

ELECTRONIC DATA INTERCHANGE IN CONSTRUCTION

By George E. Gibson Jr.¹ and Lansford C. Bell,² Fellow, ASCE

ABSTRACT: There is a need within the construction industry to electronically transmit standard documents between designers, owners, contractors, and material suppliers. These documents include purchase orders, requests for quotations, invoices, shipping notifications, materials lists, and payment transfers. Ideally, the transmission should be structured to eliminate or reduce the rekeying of transmitted data. This paper discusses the basic elements of electronic data interchange (EDI), a technology for document transfer that has produced documented cost-saving benefits in other industries. Through inexpensive translation software that uses industry standards, direct computer-to-computer transmission of most any type of document is possible. The fundamentals of electronic data interchange are discussed and an example of document translation using ANSI X12 standards is presented. A case study implementation effort that was examined as part of a research project funded by the Construction Industry Institute is also described herein. This case study illustrates the fact that EDI technology is inexpensive and that tangible cost-saving benefits can be realized in a relatively short period of time.

INTRODUCTION

During the past decade, the construction industry has witnessed a dramatic transformation in electronic data generation and management. The transition from single mainframe computers to multitudes of minicomputers and microcomputers has significantly altered the manner and means by which owners and contractors manage construction-related data. Rapidly improving technology coupled with declining hardware costs have permitted a decentralized processing environment that benefits every facet of construction project management.

These developments have resulted in a phenomenal growth in the volume and variety of data as well as the number of locations and entities generating and processing electronic data. With this growth, the ability to transfer information efficiently within and between owner, contractor, subcontractor, and material-supplier organizations becomes essential. Although sophisticated integrated computer systems have become commonplace for internal data processing, electronic data transfer frequently involves volumes of hard-copy printouts, repetitive data entry, and redundant calculation and verification.

The writers are conducting a research project for the Construction Industry Institute (CII), examining data-transfer problems within the construction industry. CII membership consists of 80 major owner and engineering contractor firms involved in industrial construction in the United States. The research has focused, in part, on a data-transfer technology that has proven effective in other industries. This technology, electronic data interchange

¹Grad. Res. Asst., Dept. of Civ. Engrg., Auburn Univ., Auburn, AL 36849.

²Prof., Dept. of Civ. Engrg., Clemson Univ., Clemson, SC 29634-0911.

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(EDI), can best be defined as the direct computer-to-computer exchange of business data in a standard format.

EDI differs from electronic mail in that data are transmitted in some standard industry format, checked for errors, and imported directly into the receiving computer system without rekeying. Documents that are routinely transmitted using EDI include purchase orders, purchase-order acknowledgments, material releases, requests for quotations, supplier bids, and fund transfers. In other industries, EDI technology is generally credited with reducing paperwork and data transmission costs, improving data accuracy, reducing material inventories, and enhancing the planning of activities that depend on accurate, timely material shipping notifications.

This paper explores the general concepts of EDI, EDI data transmission standards, and EDI translation software. In addition, a fully implemented EDI system in current use by a CII utility firm is presented as a case study.

ELECTRONIC DATA TRANSMISSION

Electronic data transmission has become a popular means of delivering business documents worldwide over the past several years. Three methods have generally emerged as the leading types of electronic data transmission and will be discussed briefly herein.

Facsimile (FAX) is a method that allows the user to scan and send graphic data from an optical scanning telecommunication device via standard telephone lines to a trading partner who also has a similar device. The information is represented by hard copy at each end. The document information is useful, but computer manipulation of the transmitted data is not possible unless the transmitted document is rekeyed into the receiving computer system. The primary advantage of fax is that the document is delivered to the user much faster than with standard mail carriers.

Electronic mail (E-mail) is a process very similar to using the Postal Service. The E-mail sender transmits data via modem to a third-party carrier. This carrier then transfers the data into the receiving party's electronic mail box. The "mail" can then be downloaded into the receiver's computer. The information can be computer manipulated as long as both parties use a compatible application software system.

EDI is a relatively recent introduction into the data integration movement within industry. It is a computer-based financial and inventory communication system that allows direct computer-to-computer exchange of standard business-format information (Monczka and Carter, unpublished report, 1987). EDI allows the data to be checked for errors and processed immediately because it is received in a standard format. Rekeying of received data is not necessary. For most applications, EDI is used to provide computer communications between two different corporate trading partners. However, internal communication within a company is also facilitated through the use of EDI using either industry-adopted or internal standards.

Each of the three electronic data transmission mechanisms has a specific function within the business world. The use of standard formatted documents promises to make EDI the system of choice within industry over the next several years. The capability of EDI to allow computer systems to perform many routine business transactions without human intervention is both unique and exciting.

EDI AND ANSI ASC X12

History

EDI had its beginnings in the rail industry in the late 1960s. Since that time, many industries, such as the automotive, banking, transportation, retail/grocery, and textile industries, have adopted the technology. Expenditures on EDI computer service software and transmissions are expected to exceed \$1 billion in 1990. "I expect the automotive industry will be a paperless environment in three to five years," said Margaret Goscinski, associate director of the Automotive Industry Action Group (AIAG) (Monczka and Carter, unpublished report, 1987).

According to Canright (1987), "By using EDI, Georgia Power estimates that it saves about \$2 million yearly on inventory reductions, resulting from shorter purchase and lead times." This does not take into consideration productivity gains in the purchasing department. Jenkins (1988) wrote, "Navistar International Corp. truck inventories have been reduced by \$167 million, or one-third, in the first eighteen months of use. RCA reduced order processing costs by \$50 per purchase order, and Dow Chemical reports savings of up to \$12 per order." Levi-Straus has regained a major portion of its previously held market share from foreign competitors due to EDI's speed and flexibility in placing and filling orders (Jerome 1989). Whereas these applications do not exactly parallel materials management applications in construction, they do suggest that the technology merits serious consideration.

Types of Networks

The two basic types of EDI systems that exist today are private and third-party networks, as illustrated in Figs. 1 and 2. Private networks are generally used within a group, such as an automobile manufacturer and its principal dealers. Internal EDI standards are established between the participants and data are transmitted from one computer to another. No other participant interactions take place. The system works well with a limited number of trading partners. However, with a larger number of users, the private network becomes complex and expensive due to software development and telephone charges.

For most EDI users, third-party networking, also known as electronic mailboxing, is a more efficient mechanism for executing EDI transactions. With this system in place, users can send and receive from multiple sources at less cost than with a private network. Third-party carriers provide converters that overcome the problems of different computer types, protocols, and line speed. The user can access the third-party "mailbox" at his convenience or transmit and receive documents at a predetermined time. The cost of using a third-party carrier generally includes a monthly minimum fixed cost and 30¢ to 50¢ per transaction, depending on the carrier selected. Third-party network services are currently provided by McDonnell Douglas, GEISCO, IBM, Control Data, Western Union, and others.

Standards

The American National Standards Institute (ANSI) has established the Accredited Standards Committee (ASC) X12 as its source for standards for EDI transmission. These standards have been endorsed by most industry groups,

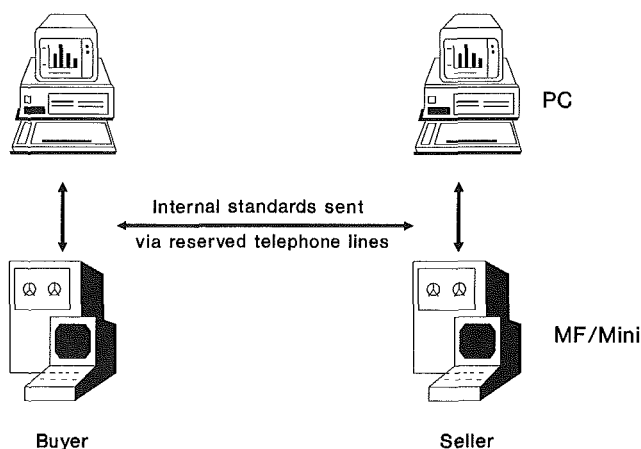


FIG. 1. EDI Hardware Configuration Showing Private Network Using Internal Standards

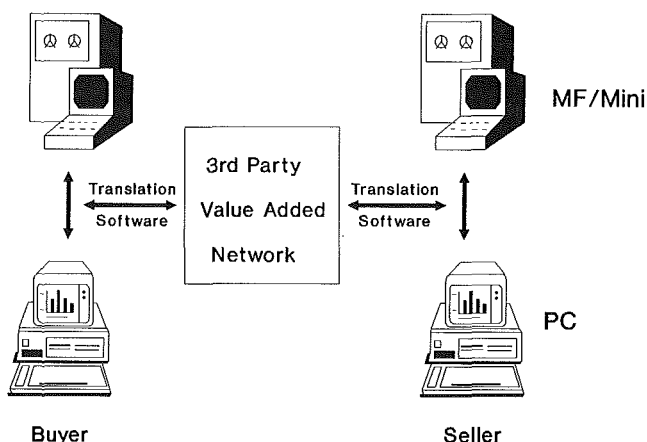


FIG. 2. EDI Hardware Configuration Showing Third-Party Network with Approved Standards

and there are currently 49 business transactions released, in ballot comment or under development, as shown in Table 1. In column 3 of Table 1, ANSI and a two-digit number denote the year of publication; release denotes X12 draft standards for trial use. The *ANSI X12* standards were published in 1983 and 1986 and are slated to be published again in 1991 ("X12/DISA" 1989). Releases take place on a more frequent basis.

Standards have also been developed for the automobile, transportation, grocery, and warehouse industries. The International Standards Organization (ISO) and the United Nations have recognized the need for international EDI standards and have set up EDI for Administrative, Commerce, and Transport (EDIFACT) to standardize EDI in the international arena.

TABLE 1. ANSI X12 Standards Status Summary

Title (1)	Code (2)	Status (3)
Invoice	810	ANSI 86, release 1, 2, 3
Operating expense statement	819	Release 3
Payment order/remittance advice	820	Release 1, 2, 3 revision 9/89
Customer account analysis	822	Release 3
Lockbox	823	Release 2, 3
Planning schedule/release	830	ANSI 86, release 1, 2, 3
Price sales catalog	832	ANSI 86, release 1, 2, 3
Request for quotation	840	ANSI 86, release 1, 2, 3
Response for request for quotation	843	ANSI 86, release 1, 2, 3
Product transfer account adjustment	844	Release 3
Price authorization acknowledgment	845	Release 3
Inventory status/advice	846	Release 1, 2, 3
Response to product transfer	849	Release 3
Purchase order	850	ANSI 86, release 1, 2, 3
Purchase-order acknowledgment	855	ANSI 86, release 1, 2, 3
Ship notice/manifest	856	ANSI 87, release 1, 2, 3
Shipment information	858	Release 3
Purchase-order change	860	ANSI 86, release 1, 2, 3
Receiving notice	861	ANSI 86, release 1, 2, 3
Shipping service	862	Release 2, 3
Report of test results	863	Release 3
Purchase-order change acknowledgment	865	ANSI 86, release 1, 2, 3
Product transfer and resale report	867	Release 2, 3
Order status inquiry	869	Release 2, 3
Order status report	870	Release 2, 3
Functional acknowledgment	997	ANSI 86, release 1, 2, 3
Financial-information reporting	821	In publication
Text	864	In publication
Application advice	824	Ballot comment/revision
Financial return notice	827	Ballot comment/revision
Payment cancellation request	829	Ballot comment/revision
Control totals	831	Ballot comment
Specifications	841	Ballot comment
Freight invoice	859	Ballot comment
Production sequence	866	Ballot comment
Electronic form structure	868	Ballot comment/revision
Cryptographic service message	815	Development
Payment status report	825	Development
Tax information reporting	826	Development
Payment status inquiry	828	Development
Electronic bid form	833	Development
Contract award	836	Development
Trading-partner profile	838	Development
Project plan and status report	839	Development
Nonconformance data	842	Development
Material-safety data sheet	848	Development
Product-activity data	852	Development
Shipment and billing notice	858	Development
File transfer	996	Development

TRANSLATION SOFTWARE

Overview

EDI requires the use of some type of software to translate standard business forms into a protocol that can be received and processed by trading partners. This software was developed internally by many corporations when EDI was in its infancy. Documents were first transmitted using internally developed standards and software that was not hardware independent.

In recent years, general industry standards such as *ANSI X12* have evolved. These standards have been developed because of the wide diversity of software and hardware systems used by the many trading partners who have entered the EDI market. As a result, many software development companies have been established specifically for the purpose of providing translation software to the competitive marketplace.

Survey

As part of an ongoing research project funded by the Construction Industry Institute, the writers have solicited information and demonstration software from a number of translation software vendors. The following conclusions are based on a review of vendor literature and an examination of representative microcomputer software packages.

Again, the purpose of a translation software package is to convert purchase orders, invoices, shipping notices, and other business documents into an EDI standard industry format. In general, the translation software package accomplishes this task with little or no modification to the user's existing computer programs.

Translation software can be purchased for microcomputer use as a stand-alone purchasing system or as the front end for mainframe or minicomputers. Document information can be either entered directly into the translation software package or imported from a central mainframe computer data base.

The microcomputer translation software diskettes reviewed by the writers were easy to use and well documented. Many packages use menus, windows, and help screens that minimize the need for lengthy user training. For most packages the process of creating a document, translating the document, and simulating the transmission of the document can be accomplished with only a few minutes of effort.

Other features of the reviewed software include management tools to track incoming and outgoing documents. All transactions can be tracked or retrieved by knowing the specific document number. Some documents—a purchase-order acknowledgment, for example—can be created with just a few keystrokes once a similar document has been created or received. Other capabilities, including file management, document printing, report generation, automatic dial-up capability, periodic document purge, standard template design, and vendor data-base maintenance, are included with most software packages.

EDI translation software is generally capable of supporting multiple EDI standards. *ANSI ASC X12*, UCS (grocery and related industries), WINS (warehouse industry standards), and TDCC (transportation data coordinating system—rail, air, freight, ocean) standards can typically be included in a single software package. Additionally, all EDI translation software vendors are working toward translation compatibility with EDIFACT.

<p style="text-align: center;">ABC Construction Co. Page 1 of 1 Purchase Order ABC-101 Date: 20 October 1989</p>						
<p>To: XYZ Pipe Co. 444 W. Elm Auburn, AL 36830 (205) 844-6269</p>			<p>Buyer: J. T. Smith</p>			
<p>From: ABC Construction Co. 217 Harbert Auburn, AL 36849</p>			<p>Ship to: ABC Construction Co. Pipe Warehouse Marne Rd. RR6 Paper Mill, AL 36777</p>			
Line No.	Product I.D.	Quan.	Unit	Description	Unit Price	Extended Price
001	356342134	5	HF	1" Black Steel Pipe	200.00	1000.00
002	356342122	4	HF	2" Black Steel Pipe	400.00	1600.00
<p>P.O. Terms and Shipping Instructions: (attached)</p>						

FIG. 3. Hypothetical Purchase Order

There is 1 document to PREPARE.

P R E P A R E L O G

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ANSI TRANSMISSION ID. T-10 to XYZ PIPE CO., dated 89/10/20 15:15
ISA*00*BG01.ISA02*01*OUT321    *ZZ*ISA06/8..BG03/4*ZZ*TRAMOD-2    *891020*151
GS*PO*GSO2/GSO3*GROUPID-32*891020*1515*2*X*002002
ST#850*2001
BEG*00*NE*ABC-101***891020
N1*BT*ABC CONSTRUCTION CO.
N1*BY*J. T. SMITH
N1*WH*MARNE RD. PAPER MILL, AL 36777
POL**5*HF*200.00**VC*356342134
PIDF*****1" BLACK STEEL PIPE
POL**4*HF*400.00**VC*356342122
PIDF*****2" BLACK STEEL PIPE
CTT*2
SE*11*2001
GE*1*2
IEA*1*000000010
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FIG. 4. Purchase Order Translated into ANSI X12 Format Using APL QUALEDI Software

Example

EDI standards are essentially sets of codes used to identify various data elements, or segments, within the transmitted document. Fig. 3 illustrates a hypothetical purchase-order document for a construction project. To interface with an EDI system, this purchase order could be manually keyed into the translation software or downloaded into the software from a materials management purchasing file. Fig. 4 shows the purchase order translated into ANSI ASC X12 form and ready for transmission. The translation illustrated in Fig. 4 was accomplished using a PC-based translation software package, QUALEDI, marketed by the APL Group, Inc.

An examination of the translated document shown in Fig. 4 illustrates the use of a standard format and accepted codes to identify transmitted information. For example, the purchase-order header information:

ABC Construction Co.
Purchase Order ABC-101
Date: 20 October 1989

is translated into *ANSI X12* in the following line:

BEG*00*NE*ABC-101***891020

where BEG denotes the beginning of a purchase order document; 00 and NE are codes denoting original purchase order and new order, respectively; and the asterisk is used to separate data fields. More than one asterisk is used to indicate the omission of one or more optional fields in a given data line. Similarly, line item 1 of the purchase order is translated into two data lines:

P01*5*HF*200.00**VC*35634134
PID*F*****1" BLACK STEEL PIPE

where P01 and PID are headers denoting purchase-order line item and description data, respectively; VC defines the vendor's catalog as the source of the product identification number; and F denotes a free form description of the product.

CII MEMBER FIRM CASE STUDY

Background

A major CII utility has developed an effective electronic communication system for transmitting purchasing-related data to and from its major material suppliers. The company maintains 66,000 standard catalog part numbers for materials used for facility operation and maintenance. The purchasing department processes approximately 32,000 requisitions annually, 82% of which are for standard catalog stock items.

A sophisticated mainframe-computer materials management system is being used to generate requisitions automatically from warehouse inventory levels, generate requests for quotations from requisitions, and perform other purchasing-related functions. To further automate the materials management system and reduce procurement costs, the company began investigating various forms of electronic data communications in February 1988. The potential for linking suppliers via electronic mailboxes (E-mail), fax, and *ANSI X12* electronic data interchange (EDI) was recognized as a means of reducing procurement-related costs.

Initially, seven vendors were selected for electronic mailbox transmission of purchase orders and requests for quotations. At present, the company is exchanging purchase orders, requests for quotations, and purchase-order acknowledgments with 412 supplier firms, 56 of which are linked to the utility via *ANSI X12* electronic data interchange. It is anticipated that the number of *ANSI X12* EDI trading partners will increase to 120 by the end of 1991.

System Description

The mainframe computer and its purchasing files are linked to a PC that uses an EDI translation software package from Metro-Mark Integrated Systems, Inc. The PC communicates with a third-party value-added network (Western Union Electronic Data Interchange Services) through a 2,400-baud modem. This particular network is capable of receiving, sorting, and transmitting electronic mailbox, fax, and/or *ANSI X12* EDI documents, depending on the communication capabilities of the material supplier.

The PC and mainframe systems interact with a minimum of operator in-

intervention. The PC is programmed to query the mainframe files two times a day automatically. Purchase orders and requests for quotations are then downloaded to the PC, translated to *ANSI X12* format if appropriate, and transmitted to the third-party network for subsequent distribution. The utility mailbox within the network is checked for incoming documents from suppliers and transmitted to the mainframe materials management system. If incoming purchase-order acknowledgments indicate anticipated shipping problems, exception reports are forwarded to the utility's expediting department. A number of standard reports are also generated by the PC that provide an audit trail and facilitate operator monitoring of the system. In the near future, the system will be expanded to include EDI invoicing and fund-transfer capability.

The utility has established a standard signed agreement that contains the terms and conditions of the electronically transmitted purchase orders. This agreement will soon be replaced with a similar agreement proposed by ANSI and approved by the American Bar Association.

The utility company has a formal price and performance rating system for its major materials suppliers. The rating system will soon be extended to include a rating component for electronic communications capability. Since electronic communications reduce procurement costs significantly, this is a logical extension of the rating system.

System Development, Costs, and Benefits

The electronic data transmission system was developed to its current status through a part-time effort of two employees over a 1-1/2-year period of time. The initial text message communications system that used seven suppliers was created and put on line in a four-month period. Modifications to the materials management and purchasing mainframe-computer system required about 40 man-days of programming effort. One of the two employees developing the system attended *ANSI X12* committee meetings to gain familiarity with the technology.

Western Union Electronic Data Interchange Services was selected as the third-party network after soliciting price and service capabilities from a number of other network services. Current billing from Western Union averages about 20¢ per transmitted document. The Metro-Mark translation software package was purchased at a cost of approximately \$2,000. This particular package was selected primarily because both PC and mainframe versions are available. Although mainframe software is considerably more expensive (\$35,000 to \$100,000), should purchasing volumes expand considerably in the future, a mainframe system may be required. Regardless, a PC system is recommended as an economical means of establishing the initial system.

It is estimated that the system in its current form has provided significant cost savings. A manual purchasing cycle time of 23 days has been reduced to an average of eight days. An estimated \$389,000 savings that can be attributed to processing costs has been saved. By 1991, when 90% of the purchasing volume will be conducted via EDI, a \$1,000,000 annual cost savings is anticipated.

PILOT PROJECTS

The case study described indicates that EDI is well suited to a home-office purchasing environment that involves repeated purchases of standard catalog

items for facility maintenance and operation. However, when executing a new facility construction project, the contractor may or may not execute repeated purchases of standard items using established trading partners. The ability of the contractor to use EDI in a field-purchasing environment has yet to be fully proven.

The CII Electronic Data Management Task Force is continuing to explore the potential for EDI applications in new project construction. As part of the ongoing research, two pilot projects have been recently initiated.

The first project involves an EDI linkage between a CII contractor and a major tool supplier. Software is being developed that will permit on-site requisition generation for tools, automatic generation of the required purchase order, and subsequent EDI transmission of purchasing and invoicing documents.

The second project establishes EDI linkages between a CII contractor and selected sole-source suppliers of materials and equipment used for offshore construction and maintenance. This firm conducted an initial survey of trading partners and identified several who were already using EDI. An EDI system, which involved 15 trading partners, was fully implemented in a three-month time period. Within 12 months, 96% of the purchase order issued by this group was transmitted using EDI.

These two pilot projects will be described in detail in forthcoming CII research publications. The pilot projects should demonstrate the viability of EDI from the contractor's perspective.

CONCLUSION

A CII utility has developed a rapidly expanding, effective electronic data transmission system. Top management support was identified as a critical element contributing to its success. The utility had a comprehensive materials management computer system in place before electronic communications enhancements were developed; this is an important factor if procurement costs are to be reduced and paperwork eliminated.

Use of EDI in business transactions has been increasing tremendously during the past few years. Although this change has not reached the construction industry to any great extent, the groundwork has been established with computer integration of material management, project scheduling, and project-cost accounting systems. Just as the telephone and fax machine have been essential to business operations over the past few years, so will EDI to construction operations in the future.

The Electronic Data Management Task Force of the Construction Industry Institute is continuing to explore and promote EDI applications in construction. Two pilot projects are under development that will examine the feasibility of using EDI for purchasing-related activities on major industrial construction projects. The CII research is also attempting to determine to what extent *ANSI X12* and other industry standards meet the need for document transmission requirements that are unique to the construction industry.

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