CIFE CENTER FOR INTEGRATED FACILITY ENGINEERING

Barriers to Electronic Data Exchange in the A/E/C Industry

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Summary: **Technical Report #86**

Title: Barriers to Electronic Data Exchange in the A/E/C Industry

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1. **Abstract:** This report summarizes a nine month CIFE seed research project that focused on A/E/C industry barriers to the increased use of electronic data exchange (EDE) for project related information. Three general areas are explored: barriers to graphic data exchange, barriers to business data exchange and general legal barriers associated with electronic data exchange. An industry survey was conducted to gain a more accurate understanding of current A/E/C industry practice and to determine what the industry feels are the critical barriers to increased EDE. Based on the barriers selected by the survey, research was performed to investigate the scope of the barriers and possible methods for overcoming them. Conclusions and recommendations are made on what steps are needed to increase A/E/C industry use of EDE amongst project team members.

2. **Subject:** Why is the A/E/C industry still using paper media to generate, share and store information related to the facility life cycle process ? Other industries use far less paper to process and communicate routine business tasks, therefore the barriers preventing increased use of EDE for A/E/C firms may not be technical. This report examines the current state of EDE within the A/E/C industry as a basis for identifying barriers to greater EDE, via an industry survey. Data taken from the survey is used to perform further research on those barriers named as being most critical from the industry's point of view. Conclusions and recommendations are proposed for short term and long term approaches to overcoming theses barriers. Emerging technologies are examined (EDI and PDES/STEP) to determine their usefulness to overcoming some of the barriers.

3. **Objectives/Benefits:** Many of the research projects performed at CIFE focus on the technical side of integrating project team members as they perform various design, construction and operation tasks for a given facility. Much of this work assumes a high level of barrier free data exchange amongst project team members. Team members might be employed by separate corporations, possibly in different physical locations. This work contributes in part to the implementation aspects of these CIFE research projects by looking at some of the issues associated with integrating project team members using electronic communication technologies.

4. **Methodology:** During the first phase of the project an industry survey was prepared and sent to 96 professionals working in the A/E/C industry. Responses from 27 out of 96 surveys were received. The survey was designed to assess the current state of industry usage of EDE technology and to identify critical barriers to increased EDE as seen by industry members. Research was then performed to further explore the barriers identified by the survey. The second phase research was primarily literature based, including some consultation with legal experts.

5. **Survey Results:** Some of the industry survey highlights are outlined below.

General
- 90% of the survey respondents expect to increase their use of EDE.
- At the same time paper and fax are the most important method for sharing project related information.
- Of the firms that do use EDE, most are more comfortable sharing the data within their firms than sharing the information with outside firms.
- Approximately 50% of design drawings are still generated by hand.

Barriers
- A lack of neutral CAD file exchange standards and CAD usage conventions are a critical barriers to increased EDE.
- Current law still requires ink stamp and signature on record documents. The lack of acceptance of electronic equivalents is a critical barrier to increased EDE.
- Uncertainty regarding the legal standing of electronic records is a barrier to increased EDE. Respondents did not know how the courts would react to an "audit trail" based on electronically shared data (i.e.: no paper trail).
- Lack of use was consistently cited as a critical barrier, possibly caused by inadequate knowledge of current EDE technology.

6. **Research Results and Conclusions:**

Graphic Data Exchange Barriers: Over the short term, coordination between project team members at the start of a project can mitigate the CAD file exchange and CAD usage barriers by mandating software, hardware and usage conventions in the project specifications. Over the long term the neutral 3D CAD file exchange standard ISO 10303 (PDES/STEP) has the potential to overcome this barrier. The CAD software user must demand that proprietary CAD vendors write translation software based on the ISO 10303 standard. Industry wide consensus on CAD usage should be the goal for A/E/C professional groups such as AIA, ASCE and AGC.

Statutory Barriers: Starting with A/E/C industry professional organizations (AIA, ASCE, AGC, etc.) professional conduct guidelines should be amended to accept and promote the use of electronic stamp and signature for record documents. Over the long term these same groups should work to have the laws changed to accept electronic equivalents.

Legal Standing of Electronic Records: research indicated that there is no legal barriers to the use of electronic versus paper records for audit trail generation. The law does not differentiate between paper and electronic records for this purpose.

EDI: EDI is an emerging EDE technology that has the potential to address some of the barriers indicted by the survey. Because EDI data exchange agreements fall under contract law, many of the concerns raised by the survey can be addressed explicitly to the satisfaction of both contracting parties.

7. **Research Status:** This research project is finished. Related topics that warrant additional research include the following.

- Draft electronic audit trail standard to perform to A/E/C industry needs.
- Attempt to quantify potential benefits of increased EDE within the A/E/C environment.
- Examine the possibility of amending A/E/C industry standard contracts to include EDI based elements.

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1.0 Introduction

1.1 Introduction

The CIFE seed research project, Barriers to Electronic Data Exchange within the A/E/C Industry, was designed to assess the current state of electronic data exchange (EDE) within the A/E/C industry and to identify the critical barriers to the increased use of EDE within the facility delivery process. As a facility progresses through the various stages of its life cycle, from conceptual design to demolition, many individuals and corporations are required to come together and act in concert to design, build and operate the project. The common elements guiding the efforts of all project participants are the design and construction documents. The term documents is used here in its broadest sense, referring to all of the information required to successfully execute the project. For the purposes of this study, a distinction is made between documents containing graphical information (such as CAD files) and documents containing business information (such as cost reports, progress billing, etc.). Before the introduction of computer tools to the A/E/C industry, all of the data created and utilized by project team members was recorded on paper as it was created. If the data needed to be exchanged with another member of the project team, it was exchanged in the same medium in which it was created. Today computer tools are integral in virtually all aspects of the facility delivery process. It is possible for all of the data generated during the life of a facility to be generated in some form of electronic media. However, when the need arises to share the information with another member of the project delivery team, what form is used for the exchange ? Anecdotal experience and the results of this research project suggest that paper is still the dominant method for sharing project data regardless of whether the data was generated or stored in electronic media.

The use of paper or hard copy to exchange electronically stored data presents many problems. When a software application such as a Computer Aided Design (CAD) program is used to generate design information and the information is then output to paper and passed on to another member of the project team, the recipient of the data cannot take advantage of the tools contained in the CAD software: multiple, scaled views; subsystem overlay for interference checking; data base links between graphical elements in the drawing and text based specifications; ability to add or remove different layer types from a given view; etc. The rekeying of data required to transfer information from one project team member's system to another introduces the possibility of human error at each rekeying step. The use of a postal service or courier service to deliver electronically generated data is significantly slower than the use of data modem which are also able to maintain the information in its original electronic form. The use of paper to record

significant project milestones requires the use of inefficient, manual document tracking and storage systems.

The A/E/C industry shows every indication of continuing to increase its use of computer based tools to generate, store and manipulate project and business related information. The adoption of computer based tools has the potential to improve the quality and efficiency of current industry practice. In addition it can be utilized to improve the quality and efficiency of the communication of project related information during the facility life cycle. In fact, electronic communication has already had a significant impact on other industries such as retailing, automotive, import-export and the airline industry. Because the electronic exchange of information offers multiple benefits to the A/E/C industry and because it appears that other industries have successfully implemented EDE in various forms, CIFE saw a need to identify the critical barriers preventing increased use of EDE and then to perform research into the underlying issues that give rise to the barriers. Based on the outcome of this research, recommendation are made on what steps should be taken to overcome these barriers. The experience with typical A/E/C industry software at CIFE and the use of EDE in other industries suggests that technical barriers may not be the most critical barriers and that business and legal issues may be more important.

The basis for this research project is an industry survey designed to measure the current state of EDE within the A/E/C industry and a literature study conducted into the business use of EDE and the legal issues related to the use of EDE in the A/E/C industry.

2.0 Background to Study

2.1 The A/E/C Industry and the Importance of Information Flow

The efficient generation and exchange of information is a crucial element for the successful delivery of every constructed facility. Figure 1 illustrates an idealized description of a project's life cycle. Each of the different phases represents a complex series of steps within itself. For example, Conceptual Design may included the generation and exchange of data between the project's architect, structural engineer, geotechnical consultant, general contractor, subsystem engineers (mechanical, electrical, plumbing, etc.) and several possible sources of input from the owner's organization. The arrows between phases represent the flow of data between each step in addition to indicating the life cycle path. In addition, depending on the type of contract employed by the owner (traditional, fast-track, design-build, etc.) there may be overlapping between each phase. Many aspects of the process are iterative, therefore the linear progression in

figure 1 would normally include some backtracking based on feedback to a preceding phase from a subsequent phase. Different types of information are generated and

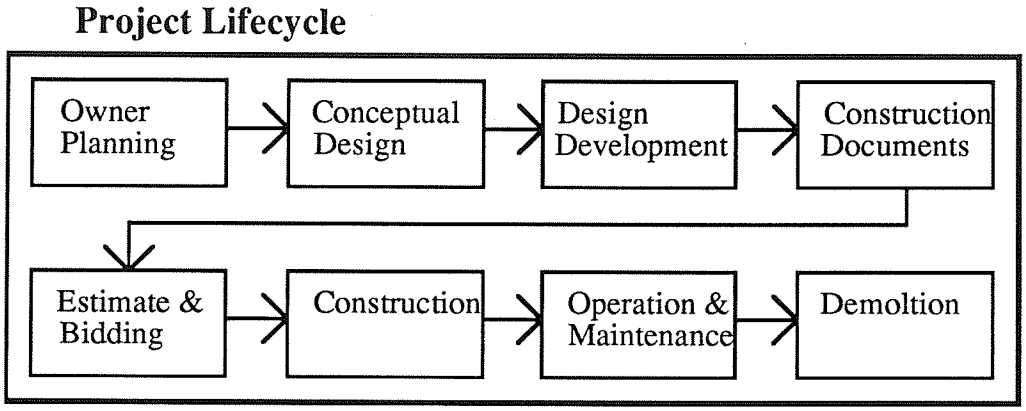


Figure 1

exchanged as well: graphical design data, cost and schedule data, marketing data, personnel and insurance data are a few examples. There are no axiomatic rules regarding who must receive what information during the course of a given project, instead participating parties must use their own judgment to determine the appropriate distribution of project data.

2.2 The A/E/C Industry, Fragmentation and Data Exchange

Fragmentation in the A/E/C industry is an important underlying factor affecting potential barriers to EDE. It is axiomatic that the more times a piece of data is transferred between two different parties, the greater the chances that the data will be altered. At the same time, as the number of participants on a given project team increases, so do the requirements for data exchange. The A/E/C industry can be characterized as fragmented for a variety of reasons. The division of labor and the rise of the specialist combine to split the whole of a project into relatively small pieces that are designed and or built simultaneously. Business cycles, the bidding mechanism and limiting resources all contribute towards favoring the use of different project teams for each project. It is likely that two identical facilities, built for the same owner at different times, within the same region, will be done by two different project teams. The impact of these conditions on data exchange practices is a general inconsistency in the way data is generated and exchanged from one project to the next. At the start of every new project a completely new system for data exchange and distribution may have to be designed.

Data exchange, in its broadest sense includes elements of the communication process used by a project team as well as the mechanical aspect of the efficient sharing of project data. The fragmented nature of project team assembly increases the danger of erroneous or incomplete information impacting the project. The fragmented nature of the A/E/C industry in general results in a large volume of data, exchanged among a large number of firms on a given project. The redesign of communication procedures and systems for each project also increases the possibility of error by requiring the project team to learn a new system for each project. As errors occur, the threat of a dispute resulting from an error in data exchange increases. It also acts to slow down the process of moving project data between project members as individuals learn the new system.

2.3 Computer Based Solutions and Barrier Free Information Exchange

There is potential for vastly improving the efficiency, accuracy, speed and quality of the facility delivery process, as practiced by the A/E/C industry, by incorporating computer based integration technology. There is a large body of recent and ongoing research at the University level that is seeking to improve on the problem of fragmentation within the A/E/C industry. Among the computerized technologies being proposed are shared project databases, several approaches to integrating the distributed project design team and expert systems used to either automate processes that are currently manual or to integrate processes that are now performed in isolation. In the commercial sector, software vendors are also attempting to integrate aspects of the facility delivery cycle. The Timberline company is promoting a tool to integrate design, estimating and scheduling. Other companies are a working to combine scheduling within the design software environment (CIFE Paper References).

All of the efforts mentioned above, and many others, are motivated in part by the fact that computers and computer tools continue to be adopted by the A/E/C industry. It is now reasonable to assume that every non-craft employee involved in the delivery of a facility has access to some form of computer. A critical element, common to the integration schemes noted earlier, is the assumption that project information will be free to move between all parts of the proposed system. The perceived need that this research project has addressed is a test of this key assumption. How much electronic data is freely exchanged within the A/E/C industry ? How much data is downloaded to paper hard copy and why is it done ? What are the perceived and actual legal limitations of information staored and shared in electronic media ? What are the steps that the A/E/C industry need to take in order to increase the freedom to exchange electronic information, thereby increasing the potential for success of computerized solutions to industry fragmentation.

3.0 Research Mehods

3.1 Research Methods

Initial efforts were focused on defining the scope of the issue through a search of relevant literature and informal interviews with knowledgeable A/E/C industry members. During this first phase, discussion with A/E/C professionals revealed a wide spectrum of experience and corporate policy regarding the exchange of electronic information. General contractors that participated mainly in the public works market reported almost no use of electronic data exchange among typical project teams. At the same time large Engineer/Procure/Construct (EPC) firms reported several advanced efforts at electronic data exchange including implementation of systems based on Electronic Data Interchange (EDI) communication standards. Efforts to locate legal precedent in the form of relevant court case histories of disputes involving the legal standing of electronic records within the A/E/C industry proved unsuccessful. Based on these early results, the decision was made to conduct a survey of A/E/C members.

The survey was designed to accomplish the following goals:

- Determine how project related data is generated and exchanged
- Determine the importance of data exchange capabilities in the marketplace
- Identify relevant technical issues: format of graphic data, access to network links, etc.
- Record individual A/E/C industry members' experience and insight into the issue of data exchange
- Identify the most important potential barriers to increased use of electronic data exchange based on A/E/C industry opinion
- Record A/E/C industry experience relating to the legal standing of electronic documents

3.2 Survey Organization and Design

The survey was sent out with a total of 9 pages. A copy of the complete survey is contained in the appendix B of this report. The first page contained an introduction and description of what was expected of the recipient. The balance of the package contained twenty-one questions. The survey was organized around three main sections: graphic data, business (non-graphic) data and legal issues. The use of the three modular sections allowed for the possibility that two or three individuals might work together to answer a single survey. The majority of the questions were based on variations of the multiple choice format to promote speed and ease of response. Each major section also provided space for the collection of anecdotal and experiential data.

3.3 Survey Procedure

To maximize the response to the survey, a pre-survey letter was mailed to CIFE members and other A/E/C firms having relevant experience. The letter requested a list of potential survey recipients, within each firm, that would have some familiarity with data exchange issues. A copy of this letter is included in appendix A. The pre-survey letter sent to industry contacts generated a list of recipients totaling 96. Figure 2 shows how the survey sample broke down by business type and by geographic region. Overall, 27 of 96 surveys were returned yielding a 28% response rate.

	OWNERS	A/E	CONTRACTOR	TOTAL
NORTH AMERICA	12 / 7	18 / 6	33 / 5	63 / 18
EUROPE	- / -	10 / 2	7 / 1	17 / 3
ASIA/ PACIFIC	- / -	- / -	16 / 6	16 / 6
TOTAL	12 / 7	28 / 8	56 / 12	96 / 27

KEY: N1 / N2

N1= surveys sent

N2= surveys returned

Survey Statistics

Figure 2

3.4 Survey Data Reduction

Data collected from the completed surveys was entered into a computer based spread sheet package (Microsoft Excel) running on a Macintosh computer. To avoid skewed data due to response error, responses to each question were checked to insure that the requested format was understood and used correctly. If a response was executed by the recipient incorrectly, the data was not included in the survey analysis. This problem occurred occasionally on survey questions 1.1.1 and 1.1.5 (percentages did not total to 100%) and 1.1.2 and 2.1.1 (reversed or incomplete ranking).

3.5 Research based on Survey Results

After the bulk of the survey responses had been returned, research into the electronic data exchange issues was undertaken, directed by the survey data. This research was conducted with the help of Professor Ellen Borgersen, Associate Dean at the Stanford University School of Law and John Ryan, law student. The focus and results of this work is discussed in sections four and five.

4.0 Research Results

4.1 General Results

When the A/E/C industry looks forward into the future of the facility delivery process, an overwhelming majority, 90%, expect to increase their use of electronic data exchange to communicate with project team members. At the same time, the most important medium for transferring information today within the A/E/C industry is paper, by the same overwhelming majority. This applies to all of the different types of information exchange: drawings, specifications, contracts, submittal materials, RFIs (requests for information), purchase orders, progress billings and payments, official correspondence and change orders. This is true in spite of the fact that many of these documents are originally generated and stored in electronic media, typically by a personal computer.

Based on questions 1.1.2 and 2.1.1, the most popular methods for exchanging both graphic and business data types are as follows (in descending order, most to least common):

1. Hand carry, post, or courier delivery of paper documents
2. Fax transmission
3. Hand carry, post, or courier delivery of documents stored as files stored on disk or tape
4. Modem transfer of documents stored as files
5. Files exchange over LAN/WAN

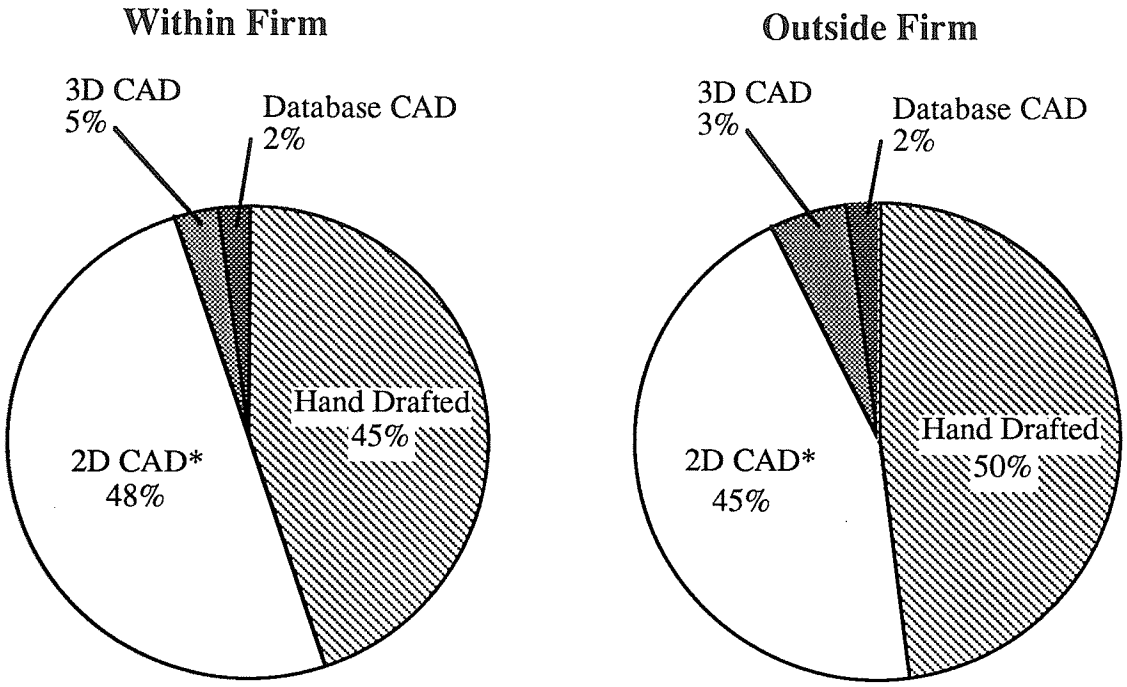
The two most common methods typically do not allow re-entry of the data into a computer environment in a manner allowing the full use of the type of software used to create the information. Thus, the recipient cannot interact, manipulate or alter the transferred data withoutfirst doing time consuming data entry. Text based faxed information can sometimes be manipulated by the recipient using Optical Character Recognition (OCR) technology, but this solution offers nothing for a faxed sketch or other graphic data.

Survey questions 1.1.1 and 2.1.2 indicated that A/E/C firms are using computer tools to process project and business information, however they are more apt to share the electronic version of the data within the firm than with other companies. This suggests that barriers to increased electronic data exchange may be related to non technical issues such as A/E/C industry business and contracting practices as well as industry concern regarding the legal standing of electronically stored data exchanged between A/E/C corporations.

4.2 Results for the Exchange of Graphic Data

Technical barriers are the most serious barrier for A/E/C firms that seek to exchange electronic graphic data. It is clear that different individuals or firms can work concurrently designing different elements of the same project. The separate parts can be combined as needed to become one integrated package of design information. The seamless integration of a distributed design effort requires the use of the same computer aided design (CAD) software, a file format that can be read across different hardware platforms e.g., a unix workstation version of AutoCAD to a DOS PC version of AutoCAD, and exacting use of identical software conventions. This last item is particularly critical. If two firms are sharing AutoCAD generated drawings, the use of such items as block types, layer and line types, symbol meanings and the placement of drawing elements such as text or dimensions in a particular layer must be coordinated from the beginning of the project. Otherwise the time saved by using CAD software will be lost in standardizing conventions on a drawing by drawing basis.

Unfortunately the three conditions listed above are seldom satisfied. Hardware and software standards have not developed to a sufficient level to support seamless concurrent design efforts. Instead, firms rely on direct file translation software and file exchange standards such as DXF and IGES. No standard solution is in use today that incorporates the third requirement of software usage conventions. Survey respondents felt that incompatible CAD file formats and inadequate CAD file exchange standards were the most important barriers to increased electronic data exchange of graphic data.



*Note: in most cases paper is used to exchange 2D CAD data.

Methods for Generating Graphic Data

Figure 3

Figure 3 illustrates A/E/C industry methods for generating graphic data based on survey question 1.1.1. As noted earlier, information available for sharing electronically is higher within the firm compared to outside the firm, by approximately 5%. Potentially one half of the graphic data used by the surveyed firms can be transferred in electronic media. Surprisingly, about half of the data is still created by hand. The continued use of hand drafting techniques to generate and store graphic data continues to be a significant barrier to electronic data exchange.

Statutory barriers are the other significant barrier to the increased use of electronic data exchange, according to survey question 1.2.1. Statutory barriers refer to the specific wording of the laws governing the practice of design in the A/E/C industry. In the state of California, there is no legal standing for an electronic version of a designer's license stamp and signature. When a design professional needs to transmit a copy of stamped documents, a paper copy is required. As the number of separate design professionals increases on a given project, so does the importance of tracking official design information. The benefit offered by communicating electronic versions of design data can only be realized if the law recognizes all elements of the data including whether or not drawings are stamped and signed. This condition is specific to the A/E/C industry. Other industries, such as banking, are already using electronic signatures in

electronic communications. In addition, the US Internal Revenue Service is moving towards acceptance of electronic tax data including electronic signatures in lieu of paper.

Liability fears are not considered to be a barrier to increased electronic data exchange. Based on survey responses, the A/E/C industry is comfortable enough with the use of CAD tools and sees no special concerns in communicating design information in machine readable form.

4.3 Results for Exchange of Business Data

The most important barrier to the exchange of business data is A/E/C firms' fear of litigation. This fear constitutes a serious threat to the increased use of electronic data transfer for the exchange of business information. Survey question 2.2.1 indicated that doubt about the legal standing of a project or business related document exchanged in electronic form, is t. In this case business data encompasses all non-graphical information required for the project delivery process. The frequent usage of government postal service, private courier delivery and fax for data exchange beyond the firm, indicated in figure 5, is partially due to the well documented legal standing of these three methods of data transmission. Uncertainty about the exchange of electronic business data centers on the ability to maintain an audit trail. An audit trail is a critical part of the evidence typically required when a dispute results in arbitration or litigation. An audit trail is a chronological reconstruction of the relevant actions, communications and decisions of the parties to a dispute. It is used by the court or arbitration review board to establish the facts in a case. Historically, documents such as letters, design documents, contracts, transmittals, etc., were used to establish the audit trail. Post marks, "received" date stamps, signatures and transmittal logs all helped to determine when an event occurred. All of these items are tangible and relatively inert. The court can easily examine a signed letter and rule as to its authenticity.

4.4 Electronic Records and the Hearsay Rule

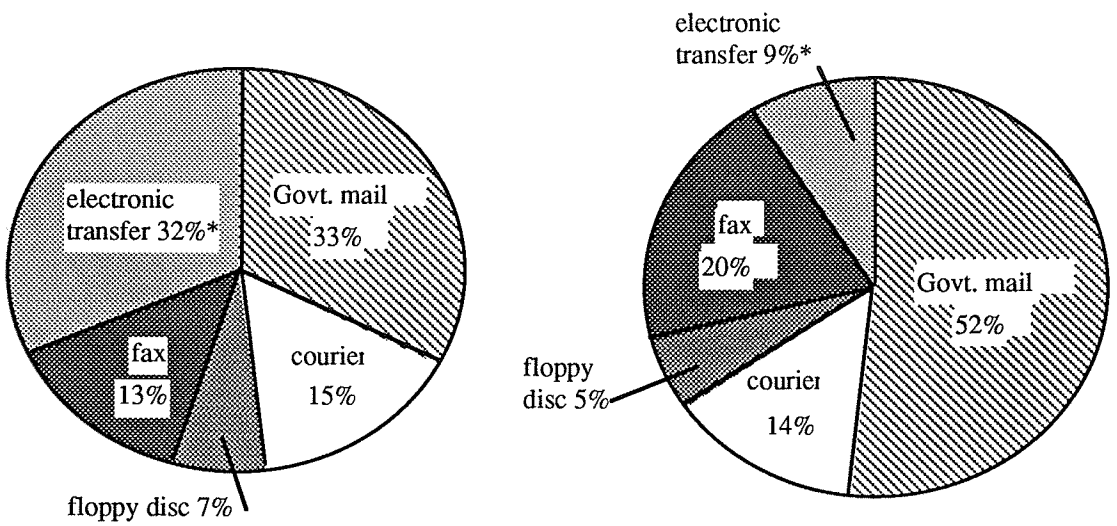
These same methods are ineffective in validating an audit trail composed of electronic records. A search of case law for precedents involving an A/E/C industry dispute and electronic documents was unsuccessful. There is ample precedent in case law taken from other industries that involves various forms of electronic record keeping and the admissibility of the records into evidence. It appears that the court has been admitting electronic records into evidence since computers were introduced into the business world. One of the earliest precedent setting cases is Transport Indemnity Company v. John Seib (1965), an appellate court case involving a transportation insurance company's dispute with a client. Computerized accounting records belonging to the insurer were offered and admitted into evidence after the appropriate expert testimony had been heard.

All business records, written or electronic, are subject to evaluation under the hearsay rule. The hearsay rule states that "any statement made outside a trial, which is offered as evidence in the trial to prove that the matter asserted in the statement is true, is hearsay and thus inadmissible as evidence unless it falls within a recognized excpetion." (Ryan). The most relevant excpetion to the hearsay rule in this case is the business records excpetion. The general test of the business records exemption recognizes and admits "...records maintained and relied upon in the course of business as being an exception to the hearsay rule." (Young, Kris et al.). The Uniform Business Records Act, the Federal Rules of Evidence, Rule 803 (6) and the United States Common Law Shop Book Rule all recognize this exception.

To introduce electronic records into evidence a proper foundation for the evidence must be laid (op cit.). A proper foundation consists of establishing the relevance of the evidence via expert testimony of an individual thoroughly versed in the generation, use and storage of the records at issue. The reliability of the records must also be established. This requires expert testimony to the accuracy of the information in the records including how the data was generated, how it was stored, the type of application software used and how the company in question insures the accuracy of its electronic records. Based on the experiences of other industries with electronic record keeping it appears that there is not a fundamental legal barrier to the use of electronic records in the A/E/C industry in spite of the fears illustrated by the survey.

4.5 Further Results for Exchange of Business Data

Technical aspects of sharing information in a machine readable form do not appear to be a barrier to the use of electronic data exchange for A/E/C firms. Figure 4 shows A/E/C industry methods for exchanging business data from survey question 2.1.2. Electronic methods for data transfer are currently much more common within the corporation than with other firms: 32% within the firm versus 9% outside the firm. The popularity of electronic transfer within the firm can be partly attributed to the growth during the last decade in the use of local/wide area networks.



*Note: includes LAN/WAN, modem, e-mail and dedicated data links

Methods for Exchanging Business Data

Figure 4

4.6 Lack of Use

Survey question 2.2.1 also indicated that a lack of users within the A/E/C industry as well as the costs associated with incorporating data exchange technology were seen as the other most significant barrier to the increased use of electronic data exchange among project teams. There are several important reasons behind theses two responses. As noted above, the uncertainty regarding the quality of any potential audit trail is one reason. In addition, there are few procedural standards within the A/E/C industry which span more than one firm. As a firm designs or builds different projects it must adapt its methods for communicating project information to each situation. Along with the continually changing project team partners there is also a good possibility that firms will work for many different owners who, in turn have unique methods for communicating on the projects they undertake. The owner, in its traditional role as client, often must be catered to by the project team, including adapting the team to the owner's information distribution system requirements.

The generation and distribution of paper based documents is a standard technology for all A/E/C industry members. The ability to exchange the same information via electronic media is not a required technology today. The decision to employ electronic data exchange technology involves costs associated with hardware (computers, modems, data lines, etc.), software, training,

long term maintenance of the system and the unpredictable costs of disrupting daily business practices to adapt to a new technology. The benefits are equally unpredictable and difficult to quantify. A piece of construction equipment has a well defined purchase price and the benefit to a firm in owning the equipment is measured in the profits derived form doing construction work with the equipment. The ability to communicate electronically with different members of a project team has no such yardstick. At the same time, the growth in the use of computer tools within the A/E/C industry is continuing and the successful examples set by other industries and their use of electronic data exchange will be a powerful motiviation to A/E/C firms.

4.7 Additional Data on A/E/C Industry Data Exchange Practice

In addition to the main survey questions that focused on barriers to increased electronic data exchange, other questions were included in the survey to gather data on current industry practice. Legal concerns relating to CAD generated and stored documents is of particular concern to A/E/C designers. Question 3.1.1 indicates that 31% of surveyed firms have some form of explicit legal policy for the transfer of CAD files via electronic media.

Owners are becoming increasingly aware of the necessity of an organized approach to communication among project team members. Questions 1.1.3 and 2.1.3 indicate that of the surveyed firms' projects, 30% included capabilities for electronic data exchange of graphic information and 23% included business information as a part of the proposal qualifications. This data shows that the market requiring A/E/C industry services is starting to consider the value of electronic data exchange capability and it is possible that this capability will increasingly be seen as an important pre-qualification for A/E/C firms.

5.0 EDI: Electronic Data Exchange and Related Developments

5.1 An EDI Primer

What is EDI ?

Electronic Data Interchange, or EDI, is "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). The successful implementation of EDI is based on the premise that "once data is entered into a computer system, that data should never have to be key-entered again" (Harmon). The development of EDI technology is a logical extension of the generation, use and processing of standardized business forms. In the past, if company A wanted to purchase an item from company B, a multi-step process was needed to execute and record the price

quotation, purchase order and invoice. Messages communicating the desired data between A and B are carried via post, telephone or fax. Expenses are incurred by both firms in personnel and office overhead to execute, process and file the required information. If a problem occurs, additional overhead is needed to develop an audit trail describing a factual record of what has taken place using the paper based file copies. The use of EDI has the potential to substantially reduce the cost and time required to perform the same purchasing task. All data pertaining to each required action in the process is entered into a computer once and is subsequently shared at data communication speeds. Software subroutines automatically create an audit trail for record keeping purposes.

There are many benefits to EDI users beyond its speed and efficiency for routine business transactions. Table 1 is a partial list of potential gains for the EDI user in a commodity type manufacturing, distribution or sales industry (Harmon). Beyond these easily quantifiable

Benefits to EDI Users

- Reduce inventory cost
- Improve customer service
- Improve product return procedures
- Improve spare parts availability
- Improve product availability knowledge
- Reduce order lead time
- Improve vendor relations

Table 1

advantages, firms that decide to implement EDI create very strong relationships between fellow EDI trading partners. In this way the use of EDI can become a strategic advantage for a firm. For example, if company A must purchase a commodity type product (i.e.: the item has no qualitative difference between suppliers; price is set by the market) and suppliers B and C both sell the product at the same price. Company A will buy from the supplier that provides the more efficient delivery process, assuming both suppliers have the item in inventory.

In Harmon's introductory article on EDI, he describes several business conditions where the application of EDI technology can provide a competitive advantage to the firm that decides to implement EDI. Several of these conditions are prevalent in the A/E/C industry. Among the conditions cited are: routine purchase of large volumes of stock items that can be described by a product code (basic construction materials). EDI could also benefit products that require precise tracking and reporting of manufacture and delivery time (critical path or long lead items such as

boilers, chillers and elevators). Also mentioned are businesses where transactions require a large volume of paperwork, or where rapid processing and delivery of goods is essential (the design and construction of government facilities such as hospitals; fast track or compressed construction schedules).

History of EDI

Starting with the introduction of the computer into the commercial world in the 1960's various industry groups have worked together to promote EDI standards for purchasing, transportation and financial tasks (DISA). Within the United States the transportation industry was one of the earliest to implement EDI using an industry wide standard, beginning in 1968 (Datapro). Members of the Air, Motor, Ocean and Rail industries formed a joint council called the Transportation Data Coordinating Committee, TDCC. Since then, two additional standards have evolved from this original group: the Uniform Communications Standard, UCS, used by the grocery industry, and the Warehouse Information Network System, WINS, used by the warehouse industry. Through the 1970's, several other industries worked in isolation to develop intra-industry EDI standards. Among them are the AIAG (automobile), PIDX (petroleum), SWIFT (international banking) and SITA (international travel) (Datapro). In 1979, the American National Standards Institute, ANS, formed the Accredited Standards Committee X12 to develop a national EDI standard that could be used to communicate across industry boundaries.

Efforts to develop EDI standards outside of the United States, primarily in Europe, have evolved along a different path. From the very start, the emphasis has been on facilitating the processes of international trade. In 1974, a United Nations Working Party on the Facilitation of International Trade Procedures began work on standardizing typical messages used by international trading companies. By 1978 initial studies had been completed and the UN published its "Guidelines for Trade Data Interchange". This publication is considered to be a catalyst in causing several international industry associations to begin work on intra industry message development. Two of the most successful to date have been ODETTE, the European auto industry and CEFIC-EDI, the European chemical industry (Datapro).

By 1986 both sides of the Atlantic saw the need for true international EDI standards and the United Nations Joint EDI initiative was started(Datapro). Since then, the Electronic Data Interchange for Administration, Commerce and Transportation, EDIFACT, has evolved into the primary body for organizing and developing international EDI. EDIFACT currently has subsidiary regional organizing groups working in North America, Western Europe, Eastern

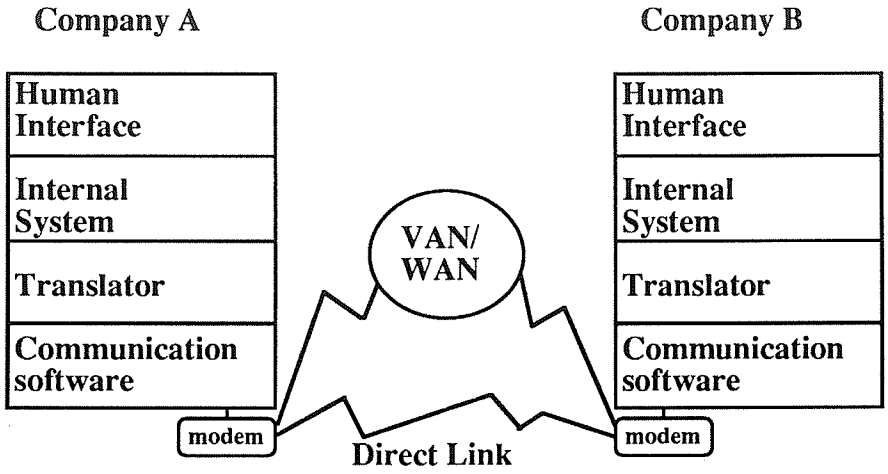
Europe, Japan/Singapore and Australia/New Zealand. Workgroups are moving to develop world wide standards in the following areas:

- Materials Management
- Purchasing
- Products and Quality Data
- Transport
- Customs
- Banking
- Construction
- Statistics
- Insurance
- Travel, Tourism and Leisure

The Construction workgroup is focusing on specific A/E/C industry EDI communication needs and will be expanded on below. At the same time several other groups affect various elements of the facility delivery cycle, such as Purchasing and Materials Management. The EDI standards developed and used by each discipline are not restricted and are available for use by any industry where they might apply.

Technical Aspects of EDI: How it Works

The EDI process begins when a business takes an internal system function, such as a computerized invoice or purchase order, and "maps" the document's functional elements to an EDI standard (DISA). This is typically done with commercial translation software. Once the function or message is translated into an EDI standard it can be sent to the trading partner via an electronic communication vehicle (see figure 5). There are two common communication methods in use today: direct point to point exchange via data modem or exchange can be done through a Value Added Network, VAN. When the message is accepted by the recipient, the process moves in reverse. The power of EDI for processing routine commercial messages becomes apparent when the number of trading partners increases. If a company only does business with a few companies, the coordination required to communicate directly form one internal system to another might be manageable. When a firm does business with tens or hundreds of other firms, the ability to translate messages into and out of a standard form is a distinct advantage because the firm is not required to learn and understand how to communicate with the different companies' systems individually.



EDI: Conceptual Diagram

Figure 5

(adapted from Harmon)

For companies considering adopting EDI technology, the Value Added Network provides several valuable services that enhance and simplify the EDI communication process. VAN's provide the hardware and software infrastructure that enables a firm to communicate with its trading partners. The basis of the VAN service is analogous to an EDI message post office. If a firm is doing EDI without a VAN, it must establish a real time link with the destination firm for each message or batch of messages it wishes to send. The VAN provides for asynchronous exchange of EDI messages just as a network e-mail server provides asynchronous e-mail exchange for members of the network. If company A wants to send an EDI message to company B via its VAN, first the message is sent to the VAN. Then the VAN takes the message and places it into a mailbox for company B, if company B is a subscriber to the same VAN, or else it forwards the message to company B's VAN. In either case the message ends up in company B's electronic mailbox. Periodically company B will check its mailbox for mail and at that point it will download the message form company A into its own system as described earlier. In addition to their basic core service VANs offer other features that are attractive especially to smaller firms that lack electronic communication expertise. VANs typically provide send and receive capability with all commercial modem and communication protocol types, all data transmission speeds and they use error correction software to insure data integrity. VANs also provide audit trails to record all message activity (Harmon).

5.2 EDI in Use Today

EDI in other Industries

The following section is a discussion of four examples of EDI use in other industries. In each case EDI has been used successfully for many years to help process various different types of business communication. The examples come form the fields of banking, US Department of Defense procurement, retail clothing and mass manufacturing of consumer goods.

Banking

The banking industry's adoption of EDI technology is one of the earliest and most successful commercial uses of EDI. Bank have used electronic communication to transfer data and funds internationally for many years. In 1986 the Society for World Interbank Financial Telecommunications provided funds transfer services to over 2000 banks in more than 50 countries. Besides bank transfers, standard messages are available for foreign exchange, securities trading and balance reporting (Butler Cox Foundation).

Current trends in banking industry EDI is an outgrowth of their customers' usage of EDI to streamline the purchase and payment process. Banks' use of EDI includes paying clients' invoices electronically and reducing the need for check writing and reconciliation. It also includes the integration of financial EDI services with clients' purchasing and material handling systems to reduce payment errors. In some cases, if a client has incorporated EDI into its accounts receivable function efficiencies are gained because remittance data is included with the electronic payment(Hollis).

United States Department of Defense-CALS

CALS, or the Computer Aided Acquisition and Logistics Support initiative, has been adopted by the US DoD to transform the weapon procurement process from a paper based one to an entirely electronic system. Under the old regime, the complete operations and maintenance data required for a submarine weighs 44,000 pounds when printed on paper. Instead, the DoD would like all the data accessible in electronic format from a computer terminal. The goal for the CALS program is to make available all design, development, production and maintenance information available of shared data bases for all new weapons systems after 1995. To achieve this goal the DoD is defining data exchange standards that will be accessible to the widest possible variety of suppliers.

Levi Strauss-Retail Clothing

In the late 1980's Levi Strauss decided to implement an EDI effort to increase the efficiency of its entire business process. The result has been named LeviLink, which is a set of business services Levi Strauss provides to its retail customers. LeviLink is involved in replenishing inventory, managing and reconciling purchase orders, receiving goods, processing and paying invoices, capturing point-of-sale data and analysis of market trends. The basis of this system is a barcode that Levi Strauss attaches to each product at the time of manufacture. As the item progresses through the manufacture, order, shipping and finally sales, data is constantly gathered and analyzed to maximize the efficiency of the entire process. If sales of a product are particularly strong in one region Levi Strauss knows as it is happening and has the ability to adjust manufacturing or inventory allocation to anticipate increased demand for the product(I/S Analyzer).

R.J. Reynolds-Consumer Goods

In the February 15th issue of Datamation magazine, it was reported that the R.J. Reynolds Company had sent letters to approximately 1500 of its key vendors in December of 1992. The letter stated that the suppliers had until the end of March 1993 to become EDI capable or the vendors would not receive any new business from Reynolds. The 1500 vendors represent only 10% of Reynolds' trading partners but account for 11,000 purchase orders each year orders. Reynolds reported that processing of the purchase orders by traditional methods cost the company $75 per order. Using EDI technology the orders cost 93 cents each to process ("EDI or Else").

5.3 Current and Future Use of EDI within the A/E/C Industry

Formal involvement of the A/E/C industry in EDIFACT began in Europe in 1987. The main participant has been the construction sector of the industry. The Western Europeans have continued to set the pace within the EDIFACT arena and are developing a series of message types for the construction industry. Both the United States and Japanese construction industry have recently joined EDIFACT. In the US, the Construction Industry Action Group (CIAG) founded in 1991, is charged with interfacing with the international message development initiative. In Japan, the Construction Industry information Network (CI-NET), was established in 1992 for the same purpose. The organization, agreement and approval of messages within the international construction industry has been a slow process.

At this point in time no EDI messages have passed from the development stage into commercial usage. The European EDIFACT group is testing some messages on a limited basis and is working towards final approval of the following list.

Western European EDIFACT Board
MD-5 Construction Group

List of Construction Specific Messages as of 9/92

Tag	Name	Description
CONTEN	Construction Tender	Commercial offer to execute construction work
CONEST	Establish Contract	Formal agreement and issue of contract
CONITT	Invitation to Tender	Client's request to contractors for bid
CONDPV	Construction Direct Payment Valuation	Contractor's request for payment
CONPVA	Construction Payment Valuation	Approval process for periodic progress payments
CONQVA	Construction Quantity Valuation	Approval process for determining quantity of work performed
CIRTLE	Circulation List	Lists recipients of a given message
CONAPW	Construction Advice of Pending Works	Advises other partners of pending work
CONRPW	Response to Advice of Pending Works	Gives data requested by CONAPW
CONDRO	Construction Drawing Organization	Advises recipient regarding status of design data
DISBTE	Distribution Provider	Attaches instruction to message regarding distribution
DISRES	Distribution Response Provider	Response to DISBTE

Most of the above messages are focused on the construction process itself. The MD-5 group also has targeted the supply and graphical information areas for future message development.

The CIAG was founded by a group of many of the largest EPC (Engineer/Procure/Construct) contractors working primarily for clients in the petrochemical industries in the Gulf States region of the US. The CIAG has focused its interest in four main areas of EDI message development: commodity codes for basic construction materials, the electronic transfer of CAD information, purchasing/materials management and accounting. The CIAG has held meetings to initiate an industry wide commodity code system and a material safety data sheet catalogue in cooperation with the chemical and petroleum industries. A successful pilot project has been completed to test the ANSI X12 841 transaction set for the EDI transmission of binary CAD and text files.

5.4 The EDI Approach to Legal Issues

One of the appealing aspects of EDI for the A/E/C industry, is its apparent success in overcoming the legal barriers to electronic commerce. EDI is one response to the challenge of achieving the paperless office. The paperless office in this case is a symbolic term for the benefits of computer based electronic business communication.

The legal basis of EDI business communication lies in the Trading Partner Agreement (Wright). The Trading Partner Agreement, or TPA, is a type of contract between two firms that desire to do buy and sell from each other using EDI technology. The typical TPA will address the following issues.

- System reliability and security
- Electronic signature procedures
- Error checking requirements for the communication channel
- Audit trail requirements and responsibilities
- Procedures for audit trail verification
- Procedures for logging all messages sent and received
- Specify periodic independent audit of EDI system reliability and control

In the event of a legal dispute between two firms that are party to a TPA agreement, the court would look to the TPA agreement as a basis for adjudicating the issue. In this context it would seem to be a valid framework to address electronic data exchange concerns within the A/E/C industry. The crucial difference between the EDI in other industries and conditions in the A/E/C industry arises concerning liabilities that do not fall under an express contract. The standard A/E/C industry scenario occurs when an owner or client contracts with a designer to design a facility and then contracts separately with a general contractor to execute the completed design furnished under the design contract. The assumption here is that when the contractor receives the design package from the owner the design is 100% complete. This is almost never the case, in fact typically built into the design package are procedures that require input, inspection or approval from the designer. Disputes often arise that involve the owner, designer and contractor, in these cases the court is often charged with determining liability issues where there is no express contractual obligations. In other words, a design firm may be faced with an unforeseen liability to a party with whom it has no contract. By definition, the protections and agreements found in the TPA would have no effect in the above case.

The above example is a traditional method to arrange for the design and construction of a facility. Today's owner has other options which are more flexible in allocating risk and liability. Construction management, design-build and turn-key contracting practices all offer possible frameworks that would allow the TPA to apply to all parties participating in the project. In fact these alternative contracting methods are gaining in favor due to the frequency of liability disputes incurred under the more traditional system. If these alternative contracting methods continue to gain favor, the use of contracts which include TPA type sections offer the potential of alleviating many of the barriers currently preventing the increased use of electronic data exchange in the A/E/C industry.

6.0 Conclusions and Recommendations for Further Study

6.1 Graphic Data Exchange Barriers

The lack of comprehensive software file exchange standards and CAD use conventions are critical barriers to the increased electronic exchange of graphic data. The use of CAD software for the generation and storage of graphic design information is widespread within the A/E/C industry, in spite of the survey data indicating that approximately half of the graphic data is generated by traditional hand drafting methods. There is no commonly used neutral file exchange standard to facilitate problem free exchange of CAD files among project team members. In addition, unless there is adequate coordination of CAD usage conventions at the start of a project, chances are high that electronically shared CAD files will contain problems due to inconsistent usage of the CAD application software (i.e.: layer types, geometric primitives, text and dimension styles, surface shape formulas, etc.).

The short term recommendation to overcoming this barrier is to address the problem at the earliest possible point in the project. At the inception of a project the owner or prime contractor (design or construction) can dictate mandatory CAD application software and usage conventions in the project specifications. At the same time a framework and procedure should be set to facilitate the exchange of CAD files among project team members.

Many projects do not have the time or budget to manage a graphic data exchange program from the start. Over the long term the A/E/C industry must promote industry wide standards for this purpose. The industry must agree on standard CAD tools for file exchange and usage conventions in order to facilitate greater computer based project communication of graphical information. The A/E/C industry, through its various professional organizations must work together to promote these standards.

ISO 10303, the product of the joint PDES/STEP effort, has been approved as a draft international standard in 1993. This file exchange standard takes over from older CAD file exchange standards such as IGES(US), SET(France) and VDA(Germany). It is also considerably better than its predecessors in that is designed around a full three dimensional product design model, as well as being a truly international standard. Due to its recent approval, it is unknown how successful it will be in use. It ultimately is the responsibility of the purchasers and users of proprietary CAD systems to demand that their software vendors write translators to work with the ISO 10303 standard.

6.2 Statutory Barriers

Currently, every state in the United States except Texas requires a physical ink stamp and signature on engineering or architectural design documents before the documents are legally considered to be a record set. Existing state laws governing the design professions do not recognize the electronic equivalent of the ink stamp and signature. In Japan, intra-corporate correspondence, such as a memorandum, require an ink stamp or signature before it can be considered a legal record. Until the legal standing of electronic information is accepted, statutory barriers will continue to prevent increased use of electronic data exchange.

The short term recommendation to overcome this barrier is for the A/E/C industry to work together and promote industry wide guidelines on the acceptance of a digitized stamp and signature, or its equivalent functions. The most appropriate forum for this effort is the professional organizations such as the AIA, ASCE and AGC. Together, these organizations set and monitor many of the professional standards followed by their membership.

Over the long term the laws governing design and engineering practice will be amended to accept electronic equivalents for the stamp and signature on record drawings. Again the professional associations are the best means for pressuring government agencies to change the laws.

6.3 Legal Barriers

Uncertainty regarding how the court will react to electronic records of business communication is a critical barrier to the increased use of EDE for business data. Based on the research conducted for this report, there is no basis for A/E/C industry fears that electronically transmitted and stored business data will not provide an adequate audit trail in the event a dispute leads to some form of litigation. In fact, some anecdotal evidence suggested that an electronic audit trail provides a better and more accurate record than traditional paper based methods.

After examining other industries involvement with electronic business communication, it is clear that, as a business tool, it is growing in popularity. In the future, an owner or client of the A/E/C industry may simply dictate the methods of communication for a given project. In order to prepare for this future, the A/E/C Industry and legal professions must work together to establish guidelines for electronic record keeping to insure that the records satisfy the court's requirements for an acceptable audit trail. At the same time the guidelines must also support the efficient management of the daily flow of project related business information.

6.4 EDI: Electronic Data Interchange

One of the most promising technologies for facilitating electronic business data communication available today is EDI. There are several benefits available to A/E/C firms that adopt EDI. EDI technology is an "off-the-shelf" product that is being used now by thousands of firms in other industries on an international basis. In the course of its development it has encountered and addressed some of the barriers indicated in the A/E/C industry survey. EDI provides automatic audit trail generation. All important concerns between partners engaged in EDI communication can be addressed explicitly by contract in the Trading Partner Agreement (TPA). It provides a well tested neutral standard for business type transactions, some of which are already in use in other industries. Efforts are now underway in Asia, Europe and North America to adapt EDI messaging technology to the A/E/C industry.

Unfortunately EDI in its current form is not a universal solution to facilitate A/E/C industry electronic communication. While EDI can be used to help transfer binary graphics files such as CAD drawings, it does not offer a neutral translation standard for the exchange of graphics files. A direct modem link without any EDI messaging would be just as good for the transfer of graphics files. The legal basis for EDI communication is based on the TPA. If there is no contract, none of the safeguards built into the TPA are in effect. The problem for the A/E/C industry occurs in the situation where two parties would share project related information with EDI yet have no explicit contract. Traditional A/E/C contracts between project owner and designer and between owner and contractor include liabilities for the designer to the contractor although they share no formal contract.

6.5 Education and Critical Mass

Lack of use within the industry was consistently cited as a critical barrier to EDE by all who responded to the survey. Electronic Data Exchange will not become a standard technology for the A/E/C industry until enough firms adopt the technology, creating a pool of users large enough to be self sustaining. Education of both industry members and their clients will continue

to be important to achieving widespread use of EDE technology. Groups such as the CIAG, MD-5 and CI-NET are working towards industry wide standards for EDI messages for the construction industry. The focus of these efforts is still only on the translation of routine business transaction into the EDI neutral standard. Efforts at educating the A/E/C industry must also focus on the need for a neutral translation standard for 2 and more importantly 3 dimensional graphics files. Additionally the A/E/C industry must educate its members to the benefits of electronic communication of all types based on computer networks that stretch beyond individual corporations.

Recommendations for Future Research

There are several areas where further research can be applied to overcome some of the barriers to EDE mentioned in this report. The A/E/C industry must reach a consensus on the basic criteria for an electronic audit trail. There is no prima facie legal barrier to the use of electronic media for the storage of project related information. At the same time care must be taken to satisfy the court's rules regarding the submission of project records into evidence in the case of litigation. An organized effort to set industry wide standards for audit trail criteria using electronic records would avoid the danger of inadmissible records and at the same time work to promote EDE technology as a legally "safe" means to manage project documents.

Another promising area for further research is to attempt to quantify the costs and benefits of electronic communication within the A/E/C environment. One of the barriers indicated by the survey was the high cost associated with purchasing and operating electronic communication systems. It may be partly due to the difficulty encountered in accurately measuring all costs and benefits to firms that implement EDE technology.

To test the viability of the introduction of EDI technology to the A/E/C industry it would be useful to research the problems associated with integrating elements of a standard EDI Trading Partner Agreement into existing industry standard contract forms. Within the United States, a large percentage of design and construction work is done under AIA and AGC standard form contracts. If aspects of the TPA could be successfully inserted into these already popular forms, it would be a great benefit to increased EDE and EDI usage.

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Appendix A

STANFORD UNIVERSITY

Center for Integrated Facility Engineering

CIFE
Terman Engineering Center
Stanford, California 94305-4020

Tel 415-723-6486
Fax 415-723-4806

October 30, 1992

Subject: AEC Industry Survey on Electronic Data Exchange Practices

Dear ,

I am drafting a survey which will be sent to CIFE members. It will attempt to identify the barriers which are preventing the AEC industry from increasing its use of electronic data exchange technology in the facility delivery process. The survey includes questions on graphic data (2D and 3D CAD/CAE etc.), and non graphic data (business data, invoices, letters, accounting information etc.). Both sections of the survey focus on data exchange barriers related to business, technical, and legal issues, as well as the issue of standards.

To improve the quality and percentage of responses, I am contacting each CIFE member before releasing the survey. I am seeking your help in identifying the individuals within your firm who are most suited to participate in the survey. If you could provide a list of people who, in your opinion, should receive the survey, I believe that it would increase the accuracy and quality of the results. I have attached a form for your use which includes information on how to return the names to CIFE. Please fax your recommendations, if possible.

Thank you for your time and attention in this matter.

Sincerely,

William Russell
Research Assistant, CIFE

cc: Paul Teicholz

Appendix B

STANFORD UNIVERSITY

Center for Integrated Facility Engineering

CIFE
Terman Engineering Center
Stanford, California 94305-4020

Tel 415-723-6486
Fax 415-723-4806

December 8, 1992

«name»
«position»
«company_name»
«address.1»
«address.2»
«address.3»

Subject: Survey on the Barriers to Electronic Data Exchange in the A/E/C Industry

Dear Mr. «last name»,

The Center for Integrated Facility Engineering (CIFE) is asking members of the A/E/C community to participate in a survey that will assess the use of Electronic Data Exchange (EDE) within the industry. Survey data will be used to guide a one year seed research project entitled: Barriers to Electronic Data Exchange in the A/E/C Industry.

Much of the information generated to support the facility delivery process is created in some form of electronic media e.g., CAD drawings, business transactions, email, word processing documents, etc. However, when the same information is shared among project team members, it is often delivered on paper. This research project will work to identify the legal, business, and technical barriers preventing increased exchange of electronically generated information.

CIFE's mission is to develop computer based tools and management techniques that will support improved automation and integration of design, engineering, construction and facility management. The ability to exchange information by the most efficient possible means is a fundamental requirement for improved productivity and quality in the A/E/C industry.

The information gathered in this survey will be used only for statistical purposes. No reference to a particular company or individual will appear in any published report. We would appreciate your attention to the attached survey, which must be completed and mailed in the enclosed envelope no later than January 15, 1993.

A copy of the final project with results and recommendations will be sent to all survey participants.

Thank you for your time and attention in this matter.

Sincerely,

Paul Teicholz
Director

CIFE, CE Department, Terman Engineering Center, Stanford University, Stanford CA., 94305-4020 (mail), Building 550, RM 553H, Stanford University (site) FAX No. 415-723-4806

0.0 Purpose of Industry Survey on Electronic Data Exchange

The Center for Integrated Facility Engineering (CIFE), is conducting a seed research project to assess the current state of affairs within the Architecture, Engineering, and Construction (AEC) industry regarding the issue of Electronic Data Exchange. Electronic Data Exchange includes such diverse data transfer technologies as Electronic Data Interchange(EDI), the .DXF and IGES CAD file formats, computer to computer fax capabilities, and electronic mail. Commercial technology is now available which allows project team members to exchange information via electronic media. The benefits to the users of EDE include an increase in the speed of data transfer (compared to post or courier delivery), reduced time, and possibly reduced cost through a reduction in paper work (filing, photocopying, etc.), greater accuracy of shared information through a reduction in data re-entry, are a few examples. There are, however, barriers preventing adoption of EDE which prompt this survey. The information gathered in this survey will form the core of a one year research effort to identify the barriers which are slowing the adoption of EDE technology by the AEC industry.

0.1 Survey Design

The survey is designed in a modular fashion with three parts. The three parts are:

1.0 Graphic Data Exchange (pages 1 through 3)

2.0 Business Data Exchange (pages 4 through 6)

3.0 Legal Aspects of Data Exchange (pages 7 through 8)

The survey can be answered by a single individual, or the modular elements can be separated into different parts, which may be given to the persons within each firm that are best suited to responding to a given section. Please use the envelope provided to return the attached pages 1 through 8, no later than December 31, 1992.

0.2 Results

The results of this research will be used to guide future efforts in research related to EDE within the AEC industry. Our goal is to identify the most promising areas where progress in EDE technology and the particular needs of the AEC industry intersect. An accurate picture of how the AEC industry currently exchanges data, combined with a knowledge of the barriers preventing further use of data exchange technologies, will be a valuable tool in helping to focus our research to the benefit of the AEC community.

The results of this research will be made available to all survey participants.

1.0 Graphic Data Section of Industry Survey on Electronic Data Exchange

Respondent's Personal Information

Name: _____

Title: _____

Telephone Number: _____

Fax Number: _____

1.1.1 When your firm shares graphic data with other project team members, please indicate what percentage of the data exists in each of the following media:

	shared within your firm	shared with other firms
hand-drafted	_____%	_____%
2D CAD	_____%	_____%
3D CAD	_____%	_____%
Product model/database linked CAD	_____%	_____%
_____ (other-please specify)	_____%	_____%
total=	100%	100%

1.1.2 When you transfer graphical data, what methods do you use for each project team member ?

For each team member listed below, please rank the possible data transfer methods from least important to most important.

Methods:
1 = hand carry, post, or courier delivery of paper drawings
2 = hand carry, post, or courier delivery of CAD file
3 = fax
4 = modem
5 = local area network/wide area network
6 = NA (not applicable)

Project Team Member	**least** important method			**most** important method	
Owner	____	____	____	____	____
Architect/Engineer	____	____	____	____	____
Structural Engineer	____	____	____	____	____
HVAC Engineer	____	____	____	____	____
Electrical Engineer	____	____	____	____	____
Process Engineer	____	____	____	____	____
_____ Engineer	____	____	____	____	____
_____ Engineer	____	____	____	____	____
_____ Engineer	____	____	____	____	____
Suppliers/Vendors	____	____	____	____	____
Construction Contractors	____	____	____	____	____
Regulatory Agencies	____	____	____	____	____
Owner's Operator	____	____	____	____	____
Public Utilities	____	____	____	____	____

1.1.3 In what percentage of projects are electronic data exchange capabilities mentioned in the proposal qualifications:

_____%

1.1.4 Do you believe that the percentage of projects requiring electronic data exchange capabilities will increase, decrease, or not change in the next three years:

increase_____ decrease_____ no change_____

1.1.5 In those cases where your firm does perform electronic data exchange of graphical data, what percentage of the data is exchanged in the formats listed below:

	percentage
1. Proprietary format of CAD system (a) name of system (a) _____	_____%
2. Proprietary format of CAD system (b) name of system (b) _____	_____%
3. IGES format	_____%
4. Other_____	_____%
5. Other_____	_____%
6. Other_____	_____%
	total = 100 %

1.1.6 If your firm is planning to increase its use of electronic data exchange for sharing graphical information, what will be your next step ?

_____

_____

_____

1.1.7 What is/are the most significant barrier(s) to the achievement of the above goals ?

_____

_____

_____

_____

_____

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_____

1.2.1 Listed below are potential barriers that may prevent greater use of electronic data exchange within the AEC industry. Please rank each issue independently, based on its importance as a barrier to your firm's exchanging of electronically stored graphical data with other project team members.

	Possible Barrier	Importance not a barrier						critical barrier
1.	inadequate CAD file standards (.DXF, IGES etc.)	0	1	2	3	4	5	6
2.	cost of hardware/software for data transfer	0	1	2	3	4	5	6
3.	possibility of data corruption during transmission	0	1	2	3	4	5	6
4.	cost of time required file transfer (modem over telephone line, etc.)	0	1	2	3	4	5	6
5.	incompatible CAD file formats	0	1	2	3	4	5	6
6.	modem technology (speed, error checking, etc.)	0	1	2	3	4	5	6
7.	lack of CAD drawing conventions (layer, linetype, blocks, entities etc.)	0	1	2	3	4	5	6
8.	lack of use within AEC industry	0	1	2	3	4	5	6
9.	legal requirement for paper copy	0	1	2	3	4	5	6
10.	legal requirement for designer's license stamp/signature	0	1	2	3	4	5	6
11.	possibility of third party alteration of electronic design documents	0	1	2	3	4	5	6
12.	restrictions of liability insurance company	0	1	2	3	4	5	6
13.	restrictions of regulatory agency	0	1	2	3	4	5	6
14.	possibility of legal challenge to design ownership	0	1	2	3	4	5	6
15.	failure of electronic media over a long time period (archival)	0	1	2	3	4	5	6
16.	data not generated in electronic CAD format	0	1	2	3	4	5	6
17.	other_____	0	1	2	3	4	5	6
18.	other_____	0	1	2	3	4	5	6

2.0 Business Data Section of Industry Survey on Electronic Data Exchange

Respondent's Personal Information (if different from previous section)

Name: _____

Title: _____

Telephone Number: _____

Fax Number: _____

2.1.1 When you transfer business data, what methods do you use for each type of information ?

For each type of data listed below, please rank the possible data transfer methods from least important to most important.

1 = hand carry, post, or courier delivery of paper drawings
2 = hand carry, post, or courier delivery of file on disk or tape
3 = fax
4 = modem
5 = local area network/wide area network
6 = NA (not applicable)

Data type	**least** important method			**most** important method	
1. job cost data	____	____	____	____	____
2. estimate data	____	____	____	____	____
3. scheduling	____	____	____	____	____
4. correspondence	____	____	____	____	____
5. RFI's	____	____	____	____	____
6. submittal related data	____	____	____	____	____
7. project specifications	____	____	____	____	____
8. manufacturer's/supplier's specifications	____	____	____	____	____
9. proposals/bid data	____	____	____	____	____
10. change order data	____	____	____	____	____
11. monthly/progress billings	____	____	____	____	____
12. operations and maintenance data	____	____	____	____	____
13. testing data	____	____	____	____	____
14. purchase orders/invoices	____	____	____	____	____
15. tax information	____	____	____	____	____
16. corporate accounting	____	____	____	____	____
17. banking data	____	____	____	____	____
18. insurance data	____	____	____	____	____
19._____ (other: please specify)	____	____	____	____	____

2.1.2 When your firm transfers business data, what percentage of the data is transferred using the following methods:

Data Transfer Method	shared within your firm	shared with other firms
Mail/hard copy	_____%	_____%
Courier/hard copy	_____%	_____%
Modem	_____%	_____%
Floppy Disk	_____%	_____%
Fax Machine	_____%	_____%
Dedicated Data Line	_____%	_____%
Network Links (local and wide)	_____%	_____%
Electronic Mail	_____%	_____%
_____	_____%	_____%

(other: please specify)

2.1.3 In what percentage of projects are electronic data exchange capabilities for business data mentioned in the proposal qualifications:

_____%

2.1.4 Has your firm implemented any Electronic Data Exchange technology or procedures for business information to date ? If yes, please give a brief outline below:

_____

_____

_____

_____

2.1.5 If your firm is planning to increase its use of electronic data exchange for sharing business information, what will be your next step ?

_____

_____

_____

2.1.6 What is/are the most significant barrier(s) to the achievement of the above goals ?

_____

_____

_____

_____

_____

_____

_____

_____

2.2.1 Listed below are potential barriers that may prevent greater use of electronic data exchange within the AEC industry. Please rank each issue independently, based on its importance as a barrier to your firm's exchanging of electronically stored business data with other project team members.

	Possible Barrier	Importance not a barrier						critical barrier
1.	cost of hardware/software for data transfer	0	1	2	3	4	5	6
2.	possibility of data corruption during transmission	0	1	2	3	4	5	6
3.	cost of time required file transfer (modem over telephone line, etc.)	0	1	2	3	4	5	6
4.	modem technology (speed, error checking, etc.)	0	1	2	3	4	5	6
5.	lack of users within the AEC industry	0	1	2	3	4	5	6
6.	legal requirement for paper copy	0	1	2	3	4	5	6
7.	possibility of third party alteration of electronic documents	0	1	2	3	4	5	6
8.	restrictions of a liability insurance company	0	1	2	3	4	5	6
9.	restrictions of a regulatory agency	0	1	2	3	4	5	6
10.	failure of electronic media over a long time period (archival)	0	1	2	3	4	5	6
11.	data not generated in electronic media	0	1	2	3	4	5	6
12.	other_____	0	1	2	3	4	5	6
13.	other_____	0	1	2	3	4	5	6

3.0 Legal Aspects Section of Industry Survey on Electronic Data Exchange

Respondent's Personal Information (if different from previous section)

Name: _____

Title: _____

Telephone Number: _____

Fax Number: _____

3.1.1 Does your firm have an established legal policy towards the transfer of CAD files via electronic media:

yes no

3.1.2 If your firm does have a policy, please give a brief outline of the policy below:

_____

_____

_____

_____

_____

3.1.3 Has your firm ever entered into a trading partner agreement for the purpose of electronic data exchange:

yes no

3.1.4 If your firm has entered into a trading partner agreement, please give a brief outline of the scope and purpose of the arrangement below:

_____

_____

_____

_____

_____

_____

3.1.5 Do you know of any legal problems that were caused or exacerbated by electronic data exchange ? If so, please outline the issue below and give reference to laws and decisions that were relevant to or resulted from the issue(s).

_____

_____

_____

_____

_____

_____

3.2.1 Listed below are potential legal barriers that may prevent more widespread use of electronic data exchange within the AEC industry. Please rank each issue independently, based on its importance as a barrier to your firm's increased use of electronic data exchange to transfer information:

	Possible Barrier	Importance not a barrier						critical barrier
1.	potential effects on professional liability	0	1	2	3	4	5	6
2.	potential effects on errors and omissions liability	0	1	2	3	4	5	6
3.	intellectual property/copyright protection	0	1	2	3	4	5	6
4.	project permit requirements of regulatory agencies	0	1	2	3	4	5	6
5.	contract requirements for project record drawings	0	1	2	3	4	5	6
6.	risk of third party changes to design documents	0	1	2	3	4	5	6
7.	risk of data loss/corruption under longterm archiving	0	1	2	3	4	5	6
8.	liability issues relating to data loss/corruption during electronic transfer	0	1	2	3	4	5	6
9.	liability for cost/quantity information derived directly from CAD file	0	1	2	3	4	5	6
10.	legal requirement for physical evidence of professional stamp/signature	0	1	2	3	4	5	6
11.	_____ (other: please specify)	0	1	2	3	4	5	6
12.	_____ (other: please specify)	0	1	2	3	4	5	6
13.	_____ (other: please specify)	0	1	2	3	4	5	6