

An Industry Based Electronic Drawing Control System

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Abstract

The current study describes the design and development of an Electronic Drawing Control System (EDCS), which enhances communication between customers and suppliers, shortens manufacturing lead times, improves product quality, and increases the overall profitability of the manufacturer. This type of system could be developed and applied to most manufacturing environments. The EDCS was developed in a Houston based company which produces oilfield equipment for customers worldwide. Development of the system lasted for about two years, utilizing one company engineer, two contract programmers and one systems developer. The system provides tools to send graphics and data in real-time allowing the customer to view the desired product electronically. The EDCS comprises of electronic communication, commercial software applications, and appropriate computer hardware. These tools include digital drawings, databases, documentation of product features, and programs to display data in several different formats. Over the last year the company has successfully used the new EDCS. However, implementing the new system resulted in a few modifications, hardware upgrades and software enhancements. The system is designed to continually accommodate the fast changing field of computer hardware and software. The paper presents a case study which identifies specific needs of a typical oil and gas customer and provides solutions through the use of the manufacturer's EDCS. The Internet is utilized to efficiently communicate with customer sites around the world.

I. Introduction

Global industrial competition requires American manufacturers to make high quality products with proven designs while satisfying the customers' demands. Electronic communications is one aspect of manufacturing which continues to improve productivity gains. Recent advances in technology provide an inexpensive and efficient communication environment for customer interaction with the manufacturing enterprise. As technology continues to enhance the ability to communicate in real-time, customers can expect their needs to be met with increasing speed, accuracy, and critical details. Current enhancements in computer hardware and software allow data processing to evolve from traditional numbers located on a mainframe into pictures quickly transmitted across the Internet. Software improvements provide more information in less time, while using a fraction of the resources. In addition, advancing hardware technologies provide inexpensive and more powerful systems, allowing manufacturing companies to adapt quickly to the changing needs of their customers. An increasing need to develop a new technology, which leads to lower lead times and higher quality and productivity was clearly identified.

Oilfield service companies provide downhole tooling for exploration and production drilling around the world. Since most oil wells are different in many aspects, service companies must produce customized products that feature many different options. Some basic variables describing downhole products include size, weight, grade of material, length, type of elastomers, thread connections, pressure ratings, and etc. A typical product line comprises of over 2000 designs, which creates a vast array of choices. Therefore, it is imperative that the best product is quickly identified and matched to the specific application. In this dynamic environment, the oilfield service company has to use an easy to change drawing control system to help satisfy the complex and changing demands of the customer.

An agile producer of oilfield equipment provides current drawings and other documentation describing its products which support a healthy relationship with the customer. To strengthen this line of communication, a successful drawing control system needs to provide tools enabling salesmen to market, sell, and maintain these oilfield equipment drawings while ensuring an accurate application. Different types of marketing tools include Equipment Drawings, Marketing Application Drawings, Illustration Drawings, Specified Illustration Drawings, Inspection Drawings, Running Instructions, and Field Service Reports. All drawings use a standardized AutoCAD generated electronic file as a source for reproducing an image of any given product. A commercial software package converts the vector image into a raster image making it an extended-metafile. This conversion eliminates sending out machine drawings and provides a user-friendly file format. Location of the image is centralized on the NT Server and on a frequently updated CD-ROM.

As shown in Figure 1, the old drawing control system uses traditional methods to accomplish repetitive tasks and does not utilize new tools to improve communication. This system requires a considerable amount of time to perform repetitive tasks such as delivery of an unformatted request for drawings, shipping of drawings to customers, manual search of drawings, and physically transmitting them between the Marketing and Engineering departments.

In response to the need for a better drawing control system the study describes the design and development of the new Electronic Drawing Control System (EDCS), which enhances communication between customers and suppliers, shortens manufacturing lead times, improves product quality, and increases the overall profitability of the manufacturer. The developed system comprises of electronic communication, commercial software applications, and appropriate computer hardware. The system provides tools to send graphics and data in real-time allowing the customer to view the desired product electronically. These tools include digital drawings, databases, documentation of product features, and programs to display data in several different formats. The system is designed to continually accommodate the fast changing field of computer hardware and software. The paper presents a case study which identifies specific needs of a typical oil and gas customer and provides solutions through the use of the manufacturer's EDCS. The Internet is utilized to efficiently communicate with customer sites around the world.

This paper also identifies current accessibility issues and solutions to effectively use the Internet as an inexpensive method of communication. Although the Internet is always on and available,

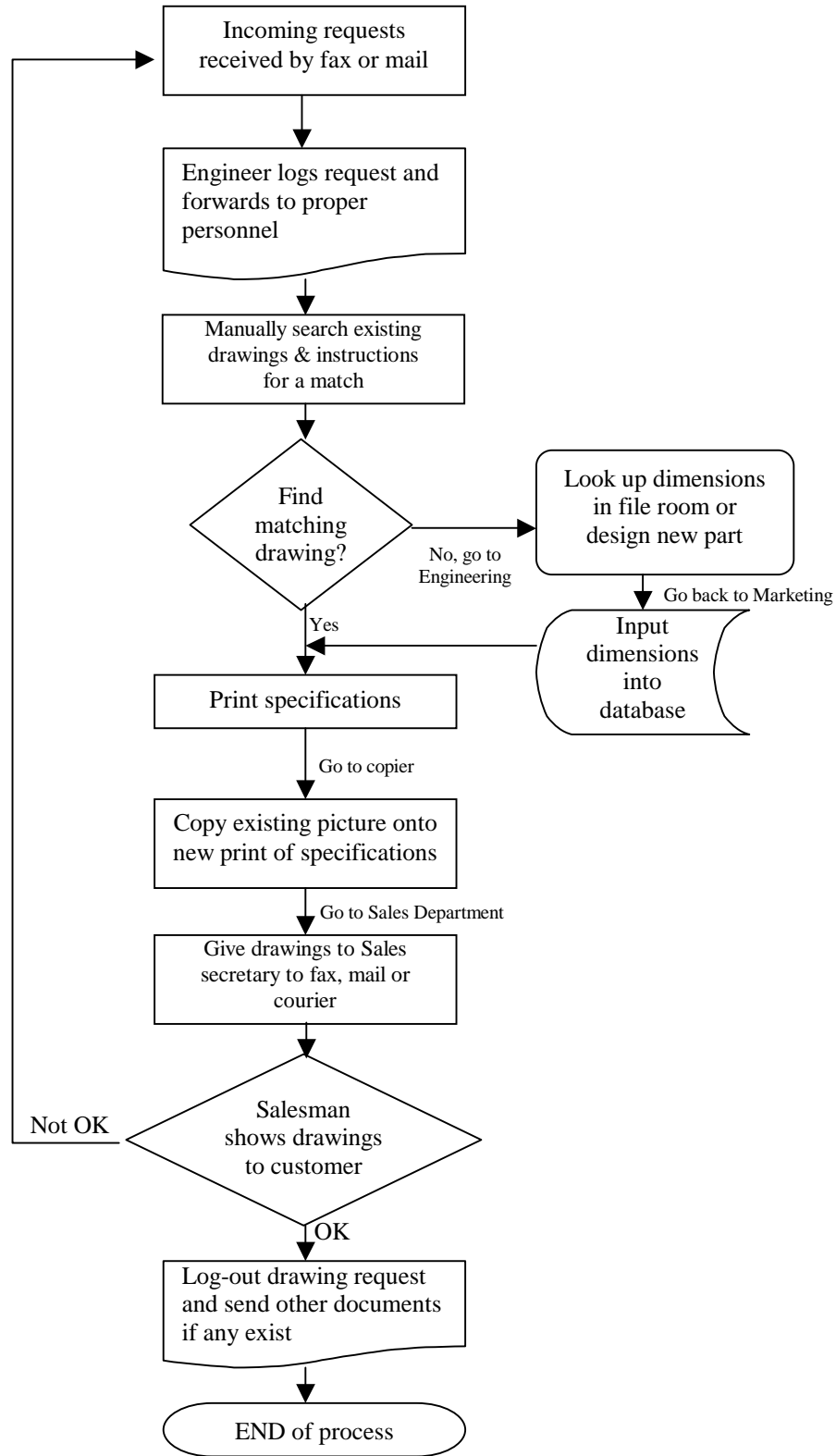


Figure 1. Flow Chart of Old Drawing Control System.

it is not always reliable due to technological issues prohibiting accessibility. The backbone of current electronic communication systems relies heavily on the Internet to quickly transmit data. The rate of transmission controls the download time of drawings sent across the Internet. Real-time transfers must rely totally on the Internet for new data, which is coupled with most of the information stored locally on a CD-ROM. The user's program downloads new data via the Internet, which in turn replaces old or incorrect data located on the CD-ROM. The new data is stored locally on the hard drive and can be used to negotiate the new purchase with a customer.

II. Advantages of the EDCS

Immediate communication with all parties involved in the manufacturing cycle greatly reduces the time required to produce a product. All excess communication time equals added costs to a product. Any amount of idle time due to inefficient communications could be eliminated to decrease lead times.⁴ An EDCS can quickly provide tools allowing the customer and salesman to communicate and quickly agree on a proposed solution. Also, the salesman is less likely to mis-communicate with the customer about the product because the provided detailed drawing shows a picture and pertinent information regarding his customized order. This electronic system will also allow any design engineer to quickly adjust the product design to satisfy the customer's requirements. By assigning a new part number, the EDCS can provide the customer with detailed information regarding the status of his purchase order.

In the early stages of a purchase inquiry, real-time communication allows the production system to collectively react and quickly satisfy all manufacturing requirements. Early reaction provides the time necessary to eliminate bottlenecks, which greatly improves lead-times and efficiencies.⁴ Upon identifying the part number, all departments involved such as purchasing, will have an early start identifying "hard to find" raw materials, etc. All subsequent manufacturing processes will have a better planning time to a particular order. The EDCS identifies part numbers based on previous applications, inquiries, and customer history. Knowing a part number quickly will greatly lower the manufacturing lead-time. The EDCS will also identify other products or services required when a particular product is purchased. It could identify special requirements including field installation procedures on how to use a product, non-standard materials, personnel needed to install a product, special shipping requirements, extra documentation, quality papers, etc.

III. System Development

An analysis was performed on the Old Drawing Control (ODC) System Figure 1, which identified processes that could either be streamlined or eliminated. The ODC System did not aid matching products to a specific application, but it contained a large amount of unmanaged data. The system lacked the knowledge required to extract the best product out of a large pool of possible solutions. The new system was developed to make use of electronic communications wherever feasible and thus eliminates costly repetitive tasks by the use of automation, Figure 2. In this way the EDCS provides knowledge based solutions when accurate information is needed.

Knowledge about the product defines the initial requirements for developing the EDCS. Knowledge is the ability to turn information and data into effective action. The ability to manage knowledge means to deliver information and data that people need at the time it is needed to be effective in their decision making.¹ For instance, adding a complex software application to manage an existing database can significantly lower the performance of all other applications, if you don't plan for the extra processing load. To effectively implement a new system into an existing network requires more than just information and data. The knowledge of a computer system includes knowing how the system functions as a whole entity, its load on a network, operating speeds under high loads, compatibility with other software, memory requirements, stability, and many other aspects. Therefore, a seasoned systems developer must possess a set of general principles to use when creating and implementing a new system. These principles or "rules of thumb" create the basis of the systems developer's knowledge base.²

To gain knowledge about a complex subject, a simplistic approach can be used to break down complex information that makes individual data manageable. Once broken down, it is easier to manage and assemble the data one piece at a time. To illustrate this concept a pyramid is used showing data located at the bottom, information in the middle and knowledge at the top. Data takes up the largest amount of volume at the bottom, information is second in the middle, and knowledge forms the least amount of space at the top. When looking down from the top of the pyramid, knowledge gives the best overall view of the surrounding landscape. Therefore, a knowledgeable systems developer should always have a clear view of the whole system.¹

The responsibility of the EDCS developer relies on the ability of the software application to extract knowledge. This extraction involves interpreting volumes of data and information to arrive at concepts and guidelines given to the end user. For example, if an exact product configuration does not exist, it may be disallowed by the knowledge programmed into the system. The extracted knowledge from the EDCS is represented by an exact application of equipment while producing a high definition drawing showing design and data pertaining to the customized order. Included on the drawing is a part number, which can act as a link to jumpstart production.³

The EDCS shown in Figure 2, was developed from an existing DBASE IV database located in a DOS environment. This database was imported into a Microsoft Access database, which could embed Windows metafiles. A retail software program was used to convert AutoCAD drawings into extended Windows metafiles. Using the Equipment Drawings Administration Program, the metafiles were then embedded into an Access database. This database acts as a hub to produce all types of drawings, refer to Equipment Drawings in Figure 2. Part numbers found in the Marketing Application Drawing Design database are linked to corresponding part numbers located on the mainframe, as seen in Figure 2. All other instructions, or reports are generated using information found in the Equipment Drawings database. The dashed box, as seen in Figure 2, illustrates how a customer's inquiry can quickly be answered if the equipment is already in the EDCS. If the desired equipment is not already in the system, the new request is submitted electronically to the corporate office through a formatted drawing request, see FREDD Administration Program in Figure 2. The request is then forwarded to proper personnel who check for matching Equipment Drawings. The Equipment Drawings are generic images of the product and it is possible to have hundreds of different variations of Marketing Application

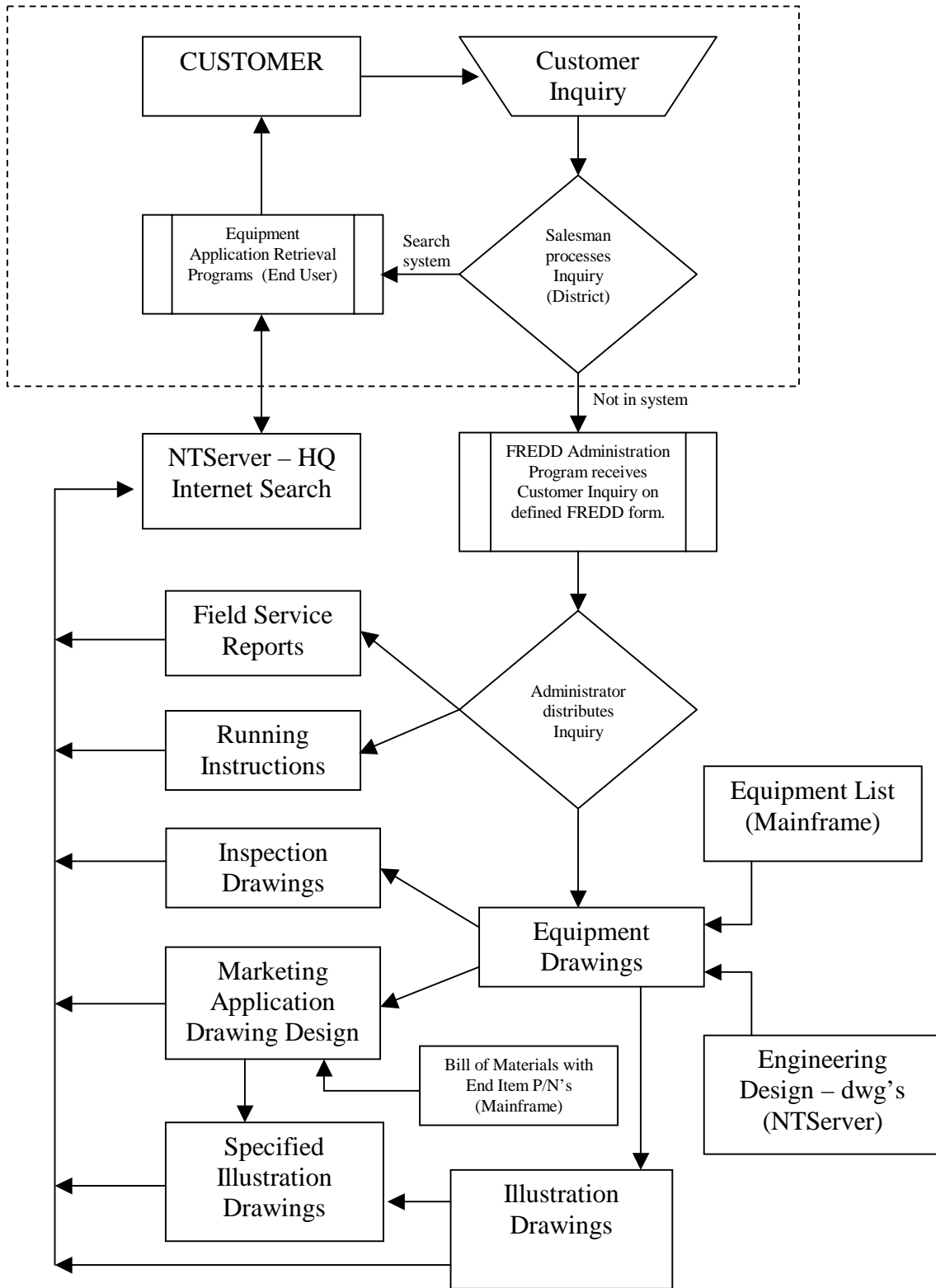


Figure 2. Development of the Electronic Drawing Control System.

Drawings using the same Equipment Drawing. Frequently, a response is e-mailed back to the customer that includes Marketing Application Drawings with exact specifications, or a part number is identified and the customer can quickly retrieve all drawings through the Equipment Application Retrieval Programs.

The Equipment Drawing Administration Program uses AutoCAD drawing files from the NTServer and assigns an equipment number and description from the Equipment List located on the mainframe. The program converts dwg files into Windows metafiles and provides CD publication tools that include indexing and updating information. These drawings must be used to create all other Equipment Application Drawings. The Marketing Application Drawing Design (MADD) Administration Program uses Equipment Drawings, Equipment Descriptions, Equipment Numbers, and Equipment Categories to create new MADD drawings. The program uses a database search tool to find the correct or closest Equipment Drawing. The program also provides a Spec Pointer Entry Tool used to input the coordinates of dimensions shown on each Equipment Drawing. Also featured is a Preview Viewer to see a picture of the equipment during a fast search. The program only allows input of new records based on an existing Equipment Drawing. Each record contains unique information including a part number if it had been built. The program allows maintenance of labels shown on each MADD drawing such as units for size, weight, yield, burst & collapse, hanging capacity, and any other special mechanical requirements. For CD publications, the program creates a CD Index of all MADD drawings.

The MADD Retrieval Program provides a quick search by unique Spec ID number or by Part Number if known. A normal search is achieved by process of elimination. Choosing selections from a dropdown list starting with a family of parts, the user can navigate through thousands of records until an exact match is found. The program can convert from the English system of measurement into the Metric system and is the source for mechanical requirements and dimensions shown on Specified Illustrations. The program also provides a custom Viewer to display, print, and save a drawing as an electronic image suitable for e-mail. The Viewer includes tools to add notes, vertical dimension lines, and pictures. It also contains a template with all logos allowing a different logo for each identified district.

The Illustration Drawing Administration Program provides an input tool for the length of the Equipment Drawing, which is used to scale the picture for proper fit with other equipment. A complete Illustration Drawing contains several liner string products linked together on one side with a string of corresponding setting tools on the other. The program also includes publishing tools to create the CD Index of all Illustration Drawings.

When using the Illustration Retrieval Program, each product shown in the drawing can be moved or disconnected from the product to which it is originally attached. The products can be moved from side to side, and extra casing links can be added to show a breakage in the string. The Illustration Viewer also contains the same features as the MADD Viewer.

The Inspection Drawing Administration Program provides tools to input the position of critical dimensions. The program also includes a tool to input labels describing the type of measurement such as OD, ID or Length and allows input of miscellaneous information such as serial numbers,

number of shear pins, and notes. The program uses the Equipment Number, Equipment Description, and picture from the Equipment Drawing database.

The Inspection Drawing Retrieval Program provides a template and border for job information, size, weight, grade, customer, phone, fax, and any other necessary information. The program allows three drawings per sheet and each drawing is scaled according to the length located in the Illustration Drawing database. The Inspection Drawings are used to record hand measurements taken in the field and verify against theoretical dimensions found on the MADD drawings.

The Specified Illustration Drawing Program provides a full length Illustration Drawing of a liner string with setting tools, including all dimensional and mechanical requirements shown on MADD drawings.

The Running Instructions Administration Program provides tools to create a search index based on the liner string of equipment to be used. The Running Instructions (RI's) exist in a Microsoft Word format. Each document includes a schematic drawing of a well bore design, a detailed description of each component, and a complete step-by-step instruction set of how to run the equipment. Also included is a publishing tool used to create a CD Index with all new and updated RI's.

Field Service Reports (FSR's), consisting of images of scanned documents, provide historical information about every job performed by a serviceman. Each report contains information regarding the type of equipment, well conditions, individual personnel, success or failure rate, customer detail, geographic region, and any other detailed information pertaining to that specific job. The search engine for FSR's allows the user to search by all of the criteria listed in the report including customer, date of service, and part numbers. FSR's exist on CD-ROMs in digital format and updating occurs once a year.

System hardware includes: Hewlett-Packard e3000/969 Series Mainframe, NT Server, personal computers, local area network (LAN), firewall, and DSL modem with a connection to the Internet. System software includes: AutoCAD, Microsoft Office Pro, Microsoft Developer's Toolkit, Visual Basic, Viewing and Conversion Enabling Technology (VCET), Windows NT Server, Windows NT, Windows 98, Windows 95, Windows 3.11, and Netscape. It was necessary to develop retrieval programs that are compatible with all of the popular Windows operating systems and to create images compatible with all types of e-mail programs.

IV. Implementation of the EDCS

Performance of the EDCS is an important issue for end users because if the system is not used, it becomes an added cost to the manufactured product. During long and slow transmissions, more time elapses allowing for error or complications during a download. In 1998, most Internet connections transmitted at a rate of 28.8 Kilobits per second (Kbps) due to limitations of phone lines and modems in the field.

The system may not readily be accepted though, because the electronic communication was too slow due to the low transfer rates of the modems. Within a year, speeds more than doubled and

the transmission of drawings became more feasible. In addition, the drawings could be converted to compressed Windows metafiles with a lower resolution, which could improve download times. The compressed files allow users to download the drawings quickly and error free when using only a 56kbps modem. End users could still easily print high definition colored drawings on standard letter sized paper or long drawings measuring 8-1/2" by 33" on standard Hewlett Packard banner paper.

Early in 1999, Internet services were available including two Integrated Services Digital Network (ISDN) lines with a transfer rate of 128Kbps/line. This speed of communication allows worldwide users to quickly download drawings and other e-mail from anywhere in the world, assuming access to the World Wide Web. Making use of the increased transmission speed, users were given the ability to download many drawings at one time and the ability to send drawings embedded into an e-mail message.

In October of 2000, a new Internet service became available which allows an upgrade from two ISDN lines to one Digital Subscriber Line (DSL) providing a transfer rate of 1.5 Megabits per second (Mbps). This change forced users to depend on one very finicky local telephone line instead of two parallel and reliable phone lines. Shortly after wide use of the DSL service, many Internet connections were lost due to problems with the local phone lines. The connections were quickly reconfigured to make use of the ISDN lines. After repeated problems with many DSL connections, it became apparent that the DSL service was at the mercy of the local telephone lines. The local serviceman claimed that the disruption in service was due to bridge taps on the lines between users and the distribution base. During installation, the line was checked for sufficient throughput required for DSL service. Apparently after installation, additional bridge taps were placed on the lines and disrupted only the DSL service. The DSL service requires a minimum sized pipeline to function in an "all or none" state. Every bridge tap used on the lines decreased the size or throughput of the pipeline. The acclaimed broadband connections became too narrow or "watered down" which completely shut down many DSL services. It may be worth noting that a conflict of interest exists between Internet Service Providers (ISP) and the local phone companies because the phone companies also provide Internet service at a much higher cost.⁶ Therefore, maintaining a clean open pipeline for another ISP is not in the best interest of the local telephone company.

Another ISP offers a residential Internet service, which uses a cable modem.⁵ This solution effectively eliminates dependency on the local telephone line, but it requires a right of access to each location of service. Reliability and speed using the cable appears superior to DSL lines and the cost is very competitive. The backbone of the service is a fiber optic network that exists between distribution hubs located across North America. Each distribution hub connects to a local hub, which then converts from fiber optic cable into coaxial cable. Most businesses do not have access to the coaxial cable distribution, which prohibits use of this type of service.

Recently, December 2000, an Internet Service was presented detailing wireless communication providing a broadcast download rate of 1.5Mbps, but it is still requiring a wired connection (ISDN or DSL) for uploads. An antenna would be provided to receive the signal broadcast across the metropolitan area, which can cover over a 40-mile radius. The price quoted was

competitive with a DSL connection but, since this system is more complicated and unproven, it was not widely accepted as an improvement to the current situation.

V. Case Study

A local Houston based oil company, Jorden Enterprises, would like to purchase premium downhole tools for use in its Singapore district. The business environment includes fierce global competition and a very volatile market based on the fluctuating price of oil. Typically, a purchase order includes a liner string of equipment, rental tools to run the equipment, complete documentation, and contract personnel to run the equipment. Also, the customer would like to receive the products as soon as possible because the cost of operations to run this offshore rig is totaling over \$500,000 per day. Since the rig is down until new equipment is received, the first manufacturer to produce the correct equipment wins the sale and a new loyal customer.

A salesman from the Houston based oilfield service company, Attia Ltd., quickly e-mailed a FREDD form to the drilling engineer at Jorden Enterprises. Within minutes, the form was filled out and e-mailed back to Houston. The salesman was notified when the e-mail returned and he quickly printed out the FREDD form. Next, the salesman used the MADD Retrieval Program to search through equipment that was already in the EDCS. Since his company has been in business for over 80 years, virtually every combination of equipment already existed. He quickly searched and found the best match for the current application and e-mailed the drawings back to Singapore for approval. The drilling engineer was impressed with the quick response and the high quality drawings, so he agreed to purchase the equipment at a premium and asked that his order receive a high priority. The salesman agreed and forwarded the MADD drawings with part numbers to his Engineering Department. An engineer quickly checked the order and submitted the part numbers to Order Entry. The engineer also alerted the Purchasing Department of any special material requirements. Then, the salesman used the Running Instruction Program to find the corresponding documents and e-mailed the Inspection Drawings (based on part numbers) and Running Instructions to his Singapore district.

Since this was a costly operation the drilling engineer also wanted proof that the equipment would work. The salesman searched the FSR's by part number and e-mailed a summary report showing how many times the equipment was used, its success rate, geographical region, serviceman, and date used.

When the equipment arrived in Singapore, the serviceman was able to measure the equipment to fill out the Inspection Drawings, compare the field dimensions to the MADD drawing dimensions, and verify that the equipment was manufactured properly and would fit down the hole. Next, he ran the equipment, filled out an FSR and e-mailed it to Houston.

Conclusion

Customers value quick and accurate service in any industry. As shown in the case study, the time required to manufacture and deliver accurate products plays a critical role in a business relationship. By using the EDCS, the customer received a more efficient and accurate response from the manufacturer and thus a lower cost for high quality products. The EDCS also provided

documentation of products purchased and would have alerted the customer before he place an incorrect order. The efficiency of communicating electronically reduced the time to perform most tasks in the manufacturing environment, which translated into lower prices charged to the customer.

The Manufacturer, realizing the efficiencies of an EDCS, quickly produced products at lower costs, sold them at competitive prices, and thus realized higher profit margins. As outlined in the case study, the cost of the manufacturer doing business was greatly reduced by the use of an EDCS. For example, the high cost to courier drawings was eliminated by the EDCS. To courier a package overnight from Houston to Singapore costs about \$100 and takes over 24 hours, compared to almost no cost and a couple of minutes to send an e-mail of high quality drawings. Since the EDCS provided communication in real-time at almost no cost, the manufacturer used it effectively to increase the speed of production and improved its product quality. Also, the inexpensive cost of an EDCS allowed the manufacturer to maintain flexibility while satisfying the changing needs of the customer. The system developments shown in section III also support use of a flexible EDCS by identifying inexpensive hardware and software. This type of system allows quick modifications to adapt to the constantly changing needs of the customer.

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