data management are to be realised in the industry it will be necessary to undertake the re-engineering of the information tasks. These benefits could provide a significant contribution to the achievement of the improvements in cost savings set by Latham.
The implementation of shared project models, utilising EDI technology, may therefore be essential to maintain the competitiveness of the UK construction industry.

Limitations of the research
The message development process described was largely based on the view of a single message developer. Whilst the process was reviewed by other individuals, the document produced only reflects the view of a small group of individuals. This limitation has been imposed by the minimal message development which has been undertaken in the industry.

The development of a description data model described does not represent the development of a complete message. However, the data model produced can be used as part of a number of existing and future messages. This process highlighted message development issues and the benefits of developing messages in a modular fashion. The message design process was not undertaken as it simply represents the conversion of a data model into a specific EDI message standard, and was therefore not considered beneficial to this research.

The trial of the bill of quantities message set, whilst technically validating the message set, did not include an interface with an estimating package. An interface was not developed because of time limitations. Whilst an interface was not required to trial the message, it would be required to use the system in a commercial environment.

9.5 Recommendations for further research

There are several recommendations for further research derived from this study. These are:

- This research identified the internet as providing a common means of communicating EDI messages between construction parties. The use of the internet in the industry should therefore be investigated by means of a survey to determine if its use is suitably widespread to provide an EDI communication solution.

- Assuming the internet can provide a communication solution, the development of web-based interfaces, possibly web forms, for existing construction industry software would be required.
• The five year longitudinal study of EDI in the construction industry should be continued with a third survey after another five year period. This would provide a true indication as to the success of the more practical methods employed by the CITE initiative.

• The message development methodology produced as part of this research would benefit from further refinement that can only be achieved through message development. This work would therefore require an increase in the rate of message development in the industry.

• The development of a modular approach to speed the process of message development as proposed by this research should be investigated further. This would not affect the methodology developed by this research but would simply promote the re-use of modules that form existing data models.

• The description data model derived in chapter 6 requires further testing by industry to ensure it provides the functionality required.

• The "Rates" program produced as part of the suite of software to trial the bill of quantity message set was produced as time limitations did not allow the development of an interface to a commercially available estimating package. The development of such an interface would be required if the bill of quantity message set is to be used for live construction projects.

• The perceived failure of EDI in construction is due to a number of interrelated factors. A series of interviews of industry leaders should be undertaken to determine their views on why EDI failed. The results of these interviews could be used to identify the potential drivers that may result in its revival and the realisation of the efficiency gains offered by the technology.

The use of EDI alone as a method to improve the efficiency of the industry’s communications has failed. Implemented as a stand-alone solution EDI is not perceived as providing enough benefit to substantiate the investment of resources required. The future of EDI is as an enabling technology that facilitates the implementation of re-engineering to achieve benefit. The use of project models, to store information that is shared between the project team, is a method of re-engineering the information tasks in the construction process that would improve the accuracy and timeliness of information. EDI could be used in such a scenario to facilitate the exchange of data between the project team and external parties. EDI messages could be automatically produced from information in the project model, thus eliminating error in the communication
process. The advent of the internet provides a cheap and simple means of exchanging EDI messages, thus facilitating its use among all project participants. The use of EDI to enable additional benefit from a project model, in addition to the ease of implementation afforded by the internet, indicates that EDI could soon form an essential part of communication in the construction industry.
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Please note that fines are charged on ALL overdue items.
Appendix A

Case studies of EDI use
APPENDIX A - Case studies of EDI use

A.1 Applications of EDI in the construction industry

A.1.A Jewsons
Jewsons is a builders merchant with over 200 trading branches nation-wide. The main business of Jewsons is to supply the small to medium builders and civil engineers to the serious DIY enthusiast. The following information was presented by Chris Weldon at the 1992 Annual EDICON Conference (Weldon 1992)

Why was EDI adopted
Jewsons first started to use EDI in 1987. At that time Jewsons were receiving over 100,000 invoices per month by post, a typical "paper mountain". Each of which had to manually entered into the computer system. The highly repetitive nature of the work led to data entry errors and a high staff turnover.

Implementation
Jewsons approached its top 30 suppliers who sent the highest volume of invoices. 60% of these suppliers were willing to commit to EDI. Jewsons sent each willing supplier an information pack and held meetings to explain how the EDI system would work. INS provided the Value Added Network services necessary to undertake EDI with such a large group of companies. By the end of 1990 5 suppliers were on-line, but by March 1991 15 suppliers sent their invoices by EDI. Jewsons discovered the time to connect a new supplier into the system varied from 2-3 weeks for knowledgeable suppliers, through an average of 2-3 months, to over 6 months for suppliers who considered EDI as a low priority.

Messages and standards
Jewsons started receiving invoices using the Tradacoms standard. This standard was selected as it is proven in the clothing, food and engineering industries. It is also easy to use and well defined. Jewsons recognised EDIFACT as the future EDI standard and can now also receive invoice messages in this format.

Benefits
The benefits identified by Jewsons are: accuracy of data; reduction in costs as less staff required; improved service as all EDI accounts are always up to date; faster transfer of documents; no lost documents; and most importantly improved relations with suppliers.

A.1.B Sheffield Insulation's
Sheffield Insulation's provide insulation materials to the construction industry. The following information was presented by John Whaling at the 1992 Annual EDICON Conference (Whaling 1992)

Why was EDI adopted
Sheffield Insulation's adopted EDI for the following reasons: to improve relationships with it's customers and suppliers; to maintain it's market position; to reduce operating costs; and to improve data accuracy.
Implementation and system description
Sheffield Insulation's targeted its EDI partners. The initial trading partners had experience of EDI, were either suppliers or customers and traded a high volume of documents. Sheffield Insulation's plan to contact every customer who receives 100 or more invoices a month. The VAN selected depends on the partner with which Sheffield Insulation's is trading. The hardware platform selected was the PC due to the low cost. Two software packages were evaluated: Interbridge and Multiplicedi. Multiplicedi was selected as it was user friendly and independent of standards.

The in-house IT team developed EDI routines to integrate EDI into the existing software. The systems have incorporated transactions of purchase orders, purchase invoices and sales invoices. Sheffield Insulation's were trading with two major suppliers and one customer by April 1992.

Messages and standards
The EDI standard used by Sheffield Insulation's is Tradacoms. However, the EDIFACT standard would be used if required by a trading partner. Sheffield Insulation's are trading using purchase order and invoice messages. The invoice messages are both sent and received, whilst the purchase orders are only received.

Benefits
The benefits of EDI identified by Sheffield insulation's are: staff reductions; improved accuracy; and a reduction in queries. Transferring a document costs an average of 10 pence.

A.1.C Charente District Department of Public Works, France
The Ministry of Public works is responsible for regional development. To implement the government's policy, it relies on the district departments. The Charente Department of Public works was selected as one of two departments of the Ministry of Public works (equivalent to the Department of the Environment) selected to take part in the Angouleme EDI experiment. The following information was presented by Jean-Michel Lorigne at the 1993 Joint EDICON/EDIBUILD Conference (Lorigne 1993)

Why was EDI adopted
The Angouleme experiment was initiated to promote EDI in the building sector. The department of public works undertake a competitive tendering process to award work to contractors. The contractors submit a tender price based on a job specification. Once the job is awarded a monthly valuation is produced to calculate interim payments. The objective of the experiment was to apply EDI to this scenario to reduce paperwork and administrative errors whilst reducing the time required for data transmission.

Implementation and system description
The Angouleme EDI experiment commenced in June 1991, the live project on which the experiment was undertaken was the expansion of the Angouleme by-pass to a dual carriageway. The contract value was FF 16 million, FF 5 million of which was subcontracted. The contract period was 8 months. Charente selected the Bull BRIO EDI service due to its compliance with the EDIFACT standard and its rigorous interchange protocol. COLAS the leading French road contractor acquired the necessary computer hardware from BULL. To manage its contracts by EDI COLAS adopted
EDITRAV software. Charente also acquired BULL hardware and messaging software which it integrated with its existing GAME software system.

Messages and standards
The experiment utilised the following EDIFACT messages: CONEST (establishment of contract); CONQVA (quantity valuation); CONDPV (direct payment valuation); and CONPVA (payment valuation). The experiment enabled 8 interim payments for the contract, worth FF 15 million, to be processed by EDI over a period of 8 months.

Benefits
The processing of an interim payment took a minimum period of one week when paper documents were exchanged between the district department of works and the contractor, was reduced to a few hours.

A.1.D Caradon Catnic
Caradon Catnic is a manufacturer of building components based in South Wales. The company specialise in the manufacture of steel lintels and garage doors and achieved a turnover of £75m in 1993. The following information is in the publication "EDI in Construction" (Adcock 1996).

Why was EDI adopted
EDI was first adopted by Catnic in 1988. This adoption was customer driven, principally from builder's merchants including Jewson and Graham. The Catnic board gave extremely strong commitment to EDI believing it was a means of improving business relationships with customers. EDI was seen as a means of providing an improved service, a reduction in administration costs and reduced delivery lead times. EDI was viewed as a commercial issue as opposed to a technical issue.

Implementation and system description
In 1988 Catnic approached EDICON, this led to the realisation of the need for EAN coding for its products. This was implemented in 1989. The first EDI implementation was with Jewson who were already experienced in EDI. The Value Added Network and standard was determined by this relationship. The first message implemented was that of invoices using the Tradacom standard, achieved in 1991. A year later the transfer of EDIFACT invoice message was achieved with another customer. Andrew Tull of Catnic stated that if he implemented EDI again he would "develop better testing environments first and may even suggest a full Business Process Redesign to give a stronger starting structure".

Messages and standards
As described above Catnic's send invoice messages in both Tradacom and EDIFACT standards. Catnic has four major trading partners using EDI, accounting for 30% of invoices, which equates to 30,000 invoices annually. Andrew Tull states that ultimately Catnic will move to EDIFACT as the sole standard, as he sees this is where the industry is leading.
Benefits
The benefits of EDI to Catnic are: an improvement in both communications and business links between trading partners; and lower transaction costs. However, Catnic have identified that EDI can be demanding on resources in a climate of changing standards and partner specific implementations.

A.1.E Wavin Building Products
Wavin Building Products specialise in the design and manufacture of plastic plumbing and drainage systems. Based in Wiltshire Wavin employ over 500 people and turnover £50 million each year. The following information is in the publication "EDI in Construction" (Adcock 1996).

Why EDI was adopted
The implementation of EDI was customer led, the adoption of EDI being primarily to increase customer satisfaction.

Implementation and system description
At Wavin the implementation process commenced in 1987, with the first systems operational in 1988. Wavin adopted Interbridge translation software which it uses to translate both EDIFACT and Tradacoms messages. Wavin developed software in house to link the EDI systems to its existing systems. This software includes the ability for remittance advice to be directly entered into the accounting system, ie. a customer payment is automatically processed and balance against open items.

Messages and standards
Wavin currently transmit over 50% of all its invoice using EDI and also sends credit notes and order acknowledgements. Wavin also receive remittance advice and purchase orders. The majority of message use the Tradacoms standards, only one customer currently uses the EDIFACT standard, but Wavin see a move to EDIFACT in the future.

Benefits
The main benefit of EDI a seen by Wavin is that it promotes "an efficient and effective trading partnership". Other benefits include: error free transactions; reduction in telephone orders; reduction in ordering lead times; reduction in stationery and postage; and savings in administration time.

A.2 EDI IN OTHER INDUSTRIES - RETAIL

A.2.A Price Chopper
Price Chopper is a supermarket chain operating in upstate New York, USA. A total of over 60 supermarkets and an annual sales turnover of of $900 million means Price Chopper, whilst not being one of the largest supermarket chains, has to deal with a high volume of goods each day. The information in this case study was published in the journal title Chain Store Age Executive, (Withington 1990).

why edi was adopted
A large percentage of goods sold by Price Chopper are perishable, it is therefore only practical for these goods to be delivered directly to its stores by suppliers. The delivery of large volumes of goods from many suppliers leads to chaos within the delivery area of each store. Price Chopper was aware that it was very difficult to maintain control of the direct to store supplies and identified EDI as a means of achieving greater control, whilst achieving a quicker turnaround of deliveries.

Implementation and system description
The system consists of a series of DEX (Direct EXchange) ports located in each stores delivery area which are connected to a PC-compatible partition of the in-store product database computer. As a delivery is made, the suppliers representative who is making the delivery plugs in their hand held computer anddownloads details of the items which are being delivered. The items are then checked as they are physically off loaded into the store by store employees using hand held computers which display the details of the order via a radio link. If there are any discrepancies they are entered into the hand held computer, which also incorporates a bar code reader for item identification. Once a delivery is complete the final invoice and totals are displayed and then stored, ready for transmittal to Price Choppers head quarters, which occurs each night. The confirmed invoice is then downloaded back into the suppliers handheld computer.

If a supplier does not have a handheld computer compatible with DEX/UCS, they can use a Price Chopper hand held computer to enter delivery information manually before plugging into the DEX port and making their delivery. This system works well for suppliers with only a few product lines, but is time consuming for suppliers of many line who soon invest in the equipment required. If a supplier does not want to invest in a hand held computer they can use a programmable data carrier, or smart card, which can be entered into a smart card reader at each store. Alternatively, the information can be transmitted prior to the delivery using a modem. Suppliers that do not have a hand held computer are given a print out of the invoice including any modifications.

Vendors which have proved to be highly reliable with the accuracy of their invoices over a period of several months, the manual checking of every item is waived. Instead only spot check occur. The check-in time of a delivery is then reduced from twenty minutes to thirty seconds.

Price Chopper had implemented this system in all their sixty stores by the end of 1990.

Messages and standards
Price Chopper selected the DEX/UCS (Direct EXchange/Uniform Communications Standard) for the electronic invoicing of the items delivered directly to store. The direct exchange part of the DEX/UCS standard relates to the transfer data using a direct connection between systems, eg. an interconnect. However, the system can also operate over telephone lines in the same way as any other EDI standard.

The DEX/UCS standard was selected as provides the support for Price Choppers retail requirements and accuracy of data. The standard is also supported by two major organisations: the Food Marketing Institute and; The Grocery Manufacturers of America.
**Benefits**

Price Chopper implemented the electronic data transfer system to obtain control over delivery of direct to store goods. The system ensures each item received is authorised and correctly marked and identifies any errors early, as the items are delivered, so that they can be resolved quickly.

The administrative costs of resolving quantity discrepancies using the paper-based system were so high that the irradiication of these processes by the DEX/UCS system resulted in the development and implementation costs being recovered in approximately two years.

The cost benefit of the accuracy of the system was quantified by an industry sponsored Arthur D. Little survey, which concluded that direct retailer benefit can range from 0.14% at supermarkets to 0.56% at convenience stores. This relates to benefits between $2000 and $4000 per store annually for Price Chopper. The same study also concluded that the suppliers also make a saving of approximately $1300 per delivery route per year.

**A.2.B Tesco**

Tesco is one of the leading UK supermarket chains, with many hundreds of stores in the UK. Tesco requires a substantial infrastructure, including warehousing to maintain stocks at a desirable levels in it's stores. EDI is one of several computer technologies Tesco has implemented to improve the efficiency in which its store are supplied. The information used for this case study was published in the journal titled Computer Bulletin (O'Reilly 1993).

**Why EDI was adopted**

Tesco adopted EDI as part of it's strategy to implement sales-based ordering. Sales based ordering utilises information of sales through the check-outs to automatically generate orders to maintain the desired stock levels in the store. Previously frequent manual stock counting was required to generate orders.

**Implementation and system description**

Sales based ordering operates by collecting sales information directly from the point of sale. Hand held units are used to record additional data, such as price changes, out of stock items and wastage. The sales and additional data are transferred daily to head office were a store specific order is produced. This order is then reviewed and then confirmed by the store.

Tesco uses EDI to transfer the orders to it's suppliers. The supplier then uses the order information to automatically generate the invoice which is electronically transferred back to Tesco. Tesco then checks the invoice against the delivery before making the correct payment.

In addition to this simple trading application of EDI Tesco transfer sales forecasts and information about stock levels to suppliers which provides them with advance notice of fluctuations in demand. Also Tesco transfers product and price information using EDI.
Messages and standards
Tesco's implementation of EDI is fully integrated into the related systems. This was achieved as EDI was seen as only part of a complete solution. The EDI messages used are: purchase orders; invoices; sales forecast message; stock level message; and their are plans to receive delivery note messages.

Benefits
The benefits of EDI are difficult to separate from the benefits of the whole sales based ordering system implemented by Tesco. However, EDI can be credited with providing Tesco with a means of ordering items in a more timely fashion, which is imperative in terms of perishable goods.

The sales based ordering system has provided a significant reduction in labour required to produce and transfer orders to the supplier. The orders produced are also more accurate which ensure there are fewer lines which become out of stock.

The ability to transfer stock levels and sales forecast to suppliers provides them with advance notice of demand, which they will then have more chance of meeting. This is very beneficial to Tesco as its suppliers should always be in the position to supply what is required.

The sales based ordering system as a whole has the benefit of providing the customer with a high level of service. This in turn is reflected in terms of turnover for Tesco.

A.3 EDI in other industries - Pharmaceutical

A.3.1 AAH
AAH is a large pharmaceutical wholesale distributor of providing drugs, toiletries and other healthcare products to retail pharmacies, health centres and hospitals in the UK. The information used to form this case study was published in the journal titled Electronic Trader, (ET 1993)

Why EDI was adopted
The handling of a drug order has to be rapid as the customer, the healthcare industry, is a vital public service. To ensure drugs are supplied promptly AAH undertakes twice daily deliveries to most parts of the UK. The response to an order is only a few hours from receipt. To achieve this level of response AAH opted for an interactive ordering system. The use of a batch processed EDI system would be too slow.

Implementation and system description
An electronic trading system has been developed by AAH for NHS clients, which is called MEDIATE. MEDIATE was initially developed to trade purchase orders. The hospital connects to the system using hardware and software supplied by AAH. This interactive system allows the user to view the availability of products and order what is required from AAH immediately. The MEDIATE system also allows the client to undertake traditional EDI with other suppliers, eg. Glaxo, Bayer, etc. The MEDIATE system can support all the NHS preferred value added networks: INS; IBM; and AT&T.
The key to the success of the system is its ability to match directly the unique product codes of suppliers to the in house coding system of hospitals. This is achieved using a database system which is updated monthly. The accuracy and maintenance of this system is essential as there are in excess of 40 000 product lines referenced in MEDIATE.

Once the MEDIATE had been proven it was developed further to deal with invoices to suppliers using traditional EDI invoice messages.

The MEDIATE system as provided by AAH includes system installation, training, help desk support and on-site maintenance.

Messages and standards
The MEDIATE system utilises a proprietary protocol to communicate with AAH distribution points. MEDIATE has also been designed to promote the use of EDI. The system supports both Tradacoms and EDIFACT standards for orders and invoices.

Benefits
MEDIATE is sold by AAH as a service. AAH therefore achieve a direct financial benefit from the system which it has developed. The performance benefit of interactive ordering over batch processed EDI is its speed. The system therefore gives AAH a benefit over other suppliers connected using traditional EDI.

The success of the system is illustrated by the fact that over 90% of the hundreds of thousands of orders received by AAH every day are transmitted electronically.

The benefits to the clients is the speed of response, and the ability to trade with any supplier. These factors mean that MEDIATE provides the quickest means of obtaining drugs as required, making the system very attractive to hospitals. The system is a good example of a supplier utilising its monopoly as a service provider to gain competitive advantage.

A.4 EDI in other industries - Logistics/transport

A.4.1 Safeway
Safeway is a multinational supermarket chain. The case study is based upon the application of EDI in Safeway's operations in the USA. A major function of the company is the transport of goods from its suppliers to its stores by means of road freight. The case study is based upon information published in the journal titled Fleet Owner (Moore 1989).

Why EDI was adopted
Safeway adopted EDI as part of a programme to improve the efficiency of its goods transport systems. EDI has been applied by Safeway to its inbound freight management system with the objective of tracking performance and boosting productivity.

Implementation and system description
Safeway identified accurate and consistent information as the common requirement of all parties involved in the supply chain. This includes: suppliers; carriers; vendors; and
receivers. The exchange of information was traditionally undertaken by phone and transfer of paper documents. This system had inherent problems, people were not available or phone lines were busy and paper documents did not conform to a standard format.

In 1989 Safeway adopted an EDI system which uses ShipNet systems to share information with all parties involved in the supply process. Safeway enters its shipment data into personal computers, this data is uploaded to a mainframe computer which can be accessed by any of the parties involved in the shipping process.

The shipment data consists a purchase order to the supplier and all pertinent delivery information. The system allows each truck to be assigned multiple orders and multiple pickup locations. The system operate so that parties connected to the system can only view pertinent information.

On receipt of the order the supplier acknowledges the order and pick up times using the EDI system.

Messages and standards
The EDI system used by Safeway and its suppliers is provided by ShipNet. This system uses its own EDI standard and message formats. The messages transferred include: purchase order; order acknowledgement; and delivery scheduling information.

Benefits
Safeway has identified the benefits of EDI as a means of: improving accuracy of data; reducing clerical work; and ensuring information is transferred rapidly to essential locations. Furthermore, Safeway views EDI as a means of improving communication between all interested parties in the supply process.

A.5 EDI in other industries - Utilities

A.5.A Oil industry
The oil industry described in this case study refers to a group of oil and related companies consisting: Conoco; Esso; BP; Chevron; Phillips; Shell; Price Waterhouse; INS. All oil companies are involved in joint venture oil and gas developments. The purpose of a joint venture is to limit risk and to economically and efficiently extract oil or gas. A joint venture is operated by a company formed by the joint venture partners, this company is required to provide regular statements of expenditure and reconciliation of cash paid by each partner into the joint venture. The volume and complexity of joint ventures has increased, leading to individual companies dealing with large volumes of paper billings from different operators in different formats. All this information being produced by one computer system and then manually entered into another. Ideally the manual processes should be replaced by a direct means of transfer between the computer systems.

The information used to form this case study was published in the journal titled Electronic Trader, (Howard 1991).
Why EDI was adopted
The London society of Chartered accountants Oil and Gas Discussion Group was first introduced to EDI in early 1988 by means of a presentation. The group was interested in the technology to the extent where a feasibility study was undertaken into potential applications of EDI in the Oil industry. The group selected Joint Interest Billings as a good initiation into EDI, thus forming EDI-JIBE.

Implementation and system description
A pilot team was formed in 1988. The team split into two sections: accounting and technical to address the identified work which consisted two parts: the production of an industry JIB standard; and the computing and data transmission aspect of the task.

The accounting group had the objective of producing a standard EDI message. The group produced a standard chart of accounts and formulated the content of the JIB. This information was used with accounting assistance from Price Waterhouse and technical assistance from the ANA to produce the JIB message.

The technical group produced software to map data between the in house accounting systems and the electronic message format. Also links between in-house systems and the INS Value Added Network were established, INS also provided technical support for the project.

Finally the message was tested by the participants. Parties who were involved in common joint ventures paired off to undertake pilot transmissions of the billings data in live projects.

Messages and standards
The JIB standard message consists three sections:

- Header Section, identifies message type and includes reference information
- Detail Section, contains detailed financial information on billings
- Summary Section, contains control totals and a trailer record.

The detail section of the message consists three segments: main account; cost centre; and sub account. The defined main account categories are: exploration; construction; development; drilling; ongoing capital; operating costs; abandonment's/retirements; and working capital. The message also incorporates tax control for billings which are subject to VAT.

Benefits
The benefits of the JIB message were to reduce administrative and clerical effort for the joint venture operator in producing the billings and the partners in entering the information into their systems. Also the information was distributed in a more timely fashion with the security of guaranteed accuracy.

A.5.B Eastern Electricity
Eastern Electricity is an electricity company which sells power to customers ranging from domestic consumers to large consumers, such as restaurant chains and regional authorities. The deregulation of the electricity industry has created a competitive
market. Previously consumers were tied to their local electricity board. Now a consumer can select any supplier in the country. Previously, if a company’s sites were spread over separate electricity board regions separate accounts had to be used. These accounts can now be consolidated leaving the customer with only one electricity supplier to deal with. This situation has led to bulk buying by major consumers to gain discount from suppliers. The increasing competitiveness of the industry has forced Eastern to become more efficient to maintain its market share. The information in this case study was published in the journal Electronic Trader,(Willmott 1995a) and (Willmott 1995b).

Why EDI was adopted
Eastern first investigated EDI as a result of customer demand. Two major customers, McDonalds fast food and Forte Hotels, made the provision of EDI utility billing a condition of contract. This forced the rapid implementation of EDI to keep these customers.

Implementation and system description
The initial implementation of an EDI system needed to be rapid to meet the requirements of McDonalds and Forte. This was achieved by installing a PC based package. At this point, however, Eastern undertook a project to establish a Unix EDI gateway with links to its corporate systems. This project was managed by ICL, who provided ICL hardware, ETS EDI software from SAA, interface design for billing systems, consultancy, support for implementation and roll-out over six months, plus technical training and EDI awareness sessions. The project was completed by 1995 at a cost of £250 000, representing a significant investment in EDI technology by Eastern.

Eastern is now running EDI billing tests with British Telecom, Anglian Water and Thames water for electricity supply, and Laser (a consortium of southern local authorities) for gas supply.

Eastern uses two Value Added Network providers: GEIS-INS and British Telecom. Bills are transferred to the EDI gateway using the Tradacoms utility billing message. Bills can also be sent in bulk by magnetic tape.

Customers also demand consumption information. Eastern supplies Appraise 100+ software to its customers. This software offers a dial up bulletin board or fax-back service which enable the comparison of price from different suppliers and to analyse their consumption. Digital meters are used at the point of consumption. These meters use a telephone line to relay readings to Eastern every half hour. These values can then be viewed by the customer using the Appraise software.

The success of EDI for utility billing has prompted Eastern to look at other applications of EDI, including the billing of other electricity generators for the use of Easterns distribution infrastructure and the notification of intended street works to local authorities.

Messages and standards
Eastern electricity uses the Tradacoms utility billing message for the transfer of billing information and the GEIS-INS Tradanet network service. The Tradacoms utility billing
message can also transfer additional information such as barcodes, allowing tailoring to suit the requirements of the customer. The transfer of billing information to British Telecom, however, use the EDIFACT standard bill message over the British Telecom value added network.

Benefits
Eastern electricity deals with 12 million energy bills from 3 million customers a year. The integrated billing system implemented at Eastern greatly reduces the administrative burden. The more customers Eastern can attract to trade electronically the greater the savings, for both Eastern and the customers involved.

In addition to costs savings from reduced administration, customers can use the analysis of consumption information and the selection of the best prices to achieve additional benefits ranging from 5% to 20% of the total energy cost.

Eastern electricity believes it has gained a competitive edge, which it considers to be very beneficial in the highly competitive electricity market. This competitive edge has been achieved not simply from the provision of enhanced information electronically, but also from the setting up of electronic trading which forges relationships between its own personnel and customers. These personal contacts are conducive to long term relationships, which can prove very beneficial in such an intensely competitive market.

A.6 EDI in other industries - manufacturing

A.6.A Black and Decker
Black and Decker manufacture a variety of electric hand tools for the DIY enthusiast in the UK. The information that forms this case study was published in Personal Computer Magazine (Harris 1992).

Why EDI was adopted
Black and Decker were first introduced to EDI in 1987 by B&Q one of their major customers using the INS value added network. This system allowed Black and Decker to send invoices and capture sales data from B&Q. Since this time Black and Decker have expanded their customer EDI links to include Texas Homecare among others. The benefits of EDI between itself and its customers for the transfer of invoices and sales data led Black and Decker to consider the use of EDI for communication with its suppliers. In particular the improved information flow would be beneficial to its Quick Response customer programme.

Implementation and system description
In 1990 Black and Decker distributed a questionnaire to its 50 main suppliers to investigate the possibility of trading electronically. Only a few of its suppliers were aware of EDI and only with even less being connected to a VAN. All of these were connected to AT&T Istel VAN. Black and Decker agreed to support links on both INS and Istel VAN's with a variety of software solutions, the predominant of which is Compowers Supplyline PC software.

Stadium Ltd has adopted an EDI trading relationship with Black and Decker. Stadium produce thermoplastic injection mouldings and electronics for Black and Decker.
Stadium use a single PC to deal with its EDI operation. The system downloads a file of invoices from the existing report writing facility in the company's sales ledger system. This file is then converted into an EDI message and transferred electronically to Black and Decker. The EDI standard selected by Black and Decker for the invoice message is EDIFACT, a single standard was selected by Black and Decker to simplify support.

Further use of the EDI system by Stadium was initiated in 1992 with the transfer of production schedules from Black and Decker to Stadium. These are currently printed out by Stadium, who hope to integrate them with an order scheduling system in the future to achieve further benefits.

Messages and standards
The EDI standard used was imposed by Black and Decker. The selection of EDIFACT is interesting as while it provides a standard which can be used by all industries, at the time of adoption it is arguable that the standard was not yet stable enough to adopt.

The messages implemented were for invoices and production schedules. Black and Decker had experience of invoices previously, but the use of production schedules was new to Black and Decker and provided a different set of benefits.

Benefits
The benefit of improved efficiency of the invoice message is common to most EDI implementations. However, the transfer of production schedules provides information to the supplier in a more timely fashion. This can provide great benefits in its own production scheduling and parts supply. It is interesting to note that the implementation of production schedules was not in itself enough to prompt Black and Decker to implement EDI initially, but it required the more obvious benefit of invoice transfer. The transfer of production schedules actually changes a method of working and could therefore provide far greater benefit to the company than an improvement in process efficiency could ever achieve.

A.6.B Texas Instruments (TI)
Texas Instruments is a multinational manufacturer with manufacturing plants in 18 countries and 75,000 employees. Regional management of TI's European companies was adopted in 1983, bringing the company into line with its major customers. The management function is effectively that of sales and marketing which is separate from the manufacturing function. The IT systems for TI's European division are based in Bedford in the UK. The information which forms this case study was published in the book titled "EDI or Die", (NEDC 1992) and the journals titled "Engineering Computers" (Trick 1990), and "Electronic Trader" (Texas 1993).

Why EDI was adopted
EDI has been investigated since 1969 by Texas Instruments, the use of EDI becoming more widespread by the mid 1980's, and by 1987 TI had formalised a world-wide EDI strategy. This strategy was formulated to use EDI as a means to improve the efficiency of its business processes.

The IT group in Europe initiated its EDI programme as a result of this strategy. TI (Europe) identified and targeted its sales and customer services departments for the
application of EDI. These areas were selected as they would provide benefits to TI directly and indirectly through improvements in service to customers.

Implementation and system description
The flow of information between TI and its distributors consists of resale data, what the distributor has sold, and inventory data. This information is useful to TI for marketing and planning manufacture. Using paper based technologies this information did not arrive back to TI until it was of little benefit. The improvement in speed of transfer afforded by EDI was therefore identified as providing a significant potential benefit.

In 1989 TI called together a group of manufacturers and suppliers to discuss the application of EDI to improve the flow of resale and inventory information. At that time no message was available for the transfer of such information. TI suggested EDIFICE developed these message using EDIFACT syntax. The RESPVRT and INVRPT messages were developed and have been implemented at TI.

TI has also implemented the receipt of EDI purchase orders with six customers, and sends order acknowledgements. In 1990 16 percent of all line order entries were made by EDI with an objective of 60 percent to be achieved by targeting the top 20 customers who place 80 percent of orders.

In 1991 TI implemented its new Strategic Business System (SBS) which is a world wide system designed to address all elements of order fulfillment. This system utilised data received using EDI, the RESPVRT and INVRPT messages for both credit claims and marketing analysis. The development of SBS indicated that certain activities between distributor and TI were time critical, and required on-line systems. For example, requests for quote are made on-line by a distributor. A quote is generated by the system and returned within a few hours. If accepted the quote is used to produce an EDI order which is returned to TI.

TI foresees the implementation of integration to its manufacturing planning systems, which would require the use of expert systems to determine manufacturing programmes. Indeed, unless the lead time in manufacturing can be reduced there is little point in implementing EDI as these lead times will negate any of the response benefits afforded by EDI.

Messages and standards
Texas instruments utilises the EDIFACT standard for the transfer of the RESPRT, INVRPT messages. However, whilst promoting the use of EDIFACT and the EDIFICE guidelines in Europe, TI uses various standards according to the requirements of the customer. Other messages in use by TI in the Europe include: an order message; order acknowledgement message and trial of a delivery message which notifies the customer of deliveries.

An unusual trading link is held with Hewlett Packard whereby HP transfers orders messages from its site in Bristol to the US using its own network. The order is then transferred to TI's Texas facility using ANSI X.12, this message is then forwarded to Bedford in the UK using TI's internal network.
Benefits
The initial business process efficiency benefits identified by TI are now considered the least important by TI. TI now considers the complete integration of EDI into the related systems as essential in any EDI implementation. SBS is a good example of the integration of systems using not only EDI but other technologies where appropriate. Without integration the benefits achieved from EDI are negligible to those that could be achieved.

The benefit of improved customer relations has proven true. EDI has provided a better work relationship with its EDI customers, as they too are able to see the benefits of EDI in the form of an improved service and reduced administration costs.

The corporate adoption of EDI in Texas Instruments has resulted in 10% of customer orders are processed by EDI, and 50% of TI's orders to suppliers are sent by EDI.

A.7 EDI in other industries - automotive

A.7.A Safelite and United Services Automobile Association (USAA)
The USAA is an insurance company in the US formed in 1922 by a group of US Army officers who found it difficult to obtain motor insurance. The organisation now offers a variety of services including property and life assurance. Safelite Glass Corporation is the United States largest auto glass replacement chain. The following information is taken from the National Underwriter (Sherman 1991), and the ASM Journal of Systems Management (Vedock and Wheeless 1990).

Why EDI was adopted
The USAA constantly examines its operational work habits. In 1989 USAA noticed the inefficiencies of manually processing auto glass repair/payment invoices. Due to the highly labour intensive processing and checking, only ten percent of invoices were completely checked for accuracy. A means of improving this situation was discussed with one of USAA's major glass companies, Safelite. In particular the use of an electronic means of transferring invoices was investigated. The result of these discussions was to adopt EDI to transfer invoices from USAA to Safelite. USAA also realised that 65 percent of all its invoice were to five or six glass companies, considering there were 137 772 payments with a total value of $26.8 million in 1990, substantial cost savings could be achieved by trading electronically with just five or six companies.

Prior to the implementation of EDI Safelite had used magnetic tape invoicing for two auto mobile leasing companies, and it had been seeking improved means of serving the large insurance companies that it bills on a regular basis. Safelite therefore viewed EDI as a means of providing a better service for its customers.

Implementation and system description
The implementation of the EDI system between Safelite and USAA began in February 1990. Prior to this a year long program of planning and testing took place. The two problem areas identified during the planning were EDI standards and computer access. The EDI standards available to the two companies, including ANSI X12, were deemed unsuitable due to their inability to deal with car makes and models. An standard specific
for the transfer of data between Safelite and USAA was developed. To maintain security of their computer systems a Value Added Network was utilised. Known as IVANS the US insurance industry VAN is utilised by over sixty insurance companies, the use of this network was selected as it would allow further insurance companies to deal with Safelite.

EDI was used as a means of streamlining the business processes involved in the claim of insurance monies for glass replacement and repair. Safelite had developed and implemented it's own in house computer systems which transfer data between it's retail outlets and head office. This allowed for the EDI link between Safelite and USAA to provide major benefits. All claims made at the retails outlets were transferred in a batch each day to the Safelite head office at Columbus. All the invoices to be sent to the USAA are collated and sent as a batch on a weekly basis. The data is checked electronically, by means of claim authorisation number and make and model details. The claims which are accepted are notified using another EDI message from USAA to safelite. The rejected claims are then dealt with manually on a regional basis. This system therefore minimises human intervention in the payment process. The acceptance rate of invoices was initially 36 percent, this has risen to 75 percent, the target acceptance rate being 90 percent.

Since the first implementation with Safelite, USAA has expanded the program and now successfully receives invoices from at least three other glass suppliers.

Messages and standards
The messages and standards used by these companies are not those widely used in the EDI world. This was due to the parties involved deeming the ANSI X12 and other standards available to be unsuitable for their requirements. The result of a specific standard is not desirable as it makes the system less accessible for other potential users. However, due to the small trading community involved this has not proved a problem. USAA has successfully implemented EDI with at least four companies.

The messages developed transfer invoice information and confirmation of acceptance of claim information.

Benefits
The benefits common to both parties of the system are those of improved business efficiency, which could be related to a direct cost. For example, the sending of a single EDI message notifying the claims which have been automatically accepted has replaced the need for individual notification of each claim which has been rejected. This usually consisted of the mailing of 750 letters a week.

The major benefit for Safelite is the improvement of services for it's customer, USAA who will therefore look upon Safelite as a preferred supplier. Such a relationship, could lead to the specification of the glass supplier in the insurance contract, due to the reduced costs in dealing with a single company. This would in turn lead to reduced insurance premiums, thus making the company more competitive.
A.7.B General Motors

General Motors, GM, is the largest motor manufacturer in the world. This case study refers to the operations of General Motors in the United States of America. The information which forms this case study was published in the Journal titled Logistics Information Management, (Takac 1993).

Why EDI was adopted

GM introduced EDI in 1984 to streamline and simplify its trading communications. EDI was also identified as a means of achieving JIT operations.

Implementation and system description

In 1984 GM commenced implementation of EDI with its suppliers. To encourage its suppliers to adopt EDI GM offered improved terms of trade. Instead of the supplier waiting between 30 and 60 days for payment, the payment would be made electronically on receipt of the goods. The payment would also be accompanied by remittance information.

GM discussed the need for electronic funds settlement with its banks, all eight of which agreed to develop suitable facilities. The First National Bank of Chicago was the first trading bank on the GM corporate trade network, which was launched in 1986. All eight of GM's banks are now part of the network as debiting banks, whilst a further eighteen banks have been connected who receive payment for the suppliers.

The network is used for the automatic transfer of invoices and payment for all 40,000 of GM's suppliers. If a supplier does not bank with an EDI user bank then remittance is provided on paper, and payment made via the automated clearing house.

The First National Bank of Chicago charge GM $1.10 per transaction, which is sufficient for the bank to recover the lost cheque processing fees.

GM's commitment to EDI is illustrated by the fact that electronic payments to suppliers exceed US$3 billion annually.

Messages and standards

GM use their trading network to: receive invoice messages; to send payment messages; and to send payment remittance messages. The standard used to send these messages is not specified.

Benefits

General Motors measure the benefits of EDI in terms of reduction in invoice and payment processing costs. These reductions relate to costs savings of US$200 to US$300 per car produced.

A.7.C Rover Group

Rover is a UK based motor manufacturer. Rover produce the mini, the 100 series and the 200 series motor vehicles at its Longbridge plant. The following information is published in the journal titled Accountancy (Classe 1991).
Why EDI was adopted
The adoption of EDI was driven by the need for Just-in-time production, or as Rover calls it minimal inventory control, at it's Longbridge plant. The Mini and 100 series, formerly known as the Metro, were the only cars produced at the Longbridge plant. The addition of off-site stores and the application of Just-in-time supply methods were seen as a means of releasing enough space at the plant to build a third production line, that for the Rover 200 series.

Implementation and system description
Rover has implemented an EDI system which operates between it's production plant, the off-site stores and it's suppliers. Message are exchange between these parties to achieve a Just-in-time manufacture. These systems are described in more detail below.

The parts stored in the off-site facility are owned by both Rover and it's suppliers. Rovers suppliers are required to maintain stock levels in these stores as determined by Rovers production programme. To achieve this suppliers need to know what's in the distribution centre, and what Rover has pulled out and is going to pay for. The EDI system transmits this information on a daily basis.

Some parts are required to be delivered directly to the production plant, in a true just-in-time manner. These parts are either too large or used in too high a volume for storage to be viable. Supplier's receive a timed weekly supply schedule for these items. This schedule details each load required over the following two weeks. A lorry load of some components are used every two hours. The timing of the deliveries of these components is therefore crucial. The variation in components is immense for the 200-series, for example there are over 150 types of door casing. To order the correct item for a specific car a synchro message is used. The sensing of a particular car at a particular point in the production line automatically generates a synchro message to order the specific part required further along the production line.

As a load is despatched by a supplier a pre-notification message is sent to Rover detailing precisely what is in the load. This message automatically updates Rovers stock control system.

To ensure all it's suppliers can communicate with the plant Rover has provided it's non EDI capable suppliers with PC software that prints out EDI messages received. The larger suppliers have been able to integrate EDI into their accounting and production planning systems, thus achieving major benefits from EDI.

Rover also utilise EDI for accounting functions, this includes the receipt of invoices from suppliers. However, due to the stringent stock control system Rover is capable of producing invoices for suppliers, as any discrepancies in deliveries, of which there are very few, are soughted much earlier in the trading cycle.

All messages are transferred using Istel's EDI service, EDICT. This provides the security of the trading parties computer systems.
Messages and standards
Rover exchanges messages with it's suppliers using ODETTE, the motor industry EDI standard. The messages exchanged to control stock in the storage facility include: notification of stock level; quantities transferred from suppliers to Rovers inventory; discrepancies between delivery notes and parts supplied; and audit trails of parts in and out of the storage facility.

The synchro message is used to specify particular parts required JIT at the production line. Also the invoice message is received from major suppliers.

Benefits
The benefit of EDI to Rover is not the increase in efficiency of existing process but to enable a new method of working, Just-in-time manufacturing. The adoption of just-in-time manufacturing has released enough floor area for an additional production line at it's Longbridge plant.

The benefit of EDI is therefore combined with the benefit of Just-in-time manufacture, together they provide a substantial benefit to Rover. However, Just-in-time manufacture would not be possible without EDI, and EDI would provide little benefit without the concept of Just-in-time manufacture.

A.8 EDI in other industries - banking

A.8.A Royal Bank of Canada
The Royal Bank of Canada is the largest bank in Canada and the fourth largest in North America, with assets of US$90 billion and 1500 branches in 34 countries. The information in this case study was published in the journal titled Logistics Information Management (Takac 1993).

Why EDI was adopted
The Royal Bank commenced the implementation of EDI in 1987. This was driven by it's clients. General Motors and it's own banks influenced Royal Bank to approach many of GM's suppliers who were customers of the Bank. The Royal Bank approached these suppliers and implemented the EDI relationships.

Implementation and system description
EDI systems for some of GM's suppliers became operational in 1988. The experience of EDI made Royal aware of the value of providing information concurrently with the payment. Royal concluded that reconciliation information is as important as EFT and that the banks are in the best position to assist clients to achieve reconciliation.

Royal approached it's major clients in 1988 with the view of becoming an EDI originator bank. Thus filling the gap between the Value Added Networks and the trading partners. The first step of the implementation was a round of discussions with clearing banks to define a clear set of processes and procedures for reconciliation transactions. The next stage was to develop relationships with particular clients.

The difficulties encountered in the implementation were not technical but were of understanding how clients operated.
The resulting EFT system with built in reconciliation meant that funds and data did not require separate reconciliation. In other words deposited funds would be directly cross referenced to the data, if they arrive concurrently a payee would be able to operate on the assumption that if they have the data they have the funds.

Messages and standards
The Royal bank utilised existing standard EFT messages. However, the reconciliation of the data to funds provides the significant benefit the banks clients. It is therefore the way in which the messages were implemented that was innovative in this case.

Benefits
The benefit of EDI to the Royal Bank of Canada is that of providing an improved service to it's customer. This ensures it maintains it's customer base and possibly increases it's number of customers.

The initial implementation of EDI at the Royal Bank was driven by a major supplier. It would be reasonable to assume that if the Royal Bank had resisted EDI the major client would have sought a more forward looking bank.

A.8.B BACS Limited
BACS (Bankers Automated Clearing Service) provide one of the major EFT (Electronic Funds Transfer) services in the UK. BACS provides a service by which funds are transferred electronically between banks. This systems whilst not using one of the recognised EDI standards is a form of EDI, as BACS consists the transfer of information using predefined structured standards. The information in this case study was published in the EDI Handbook, (EDI, 1993) and the publication titled Perwill Update, (Perwill 1992).

Why EDI was adopted
Over twenty years ago the high street banks developed BACS as a means of transferring payments between banks. Such a system was developed to reduce the increasing volumes of paperwork associated with the growing volume of payment transfers between banks. Originally BACS was developed for the use for payment transfer between banks, however, companies soon realised that it provided a means of direct payment from their payroll systems to employees accounts. BACS is now used for a variety of applications including: pensions; loans; dividends; utility bills; supplier payments; and collecting customer payments.

Implementation and system description
Funds are transferred using a three stage electronic fund transfer operation.

1) The transactions are prepared and submitted to BACS by the originating company (a bureau service maybe used for this function by small companies).
2) The transactions are accepted, checked, sorted and merged by BACS Ltd. into groups, one for each bank.
3) The transactions are posted to each bank and the accounts affected by the batch of transactions are updated.
BACS accepts a variety of input media including: modem (PSTN), Kilostream, PSS (Packet Switch Stream), magnetic tape and magnetic disk. Approximately 40% of BACS users submit the transactions to BACS directly, these customers are responsible for 86% of all BACS transactions. This indicates that the companies who have high volumes of transaction using BACS deal directly with BACS Ltd.

There are two types of service available, either single processing day or multi-processing day file processing. The first is where the EFT transactions in a batch submitted to BACS are output on the same processing day. This is used for the payroll transfers. The second type of service allows the payment of transactions in a batch to occur on any day up to one month ahead of the batch date. This is useful for payments to suppliers, allowing payments to be made only at the end of the agreed credit period.

**Messages and standards**
BACS does not use a recognised EDI standard such as EDIFACT or ANSI X.12. The BACS standard was developed for the specific purpose of electronic funds transfer. The message structure is therefore very simple, but completely inflexible. One of the strengths of the BACS standard is the security procedures, which ensure the validity of the data transferred. This is essential due to the nature of the data, representing fund transfer.

**Benefits**
The BACS standard is the most common application of EDI in the UK. This is due to the tangible benefit of a significant reduction in administration for companies and banks using the system. The BACS system is inexpensive, reliable and precise. It must be noted that it must be all of these things otherwise the benefit of reduced administration costs would be nullified by the failings of the system. Today the volume of fund transfer between banks is such, that it reasonable to argue that it would not be possible for the banks to operate with the current levels of charges without BACS.
Appendix B

Electronic Data Interchange Association
    interchange agreement
EDI ASSOCIATION
STANDARD ELECTRONIC DATA INTERCHANGE AGREEMENT

The Terms of this Agreement shall govern the conduct and methods of operation between the Parties in relation to the interchange of data by teletransmission for the purposes of or associated with the supply of goods and/or services. They take account of the Uniform Rules of Conduct for Interchange of Trade Data by Teletransmission as adopted by the International Chamber of Commerce.

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1. Definitions

"Adopted Protocol": the accepted method for the interchange of Messages based on the EDIFACT standard for the presentation and structuring of the transmission of Messages, or such other protocol as may be agreed in writing by the parties.

"Message": data structured in accordance with the Adopted Protocol and transmitted electronically between the parties, including where the context admits any part of such data.

"Data Log": the complete record of data interchanged representing the Messages between the parties.

"User Manual": the handbook of commercial and technical procedures and rules and legal requirements applicable to the transmission of Messages using the Adopted Protocol.

2. Scope

2.1 This agreement shall apply to all Messages between the parties using the Adopted Protocol and the parties agree that all such Messages shall be transmitted in accordance with the provisions of the User Manual.

2.2 Notwithstanding the existence of a User Manual the parties may agree terms to reflect additional or different requirements which they may have for the interchange of Messages, which terms shall be included in an Appendix which shall form part of this Agreement.

3. Security of Data

3.1 Each of the parties shall:

3.1.1 take all such appropriate steps and establish and maintain such procedures so as to ensure that as far as reasonably practicable Messages are properly stored, are not accessible to unauthorised persons, are not altered, lost or destroyed, and are capable of being retrieved only by properly authorised persons.

3.1.2 ensure that any Message containing confidential information as designated by the sender of the Message is maintained by the recipient in confidence and is not disclosed to any unauthorised person or used by the recipient other than for the purposes of the business transaction to which it relates. Messages shall not be regarded as containing confidential information to the extent that such information is in the public domain, or the recipient is already in receipt of it or receives the information from a third party entitled to disclose it. Any authorised disclosure to another person shall be on the same terms as to confidentiality as contained in this clause.

3.2 Where permitted by law, the parties may apply special protection to Messages by encryption or by other agreed means including those set out in the User Manual. Unless the parties otherwise agree, the recipient of a Message so protected shall use at least the same level of protection for any further transmission of the Message.

4. Authenticity of Messages

4.1 All Messages must identify the sender and recipient(s) and must include a means of verifying the authenticity of the Message either through a technique used in the Message itself or by some other means provided for in the Adopted Protocol.

4.2 Parties may by agreement also use higher levels of authentication to verify the Message.

5. Integrity of Messages

5.1 Each party being a sender shall ensure that all Messages are complete, accurate and secure against being altered in the course of transmission by him and, subject to clauses 5.2 and 5.4, shall be liable to any other person for the direct consequences of any failure to perform his obligations under this clause.
5.2 Each party accepts the integrity of all Messages and agrees to accord these the same status as would be applicable to a document or to information sent other than by electronic means, unless such Messages can be shown to have been corrupted as a result of technical failure on the part of machine, system or transmission line.

5.3 Where there is evidence that a Message has been corrupted or if any Message is identified or capable of being identified as incorrect it shall be re-transmitted by the sender as soon as practicable with a clear indication that it is a corrected Message.

5.4 Notwithstanding clause 5.1, the sender will not be liable for the consequences of an incomplete or incorrect transmission if the error is or should in all the circumstances be reasonably obvious to the recipient. In such event the recipient must immediately notify the sender thereof.

5.5 If the recipient has reason to believe that a Message is not intended for him he should notify the sender and should delete from his system the information contained in such Message but not the record of its receipt.

6. Confirmation of Receipt of Messages
6.1 Except where receipt of a Message is automatically confirmed the sender of a Message may request the recipient to confirm receipt of that Message.

6.2 When the recipient has received such a request or where the User Manual requires a confirmation he must send it without unreasonable delay.

6.3 Each party shall process or deal with Messages received by him in accordance with any response times specified in the User Manual, or as the parties may agree or, in the absence of specification or agreement, as soon as possible.

7. Storage of Data
7.1 The Data Log including any Message as sent and received and comprised in each party's Data Log shall be maintained without any modification.

7.2 Subject to any requirements of the national law in the country of the party maintaining a Data Log or any requirements contained in the User Manual, the parties may agree a period during which the Data Log must be stored unchanged but in the absence of such agreement, a party shall have the right to maintain its Data Log for such period as it thinks fit.

7.3 The Data Log may be maintained on computer media or other suitable means provided that the data can be readily retrieved and presented in readable form.

7.4 Each party shall be responsible for making such arrangements as may be necessary for the data contained in the Data Log to be prepared as a correct record of the Messages as sent and received by that party.

7.5 Each party shall ensure that the person responsible for the data processing system of the party concerned, or such other person as may be agreed by the parties or required by law, shall certify that the Data Log and any reproduction made from it is correct.

8. Intermediaries
8.1 If a party to this Agreement uses the services of an intermediary in order to transmit, log or process Messages, that party shall be responsible towards another party or other parties to this Agreement for any acts, failures or omissions by that intermediary in its provision of the said services as though they were his own acts, failures or omissions, and for the purposes of this Agreement the intermediary shall be deemed to be an agent of that party.

8.2 If a party instructs any other party to use the services of such intermediary for transmitting a Message, then that party shall be responsible towards the other party for such intermediary's acts and omissions.

8.3 Any party giving such instructions shall ensure that it is a contractual responsibility of the intermediary that no change in the substantive data content of the Messages to be re-transmitted is made and that such Messages are not disclosed to any unauthorised person.

9. Term and Termination
9.1 This Agreement shall take effect from the date of this Agreement. A party may terminate its participation in this Agreement at any time by giving to the other party or parties not less than four weeks notice.
9.2 Notwithstanding termination for any reason, Clauses 3, 7, 8 and 15 shall survive termination of this Agreement.
9.3 Termination of this Agreement shall not affect any action required to complete or implement Messages which are sent prior to such termination.

10. Interpretation of The User Manual
10.1 Any question relating to the interpretation of the User Manual may be referred by the parties to the body responsible for the publication of the User Manual or the Council of the EDI Association as may be applicable acting as experts and not arbitrators, whose decision shall be final and binding on the parties making the reference.

11. Force Majeure
11.1 A party shall not be deemed to be in breach of this Agreement or otherwise be liable to any other party, by reason of any delay in performance, or non-performance, of any of its obligations hereunder to the extent that such delay or non-performance is due to any Force Majeure of which he has notified such other party, and the time for performance of that obligation shall be extended accordingly.
11.2 For the purposes of this clause "Force Majeure" means, in relation to any party, any circumstances beyond the reasonable control of that party (including, without limitation, any strike, lock-out or other form of industrial action).

12. Invalidity and Severability
12.1 In the event of a conflict between any provision of this Agreement and any law regulation or decree affecting this Agreement, the provision of this Agreement so affected shall be regarded as null and void or shall, where practicable, be curtailed and limited to the extent necessary to bring it within the requirements of such law regulation or decree but otherwise it shall not render null and void other provisions of this Agreement.

13. Notices
13.1 All notices or other forms of notification, request or instruction required to be given by a party to any other party under this Agreement shall be delivered by hand or sent by first class post to the address of the addressee as set out in this Agreement or to such other address as the addressee may from time to time have notified for the purpose of this clause or sent by electronic means of message transmission producing hard copy read-out including telex and facsimile, and shall be deemed to have been received:
13.1.1 if sent by first-class post: 3 business days after posting exclusive of the day of posting;
13.1.2 if delivered by hand: on the day of delivery;
13.1.3 if sent by electronic means: at the time of transmission if transmitted during business hours of the receiving instrument and if not during business hours, one hour after the commencement of the next working day following the day of transmission.

14. Amendments In Writing
14.1 Any terms agreed between the parties as additions or amendments to this Agreement shall only be valid if they are set out in the Appendix referred to in clause 2.2 or are otherwise in writing and signed by the parties.

15. Disputes and Law
15.1 Unless the parties agree to submit the matter to arbitration or other procedure for the resolution of disputes, or to select a different jurisdiction, any matter or dispute arising from, out of or in connection with this Agreement, as to its validity, interpretation, construction or performance shall be subject to the sole and exclusive jurisdiction of the English Courts.
15.2 Unless the parties otherwise agree this Agreement shall be construed and have effect according to English Law.

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PART I

The purpose of an Interchange Agreement

Any method of communication requires discipline in order to be effective. The discipline is achieved by applying rules of conduct which by their use have become customary or by law have been imposed. Electronic Data Interchange (EDI) has not yet been in existence long enough to have acquired in these ways a collection of standard rules of conduct. An Interchange Agreement provides them.

The Standard Electronic Data Interchange Agreement (SIA) can be used in bilateral or multilateral EDI relationships. Its terms govern the conduct of the parties and set out those rules which are applicable to the general use of EDI. If they use the SIA, the parties are confirming their intention, when communicating by EDI, to be committed to each other and they cannot claim ignorance of the rules of behaviour or that they do not accept them and are not bound by them.

The distinction between an Interchange Agreement and other contracts or agreements

A fundamental principle is that the SIA relates to the interchange of data, not to the various underlying commercial or contractual obligations of the parties. The SIA is not itself a substitute for any individual contracts, express or implied, between trading partners, such as those for the supply and purchase of goods or services. Such underlying contracts and contractual relationships are assumed to exist, or to be brought into existence, just as they would if the exchange of information between the parties had been by means other than electronic. The SIA should not disturb or interfere with these normal commercial and contractual relationships. In this respect, as in others, the SIA follows the precepts of UNCID, developed in 1987 by the International Chamber of Commerce.

General Rules

The SIA addresses in a conveniently uniform manner those issues which are present in all EDI relationships and some which are present in most. Its rules can, therefore, be used by any EDI pair or group. A detailed commentary on the SIA clauses is in Part II.

Special Rules, User Manuals and Appendices

In individual trade sectors there will be additional rules concerning communication between the parties; rules which are specific to the requirements of that trade and not to all others. Such rules need to be set down somewhere and to be embraced by the same commitment evidenced by the SIA.
PART II

The implications of many of the Clauses are self-evident but the following is an explanation of the reasoning behind some of them, where this might be helpful.

Clause 1.
The importance of the EDIFACT standards is reflected in the definition of the 'Adopted Protocol'.

Clause 2.1.
The use of a User Manual or an Appendix has been referred to in Part I of this commentary.

Clause 3.1.1
An important clause dealing with the security of messages.

Clause 3.1.2
"Confidentiality" is an obvious requirement in certain cases but it needs some qualification in order to avoid one party unreasonably using it to describe information which is not really confidential.

Clause 3.2
It is inappropriate for the SIA to compel encryption or any other particular methods of message protection; they must be selected by those engaged in the trades concerned. It is, however, a sound principle that the same level of protection should be required for further transmissions. It should be noted that encryption, or some methods of it, are not permitted in some jurisdictions.

Clauses 4 & 5
There could be some confusion as to the terminology frequently used; "integrity", "verification", "authenticity", "identity", "completeness" etc.

Clause 4 requires a sender of a message to state his "identity" (and, obviously, that of his addressee). There must be a means of checking that his statement is true ("verification") so that the other parties know that his message and his identity are genuine.

Clause 5 deals with the "integrity" of messages; meaning that messages must be complete and have no inaccuracies and that they stay that way. With this integrity, together with the authentication resulting from Clause 4, there is no reason for parties to the SIA to regard an EDI message as inferior in reliability to other more conventional means of communication. They can therefore agree that they will regard an EDI message as having as good a status as is possessed by a document or other form of communication. Moreover, provided the level of authentication and the technique used are good enough, they can even be confident that the message has the same essential and characteristic attributes which are present in a written communication which has been signed.

Clause 5 also deals with the procedural discipline necessary if there is obvious message corruption or misdirection.
In most EDI operations there are User Manuals. These contain the procedures and rules for the technical aspects of transmission and the commercial meanings of the messages used in that trade. A User Manual can be a suitable place to set down the legal requirements associated with the specialist, trade-specific messages.

Not all trade sectors, however, will have developed and published formal User Manuals or it may be that these are for some reason not the most suitable place for some trade-specific additions or modifications. The SIA therefore provides, as an alternative, for the additional or different trade-specific requirements to be included in an Appendix forming part of the Agreement.

**Liability**

If a party to an agreement fails to ensure that his obligations under it are met it is possible that damage will be caused. The liability for that damage then falls upon the party whose breach caused it to occur. Unless this principle needs special emphasis or must be modified for some special reason, there is no need for an agreement to elaborate on the attribution of liability. The SIA makes little reference to attribution of liability; and then only for emphasis.

Agreements might also contain references to liability in order to place limits on it. In the SIA there is no general limitation of one party’s potential liability to another because that would be to the detriment of the latter.

The SIA deals only with the conduct of the parties’ communications, not with their obligations to act in accordance with the terms of their underlying commercial contract. A breach of the terms of the SIA is not of itself likely to be the direct cause of damage. If damage is caused it is more likely to have arisen out of the negligence of one party or from a breach of the underlying commercial contract which will have, if necessary, its own terms for attributing or limiting liability.

It is for these reasons that the SIA contains no special clauses about attribution or limitation of liability. If any liability were to occur it would lie where it falls.

**Insurance**

For reasons similar to those used in considering liability, one party or another does not acquire a significant additional burden of risk just because of the use of EDI. There is, therefore, no obligation on the parties to make special insurance arrangements. It is nevertheless recommended that individual users should check their existing insurance arrangements, advising their brokers or underwriters that they are intending to use EDI.
Clause 6
There has been much debate about whether every message should be acknowledged by the recipient. It is felt that to insist on this would result in an unnecessarily and unacceptably large and costly volume of transmissions. With some messages it is not important for the sender to know that his message has been received. With some messages the sender will be made aware of the receipt because of some subsequent action by the recipient which he would not take if the message had not been received. Many EDI systems in any case automatically provide an acknowledgement signal.

Nevertheless, it is important that some messages have their receipt acknowledged. The particular trade-specific rules, which may be contained in the User Manual, will specify what is to be done; alternatively the sender will request the acknowledgement. The recipient must then comply.

Clause 7
This clause deals with the maintaining of a Data Log. Its text is such that it should result in the parties retaining essential records to satisfy commercial, administrative and fiscal requirements. Such records should also satisfy most evidential requirements, both as to admissibility and as to probative value.

Clause 8
It is not a purpose of the SIA to lay down the terms and conditions of network service providers' contracts with their clients. That must be dealt with by the clients negotiating with their network operators. However, the use of a network should not be an excuse for a sender to escape his responsibilities under the SIA. This clause therefore makes the sender's obligations clear. He is responsible for the network's acts, failures or omissions. The exception is when his use of the network is on the instructions of another party, in which case the latter party is responsible.

Clause 10
This clause refers to questions of interpretation of the contents of the User Manual. This is not to be confused with the actual settlement of disputes arising from the Agreement, which is referred to in clause 15.

Clause 12
It is possible, though not probable, that under some jurisdictions some provisions of the SIA might not be permissible. This clause enables the SIA to be widely adopted but without partial exclusions invalidating the whole agreement.

Clause 14
Additions or amendments should only be considered if they are absolutely necessary. This clause sets out the disciplined manner in which they should be made.

Clause 15
Some trades prefer Arbitration for dispute settlement. Furthermore, some parties may require that their dispute settlements are made in particular jurisdictions or that particular laws should apply. This clause provides for these alternatives to be arranged by the parties if they wish. In the event, however, of the parties making no such special arrangements, rather than having no applicable law or jurisdiction, this clause provides for English law and the English courts to be used.
Appendix C

Questionnaire used for five year study of EDI in construction
Electronic Data Interchange Questionnaire

SECTION A

1. What is the predominant discipline of your company?

   CONSULTING [ ]
   DESIGN AND BUILD [ ]
   CONTRACTING [ ]
   ARCHITECT [ ]
   OTHER (please specify) ____________________________

2. What is the annual turnover of your company?

   £________ (millions)

3. Approximately how many people does your company employ?

   0 - 100 [ ]
   101 - 1000 [ ]
   1001 - 5000 [ ]
   5001 + [ ] (please tick the appropriate box)

SECTION B

4. Does your company currently use EDI?

   YES [ ]
   NO [ ]

   If YES, go to SECTION C.
   If NO, go to Question 5.

5. Does your company have any plans to use EDI in the future?

   YES:
   immediately [ ]
   within one year [ ]
   within five years [ ]
   after five years [ ]

   NO [ ]
If YES, briefly describe the purpose for which EDI is to be used.

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

If NO, briefly describe the reasons why.

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

SECTION C - FOR CURRENT EDI USERS

6. How companies do you trade with electronically? [ ]

7. What is the discipline of companies with which you trade electronically?

CONTRACTORS [ ] SUPPLIERS [ ]
CONSULTANTS [ ] BANKS [ ]
ARCHITECTS [ ] CLIENTS [ ]
DESIGN/BUILD [ ] OTHER [ ]
(please specify) __________________________________________________________

8. Does your company:

receive EDI messages only; [ ]
transmit EDI message only; or [ ]
receive/transmit EDI messages. [ ]

9. What type of EDI messages do you transmit/receive?
(eg. invoices, purchase orders, quotations)

________________________________________________________________________
________________________________________________________________________

10. Do you use any messages other than those that form the trading cycle?
(Trading cycle messages include: order; invoice; quotation; etc.)

YES [ ] If YES, please specify ________________________________________________
NO [ ] ________________________________________________________________

Tony Lewis
11. Once an EDI message is received is it:

(a) distributed to the relevant part of the company by electronic means and then processed; or is it [ ]

(b) converted to a hard copy, which is distributed and then processed. [ ]

12. Do you use a third party network to manage your EDI messages?

YES [ ]
NO [ ]

If YES, which do you use?

______________________________

13. Which data exchange standards do you use?

<table>
<thead>
<tr>
<th>EDIFACT</th>
<th>ANSI X.12</th>
<th>TRADACOMS</th>
<th>ODETTE</th>
<th>OTHER</th>
</tr>
</thead>
<tbody>
<tr>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
</tr>
</tbody>
</table>

(please specify) ___________________

14. Do you have a legal agreement with your electronic trading partners?

YES [ ]
NO [ ]

15. Do you use a standard legal agreement for all your electronic trading partners?

YES [ ]
NO [ ]

16. Do you provide EDI training courses for your employees?

YES [ ]
NO [ ]

17. What were the anticipated benefits influencing your company’s decision to implement EDI?

______________________________

______________________________

______________________________

18. Have these benefits been fully realised?

YES [ ]
PARTIALLY [ ]
NO [ ]

Tony Lewis
19. Give brief details of any plans to expand EDI operations in your company. (please include approximate time scales).

__________________________________________________________________________
__________________________________________________________________________
__________________________________________________________________________

SECTION D

20. Please rank the following EDI messages in order of benefit to your company.

(1 - very beneficial, to, 6 - no benefit)

<table>
<thead>
<tr>
<th>Message</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
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<tr>
<td>Specifications</td>
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<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
</tr>
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<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
</tr>
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<td>Conditions of Contract</td>
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<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
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<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>Invitation to tender</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>Priced Tender</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
</tr>
</tbody>
</table>

(please circle the appropriate number for each message)

21. On a scale of 1 to 10, how do you rate the future of EDI in the construction industry? (10 - excellent, 5 - 50% chance of survival, 1 - a lost cause)

[ ]

Please state the reasons for your answer.

__________________________________________________________________________
__________________________________________________________________________
__________________________________________________________________________

22. Which data exchange standard do you envisage as being adopted by the construction industry?

<table>
<thead>
<tr>
<th>Standard</th>
<th>[ ]</th>
<th>[ ]</th>
<th>[ ]</th>
<th>[ ]</th>
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<tr>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TRADACOMS</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CITE</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>OTHER</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(please specify)

23. Is your company currently a member of EDICON?

YES [ ]

NO [ ]

Tony Lewis
24. What factors do you consider as inhibitors to the adoption of EDI in the construction industry?

| POOR AVAILABILITY OF HARDWARE/SOFTWARE | [ ] |
| THE ECONOMIC CLIMATE                  | [ ] |
| THE DISLIKE OF CHANGE IN THE INDUSTRY  | [ ] |
| THE APPARENT LACK OF BENEFITS OFFERED BY EDI | [ ] |
| THE LACK OF AWARENESS OF EDI          | [ ] |
| OTHER                                   | [ ] |
| (please specify)                        |     |

THANK YOU FOR COMPLETING THIS QUESTIONNAIRE

Please tick the box if you would like a copy of the results of this survey [ ]

Would you be willing to be contacted regarding EDI in the construction industry?

YES [ ]
NO [ ]

Please write your name and address below

__________________________________________________________________________
__________________________________________________________________________
__________________________________________________________________________
__________________________________________________________________________
__________________________________________________________________________

Telephone number ________________________________________________________
Appendix D

Example page from a mechanical services specification and the corresponding completed description data model
2.5 MEDIUM TEMPERATURE HOT WATER CIRCULATION PUMPS

The Contractor shall provide and install new winter heating (MTHW) circulation pumps (run and standby). The pumps shall be complete with all new isolation valves, strainers, non-return valves and connecting pipework as shown on Drawings Nr LAK 89/52/HB1/1 and LAK 89/52/HB1/2 in accordance with the standard specification M&E Nr 3.

The pumps must be located on the purpose-built concrete plinths as per structural Engineers drawing.

The Contractor shall provide pressure gauges, gauge cocks, and connections in the new pipework associated with the circulation pumps.

The Contractor shall obtain from the pump manufacturer pump performance curves indicating clearly the impeller size associated with the pump to be installed. A separate curve shall be provided for each pump prior to installation for approval by the SO.

2.5.1 Circulating Pumps MTHW

The pumps shall be of the horizontal end suction, single stage close coupled direct drive configuration.

The pumps are to be manufactured in cast iron casings and bronze impellers.

The pumps will have the following design duties:

- Operating water flow temperature: 100°C
- Water flow rate: 22 l/s
- Estimated motor rating: 11 kW
- Pump motor rpm: 1450 rpm
- Number of poles: 2
- Pump pressure head: 200 kPa
- Motor electrical supply: 3 phase/50 Hz/415 V
- Seal type: Mechanical seals
<table>
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<th>Description</th>
<th>Unit</th>
<th>Data</th>
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<td>Circulating Pumps MTHW</td>
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<tbody>
<tr>
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<tbody>
<tr>
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<td>strainers</td>
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<tr>
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<td>Auxiliary Fittings</td>
<td>non-return values</td>
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<tbody>
<tr>
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<td>Drawing detailing auxiliary fittings &amp; pumps</td>
<td>AAK89/52/HBV1</td>
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<td>71.2 56.4</td>
<td>Circulating pumps MTW</td>
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**ATTRIBUTE**

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<tbody>
<tr>
<td>6 4</td>
<td>pump installation</td>
<td></td>
<td>pumps to be located on purpose built concrete pl</td>
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<td>11</td>
<td>pump installation</td>
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<td>structural engineers drawing</td>
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</tr>
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<tbody>
<tr>
<td>3 3</td>
<td>Ancillary fittings</td>
<td></td>
<td>pressure cages</td>
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<tr>
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<td>Ancillary fittings</td>
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<td>gauge cocks</td>
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<tbody>
<tr>
<td>3 3</td>
<td>Ancillary fittings</td>
<td></td>
<td>connections in pipework for ancillary equipment and pumps</td>
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</table>

<table>
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<th>Description</th>
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<th>Data</th>
</tr>
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<tbody>
<tr>
<td>6 5</td>
<td>Pump performance</td>
<td></td>
<td>performance curves for pump must be given to t so for approval before installation.</td>
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<table>
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<th>Unit</th>
<th>Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 5</td>
<td>Pump type</td>
<td></td>
<td>horizontal end-suction, single stage, close coupled direct drive configuration</td>
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### PRODUCT

<table>
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<tr>
<th>Identification code</th>
<th>Description</th>
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<tr>
<td>112 56 4</td>
<td>circulating pumps MTHW</td>
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### ATTRIBUTE

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<tbody>
<tr>
<td>3 1</td>
<td>casing material</td>
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<th>Data</th>
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<tr>
<td>3 1</td>
<td>impeller material</td>
<td>bronze</td>
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<td>operating water flow temp.</td>
<td>°C</td>
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<td>L/s</td>
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<td>Estimated motor rating</td>
<td>kW</td>
<td>11</td>
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<th>Data</th>
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<tbody>
<tr>
<td>4 1</td>
<td>pump motor rpm</td>
<td>rpm</td>
<td>1450</td>
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</tr>
</thead>
<tbody>
<tr>
<td>1 2 3 4 5</td>
<td>number of poles in motor</td>
<td></td>
<td>2</td>
</tr>
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## PRODUCT

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<tr>
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<tbody>
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<td>712 56 4</td>
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## ATTRIBUTE

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<td>4 1</td>
<td>pump pressure head</td>
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<tr>
<td>4 1</td>
<td>motor electrical supply</td>
<td></td>
<td>3 phase, 50 Hz, 415V</td>
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## ATTRIBUTE

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<td>3 1</td>
<td>seal type</td>
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## ATTRIBUTE

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## ATTRIBUTE

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<tr>
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<tr>
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Appendix E

CI/Sfb code list - part of the code list for the description data model
Table 0

Physical environment

Key

Scope
End results of the construction process including planning areas, facilities such as works, buildings, internal or external spaces for particular purposes.

Structure
Three main divisions:
- Areas and complexes, coded 0;
- Facilities for particular purposes, coded 1 to 8;
- Facilities for common activities, coded 9.
A diagrammatic view of the whole table is shown on the next page.

Changes
Most changes from the last edition are at a detailed level and aim to make the table a useful tool for the classification of information on internal and external spaces eg 'computer rooms' as well as on building types. Classes 1 and 2 have been substantially re-arranged.

Coding
1 followed by 10 to 19; then 2 followed by 20 to 29; and so on.
Code positions marked 'vacant' may be used for any purpose in private applications but not on published literature.

Use
Where two classes seem equally relevant use the first in the absence of any private rule to the contrary. When using the table for a particular purpose consider:

Simplicity of use
For a small set of data it may be possible use just the nine division codes and headings, eg 1 Utilities, and ignore all the detailed codes and headings. Use codes only if they serve a useful purpose.

Compound subjects
Adopt suitable rules for dealing consists with documents or items which relate to two or more headings.
In cases where a very detailed systematic breakdown is required, two codes from the table can be used together, separated by a colon eg
2:94 Sanitary spaces in industrial buildings
282:94 Sanitary spaces in factories

Filing
The heading 'Other types etc' at the end of each class indicates that all other aspects the main subject not listed specifically follow on at the position.
Some users may prefer to ignore these headings and file this material immediately after the main heading (see Application 2.3).
### Table 0 matrix

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<td>linear = ribbon, cluster,</td>
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<td>097 Areas by social environmental factors eg: racially mixed areas, high amenity areas, areas with particular types of population, areas administered in various ways</td>
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<td>098 Areas by other aspects of town and country planning</td>
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<td>Parts of national planning areas If necessary, subdivide eg:</td>
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<td>031 Regional planning eg:</td>
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<td>South East region</td>
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<tr>
<td>Sub-regional planning areas 033/038</td>
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<td>033 County planning, including metropolitan counties</td>
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<td>035 District planning, including metropolitan districts</td>
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<td>036 Local planning</td>
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<td>038 Other sub-regional planning areas eg: structure plans (formerly ‘development plans’), tactical plans</td>
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<td>04 Vacant</td>
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</tbody>
</table>
Utilities, civil engineering facilities

1 UTILITIES, CIVIL ENGINEERING FACILITIES
Includes transport, telecommunications, basic supply and disposal facilities, general engineering works.

If subdivision of this class is needed it will often be enough to use only the headings below.

11 Rail transport facilities
12 Road transport facilities
13 Water transport facilities
14 Air transport facilities, other transport facilities
15 Communications facilities
16 Power supply, mineral supply facilities
17 Water supply; disposal facilities
18 Other utilities, civil engineering facilities

The schedule may be used in a flexible way to divide information into eg three classes:

11/14 Transport facilities
16/18

11 RAIL TRANSPORT FACILITIES
Includes railway engineering, rail transportation

If necessary, subdivide eg:

111 Surface, overhead railways eg: intercity, suburban lines

112 Underground railways

113 Other railways (track operated transport) eg:
mountains, rack, cable railways;
monorails;
guideways; cable transport including cable ways, aerial ropeways eg: cable cars, ski-lifts

114 Embarkation facilities eg:
stations, terminals, stops, halts, platforms

115 Rail vehicle control facilities eg:
signal boxes, marshalling yards

116 Rail vehicle storage, repair facilities eg:
loco sheds, carriage sheds

117 Other types, parts of rail transport facilities eg:
permanent way, track; rail bridges, rail tunnels; (rolling stock may also be included here)

12 ROAD TRANSPORT FACILITIES
Includes highway engineering, road transportation including bus systems, road haulage systems

If necessary, subdivide eg:

121 Motorways, autobahns

122 Other motor roads
1 Primary roads other than motorways (trunk roads, arterial roads, main roads)
2 Secondary roads (minor roads)
3 By-passes (loop roads), ring roads, radial roads
4 Access roads, drives, approach roads, cul-de-sacs
5 Single and dual carriageway roads, grade separated roads
8 Other types, parts of motor roads

123 Other roads
1 Pedestrian streets
2 Cycle tracks
3 Broadways
4 Footpaths (field paths, footways, paths), towpaths
8 Other types

124 Embarkation facilities eg:
coach stations, bus stations, bus stops, bus shelters

125 Car parks, parking bays, street parking, loading bays

126 Road vehicle control facilities eg:
filling stations (petrol stations), traffic controls

127 Road vehicle storage, repair facilities eg:
garages, spare parts and accessories shops, showrooms, repair shops;
inspection pits, washbays, degreasing, lubricating, body building units

128 Other types, parts of road transport facilities eg:
carriage ways including traffic lanes, junctions (intersections), slip ways, laybys (drive ins), passing places, skid pads;
hardstandings, pavements, refuges (islands), crossings; road tunnels, road bridges, road flyovers;
street furniture, hoardings; (road vehicles may also be included here)

13 WATER TRANSPORT FACILITIES
Includes sea, river, canal transport

If necessary, subdivide eg:

131 Maritime water transport facilities including coastal, ocean Harbours if shown separately see 134

132 Inland water transport facilities including canal, non-tidal rivers, lake transport

Other types, parts of waterways Water flow control see 187

134 Embarkation facilities eg:
harbours (ports) eg: hovercraft; stations, transit sheds, termini

135 Customs houses see 315

136 Pier buildings see 989

137 Boat storage, repair facilities repair yards, boat houses Shipbuilding, boat building facilities see 2755

138 Other types, parts of water transport facilities eg:
locks, docks including vet., c floating docks (see also 275); jetties (piers), quays (wharves, berths, moorings); slipways, gangways; (ships, barges may also be included here)
AIR TRANSPORT FACILITIES, OTHER TRANSPORT FACILITIES
If necessary, subdivide eg:
Airport facilities including aerodromes (air fields)
Terminals if shown separately see 164
Heliports, VTOL facilities
Embarkation facilities eg:
Aircraft control facilities eg:
Aircraft storage, repair facilities eg:
Hangers
Other types, parts of air transport facilities eg:
landing pads, runways, taxi ways, stop ways, clear ways, aprons, holding bays, disposal bays;
(aircraft may also be included here)
This position may be used for pervasive facilities common to two or more of classes 11/14 eg:
embarkation facilities, vehicle control facilities, vehicle storage and repair facilities, level crossings, transportation and travel facilities generally (air cushion transport may also be included here)

COMMUNICATIONS FACILITIES
If necessary, subdivide eg:
Telecommunications facilities
Broadcasting facilities
Radio facilities
Television facilities eg: closed circuit television
Telephone, telegraph facilities
1 Telephone facilities eg: telephone exchanges
2 Telegraph facilities eg: telex, facsimile transmission, data communications
Lines facilities, micro-wave beam, laser beam, radio wave facilities
Transmission facilities eg: transmitting, receiving, monitoring stations including satellite ground stations, aerial masts and towers
Switching facilities eg: exchanges, switching centres, telecommunications control facilities
Other telecommunications facilities
Postal communications facilities eg:
post offices, sorting offices, mail rooms, parcels offices
Other types, parts of communications facilities

POWER SUPPLY, MINERAL SUPPLY FACILITIES
If necessary, subdivide eg:
160 Heat supply facilities
Heat production facilities eg:
geothermal
Heat dissipation facilities eg: cooling towers, freestanding chimneys
162 Electricity supply facilities
power production, electricity, power stations (generating stations) including nuclear, hydroelectric:
163 Mechanical power supply facilities eg:
windmills, watermills
164 Oil (petroleum) extraction, supply facilities
165 Gas extraction, supply facilities
166 Solid fuel extraction, supply facilities eg:
coal mines (collieries), pits, galleries, shafts, pit cuttings
167 Other mineral extraction, supply facilities eg:
mines, quarries, open-cast workings
168 Other types, parts of mineral supply facilities

WATER SUPPLY; DISPOSAL FACILITIES
Public health engineering
If necessary, subdivide eg:
170 Water supply facilities
1 Water supply storage facilities eg: wells, reservoirs, water tanks
2 Water supply treatment facilities eg: water works
3 Water supply distribution facilities eg: pumping stations
8 Other water supply facilities

174 Sewage disposal facilities
175 Refuse disposal facilities
176 Mineral waste disposal facilities eg:
slag heaps, nuclear fission waste products disposal facilities
177 Disposal of the dead eg:
mortuaries, morgues
Crematoria, cemeteries etc see 67

OTHER UTILITIES, CIVIL ENGINEERING FACILITIES
If necessary, subdivide eg:
181 Tunnels, subways, underpasses, culverts, pipelines
182 Bridges
1 Aqueducts
2 Vehicle bridges
3 Footbridges
4 Pipe, cable bridges
5 Moveable bridges eg: horizontal including swing, roller, transporter bridges; vertical including vertical lift, bascule, counterbalanced, cable lift bridges
6 Viaducts
8 Other bridges eg: suspension, cantilever, arch, portal frame, cable braced (stayed) bridges
183 Towers and other vertical engineering structures
Aerial masts and towers see 156

184 Bulk goods storage facilities
1 Silos, bins, hoppers, tanks
2 Structures with thrust resistant walls
3 Structures with non-thrust resistant walls
4 Structures with little or no wall
8 Other bulk goods storage facilities eg: dumps
See also 164, 165, 171, 175, 268
185 Land reclamation eg:
polders, ferry
186 Land retention facilities
1 Avalanche protection
2 Landslide protection
3 Erosion protection eg: soil erosion, sea defence, coastal protection facilities eg: sea walls, breakwaters (moles), groynes
4 Revegetation
8 Other land retention facilities
187 Water retention and flow control
Water retention facilities eg:
dykes, levees, cofferdams; dams, barrages, weirs
Water control facilities eg:
flood protection, drainage, irrigation
188 Other types, parts of utilities, civil engineering facilities eg: supports
19 Vacant
2 INDUSTRIAL FACILITIES
Includes agricultural and manufacturing facilities
Power supply, mineral supply facilities see 16
This class may apply to eg: a works, an individual block, a department, a room, an internal or external space

If subdivision of this class is needed it will often be enough to use only the headings below:

26 Agricultural facilities
27 Manufacturing facilities
28 Other industrial facilities

26 AGRICULTURAL FACILITIES
If necessary, subdivide eg:
261 Forestry facilities, shelter belt facilities
262 Fishing facilities, fisheries
263 Farming facilities eg: farms
264 Horticultural (market gardening) facilities eg: nurseries, hothouses, greenhouses, glasshouses; agricultural produce facilities
265 Livestock facilities
Subdivide as 264 eg: 2654 cattle unit, cowshed, milking parlour
Abattoirs, dairies see 273
Animal houses generally see 48

268 Other types, parts of agricultural facilities eg:
1 Silos, bins, hoppers, tanks
2 Bulk storage with thrust-resistant walls
3 Storage with non-thrust resistant walls
4 Storage with little or no wall, Dutch barns
5 Controlled environment facilities
6 Fields, yards, pens, pits

27 MANUFACTURING FACILITIES
Codes in Roman numerals or right below are taken from the Standard Industrial Classification (SIC), available from HMSO
Factories etc for specific purposes eg:
273 Food, drink, tobacco industry eg: abattoirs, dairies
274 Chemicals and allied industries
275 Engineering industries, metal industries
1 Metals
2 Mechanical engineering
3 Instrument engineering
4 Electrical engineering
5 Shipbuilding and marine engineering eg: launching ramps
Ship repair if not at 137; see at 138
6 Vehicles
Rail vehicles if not at 11: see at 12
Other metal goods
7 Textile, clothing industries
1 Textiles
2 Leather, leather goods and fur
3 Clothes, footwear
8 Clay, cement, timber industries
1 Bricks, pottery, glass, cement
2 Timber, furniture
3 Paper, printing and publishing
4 Other manufacturing industries
276 Construction industry eg: builders' yards

28 OTHER INDUSTRIAL FACILITIES
Facilities common to two or more industries
If necessary, subdivide eg:
281 Heavy industry facilities eg: works, mills
282 Factories eg: standard factories, flatted factories, industrial works
284 Industrial storage facilities; industrial warehouses
285 Industrial process facilities; assembly lines, industrial facilities, production maclrooms
286 Other types, parts of industrial facilities eg: repair facilities

29 Vacant
### Administrative, commercial, protective service facilities

#### OFFICE FACILITIES, OFFICES
- Offices associated with a particular facility see that facility eg: shops and offices see 34
- Drawing offices, design offices, studios; art, photographic studios; professional offices, executive offices, offices of nationalised industries, secretarial offices
- Landsided offices
- (Bürolandschaft)
- Open plan spaces generally see 997

#### COMMERCIAL FACILITIES
- If necessary, subdivide eg:
- Commercial and trading facilities
- Mixed commercial developments
- Insurance facilities eg: underwriting
- Building societies
- Investment facilities eg: stock exchanges, stockbroking facilities
- Other types, parts of commercial facilities eg:
  - banks including banking halls, tellers boxes, safe deposits

#### TRADING FACILITIES, SHOPS
- If necessary, subdivide eg:
- Wholesaling facilities, auction rooms; bulk-buying stores, discount trading stores, mail order stores, cash and carry stores
- Shopping centres including local centres, shopping arcades, markets
- Department stores
- Hypermarkets, supermarkets
- Self-service shops, corner shops, shops by goods sold eg:
  - food shops, durable goods shops
- Service shops eg:
  - dry cleaners, cobblers, launderettes, forges, gunsmiths, upholsterers, book binders, tailors
- Dealers eg:
  - coal merchants, builders’ merchants
- Other types, parts of trading facilities eg:
  - shop showrooms, fitting facilities, sales facilities including booking halls, trading stalls, kiosks

#### PROTECTIVE SERVICE FACILITIES
- If necessary, subdivide eg:
- Coastguard, lifeboat stations (if not at 136)
- Fire protection facilities eg:
  - fire stations, fire practice towers, smoke chambers, fire hose drying spaces
- Ambulance facilities
- Civil law, criminal law enforcement facilities eg:
  - police stations
- Defence facilities
- Armed forces facilities 3751/3753
  - 1 Air force facilities
  - 2 Navy facilities
  - 3 Army facilities, other armed forces facilities eg: barracks generally
  - 4 Civil defence facilities
  - 5 Camps, depots, bases, ranges
  - 6 Blockhouses, city walls
  - 7 Air raid shelters, fall-out (radiation) shelters
  - 8 Aggressive facilities eg: missile sites;
    - Other defence facilities
- Prisons (gaols, jails, penitentiaries)
  - 1 Open prisons
  - 2 Closed prisons eg: semi-secure prisons: secure prisons;
    - maximum security prisons
  - 5 Reformatories (borstals)
  - 8 Other detention facilities eg: assessment centres
- Approved schools see 7175
- Other types, parts of protective service facilities eg:
  - secure facilities

#### OTHER ADMINISTRATIVE, COMMERCIAL, PROTECTIVE SERVICE FACILITIES
- Vacant

#### OFFICIAL ADMINISTRATIVE FACILITIES, LAW COURTS
- Offices see 92
- If necessary, subdivide eg:
- International legislative and administrative facilities eg:
  - European parliament, EEC Commission, UN
- National legislative and administrative facilities eg:
  - parliaments, capitols, ministries
- Regional and local legislative and administrative facilities eg:
  - regional, county and district offices; civic centres; county, city and town halls; guildhalls; mayor’s parlour
- Local offices of government departments eg:
  - taxation facilities eg: customs houses, labour exchange facilities eg: employment exchanges, job centres
- Official representation facilities eg:
  - palaces, presidential residences, embassies, consulates, legations, high commissions
- Law courts eg:
  - civil courts including county courts, magistrates courts; criminal courts, assizes; court rooms, bench, dock; witness box, jury box
- Other types, parts of official administrative facilities eg:
  - ceremonial suites, robing rooms, debating chambers
4 HEALTH, WELFARE FACILITIES
This class may apply to eg: a multi-block project, an individual block, a department, a room, an internal or external space

If subdivision of this class is needed it will often be enough to use only the headings below:
41 Hospital facilities, hospitals
42 Other medical facilities
44 Welfare facilities, homes
46 Animal welfare facilities
48 Other health, welfare facilities

40 Vacant

41 HOSPITAL FACILITIES, HOSPITALS
If necessary, subdivide eg:
411 Teaching hospitals including postgraduate teaching centres
412 General hospitals, GP hospitals, cottage hospitals
Hospital facilities by part of body
413 Medical, psychiatric
414 Ear, nose and throat, dental, heart, other types by part of body
Hospital facilities by patient
415 Maternity, gynaecological
416 Paediatric (children); geriatric (old people)
417 Hospital facilities by technique
1 Diagnosis including radiography (X-ray)
2 Surgery including operating theatres
4 Pathology
5 Physical medicine, occupational therapy
7 Chemotherapy, including pharmacies, dispensaries
8 Other techniques including physiotherapy, radio therapy
418 Other types, parts of hospital facilities eg:
outpatients facilities, casualty facilities; day patients facilities; in-patients facilities: admission units; private patients facilities: isolation facilities; field hospital facilities; nursing facilities including wards

42 OTHER MEDICAL FACILITIES
If necessary, subdivide eg:
421 Health centres; health clubs
422 Clinics eg:
maternity and child clinics, geriatric, screening clinics
423 Surgeries including group practices, doctors' surgeries, consulting rooms
424 Special centres, clinics, surgeries eg:
dentists' surgeries
426 First aid posts including emergency and field posts
427 Medical research facilities
428 Other types, parts of medical facilities eg:
blood transfusion, forensic facilities, examination facilities

43 Vacant

44 WELFARE FACILITIES, HOMES
If necessary, subdivide eg:
442 Nursing homes, convalescent homes, sanatoria
Welfare facilities by condition c user 443/445
443 Chronic invalids, addicts
444 Mentally handicapped eg:
physically handicapped eg: polio, spastic, blind, deaf; other welfare facilities by condition of user eg:
unmarried mothers, battered wives, destitute people
Welfare facilities by age of use:
446/447 Orphanages, nurseries (crèche)
447 Old people's homes Old people's housing generally see 843
Other welfare facilities by age user
448 Other types, parts of welfare facilities eg:
overnight, short stay, long stay accommodation

45 Vacant

46 ANIMAL WELFARE FACILITIES
If necessary, subdivide eg:
461 Veterinary hospitals
462 Animal clinics, dispensaries
463 Animal clipping and pedicure facilities
464 Animal rearing and living facilities:
Agricultural facilities see 26
1 Fish
2 Cats, dogs (kennels)
3 Horses (stables) Riding schools see 565
4 Cattle
5 Sheep, goats
6 Pigs
7 Birds, poultry
8 Other animal rearing and facilities eg: rodents, bees insects, exotic animals
468 Other types, parts of animal welfare facilities eg:
quarantine facilities

47 Vacant

48 OTHER HEALTH, WELFARE FACILITIES

49 Vacant
RECREATIONAL FACILITIES
Includes social recreation and refreshment facilities eg: leisure facilities
This class may apply to eg: a multi-block project, an individual block, a department, a room, an internal or external space

If subdivision of this class is needed it will often be enough to use only the headings below:
Refresher facilities
Entertainment facilities
Social recreation facilities
Aquatic sports facilities
Sports facilities
Other recreational facilities

The schedule may be used in a flexible way to divide information into two classes: 51/53 Refreshment, entertainment, social recreation facilities 54/58 Water and other sports facilities etc.

53 SOCIAL RECREATION FACILITIES
Congress and conference halls see 916
If necessary, subdivide eg:
532 Community centres eg: cultural centres, arts centres, village halls
534 Clubs eg: youth centres, students unions, other non-residential, non-commercial clubs
536 Residential clubs
537 Commercial clubs, night clubs
538 Other types, parts of social recreation facilities

54 AQUATIC SPORTS FACILITIES
If necessary, subdivide eg:
541 Swimming facilities 541/544
543 Covered swimming pools
544 Other types, parts of swimming facilities eg: diving pools
546 Boating facilities eg: sailing, canoeing, rowing facilities, marinas
548 Other types, parts of aquatic sports facilities eg: water skiing facilities

56 SPORTS FACILITIES
If necessary, subdivide eg:
561 Sports centres eg: Crystal Palace
562 Sports halls
Gymnasium, physical training facilities eg: gymnastics, acrobatics, bodybuilding, weight lifting:
Fighting sports facilities eg: boxing, fencing, wrestling, judo, aikido, karate;
One-to-one sports facilities eg: badminton, fives, squash, tennis, billiards, snooker, table tennis
563 Bowling alleys (tenpin bowling alleys)

57 Vacant

58 OTHER RECREATIONAL FACILITIES
If necessary, subdivide eg:
581 Gambling facilities, casinos
582 Amusement arcades
583 Fairgrounds, funfairs, showgrounds
585 Play facilities eg: playgrounds, adventure playgrounds, play centres, play spaces
587 Parks, leisure gardens eg: gardens for the blind; outdoor recreation facilities
Natural areas in the service of man see 087
Landscape areas see 092
Outdoor sports facilities see 568
Gardens, external spaces generally see 998
Environmental features see 998
Other types, parts of recreational facilities eg: holiday facilities, holiday camps

59 Vacant
RELIGIOUS FACILITIES
This class may apply to e.g.: a multi-block project, an individual block, a department, a room, an internal or external space.

If subdivision of this class is needed it will usually be enough to use the headings below: no further subdivision is provided but the scope of each heading is illustrated on the right.

61 Religious centre facilities
62 Cathedrals
63 Churches, chapels
64 Mission halls, meeting houses
65 Temples, mosques, synagogues
66 Convents
67 Funerary facilities, shrines
68 Other religious facilities

60 Vacant

RELIGIOUS CENTRE FACILITIES
e.g.: episcopal palaces, deaneries, pastoral centres, ecumenical centres

CATHEDRALS
e.g.: chapter houses, cathedral treasuries

CHURCHES, CHAPELS
e.g.: churches, church halls (if also used or described with churches), chapels, chantries

MISSION HALLS, MEETING HOUSES

TEMPLES, MOSQUES, SYNAGOGUES

CONVENTS
Residential religious facilities e.g.: monasteries, nunneries, abbeys, priories, friaries, retreats

FUNERARY FACILITIES, SHRINES
e.g.: crematoria, cemeteries (grave yards); funeral vaults; tombs, mausoleums; shrines, feretory spaces, relics spaces, reliquaries
Monuments see 984
Morgues, mortuaries see 177

OTHER RELIGIOUS FACILITIES
Chancels including sanctuaries, choirs, altars; transepts; crypts; watching galleries; belfries; side chapels; baptisteries; confessing facilities; preaching facilities; sacramental facilities; ambulatory facilities including cloisters, aisles, retrochoirs; vestries, sacristies

Vacant
### Educational, Scientific, Information Facilities

**4.1 Educational, Scientific, Information Facilities**

Facilities for the acquisition of knowledge

This class may apply to: eg a multi-block project, an individual block, a department, a room, an internal or external space.

If subdivision of this class is needed it will often be enough to use only the headings below:

- **Schools facilities**
- **Universities, colleges, other education facilities**
- **Scientific facilities**
- **Exhibition, display facilities**
- **Information facilities, libraries**
- **Other educational, scientific, information facilities**

The schedule may be used in a flexible way to divide information into two classes:

- 71/72 Educational, scientific facilities
- 75/78 Exhibition, information facilities etc

### 71 Schools Facilities

<table>
<thead>
<tr>
<th>Class</th>
<th>Description</th>
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<tbody>
<tr>
<td>711</td>
<td>Nursery schools, classrooms</td>
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<tr>
<td>712</td>
<td>Primary schools eg: infants schools, classrooms; first schools; junior (preparatory) schools; middle schools</td>
</tr>
<tr>
<td>713</td>
<td>Secondary schools (high schools) eg: grammar, secondary modern, secondary technical, comprehensive, community schools</td>
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<tr>
<td>714</td>
<td>Sixth form colleges, centres</td>
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<tr>
<td>715</td>
<td>Special schools eg: Educationally subnormal (ESN) schools, including severely mentally handicapped, maladjusted, delinquent, hospital schools</td>
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<td>716</td>
<td>Physically handicapped</td>
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<td>717</td>
<td>Approved schools</td>
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<tr>
<td>718</td>
<td>Other special schools eg: boarding, residential schools</td>
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<tr>
<td>719</td>
<td>Other types, parts of school facilities eg: state, independent schools; school learning, teaching facilities eg: school classrooms</td>
</tr>
</tbody>
</table>

### 72 Universities, Colleges, Other Education Facilities

<table>
<thead>
<tr>
<th>Class</th>
<th>Description</th>
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<tbody>
<tr>
<td>721</td>
<td>Universities including technological universities, university colleges</td>
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<tr>
<td>722</td>
<td>Polytechnics, technical colleges, colleges of education, colleges of further education, colleges of art and design</td>
</tr>
<tr>
<td>723</td>
<td>Academies eg: music academies</td>
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<tr>
<td>724</td>
<td>Other specialist colleges</td>
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<tr>
<td>725</td>
<td>Adult education facilities; Learned societies</td>
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<tr>
<td>726</td>
<td>Other types, parts of higher education facilities eg: learning, teaching facilities Students unions see 534 Halls of residence see 656</td>
</tr>
<tr>
<td>727</td>
<td>Other types, parts of education facilities Facilities common to 71/72 eg: 1 Classrooms, lecture theatres 2 Special subject facilities 4 Special technique facilities eg: team teaching facilities 8 Other facilities for imparting knowledge</td>
</tr>
</tbody>
</table>

### 73 Scientific Facilities

**731 Research facilities**

- Medical research facilities see 427
- Laboratory facilities eg: fume chambers, instrument rooms, dark rooms
- Observatories, recording stations eg: meteorological, geophysical, seismographic stations (earthquake stations)
- Other types, parts of scientific facilities

### 74 Vacant

### 75 Exhibition, Display Facilities

If necessary, subdivide eg:

- Botanical gardens; herbaria; zoos Animal welfare facilities see 46
- Aviaries Aquaria Museums, planetariums Art galleries, facilities for special display eg: of paintings, murals, sculptures Other types, parts of exhibition, display facilities eg: design centres, building centres, exhibitions, galleries, showrooms

### 76 Information Facilities, Libraries

If necessary, subdivide eg:

- National libraries
- Public libraries including commercial lending libraries
- Information facilities by special subject eg: architecture
- Information facilities by form of material eg: resource centres, illustrations, drawings, photographs
- Data processing facilities eg: computer, reprographic facilities
- Record offices, archives, patent offices
- Other types, parts of information facilities eg: enquiry, browsing, lending, reference facilities; study facilities eg: carrels, audio-visual presentation, projection facilities

### 77 Vacant

### 78 Other Educational, Scientific, Information Facilities

E-13

### 79 Vacant
**RESIDENTIAL FACILITIES**

This class may apply to eg: a multi-block project, an individual block, a residential unit, an internal or external space.

If subdivision of this class is needed it will often be enough to use only the headings below:

- **81 Housing**
- **82 One-off housing units, houses**
- **84 Special housing facilities**
- **85 Communal residential facilities**
- **86 Historical residential facilities**
- **87 Temporary, mobile residential facilities**
- **88 Other residential facilities**

**80 Vacant**

**81 HOUSING**

Housing units (dwellings) for single families, and single family housing as a whole (including one off houses 82 and special housing 84).

If necessary, subdivide eg:

- **811 Single storey**
- **812 Two storey**
- **814 Three and four storey**
- **815 Five storeys and over**
- **816 Flats (apartments)**
- **817 Maisonsettes**
- **818 Other types, parts of housing facilities eg:**
  - existing housing; housing with offices or shops; local authority; housing association; private; speculative housing

**82 ONE-OFF HOUSING UNITS, HOUSES**

Individually designed houses

**83 Vacant**

**84 SPECIAL HOUSING FACILITIES**

Dwellings for special classes of user. Housing related to facilities already listed may be included at 848 or kept with them as required eg: armed forces housing see 375

If necessary, subdivide eg:

- **841 Caretakers, wardens' houses**
- **843 Old people's housing including sheltered housing Old people's homes see 447**
- **847 Single persons' housing**
- **848 Other types, parts of special housing units eg:**
  - disabled, handicapped persons' housing

**85 COMMUNAL RESIDENTIAL FACILITIES**

Shared facilities

If necessary, subdivide eg:

- **852 Hotels**
- **853 Motels**
- **854 Guesthouses**
- **856 Hostels eg:**
  - YMCA, youth hostels; halls of residence
- **858 Other types, parts of communal residential facilities**

The following subdivision by form can be applied to 81 to 84:

1. **Detached eg:**
   - **8111 Detached single storey housing**

2. **Semi-detached**

3. **Terraced, row houses**

4. **Others**
COMMON FACILITIES, OTHER FACILITIES

Facilities common to two or more classes 2/8, for general activities eg: work, rest, personal hygiene, including also those in Class 1 when they occur as subordinate parts of construction work (see 914/915, 96/97)

This class may apply to eg: a multi-block project, an individual block, a department, a room, an internal or external space

If subdivision of this class is needed it will often be enough to use only the headings below:

Circulation, assembly facilities
Rest, work facilities
Culinary facilities
Sanitary, hygiene facilities
Cleaning, maintenance facilities
Storage facilities
Processing, plant, control facilities
Other types of facilities, buildings
Parts of facilities, other aspects of the physical environment, architecture as a fine art

The schedule may be used in a flexible way to divide information into eg two classes:
91/97 Common facilities
98/99 Buildings, architecture, landscape design

Vacant

CIRCULATION, ASSEMBLY FACILITIES

If necessary, subdivide eg:
913 Access, egress facilities eg: porches, entrance halls, exits, vestibules, lobbies, reception spaces, foyers, waiting facilities
914 Movement facilities
1 Horizontal circulation eg: concourses, precincts: passages (alleys) eg: corridors; links eg: link buildings, gangways, galleries, arcades
2 Vertical circulation eg: stairs, stair enclosures; elevator ways, elevator enclosures; lift enclosures, lift lobbies
915 Materials handling (movement) facilities
916 Assembly facilities eg: congress, conference, assembly centres, halls
917 Special assembly facilities eg: board rooms, committee rooms
918 Other types, parts of assembly, circulation facilities

REST, WORK FACILITIES

921 Rest facilities including rest/work facilities eg: study-bedrooms
Sleep facilities eg: dormitories, bedrooms, bunk rooms
Living facilities eg: living rooms if not at 88
922 Relaxation facilities eg: lounges, break facilities, restrooms (staff rooms, common rooms), recovery rooms
923 Work facilities, work places, work stations
926 Facilities for particular skills eg: art design, photography Offices, studios see 32
Dark rooms see 732
928 Other types, parts of rest, work facilities eg: reading, discussion, hobby facilities; consulting, interview facilities

CULINARY FACILITIES

Includes catering facilities
If necessary, subdivide eg:
931 Culinary facilities eg: kitchens
932 Washing-up facilities
934 Food preparation, cooking facilities
935 Culinary storage facilities eg: larders, wine cellars, pantries
937 Eating (dining) facilities
Social refreshment facilities, cantines, refectories see 51
938 Other types, parts of culinary facilities

SANITARY, HYGIENE FACILITIES

If necessary, subdivide eg:
941 Lavatories (toilets, conveniences, latrines) including public facilities
942 Bathrooms, bath houses, slipper baths, sauna baths, Turkish baths; shower facilities, showers;
944 Water closets, urinals (as spaces)
947 Dressing, changing rooms
948 Other types, parts of sanitary, hygiene facilities

CLEANING, MAINTENANCE FACILITIES

If necessary, subdivide eg:
951 Washing facilities eg: sluice rooms
952 Laundries (wash houses)
Laundries see 346
953 Ironing, drying, airing facilities
955 Utility rooms
958 Other types, parts of cleaning, maintenance facilities

STORAGE FACILITIES

See also 164, 165, 171, 175, 184, 268
If necessary, subdivide eg:
961 Cloakrooms, luggage rooms, stock rooms
963 Sheds eg: garages, car ports, car spaces, cycle sheds
Large scale car parks etc see 125
964 Liquids storage facilities
965 Cold storage facilities (as spaces) eg: coldrooms, refrigerated storage, deep freeze storage Culinary cold storage fittings see (73 5)
966 Hot storage facilities (as spaces)
Culinary hot storage fittings see (73 5)
967 Secure storage facilities eg: strong rooms (vaults)
968 Other types, parts of storage facilities
97 **PROCESSING, PLANT, CONTROL FACILITIES**
Including facilities for all activities not listed or implied above eg: plant rooms, control rooms
If necessary; subdivide eg:
- **Power supply eg:** electricity
- **Heat supply facilities eg:** boiler houses
- **Cold supply, chilling facilities**
- **Large scale facilities see 16**

972 **Water supply facilities**
- **Large scale facilities see 17**

973 **Waste disposal facilities eg:**
- **bin ponds**
- **Large scale facilities see 17**

975 **Control and communications facilities eg:**
- **control rooms**

978 **Other types, parts of processing facilities**

98 **OTHER TYPES OF FACILITIES, BUILDINGS**
Facilities by characteristics other than purpose
Buildings generally
If necessary subdivide eg:
- **High rise buildings eg:**
  - multi-storey buildings
  - tall buildings, skyscrapers, masts, poles
  - **Medium rise, low rise buildings**

982 Detached buildings; semi-detached buildings; linked buildings, including lean-to:
- **terraces, parades, infill buildings**

983 **Demountable, floating, temporary, mobile buildings**

984 **Monuments eg:**
- obelisks, cenotaphs, memorials;
  - Ornamental buildings eg:
    - specially decorative;
    - Sculptures, murals, fountains
- **Shrines see 67**

986 **Historical buildings eg:**
- **modern, ancient monuments**
  - (divide by style/date)

987 **Buildings by particular architects, engineers (divide by name);**
- **The general concept of shelter**

988 **Other types of facilities eg:**
- buildings in special locations eg:
  - pier buildings, underground buildings; windowless buildings;
  - ruined, dilapidated, dangerous, defective buildings;
  - facilities for types of users eg:
    - pedestrian facilities; facilities for the handicapped

99 **PARTS OF FACILITIES; OTHER ASPECTS OF THE PHYSICAL ENVIRONMENT; ARCHITECTURE AS A FINE ART**
If necessary, subdivide eg:
- **Blocks; compartments (fire divisions); departments (functional divisions)**

992 **Storeys (horizontal divisions) eg:**
- first floor, second floor, roof top
- roof gardens; basements, cellars, attics (lofts, garrets), mezzanines

994 **Wings, bays, core (vertical divisions); rooms, including halls, cubicles, booths**

996 **FacadeS, external aspects**

998 **Covered spaces eg:**
- loggias, verandas, conservatories, pavilions

997 **Spaces**
- **Internal spaces, interior design eg:**
  - open plan spaces, landscaped spaces
- **External spaces, landscape design eg:**
  - landscaped spaces, gardens, spaces between buildings, specific external spaces eg:
    - 'areas', courtyards, patios, quadrangles, forecourts
  - Urban squares, streets see 056
  - Landscape see 092

999 **Architecture as a fine art**
Any or all the subdivisions 994/998 may alternatively be placed here
Table 1

Elements

Key

Scope
Parts with particular functions which combine to make the facilities in Table 0.

Structure
Three main divisions:
The building fabric at (1--) to (4--):
Services coded (5--) to (6--):
Fittings coded (7--) to (8--).
A diagrammatic view of the whole table is shown on the next page.

Changes
Most changes from the last edition are at a detailed level. The list of common element parts in Appendix 1 can be used for the subdivision of very large sets of data on Table 1 elements but is not for use for CI/SFB references in the top right hand corner on published trade literature, or for normal project applications.

Coding
(1--) followed by (10) to (19);
then (2--) followed by (20) to (29);
and so on.
Code positions marked 'vacant' may be left for any purpose in private applications but not on published literature.

Use
Where two classes seem equally relevant, use the first in the absence of any private rule to the contrary. When using the table for a particular purpose, consider:

Simplicity of use
For a small set of data it may be possible to use the nine element divisions eg: (1--) Substructure, and to ignore all the detailed codes and headings. Use codes only if they serve a useful purpose.

Compound subjects
Adopt suitable rules for dealing consistently with documents or items which relate to two or more different elements eg: 'space heating in floor beds' or 'stair and wall junctions'. In cases where a very detailed systematic breakdown is required, two codes from the table can be used together, separated by a colon eg: (13):(56) space heating systems in relation to floor beds.

Filing
The headings 'Other types', 'Parts, accessories etc.' at the end of each class indicate that all aspects of the main subject not specifically listed may follow on at the position. Some users may prefer to ignore these headings and file this material immediately after the main heading (see Applications 2.3).

Definitions
Two definitions are given for many Table 1 elements.
The first definition should normally be used by all producing new information required for project purposes, eg: 'bills of quantities, drawings (see Applications 1.4 for cost planning definitions).
The second is a broader definition, relevant to the classification of already existing literature and to some project information purposes.

External elements, External works
Elements at (1--) to (8--) are 'internal' and/or 'external', but (90) is restricted to external only. For some applications it may be useful to restrict the use of (1--) to (8--) to 'internal' only, or to use eg: (20) for 'external' and (21) to (29) for 'internal'.

E-17
<table>
<thead>
<tr>
<th>Substructure</th>
<th>Structure</th>
<th>Secondary elements, completion of structure</th>
<th>Finishes to structure</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1-) Ground, substructure</td>
<td>(2-) Structure, primary elements, carcass</td>
<td>(3-)</td>
<td>(4-)</td>
</tr>
<tr>
<td>(10) Vacant*</td>
<td>(20) Vacant*</td>
<td>(30) Vacant*</td>
<td>(40) Vacant*</td>
</tr>
<tr>
<td>(11) Ground</td>
<td>(21) Walls, external walls</td>
<td>(31) Secondary elements to walls, external walls</td>
<td>(41) Wall finishes, external</td>
</tr>
<tr>
<td>(12) Vacant*</td>
<td>(22) Internal walls, partitions</td>
<td>(32) Secondary elements to internal walls, partitions</td>
<td>(42) Wall finishes, internal</td>
</tr>
<tr>
<td>(13) Floor beds</td>
<td>(23) Floors, galleries</td>
<td>(33) Secondary elements to floors</td>
<td>(43) Floor finishes</td>
</tr>
<tr>
<td>(14) Vacant*</td>
<td>(24) Stairs, ramps</td>
<td>(34) Secondary elements to stairs</td>
<td>(44) Stair finishes</td>
</tr>
<tr>
<td>(15) Vacant*</td>
<td>(25) Vacant*</td>
<td>(35) Suspended ceilings</td>
<td>(45) Ceiling finishes</td>
</tr>
<tr>
<td>(16) Retaining walls, foundations*</td>
<td>(26) Vacant*</td>
<td>(36) Vacant*</td>
<td>(46) Vacant*</td>
</tr>
<tr>
<td>(17) Pile foundations</td>
<td>(27) Roofs</td>
<td>(37) Secondary elements to roofs</td>
<td>(47) Roof finishes</td>
</tr>
<tr>
<td>(18) Other substructure elements</td>
<td>(28) Building frames, other primary elements</td>
<td>(38) Other secondary elements</td>
<td>(48) Other finishes to structure</td>
</tr>
<tr>
<td>(19) Parts, accessories etc.</td>
<td>(29) Parts, accessories etc.</td>
<td>(39) Parts, accessories etc.</td>
<td>(49) Parts, accessories etc.</td>
</tr>
<tr>
<td>Cost summary</td>
<td>Cost summary</td>
<td>Cost summary</td>
<td>Cost summary</td>
</tr>
</tbody>
</table>

*See Appendix 6
<table>
<thead>
<tr>
<th>Services</th>
<th>Fittings</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>(6-) Services, mainly piped, ducted</td>
<td>(6-) Services, mainly electrical</td>
<td>(6-) Vacant*</td>
</tr>
<tr>
<td>(50) Vacuum</td>
<td>(60) Vacuum</td>
<td>(70) Vacuum</td>
</tr>
<tr>
<td>(51) Vacuum</td>
<td>(61) Electrical supply</td>
<td>(80) Vacuum</td>
</tr>
<tr>
<td>(52) Waste disposal, drainage</td>
<td>(62) Power</td>
<td>(90) External works*</td>
</tr>
<tr>
<td>(53) Liquids supply</td>
<td>(63) Lighting</td>
<td>(91) Vacuum*</td>
</tr>
<tr>
<td>(54) Gases supply</td>
<td>(64) Communications</td>
<td>(92) Vacuum*</td>
</tr>
<tr>
<td>(55) Space cooling</td>
<td>(65) Vacuum*</td>
<td>(93) Vacuum*</td>
</tr>
<tr>
<td>(56) Space heating</td>
<td>(66) Transport</td>
<td>(94) Vacuum*</td>
</tr>
<tr>
<td>(57) Air conditioning, ventilation</td>
<td>(67) Vacuum*</td>
<td>(95) Vacuum*</td>
</tr>
<tr>
<td>(58) Other piped, ducted services</td>
<td>(68) Security, control, other services</td>
<td>(96) Vacuum*</td>
</tr>
<tr>
<td>(59) Parts, accessories etc</td>
<td>(69) Parts, accessories etc</td>
<td>(97) Vacuum*</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(98) Other elements</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(99) Parts, accessories etc</td>
</tr>
</tbody>
</table>

| Cost summary | Cost summary | Cost summary | Cost summary |

* See Appendix 6
SITES, PROJECTS

Elements from two or more of
element divisions (1-) to (8-) eg:
structure plus fittings

Broader definition:
Sites, projects as a whole, ie sites
for development, development of
sites, building plus external
works, building systems (several or
all elements).

Building construction see (6d)
Structure if described separately
see (2-)
External works if described separately see (90)

This position is used eg:
for library files for sites, building
systems;
for location drawings, usually
divided into eg:
- block plans, general arrangement
- plans, elevations, sections etc for
the whole project or for particular
blocks, levels, rooms.

If subdivision is needed it will
often be enough to use only the
headings below. Examples of
their use are given:

(1-) Ground, substructure
Library files; dimensioned
location drawings; assembly
drawings; elemental
specifications; bq sections

(2-) Structure
Library files; dimensioned
location drawings

(3-) Secondary elements
Library files; project schedules of
openings in structure; elemental
specifications

(4-) Finishes
Library files; project schedules of
finishes to structure; elemental
specifications

(5-) Services (mainly piped)
Library files; location drawings
showing position of pipe runs;
 elemental specifications

(6-) Services (mainly electrical)
Library files; location drawings;
 elemental specifications

(7-) Fittings
Library files; location drawings
showing position of fittings;
 elemental specifications

(8-) Loose furniture, equipment
Library files; location drawings
showing position of client's
fittings

(9-) External works
Library files; location drawings;
 elemental specifications; bq
 sections

Some users of CI/SfB use (0)
'brackets nought' or (0-) instead
of (--), so that the main classes of
Table 1 can be coded (0) (1) (2)
(3) (4) (5) (6) (7) (8) (9)
or
(0-) (1-) (2-) (3-) (4-) (5-) (6-)
(7-) (8-) (9-)

E-20
(11) GROUND

Ground for construction eg:
excavated and filled ground,
stabilised ground; underground
Broader definition:
Ground, earth shapes as a whole,
site morphology, ground
ingineering
External works if described
separately see (90.1)(90.4)

(11.1) Ground relief eg:
- prominences, mounds,
- embankments; depressions,
hollows, cuttings.
- Ground inclination eg:
- flat ground; slopes including
sheer slopes, terraced slopes

(11.3) Ground composition eg:
- stabilised ground

(11.4) Ground water
Ground underwater if described
separately see (13.6)

(11.5) Underground eg:
- tunnels, underground ducts
- including culverts; land drainage
- unless at (52)

(11.8) Other types of ground elements
(11.9) Parts, accessories etc special to
ground elements may be included
here if described separately from
specific types above eg:
- excavations, trenches, fill

(12) Vacant
(17) PILE FOUNDATIONS

If described separately from class (16)

Pile foundations below lowest floor level damp proof course

Broader definition:
Pile foundations as a whole
External works if described separately see (90.1)
Temporary sheet piling see (B2r)
If necessary, subdivide eg:
(17.1) Sheet piling
(17.2) Replacement, in-situ formed pile foundations eg:
bored, cased, uncased
(17.3) Displacement, pre-formed pile foundations eg:
driven, jacked, screwed
(17.4) Small displacement
(17.8) Other types of pile foundations
(17.9) Parts, accessories etc special to pile foundations may be included here if described separately from specific types above, eg:
reinforcement to pile foundations in general

(18) OTHER SUBSTRUCTURE ELEMENTS

(19) PARTS, ACCESSORIES ETC SPECIAL TO SUBSTRUCTURE ELEMENTS
may be included here if described separately from specific types above eg:
damp proofing, insulation, reinforcement to retaining walls, foundations in general

Cost summary
(2) Structure primary elements, carcass

(2.1) Loadbearing structures eg:
- box frame, cross wall structures
- beam and column structures
- column structures
- ring beam structures

(2.2) Framed structures eg:
- steel frame structures
- concrete frame structures
- masonry frame structures

(2.3) Cellular structures eg:
- box, slabs and panel structures
- grid shell structures

(2.4) Stressed skin, geodesic structures eg:
- folded plate structures
- membrane structures

(2.5) Shell structures
(2.6) Tension structures eg:
- cable structures, membrane structures

(2.7) Other types of structures eg:
- air supported structures, stressed skin structures (structures with structural core)

(2.8) Major divisions of structure, carcass eg:
- external envelope, horizontal dividing elements
  - If necessary, subdivide eg:

(20) Vacant

(21) WALLS, EXTERNAL WALLS

External walls carcass above lowest floor level damp proof course, ie excluding secondary elements, finishes, services and fittings unless described with carcass

(21.1) Loadbearing internal walls, cross walls including cavity

(21.2) Non-loadbearing internal walls eg:
- fixed partitions, including post-to-panel, panel-to-panel;
- demountable partitions, including post-to-panel, panel-to-panel

(21.3) Framing and cladding, monolithic internal walls

(21.4) Parts, accessories etc special to internal walls may be included here if described separately from specific types above, eg:
- insulation, reinforcement to internal walls in general

If the distinction between external walls and internal walls unimportant class (22) may be wholly or partially omitted.

(22) INTERNAL WALLS, PARTITIONS

If described separately from class (21)

Internal walls carcass above lowest floor level damp proof course, ie excluding secondary elements, finishes, services and fittings unless described with carcass

Broader definition:
Internal walls, partitions as a whole:
- Internal walls secondary elements, folding doors/partitions if described separately see (32)

Wall finishes externally if described separately see (42)

If necessary, subdivide eg:

(22.1) Loadbearing internal walls, cross walls including cavity

(22.2) Non-loadbearing internal walls eg:
- fixed partitions, including post-to-panel, panel-to-panel;
- demountable partitions, including post-to-panel, panel-to-panel

(22.3) Framing and cladding, monolithic internal walls

(22.4) Parts, accessories etc special to internal walls may be included here if described separately from specific types above, eg:
- insulation, reinforcement to internal walls in general

If the distinction between external walls and internal walls unimportant class (22) may be wholly or partially omitted.
3.2) Assembled, composite floors eg:
3.7) Galleries, balconies
3.8) Parts, accessories etc special to floors, galleries may be included here if described separately from specific types above, eg: insulation, reinforcement to vertical circulation elements in general

3.4) Monolithic, slab floors eg:
3.5) Floors as a whole, including ceilings

3.6) Suspended floors, galleries, balconies, ie excluding secondary elements, finishes, services and fittings unless described with carcass

Broader definition:
Floors, suspended floors, galleries, balconies as a whole, including ceilings
Floor beds see (13)
Secondary floors if described separately see (33)
Suspended ceilings if described separately see (35)
Floor finishes if described separately see (43)
Platform fittings see (71.3)
If necessary, subdivide eg:

Suspended floors, galleries, balconies carcass, ie excluding secondary elements, finishes, services and fittings unless described with carcass

Broader definition:
Floors, suspended floors, galleries, balconies as a whole, including ceilings
Floor beds see (13)
Secondary floors if described separately see (33)
Suspended ceilings if described separately see (35)
Floor finishes if described separately see (43)
Platform fittings see (71.3)
If necessary, subdivide eg:

1. Suspended floors, galleries, balconies carcass, ie excluding secondary elements, finishes, services and fittings unless described with carcass
2. Secondary floors if described separately see (33)
3. Suspended ceilings if described separately see (35)
4. Floor finishes if described separately see (43)
5. Platform fittings see (71.3)

If necessary, subdivide eg:

24) STAIRS, RAMPS

Stairs, ramps carcass ie excluding secondary elements, finishes, services and fittings unless described with carcass. Also lift wells carcass if shown separately

Broader definition:
Stairs, ramps, including softs, vertical circulation elements as a whole
Stairs balustrades if described separately see (34)
Stairs finishes if described separately see (44)

If necessary, subdivide eg:

24.1) Straight stairs, including straightlight stairs
24.2) Assembled, composite stairs
24.3) Dog leg stairs, other straight stairs
24.4) Curved stairs including helical stairs (spiral stairs)
24.5) Other types of stairs by amount of turn, open well stairs, escape stairs
24.6) Ladders, step irons, sliding poles
24.7) Ramps
24.8) Other types of vertical circulation elements eg:
   lift shaft
   Lifts, transport services see (66.1)
24.9) Parts, accessories etc special to stairs, ramps, vertical circulation elements may be included here if described separately from specific types above, eg: reinforcement to vertical circulation elements in general

25) Vacant
26) Vacant

27) ROOFS

Roofs carcass excluding secondary elements, finishes, services, and fittings unless described with carcass

Broader definition:
Roofs as a whole, including ceilings
Suspended ceilings if described separately see (35)
Roof secondary elements if described separately see (37)
Roof finishes if described separately see (47)
If necessary, subdivide eg:

27.1) Flat roofs, terraces, platform roofs – up to 10° above horizontal
27.2) Pitched roofs eg:
   1 Single pitch, cut, lean-to, sloping
   2 Double pitch, saddleback
   3 Four pitch, hipped, helm
   4 Other types of pitched roofs eg: Mansard
   27.3) Folded plate roofs
27.4) Other roofs by form eg:
   27.5) Other roofs by form eg:
   cylindrical roofs, conoidal roofs, hyperbolic paraboloid roofs, domes, cupolas, steeples, spires

27.6) Roofs by structure eg:
   shell roofs, arched roofs, vaulted roofs, suspended roofs, space frame roofs
27.7) Cantilevered roofs, canopies
27.8) Other types of roofs eg: northlight roofs, gabled roofs, retractable roofs
27.9) Parts, accessories etc special to roofs may be included here if described separately from specific types above, eg: decking, trusses, damp proofing, insulation, reinforcement to roofs in general

28) BUILDING FRAMES, OTHER PRIMARY ELEMENTS

Building frame excluding secondary elements, finishes, services and fittings unless described with frame. Also chimneys, shafts

Broader definition:
Building frame, skeleton as a whole; other primary elements
If necessary, subdivide eg:

28.2) Column and beam frames, portal frames, column beam and slab frames
28.3) Column and slab frames
28.4) Column and cable 'frames'
28.5) Space frames as building frames
28.6) Other building frames eg: pin-jointed, rigid-jointed
28.7) Other types of primary elements eg:
   shafts, ducts, chimneys including flues
   Free standing chimneys see 161
   Flues described separately see (59)
28.9) Parts, accessories etc special to building frames etc may be included here if described separately from specific types above, eg: reinforcement to building frames in general

29) PARTS, ACCESSORIES ETC SPECIAL TO PRIMARY ELEMENTS, CARCASS

may be included here if described separately from specific primary elements above eg: damp proofing, insulation, reinforcement to primary elements in general

Cost summary
(3-) Secondary elements, completion of structure

(31) Secondary elements to walls, external walls

Library files for eg:
- windows and external doors*
- assembly, component drawings; elemental specifications, bq sections; cost plans
- Some users prefer to keep (31) for windows only and (32) for all doors; or to keep windows and all doors at (31) and omit (32).

(32) Secondary elements to internal walls, partitions

Library files for eg:
- internal doors; assembly, component drawings; elemental specifications, bq sections; cost plans

(33) Secondary elements to floors

Library files for eg:
- continuous access floors, trap doors; assembly, component drawings; elemental specifications, bq sections; cost plans

(34) Secondary elements to stairs

Library files for eg:
- staircase balustrades; assembly, component drawings; elemental specifications, bq sections; cost plans; or include in (23)

(35) Suspended ceilings

Library files for eg:
- ceiling suspension systems; assembly, component drawings; elemental specifications, bq sections; cost plans; or include in (45)

(37) Secondary elements to roofs

Library files for eg:
- eaves, rooflights; assembly, component drawings; elemental specifications, bq sections; cost plans; or include in (27)

(39) Minor parts of secondary elements

Library file for eg:
- ironmongery

(33) Summary of this group
Cost plans

(30) Vacant
(33) SECONDARY ELEMENTS TO FLOORS

If described separately from classes (13), (23)
Completion around and within openings in suspended floors and floor beds; and other floors, galleries secondary elements
Floors, suspended floors as a whole see (23)
Suspended ceilings see (35)
Floors, suspended floors as a whole see (23)
Suspended ceilings see (35)
Floor finishes if described separately see (43)
Platform fittings see (71.3)
If necessary, subdivide eg:
1 (33.1) Secondary suspended floors eg: access floors including continuous access floors, cavity floors: stages
Floating floors (floor finishes) see (43)
(33.2) Secondary floor beds eg:
Machine bases, hearths
(33.5) Floor (floor) openings eg:
Trap doorways, and parts to fill them
Pavement lights see (37.47)
(33.8) Other types of floor, secondary elements eg:
Barred openings
(33.9) Parts, accessories etc special to floors, galleries secondary elements may be included here if described separately from specific types above, eg:
reinforcement, ironmongery to floor openings in general

(34) SECONDARY ELEMENTS TO STAIRS

If described separately from class (24)
Completion around and within stair openings; and other stairs, ramps, lift shafts secondary elements eg:
Stair balustrades, ramp balustrades, lift shaft guide rails
Stairs, ramps as a whole see (24)
Stair finishes if described separately see (44)

(35) SUSPENDED CEILINGS

If described separately from classes (23), (27)
Completion under floors, roofs
Suspended floors as a whole see (23)
Roofs as a whole see (27)
Services if described separately see (5), (6)
If necessary, subdivide eg:
(35.1) Jointless suspended ceilings; panelled suspended ceilings constructed with panels, tiles, strips which may be solid, perforated, louvred, textured, sculptured etc
(35.2) Louvred suspended ceilings with separate vanes, not panels
(35.3) Ceiling openings and parts to fill them eg:
Lay lights
(35.8) Other types of suspended ceiling elements eg:
Ceiling walkways
(35.9) Parts, accessories etc special to suspended ceilings may be included here if described separately from specific types above, eg:
Insulation to suspended ceilings in general

(36) Vacant

(37) SECONDARY ELEMENTS TO ROOFS

If described separately from class (27)
Completion around and within roof openings; and other roof secondary elements
Roofs as a whole see (27)
Suspended ceilings see (35)
Roof finishes if described separately see (47)
If necessary, subdivide eg:
(37.3) Roof window/door openings including composite window and door openings, and parts to fill them
(37.4) Roof window openings and parts to fill them eg:
1 Roof lights, including dome lights
2 Barrel lights, lantern lights, monitor lights, northlights
4 Dormer windows, eyebrow windows
5 Roof windows, skylights
7 Pavement lights
8 Other types of roof window openings
(37.5) Roof doorways eg:
Trap doorways, access traps, and parts to fill them
(37.6) Roof eaves, parapets, balustrades if described separately
(37.8) Other types of roof secondary elements eg:
Roof walkways
(37.9) Parts, accessories etc special to roof secondary elements may be included here if described separately from specific types above, eg:
weather proofing, ironmongery to roof secondary elements in general

(38) OTHER SECONDARY ELEMENTS
eg: ducts, balustrades
Ducts as part of carcass see (28.8)

(39) PARTS, ACCESSORIES ETC SPECIAL TO SECONDARY ELEMENTS
may be included here if described separately from specific secondary elements above eg:
weather proofing, insulation, ironmongery to secondary elements in general

Cost summary
(4-) FINISHES TO STRUCTURE
Finishes applied to surface of structure including preparatory work, sub-layers or supports
Structure as a whole see (2-)
Completions, secondary elements see (3-)

If subdivision of this class is needed it will often be enough to use only the headings below.
Examples of their use are given:

(41) WALL FINISHES, EXTERNAL
Finishes applied to external surface of external walls, including preparatory work, sub-layers or supports.
Parts, accessories etc special to wall finishes external may be included here
External walls as a whole see (21)
External walls secondary elements see (31)

(42) WALL FINISHES, INTERNAL
Finishes applied to internal surface of internal and external walls, including preparatory work, sub-layers or supports.
Parts, accessories etc special to wall finishes internal may be included here
Internal walls as a whole see (2)
Internal walls secondary elements see (32)

If the distinction between external wall finishes and internal wall finishes is unimportant, cf. (42) may be wholly or partially omitted.

(43) FLOOR FINISHES
Library files; elemental specifications, bq sections; cost plans

(44) STAIR FINISHES
Library files; elemental specifications, bq sections; cost plans

(45) CEILING FINISHES
Library files; elemental specifications, bq sections; cost plans

(46) ROOF FINISHES
Library files; elemental specifications, bq sections; cost plans

(47) SUMMARY OF THIS GROUP
Cost plans
(43) FLOOR FINISHES
If described separately from classes (13), (23), (33)
Finishes applied to surface of suspended floors and floor beds, including preparatory work, sub-layers or supports. Includes floating floors (finishes)
Parts, accessories etc special to floor finishes may be included here, eg:
skirtings
Floor beds as a whole see (13)
Floors as a whole see (23)
Floors secondary elements see (33)
Stair finishes see (44)

(44) STAIR FINISHES
If described separately from (24), (34)
Finishes applied to surface of stairs, ramps, including preparatory work, sub-layers or supports.
Parts, accessories etc special to stair finishes may be included here, eg:
stair nosings
Stairs as a whole see (24)
Stairs, ramps secondary elements see (34)

(45) CEILING FINISHES
If described separately from (35)
Finishes applied to soffits of floors, roofs, to suspended ceilings, to other overhead surfaces, including preparatory work, sub-layers or supports
Parts, accessories etc special to ceiling finishes may be included here, eg:
ceiling coves, ceiling cornices
Floors as a whole see (23)
Roofs as a whole see (27)
Suspended ceilings as a whole see (35)

(46) Vacant

(47) ROOF FINISHES
If described separately from (27), (37)
Finishes applied to surface of roof, including preparatory work, sub-layers or supports.
Parts, accessories etc special to roof finishes may be included here, eg:
roof edgings, fascias, flashings
Roofs as a whole see (27)
Roof secondary elements see (37)

(48) OTHER FINISHES TO STRUCTURE
eg: decorations

(49) PARTS, ACCESSORIES ETC SPECIAL TO FINISHES TO STRUCTURE ELEMENTS
may be included here if described separately from specific finishes above, eg:
sub-layers or supports, flashings, edgings to structure finishes in general

Cost summary
Waste, Hot and Gases Refrigeration Space heating, Air conditioning, Minor parts of piped services

Summary of this group

Power sources for services
1 Solid fuel
2 Oil
3 Gas
4 Electricity
5 Solar radiation
6 Other eg: occupants, machines, waste matter

This subdivision can be applied to (5-) classes as appropriate

See eg note at (56.1)

Integrated services eg: heart units

District or community, centralised, localised services

SERVICES
Mainly piped and ducted services excluding electrical inputs and fittings connected to two or more services

Broader definition:
Services as a whole

Multi-service fittings see (7-)

Services in external works if described separately see (90.5)

Temporary services see (92c)

If needed it will often be enough to use only the headings below.

Separate component drawings; elemental specifications, disposal, drainage, assembly

Examples of their use are given:

Component drawings; elemental specifications, bq sections; cost

Library plans

Component library plans

Library files; assembly, drawings; elemental specifications, bq sections; cost plans

WASTE DISPOSAL, DRAINAGE

Waste disposal, drainage services excluding installations described with other elements eg: sink waste

Broader definition:
Disposal services as a whole

If necessary, subdivide eg:

Refuse, rubbish, garbage disposal
3 Dry carriage eg: chute and hopper systems, vacuum systems
4 Manual including dustbins, sacks
8 Other types of refuse disposal including local disposal eg: incinerators, crushers, grinders, shredders, compactors, balers

Special disposal fittings if described separately see (73), (74), (75)

Gases supply services

Library files; assembly, component drawings; elemental specifications, bq sections; cost plans

Gases supply

Library files; assembly, component drawings; elemental specifications, bq sections; cost plans

Refrigeration

Useful where refrigeration needs to be shown separately from air conditioning at (57)

Air conditioning, ventilation

Library files; assembly, component drawings; elemental specifications, bq sections; cost plans

Minor parts of piped services

Library files

Summary of this group

Cost plans

LIQUIDS SUPPLY

Liquids supply services, excluding installations described with other elements eg: Header tanks for central heating services see (56.9)

Broader definition:
Liquids supply services as a whole

If necessary, subdivide eg:

Cold water eg: potable (drinking) water; chilled water

Hot water eg: Hot water from common supply

Hot water from individual appliances

Other water supply services eg: filtration and treatment of water for special purposes; softened water, de-ionised water

Petrol, oil

Other types of liquids supply services
Soap dispensers see (74.7)

Parts, accessories etc special to liquids supply services may be included here if described separately from specific types above, eg:

cisterns, ball valves, lagging to liquids supply services to genera

GASES SUPPLY

Gases supply services, excluding installations described with other elements eg: Gas heaters for hot water supply see (53.5)

Broader definition:
Gases supply services as a whole

If necessary, subdivide eg:

Fuel gas, combustible gas supply eg:

natural gas, propane, butane
4.2) Vapour supply eg: steam supply and condensate services including vacuum, atmospheric and pressurised services, heated steam services.

4.3) Air supply eg: compressed air, Warm air heating services see (56.5) Ventilation, air conditioning services see (57)

4.4) Other gas supply eg: medical gases, industrial gases

4.5) Vacuum supply Vacuum refuse removal see (52.13)

4.8) Other types of gases supply services eg: supply of solids using gas pressure or vacuum Pneumatic message systems see (64.8)

4.9) Parts, accessories etc special to gases supply may be included here if described separately from specific types above, eg: meters for gases supply services in general

56) SPACE HEATING

Space heating services excluding installations described with other elements eg: Space heating for air conditioning services see (57)

Broader definition: Space heating services as a whole. If necessary, subdivide eg:

(56.1) Heating by power source
Subdivide here and in other subclasses below as at (5.1) eg: solid fuel heating (56.11)

(56.2) Communal heating (remote centre with mains and local distribution) eg: district heating (supplied to any consumer within economic distance of heat centre); group heating (supplied to groups of buildings in common ownership)

(56.3) Central heating (local centre and/or distribution) eg:

(56.4) Hot water, steam distribution
(56.5) Warm air distribution

(56.6) Electrical distribution eg: coils, storage heaters
(56.7) Other types of central heating

(56.8) Other types of space heating services eg: direct space heating (local appliances not part of a central system)

(56.9) Parts, accessories etc special to space heating services may be included here if described separately from specific types above, eg: lagging for space heating services in general

57) AIR CONDITIONING, VENTILATION

Air conditioning services (with air treatment) or ventilation services (without air treatment) excluding installations described with other elements

Broader definition: Air conditioning, ventilation services as a whole. If necessary, subdivide eg:

(57.1) Central air conditioning eg: air heating and cooling
(57.2) Air heating only
(57.3) Local air conditioning (local appliances not part of a central system) eg: air heating and cooling
(57.4) Air heating only
(57.5) Air treatment eg: heating, cooling, humidifying, drying, filtration, pressurisation, recirculation, extraction

(57.6) Mechanical ventilation services (no air treatment), including powered supply or extract, or both eg: central ventilation
(57.7) Unit ventilation (local appliances not part of a central system)
(57.8) Other types of air conditioning, ventilation services

(57.9) Parts, accessories etc special to air conditioning, ventilation services may be included here if shown separately from specific types above, eg: lagging to air conditioning, ventilation services in general

58) OTHER PIPED, DUCTED SERVICES

59) PARTS, ACCESSORIES ETC SPECIAL TO PIPED, DUCTED SERVICES ELEMENTS

Cost summary
(6-) SERVICES, MAINLY ELECTRICAL

Mainly electrical services excluding fittings connected to two or more services, installations described with other elements eg: electrical circuits for space heating at (56)

Broader definition:
Electrical services as a whole
Electrical services in external works if described separately see (90.6)

If subdivision of this class is needed it will often be enough to use only the headings below. Examples of their use are given:

(61) ELECTRICAL SUPPLY

Electrical load centre and mains including mains intake, control gear, distribution to local subcircuit boards or to equipment permanently attached to electrical installation; excluding installations described with other elements

Broader definition:
Electrical supply services as a whole

If necessary, subdivide eg:

(61.1) Radial distribution: mains intake to local control gear
(61.2) Ring main distribution: mains intake to local control gear
(61.3) Rising main distribution: mains intake to local control gear
(61.6) Public mains supply eg:
high voltage supply > 650v: medium voltage supply 250v-650v: low voltage supply > 250v
(61.7) Privately generated supply eg:
emergency/standby supply
(61.8) Other types of electrical supply services
(61.9) Parts, accessories etc special to electrical supply services may be included here if described separately from specific types above eg: distribution boards, conduit, meters for electrical supply services in general

(62) POWER

If described separately from (61)
Electric power subcircuits from local distribution boards to general purpose socket outlets; excluding installations described with other elements

Parts, accessories etc special to power distribution may be included here eg:
socket outlets

Broader definition:
Electrical power supply as a whole
Electrical heating see (56)

(63) LIGHTING

If described separately from (61)
Electric lighting circuits from local distribution boards, including lighting fittings; excluding installations described with other elements eg:
Illuminated signs see (71.1)

Broader definition:
Electric lighting supply as a whole

If necessary, subdivide eg:

(63.1) General lighting, localised lighting
(63.2) Local lighting including spot lighting, other display lighting
(63.6) Floodlighting
(63.8) Other types of lighting services eg:
emergency lighting: flameproof, water proof lighting: gas lighting
(63.9) Parts, accessories etc special to lighting may be included here if described separately from specific types above eg:
lighting fittings eg: trough, bowl, louvred, recessed flush, pendant, portable lighting sources eg: filament (incandescent) including tungsten; discharge including fluorescent; other lighting by lamp type

(60) Vacant
COMMUNICATIONS

Communications services, including those linked to public networks, and complete private networks; excluding installations described with other elements eg: Audio-visual security services see (68.2) Broader definition: Communications services as a whole
If necessary, subdivide eg:

(64.1) Visual, including audio-visual
1 Television
2 Film projection
3 Indicating eg: staff location
8 Other types of visual, audio-visual services

(64.2) Audio
1 Radio
2 Telephone and intercom including telephone booths
3 Relaying eg: public address
4 Recording eg: central dictation
5 Indicating eg: staff location
8 Other types of audio services

(64.3) Signals other than visual or audio
1 Telegraph
2 Teletypewriter, telex
3 Facsimile transmission
4 Data transmission
8 Other types of signals

(64.4) Synchronous clocks
(64.5) Other types of communications services eg: pneumatic message systems
(64.6) Parts, accessories etc special to communication services may be included here if described separately from specific types above eg: loudspeakers, exchanges, handsets, conduit for communications services in general

TRANSPORT

Transport, mechanical circulation services excluding installations described with other elements Broader definition: Transport, mechanical circulation services as a whole
Transport plant see (63)
If necessary, subdivide eg:

(66.1) Lifts eg: passenger, goods, service lifts; paternosters, telescopic shaft lifts; scissor lifts; hydraulic lifts
(66.2) Other types of internal lifts, hoists
Lift shafts if described separately see (24.8)
(66.3) Travelling cradles etc eg: for facade cleaning
(66.4) Escalators
(66.5) Conveyors eg: moving pavements; turntables; pneumatic, gravity conveyors
(66.6) Cranes
(66.7) Other types of transport services eg: mechanised transport/storage services eg: palletized systems
(66.8) Parts, accessories etc special to transport services may be included here if described separately from specific types above eg: buzzers, motors, pulleys for transport services in general

SECURITY, CONTROL, OTHER SERVICES

Security, protection, control services excluding installations described with other elements Broader definition: Protection, control services as a whole
Protection plant see (B1)
If necessary, subdivide eg:

(68.1) Security/fire protection services
(68.2) Security services eg: intruder, burglar detection, surveillance, alarm
(68.3) Fire protection services eg:
1 Fire detection, alarm
2 Fire fighting services
4 Automatic eg: water (sprinklers), foam, carbon dioxide, dry chemical, vapourising liquid
5 Manual eg: hose reels
6 Portable eg: fire extinguishers, blankets
8 Other types of fire protection services

(68.4) Other security, protection services eg: flood, lightning, bird nuisance
(68.5) Control services including process control, monitoring services eg: pneumatic, hydraulic control, electric, electronic, radio control; mechanical, clockwork control
(68.6) Other types of security, control services eg: sound control and attenuation
(68.7) Parts, accessories etc special to security, control services may be included here if described separately from specific types above eg: buzzers, bells, conduit for security, control services in general

PARTS, ACCESSORIES ETC SPECIAL TO ELECTRICAL SERVICES ELEMENTS
may be included here if described separately from specific types above eg: buzzers, conduit, outlets for electrical services in general
(7–) FITTINGS

Fittings excluding loose furniture and equipment and installations described with other elements eg: taps as part of water supply see (53.9)

Broad definition: Fittings as a whole, including built-in or otherwise fixed fittings and loose furniture, equipment

Loose furniture, equipment if described separately see (71.9)

If described in external works if described separately see (90.7)

(71) CIRCULATION FITTINGS

Built-in or otherwise fixed circulation fittings excluding installations described with other elements

These are fittings unconnected with any user activity at (72)/(77)

Broader definition: Circulation fittings and furniture as a whole, including built-in or otherwise fixed fittings, and loose furniture, equipment

Loose furniture, equipment if described separately see (81)

If necessary, subdivide eg:

(71.1) Signs, symbols eg: flagpoles, illuminated signs, emergency signs; lettering; notice boards

(71.2) Display fittings eg: plant display containers

(71.3) Access fittings eg: entrance mats; platforms, sets of steps

(71.8) Other types of circulation fittings

If necessary, subdivide eg: (71.9) Parts, accessories etc special to circulation fittings may be included here if described separately from specific types above

(72) REST, WORK FITTINGS

Built-in or otherwise fixed rest, work fittings, excluding installations described with other elements eg: Catering fittings see (73)

Broad definition: Rest, work, fittings and furniture as a whole, including built-in or otherwise fixed fittings, and loose furniture, equipment

Loose furniture, equipment if described separately see (82)

If necessary, subdivide eg:

(72.1) Rest fittings

Fittings for sleep eg: beds, bunks, cots, cradles

(72.2) Fittings for relaxation eg: easy chairs, armchairs, couches

(72.3) Work fittings eg: work stations, work benches, desks

(72.6) Benches, tables; seating, chairs

Dining tables, seating etc if described separately see (73.7), (83)

(72.8) Other types of rest, work fittings

(72.9) Parts, accessories etc special to rest, work fittings may be included here if described separately from specific types above

Upholstery see (78.3)

(73) CULINARY FITTINGS

Built-in or otherwise fixed culinary fittings including catering fittings, but excluding installations described with other elements

Broader definition: Culinary fittings as a whole, including built-in or otherwise fixed fittings and loose furniture, equipment

Culinary loose furniture, equipment if described separately see (83)

If necessary, subdivide eg:

(73.1) Culinary work fittings eg: work tops, suites

(73.2) Culinary sink units, draining boards, disposal units, washing-up machines

(73.4) Culinary processing, chocking fittings eg: potato peelers; cookers, hotplates, boiling pans, fryers, grills, ovens; hoods

(73.5) Culinary storage fittings eg: refrigerators, freezers; bains maries, hot cupboards, hot/cold storage/display fittings; larder fittings

(73.7) Bar counters, food counters, dining tables, seating etc

Loose fittings if described separately see (83)

(73.8) Other types of culinary, catering fittings eg: food, drink vending machines, drinking fountains, water coals

Table ware if described separately see (83)

(73.9) Parts, accessories etc special to culinary, catering fittings may be included here if described separately from specific types above

(74) Storage, screening fittings

Library files; assembly, component drawings; elemental specifications, bq sections

(75) Sanitary, hygiene fittings

Library files; assembly, component drawings; elemental specifications, bq sections

(76) Cleaning, maintenance fittings

Library files; assembly, component drawings; elemental specifications, bq sections

(77) Special activity fittings

Library files; assembly, component drawings; elemental specifications, bq sections

(78) Minor parts of fittings

Library files

(79) Summary of this group

Cost plans
(8-) Loose furniture, equipment

LOOSE FURNITURE, EQUIPMENT
Loose fittings, furniture, equipment

A library file may eventually be required for each of the headings below but the (8-) group of headings as a whole is unlikely to be used for project information unless for the positioning of 'client's fittings'.

(80) Vacant

(81) CIRCULATION LOOSE FURNITURE, EQUIPMENT
If described separately from class (71)

(82) REST, WORK LOOSE FURNITURE, EQUIPMENT
If described separately from class (72)

(83) CULINARY LOOSE FURNITURE, EQUIPMENT
If described separately from class (73)

(84) SANITARY, HYGIENE LOOSE FURNITURE, EQUIPMENT
If described separately from class (74)

(85) CLEANING, MAINTENANCE, LOOSE FURNITURE, EQUIPMENT
If described separately from class (75)

(86) STORAGE, SCREENING LOOSE FURNITURE, EQUIPMENT
If described separately from class (76)

(87) SPECIAL ACTIVITY LOOSE FURNITURE, EQUIPMENT
If described separately from class (77)

(88) OTHER LOOSE FURNITURE, EQUIPMENT
If described separately from class (78)

(89) PARTS, ACCESSORIES ETC SPECIAL TO LOOSE FURNITURE, EQUIPMENT
Cost summary

If the distinction between fixed and loose fittings, furniture and equipment is unimportant, class (8-) may be wholly or partially omitted
(74) SANITARY, HYGIENE FITTINGS

Built-in or otherwise fixed sanitary, hygiene fittings, excluding installations described with other elements

Broader definition:
Sanitary, hygiene fittings as a whole, built-in or otherwise fixed fittings and loose furniture, equipment
Sanitary, hygiene loose furniture, equipment if described separately see (84)
If necessary, subdivide eg:

(74.1) Sanitary suites
(74.2) Washing fittings eg:
  2 Baths
  3 Washbasins, troughs, fountains
  4 Bidets, footbaths
  6 Shower fittings
  7 Sauna fittings
  8 Other types of washing fittings
(74.3) Drying fittings eg:
  4 Closets, including WC's
  5 Urinals, including stall and bowl
  8 Other sanitary disposal fittings eg: macerating, packaging, incinerating, chemical disposal fittings
(74.4) Disposal fittings eg:
  4 Closets, including WC's
  5 Urinals, including stall and bowl
  8 Other sanitary disposal fittings eg: macerating, packaging, incinerating, chemical disposal fittings
(74.7) Supply fittings eg:
  soap dispensers, sanitary goods dispensers
(74.8) Other types of sanitary, hygiene fittings eg:
  sanitary fixtures, mirrors
(74.9) Parts, accessories etc special to sanitary, hygiene fittings may be included here if described separately from specific types above

(75) CLEANING, MAINTENANCE FITTINGS

Built-in or otherwise fixed cleaning, maintenance fittings excluding installations described with other elements eg:
Culinary sinks see (73.2)

Broader definition:
Cleaning, maintenance fittings as a whole including built-in or otherwise fixed fittings, and loose furniture, equipment
Cleaning, maintenance loose equipment if described separately see (85)
If necessary, subdivide eg:

(75.1) Washing fittings eg:
  washing machines, sinks
(75.3) Drying fittings eg:
  airing machines, drying machines
(75.4) Pressing fittings
(75.8) Other types of cleaning, maintenance fittings eg:
  dry cleaning fittings
  Vacuum cleaners, floor polishers if described separately see (85)
(75.9) Parts, accessories etc special to cleaning, maintenance fittings may be included here if described separately from specific types above

(76) STORAGE, SCREENING FITTINGS

Built-in or otherwise fixed storage, screening fittings, excluding installations described with other elements eg:
Culinary storage see (73.5)

Broader definition:
Storage, screening fittings as a whole, including built-in or otherwise fixed fittings and loose furniture, equipment
Storage loose furniture, equipment if described separately see (86)
If necessary, subdivide eg:

(76.1) Composite storage fittings, different configurations of cupboards, drawers, shelves eg:
  storage walls
(76.2) Cupboards fittings
  which may contain shelves, drawers, suspended storage
(76.3) Drawers fittings
  which may contain suspended storage
(76.4) Shelving, racking fittings
  which may contain cupboards, drawers, suspended storage
(76.5) Suspended storage fittings
(76.6) Storage fittings with additional facility eg:
  Secure storage fittings including safes, lockers, hot/cold storage
  Strong boxes, travel equipment if described separately (86)
Other types of storage fittings eg:
  storage by what stored, such as clothes storage
  Food storage see (73.5)

(76.7) Screening fittings eg:
  screens, blind boxes, blinds, shutters; curtain tracks, curtains, drapes
(76.8) Other types of storage, screening fittings
(76.9) Parts, accessories etc special to storage, screening fittings may be included here if described separately from specific types above

(77) SPECIAL ACTIVITY FITTINGS

Built-in or otherwise fixed special activity fittings excluding installations described with other elements

Broader definition:
Special activity fittings as a whole, including built-in or otherwise fixed fittings and loose furniture, equipment
This class can be used for Table 0 facilities when they occur in the form of fittings and have not been listed so far in this element division
They can be coded eg:
562(77) Trampoline, filed at class 562; or:
(77)562 Trampoline, filed at this position

(78) OTHER FITTINGS

Other built-in or otherwise fixed fittings excluding installations described with other elements

Broader definition:
Other fittings as a whole, including built-in or otherwise fixed fittings and loose furniture, equipment
If necessary, subdivide eg:

(78.3) Soft furnishings including upholstery
(78.5) Works of art

(79) PARTS, ACCESSORIES ETC SPECIAL TO FITTINGS ELEMENTS

may be included here if described separately from the specific types above eg:
  castors

Cost summary
(90) EXTERNAL WORKS
Work outside the external face of
the external wall where shown
separately from building works

(90.1) Ground preparation in
external works if not at (1-) eg:
ground clearing, shaping

(90.2) Minor structures in external
works if not at (1-)/(8-) eg:
ancillary shelters, sheds etc

(90.3) Enclosures in external works
if not at (1-)/(3-) eg:
site walls, fences, trellis, gates,
barriers, bollards

(90.4) Ground surface treatments in
external works if not at (1-)
1 Hard surfaces eg:
vehicular hardstandings, roads,
paths, steps:
edgings, trim eg:
tree grilles, cattle grids
2 Soft surfaces, planted surfaces
3 Water surfaces, pools
8 Other types of ground surface
treatments

(90.5) Piped services in external
works if not at (5-) 1
1 Drainage eg:
septic tanks
2 Other types of piped services eg:
heating mains, pumps, jets, soil
heating

(90.6) Electrical services in external
works if not at (6-) eg:
outdoor lighting

(90.7) Fittings in external works if
not at (7-) eg:
hoardings, outdoor benches,
outdoor plant containers etc,
outdoor play, sports equipment
(as parts of project)

(90.8) Special landscaping in
external works eg:
tennis courts, swimming pools
(as part of project) if not divided
between classes above

Two digits may be preferred
instead of the codes above eg:
(91) rather than (90.1)

(99) OTHER ELEMENTS
PARTS, ACCESSORIES ETC
COMMON TO TWO OR
MORE ELEMENT
DIVISIONS (1-)/(7-) may be
included here if described
separately from specific elements
above

Cost summary

At class (99), as throughout
Table 1, Appendix 1 provides a
subdivision if the amount of
material justifies this eg:
(99.53) Damp proof courses,
tanking, insulation;
(99.71) Frames in general;
(99.79) Reinforcement.

All the subjects in Appendix 1 can
be classified at appropriate levels
in Table 1 if placed at classes
ending in 9 as well as at the
specific Table 1 classes eg:
(31.49) Window frames
(31.59) Door frames
(31.9) Window and door frames

The SfB Agency UK will not use
Appendix 1 in classifying
literature for manufacturers.
Appendix F

CIB master list - part of the code list for the description data model
<table>
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<tr>
<th>Heading</th>
<th>Information given under heading</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 DOCUMENT</td>
<td>Title of document; originator; publication details</td>
</tr>
<tr>
<td>1 IDENTIFICATION BRIEF DESCRIPTION</td>
<td>Range of products or services covered; proprietary/trade name; manufacturer/supplier; identification information eg material, intended use, finish, method of manufacture</td>
</tr>
<tr>
<td>2 REQUIREMENTS</td>
<td>Requirements that the product or service will meet like technical specifications, regulations and standards</td>
</tr>
<tr>
<td>3 TECHNICAL DESCRIPTION</td>
<td>Intrinsic properties eg composition, size, mass, colour</td>
</tr>
<tr>
<td>4 PERFORMANCE</td>
<td>Behaviour of product or service in use: structural; fire; resistance to water, chemicals, mould etc; thermal, optical, acoustic, electrical; resistance to attack; service life, durability, reliability</td>
</tr>
<tr>
<td>5 DESIGN WORK</td>
<td>Technical and economic suitability; design methods and calculations; limitations and precautions; model specification clauses; examples of design details</td>
</tr>
<tr>
<td>6 SITE WORK</td>
<td>Handling, storage, installation, fixing, cleaning, protection and other information of direct interest to builders</td>
</tr>
<tr>
<td>7 OPERATION</td>
<td>Information for building users, including operation of components like blinds, windows and security devices; commissioning and operation of services and equipment</td>
</tr>
<tr>
<td>8 MAINTENANCE, REPAIR, REPLACEMENT, DISPOSAL</td>
<td>Information required, after installation or completion of work, on cleaning, maintenance, servicing, repair, replacement and disposal of used products</td>
</tr>
<tr>
<td>9 SUPPLY</td>
<td>Packaging, transport and delivery; prices, conditions of sale and other commercial and contractual information</td>
</tr>
<tr>
<td>10 MANUFACTURER/SUPPLIER</td>
<td>Information about manufacturer/supplier/importer's administrative and technical organisation</td>
</tr>
<tr>
<td>11 REFERENCES</td>
<td>Related publications eg test reports and installation instructions; reference to other publications with addresses of manufacturers/suppliers of associated products and services; locations where examples of installed work can be inspected</td>
</tr>
</tbody>
</table>
Table 2: CHECKLIST FOR HEADINGS
This is a comprehensive list of headings for construction information. Not every heading is suitable, or will be needed in every technical document. Authors should select headings from the list appropriate to a documents intended use.

<table>
<thead>
<tr>
<th>DOCUMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Title and format; originator; publication details</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>IDENTIFICATION, BRIEF DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.1 Manufacturer of product; supplier of service</td>
</tr>
<tr>
<td>Sufficient information to identify manufacturer and/or supplier; in non-commercial documents author/publisher (full information will be given under Heading 10)</td>
</tr>
<tr>
<td>1.2 Date of publication</td>
</tr>
<tr>
<td>Series/volume number may also be given.</td>
</tr>
<tr>
<td>1.3 Generic name</td>
</tr>
<tr>
<td>Name in common use identifying group or family to which product or service belong; may reflect material, method of manufacture, function and use, or a combination of these attributes.</td>
</tr>
<tr>
<td>1.4 Commercial name</td>
</tr>
<tr>
<td>Manufacturer's or supplier's brand or trade name; logotype.</td>
</tr>
<tr>
<td>1.5 Brief description</td>
</tr>
<tr>
<td>Summary of key information about product or service to which author may wish to draw special attention: composition, size, appearance, outstanding characteristics, intended uses, merits, limitations to use, precautions.</td>
</tr>
<tr>
<td>1.6 Authority for technical claims</td>
</tr>
<tr>
<td>Quality and safety marks: conformity to related standards - industrial, national, European, International, Agrément certificate; European technical approval; CE conformity mark/certificate: issuing authority; reference number; date, period of validity; reservations</td>
</tr>
</tbody>
</table>
2 REQUIREMENTS

A manufacturer or supplier may wish to refer to a regulation or other requirement, eg technical specification of a public authority or other major client, which the product or service is intended to satisfy relating to: structural strength and stability; serviceability; fire protection; fire safety; safety and security in use; habitability; indoor climate - thermal, acoustic; space provision; protection of the environment; facility in site work, operation, maintenance; economy in use; conservation of energy; water conservation; service life.

The six essential requirements listed in Annex 1 of the Construction Products Directive: 89/106/EEC, namely:

1. Mechanical resistance and stability
2. Safety in case of fire
3. Hygiene, health and the environment
4. Safety in use
5. Protection against noise
6. Energy economy and heat retention

and associated interpretative documents may serve as a reference source.

3 TECHNICAL DESCRIPTION

3.1 Composition

Materials used; method of manufacture; constituent parts.

3.2 Methods of assembly and connection

Provision for adjustment, movement.

3.3 Accessories

Where there is a range of accessories, reference to associated documents may be needed: safety and security devices; operating mechanisms; special aids for the handicapped.

3.4 Shape, size

In what form, and how much information on shape and size is given depends on nature of product or installation, and use of document; information may be in the form of tables, possibly giving a range of shapes, sizes, colours etc, supplemented by line drawings and/or photographs.

3.5 Weight, density

In what form, and how much information on weight (mass) is given will depend both on the needs of target readers and a product's use; information on weight as delivered may be required for site work; weight of an item intended to contain water or another liquid may usefully include information when container is full. A designer may need information on density, and moisture content at which density measured.

3.6 Surface and sensory characteristics

Characteristics may be described in terms of a physical measure, or some acknowledged scale; in qualitative terms, or illustrated by samples. To be considered: colour, pattern, texture, lustre, shine, opacity, smoothness, evenness, toughness, feel, smell.
4 PERFORMANCE

In selecting a product or service for an intended use, information about performance, or behaviour in use, is specially important. Headings group information on reaction to effects, for example, of loadings, high temperatures, chemical, biological attack, etc - singly or in combination.

Performance may be measured using tests which represent 'standard' conditions of use; may be assessed by calculation or observations of behaviour in use; or may be compared with one or more requirements listed under Heading 2; technical approval bodies may give independent assessments of performance under stated conditions.

Usually, authors will make a limited, appropriate selection from the list of performance attributes given here. Where performance is superior to that required in a regulation, harmonised European standard or similar document, an author may wish to refer to this feature, giving authority for the claim.

4.1 Active: capacity, output, consumption

Under this heading information will be given where a product or service has an output, does work, contains water or another liquid, or consumes a resource like energy; it will mostly be used for information needed for building and environmental services.

4.2 Structural, mechanical

Information under this heading is relevant to essential requirement 1: Mechanical resistance and stability. Attributes to be considered include: resistance to effects of external forces causing collapse, deformation, bursting, tearing, peeling, cracking, shattering, indentation, scratching, mechanical wear, fatigue, creep, soft or hard body impact; may be described in terms of compressive, shear, tensile strength, bending strength, long term deflection; modulus of elasticity - dynamic, static; stiffness; coefficient of friction, slipperiness, skid resistance; resistance to shock.

4.3 Fire

Information under this heading is relevant to essential requirement 2: Safety in case of fire; reference should be made to international and national fire standards. Attributes to be considered include: burning behaviour; reaction to fire; non-combustibility; ignitability, flammability; resistance to surface spread of flame; heat, smoke and gas release; penetration of flame, smoke, gas, heat; fire resistance of components and structural elements - stability, integrity, insulation (time, class); flashpoint of liquids; heat emission from building materials; contribution to fire load; resistance to exposure from heat radiation; smoke and flame stopping; containment of effects of explosions.

Mention may be made of active fire protection measures like facility for evacuation of occupants, assistance to rescue and firefighting personnel.
4.4 Gaseous, liquid, solid

Information under this heading may be relevant to essential requirements 3: Hygiene, health and the environment, and 4: Safety in use. There are a wide range of physical and chemical effects which - singly, or in combination - affect performance of products and services. Attributes and features to be considered include in general:
- Air tightness of joints; effectiveness of sealing air gaps; control of air leakage of ductwork, etc after installation; permeability to gases and water;
- Frost resistance; release of volatile organic compounds, odours, and other air pollutants; effectiveness of control by coatings, etc; effectiveness of removal of water vapour, combustion products, tobacco smoke and other harmful gases and airborne substances; supply of air of satisfactory quality;
- Liquid water absorption, imperviousness to water; resistance to penetration of driving rain and snow; resistance to rising damp; vapour permeability; control of interstitial and surface condensation; moisture absorption; hygroscopic humidity content; hygrometric expansion coefficient, effect of relative humidity change; precautions against hazard of Legionnaires' disease;
- For pipework, valves, taps, backflow devices, connections and other fittings, cisterns and tanks, sanitary appliances, drains and manholes: mechanical endurance, tightness, resistance to corrosion, resistance to abrasion, permeability to pollutants, effectiveness in disposal of liquid waste, non-release of foul air, ease of cleaning, effectiveness of self-cleaning.

4.5 Biological

A wide range of living organisms - singly, or in combination - affect performance of products and services, their actions being influenced by associated gaseous or liquid and/or temperature conditions. Information under this heading may be relevant to essential requirements 3: Hygiene, health and the environment, and 4: Safety in use. Attributes to be considered include, in general: susceptibility to harmful micro-organisms, growth of fungi, insect attack; effectiveness of fungicides for surface treatment, for pressure treatment, uptake of preservative; effectiveness of barriers against termites, flies, other insects, rodents and other vermin for solid waste storage and disposal equipment: size, shape to facilitate cleaning, tightness of container and cover, effectiveness of control over flies, other insects, rodents and other animals.

4.6 Thermal

Information under this heading is relevant to essential requirement 6: Energy economy and heat retention. Gaseous or liquid conditions, and ambient temperature may affect performance. Attributes to be considered include: for fabric materials: thermal conductivity, surface conductance for radiation, convection; thermal resistance, diffusivity; specific heat capacity; emissivity for long-wave radiation, thermal stability, thermal expansion coefficient, thermal distortion, brittleness, heat ageing, calorific value; melting, boiling point, spalling, effect of thermal shock; for elements of construction: thermal transmittance (U-value), thermal capacity, thermal inertia, heat loss characteristics; for solar protection: transmissivity and absorptivity of solar radiation, shading, effectiveness in reducing solar radiation; for heating appliances and systems: mode of heat transfer, full load efficiency, part load efficiency, rated output for specific operating conditions, power consumption, thermal storage capacity, temperature control, temperature of accessible surfaces.
4.7 Optical

Information under this heading may be relevant to essential requirements 4: Safety in use; for solar radiation, also 6: Energy economy and heat retention. Attributes to be considered include: daylight transmission, spectral transmission characteristics, retroreflection, transparency; for luminaires: efficacy (light output/power), brightness, illuminance - direct, indirect; for visual signs: legibility, optical clarity, visibility.

4.8 Acoustic

Information under this heading may be relevant to essential requirement 5: Protection against noise. Attributes to be considered include: protection against airborne noise from outside, from another internal space; protection against structure-borne and impact noise; direct and flanking airborne sound reduction; protection against equipment noise, against reverberant noise; absorption coefficient, damping, dynamic stiffness; noise frequency weighting, single number noise rating; sound power level, sound pressure level; sound radiation, sound scattering; speech intelligibility rating [objective]; vibration effects, intensity, frequency.

4.9 Electric, magnetic, electro-magnetic radiation

Information under this heading may be relevant to essential requirements 3: Hygiene, health and the environment, 4: Safety in use, and 6: Energy economy and heat retention. Attributes to be considered include: effects of energy in electrical and electromagnetic forms; electric field strength, potential, resistance, capacitance; reaction to radio-active emissions, radon; ionization; electro-magnetic disturbance, compatatability; static electricity; avoidance of shocks; lightning protection.

4.10 Resistance to attack

Information on resistance to arson, vandalism, forced entry; protection against threatening behaviour.

4.11 Service life, durability, reliability

Information may be given here under this heading, or, where appropriate, under another relevant heading; factors, which shorten or prolong service life, may be indicated. Attributes to be considered include: effects of biological, chemical and physical agents, of conditions of use; durability rating, vulnerability to decay; resistance to abrasion, corrosion, acid or sulphate attack; carbonation, alkali-silica reaction; ageing, loss of solvents and plasticisers; blistering; creep, loss of flexibility; chemical and mechanical effects of cleaning substances; light fastness; loss of serviceability, deterioration of fail-safe mechanism.
5 DESIGN WORK

Headings for information of direct use to designers and specifiers; references to design aids, codes of practice; and to regulations affecting design: guidance may be given in special documents.

5.1 Technical and economic implications

Factors which influence selection and use include: clarity and reliability of technical information; availability; reliability of product or service; cost-effectiveness in conservation of resources - manpower, energy, water, etc; initial, operating and maintenance costs; possible need for specialist workers, power, fuel, water, 'disposables', replacement parts; limitations or special conditions imposed by handling and storage on site, on installation, operation, disposal of waste; suitability for use by children, the elderly and/or handicapped.

5.2 Side effects, precautions in use

Reference to design precautions and/or need for care in use to ensure security and safety, and to minimise: health hazards, risks of injury to siteworkers, occupants and passers-by; risk of damage to nearby property; measures required to limit abnormal degradation through contact between incompatible materials.

5.3 Design aids

Technical publications may include, or be supplemented by design aids to show: uses of products; design details; layouts of services; calculation procedures; alignment charts, nomographs; references to computer programs; samples of workmanship specifications.

6 SITEWORK

Headings for information of direct use to builders and estimators; some information may have been given as part of information required in design work.

6.1 Planning sitework

Information required when considering economic and technical suitability of a product, or item of equipment for planning work and use on site, or estimating costs: arrangements for supervision, inspection and site testing; reception, handling and storage of delivered products and equipment; safety and welfare of workers and other site personnel, safety of occupants of nearby buildings and passers-by.

6.2 Resource requirements

Information on requirements for: labour, plant and material resources, including water, gas, electricity and compressed air; advanced provision for vehicle access, offloading, stacking and storage; special tools and equipment for installation and fixing.

6.3 Handling; storage

Some products and items of equipment require special precautions in: offloading, handling and storage on site, protection against damage by weather, precautions against theft and arson; special arrangements may be required for safe handling, security and storage of explosives, toxic and other hazardous products; prevention of blockage of drains and watercourses by waste materials, packaging etc.
6.4 Erection, installation and fixing
Guidance on: temporary works; lifting, temporary support, access for fixing of assemblies and structural frames

6.5 Supervision, quality control
Measures to maintain quality standards; arrangements for taking test samples, for non-destructive testing.

6.6 Commissioning
Measures to protect finished work; clean down work on completion and equipment after installation; cautions against use of unsuitable cleaning materials. Arrangements for commissioning mechanical, electrical and electronic equipment.

6.7 Security, safety, welfare on site
Security of specialist installers' equipment. Labour protection legislation, including: control of toxic and hazardous substances; fire precautions; site security; control of noise, dust, smoke and fumes; facilities on site for shelter, sanitation, mess rooms, first aid.

7 OPERATION AND USE
Building managers, householders or other users may need special operating instructions, the technical content and degree of detail depending on kind of user, and type of product or item of equipment.

7.1 Methods of operation
Instructions may include: significance and use of control devices; starting up procedures; operational range; overload and other safety devices; avoidance of conditions likely to cause overload, excessive wear etc; special instructions on replacement of 'disposables'; location of lubrication points etc.; use by elderly and/or handicapped of special equipment/fittings; advice on action when product fails, or equipment malfunctions; routine checking procedures.

7.2 Safety, security
Product or item of equipment may call for special fire precautions; special precautions may be needed during operation to protect children, the elderly and handicapped, domestic animals.

8 MAINTENANCE, REPAIR, REPLACEMENT, DISPOSAL
General information about maintenance needs may have been given as part of information required in design work; additional information may be required by maintenance personnel, possibly in a separate maintenance manual.

8.1 Cleaning, servicing
Information on recommended cleaning practices and materials; cleaning practices to be avoided; need to protect nearby work from damage, staining, wet etc during cleaning; service intervals; need and arrangements for specialist servicing; protective equipment during servicing; arrangements for preparation, storage etc at end of seasonal use. Equipment handling gases, dusts, liquids may require arrangements to clean or replace filters.
8.2 Resource requirements

Information on requirements for, and source of: cleaning and protective materials; lubricants for mechanical equipment; 'disposables' - filters, etc; materials for renewal of paint work and other surface coatings; special tools and equipment; instruments for monitoring performance, checking defects and malfunctioning; maintenance schedules, records. For mechanical and electrical equipment, there may be special requirements for energy in one or more forms. Treatment equipment, like water softeners, may require special chemicals.

8.3 Labour requirements

Information on maintenance labour requirements; need for specialist skills; availability of specialist maintenance services.

8.4 Access

Information on temporary/permanent provision for access by maintenance workers; need to allow space for installation of 'disposables' and replacement items; location of inspection and lubrication points, junctions and connections.

8.5 Repairs and replacement

Information on: replacement of parts; renewal of equipment; making good damage; expected life of 'disposables'; need to maintain stock of 'spares'; mistakes to avoid when making good damage.

8.6 Precautions during maintenance and repairs

Protective measures of equipment and nearby work from damage, staining, oil and mortar droppings, damp etc; need for sheets, covers and other protective equipment.

8.7 Safety, security

Where operations take place in occupied buildings, measures to protect occupants and passers-by, children.

8.8 Disposal

Certain 'disposables', waste, used and damaged parts, etc may be or contain toxic or radio-active substances, or otherwise be a hazard to persons, animals and/or the environment, and require special disposal arrangements.

9 SUPPLY

Commercial and contractual information relating to supply and purchase of product or service may be given in separate commercial documents, and only referred to, or summarised in technical documents.

9.1 Ordering

Information on availability and ordering procedures; order forms; arrangements for hire of special tools and equipment for installation; supply of 'disposables' like filters and special chemicals; supply of spares and replacement parts.
9.2 Conditions of sale

Information on prices including discounts; method of payment, including credit terms; handling and delivery charges; prices of spares and 'disposables'; taxes and customs dues; responsibilities for insurance, fees and charges; references required; terms of warranties and guarantees.

9.3 Delivery, special services

Information on packaging, labelling; use of pallets and containers, arrangements for return; possibilities for bulk delivery to site; requirements for access, handling, lifting and stacking on site.

10 MANUFACTURER, SUPPLIER

Information about the firm making and/or supplying the product or providing the service; and/or originator of document

10.1 Commercial and administrative

Information on head office; home and export sales offices; overseas, regional and branch offices; agents and administrative representatives: postal codes, telephone, fax, telex; parent organisation; membership of trade association.

10.2 Technical and advisory organisation

Information on technical and advisory services; facilities for training; for testing, research and development; membership of professional, technical and/or research organisations.

10.3 Manufacturing and warehouse organisation

Information on location of factories; manufacturing capacity; arrangements for stockholding, holding of 'disposables', spares; stockists.

10.4 Quality assurance arrangements

Information on scope: management, factory production, stockholding, personnel; certification body, reference code.

11 REFERENCES

Information on firm activities; examples of work; buildings where product has been used, or services installed; location of showrooms, displays at building centres and trade fairs. References to firm's other publications, test reports etc; trade and technical journals; publications of supplier's of associated products, tools, 'disposables' etc; suppliers of specialist services, with addresses.
Explanatory notes on application and uses of Master Headings

0 DESCRIPTION of document

1 IDENTIFICATION, BRIEF DESCRIPTION of product or service
In applying the Master List headings, it is important to distinguish between 0 Description of document and 1 Identification and description of the product or service which is the subject of the technical document. Together, the information given under these headings helps readers decide if the document, and its contents, are relevant to their needs. The document should give the name of the originator and be dated to show its status and currency. Headings serve to draw attention to the document as a whole.

Style and layout are matters for the originator who may find guidance, where applicable, in BS4940:1993 Technical information on construction products and services; CIB Report No. 35: Recommendations for trade literature; and in any relevant national or 'house' standard.

Readers may want to know that a product or service conforms to the requirements of an international, European or national standard or standards; whether the supplier's claim is supported by third-party assessment, testing and/or quality assurance, or by the supplier’s guarantee, with appropriate information on issuing authority, period of validity, and any reservations on use. Documents may carry the appropriate conformity or quality mark. Detailed information on available test and similar technical reports is best given under 11 References.

2 REQUIREMENTS
Products and services have to meet requirements of authorities, owners and users. These may be in the form of technical specifications in regulations, standards etc; or specific to a customer, stated use, or works. CIB Master List 1983 included, as an appendix, Table 2: Requirements, drawn from ISO/DP 6241:1982. More recently, 89/106/EEC, the Construction Products Directive, has listed six essential requirements relating to safety, health, durability, energy economy, and protection of the environment in buildings and civil engineering works. Guidance on how these requirements are given concrete form is being given in a series of interpretative documents. Authors of technical descriptions may wish to refer here to any requirements a product or service are intended, or required to satisfy, giving further information under 4 Performance.

3 TECHNICAL DESCRIPTION
This section is used for information about features (attributes) intrinsic to a product or service, and normally not affected by use. Where descriptive information is extensive or complex, it may, with advantage be presented by means of tables, diagrams, drawings and other kinds of illustration. There may be separate documents devoted to descriptions of accessories. Where there are examples to be inspected, information may be given under 11 References.

4 PERFORMANCE
Information under this heading, named in the 1983 edition 'Properties', relates to behaviour in use - ie reaction of a product or service to effects of agents - single or in combination. Performance may be measured using test procedures which aim to represent 'standard' conditions of use, and which may be set out in technical specifications like international, European or national standards; may be assessed by calculation, which again may be set out in technical specifications, or by technical judgement based on observation of performance in use. It may be assessed by a combination of procedures like that set out in a UEAtc Method of Assessment and Test.
Technical specifications may use the concept of classes as a way of expressing a range within the upper and lower levels of which the behaviour of a product or service falls. Where they do, a class is usually designated in one of several ways, e.g., a letter (e.g., classes A, B, etc.), a number (e.g., classes I, II, etc.), or a symbol (e.g., *, **, etc.); or by a combination, e.g., A1, B2, etc. For convenience of users of technical documents, where conventions are given in technical specifications, these should be followed. Where, in their absence, an author adopts an 'in house' convention, he should explain its basis.

Information given under this heading will be of importance in enabling users to compare the performance of a product or service with their requirements, or the requirements of an authority. Not all the headings will necessarily be required for every document and authors must take into account both the user of a document and the matter being described in deciding what headings are needed, and on what attributes in the checklists are relevant. In all documents, however, the order in which information is arranged should be followed.

The manner in which this and the following sections are presented differs somewhat from that of the 1983 CIB Master List in that extensive checklists, drawn in part from standards and interpretative documents, are included for the convenience of authors and users.

A new heading: 4.10 Resistance to attack, is introduced covering matters like resistance to arson attack, vandalism, forced entry, and protection of occupiers against violence and threats of violent behaviour. Whether this kind of information is given here or given special notice under a heading like 4.2 Structural; mechanical, or 4.3 Fire, is likely to depend on the product or service being described, and its intended use.

The attributes listed under the heading 4.11 Service life, has been extended to take into account both the concern of users with performance over a period of time and greater understanding of the factors which may shorten or prolong service life.

5 DESIGN WORK and

6 SITEWORK

Information under the headings 5 Design work, and 6 Site work, will be directed, respectively, at designers and specifiers, and those responsible for carrying out work on construction sites. Depending on the purpose of a technical document, the information may be part of a main document or given in separate documents containing for example, design aids, lists of tools required or sitework instructions. Special attention may be drawn to side effects, health and other hazards, and to precautions to be taken to ensure safety. Headings have been introduced for information on supervision and quality control, and on commissioning.

7 OPERATION AND USE

Products and equipment may be operated by skilled personnel, or by lay users, and depending on the item, and its intended use, information under 7: Operation and use, may be tailored to particular groups of users. Reference may be made to special precautions needed where an item may be used by children, the elderly, etc. It may also be made available in separate, possibly less technical documents for lay users.

8 MAINTENANCE, REPAIR, REPLACEMENT, DISPOSAL

Compared with the 1983 Master List, this section is more detailed, reflecting the importance of these matters both for building owners and maintenance personnel. Authors of technical documents may wish to draw attention to safety measures needed where maintenance and repair operations take place in occupied buildings or passers-by are at risk. Guidance on disposal of waste, used and damaged parts may be needed where these present special hazards.

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9 SUPPLY and
10 MANUFACTURER, SUPPLIER
Information under these two headings may only be summarised in a general technical document; and be dealt with more comprehensively in separate documents designed to meet commercial and trade practices.

11 REFERENCES
This heading may be used for information about a supplier's activities, and/or for references to any further sources of information to which an author wishes to direct attention.
Appendix G

The code of procedure for the exchange of CONITT and CONTEN messages
CODE OF PROCEDURE
for use with the
CONITT AND CONTENT
EDI Messages

This Code provides guidance for the procedures to follow in connection with the use of the CONITT AND CONTENT EDI messages.

Details of the appropriate procedure may vary depending upon the form of communication adopted to carry the message (e.g. VAN, diskette...)

A. Transfer of Tender Documentation to Tenderer

- Preliminary enquiries for invitation to tender should advise that tender documents will be available to EDI registered organisations in the EDI format.
- A written copy of the letter of invitation to tender itemising the tender documentation cross references information provided by EDI should be sent to each tenderer.
- Receipt and verification of documentation will be deemed to have been carried out by the EDI software employed.
- The tenderer shall confirm receipt and verification of documentation immediately upon receipt via VAN / facsimile / post.
- Details of supplementary documents (Drawings, Specifications, etc.) to be issued manually should be included in the EDI message.
- Supplementary documents should be issued at the same time as the EDI message.
- The sender will be responsible for the accuracy of the contents of the CONITT message as required by the method of measurement and/or proposed form of contract provided always that the receiver does not alter the contents in any manner whatsoever unless authorised amendments are subsequently received.
- It is entirely at the tenderers discretion to use additional information to the above (e.g dimensions, annotations, locational information) for any reasonable purpose in connection with the tender. This information will not form part of any future contract documentation.
B. Transfer of Tender Amendments to Tenderer

- Any amended items / pages will be issued to the tenderer on an 'add and omit' basis.
- Any changes in the number of pages of original documentation will be confirmed by the sender.
- The contractor shall confirm receipt and verification of amendments immediately upon receipt via VAN / facsimile / post.
- A consolidated version of the bills of quantities incorporating all amendments should be sent to tenderers utilising the EDI format.

C. Transfer of Tender to Employer / Architect / QS

- All tenderers are to provide the Form of Tender on hard copy.

D. Receipt of Priced Bills of Quantities in Support of Tender

- When submitting a set of priced bills of quantities in support of his tender, the tenderer shall undertake not to have altered or qualified any of the information received, original or amended as in sections A and B, whether in the form of descriptions, quantities or any other form. Any such alterations or qualifications shall be withdrawn upon notification thereof.
- The recipient should check and verify that the original information has not been amended.
- The tenderer may incorporate additional information to his item rates, extensions and totals if requested.
- In the event of amendments to the priced bills of quantities arising from the technical check by the QS, and if the tenderer chooses to amend his tender accordingly, then an amended set of priced bills of quantities shall be sent to the tenderer who shall confirm its receipt and verify its accuracy.

or

In the event of amendments to the priced bills of quantities arising from the technical check by the QS, and if the tenderer chooses to amend his tender accordingly, then a copy of all amended pages of the priced of bills of quantities shall be sent to the tenderer who shall confirm their receipt and verify their accuracy.
Appendix H

Source code for “Cato”, “Rates” and “Cinter” programs
Appendix H.1 - “Cato” program source code

CAT2.C
#include <stdio.h>
#include <string.h>
#include <io.h>
#include <conio.h>
#include <stdlib.h>
#include <ctype.h>
#include "cato.h"

int n,page=1,bii_flag=1,item_level=1;
long unsigned int control_total=0;
char bill_nr[3],sect_code[3],subsect_code[5],item_letter[3];
char q_source[3],q_status[3],action_req[3],message_ref_no[15];
FILE *fp2,*fp3;
maint()
{
char aline[MAXLINE];
_setcursortype(_NORMALCURSOR);
textcolor(15);textbackground(4);
csr();
gotoxy(1,1);
puts("CATO -> EDIFACT CONVERSION");
window(2,3,79,24);
textcolor(15);textbackground(0);
csr();
lofle()
if (convert()==1)
{
    /* close item output file */
    fclose(fp3);
    /* merge files index and items */
    /* open item file to read in */
    fp3=fopen("EDIFACT.ITM","r");
    while (getline(fp3,aline,MAXLINE)!=0)
    {
        fputs(aline,fp2);
    }
    /* close files */
    fclose(fp2);
    fclose(fp3);
    /* add message trailer onto end of item file */
    if (message_trailer()==0)
    {
        clrscr();
        puts("Conversion failed");
        leave();
    }
    else
    {
        /* add message trailer section to message */
        /* open main and trailer files */
        fp2=fopen("EDIFACT.IDX","a");
        fp3=fopen("EDIFACT.END","r");
        while (getline(fp3,aline,MAXLINE)!=0)

H-2
```c
else
{
    /* close files */
    fclose(fp2);
    fclose(fp3);
}

close files
fclose(fp2);
fclose(fp3);
clrscr();
puts("Conversion failed");
leave();

close files
fclose(fp2);
close files
fclose(fp3);
clrscr();
puts("Successful conversion");
leave();
return 1;
}

leave()
{
    /* Ensure files are closed */
    n=getch();
    _setcursortype(_NORMALCURSOR);
    exit(0);
    return 1;
}

loadfile()
{
    int a,b,ca,fla;
    char line[MAXLINE],sline[6][MAXLINE],resp[30],fname[12];
    FILE *fin,*fout;
    strcpy(fname,"boq.txt");
    puts("Enter file name");
    gotoxy(1,4);gets(resp);
    if(strlen(resp)>0) strcpy(fname,resp);
    if((fin=fopen(fname,"r"))==NULL) gotoxy(1,6);
    puts("file does not exist");
    if((fin=fopen(fname,"r"))===NULL)
    {
        gotoxy(1,6);
        puts("file does not exist");
    }else
    {
        fout=fopen("boq.con","w");
        for (ca=1;ca<=6;ca++) strcpy(sline[ca],"0");
        strcpy(resp,"0");
        while(!feof(fin) &
```
if (a==12)
{
    for (b=1;b<=10;b++)
    {
        if (!feof(fin))
        {
            getline(fin, line, MAXLINE);
            for (ca=1;ca<=5;ca++) strcpy(sline[ca], sline[ca+1]);
            strcpy(sline[6], line);
        }
        /*put page break into converted file*/
        fprintf(fout, "%s
", "pagebreak");
    }
    sscanf(sline[6], "%s", &resp);
    if (strlen(sline[1])>1) fprintf(fout, "%s", sline[1]);
}
fclose(fin);
fclose(fout);
return 0;
}

convert()
{
    char line[MAXLINE], format[71], authname[36], authpass[36], date[7], refnum[36];
    char cont_type[71], resp[71], bill_line[11][MAXLINE], proj_ref_num[36];
    int count, pos, a;
    FILE *fpp, *fpl;
    clrscr();
    do
    {
        gotoxy(1,1);
        puts("Enter project reference number");
        gotoxy(1,2);
        puts("(35 characters max.)");
        gotoxy(1,4); gets(resp);
    } while (strlen(resp)>35 || strlen(resp)==0);
    strcpy(proj_ref_num, resp);
    clrscr();
    do
    {
        gotoxy(1,1);
        puts("Enter date (format : YYMMDD)" );
        gotoxy(1,4); gets(resp);
    } while (strlen(resp)!=6);
    strcpy(date, resp );
    clrscr();
    do
    {
        gotoxy(1,1);
        puts("Enter message reference number");
        gotoxy(1,4); gets(resp);
    } while (strlen(resp)<=0 || strlen(resp)>14);
    strcpy(message_ref_no, resp);
}
clrscr();
do{
    gotoxy(1,1);
    puts("Enter document reference number");
    gotoxy(1,4);gets(resp);
}
while (strlen(resp)<=0 || strlen(resp)>35);
strcpy(refnum,resp);
clrscr();
do{
    gotoxy(1,1);
    puts("Enter senders authorised name");
    gotoxy(1,4);gets(resp);
}
while(strlen(resp)<=0 || strlen(resp)>35);
strcpy(authname,resp);
clrscr();
do{
    gotoxy(1,1);
    puts("Enter senders password");
    gotoxy(1,4);gets(resp);
}
while(strlen(resp)<=0 || strlen(resp)>35);
strcpy(authpass,resp);
clrscr();
do{
    gotoxy(1,1);
    puts("Enter form of tender");
    gotoxy(1,4);gets(resp);
}
while (strlen(resp)<=0 || strlen(resp)>70);
strcpy(formot,resp);
clrscr();  //enter global variable requirements*/
_setcursortype(_NOCURSOR);
clrscr();
do{
    gotoxy(1,1);puts("1/ Contractors items");
    gotoxy(1,2);puts("2/ New items");
    gotoxy(1,3);puts("3/ Take off");
    gotoxy(1,4);puts("4/ BoQ");
    gotoxy(1,6);puts("Press source of quantities");
    n=getch();
}
while (n<49 || n>52);
sprintf(resp, "%d", n-48);
strcpy(q_source, resp);
clrscr();
do {
    gotoxy(1,1);puts("1/ tAgreed");
    gotoxy(1,2);puts("2/ tProvisional");
    gotoxy(1,3);puts("3/ tDisputed");
    gotoxy(1,6);puts("Press quantity status");
    n=getch();
}
while (n<49 || n>51);
sprintf(resp, "%d", n-48);
strcpy(q_status, resp);
clrscr();
do {
    gotoxy(1,1);puts("1/ tAdd");
    gotoxy(1,2);puts("2/ tDelete");
    gotoxy(1,3);puts("3/ tChange");
    gotoxy(1,4);puts("4/ tNo action");
    gotoxy(1,6);puts("Press action to be taken with items");
    n=getch();
}
while (n<49 || n>52);
sprintf(resp, "%d", n-48);
strcpy(action_req, resp);
_setcursortype(NORMALCURSOR);
/*open two edifact destination files (item and index files)*/
if ((fp2=fopen("EDIFACT.IDX","w"))!=NULL && (fp3=fopen("EDIFACT.ITM","w"))!=NULL)
{
    puts("Read/write error");
    n=getch();
    return 0;
}
/*open project header data file*/
if ((fpp=fopen("phf.dat","r"))!=NULL)
{
    puts("Project header file not available");
}
else
{
    for(count=1;count<=8;count++)
    {
        if (getline(fpp,line,MAXLINE)!=0)
        {
            switch(count)
            {
                case 1:
                    place(line, message_ref_no);
                    break;
                case 2:
                    place(line, refnum);
                    break;
                case 3:
                    place(line, proj_ref_num);
                    break;
                case 4:
                    place(line, date);
            }
        }
    }
case 5:
    place(line,authpass);
    break;

case 6:
    place(line,authname);
    break;

case 7:
    place(line,formot);
    break;

case 8:
    place(line,cont_type);
    break;

    fputs(line,fp2);
}
}
fclose(fpp);

/* Add index definition to index output file */
if ((fpp=fopen("index2.dat", "r")==NULL)
{
    puts("Cannot open index definition file");
    n=getch();
    return 0;
}
else
{
    while (getline(fpp,line,MAXLINE)!=0)
    {
        fputs(line,fp2);
    }
    fputs("\n",fp2);
    fclose(fpp);
}

/* Index and Item section conversion */
if ((fp1=fopen("boq.con", "r")==NULL)
{
    puts("cannot open bill conversion file");
    n=getch();
    return 0;
}
else
{
    /*set up 10 bill buffer lines to work through bill.con file*/
    for(a=1;a<=10;a++)
    {
        getline(fp1,bill_line[a],MAXLINE);
    }
    /* scroll through bill, identify data and initiate EDIFACT conversion routines*/
    do
    {
        pos=text_start(bill_line[1],0);
        switch(pos)
        {
        case 0:
            page++;
            break;
case 6:
    if (item_conv(fp,t,bill_line)==0) return 0;
    break;

case 19:
    if (bill_line[2][19]=='_')
    { /*if index conversion fails drop out of conversion */
        if ((index_conv(fp1,bill_line,pos))==0) {fclose(fp1);return 0;}
    } else
    { item_level=5;
        if (item_head(fp1,bill_line,pos)==0) return 0;
    }
    break;

case 23:
    item_level=6;
    if (item_head(fp1,bill_line,pos)==0) return 0;
    break;

case 66:
    if ((bill_head(fp1,bill_line,pos))==0) {fclose(fp1);return 0;}
    break;
}
scroll_bill_line(fp1,bill_line);
while(strlen(bill_line)>0);
/* add project information onto end of index file */
if (project_group()==0) return 0;
fclose(fp1);
return 1;
}

CONVER.C
#include <stdio.h>
#include <string.h>
#include <io.h>
#include <conio.h>
#include <stdlib.h>
#include <ctype.h>
#include <math.h>
#include "cato.h"
extern int page,bii_flag,item_level,n;
extern long unsigned int control_total;
extern char bill_nr[],sect_code[],subsect_code[],item_letter[];
extern char q_source[],q_status[],action_req[],message_ref_no[15];
extern FILE *fp2,*fp3;

message_trailer()
{
    char line[256],line2[256];
    char resp[36];
    FILE *fpp;
    int count;
    unsigned long int a;
    /* count number of segments in message */
    /* open project information data file (message1.dat)*/

    H-8
if ((fpp=fopen("message 1.dat", "r")) == NULL || (fp2=fopen("edifact.idx","r"))==NULL || (fp3=fopen("edifact.end","w"))==NULL)
{
    puts("Message 1.dat or edifact.idx file not available");
    return 0;
}
else
{
    for(count=1;count<=2;count++)
    {
        if (getline(fpp,line,256)!=0)
        {
            switch(count)
            {
            case 1:
                sprintf(resp,"%lu",control_total);
                place(line,resp);
                fputs(line,fp3);
                break;
            case 2:
                /* count number of segments */
                a=0;
                while(getline(fp2,line2,256)>0) a++;
                a+=3; /* add number of segments in message trailer */
                sprintf(resp,"%lu",a);
                place(line,resp);
                place(line,message_ref_no);
                fputs(line,fp3);
                break;
            }
        }
        fputs("\n",fp3);
        /* close files */
        fclose(fpp);
        fclose(fp2);
        fclose(fp3);
    }
    return 1;
}

project_group()
{
    char line[256],line_copy[256],nad[6][36],contact[4][4]={"CLI","ARC","PQS","ENG"};
    char resp[36],prf_name[20];
    FILE *fpp,*prf;
    int a,count;
    /* open project file reference */
do
    {
        clrscr();
        gotoxy(1,1);
        puts("Enter project file reference");
        gotoxy(1,3);
        gets(prf_name);
        while(prf_name[0]== ' ' || strlen(prf_name)<=0 || strchr(prf_name, '.')!=0);
        strcat(prf_name,".prf");
    }
}
if ((prf=fopen(prf_name,"r"))==NULL)  
{
    if ((prf=fopen(prf_name,"w"))==NULL) return 0;
    clrscr();
    gotoxy(1,1);puts("PROJECT INFORMATION");
    fputs("EL\n",prf);
    name_address(nad);
    for (a=1;a<=5;a++)
    {
        fputs(nad[a],prf);
        fputs("\n",prf);
    }
    clrscr();
    do
    {
        gotoxy(1,1);
        puts("Enter a shorthand project name");
        gotoxy(1,2);puts("(35 characters)" );
        gotoxy(1,4);gets(resp);
    }
    while(strlen(resp)<=0 || strlen(resp)>35);
    fputs(resp,prf);fputs("\n",prf);
    clrscr();
    do
    {
        gotoxy(1,1);
        puts("Enter a shorthand project address");
        gotoxy(1,2);puts("(35 characters)" );
        gotoxy(1,4);gets(resp);
    }
    while(strlen(resp)<=0 || strlen(resp)>35);
    fputs(resp,prf);fputs("\n",prf);
    clrscr();
    /*enter tender submission date only, when new codes available add other dates */
    place(line,"286");
    do
    {
        gotoxy(1,1);
        puts("Enter tender submission date");
        gotoxy(1,2);puts("(YYMMDD)" );
        gotoxy(1,4);gets(resp);
    }
    while(strlen(resp)!=6);
    fputs(resp,prf);fputs("\n",prf);
    clrscr();
    do
    {
        gotoxy(1,1);
        puts("Enter name of BoQ author");
        gotoxy(1,4);gets(resp);
    }
    while(strlen(resp)<=0 || strlen(resp)>35);
    fputs(resp,prf);fputs("\n",prf);
    do
    {
        _setcursortype(_NOCURSOR);
        clrscr();
        gotoxy(1,1);puts("CONTACT NAME AND ADDRESS DATA ENTRY");
        gotoxy(1,3);puts("@1@AtClient");
    }
gotoxy(1,4);puts("1/2/Architect");
gotoxy(1,5);puts("3/1/Quantity surveyor");
gotoxy(1,6);puts("4/1/Engineer");
gotoxy(1,7);puts("5/1/Continue");
do
{
    gotoxy(1,9);
    puts("press selection");
    n=getch();
}
while (n<48 || n>52);
_setcursortype(_NORMALCURSOR);
if (n!=48)
{
    clrscr();
gotoxy(1,1);printf("PARTY IDENTIFIER : %s",contact[n-49]);
fputs(contact[n-49],prf);fputs("\n",prf);
name_address(nad);
for (a=1;a<=5;a++)
{
    fputs(nad[a],prf);
    fputs("\n",prf);
}
}
while(n!=48);
/* close project ref. file for writing */
fclose(prf);
/* open project ref. file for reading */
if ((prf=fopen(prf_name,"r"))==NULL) return 0;
/* open project information data file (project1.dat) */
if ((fpp=fopen("project1.dat","r"))==NULL)
{
    puts("Project1 data file not available");
    return 0;
}
else
{
    for(count=1;count<=14;count++)
    {
        if (getline(fpp,line,256))!=0)
        {
            switch(count)
            {
            case 1:
                fputs(line,fp2);
                break;
            case 2:
                fputs(line,fp2);
                break;
            case 3:
                fputs(line,fp2);
                break;
            case 4:
                /* project name and address info. */
                for (a=1;a<=6;a++)
                {
                    fgets(resp,MAXLINE,prf);
                }
            }
        }
        else
        {
            puts("Project1 data file not available");
            return 0;
        }
    }
}
/* close project ref. file for writing */
fclose(prf);
/* open project ref. file for reading */
if ((prf=fopen(prf_name,"r"))==NULL) return 0;
/* open project information data file (project1.dat) */
if ((fpp=fopen("project1.dat","r"))==NULL)
{
    puts("Project1 data file not available");
    return 0;
}
else
{
    for(count=1;count<=14;count++)
    {
        if (getline(fpp,line,256))!=0)
        {
            switch(count)
            {
            case 1:
                fputs(line,fp2);
                break;
            case 2:
                fputs(line,fp2);
                break;
            case 3:
                fputs(line,fp2);
                break;
            case 4:
                /* project name and address info. */
                for (a=1;a<=6;a++)
                {
                    fgets(resp,MAXLINE,prf);
                }
            }
        }
        else
        {
            puts("Project1 data file not available");
            return 0;
        }
    }
}
case 5:
    /* shorthand project name and address information */
    fgets(resp[MAXLINE],prf);
    resp[strlen(resp)-1]=\'0\';
    place(line,resp);
    fputs(line,fp2);
    break;

case 6:
    /* tender submission date */
    place(line,\"286\")
    fgets(resp[MAXLINE],prf);
    resp[strlen(resp)-1]=\'0\';
    place(line,resp);
    fputs(line,fp2);
    break;

case 7:
    fputs(line,fp2);
    break;

case 8:
    /* BQ author */
    fgets(resp[MAXLINE],prf);
    resp[strlen(resp)-1]=\'0\';
    place(line,resp);
    fputs(line,fp2);
    break;

case 9:
    fputs(line,fp2);
    break;

case 10:
    fputs(line,fp2);
    break;

case 11:
    fputs(line,fp2);
    break;

case 12:
    fputs(line,fp2);
    break;

case 13:
    while(fgets(resp[MAXLINE],prf)!=NULL)
    {
        strcpy(line_copy,line);
        resp[strlen(resp)-1]=\'0\';
        place(line_copy,resp);
        for (a=1;a<=5;a++)
        {
            fgets(resp[MAXLINE],prf);
            resp[strlen(resp)-1]=\'0\';
            place(line_copy,resp);
        }
        fputs(line_copy,fp2);
    }
break;
case 14:
    fputs(line,fp2);
    break;
}
}
fputs("\n",fp2);
fclose(fpp);
return 1;

item_head(fp1,bill_line,pos)
char bill_line[11][MAXLINE];
int pos;
FILE *fp1;
{
    int a,nodl;
    char desc[350];
    if ((nodl=desc_creat(desc,bill_line,pos,NO,MAXLINE,NO))==0) return 0;
    /* if necessary update bii item header */
    if (bii_flag) update_bii(bill_line);
    /* update item heading */
    item_update(desc,"HEA");
    /*scroll through description lines used*/
    if (nodl>1) for(a=1;a<=nodl-1;a++) scroll_bill_line(fp1,bill_line);
    return 1;
}

index_conv(fp1,bill_line,pos)
char bill_line[11][MAXLINE];
int pos;
FILE *fp1;
{
    char tempc[36],code[5],desc[350];
    int length,a,nodl;
    length=text_copy(tempc,bill_line[0],pos);
    /*check if level 2 index*/
    if ((length==1) && isupper(tempc[0]) && isupper(bill_line[0][pos+2]))
    {
        strcpy(sect_code,tempc);
        strcpy(subsect_code," ");
        item_level=2;
        portion_copy(desc,bill_line[0],pos+2,strlen(bill_line[0])-2);
        /*update index section*/
        if ((index_update("CON" ,"2",desc))==0) return 0;
    }
    else
    {
        /*check if level 3 index*/
        if ((length==3) && isupper(tempc[0]) && atoi(code)>0)
        {
            strcpy(subsect_code,tempc);
            item_level=3;
            portion_copy(desc,bill_line[0],pos+4,strlen(bill_line[0])-2);
        }
/*update index section*/
if ((index_update("CON","3",desc))=0) return 0;
else
{
    if (length!=1 && isupper(tempc[1]))
    {
        /* bill heading */
    }
    else
    {
        /* level 4 index */
        item_level=4;
        /* put bii section into EDIFACT if necessary */
        if (bii_flag)
        {
            if ((update_bii(bill_line))==0) return 0;
        }
        if ((nodl=desc_creat(desc,bill_line,pos,YES,71,N0))==0) return 0;
        /* put item 2 section into EDIFACT */
        item_update(desc,"HEA");
        /*scroll through description lines used. Use nodl-2 as two scroll_lines follow
in standard code*/
        if (nodl>2) for(a=1;a<nodl-1;a++) scroll_bill_line(fp1,bill_line);
    }
}
/*scroll through bill file by one line to avoid underlining*/
scroll_bill_line(fp1,bill_line);
return 1;

item_conv(fp1,bill_line)
char bill_line[11][MAXLINE];
FILE *fp1;
{
    char desc[350],unit[5],quant[20],aline[MAXLINE],alt_item_ref[10];
    char unit_conv1[10][5]={"m","m2","m3","t","hr","nr","n"};
    char unit_conv2[10][5]={"MTR","MTK","MTQ","TNE","HUR","NMB","NMB"];
    int dpos,nodl,a,count;
    unsigned long int l_quant;
    long double f_quant;
    FILE *fpi;
    /* put bii section into EDIFACT if necessary */
    if (bii_flag)
    {
        if ((update_bii(bill_line))==0) return 0;
    }
    /* check item letter matches that in last bii header */
    if ((bill_line[1][14]=item_letter[0]) return 0;
    /* read in alternative item reference number (CATO item code) */
    text_copy(alt_item_ref,bill_line[1],6);
    /* find start of description */
    dpos=text_start(bill_line[1],15);
    /* ascertain and check item_level */
    switch(dpos)
    {
        case 19:
item_level=5;
break;

case 23:
item_level=6;
break;

case 27:
item_level=7;
break;

} /* create a description string */
if (((nodel=desc_create(desc,bill_line,dpos,NO,64,70))==0) return 0;
/* read in quantity and units if no unit or no quant put a space in relevant string to erase */
if (text_copy_backwards(quant,bill_line[nodl],71)==0) strcpy(quant," ");
if (text_copy(unit,bill_line[nodl],74)==0) strcpy(unit,quant);
/* convert units */
for (a=0; a<6; a++)
{ if (strcmp(unit,unit_conv1[a])==0)
  {
    strcpy(unit,unit_conv2[a]);
    break;
  }
}

/* check if item and assign a value of 1 */
if (strcmp(quant,"ITEM")==0)
{
  strcpy(quant,"I");
  strcpy(unit,"IT");
}
/* convert quant values into values with 3 implied decimal places */
_f_quant=_atold(quant);
_l_quant=_f_quant*1000;
/* add to control total */
control_total+=_l_quant;
/* put item 2 section into EDIFACT */
item_update(desc,"DES");
/* write quantities and units to EDIFACT file (item3.dat) */
if (((fpi=fopen("item3.dat", "r") )==NULL)
{
  puts("Item3 data file not available");
  return 0;
}
else
{
  for(count=1; count<=5; count++)
  {
    if (getline(fpi, aline, MAXLIME)!=0)
    {
      switch(count)
      {
        case 1:
          place(aline,"99");
          place(aline,quant);
          place(aline,unit);
          break;
        case 2:
          place(aline,q_source);
          break;
      }
    }
  }
}
case 3:
place(aline,q_status);
break;

case 4:
place(aline,alt_item_ref);
break;

fputs(aline,fp3);
}

fputs("ln",fp3);
fclose(fpi);

/* scroll through description lines used*/
if (nodi>1) for(a=1;a<nodi-1;a++) scroll_bill_line(fp1,bill_line);
/* set bii flag */
bii_flag=1;
}
return 1;
}

int bill_head(fp1,bill_line,pos)
char bill_line[11][MAXLINE];
ing pos;
FILE *fp1;
{
char tempc[36];
text_copy(tempc,bill_line[1],pos);
if (atoi(tempc)>0)
{
    /*set bill nr. and reset sect and subsect codes*/
    strcpy(bill_nr,tempc);
    strcpy(sect_code," ");
    strcpy(subsect_code," ");
    item_level=1;
    /*copy description from file*/
    portion_copy(tempc,bill_line[2],pos,strlen(bill_line[2])-2);
    /*scroll through bill file by one line*/
    scroll_bill_line(fp1,bill_line);
    /*add data to EDIFACT index file */
    if ((index_update("CON","I",tempc))==0) return 0;
}
else return 0;
return 1;
}

UPDATE.C
#include<stdio.h>
#include<string.h>
#include"cato.h"

extern int page,bii_flag,item_level,n;
extern char bill_nr[],sect_code[],subsect_code[],item_letter[];
extern char action_req[],q_source[],q_status[];
extern FILE *fp2,*fp3;

static char dref110[2]=( "A","B","C","D","E","F","G","H","I","J" );
item_update(desc,item_type)
char desc[],item_type[];
{
FILE *fpi;
int nol,count,a;
char line[MAXLINE],dline[10][36],level[10],line_copy[MAXLINE];
/* open index header data file */
if (((fpi=fopen("item2.dat","r"))==NULL) { 
    puts("Item2 data file not available");
    return 0;
} else {
    if ((nol=desc_div(dline,desc))==0) return 0;
    for(count=1;count<=2;count++) {
        if (getline(fpi,line,MAXLINE)!=0) {
            switch(count) {
            case 1:
                sprintf(level,"%06d",item_level);
                place(line,level);
                place(line,action_req);
                fputs(line,fpi);
                break;
            case 2:
                for(a=1;a<=nol;a++) {
                    strcpy(line_copy,line);
                    place(line_copy,item_type);
                    place(line_copy,dref[a-1]);
                    place(line_copy,dline[a]);
                    fputs(line_copy,fpi);
                } break;
            }
        }
    } fclose(fpi);
} return 1;
}

index_update(ind_type,ind_level,desc)
char ind_type[],ind_level[],desc[];
{
int count,nol,a;
char line[MAXLINE],dline[10][36],line_copy[MAXLINE];
FILE *fpi;
/* open index header data file */
if (((fpi=fopen("index.dat","r"))==NULL) { 
    puts("Index data file not available");
    return 0;
}
else
{
    if ((nol=desc_div(dline,desc))!=0) return 0;
    for(count=1;count<=5;count++)
    {
        if (getline(fpi,line,MAXLINE)!=0)
        {
            switch(count)
            {
            case 1:
                place(line,"PJT");
                place(line,ind_type);
                fputs(line,fp2);
                break;
            case 2:
                fputs(line,fp2);
                break;
            case 3:
                place(line,ind_level);
                fputs(line,fp2);
                break;
            case 4:
                place(line,bill_nr);
                place(line,sect_code);
                place(line,subsect_code);
                fputs(line,fp2);
                break;
            case 5:
                for(a=1;a<=nol;a++)
                {
                    strcpy(line_copy,line);
                    place(line_copy,dref[a-1]);
                    place(line_copy,dline[a]);
                    fputs(line_copy,fp2);
                }
                break;
            }
        }
    }
    fclose(fp);
}
return 1;
}

update_bill(bill_line)
char bill_line[11][MAXLINE];
{
    int a,line_pos=0,count;
    char item_ref[5],aline[MAXLINE];
    FILE *fp;
    for (a=1;a<=10;a++)
    {
        if (text_start(bill_line[a],0)==6)
        {
            line_pos=a;
            break;
        }
    }
}
if (!line_pos) return 0;
/* put item letter into a global string */
item_letter[0]=bill_line[line_pos][14];item_letter[1]=’0’;
sprintf(item_ref,"%d%c",page,item_letter[0]);
/* open item (bii) data file */
if ((fpb=fopen("iteml.dat","r"))==NULL)
{
    puts("ItemI data file not available");
    return 0;
}
else
{
    for(count=1;count<=3;count++)
    {
        if (getline(fpb,aline,MAXLINE)!=0)
        {
            switch(count)
            {
            case 1:
                place(aline,bill_ni);
                place(aline,sect_code);
                place(aline,subsect_code);
                place(aline,item_ref);
                break;
            }
            fputs(aline,fp3);
        }
        fputs("\n",fp3);
        fclose(fpb);
    }
    bii_flag=0;
    return 1;
}

ROUTINE.C
#include <conio.h>
#include <stdio.h>
#include <string.h>
#include "cato.h"

scroll_bill_line(fp1,bill_line)
FILE *fp1;
char bill_line[11][MAXLINE];
{
    int a;
    for (a=1;a<=9;a++) strcpy(bill_line[a],bill_line[a+1]);
    if ((getline(fp1,bill_line[10],MAXLINE))==0) strset(bill_line[10],’0’);
    return 1;
}

place(line,data)
char line[],data[];
{
    int a,length;
    char *ptr,*pt2,c='*';
    length=strlen(line);

    H-19
if ((ptr=strchr(line,c))!=NULL)
{
    for (a=0;a<strlen(data);a++)
    {
        line[ptr-line]=data[a];
        ptr++;
    }
    if ((ptr-line)>=length)
    {
        line[ptr-line]="\n";
        line[ptr-line+1]="\0";
    }
}
return 1;
}

desc_create(desc,bill_line,pos,underline,desc_end,last_line)
char desc[],bill_line[11][MAXLINE];
int pos,underline,desc_end,last_line;
{
    int a,b=1,inc,end_pos,c;
    char aline[MAXLINE];
    /* clear variables */
    memset(aline,0);
    memset(desc,0);
    a=pos;
    inc=1+underline;
    do
    {
        if ((end_pos=strlen(bill_line[b])-2)>desc_end) end_pos=desc_end;
        portion_copy(aline,bill_line[b],pos,end_pos);
        strcat(desc,aline);
        strcat(desc," ");
        b+=inc;
        a=text_start(bill_line[b],0);
        if (underline==1 && bill_line[b+1][pos]!="-") break;
    }
    while(a==pos & b<10 & bill_line[b+inc][last_line]==" ");
    if (b>=10) return 0;
    c=strlen(desc)-1;
    /* knock spaces off end of description */
    while (desc[c]==" ")
    {
        desc[c]="\0";
        c--;
    }
    return b-inc;
}

desc_div(line,string)
char line[10][36],string[];
{
    int a,oos=0,b=1;
    while (oos+34<=strlen(string))
    {
        a=oos+34;
        while (string[a]==" ") a--;
    }
portion_copy(line[b],string,opos,a);
  opos=a+1;
  b++;
}
portion_copy(line[b],string,opos,strlen(string));
if (b>10) return 0;
return b;

int text_start(line,i)
char line[];
int i;
{
  int length;
  length = strlen(line);
  /* find first non-space character */
  while ((line[i] == ' ') && (i < length)) i++;
  if (i==length) return NULL;
  return i;
}

portion_copy(line1,line2,pos1,pos2)
char line1[],line2[];
int pos1,pos2;
{
  int a,b=0;
  /* copy portion of line2 to line1 */
  for (a=pos1;a<=pos2;a++)
    {
      line1[b]=line2[a];
      b++;
    }
  /* knock space off the end of destination string (line1) */
do {
    line1[b]='\0';
    b--;
  }while(line1[b]==' ');
  return;
}

/* copy text up to first space from line2 to line1 starting at position pos */
int text_copy(line1,line2,pos)
char line1[],line2[];
int pos;
{
  int b=0;
  while (line2[pos]!='' && line2[pos]!='\0')
    {
      line1[b]=line2[pos];
      b++;
      pos++;
    }
  line1[b]='\0';
  return b;
}
```c
int text_copy_backwards(line1, line2, pos)
char line1[], line2[];
int pos;
{
    int a, b = 0, length;
    /* find text */
    while ((line2[pos] == ' ') && (pos > 0)) pos--;
    /* read text into line1 */
    while (line2[pos] != ' ' && pos >= 0)
    {
        line1[b] = line2[pos];
        b++;
        pos--;
    }
    line1[b] = '\0';
    /* reverse line1 */
    strrev(line1);
    return b;
}

int getline(fp, line, max)
FILE *fp;
char line[];
int max;
{
    if (fgets(line, max, fp) == NULL)
        return(0);
    else
        return strlen(line);
}

ame_address(nad)
char nad[6][36];
{
    int a;
    char resp[36];
    window(3,5,41,12);
    textcolor(14);
    textbackground(1);
    clrscr();
    puts("NAME AND ADDRESS DATA ENTRY");
    gotoxy(1,2);puts("(5 lines of up to 35 characters)");
    for (a=1; a<=5; a++)
    {
        gotoxy(1, a+3);
        puts("->");
        gotoxy(38, a+3);
        puts("<-");
    }
    for (a=1; a<=5; a++)
    {
        do
        {
            gotoxy(3, a+3);
            gets(resp);
        } while (true);
    }
```
while(strlen(resp)>35);
/* ensure a space covers '#' flag in edifact file */
if (strlen(resp)==0) strcpy(resp,"");
strcpy(nad[a],resp);
}
window(2,3,79,24);
textcolor(15);textbackground(0);
return 1;
}
Appendix H.2 - “Rates” program source code

MAIN.C
#include <stdio.h>
#include <dos.h>
#include <conio.h>
#include <string.h>
#include <stdlib.h>
#include "rates.h"

#define MAXLINE 256

extern unsigned _stklen=128000U;
FILE *fp1,*fp2,*fp3;
char _head[4][36],ind_no[10][10],ind_desc[100][36];
char proj_name[5][5][37],ten_date[10],proj_ref_num[36];
int icount=0;
unsigned long int control_total;

main()
{
    int n,a;
    clrscr();
do
    {
        _setcursortype(_NOCURSOR);
        /*menu screen*/
textmode(C80);
        window(1,1,40,1);
textcolor(WHITE);textbackground(RED);
        clrscr();
        puts("Project");
        window(1,8,80,25);
textcolor(YELLOW);textbackground(BLACK);
        clrscr();
gotoxy(5,5);puts("1/ Open a EDIFACT CONFITT file");
gotoxy(5,6);puts("2/ View project file");
gotoxy(5,7);puts("3/ Add rates to bill");
gotoxy(5,8);puts("4/ Quit");
gotoxy(5,15);puts("press selection");
n=getch();
switch(n-48)
{
    case 1:
        /*open file routine*/
        if (!openfile()) {getch();exit(0);}break;
    case 2:
        view_proj_info();
}
case 3:
    add_rates();
    driver();
    break;

} while (n!=52);
exit(0);
return 1;
}

openfile()
{
    int line_no;
    char file_line[MAXLINE],bq_line[11][MAXLINE],resp[30],file_name[12];
    clrscr();
    gotoxy(1,2);
    puts("Enter file name");
    gotoxy(1,4);
    _setcursortype(_NORMALCURSOR);
    gets(resp);
    _setcursortype(_NOCURSOR);
    strcpy(file_name,resp);
    if ((fp=fopen(file_name,"rt"))==NULL)
    {
        gotoxy(1,6);
        puts("file does not exist");
    }
    else
    {
        /*empty strings*/
        for (line_no=1;line_no<=10;line_no++) strcpy(bq_line[line_no],"\0");
        strcpy(resp,'\0');
        /*read first nine lines of file into buffer*/
        for (line_no=1;line_no<=9;line_no++)
        {
            scroll_bq_line(fp1,bq_line);
        }
        /*read through edifact file and o/p to a new file */
        do
        {
            scroll_bq_line(fp1,bq_line);
            if (strncmp("UNH ",bq_line[1],4)==0) project_header(fp1,bq_line);
            if (strncmp("IND ",bq_line[1],4)==0) index(fp1,bq_line);
            if (strncmp("BIIA",bq_line[1],4)==0)
            {
                project1(fp1,bq_line);
                item_conv(fp1,bq_line);
            }
        } while(strncmp(bq_line[1],"UNT",3)!=0);
    fclose(fp1);
    return 1;
}

view_proj_info()
{
```c
int a;
/*print tender submission date in top right corner of screen*/
window(41,1,80,8);
textbackground(BLACK);
textcolor(YELLOW);
c1rsr();
gotoxy(1,3);
puts(" Tender submission date :");
gotoxy(8,5);
printf("%s",ten_date);
/*print party id.s to screen*/
window(1,8,80,8);
textbackground(BLUE);
textcolor(WHITE);
c1rsr();
puts("CLIENT");
gotoxy(41,1);
puts("ARCHITECT");
window(1,15,80,15);
c1rsr();
puts("ENGINEER");
gotoxy(41,1);
puts("QUANTITY SURVEYOR");
/*print party data to screen*/
window(1,9,40,14);
textcolor(YELLOW);
c1rsr();
for (a=0;a<=4;a++)
{
    gotoxy(1,a+1);
    printf("%s",proj_name[1][a]);
}
window(41,9,80,14);
c1rsr();
for (a=0;a<=4;a++)
{
    gotoxy(1,a+1);
    printf("%s",proj_name[2][a]);
}
window(1,16,40,21);
c1rsr();
for (a=0;a<=4;a++)
{
    gotoxy(1,a+1);
    printf("%s",proj_name[3][a]);
}
window(41,16,80,21);
c1rsr();
for (a=0;a<=4;a++)
{
    gotoxy(1,a+1);
    printf("%s",proj_name[4][a]);
}
window(1,22,80,22);
textbackground(BLACK);
textcolor(YELLOW);
c1rsr();
puts("Press any key");
getch();
```
ADD RATE2.C

#include <stdio.h>
#include <conio.h>
#include <string.h>
#include <stdlib.h>
#include "rates.h"

extern int _wscroll=0;
extern FILE *fp1,*fp2,*fp3;

add_rates()
{
    int n,flag=0;
    float qty,frate,fsum;
    char line[129],otext[36],text[36],text2[36];
    char resp[36],quant[36],srate[36],ssum[36];
    _setcursortype(_NOCURSOR);
    textmode(C80);
    clrscr();
    /*clear text and text2 strings*/
    for (n=0;n<=35;n++)
    {
        text[n]='\0';
        text2[n]='\0';
        quant[n]='\0';
    }
    if ((fp2=fopen("EDI.CON","rt"))==NULL)
    {
        gotoxy(1,6);
        puts("CONm file has not been loaded

press a key");
        getch();
        return 0;
    }
    if ((fp3=fopen("ITEM.REF","rt"))==NULL)
    {
        gotoxy(1,6);
        puts("Item reference file not found

press a key");
        getch();
        return 0;
    }
    if ((fp1=fopen("tender.ref","wt"))==NULL)
    {
        gotoxy(1,6);
        puts("Item reference file not found

press a key");
        getch();
        return 0;
    }
    window(1,1,80,24);
    textbackground(BLACK);textcolor(YELLOW);
cr
    return 1;
}
window(1,2,80,25);
textbackground(BLACK);textcolor(WHITE);
clrscr();
gotoxy(78,18);
textcolor(YELLOW);
cprintf("<--");
textcolor(WHITE);
/*scroll bq file to next item*/
do{
    do{
        fgets(line,l28,fp2);
movetext(1,3,77,21,1,2);
gotoxy(1,20);
clear();
printf("%s",line);
strset(text,"\0");
gettext(1,19,3,19,text);
strip_string(text);
if (strlen(text)!=0)
    strcpy(otext,text);
strset(text2,"\0");
gettext(61,19,62,19,text2);
strip_string(text2);
}while(strlen(text2)==0);
if (strncmpi("en",text2,2)!=0)
{
    gotoxy(1,6);
    puts("Unable to locate item\npress a key");
    getch();
    return 0;
}
if (getline(fp3,line,MAXLINE)==NULL)
{
    gotoxy(l,6);
    puts("Unable to locate item\npress a key");
    getch();
    return 0;
}
clear_string(line);
/*output item data, plus quant, rate and sum to tender.ref*/
if (flag)
    fputs("n",fp1);
strcat(line,"\n");strcat(line,quant);
strcat(line,"\n");strcat(line,text2);
strcat(line,"\n");strcat(line,srate);
```c
#include <stdio.h>
#include <ctype.h>
#include <conio.h>
#include <string.h>
#include <stdlib.h>
#include "rates.h"

#define MAXLINE 256

extern char _head[4][36],ind_no[100][10],ind_desc[100][36];
extern char proj_name[5][5][37],ten_date[10],proj_ref_num[36];
extern FILE *fpl,*fp2,*fp3;
extern int icount;

project1(fin,bq_line)
FILE *fin;
char bq_line[11][MAXLINE];
{
    int a,spos,epos,select;
    char resp[50],party[5][5]=
    "EL", "CLI", "ARC", "ENG", "PQS";
    do {
        if (strncmpi(bq_line[1],"DTMA 286",8)==0)
            /*copy date*/
            text_copy(ten_date,bq_line[1],9);
        if (strncmpi(bq_line[1],"NAD ",4)==0)
            /*identify party*/
            text_copy(resp,bq_line[1],5);
            select=0;
            for (a=0;a<=4;a++)
                if (strcmp(resp,party[a])==0) select=a;
            /*read in name and address information*/
            for (a=0;a<=4;a++)
                {
                    spos=35+a*37;
                    epos=71+a*37;
                    if (spos<strlen(bq_line[1]))
                        portion_copy(resp,bq_line[1],spos,epos);
                    clear_string(resp);
                    strcpy(proj_name[select][a],resp);
                }
    }
    return 1;
}
```

---

I}strcat(line," ");strcat(line,ssum);
fputs(line,fp1);

flag=1;
while(flag);
fclose(fp1);
window(1,1,80,25);
textbackground(BLACK);textcolor(YELLOW);
clearscr();
return 1;
}
scroll_bq_line(fin,bq_line);
}
while (strncmpi(bq_line[1],"UNS",4)!=0);
return 1;
}

index(fin,bq_line)
FILE *fin;
char bq_line[11][MAXLINE];
{
char ident[10],_level[5],resp[10];
int a,level;
text_copy(ident,bq_line[1],9);
/*scroll twice to position onto level id*/
scroll_bq_line(fin,bq_line);
scroll_bq_line(fin,bq_line);
/*identify project index definition data*/
if (strncmpi(ident,"DEF",3)==0)
{
text_copy(_level,bq_line[1],5);
level=atoi(_level);
/*scroll twice to position onto level description*/
scroll_bq_line(fin,bq_line);
scroll_bq_line(fin,bq_line);
portion_copy(_head[level],bq_line[1],29,63);
return 1;
}

/*project index contents data*/
icount++; /*increment index reference line */
text_copy(_level,bq_line[1],5);
level=atoi(_level);
scroll_bq_line(fin,bq_line);
/*clear string variables*/
ind_no[icount][0]="0";
ind_desc[icount][0]="0";
/*read in reference no*/
for (a=1;a<=level;a++)
{
portion_copy(resp,bq_line[1],(9+18*(a-1)),(25+18*(a-1)));
strcat(ind_no[icount],resp);
}
/* knock space and control characters off the end of ref no string*/
a=strlen(ind_no[icount]);
do {
    ind_no[icount][a]="0";
a--;
} while(isalnum((ind_no[icount][a]))==0);
scroll_bq_line(fin,bq_line);
/*read in reference description*/
portion_copy(ind_desc[icount],bq_line[1],29,63);
a=strlen(ind_desc[icount]);
/*knock off spaces and control chars*/
do {
    ind_desc[icount][a]="0";
a--;
}
while(isalnum((find desc[icount][a]))==0);
return 1;

project_header(fin,bq_line)
FILE *fin;
char bq_line[11][MAXLINE];
{
do
{
if (strncmpi(bq_line[1],"RFF AEP",8)==0)
{
  /*copy project reference*/
  text_copy(proj_ref_num,bq_line[1],9);
  clear_string(proj_ref_num);
}
}
scroll_bq_line(fin,bq_line);
}while (strncmpi(bq_line[1],"IND ",4)!=0);
return I;

#include <stdio.h>
#include <string.h>
#include <io.h>
#include <conio.h>
#include <stdlib.h>
#include <ctype.h>
#include <math.h>
#include "rates.h"

#define MAXLINE 256
extern char ten_date[10],proj_name[5][5][37],proj_ref_num[36];
extern unsigned long int control_total;
extern FILE *fp1,*fp2,*fp3;
char message_ref_num[36];
char rate_source[5];
driver()
{
  if ((fp1=fopen("CONTEN.EDI","wt"))==NULL)
  {
    puts("Unable to write to file");
    getch();
    return 0;
  }
control_total=0;
header_conv();
project_conv();
item2_conv();
fclose(fp1);
end_conv();
return 1;
}
header_conv()
{
    int count;
    char resp[20], date[10], ref_num[35];
    char authname[35], authpass[35], line[256];
    clrscr();
    do
    {
        gotoxy(1,1);
        puts("Enter date (format: YYMMDD)");
        gotoxy(1,4);gets(resp);
    } while (strlen(resp)<6);
    strcpy(date, resp);
    clrscr();
    do
    {
        gotoxy(1,1);
        puts("Enter message reference number");
        gotoxy(1,4);gets(resp);
    } while (strlen(resp)<0 || strlen(resp)>14);
    strcpy(message_ref_num, resp);
    clrscr();
    do
    {
        gotoxy(1,1);
        puts("Enter document reference number");
        gotoxy(1,4);gets(resp);
    } while (strlen(resp)<0 || strlen(resp)>35);
    strcpy(ref_num, resp);
    clrscr();
    do
    {
        gotoxy(1,1);
        puts("Enter senders authorised name");
        gotoxy(1,4);gets(resp);
    } while (strlen(resp)<0 || strlen(resp)>35);
    strcpy(authname, resp);
    clrscr();
    do
    {
        gotoxy(1,1);
        puts("Enter senders password");
        gotoxy(1,4);gets(resp);
    } while (strlen(resp)<0 || strlen(resp)>35);
    strcpy(authpass, resp);
    /* open project header data file */
    if ((fp2=fopen("rheader.dat", "rt")==NULL))
    { 
        puts("Project header file not available");
        return 0;
    }
    else
    {
        H-32
for(count=1;count<=6;count++)
{
    if (getline(fp2,line,MAXLINE)!=0)
    {
        switch(count)
        {
            case 1:
                place(line,message_ref_num);
                break;
            case 2:
                place(line,ref_num);
                break;
            case 3:
                place(line,proj_ref_num);
                break;
            case 4:
                place(line,date);
                break;
            case 5:
                place(line,authpass);
                break;
            case 6:
                place(line,authname);
                break;
        }
        puts(line,fp1);
    }
    fclose(fp2);
}
return 1;

project_conv()
{
    int a=1,count,n;
    unsigned long int tender_sum;
    char line[256],resp[36],sten_sum[20],nad[6][36];
    if ((fp2=fopen("tender.ref","rt"))==NULL)
    {
        puts("Tender reference file not available,\nload CONITT file and add rates");
        getch();
        return 0;
    }
tender_sum=0.0;
    while (a)
    {
        if (fgets(line,MAXLINE,fp2)==NULL) break;
        a=strlen(line);
        text_copy_backwards(resp,line,a-1);
        tender_sum=tender_sum+(atof(resp)*1000);
    }
    fclose(fp2);
    /*convert double float to edifact value*/
    sprintf(sten_sum,"%018lu",tender_sum);
    /*open project header data file*/
    if ((fp3=fopen("rproject.dat","rt"))==NULL)
    {
        puts("Project file not available");
    }
return 0;
}
else
{
_setcursortype(_NORMALCURSOR);
crsc();
gotox(1,1);
puts("Enter contractor information");
name_address(nad);
window(1,1,80,25);
textbackground(BLACK);textcolor(YELLOW);
crsc();
_setcursortype(_NOCURSOR);
do{
    crsc();
    puts("ln	l/ Contractor's item\n\nt2/ New item\n\nt3/ Take off\n\n4/ BoQ");
gotox(5,10);
    puts("press selection");
} while ((n=getch())<49 || n>52);
n=n-48;
sprintf(rate_source,"%d",n);
for(count=1;count<=8;count++)
{
    if (getline(fp3,line,MAXLINE)!=0)
    {
        switch(count)
        {
        case 3:
            place(line,proj_ref_num);
            break;
        case 4:
            place(line,"286");
            place(line,ten_date);
            break;
        case 6:
            place(line,sten_sum);
            break;
        case 7:
            place(line,"EN");
            for(a=0;a<=4;a++) place(line,nad[a]);
            break;
        }
        fputs(line,fp1);
    }
    fclose(fp3);
    fputs("ln",fp1);
}
return 1;
}

item2_conv()
{
    int count,a;
    long unsigned int dub1;
    char line[256],line2[256];
char temp1[36],temp2[36],temp3[36],temp4[36],
    temp5[10][5]={"m","m2","m3","t","hr","nr","n","n","ITEM"};
char unit_convl[10][5]={"MTR","MTK","MTQ","TNE","HUR","NMB","NMB","IT"};
if ((fp3=fopen("tender.ref","rt"))==NULL)
    {
        puts("Tender reference file not available,\n        unload CONIT file and add\n        rates");
        getch();
        return 0;
    }
if ((fp2=fopen("ritem.dat","rt"))==NULL)
    {
        puts("Item data file not available");
        return 0;
    }
/*while(getline(fp3,line2,MAXLINE)==0);*/
do
    {
        getline(fp3,line2,MAXLINE);
        fseek(fp2,0L,SEEK_SET);
        for(count=1;count<=9;count++)
            {
                if (getline(fp2,line,MAXLINE)!=0)
                    {
                        switch(count)
                        {
                            case 1:
                                text_copy_gap(temp1,line2,0);
                                text_copy_gap(temp2,line2,1);
                                text_copy_gap(temp3,line2,2);
                                text_copy_gap(temp4,line2,3);
                                place(line,temp2);
                                place(line,temp3);
                                place(line,temp4);
                                place(line,temp1);
                                break;
                            case 4:
                                text_copy_gap(temp1,line2,5);
                                dub1=(atof(temp1)*1000);
                                sprintf(temp1,"%015lu",dub1);
                                /*add quant to control total*/
                                control_total=control_total+dub1;
                                /*convert units to EDIFACT units*/
                                for (a=0;a<=7;a++)
                                    {
                                        if (strcmp(temp2,unit_convl[a])==0)
                                            {
                                                strcpy(temp2,unit_conv2[a]);
                                                break;
                                            }
                                }
                                place(line,temp1);
                                place(line,temp2);
                                break;
                            case 5:
                                text_copy_gap(temp1,line2,7);
                                dub1=(atof(temp1)*1000);
                                sprintf(temp1,"%015lu",dub1);
                                place(line,temp1);
case 6:
    place(line,rate_source);
    break;

case 8:
    text_copy_gap(temp1,line2,8);
    dub1=(atof(temp1)*1000);
    sprintf(temp1,"%018lu",dub1);
    place(line,temp1);
    break;

case 9:
    text_copy_gap(temp1,line2,4);
    clear_string(temp1);
    place(line,temp1);
    break;

} fputs(line,fpl);
}
/* fputs("ln",fpl); */
/* getline(fp3,line2,MAXLINE); */
}

while(!feof(fp3));
fclose(fp2);
fclose(fp3);
return 1;

end_conv()
{
char line[256],line2[256];
char resp[36];
int count;
unsigned long int a;
if ((fp3=fopen("endbit.edi", "wt") == NULL)
{
    puts("Unable to write ENDBIT.EDI file");
    getch();
    return 0;
}
/* count number of segments in message */
/* open project information data file (message1.dat) */
if ((fp1=fopen("message1.dat", "rt") == NULL && (fp2=fopen("conten.edi","rt") == NULL))
{
    puts("Message1 data file or CONTEN.EDI file not available");
    return 0;
}
else
{
    for(count=1;count<=2;count++)
    {
        if (getline(fp1,line,256)!=0)
        {
            switch(count)
    {
        case 1:
            sprintf(resp,"%018lu",control_total);
            place(line,resp);
        }
ITEM2.C

#include <stdio.h>
#include <ctype.h>
#include <conio.h>
#include <string.h>
#include <stdlib.h>
#include "rates.h"

#define MAXLINE 256

extern char _head[4][36], ind_no[100][10], ind_desc[100][36];
extern FILE *fpl,*fp2,*fp3;
char _store[4][5], item_id[10]={"\0"}, fline[128];
int lev_ind=10;

item_conv(fin,bq_line)
FILE *fin;
char bq_line[11][MAXLINE];
{
  int a;
  /*set up fline variable to 127 spaces,1 newline,1 null character */
  for (a=0; a<=125; a++) fline[a]=' ';
fline[126]='\n';fline[127]='\0';
  /*open bq output file*/
  if ((fp1=fopen("EDI.CON","wt"))==NULL)
    gotoxy(1,6);
    puts("cannot create file\n
press a key");
    getch();
    return 0;
  /* open item reference file */
  if ((fp2=fopen("ITEM.REF","wt"))==NULL)
    gotoxy(1,6);
    puts("cannot
create file

press a
key");
    getch();
    return 0;
  do
  {
    scroll_bq_line(fin,bq_line);
    if (strncmpi("BIIC",bq_line[1],4)==0) item1(bq_line);
    if (strncmpi("LIN ",bq_line[1],4)==0) item2(fin,bq_line);
    if (strncmpi("CNT ",bq_line[1],4)==0) {puts("end");message1();}
  }while(strncmpi(bq_line[1],"UNT ",4)!=0 && strlen(bq_line[1])>1);
  fclose(fp1);
  fclose(fp2);
  return 1;
}

item1(bq_line)
char bq_line[11][MAXLINE];
{
  int a,b,c;
  char _level[4][5],ind_search[10];
  /*get item identity*/
  text_copy(item_id,bq_line[1],117);
  clear_string(item_id);
  /*get headings and print to file if necessary*/
  for (a=1; a<=3; a++) text_copy(_level[a],bq_line[1],(9+18*(a-1)));
  clear_string(_level[a]);
  for (a=1; a<=3; a++)
    if (strcomp(l_store[a],_level[a])!=0)
    {
      strcpy(l_store[a],_level[a]);
      /*construct search string*/
      memset(ind_search,'0',10);
    }

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for (b=1;b<=a;b++) strcat(ind_search, _level[b]);
/*search ind_no for description then print it to file*/
b=0;
while(strcmp(ind_no[b],ind_search)!=0 & & b<100) b++;
/*output index title to file*/
fputs(" ",fp1);
fputs(_level[a],fp1);fputs(" ",fp1);
fputs(ind_desc[b],fp1);
fputs("\n",fp1);
fputs(" ",fp1);
for(c=1;c<=1+strlen(ind_no[b])+strlen(ind_desc[b]));c++) fputs(" ",fp1);
fputs("\n\n",fp1);
}
return 1;
}

item2(fin,bq_line)
FILE *fin;
char bq_line[11][MAXLINE];
{
int level,a,item=0;
char _level[10],desc[36];
/*get heading level*/
text_copy(_level,bq_line[1],5);
level=atoi(_level);
/*check if item description*/
text_copy(desc,bq_line[2],9);
if (strncmpi("DES",desc,3)==0) {item=1;put_string(fline,item_id,0);}
else item=0;
/* get description */
do {
    scroll_bq_line(fin,bq_line);
    portion_copy(desc,bq_line[1],29,63);
    clear_string(desc);
    switch(level)
    {
    case 4:
        put_string(fline,desc,5);
        fput(fline,fp1);
        for(a=5;a<=5+strlen(desc);a++) put_string(fline," ",a);
        break;
    case 5:
        put_string(fline,desc,5);
        break;
    case 6:
        put_string(fline,desc,10);
        break;
    }
    if ((item) & & strncmpi("IMDA",bq_line[2],4)!=0) item3(fin,bq_line); /*add quantities to
item line*/
else fput(fline,fp1);
}
while(strncmpi("IMDA",bq_line[2],4)==0);
fputs("\n",fp1);
lev_ind=level;
return 1;
}
#include <conio.h>
#include <ctype.h>
#include <stdio.h>
#include <string.h>
#include "rates.h"

#define MAXLINE 256

void item3(FILE *fin, char bq_line[11][MAXLINE])
{
    FILE *fpl;
    char unit_conv1[10][5] = { "m", "m2", "m3", "s", "hr", "nr", "n", "ITEM" };
    char unit_conv2[10][5] = { "MTR", "MTK", "MTQ", "TNE", "HUR", "NMB", "NMB", "IT" };
    char quant[20], unit[5], alt_id[10], line[50];
    int a;
    long int la;

double da, dla;

    /* put quant, unit and rate place after desc in line then print to file */
    scroll_bq_line(fin, bq_line);
    text_copy(quant, bq_line[1], 9);
    la = atol(quant);
    dla = la;
    da = dla/1000;
    printf("%5.2f", da);
    put_string(fline, quant, 50);

    /* convert units */
    text_copy(unit, bq_line[1], 25);
    clear_string(unit);
    for (a = 0; a <= 7; a++)
        if (strcmp(unit, unit_conv2[a]) == 0)
            strcpy(unit, unit_conv1[a]);
        break;
    put_string(fline, unit, 60);

    /* output constructed line to file */
    fputs(fline, fp1);

    /* search for alternative ref. */
    while (strncmpi("BID", bq_line[1], 4) != 0) scroll_bq_line(fin, bq_line);
    text_copy(alt_id, bq_line[1], 117);
    clear_string(alt_id);

    /* output item details to file */
    strftime(line, "0");
    printf("%s %s %s %s %s
", item_id, l_store[1], l_store[2], l_store[3], alt_id);
    fputs(line, fp2);
    return 1;
}

message1()
{
    fputs("en", fp1);
    return 1;
}

ROUTINE.C
strip_string(line1)
char line1[];
{
int a,b=0,l;
char line2[MAXLINE];
l=strlen(line1)-1;
for (a=0;a<l;a+=2)
{
    line2[b]=line1[a];
b++;
}
line2[b]=\0;
strcpy(line1,line2);
clear_string(line1);
return l;
}
fput(line,fp)
char line[];
FILE *fp;
{
    fputs(line,fp);
strset(line,' ');
    line[127]=\n';
return 1;
}

name_address(nad)
char nad[6][36];
{
    int a;
    char resp[36];
    window(3,5,41,12);
textcolor(14);
textbackground(1);
clrscr();
puts("NAME AND ADDRESS DATA ENTRY");
gotoxy(1,2);puts("(5 lines of up to 35 characters)");
for (a=1;a<=5;a++)
{
    gotoxy(1,a+3);
    puts("->");
    gotoxy(38,a+3);
    puts("<-");
}
for (a=1;a<=5;a++)
{
    do
    {
        gotoxy(3,a+3);
        gets(resp);
    } while(strlen(resp)>35);
    /* ensure a space covers '*' flag in edifact file */
    if (strlen(resp)<=0) strcpy(resp," ");
    strcpy(nad[a-1],resp);
}
window(2,3,79,24);
textcolor(l5);textbackground(O);
return 1;
}

put_string(line1,line2,pos)
char line1[],line2[];
int pos;
{
    int a,b=0;
    /* put line2 into line1 starting at pos (no \0 is transferred)*/
    for (a=pos;a<pos+strlen(line2);a++)
    {
        line1[a]=line2[b];
        b++;
    }
    return 1;
}

clear_string(line)
char line[];
{
    int a;
    /*clear spaces and control chars from end of string*/
a=strlen(line);
    do
    {
        line[a]='\0';
a--;
    }while(isalnum((line[a]))==0);
    return 1;
}

scroll_bq_line(fp l,bq_line)
FILE *fp l;
char bq_line[11][MAXLINE];
{
    int a;
    for (a=l;a<=9;a++) strcpy(bq_line[a],bq_line[a+1]);
    if ((getline(fp l,bq_line[10],MAXLINE))==0) strset(bq_line[10],'\0');
    return 1;
}

place(line,data)
char line[],data[];
{
    int a,length;
    char *ptr,*pt2,c='*';
    length=strlen(line);
    if ((ptr=strchr(line,c)) !=NULL)
    {
        for (a=0;a<strlen(data);a++)
        {
            line[ptr-line]=data[a];
            ptr++;
        }
    }
}
if ((ptr-line) >= length)
{
    line[ptr-line] = 'n';
    line[ptr-line+1] = '0';
}
return 1;
}

desc_creat(desc,bill_line,pos,underline,desc_end,last_line)
char desc[],bill_line[11][MAXLINE];
int pos,underline,desc_end,last_line;
{
    int a,b=1,inc,end_pos,c;
    char aline[MAXLINE];
    /* clear variables */
    strset(aline, '0');
    strset(desc, '0');
    a=pos;
    inc=1+underline;
    do
    {
        if ((end_pos=strlen(bill_line[b])-2)>desc_end) end_pos=desc_end;
        portion_copy(aline,bill_line[b],pos,end_pos);
        strcat(desc,aline);
        strcat(desc, " ");
        b+=inc;
        a=text_start(bill_line[b],0);
        if (underline==1 && bill_line[b+1][pos]!='_') break;
    }
    while(a=pos && b<10 && bill_line[b-inc][last_line]==' ');
    if (b>=10) return 0;
    c=strlen(desc)-1;
    /* knock spaces off end of description */
    while (desc[c]==' ') 
    {
        desc[c]='0';
        c--;
    }
    return b-inc;
}

desc_div(line,string)
char line[10][36],string[];
{
    int a,o.pos=0,b=1;
    while (o.pos+34<=strlen(string))
    {
        a=opos+34;
        while (string[a]==' ') a--;
        portion_copy(line[b],string,o.pos,a);
        opos=a+1;
        b++;
    }
    portion_copy(line[b],string,o.pos,strlen(string));
    if (b>10) return 0;
    return b;
}
int text_start(line, i)
char line[];
int i;
{
int length;
length = strlen(line);
/* find first non-space character */
while ((line[i] == ' ') && (i < length)) i++;  
if (i == length) return NULL;
return i;
}

portion_copy(line1, line2, pos1, pos2)
char line1[], line2[];
int pos1, pos2;
{
int a, b = 0;
/* copy portion of line2 to line1 */
for (a = pos1; a <= pos2; a++)
{
    line1[b] = line2[a];
    b++;
}
/* knock space and control characters off the end of destination string (line1) */
do {
    line1[b] = '\0';
    b--;
}
while (isalnum((line1[b])) == 0);
return b;
}

/*copy text up to first space from line2 to line1 starting at position pos */
int text_copy(line1, line2, pos)
char line1[], line2[];
int pos;
{
int b = 0;
while ((line2[pos] != ' ') && (line2[pos] != '\0'))
{
    line1[b] = line2[pos];
    b++;
    pos++;
}
line1[b] = '\0';
return b;
}

/*copies string2 to string1 starting after gap no.(gaps) in string2*/
/*a gap is one or more consecutive spaces*/
int text_copy_gap(line1, line2, gaps)
char line1[], line2[];
int gaps;
{
/*remaining */
}
```c
{
    int gap_count=0,a=0,start=0,length;
    length=strlen(line2);
    while(gaps!=gap_count)
    {
        while(line2[a]!=' ') a++;
        if (line2[a-1]!=' ') gap_count++;
        a++;
        if (a>=length)
        {
            strset(line1,'\0');
            return NULL;
        }
    }
    start=text_start(line2,a);
    text_copy(line1,line2,start);
    return 1;
}
int text_copy_backwards(line1,line2,pos)
    char line1[],line2[];
    int pos;
    {
        int a,b=0,length;
        /* find text */
        while (line2[pos] == ' ') & (pos > 0) pos--;
        /* read text into line1 */
        while (line2[pos] == ' ' & & pos>=0) {
            line1[b] = line2[pos];
            b++;
            pos--;
        }
        line1[b] = '\0';
        /* reverse line1 */
        strrev(line1);
        return b;
    }

int getline(fp,line,max)
    FILE *fp;
    char line[];
    int max;
    {
        if (fgets(line,max,fp) == NULL)
            return(NULL);
        else
            return strlen(line);
    }
}
```

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Appendix H.3 - “Cinter” program source code

MAIN.C

#include <stdio.h>
#include <dos.h>
#include <conio.h>
#include <string.h>
#include <stdlib.h>
#include "cinter.h"

#define MAXLINE 256

extern unsigned _stklen=128000U;
FILE *fp1,*fp2;
char cont_name[5][37],ten_date[10],proj_ref_num[36],date_document_issued[10];
int icount=0;

main()
{
    int n,a;
    clrscr();
    /*clear variables*/
    for (a=0;a<=4;a++)
    {
        strset(cont_name[a],'0');
    }
    do
    {
        _setcursortype(NOCURSOR);
        /*menu screen*/
        textmode(C80);
        window(1,1,40,1);
        textcolor(WHITE);textbackground(RED);
        clrscr();
        puts("CONTRACTOR");
        window(1,2,40,7);
        textcolor(YELLOW);
        clrscr();
        for (a=0;a<=4;a++)
        {
            gotoxy(1,a+1);
            printf("%s",cont_name[a]);
        }
        window(41,1,80,7);
        textbackground(BLUE);
        clrscr();
        gotoxy(1,1);
        puts("PROJECT REFERENCE");
        gotoxy(1,3);
        printf("%s",proj_ref_num);
        /*menu*/
        window(1,8,80,25);
        textcolor(YELLOW);textbackground(BLACK);
        clrscr();
        gotoxy(5,5);puts("1/ Open a CONTEN file and convert to CATO in-house file");
        gotoxy(5,7);puts("9/ Quit");
        gotoxy(5,15);puts("press selection");
        n=getch();
    }while(1);
switch(n-48)
{
  case 1:
    /*open file routine*/
    if (!openfile()) {getch();exit(0);}
    break;
}
while (n!=57);
exit(0);
return 1;
}

openfile()
{
  int line_no;
  char file_line[MAXLINE],bq_line[11][MAXLINE],resp[30],file_name[12];
  clrscr();
  gotoxy(1,2);
  puts("Enter file name");
  gotoxy(1,4);
  _setcursortype(_NORMALCURSOR);
  gets(resp);
  _setcursortype(_NOCursor);
  strcpy(file_name,resp);
  if ((fp=fopen(file_name,"rt"))==NULL)
  {
    gotoxy(1,6);
    puts("file does not exist");
    getch();
  }
  else
  {
    /*open the CATO output file*/
    if ((fp2=fopen("CATOFILE.INP","wt"))==NULL)
    {
      gotoxy(1,6);
      puts("Cannot create file !");
      getch();
    }
    else
    {
      /*empty strings*/
      for (line_no=1;line_no<=10;line_no++) strcpy(bq_line[line_no],"0");
      strcpy(resp,"0");
      /*read first nine lines of file into buffer*/
      for (line_no=1;line_no<=9;line_no++)
      {
        scroll_bq_line(fp1,bq_line);
      }
      /*read through edifact file and o/p to a new file */
      do
      {
        scroll_bq_line(fp1,bq_line);
        if (strncmp("UNH",bq_line[1],4)==0) project_header(bq_line);
        if (strncmp("BIIA",bq_line[1],4)==0)
        {
          project1(bq_line);
          output_project_data();
        }
      }
    }
  }
}

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if (strncmpi("BIIC", bq_line[1], 4) == 0) item_conv(bq_line);
}

while (strncmpi(bq_line[1], "UNT", 3) != 0);
}
fclose(fp1);
fclose(fp2);
return 1;

#include <stdio.h>
#include <ctype.h>
#include <conio.h>
#include <string.h>
#include <stdlib.h>
#include "cinter.h"
#define MAXLINE 256

extern char cont_narne[5][37], ten_date[10], proj_ref_num[36], date_document_issued[10];
extern FILE *fp1, *fp2;
extern int icount;

project1(bq_line)
char bq_line[11][MAXLINE];
{
    int a, spos, epos;
    char resp[50];
    do
    {
        if (strncmpi(bq_line[1], "DTMA 286", 8) == 0)
        {
            /*copy date*/
            text_copy(ten_date, bq_line[1], 9);
        }
        if (strncmpi(bq_line[1], "NADB", 4) == 0)
        {
            /*identify party*/
            text_copy(resp, bq_line[1], 5);
            if (strcmp(resp, "EN") == 0)
            {
                /*read in name and address information*/
                for (a = 0; a <= 4; a++)
                {
                    spos = 35 + a * 37;
                    epos = 71 + a * 37;
                    if (spos < strlen(bq_line[1]))
                        portion_copy(resp, bq_line[1], spos, epos);
                    clear_string(resp);
                    strcpy(cont_name[a], resp);
                }
            }
        }
    }
    scroll_bq_line(fp1, bq_line);

    while (strncmpi(bq_line[1], "UNS ", 4) != 0);
return 1;
}

project_header(bq_line)
char bq_line[1][MAXLINE];
{
do
{
if (strncmpi(bq_line[1], "RFF AEP", 8)==0)
{
    /*copy project reference*/
    text_copy(proj_ref_num, bq_line[1], 9);
}
if (strncmpi(bq_line[1], "DTM 137", 8)==0)
{
    /*copy rate date*/
    text_copy(date_document_issued, bq_line[1], 9);
}
    scroll_bq_line(fp1, bq_line);
} while (strncmpi(bq_line[1], "BIIA", 4)!=0);
return 1;
}

output_project_data()
{
FILE *fin;
int count;
char line[256];
/*output project_header and project data to CATO file*/
/* open BPHD1 data file */
if ((fin=fopen("BPHD1.DAT", "rt")) == NULL) 
{
    puts("BPHD1 data file not available");
    return 0;
}
else
{
if (getline(fin, line, MAXLINE)!=0)
{
    place(line, " 000"); /*place item code*/
    place(line, " "); /*place bill number*/
    place(line, " "); /*place bill name*/
    fputs(line, fp2);
}
fclose(fin);
/* open BPHD2 data file */
if ((fin=fopen("BPHD2.DAT", "rt")) == NULL) 
{
    puts("BPHD2 data file not available");
    return 0;
}
else
{
if (getline(fin, line, MAXLINE)!=0)
{
    place(line, " 001"); /*place item code*/
    place(line, " "); /*place bill name - 2nd part*/
}
ITEM.C

#include <stdio.h>
#include <ctype.h>
#include <conio.h>
#include <string.h>
#include <stdlib.h>
#include "cinter.h"

#define MAXLINE 256
extern char cont_name[5][37],ten_date[10],proj_ref_num[36];
extern FILE *fp1,*fp2;

item_conv(bq_line)
char bq_line[11][MAXLINE];
{
    do
    {
        if (strncmpi("QTYB",bq_line[1],4)==0) item_1(bq_line);
        scroll_bq_line(fp1,bq_line);
    } while(strncmpi(bq_line[1],"UNT ",4)!==0 || strlen(bq_line[1])>1);
    return 1;
}

/*read in and output to CATO file details of one item*/
item_1(bq_line)
char bq_line[11][MAXLINE];
{
    char unit_conv1[10][5]={'m","m2","m3","t","hr","nr","n","IT"};
    char unit_conv2[10][5]={'MTR","MTK","MTQ","TNE","HUR","NMB","NMB","IT"};
    char quant[20],unit[5],alt_id[10],line[50],rate[20];
    char temp_store[20];
    int a;
    long unsigned int la;
    FILE *fin;
    /* read in quant,unit and rate*/
    text_copy(quant,bq_line[1],9);
    la=atol(quant);
    la=la/10;
    sprintf(quant,"%010lu",la);
    /* convert units */
    text_copy(unit,bq_line[1],25);
    clear_string(unit);
    for (a=0;a<=7;a++)
    {
        if (strcmp(unit,unit_conv2[a])==0)
        {
            strcpy(unit,unit_conv1[a]);
            break;
        }
    }
    /*search for rate*/
    while(strncmpi("PRI TEN",bq_line[1],8)!=0) scroll_bq_line(fp1,bq_line);
    text_copy(rate,bq_line[1],9);
    la=atol(rate);
    la=la/10;
    sprintf(rate,"%010lu",la);
    /*search for alternative ref.*/
    while(strncmpi("BIID",bq_line[1],4)!=0) scroll_bq_line(fp1,bq_line);
    text_copy(alt_id,bq_line[1],117);
    clear_string(alt_id);
    sprintf(temp_store,"%5s",alt_id);
    strcpy(alt_id,temp_store);
    /*output item details to file*/
    /*open BPHDX data file */
    if ((fin=fopen("BPDET.DAT","rt"))==NULL)
    {
        puts("BPDET data file not available");
    }
return 0;
}
else
{
    if (getline(fin,line,MAXLINE)!=0)
    {
        place(line,alt_id); /*place item code*/
        place(line,unit); /*place item unit*/
        place(line," "); /*place filler*/
        place(line,quant); /*place quantity*/
        place(line," "); /*place rate indicator*/
        place(line,rate); /*place rate*/
        place(line,"0"); /*place adjustment code*/
        place(line," "); /*place rogue indicator*/
        place(line," "); /*place star indicator*/
        place(line," "); /*place filler*/
    }
    fputs(line,fp2);
}
fclose(fin);

return 1;
}

ROUTINE.C
#include <conio.h>
#include <ctype.h>
#include <stdio.h>
#include <string.h>
#include "cinter.h"
#define MAXLINE 256

strip_string(line1)
char line1[];
{
    int a,b=0,l;
    char line2[MAXLINE];
    l=strlen(line1)-1;
    for (a=0;a<l;a+=2)
    {
        line2[b]=line1[a];
        b++;
    }
    line2[b]=\0;
    strcpy(line1,line2);
    clear_string(line1);
    return 1;
}

fput(line,fp)
char line[];
FILE *fp;
{
    fputs(line,fp);
    strset(line," ");
}
line[127]="\n";
return 1;
}

d_name_address(nad)
char nad[6][36];
{
int a;
char resp[36];
window(3,5,41,12);
textcolor(14);
textbackground(1);
cilscr();
puts("NAME AND ADDRESS DATA ENTRY");
gotoxy(1,2);puts("5 lines of up to 35 characters");
for (a=1;a<=5;a++)
{
    gotoxy(1,a+3);
    puts("->");
    gotoxy(38,a+3);
    puts("<-");
}
for (a=1;a<=5;a++)
{
do
    gotoxy(3,a+3);
    gets(resp);
}
while(strlen(resp)>35);
/* ensure a space covers '*' flag in edifact file */
if (strlen(resp)<=0) strcpy(resp," ");
strcpy(nad[a-1],resp);
window(2,3,79,24);
textcolor(15);textbackground(0);
return 1;
}

put_string(line1,line2,pos)
char line1[],line2[];
int pos;
{
int a,b=0;
/* put line2 into line1 starting at pos (no \0 is transferred)*/
for (a=pos;a<pos+strlen(line2);a++)
{
    line1[a]=line2[b];
    b++;
}
return 1;
}

clear_string(line)
char line[];
{
int a:
/* clear spaces and control chars from end of string */
a = strlen(line);
do {
    line[a] = '0';
a--;
} while(isalnum(line[a]) == 0);
return 1;
}

scroll_bq_line(fp1, bq_line)
FILE *fp1;
char bq_line[11][MAXLINE];
int a;
for (a = 1; a < 9; a++) strcpy(bq_line[a], bq_line[a + 1]);
if ((getline(fp1, bq_line[10], MAXLINE)) == 0) strset(bq_line[10], '0');
return 1;
}

place(line, data)
char line[], data[];
{
    int a, length;
    char *ptr, *pt2, c = '*';
    length = strlen(line);
    if ((ptr = strchr(line, c)) != NULL)
        return 1;
    for (a = 0; a < strlen(data); a++)
    {
        line[ptr - line] = data[a];
        ptr++;
    }
    if ((ptr - line) >= length)
    {
        line[ptr - line] = '
';
        line[ptr - line + 1] = '0';
    }
    return 1;
}

desc_create(desc, bill_line, pos, underline, desc_end, last_line)
char desc[], bill_line[11][MAXLINE];
int pos, underline, desc_end, last_line;
{
    int a, b = 1, inc, end_pos, c;
    char aline[MAXLINE];
    /* clear variables */
    strset(aline, '0');
    strset(desc, '0');
    a = pos;
    inc = 1 + underline;
do {
    if ((end_pos = strlen(bill_line[b]) - 2) > desc_end) end_pos = desc_end;
portion_copy(aline,bill_line[b],pos,end_pos);
strcat(desc,aline);
strcat(desc," ");
b+=inc;
a=text_start(bill_line[b],0);
if (underline==1 && bill_line[b+1][pos]!=' ') break;
}
while(a==pos && b<10 && bill_line[b-inc][last_line]==' ');
if (b==10) return 0;
c=strlen(desc)-1;
/* knock spaces off end of description */
while (desc[c]==' ')
{
    desc[c]='\0';
c--;
}
return b-inc;
}

desc_div(line,string)
char line[10][36],string[];
{
int a,opos=0,b=1;
while (opos+34<=strlen(string))
{
    a=opos+34;
    while (string[a]==' ') a--;
    portion_copy(line[b],string,opos,a);
    opos=a+1;
    b++;
}
portion_copy(line[b],string,opos,strlen(string));
if (b>10) return 0;
return b;
}

int text_start(line,i)
char line[];
int i;
{
int length;
length = strlen(line);
/* find first non-space character */
while ((line[i]==' ') && (i < length)) i++;
if (i==length) return NULL;
return i;
}

portion_copy(line1,line2,pos1,pos2)
char line1[],line2[];
int pos1,pos2;
{
int a,b=0;
/* copy portion of line2 to line1 */
for (a=pos1;a<=pos2;a++)
{
line1[b]=line2[a];
b++;}

/* knock space and control characters off the end of destination string (line1) */
do
{    line1[b]='\0';
b--;}
while(isalnum((line1[b]))==0);
return 1;

/*copy text up to first space from line2 to line I starting at position pos */
int text_copy(line I,line2,pos)
char line I[] ,line2[];
int pos;
{
    int b=0;
    while (line2[pos]!=' ' && line2[pos]!='\0')
    {
        line1[b]=line2[pos];
b++;
pos++;
    }
    line1[b]='\0';
return b;
}

/*copies string2 to string1 starting after gap no.(gaps) in string2*/
/*a gap is one or more consecutive spaces*/
int text_copy_gap(line I,line2,gaps)
char line I[] ,line2[];
int gaps;
{
    int gap_count=0,a=0,start=0,length;
    length=strlen(line2);
    while(gaps!=gap_count)
    {
        while(line2[a] !=' ')a++;
        if (line2[a-1] !=' ') gap_count++;
a++;
        if (a>=length)
        {
            return NULL;
        }
        start=text_start(line2,a);
text_copy(line I ,line2,start);
return 1;
    }
}

int text_copy_backwards(line I,line2,pos)
char line I[] ,line2[];
int pos;
{
    int a,b=0,length;

H-56
/* find text */
while ((line2[pos] == ' ') && (pos > 0)) pos--;
/* read text into line1 */
while (line2[pos]!= ' ' && pos>=0)
{    
    line1[b]=line2[pos];
    b++;
    pos--;
}
line1[b]=\0;
/* reverse line1 */
strrev(line1);
return b;

int getline(fp,line,max)
FILE *fp;
char line[];
int max;
{
    if (fgets(line,max,fp) == NULL)
        return(NULL);
    else
        return strlen(line);
}
Appendix I

Sample bill of quantities and associated CONITT message, CONTEN message and CATO file format
Bill of quantities

24-Aug-93

<table>
<thead>
<tr>
<th>BILL Nr 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>LIBRARY</td>
</tr>
<tr>
<td>FOUNDATIONS</td>
</tr>
<tr>
<td>D GROUNDWORK</td>
</tr>
<tr>
<td>D20 EXCAVATING AND FILLING</td>
</tr>
</tbody>
</table>

Site Preparation

Top soil for preservation

<table>
<thead>
<tr>
<th>DB022</th>
<th>A</th>
<th>150 average depth</th>
<th>634 m2</th>
</tr>
</thead>
</table>

Excavation

To reduce levels

<table>
<thead>
<tr>
<th>DB103</th>
<th>B</th>
<th>0.25 m maximum depth</th>
<th>21 m3</th>
</tr>
</thead>
<tbody>
<tr>
<td>DB112</td>
<td>C</td>
<td>1 m maximum depth</td>
<td>20 m3</td>
</tr>
</tbody>
</table>

Basements and the like

<table>
<thead>
<tr>
<th>DB213</th>
<th>D</th>
<th>1 m maximum depth</th>
<th>121 m3</th>
</tr>
</thead>
</table>

For pile caps and ground beams between piles

<table>
<thead>
<tr>
<th>DB626</th>
<th>E</th>
<th>starting from reduced level; over 0.3 m wide; 0.25 m maximum depth</th>
<th>2 m3</th>
</tr>
</thead>
<tbody>
<tr>
<td>DB628</td>
<td>F</td>
<td>starting from reduced level; over 0.3 m wide; 1 m maximum depth</td>
<td>25 m3</td>
</tr>
<tr>
<td>DB62A</td>
<td>G</td>
<td>starting from reduced level; over 0.3 m wide; 2 m maximum depth</td>
<td>9 m3</td>
</tr>
<tr>
<td>DB62G</td>
<td>H</td>
<td>starting from basement level; over 0.3 m wide; not exceeding 0.25 m maximum depth</td>
<td>6 m3</td>
</tr>
</tbody>
</table>

Working space allowance to excavations

I-2
basements or the like; backfilling with selected excavated material; not exceeding 1 m deep 6 m³

pile caps or trenches for ground beams; backfilling with selected excavated material; not exceeding 0.25 m deep 12 m³
Foundations

Working space allowance to excavations

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
<th>Allowance</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>DBD85</td>
<td>A pile caps or trenches for ground beams; backfilling with selected excavated material; not exceeding 1 m deep</td>
<td>13</td>
<td>m³</td>
</tr>
<tr>
<td>DBD87</td>
<td>B pile caps or trenches for ground beams; backfilling with selected excavated material; not exceeding 2 m deep</td>
<td>15</td>
<td>m³</td>
</tr>
</tbody>
</table>

To faces of excavation

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
<th>Allowance</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>DC111</td>
<td>C 1 m maximum depth; distance between opposing faces not exceeding 2 m</td>
<td>100</td>
<td>m²</td>
</tr>
<tr>
<td>DC114</td>
<td>D 1 m maximum depth; distance between opposing faces over 4 m</td>
<td>24</td>
<td>m²</td>
</tr>
<tr>
<td>DC312</td>
<td>E 2 m maximum depth; distance between opposing faces not exceeding 2 m</td>
<td>32</td>
<td>m²</td>
</tr>
<tr>
<td>DC317</td>
<td>F 2 m maximum depth; distance between opposing faces over 4 m</td>
<td>23</td>
<td>m²</td>
</tr>
</tbody>
</table>

Bottoms of excavations

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
<th>Allowance</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>DCA42</td>
<td>G levelling; compacting</td>
<td>322</td>
<td>m²</td>
</tr>
</tbody>
</table>

Excavated material

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
<th>Allowance</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>DCB14</td>
<td>H off site</td>
<td>204</td>
<td>m³</td>
</tr>
</tbody>
</table>

Preserved topsoil

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
<th>Allowance</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>DCB17</td>
<td>I depositing on site in permanent spoil heaps located to Contractor's discretion</td>
<td>95</td>
<td>m³</td>
</tr>
</tbody>
</table>

Sundries in excavation and earthwork

Disposal of water

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
<th>Allowance</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>DCB63</td>
<td>J keeping the surface of the site and the excavations free of surface water</td>
<td>ITEM</td>
<td></td>
</tr>
</tbody>
</table>

Dry sand

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
<th>Allowance</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>DE005</td>
<td>K 50 mm thick; to excavations</td>
<td>219</td>
<td>m²</td>
</tr>
</tbody>
</table>
DE008  L  50 thick; to hardcore filling  297 m²
DE009  M  50 thick; to bottom of trenches  103 m²

---

To Collection  ø

4/2
24-Aug-93

Foundations

Filling; hardcore to be obtained off site

Filling

DE140 A to make up levels 83 m³
DE141 B to make up levels average 50 thick 20 m²
DE145 C to make up levels average 100 thick 46 m²
DE147 D to make up levels average 150 thick 42 m²
DE149 E to make up levels average 200 thick 10 m²
DE14B F to make up levels average 250 thick 1 m²

Surfaces of filling

DF213 G levelling; compacting 297 m²

D30 CAST IN PLACE CONCRETE PILING

Reinforced in-situ concrete; sulphate resisting; mix

1 strength grade 30 - 20 mm aggregate

450 mm diameter

DG022 H total completed length; 51 Nr 542 m
DG023 I total bored depth of piles 5 - 10 m long 199 m
DG025 J total bored depth of piles 10 - 15 m long 276 m
DG026 K total bored depth of piles 15 - 20 m long 96 m
DG028 L total length of extensions; 17 Nr 6 m
DG029 M cutting off tops to required levels 51 nr
DG02B N preparing heads and reinforcement for capping 51 nr

Reinforcement bars; BS 4449, hot rolled mild steel

16 mm; straight or bent in
DGZ31 O piles; 8 - 11 m long, vertical or sloping more than 30 degrees from horizontal 2.68 t

To Collection  4/3
24-Aug-93

16 mm; straight or bent in

DGZ33 A piles; 11 - 14 m long, vertical or sloping more than 30 degrees from horizontal 2.89 t

DGZ35 B piles; 14 - 17 m long, vertical or sloping more than 30 degrees from horizontal 1.63 t

6 mm; curved

DGZ37 C in piles 6.31 t

Sundries

Excavated material

DGZ77 D removing from site 95 m3

E IN SITU CONCRETE/LARGE PRECAST CONCRETE

E10 IN SITU CONCRETE

Plain in-situ concrete; sulphate resisting; mix 2

strength grade 7 - 10 mm aggregate

Filling hollow walls

EA187 E not exceeding 100 thick 6 m3

Reinforced in-situ concrete; sulphate resisting; mix

strength grade 30 - 20 mm aggregate

Ground beams

EB731 F sectional area over 0.25 m2 14 m3

EB733 G sectional area 0.10 - 0.25 m2 3 m3

EB736 H sectional area 0.03 - 0.10 m2 16 m3

Pile caps

EB757 I 39 Nr 21 m3
Beds

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
<th>Thickness</th>
<th>Volume</th>
</tr>
</thead>
<tbody>
<tr>
<td>EB773</td>
<td>J</td>
<td>150 - 300 thick</td>
<td>109 m³</td>
</tr>
</tbody>
</table>

Walls not exceeding 1.5 m high

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
<th>Thickness</th>
<th>Volume</th>
</tr>
</thead>
<tbody>
<tr>
<td>EB793</td>
<td>K</td>
<td>150 - 300 thick</td>
<td>5 m³</td>
</tr>
</tbody>
</table>

To Collection αɛ

4/4
Treating surface of unset concrete

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
<th>Area</th>
<th>Reinforcement bars; BS 4449, hot rolled mild steel</th>
</tr>
</thead>
<tbody>
<tr>
<td>EB803</td>
<td>A tamping</td>
<td>585 m²</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>10 mm; straight or bent, in</td>
</tr>
<tr>
<td>EL8A9</td>
<td>B foundations</td>
<td>0.12 t</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>6 mm; straight or bent, in</td>
</tr>
<tr>
<td>EL8AB</td>
<td>C foundations</td>
<td>0.02 t</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>12 mm; links or the like, in</td>
</tr>
<tr>
<td>EL8N3</td>
<td>D foundations</td>
<td>0.18 t</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>10 mm; links or the like, in</td>
</tr>
<tr>
<td>EL8S3</td>
<td>E foundations</td>
<td>0.56 t</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>8 mm; links or the like, in</td>
</tr>
<tr>
<td>EL8S9</td>
<td>F foundations</td>
<td>0.50 t</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>40 mm; straight or bent, in</td>
</tr>
<tr>
<td>EL8T1</td>
<td>G foundations</td>
<td>0.24 t</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>32 mm; straight or bent, in</td>
</tr>
<tr>
<td>EL8T3</td>
<td>H foundations</td>
<td>2.48 t</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>25 mm; straight or bent, in</td>
</tr>
<tr>
<td>EL8T5</td>
<td>I foundations</td>
<td>2.68 t</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>20 mm; straight or bent, in</td>
</tr>
<tr>
<td>EL8T7</td>
<td>J foundations</td>
<td>1.00 t</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
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I-10
24-Aug-93

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<th>10 mm; straight or bent, in</th>
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<td>EL8TE B ground slabs</td>
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<td>EL8TG C foundations</td>
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Foundations

Collection

4/1
4/2
4/3
4/4
4/5
4/6
To Summary 

4/7
CONITT Message

UNH MESS1234   CONITT 92 1 UN
BGM 208        DOC1234
RFF AEP PROJ1234
DTM 137.971122  101
AUT PASSWORD
AUT TONY LEWIS
AGR FOT JCT80
AGR ODW JCT80
IND PJT DEF 00000
RCS 1 DUMMY
GIS 1
BII INX
IMD B IXH A BILL
IND PJT DEF 00000
RCS 1 DUMMY
GIS 2
BII INX
IMD B IXH A SECTION
IND PJT DEF 00000
RCS 1 DUMMY
GIS 3
BII INX
IMD B IXH A SUB-SECTION
IND PJT CON 00000
RCS 1 DUMMY
GIS 1
BII INX
IMD B IXH A Foundations
IND PJT CON 00000
RCS 1 DUMMY
GIS 2
BII INX
IMD B IXH A GROUNDWORK
IND PJT CON 00000
RCS 1 DUMMY
GIS 3
BII INX
IMD B IXH A EXCAVATING AND FILLING
IND PJT CON 00000
RCS 1 DUMMY
GIS 3
BII INX
IMD B IXH A CAST IN PLACE CONCRETE PILING
IND PJT CON 00000
RCS 1 DUMMY
GIS 3
BII INX
IMD B IXH A IN SITU CONCRETE/LARGE PRECAST
IND PJT CON 00000
RCS 1 DUMMY
GIS 3
BII INX
IMD B IXH A CONCRETE
RCSA 1 DUMMY

I-16
GISAPRJ
NAD EL PROJECT HOUSE PROJECT ROAD
CAMBRIDGE UK
LOC SHN PROJECT HOUSE PROJECT ROAD
DTMA 286 971231 101
RFFA SS CATO CONVERSION BY TONY LEWIS
RFFA IA TONY LEWIS
RFFA SMM SMM7
GISB NO
FTX SMM 1 SMM7 has been used
CUX 2 GBP 0000 0000 000000000
NAD CLI A. CLIENT & CO. STATION ROAD
CAMBRIDGE UK
NAD ARC NICE VIEW ARCHITECTS WARNERS AVENUE
CAMBRIDGE UK
NAD PQS ABACUS (QS) LTD PEAR TREE LANE
CAMBRIDGE UK
NAD ENG CONSULTANTS 'R' US CONCRETE DESIGN HOUSE
STATION ROAD CAMBRIDGE UK
UNS D
BIC IDX 4 D D20 1A
RCSC 1 DUMMY 1
GISC IT WI
LIN 000004 1 00
IMDA B HEA A Site Preparation
LIN 000005 1 00
IMDA B HEA A Top soil for preservation
LIN 000006 1 00
IMDA B DES A 150 average depth
QTYB 99 000000000340000 MTK
GISE QSO 4
GISE QST 2
BIID INX
DB022
GISG ALT
BIC IDX 4 D D20 1B
RCSC 1 DUMMY 1
GISC IT WI
LIN 000004 1 00
IMDA B HEA A Excavation
LIN 000005 1 00
IMDA B HEA A To reduce levels
LIN 000006 1 00
IMDA B DES A 0.25 m maximum depth
QTYB 99 000000000210000 MTQ
GISE QSO 4
GISE QST 2
BIID INX
DB103
GISG ALT
BIC IDX 4 D D20 1C
RCSC 1 DUMMY 1
GISC IT WI
LIN 000006 1 00
IMDA B DES A 1 m maximum depth
QTYB 99 000000000200000 MTQ
GISE QSO 4
GISE QST 2
BIID INX
DB112
GISG ALT
BIC IDX 4 D D20 1D

I-17
IMDA B HEA A Basements and the like
IMDA B DES A 1 m maximum depth
QTYB 99 0000000121000 MTQ
GISE QSO 4
GISE QST 2
BIID INX
GISS ALT
BIIC IDX 4 D D20
RCSC 1 DUMMY 1
IMDA B HEA A For pile caps and ground beams
IMDA B HEA B between piles
IMDA B DES A starting from reduced level; over
IMDA B DES B 0.3 m wide; 0.25 m maximum depth
QTYB 99 000000020000 MTQ
GISE QSO 4
GISE QST 2
BIID INX
GISS ALT
BIIC IDX 4 D D20
RCSC 1 DUMMY 1
IMDA B DES A starting from reduced level; over
IMDA B DES B 0.3 m wide; 1 m maximum depth
QTYB 99 000000250000 MTQ
GISE QSO 4
GISE QST 2
BIID INX
GISS ALT
BIIC IDX 4 D D20
RCSC 1 DUMMY 1
IMDA B DES A starting from basement level; over
IMDA B DES B 0.3 m wide; not exceeding 0.25 m
IMDA B DES C maximum depth
QTYB 99 0000006000 MTQ
GISE QSO 4
GISE QST 2
BIID INX
GISS ALT
IMDAB HEAA Working space allowance to excavations
IMDAB DESA pile caps or trenches for ground beams; backfilling with selected excavated material; not exceeding 1 m deep
IMDAB DESB pile caps or trenches for ground beams; backfilling with selected excavated material; not exceeding 0.25 m deep
IMDAB DESD pile caps or trenches for ground beams; backfilling with selected excavated material; not exceeding 1 m deep
IMDAB DESD pile caps or trenches for ground beams; backfilling with selected excavated material; not exceeding 2 m deep
IMDA B HEA A To faces of excavation
IMDA B DES A 1 m maximum depth; distance
IMDA B DES B between opposing faces not exceeding 2 m
IMDA B DES C exceeding 2 m

IMDA B HEA A Bottoms of excavations
IMDA B DES A 1 m maximum depth; distance
IMDA B DES B between opposing faces not over 4 m
IMDA B DES C exceeding 2 m
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<td>IMDA B DES B</td>
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<td>Contractor’s discretion</td>
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<td>GISE QSO 4</td>
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I-21
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<td>to make up levels average 100</td>
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<td>IMDA B DES A</td>
<td>to make up levels average 150</td>
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- IMDA B HEA A: Filling
- IMDA B HEA B: Off site
- IMDA B DES A: hardcore
- IMDA B DES B: hardcore
- IMDA B DES A: to make up levels 50
- IMDA B DES B: to make up levels 100
- IMDA B DES A: to make up levels 150
| IMDA B | DES B thick | QTYB 99 000000000042000 MTK |
| GISE QSO 4 | GISE QST 2 | BIID INX |
| GISP ALT | BIIC IDX 4 | RCSC 1 DUMMY 1 |
| GISC IT WI | LIN 000006 1 | 00 |
| IMDA B DES A | to make up levels average 200 |
| IMDA B DES B thick | QTYB 99 000000000010000 MTK |
| GISE QSO 4 | GISE QST 2 | BIID INX |
| GISP ALT | BIIC IDX 4 | RCSC 1 DUMMY 1 |
| GISC IT WI | LIN 000006 1 | 00 |
| IMDA B DES A | to make up levels average 250 |
| IMDA B DES B thick | QTYB 99 000000000010000 MTK |
| GISE QSO 4 | GISE QST 2 | BIID INX |
| GISP ALT | BIIC IDX 4 | RCSC 1 DUMMY 1 |
| GISC IT WI | LIN 000005 1 | 00 |
| IMDA B HEA A | Surfaces of filling |
| LIN 000006 1 | 00 |
| IMDA B DES A | levelling; compacting |
| QTYB 99 000000000297000 MTK |
| GISE QSO 4 | GISE QST 2 | BIID INX |
| GISP ALT | BIIC IDX 4 | RCSC 1 DUMMY 1 |
| GISC IT WI | LIN 000004 1 | 00 |
| IMDA B HEA A | Reinforced in-situ concrete; |
| IMDA B HEA B | sulphate resisting; mix 1 strength |
| IMDA B HEA C | grade 30 - 20 mm aggregate |
| LIN 000005 1 | 00 |
| IMDA B HEA A | 450 mm diameter |
| LIN 000006 1 | 00 |
| IMDA B DES A | total completed length; 51 Nr |
| QTYB 99 000000000542000 MTR |
| GISE QSO 4 | GISE QST 2 | BIID INX |
| GISP ALT | BIIC IDX 4 | RCSC 1 DUMMY 1 |
| GISC IT WI | LIN 000004 1 | 00 |
| IMDA B HEA A | Reinforced in-situ concrete; |
| IMDA B HEA B | sulphate resisting; mix 1 strength |
| IMDA B HEA C | grade 30 - 20 mm aggregate |
| LIN 000005 1 | 00 |
| IMDA B HEA A | 450 mm diameter |
| LIN 000006 1 | 00 |
| IMDA B DES A | total completed length; 51 Nr |
| QTYB 99 000000000542000 MTR |
| GISE QSO 4 | GISE QST 2 | BIID INX |
| GISP ALT | BIIC IDX 4 | RCSC 1 DUMMY 1 |
| GISC IT WI | LIN 000004 1 | 00 |
| LIN 000006 | 00 |
| IMDA B DES A | total bored depth of piles 5 - 10 |
| IMDA B DES B | m long |
| QTBY 99 | 00000000276000 MTR |
| GISE QSO 4 |
| GISE QST 2 |
| BIID INX |
| GISP ALT |
| BIIC IDX 4 D | D30 |
| RCSC 1 DUMMY | 1 |
| GISG IT WI |
| LIN 000006 | 00 |
| IMDA B DES A | total bored depth of piles 10 - 15 |
| IMDA B DES B | m long |
| QTBY 99 | 00000000276000 MTR |
| GISE QSO 4 |
| GISE QST 2 |
| BIID INX |
| GISP ALT |
| BIIC IDX 4 D | D30 |
| RCSC 1 DUMMY | 1 |
| GISG IT WI |
| LIN 000006 | 00 |
| IMDA B DES A | total length of extensions; 17 Nr |
| IMDA B DES B | m long |
| QTBY 99 | 00000000276000 MTR |
| GISE QSO 4 |
| GISE QST 2 |
| BIID INX |
| GISP ALT |
| BIIC IDX 4 D | D30 |
| RCSC 1 DUMMY | 1 |
| GISG IT WI |
| LIN 000006 | 00 |
| IMDA B DES A | cutting off tops to required levels |
| IMDA B DES B | |
| QTBY 99 | 0000000051000 NMB |
| GISE QSO 4 |
| GISE QST 2 |
| BIID INX |
| GISP ALT |
| BIIC IDX 4 D | D30 |
| RCSC 1 DUMMY | 1 |
| GISG IT WI |
| LIN 000006 | 00 |
| IMDA B DES A | preparing heads and reinforcement |
| IMDA B DES B | for capping |
| QTBY 99 | 0000000051000 NMB |
| GISE QSO 4 |
IMDAB HEAA Reinforcement bars; BS 4449, hot rolled mild steel
IMDAB HEAA 16 mm; straight or bent in
IMDAB DES A piles; 8 - 11 m long, vertical or sloping more than 30 degrees from horizontal
IMDAB DES B 11 - 14 m long, vertical or sloping more than 30 degrees from horizontal
IMDAB DES C 14 - 17 m long, vertical or sloping more than 30 degrees from horizontal
IMDAB in piles
IMDAB 6 mm; curved in piles
IMDAB horizontal
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<tr>
<td>IMDA B HEA A</td>
<td>Sundries</td>
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<td>IMDA B DES A</td>
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<td>IMDA B HEA A</td>
<td>Plain in-situ concrete; sulphate resisting; mix 2 strength grade 7</td>
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<td>IMDA B HEA C</td>
<td>10 mm aggregate</td>
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<td>IMDA B HEA A</td>
<td>Filling hollow walls</td>
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<td>IMDA B HEA C</td>
<td>grade 30 - 20 mm aggregate</td>
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<td>IMDA B HEA A</td>
<td>Ground beams</td>
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<td>IMDA B DES A</td>
<td>sectional area over 0.25 m²</td>
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<td>IMDA B DES A</td>
<td>sectional area 0.10 - 0.25 m²</td>
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I-26
IMDA B  DES A  sectional area 0.03 - 0.10 m²
QTQB 99  0000000000160000 MTQ
GISE QSO 4
GISE QST 2
BIID INX
GISG ALT
BIIC IDX 4  E  E10
RCSC 1  DUMMY  1
GISC IT WI
LIN 000005 1  00
IMDA B  HEA A  Pile caps
LIN 000006 1  00
IMDA B  DES A  39 Nr
QTQB 99  0000000000210000 MTQ
GISE QSO 4
GISE QST 2
BIID INX
GISG ALT
BIIC IDX 4  E  E10
RCSC 1  DUMMY  1
GISC IT WI
LIN 000005 1  00
IMDA B  HEA A  Beds
LIN 000006 1  00
IMDA B  DES A  150 - 300 thick
QTQB 99  0000000001090000 MTQ
GISE QSO 4
GISE QST 2
BIID INX
GISG ALT
BIIC IDX 4  E  E10
RCSC 1  DUMMY  1
GISC IT WI
LIN 000005 1  00
IMDA B  HEA A  Walls not exceeding 1.5 m high
LIN 000006 1  00
IMDA B  DES A  150 - 300 thick
QTQB 99  0000000000500000 MTQ
GISE QSO 4
GISE QST 2
BIID INX
GISG ALT
BIIC IDX 4  E  E10
RCSC 1  DUMMY  1
GISC IT WI
LIN 000005 1  00
IMDA B  HEA A  Treating surface of unset
IMDA B  HEA B  concrete
LIN 000006 1  00
IMDA B  DES A  tamping
QTQB 99  0000000005850000 MTK
GISE QSO 4
GISE QST 2
BIID INX
GISG ALT
BIIC IDX 4  E  E10
RCSC 1  DUMMY  1
GISC IT WI
LIN 000004 1  00
IMDA B HEA A Reinforcement bars; BS 4449, hot rolled mild steel
IMDA B HEA B
LIN 000005 1 00
IMDA B HEA A 10 mm; straight or bent, in
LIN 000006 1 00
IMDA B DES A foundations
QTYB 99 0000000000000120 TNE
GISE QSO 4
GISE QST 2
BIID INX
GISG ALT
BIIC IDX 4 E E10
RCSC 1 DUMMY 1
GISC IT WI
LIN 000005 1 00
IMDA B HEA A 6 mm; straight or bent, in
LIN 000006 1 00
IMDA B DES A foundations
QTYB 99 0000000000000180 TNE
GISE QSO 4
GISE QST 2
BIID INX
GISG ALT
BIIC IDX 4 E E10
RCSC 1 DUMMY 1
GISC IT WI
LIN 000005 1 00
IMDA B HEA A 12 mm; links or the like, in
LIN 000006 1 00
IMDA B DES A foundations
QTYB 99 000000000000180 TNE
GISE QSO 4
GISE QST 2
BIID INX
GISG ALT
BIIC IDX 4 E E10
RCSC 1 DUMMY 1
GISC IT WI
LIN 000005 1 00
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IMDA B DES A foundations
QTYB 99 00000000000560 TNE
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GISE QST 2
BIID INX
GISG ALT
BIIC IDX 4 E E10
RCSC 1 DUMMY 1
GISC IT WI
LIN 000005 1 00
IMDA B HEA A 8 mm; links or the like, in
LIN 000006 1 00
IMDA B DES A foundations
QTYB 99 00000000000500 TNE
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GISE QST 2
BIID INX
GISG ALT

EL8A9
EL8AB
EL8N3
EL8S3
EL8S9
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<td>IMDAB HEAE</td>
<td>20 mm; straight or bent, in foundations</td>
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<td>IMDAB HEAF</td>
<td>16 mm; straight or bent, in foundations</td>
<td>99</td>
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IMDA B HEA A 12 mm; straight or bent, in
foundations

IMDA B DES A

QTYB 99 000000000000770 TNE

GISE QSO 4

GIQST 2

BIID INX

GIGSC ALT

BIIC IDX 4 E E10 6A

RCSC 1 DUMMY 1

GISC IT WI

LIN 000005 1 00

IMDA B HEA A 10 mm; straight or bent, in
foundations

QTYB 99 00000000000300 TNE

GISE QSO 4

GIQST 2

BIID INX

GIGSC ALT

BIIC IDX 4 E E10 6B

RCSC 1 DUMMY 1

GISC IT WI

LIN 000006 1 00

IMDA B DES A ground slabs

QTYB 99 00000000006040 TNE

GISE QSO 4

GIQST 2

BIID INX

GIGSC ALT

BIIC IDX 4 E E10 6C

RCSC 1 DUMMY 1

GISC IT WI

LIN 000005 1 00

IMDA B HEA A 8 mm; straight or bent, in
foundations

QTYB 99 00000000000010 TNE

GISE QSO 4

GIQST 2

BIID INX

GIGSC ALT

CNT 1 00000004909090
UNT 871 MESS1234
CONTEN Message

UNH MESS54321  CONTEN 92  1 UN
BGM 209  DOC54321
RFF AEP PROJ1234
DTM 137 971125  101
AUT PASSWORD2
AUT TONY CONTRACTOR
BIII A INX
RCSA 1 DUMMY  1
GISA PRJ
DTMA 286 971231  101
ARD XXX  0000
MOAD TEN 000000000077652210 GBP
NADB EN N.E. CONTRACTOR LTD  ASHPHALT ROAD
CAST IRON TRADING ESTATE  CAMBRIDGE  UK
UNS D
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RCSC 1 DUMMY  1
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GISC IT WI
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MOAD TEN 000000000052500 GBP
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BIIIC IDX 4 D D20  1C
RCSC 1 DUMMY  1
GISC IT WI
QTYB 99 00000000350000 MTQ
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ARDA XXX  0000
MOAD TEN 0000000000700000 GBP
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BIIIC IDX 4 D D20  1D
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GISC IT WI
QTYB 99 00000000121000 MTQ
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ARDA XXX  0000
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BIIID INX  DB213
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RCSC 1 DUMMY  1
GISC IT WI
QTYB 99 000000000020000 MTQ
PRI TEN 00000000100000 PU  0000000000 MT

I-31
ARDAXXX 0000
MOAD TEN 000000000001020000 GBP
BIID INX D20
BIIC IDX 4 D20
RCSC 1 DUMMY 1
GISC IT WI
QTYB 99 0000000000950000 MTQ
PRI TEN 000000000035000 PU 000000000000
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BIIC IDX 4 D20
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GISC IT WI
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MOAD TEN 0000000000150000 GBP
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BIIC IDX 4 D20
RCSC 1 DUMMY 1
GISC IT WI
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GISC IT WI
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PRI TEN 000000003000000 PU 00000000000000000 MT
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ARDA XXX 0000
MOAD TEN 000000000005970000 GBP
BIID INX
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RCSC 1 DUMMY 1
GISC IT WI
QTYB 99 000000002760000 MTR
PRI TEN 00000000054500000 PU 00000000000000000 MT
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I-38
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RCSC 1  DUMMY  1
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BIIC IDX4  E  E10  EL8T5
RCSC 1  DUMMY  1
GISC IT WI
QTYB 99 00000000001000 TNE
PRI TEN 000000000250000 PU 0000000000 MT
GISF RSO 4
ARDA XXX 0000
MOAD TEN 0000000000025000 GBP
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BIIC IDX4  E  E10  EL8T7
RCSC 1  DUMMY  1
GISC IT WI
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PRI TEN 000000000200000 PU 0000000000 MT
GISF RSO 4
ARDA XXX 0000
MOAD TEN 000000000053600 GBP
BIID INX
BIIC IDX4  E  E10  EL8T9
RCSC 1  DUMMY  1
GISC IT WI
QTYB 99 00000000000770 TNE
PRI TEN 000000000180000 PU 0000000000 MT
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ARDA XXX 0000
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BIIC IDX4  E  E10  EL8TB
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GISC IT WI
QTYB 99 00000000000300 TNE
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GISC IT WI
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I-40
CATO File Format

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DGZ33t 0000000289 0000009500
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Appendix J

EDICON implementation of the bill of quantities message set
J.1.1 Introduction

The completion of the development and ratification, by the western European EDIFACT board, of the bill of quantities messages was achieved by July 1992 (Lewis 1993). Once the set of messages had been developed EDICON focused its attention on the implementation of the bill of quantities messages. In 1992 EDICON had only implemented EDIFACT messages which were developed by other groups and which had already been implemented in other industries. The bill of quantities messages provided the first test of EDICON's ability to undertake the complete development cycle of an EDI message. The success or failure of the implementation of the EDIFACT message would therefore indicate the validity of the selection, development and implementation processes used by EDICON.

To implement the bill of quantities messages EDICON identified 3 working parties consisting of interested representatives from construction related companies. The working parties operated under a small steering committee. Each working party was assigned an area of implementation to investigate.

By July 1992 EDICON had determined what it considered the key issues of implementation and the tasks to be undertaken by the working parties. The objectives and achievements of the working parties are described in the following sections.
J.1.2 Key issues of implementation

EDICON identified the following as key issues which required resolving to achieve a successful implementation of the bill of quantities messages.

1 Co-ordination and standardisation of the use of the messages
2 Preparation of documentation, training and advisory services
3 Advice and support for software developers
4 Attention to the procedures that surround the use of the messages
5 Promotion of EDI as a new construction industry business method
6 Analysis of the “futures” available with the messages
7 Liaison with message developers

(EDICON 1992)

A number of subsidiary issues were identified regarding the commercial and operational aspects of the bill of quantities messages.

These subsidiary issues were (EDICON 1992):

Commercial issues:
- sale of material and consultancy to software developers; and
- sale of documentation to other construction EDI communities.

Operational use:
- ongoing monitoring;
- support (surgery);
- new message developments (distribution/specification); and
- links with other initiatives (CAD messages, request for pending works, quantity determination).

J.1.3 Forming of working parties

A meeting of interested parties was called on 9th July 1992 at the RICS Great George Street, London. At this meeting members of EDICON presented basic information regarding the bill of quantities set of messages and the tasks required to achieve implementation of these messages. The purpose and tasks of each working party was also explained. The attendees were asked to join the working party to which they considered they could best contribute.
The attendees who were interested in joining a working party posted their intentions to EDICON after the meeting. These responses were then used to form the 3 working parties.

**Topics of the working parties**
The topic under consideration for each working party was defined by EDICON as follows.

- **Working Party no.1** - The impact of EDI on working procedures.
- **Working Party no.2** - Matching EDI messages to working practice.
- **Working Party no.3** - Support and maintenance.

Working party 3, by definition was not required until a working set of messages was available. The creation of this working party was therefore postponed.

**Tasks to be undertaken by the working parties**
The steering committee and working parties were given the following tasks to consider (EDICON 1992).

1. Co-ordination and standardisation of the use of messages:
   - how the message should be matched to current business practice (WP 1 & 2);
   - standardisation of terminology and use (WP 1 & 2);
   - establishment of codes and qualifiers (WP 2 & 3);
   - maintenance of codes and qualifiers (WP 2 & 3); and
   - consideration of the initial limitation of use of all levels of message (WP 1 & 2).
2. Preparation of documentation, training and advisory services:
   - preparation of user guides (WP 1 & 2);
   - ongoing improvement of documentation material (WP 2 & 3); and
   - promotion (Steering).
3. Advice and support for software developers:
   - specification of EDI interfaces (Steering and WP 3); and
   - consultancy and workshops (Steering and WP 3).
4. Attention to the procedures that surround the use of messages:
   - legal issues (WP 1);
   - tendering process (WP 1); and
   - minimum data content of a tender (WP 1).
5- Promotion of EDI as a new construction industry business method:
preparation of promotional material (Steering); and
liaison with other construction industry bodies in order to gain acceptance for EDI (Steering).

6- Analysis of the “futures” available within messages:
consideration of what needs to be done to introduce new features available within messages and how these can be introduced (Steering).

7- Liaison with message developers:
maintenance of messages (change control/new directories) (WP 3);
standardisation (WP 3); and
consistency of future messages (WP 3).

J.1.4 Working party I
Working party I held a series of meetings from November 1992 to April 1993.

At the start of the meetings EDICON had the set of bill of quantities messages ratified at level 1, which indicates they were ready for trials. However, the structure and content of the messages were not made available to the working parties.

Objectives
The tasks to be undertaken by the working parties, defined in section J.1.3 dictated the objectives of working party I. Working party I considered the tasks which should be undertaken in preparation of a practical implementation of the message. The objectives selected were therefore from the first and fourth sections of the task list. The working party summarised its objective as follows: to highlight and propose solutions to potential problems that may arise with the introduction of EDI on current working practices and procedures.

The working party recommended the compilation of a formal Code of Procedure for use with the CONITT and CONTEN EDI messages. Two members of the group, S Raine and D Lavelle, were tasked with the development of a Code of Procedure, incorporating the comments of the working party. D Lavelle was to check code against the NJCC Code of Procedure for Selective Tendering.

The informal testing of the CONITT and CONTEN messages was reported at an EDICON trading cycle meeting. Working party I considered it vital that it was able to closely monitor testing of the messages to gain first hand knowledge of procedural problems that may arise.
Achievement of working party

The Code of Procedure document produced was issued to all members of the working party and steering committee for approval. The Code of Procedure for the exchange of the CONITT and CONTEN messages is presented in appendix G.

The Code of Procedure led to a joint meeting between working parties to discuss various details leading to the final submission of a tender. This resulted in the consideration of Adds and Omits for modifications, with the use of a final consolidated document being transferred 48 hours before submission to ensure all parties involved have a true copy of the final bill of quantity document.

The request in conjunction with the request of working party 2 to be involved with the trials of the message resulted in the official EDICON trial which was initiated in March 1993 (see section J.1.6).

J.1.5 Working party 2


Objectives

The tasks to be undertaken by the working parties, defined in section J.1.3 dictate the objectives of working party 2. Working party 2 selected to consider the tasks which should be undertaken in preparation of a practical implementation of the message. The objectives selected were therefore from the first section and included: matching the message to current business practice; standardisation of terminology and use; and establishment of codes and qualifiers.

The working party defined a scope of work by agreeing that it should address only the basic data which currently passes between the originator and receiver (Professional Quantity Surveyor/Contractors). The additional functionality available from the messages could be added once the messages were in use.

As a first step to match the messages to current business practice, it was agreed that members of working party 2 would submit the following to the chairman by 1st December 1992.

a/ A view of the basic data requirements of a bill of quantity from their company perspective.

b/ Added value data, or possible future requirements for data.
These data requirements could then be matched to the branch diagrams of the bill of quantity messages.

The structure of the message was not understood by the working party. This was considered key to achieve the selected tasks.

The second task of establishing codes was identified as necessary for a practical implementation. This was therefore given a high priority.

Achievements/Conclusions
The working party received a thorough explanation of the message structure from Peter Vice. Once the working party was happy with the structure of the message set the majority of their original concerns with the message were answered. The practical problems of coding and procedure then became the priority.

The following guidelines were set for the development of a coding structure.

- Ensure code lists are sensible for use in the construction industry.
- Define code lists for construction purposes.
- Write a textual definition of the requirements of each code.
- Do not attempt to assign actual codes.

Procedures required to use the message were already being developed by the first working party, a joint meeting was therefore called to discuss this issue. The results of which are in section J.1.4.

The working party considered the best way to further the understanding of the issues of implementation a trial would be required.

The working party therefore applied pressure for an industry trial of the messages. This resulted in the trial described in the following sections.

J.1.6 Initiation of the bill of quantities message trial
The formal trial of the bill of quantities message set was initiated by EDICON on 4th March 1993. The trial was started because of the pressure exerted by working parties 1 and 2 on the steering committee.
EDICON publicised the launch in the construction press and invited all its members to the trial launch meeting. Approximately 30 interested parties attended.

**Objectives of trial**
The objectives of the trial were defined as follows.

- To test if the standard works
- To identify software implications
- To identify procedures and rules required to achieve exchange

The Bill messages at this stage were stable, but not fixed. Any necessary modifications identified by the trial could therefore be incorporated in the message.

**Scope of trial**
The steering committee defined the trial to consist the following.

1/ Transfer of un-priced bill to tenderer.
2/ Pricing of bill.
3/ Transfer of priced bill back to creator of un-priced bill.

The trial would be undertaken using diskettes. The issues of communications were considered irrelevant to the trial. The scope of the trial is presented diagrammatically in figure J.1.

There are three types of software required to undertake the transfer of bill information in the bill of quantity trial scenario. These software types can be defined as:

1/ communication software;
2/ EDI message translation software; and
3/ processing software.

The software processes used in the bill of quantity trial scenario are presented in figure J.2 marked with the number of the software type required to undertake each process.
The communication software converts an EDIFACT message into its smallest ASCII form, using EDIFACT syntax, and facilitates the transfer of the message. The processing software already exists within many companies in the form of the applications for Bill production and estimating. The trials were to concentrate on level 2 software which undertakes the translation of the bill to form the EDIFACT message, a process which must maintain the structure and indexing of the document. This area of software is specific to the application of bill transfer and had not yet been developed.

**Actions**

The trial was envisaged as being undertaken by several groups. These groups each would identify themselves as a producer of un-priced bills and receiver of priced bills, or a tenderer who receive un-priced bills and applies prices. Once established groups could then undertake the process of exchanging an un-priced Bill, applying rates, and exchanging a priced Bill.

The groups formed were to consist of representatives from a construction related company and a software house. The software house providing the structuring/indexing software and the construction company providing the industry knowledge required.
A technical briefing was scheduled for the 1st April for the software companies.

**J.1.7 Bill of quantity message trial - dissemination of technical information**

A technical briefing was held on 1st April 1993. A number of software companies attended this briefing to obtain the knowledge required to develop suitable EDI interfaces for applications.

In addition to the requirements of the EDIFACT standard and the bill of quantity message format, the following rules were set for the trial:

- To identify each field, a blank character should be placed between each field;
- A suffix of a single character should be placed on each segment (these characters should be in a sequence to aid identification of the segment); and
- The bill page number should be included in each reference.

Figure J.2 - Software processes in the bill of quantity trial scenario
J.1.8 Implementation - further activities

Working parties 1 and 2 suspended their work until the trial was completed, and the results made available to them.

Though several parties expressed an interest in the trial of the CONITT and CONTEN messages, none, except Loughborough University, were willing to expend resources on the trials.

Due to the lack of substantial trials the working parties did not undertake any further work.

J.1.9 Conclusions

The work of the working parties resulted in the production of a Code of Procedure for the use of CONITT and CONTEN messages. However, the majority of the time spent by the working parties, particularly working party 2, was used to educate the working party members as to the structure and details of the bill messages.

The lack of a comprehensive trial of the bill messages halted the implementation process. Several parties showed interest in the trial by attending the initiation meeting, however only the trial undertaken as part of this research was completed and reported.

The interested representatives of companies attending may not have had the authority to employ the resources required for such a project. Alternatively, the conclusion can be drawn that the attendees of the initiation meeting simply wished to obtain knowledge of the messages to gain some competitive advantage.

The failure of the bill of quantities message trials highlights the many technical and commercial problems still to be overcome by the industry and its software vendors.