FHWA/IN/JTRP-2000/7

Final Report

CONSTRUCTION DATA MANAGEMENT 2000

Bob McCullouch

July 12, 2000

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Construction Data Management 2000

FHWA/IN/JTRP-2000/7

By

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School of Civil Engineering

Joint Transportation Research Program

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Purdue University
West Lafayette, Indiana 47907
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16. Abstract

Construction Data Management 2000 was a project designed to help guide INDOT into using emerging technologies to meet data management needs in the construction process. The landscape at INDOT has changed, having been shaped through the factors of increased workloads, a reduced number of employees, and increasing dependence on outside consultants to fill the needs. This has resulted in changing roles for INDOT employees creating differing data management needs. This project looked into this area, studied various answers, and is recommending solutions. This report describes the work performed and proposes recommendations with supporting documentation.

The original project scope had the following activities: 1. Develop a Data Management Plan; 2. Analyze the AASHTO SiteManager System; 3. Define gaps within the SiteManager Software; 4. Design modules that work with SiteManager; 5. Perform a financial and operational analysis of various field data collection devices; 6. Determine teleconferencing opportunities; 7. Investigate the use of digital cameras; and, 8. Research the use of internet tools for managing site data.

The majority of this was accomplished. One additional area in computer and web-based training was investigated and described. This approach will be new for the Department but is an effective approach for delivering training.

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INDOT Research

TECHNICAL *Summary*

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Construction Data Management

Introduction

INDOT, like most state DOTs, has experienced increased construction volume and diminishing resources to manage and operate the program. This creates a need for utilizing technologies to support personnel involved in this effort. This project looked at the current construction data management tools and investigated new tools to enhance and further automate; thereby providing a support environment for personnel involved in the supervision and management of the construction projects.

Construction Data Management 2000 was a project designed to help guide INDOT into using emerging technologies to meet data management needs in the construction process. The landscape at INDOT has changed having been shaped through the factors of increased workloads, a reduced number of employees, and increasing dependence on outside consultants to fill the needs. This has resulted in changing roles for INDOT employees creating differing data management needs. This project looked into this area, studied various answers and is recommending solutions. This report describes the work performed and proposes recommendations with supporting documentation.

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Findings

INDOT has joined the AASHTO effort in developing the SiteManager tool. It will be the nucleus of the construction data automation effort. It will help to eliminate duplicate effort and paperwork. Even though it will provide significant support there are some gaps that are not filled and there are other functions that need technology support.

Field data collection is another time consuming activity in the construction process. Add-on tools for this purpose have been developed for SiteManager. These are described as well as what hardware options are available to perform automated field data acquistion with these tools as well as other options for recording field data.

Videoconferencing is one technology that provides employee performance support by saving employee time and reducing travel costs. Two desktop systems were purchased and tested for use within the Department. Results are reported. Several state DOTs have invested in the technology and are experiencing these types of benefits with a relatively short payback time on the initial investment. Summaries of these experiences are provided in this report. Videoconferencing and streaming video can be used for training purposes. Training materials can be delivered more efficiently and effectively with these technologies. The requirements and opportunities are described.

Other SiteManager supporting tools in the areas of field CAD, earthwork analysis, digital camera utilization, were investigated and either recommended or developed. The earthwork analysis program reduces survey field notes, provides for importing total station files, calculates earth volumes for different template types (constructed, design), and plots and prints template profiles. It is an Excel spreadsheet with macros that perform these functions.

Internet based tools for construction were investigated and the results summarized. Most are generic project management tools which can be used on transportation projects.

Implementation

The driving force now and into the near future in construction data management is SiteManager. Jim Snyder and Rick Yunker of INDOT are heading the phased implementation effort. The efforts on this project have focused on tools to support and enhance SiteManager. Each has been described in this report. Each can be implemented to augment SiteManager. One independent technology investigated is videoconferencing. This technology is a natural fit for INDOT operations with geographically separated offices and projects scattered throughout the state. The need for this type of communication and collaboration justifies the initial investment. Costs for regularly scheduled meetings were calculated and reports from other state DOTs indicate a good return on investment and a technology that can be very beneficial for the Department. This technology should be implemented.

The earthwork analysis program can be used throughout the state and it is designed to supplement SiteManager. Any new tools added should be built around the capabilities of SiteManager. It is recommended that these tools be browser based for accessibility and universality reasons.

INDOT has a very serious condition in the data management infrastructure that will cause problems and restrictions on future information technology tools. At each of the main hubs, central office and district offices, the internal data path capacity will be 100MB, while the connection between these locations is at 1.5MB. This is a serious bottleneck. With new data management tools Microstation CAD, Geographic Information System (GIS), Scheduling and Project Management System (SPMS), Client/Server Trns-port, Exor (Road and Bridge Inventory in Oracle), Electronic Records Management System (ERMS), and SiteManager rolling out within the next year, the current data path will become overloaded. Also, with new needs in the areas of videoconferencing, on-line training, and streaming video, the need for more capacity is here, now. The department needs to request a major upgrade in data path capacity between the central office and district locations and toll road.

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INDOT Research Project Implementation Plan

Date: July12, 2000

Research Project Number: SPR- 2192

Project Title: Construction Data Management 2000

Principal Investigator (PI): Bob McCullouch

Project Administrator (PA): Tommy Nantung

Note: If more than one implementer recommended, please fill in the information on each implementer's implementation items:

Name of Implementer: Jim Snyder and Rick Yunker

Items (Research Results) to be implemented:

1. SiteManager

2. Earthwork Analysis Program

3. Videoconferencing for the Department

4. Increase data path capacity from central office to Districts.

Help or resources needed for implementation (e.g., help from PI, funding, equipment, etc.):

Signatures of SAC members: _____

_____

_____

Please send a copy of this form to the INDOT Research Division and FHWA with the final report.

Introduction

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SiteManager will take over the construction data management needs for the Department. The current effort headed by Jim Snyder and Rick Yunker has a timetable for a gradual phase-in into all new projects over the next two construction seasons. All projects including design-build will use SiteManager. The committee consensus was there isn't a need to develop a data management plan since this will be mostly performed by SiteManager.

INDOT is evaluating an electronic document management system in the Crawfordsville District. It will track documents up to letting. It does not interface with SiteManager.

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(hard and soft) and to the world through the Internet. The stand-alone machine (PC) still exists but is a dying concept. It is being replaced by the client/server environment, Local Area Network (LAN), Wide Area Network (WAN), an Intranet, the Internet, all represent a connected information world. Even the physical network architecture is changing. For example, gigabyte cable capacity exists or even wireless networks are available at 10 Mb capacity. Mobility and flexibility are definitely in.

These new trends and developments provide options that may not be appropriate for INDOT. For example a wireless campus sounds good but is probably not needed. Planning for construction data management must consider past trends and future predictions at INDOT. Influencing factors that will affect data management planning are more demands on employees resulting in more employee diversification, downsizing will continue resulting in increased needs for information, and increasing dependence on information technologies. If the recent past is any indication of what the future will be then INDOT will have to improve the current information technology infrastructure.

SiteManager

SiteManager is basically an integrated series of forms for entering and viewing information needed for a contract from the contract award to the archival stage. The information is stored in a database. There are six main modules that automate contract administration, daily work reports, contractor payments, change orders, civil rights, and materials management. This will be the software that replaces CRA. The following describes this product.

Description

SiteManager is a new construction management computer system from AASHTO. The system is the result of a joint development project of AASHTO, 18 states, FHWA, and New Brunswick, Canada.

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It provides automated and integrated means of managing construction projects from Notice to Proceed through final payment and close out of the contract. Major functions include:

- online basic contract information management, including personnel assignment;
- online creation and authorization of inspector's daily work reports;
- online creation and processing of contract change orders;
- online creation and processing of contractor payments;
- online recording of materials tests data;
- automated linking of materials and materials tests data to contract pay items;
- basic contract related EEO tracking, and;
- online review by auditors and management.

SiteManager will electronically link and integrate various INDOT central office divisions, materials & tests central labs, district offices, area tests labs, construction project offices, Research Center, FHWA, local agencies, and contractors. SiteManager will be able to interface with other systems, such as INDOT's central office contract development and management system ,Trns*port ("transport" aka BAMS), INDOT's accounting system, and other systems now being developed by INDOT.

The SiteManager software is a Windows-based client/server architecture, to be interoperable across various hardware platforms, and comply with ODBC and OLE2 standards. It was developed primarily in PowerBuilder, with some background processes and special routines developed in “C”. Standardized reports are incorporated, with the ability to create additional reports as needed. See Appendix for product data sheets.

As deployed by INDOT. the system uses Oracle as the server database. The application resides on the client PC, which permits the user to operate connected to the database server, or to work with reduced functionality in standalone mode. For INDOT, Project Managers (Project Engineers/Supervisors), inspectors, and area test lab staff will

normally work in the standalone mode, connecting to the main server a couple of times a day to sync up the data.

Permanent locations will be connected through 56kb and T-1 LAN/WAN systems, with remote project field offices, area test labs connected via 56kb modems. Current plans are to use the AT&T Global Network as the dial-up service provider.

Current plans also call for INDOT to provide permanently assigned laptops computers to Project Managers, and phase in laptops for inspectors. Consultants working on INDOT administered LPA projects will be provided with a laptop on a temporary basis while acting as Project Manager.

Field Data Collection

How do the mobile tools fit in with the SiteManager product? SiteManager will be the foundational tool used for managing construction project data. It will track equipment and materials, contractor progress, inspection data, required reports, progress payments, etc.

One of the project tasks was to investigate the use of portable computer devices that can be used in the field. Currently there are two options available, laptops and Personal Data Assistants (PDA), and that will continue to be the case in the near future (2-3 years). The PDA devices are suitable for mobile field type environments. They are relatively inexpensive ($300 - $800), versatile, and possess enough capability to perform field functions necessary for INDOT. PDAs can be further divided into two general classes based on the operating system, proprietary and Windows CE. The most widely used and popular PDA has been the Palmpilot family of products, which has its own operating system. The Windows CE devices come in various shapes and sizes and its operating system is a subset of the PC Windows environment. The CE operating environment theoretically provides the same look and feel as desktops and laptops but does not have the same capabilities.

Palm devices come in different models and a summary of the product line describes what they can be used for. The Palm is a decent device for displaying information. But it has never been particularly adept at receiving information, whether by direct input into the device or by synchronizing with a desktop. At its core, the Palm V works just like all other Palm OS-based organizers, with an uncluttered, intuitive collection of address, calendar, and to-do apps. The Palm V was the first Palm organizer to make use of the Microsoft Outlook conduit, which enables users to hot-sync the Palm V data with Outlook.

Now, in addition to organizing your contacts, tasks, and appointments on a pocket-size PDA, you can use the same device to send and retrieve e-mail and to query Web sites for information. You can't use the Palm VII to cruise Web sites, download files from FTP sites, or converse in chat rooms. You can exchange e-mail, do e-commerce transactions, and interact with specific Internet sites to retrieve information such as news, traffic, and weather reports.

The Palm devices, though very popular with a wide variety of software and development tools available, is not the type of portable hand-held unit for INDOT. The primary reason is these devices target the mobile user found in the standard business/sales industries. The CE device will probably be the more compatible device for INDOT.

There are considerable resources available to CE machines. These include: electronic forms, databases, spreadsheets, Internet connectivity, email, organizational info- phone numbers, addresses, etc., and even recording project as-built info. Several form development packages have been investigated. One mandatory requirement is the field collected data must be structured to import into SiteManager. One option for creating this flexibility is to use Microsoft Visual Basic (VB). It has a database engine compatible with several databases with Access its foundational database. The VB CE version runs on NT and currently costs $175. Both MS Access and NT are standards adopted and supported by INDOT. One advantage with CE hardware is the variability in functionality, there are devices with keyboards, without keyboards, pen devices, handwriting capabilities, cellular capability, etc. The price ranges from $500 - $1000.

One option for collecting field data is a suite of software tools developed through the Michigan DOT. It is named FieldManager. Michigan DOT was contacted and the individual is Cliff Farr (phone 517-335-2246). Michigan is currently using FieldManager to collect progress data on notebooks. They are planning to migrate to handhelds(PDAs)and will most likely use the HP palmpad which is a Windows CE device. The Field Manager product line is in direct competition with SiteManager. AASHTO, who is responsible for the development of SiteManager, has now adopted the Field Manager products with the intent to make them available to local government organizations who cannot use SiteManager. A few states, led by Iowa, are modifying the Fieldpad product to provide some minimum SiteManager functions and operate in the Windows CE environment. Indiana is not involved in this effort for the reason this product will not provide the field inspector with the capabilities that Indiana intends to use. This product is distributed by Infotech and the contact there is Joe Phelan. He can be contacted at 352-375-7624 and the web address is www.fieldmanager.com. Contacted by phone and I was told that Fieldpad is available. Additional information and pricing for this product is found in the Appendix.

The below information on FieldManager is from its website and describes what it does and the companion products.

FieldManager

FieldManager is a comprehensive electronic construction management system for managing and tracking construction projects, documenting construction progress, initiating contractor payments and communicating with your agency's central office contract administration system. FieldManager was created as part of a joint development project between Info Tech, Inc. and the State of Michigan through the Michigan Department of Transportation. It was designed for use by state departments of transportation, local government agencies, engineering consultants, large contractors, or any organization that manages construction projects.

With its companion products (FieldBook, FieldPad, FieldBuilder and FieldNet), FieldManager focuses on refining the work flow of construction contract management at

the field office level; the field office can manage field gathered data, then interface with a central office. This allows several users to update contract information, implementing a shared database to expand an agency's data-sharing capabilities. It also provides a high degree of data accuracy; the data can be entered once and shared electronically, replacing the need to manually enter the same data in multiple locations.

FieldManager allows you to record and maintain item progress information, stockpiles, contract modifications and daily diaries. At the end of the pay period, an estimate can be generated and exported to your agency's central office contract administration system. After processing, the updated payment information is imported back from your agency's system into FieldManager. Contract modifications are initiated in FieldManager, and once approved, are sent to your agency's central office contract administration system. All item progress data, daily diary entries, contract modifications and reports are maintained in FieldManager and are instantly available to you. In addition to over 50 standard reports and inquiries, FieldManager accommodates your business needs by allowing you to create customized reports using third party ODBC compliant query tools.

FieldManager further accommodates your business needs by providing a variety of operating environments, from Windows 3.1 to Windows 95/98 or Windows NT; on a laptop in the field, a handheld in the field, a desktop in the field office, or in a client/server environment connected to a local area or wide area network. It functions either with a central office interface or as a stand-alone system.

Companion Products

The FieldManager suite contains four companion products that work together to comprise this powerful construction management system. From the ability of FieldBook and FieldPad to gather data in the field to the data sharing capabilities of FieldNet to the flexibility offered by FieldBuilder, each component plays a crucial role in making the system work for a single project manager or a state department of transportation. The close interaction of these products provides many benefits for your organization, including a high level of communication, data sharing and accuracy, information

management and record keeping, and administrative time and cost savings. Following is a brief description of each component of the FieldManager suite.

FieldBook

FieldBook is a subset of FieldManager, designed to automate the construction inspector's task of documenting the progress of a construction project. Operating on a laptop computer, FieldBook allows inspectors to take a more active role in the project, providing the flexibility of recording construction information at the project site, including work item and material progress, contractor/subcontractor documentation, sketching, site conditions and general comments. The construction progress is recorded in Inspector's Daily Reports (IDRs), which are uploaded to FieldManager in the field office. Contract updates are downloaded from FieldManager, giving inspectors direct access to the latest contract data and other information vital to their field operations.

FieldPad

FieldPad is a small, easily portable data collection device used in conjunction with FieldManager to help manage a construction project from the field. It offers all of the onsite data recording and transfer functionality of FieldBook on a handheld PC. To minimize data entry time and errors, dropdown lists are supplied wherever possible, including previous entry lists. Through the creation of Inspector's Daily Reports (IDRs) you can track item and material progress, record weather and temperature data, track contractor personnel and equipment, and document site conditions. Back at the field office, the handheld PC is easily synchronized with a desktop PC to load the onsite data into FieldManager.

FieldBuilder

FieldBuilder is a data entry interface that enables you to enter contract information directly into FieldManager. This gives your organization the flexibility to use FieldManager as a stand-alone system, creating contracts from scratch. All of your organization's spec items and contractors can be managed by importing information from your central office, from a text file, or by adding them directly into FieldBuilder. Once a

contract has initially been created you can copy it, modify any necessary information, and quickly create a new contract.

FieldNet

FieldNet improves your organization's communication by automating the transfer of contract information among your offices. It provides an automated interface between FieldManager and your organization's central office contract administration system that enables the transparent, electronic transfer of contract, estimate and contract modification information. FieldNet can also be used to obtain supervisor approvals for estimates and contract modifications, and to transfer both read-only and working copies of contracts to other FieldManager machines.

Outlook

Electronic mail, Personal calendar and group scheduling, Personal information such as contacts and tasks, Custom collaboration and information-sharing applications, Outlook helps users organize, find and view all of this information — all in one place — using a consistent interface. Outlook 2000 builds upon this product vision, particularly in the areas of Internet standards support, ease of use and simplicity, and support for collaborative solutions. Outlook 2000 offers industry-leading e-mail and collaboration features when used with Internet-based messaging systems and even more advanced functionality when used on a business intranet with Microsoft Exchange Server.

Network Capabilities

Currently the data path backbone from the central office to the Districts, Materials and Test, and Division of Research is a T1 line. This has an approximate capacity of 1.2 Mbps. Will this provide enough bandwidth for future information demands? Can this support videoconferencing over the Intranet? Most videoconferencing systems require approximately 400k and at today use rates, yes the network can support this. But there are some systems under development that are projected to come on-line within the next year that will consume some of this bandwidth. These new products are the new

Microstation CAD tool, Geographic Information System (GIS), Scheduling and Project Management System (SPMS), Client/Server Trns-port, Exor (Road and Bridge Inventory in Oracle), Electronic Records Management System (ERMS), and SiteManager. After these come on-line the current bandwidth capacity will most likely be consumed. This will prevent videoconferencing over the INDOT WAN. Are there any plans to enlarge this data path? Currently, there are no immediate plans, but this needs to be monitored for capacity requirements and usage patterns as these application are deployed. A request for additional bandwidth needs to be in the next biennium budget for upgrade considerations to these data paths. If this is not improved then INDOT computer networks will experience something like I-65 going from four lanes to two lanes from Louisville to Gary.

Figure 1 – INDOT District Data-paths

Training Applications

A training needs assessment research project evaluated INDOT's training program, surveyed to determine training needs for different employment classifications, and evaluated INDOT's training program with other state DOTs and private industries. Results are published in the final report and will not be duplicated here. However, some information is worth repeating because it will become important in the overall data management scheme.

In the past five years, the possibilities for providing training and education to employees have increased dramatically. Training is no longer constrained by space and time. With the proliferation of multimedia training materials, the quality of the training can improve, if done correctly, while it is delivered at a lower cost. Through computer based instruction and web based training (CBI & WBT) more INDOT employees can have access to training. This method of delivery is only possible if the network structure can support this load and employees have multimedia equipped computer hardware.

Many organizations are struggling to determine how to increase training quality and, at the same time, reduce costs. Now is the time for INDOT to evaluate its present training program and consider possible new directions that utilize these new technologies. Most of the INDOT managers interviewed in this study are interested in using these new technologies for training. Through CBI and WBT, INDOT can increase the quality of its training, make training programs conveniently available to more employees, and reduce overall training costs.

Findings from the surveys and questionnaires revealed the following related to data management..

- Develop a policy for Computer Based Instruction (CBI) and Web Based Training (WBT) on the job. Increase the number of offerings through these delivery methods. Increase Internet accessibility for INDOT employees.

- Offer more computer skill training through multimedia training tools, which is a very cost effective approach.

- Obtain videoconferencing capability at the district offices that will provide training capabilities and accommodate meetings. This will save time and money for the Department.

- Determine which topics can effectively be delivered through CBI or WBT. Work with Information Services to determine the network demands and support requirements for delivering training through the LAN and WAN.

- Jobs are changing within the Department. Influencing factors will be more demand on employees, more technical products and materials to work with, downsizing will continue, more reliance on information technologies, and the necessity for employee diversification. Training needs will be more cross-training for employees, increased need for computer skills, increased need for time, project and people management skills, more efficient training delivery, customizable and timely CBI and WBT topics, and increased need for continuing education.

Using Videoconferencing in Training

Currently, sharing and linking at INDOT is done through travel. The advantage to this method is that it is familiar and no hardware or software is needed. The big disadvantage is expense. Approximately 80% of INDOT's training costs are due to indirect costs such as salaries when taking classes or when traveling to sites to receive the training. Reducing travel would be one method to reduce these costs.

With videoconferencing, training could be held at different sites with each site connected through the videoconferencing facility. Two-way interactive, live classes could be conducted. The problem with this method is that sites would need to purchase the hardware and software for videoconferencing. Prices have dropped considerably and current systems cost approximately $15,000 that will allow room type training exercises delivered over the network. Otherwise sites need to be connected through ISDN phone lines, which are expensive to operate and install. Another problem is ease of use. Interactions with these methods are certainly not as good as live interactions. If students placed effort on how to interact with the equipment rather than learning the material, then the training environment suffers. Scheduling could also be a problem.

Streaming Video

Another possibility for training is to use Webcasts and streaming video on demand. Both methods use computerized streaming video technology. Video requires huge amounts of Internet resources to broadcast through the Internet. Streamed video means that a small amount of the video is delivered to the user's computer, when needed, in a compressed format. A potential problem with streaming video is that the video will "freeze" on certain frames if the Internet connection is not fast enough. Typically, the minimum requirement for an Internet connection is 56 Kbits per second, which is not possible through conventional phone lines. Cable modems, DSL lines through the phone lines, or ISDN connections are sufficient for streaming video. The difference between Webcasts and streaming video on demand is that Webcasts are live broadcasts of streaming video and streaming video on demand can be accessed at will.

The current network infrastructure for the Department provides different capabilities that limit options for delivering training. The central office Local Area Network (LAN) has two architectures, token ring and Ethernet. Both are 10MB capacity. The plan is to upgrade to Fast Ethernet (100MB) architecture. The estimated cost is $80,000 to $100,000. The District offices have Fast Ethernet (100MB). Each district office is connected to the main office through a T1 (1.5MB) line. Connection to the subdistricts is

through a phone link and will not allow streaming. The bottleneck for distributing this training will be the T1 line to the districts. Internal capacity (100MB) at the district and central offices is sufficient for streaming video and delivering training.

Image quality is a very important issue in streaming video. Video can be streamed as low as 20kbps (kilobytes per second), which is the typical speed of a 28.8k modem. At this rate video quality is poor and the type is limited to a talking head with no motion. This is true even at current modem speeds of 56k. Decent video quality occurs at 100kbps, which is not possible over a dialup connection. But over the LAN and between the districts and the central office, this data rate is available.

With on-demand streaming video, individuals would access the video to fit their schedule. This could occur at all times of the day and would not tax the system as long as many users do not try to access the same lesson at the same time. Webcasts, however, are broadcast live so that many users at different sites could need to access the same stream. For an audience of 50 all at different locations, theoretically the bandwidth requirement would be 100 x 50 which is 5000 kbps or 5Mbps. The maximum data rate possible on the LAN in the central office is 10Mbps and to the districts at T1 the rate is 1.5Mbps. So this is not possible to stream to Districts. Even at the central office this would consume too much bandwidth. If the Webcast audience is 20 then the requirement is 2Mbps, which is still too large for these networks. Streaming is feasible in the fast Ethernet networks (100Mbps) that exists in the Districts. Realistically, Webcasts to multiple sites are not an option using the current infrastructure. On-demand streaming video, as long as multiple users do not try to access the streaming video all at the same time, would be an option with the current infrastructure.

Streaming video requires server software and places extra requirements on the hardware. For example, Real Networks is a major vendor. The latest streamer version is RealServer Plus 7.0. For 60 simultaneous streams and development software the price is approximately $2800. The RAM required for 50 streams at 100kbps is 124 MB. So the web server's RAM may have to be upgraded to dedicate this amount for streaming.

One solution to this video limitation is to place video content on CD-ROM disks and use the network to deliver the textual and image content. This hybrid approach has been used successfully in companies. This would require the trainee to insert the CD-ROM into the computer where training is occurring.

Videoconferencing

Videoconferencing is a technology that can be a useful tool for INDOT in delivering training and accommodating meetings. These types of systems fall primarily into two categories, room systems and desktop. The room systems allow for bigger audiences while the desktop is attached to a desktop computer and is limited to an individual user. Desktop systems are priced below $1000 while room systems price ranges from $10,000 to over $30,000.

The state of Indiana has established a statewide videoconferencing network. This was performed through the Indiana Department of Administration (IDOA) acting on behalf of the Information Services Division. Initially five room systems are established at state police posts in Evansville, Madison, Indianapolis (IGCS), Ft.Wayne, and Gary. These systems are a dual 32" monitor with integrated whiteboard and automatic switching document camera. IDOA will charge state departments $30 an hour to use the facilities. Except for the IGCS location, the other locations are not easily accessible by INDOT and will most likely not be utilized.

<u>Room Systems</u>

Room systems typically have the ability to host meetings and distance education sessions. These sessions are a traditional lecture experience where the instructor is on one end and the student is at the other end. Most systems are equipped with a document camera, a whiteboard, microphones, and the ability to work with and share computer applications and can be purchased for approximately $15,000. These systems should comply with ISDN and LAN standards allowing a session to occur over ISDN phone lines or a LAN at the TCP/IP standard. Most systems require 3 ISDN lines. These lines cost $1500 each

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to install and cost approximately $1 a minute to use (all three together). At 30 frames per second video the required bandwidth is 384 kbps. Lower bandwidths are possible but the quality and the video experience suffers. At 384 kbps this is a bandwidth consuming application. On 100 MB LAN systems this is not a problem but a T1 connection does not provide enough capacity. Also, remote management is a common feature. This is the ability to remotely manage a room system and perform administrative duties for operating individual systems. Most systems operate on the Windows NT operating system which is the INDOT standard.

Desktop

There are several systems on the market but three have captured the majority of users. These are: Microsoft Netmeeting, Cu-SeeMe, and Intel ProShare. Netmeeting was purchased and tried with an installation at Purdue and one in the Central Office in Indianapolis. This software uses the Internet as its communication platform. Both installations connect to the Internet through a high speed LAN connection. All communications are routed through Microsoft Internet Locator Servers (ILS).

The results from this initial setup were poor. Video cannot be transmitted fast enough to achieve a level of real time quality. The image is choppy and blocked. Any kind of movement is not tolerated very well. A talking head situation is acceptable. The other applications (sound and whiteboard) work. Since Microsoft servers are used there is no screening of users on their directories. This allows access to all types of users that are unacceptable. Secondly, the servers are not very dependable. One time you may get to log-on and the next several times you are prevented. These two reasons make this option completely unacceptable.

Information on the other two was obtained. Cu-SeeMe Pro uses the software Meeting Point. It can also use NetMeeting as well as Intel ProShare. Meeting Point runs on a NT Server Version 4.0. and is TCP/IP based for Lan/Internet conferences. MeetingPoint is expensive, for Windows NT a 10 user license is $8,995. Intel Proshare will run on

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Windows 95,98, and NT. It will operate over a TCP/IP LAN. It requires a ISDN line for a phone connection. It costs $799 per installation. The conferencing software is NetMeeting so the same problems are there with this service.

Another option was tried. That is to use a server in a District office to serve as a host for videoconferencing and create an internal intranet videoconferencing tool. If a host can be established then the other installation will use a dial-up connection to the Internet. This will be the typical configuration for a construction jobsite trailer communicating with District offices or the Indianapolis Central Office. In August 1999 this option was tried between INDOT,s Crawfordsville Office and a system at Purdue University. Both setups were running Netmeeting. Both systems were connected to the Internet through a local network connection so transmission speeds are fast compared to a dial up connection through an Internet Service Provider. Several sessions were attempted between these two sites. After the first attempt, Microsoft support was solicited to help establish a quality session. After receiving their assistance, two sessions were tried. All sessions were held where Crawfordsville was the host for the conference. None of the sessions were successful. Based on these tests this option is not a viable one. After INDOT upgrades the network capacity the desktop option should be revisited because it offers personal communications that are important to INDOT functions at some levels and positions. This option would be useful in the executive offices and for district directors, district operation engineers, district construction engineers, and division chiefs.

Recommendations

One is the Indiana Department of Administration system is not convenient for INDOT operations. Initially the system will locate at five cities (Evansville, Madison, Indianapolis, Ft. Wayne, and Gary) in the state police posts. These locations will make access undesirable for INDOT operations. Secondly, based on experiences of other DOTs , INDOT should investigate investing in a videoconferencing network for their operations. A travel cost analysis performed by Amy Miller from INDOT in March 1999 reveals that INDOT spends approximately $50,000 annually on travel expenses to regular programmed meetings and for personnel time at these meetings the cost is $187,238. So

together, over $225,000 is spent annually on regularly scheduled meetings. The vast majority of travel is project related and is done on an ad-hoc basis. The costs for these are difficult to quantify. This is not suggesting or recommending that this technology will eliminate the need for meetings. But certainly some travel and time can be saved. If all Districts , the Toll Road, and central office had a room system that would make eight systems. At $15,000 each the initial investment is approximately $120,000, roughly half what regularly scheduled meetings are costing. There has not been an analysis done on overall travel when informal and field trips are included. Based on this information it is recommended that INDOT perform a formal cost/benefit analysis for obtaining a room videoconferencing system at each district office, the main office, and for the toll road. The economical option is to operate videoconferencing over the network and not through ISDN phone lines. Even without results from a cost analysis the use of this technology is a natural fit for INDOT operations.

Located in the Appendix are two supporting documents. One is a document that summarizes eleven other DOT experiences with using Videoconferencing. Some of the main points from the individual summaries are the following. Most states have equipped all District offices and the main office with room systems. They are being used for mainly for meetings and some training. The equipment is dedicated for DOT usage. Missouri DOT did a cost/benefit analysis and determined a 6 month payback period on the investment and a 2-3 to 1 benefit to cost ratio. In Pennsylvania the payback period on the initial investment ($700,000) was 9 months. PennDOT uses the equipment for all types of meetings and particularly design review sessions, FHWA meetings, and consultant meetings. Videoconferencing at Iowa DOT is an integral part of their operations. It has become the number one option for meetings because it has allowed more participants and brought improved input and decision-making. A very detailed cost analysis of videoconferencing in FY98 was performed and is included in the Appendix. The State Legislature mandated this report. The report states a $70,500 cost savings through productivity gains and cost avoidance. They reported 134 DOT sessions using the equipment. In Wyoming the equipment is frequently used for training, both technical and non-technical, some graduate CE education, TRB sessions, and conferences from

North Carolina State University. This summary document contains contact names and phone numbers for follow-up reasons.

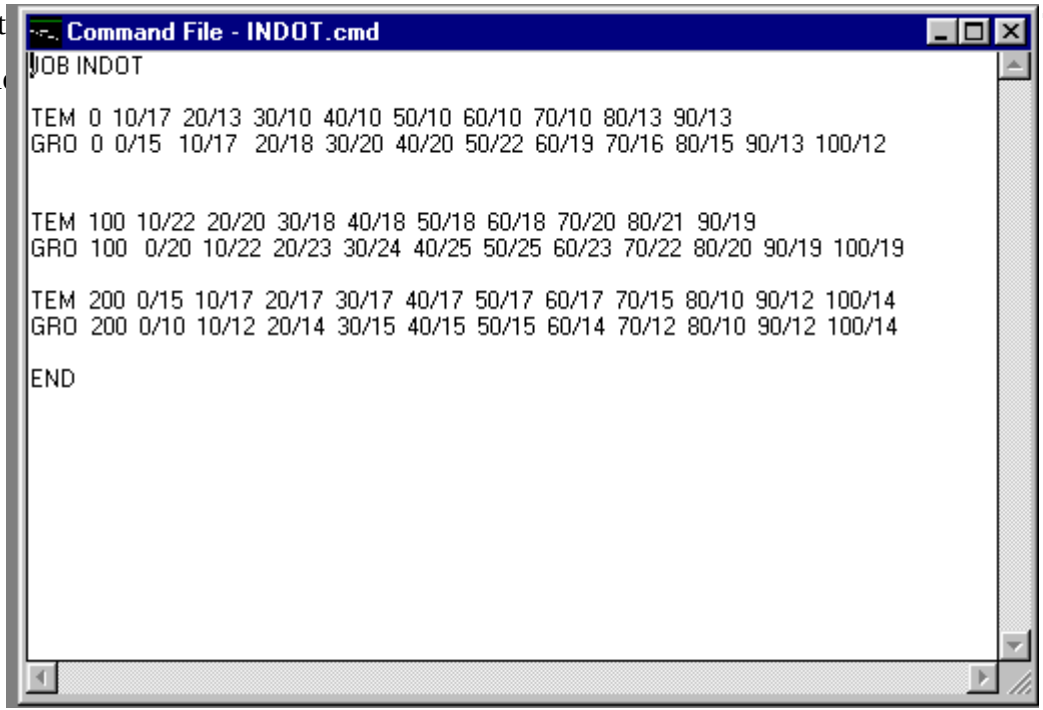
Earthwork Analysis Program

A Internet search was performed to locate software that can perform earthwork(cut and fill volumetric analysis) calculations. Descriptions of the other software are included in this section. Software was obtained on a 30 day trial basis named Earth by Pizer Engineering software.

Earth is for calculating volumetric quantities by either the average end area method or the modified prismatic method. It can calculate quantities for roadways, runways, ditches, borrow pits, site preparation, building excavations, parking lots, retaining walls, and land developments. It is designed for the Windows 95/NT operating systems.

Earth takes the cross-section data for both existing and proposed ground levels and calculates the volume of cut and fill material. Cross-sections and profiles are plotted and station and total quantities are calculated. The cross-sections and profile can be saved in DXF format and can be exported into AutoCAD.

A sample project was created to learn the software. The sample is a cut and fill roadway project with cross-sections at 100 ft. stations. It is easy to enter the data points and the soft



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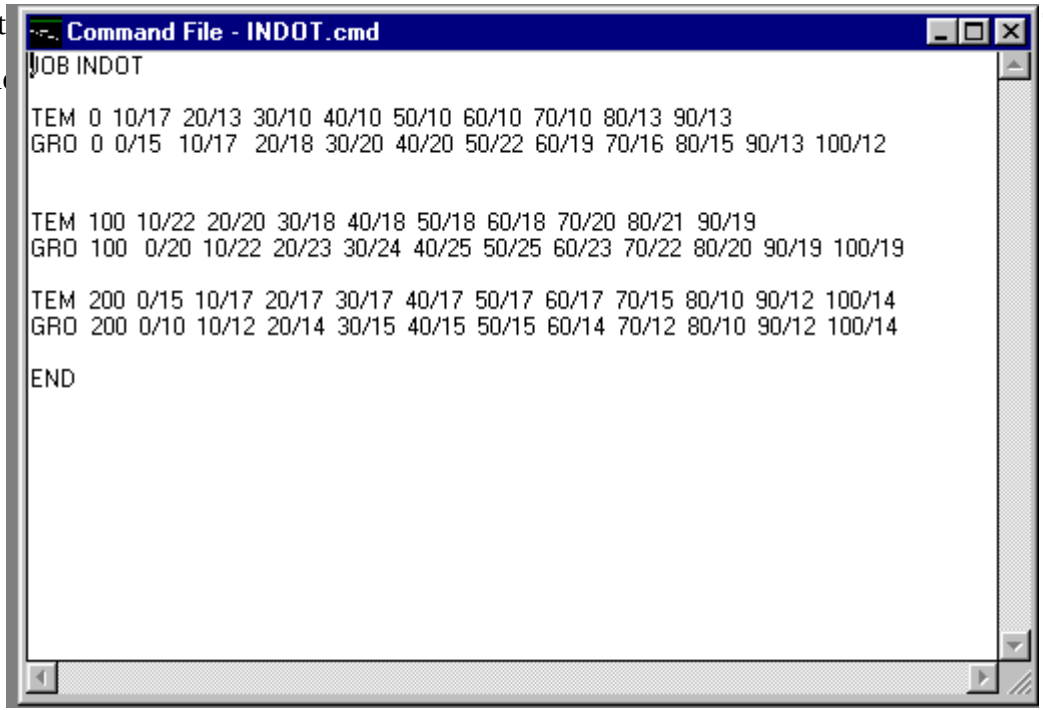

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The above table shows the input data. There are three stations:0, 100, & 200. At each station reference points for existing grade(GRO) and proposed grade(TEM) are entered. Volumetric calculations are generated and displayed in the below table.

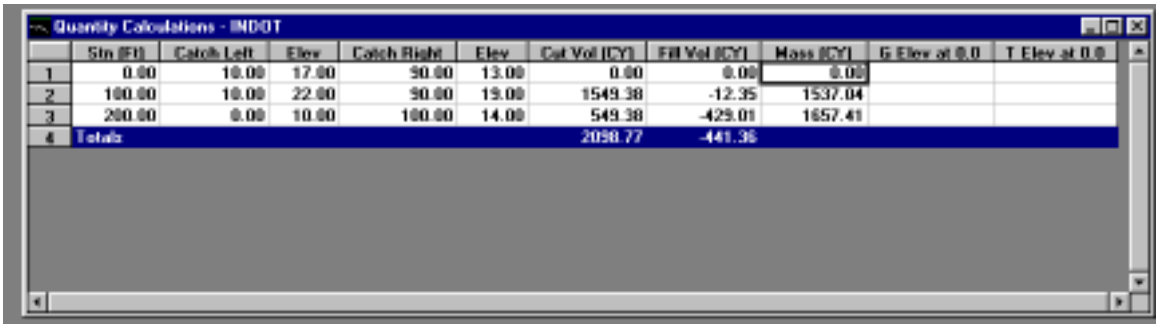

Figure 3 – Quantity Calculation Table

A table containing cross-section data is generated and is shown next.

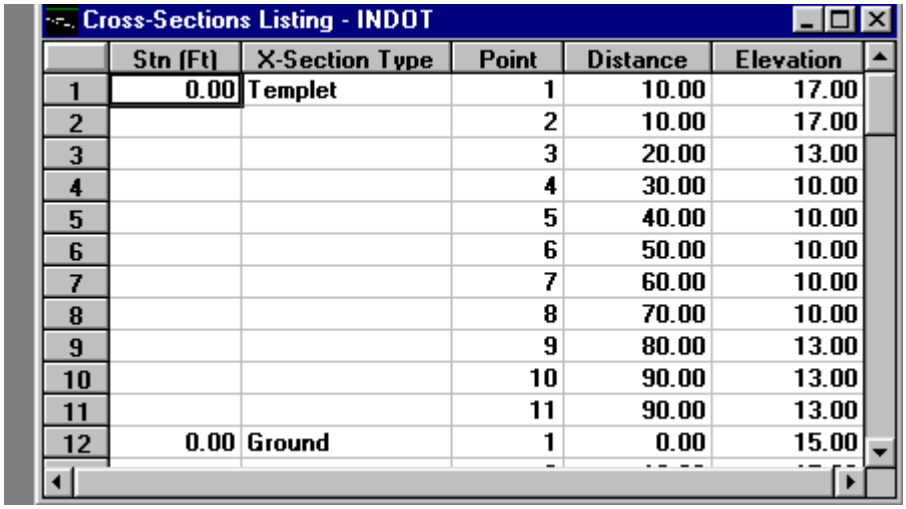

Figure 4 – Cross-section Data

A profile is also plotted across cross-section and its screen is shown below.

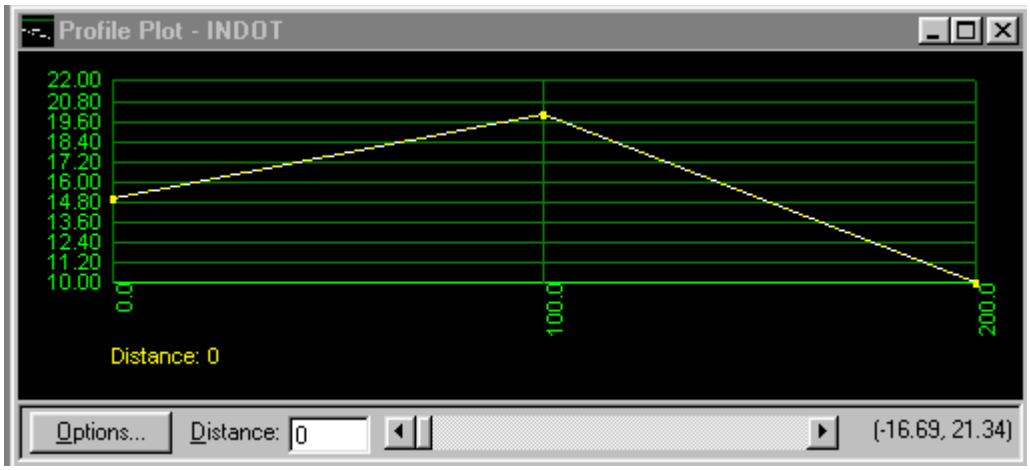

Figure 5 – Plotted Profile

A cross-section for each station is also generated showing existing elevations and proposed elevations.

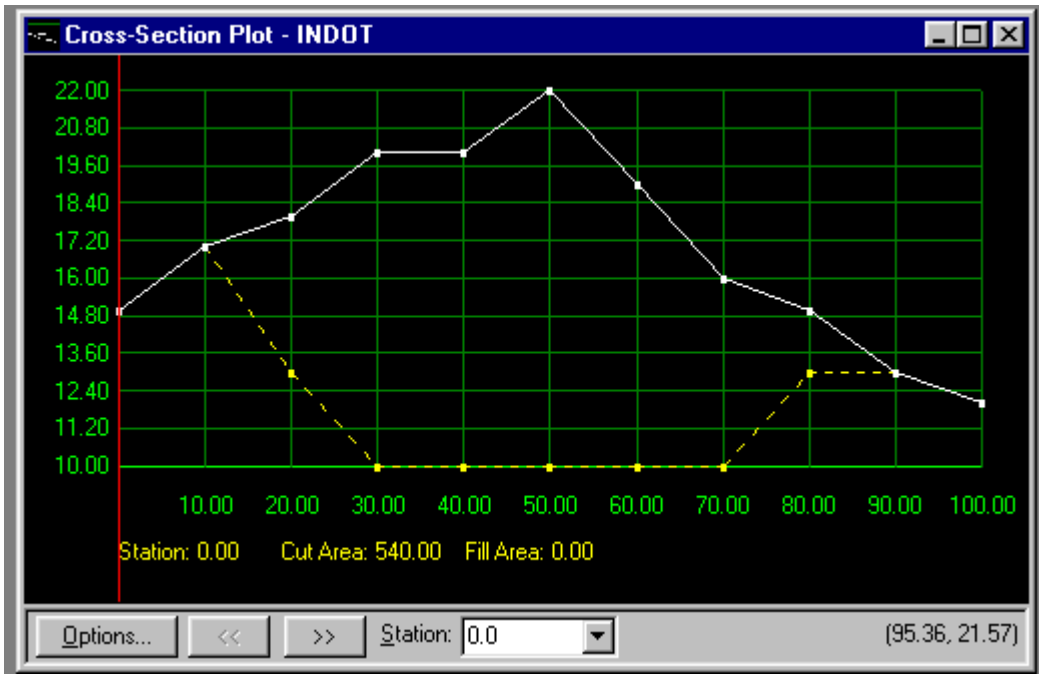

Figure 6 – Plotted Cross-sections

The program is easy to learn and use. The cross-sections can be saved and imported in CAD programs.

Because of the cost ($500) and the inability to accept total station files easily, this software is not a desirable option. Jim Snyder requested that a spreadsheet program be

developed for earthwork analysis. The Department is currently using a DOS based program.

An earthwork analysis program has been developed through this project to meet this need. It is an Microsoft Excel program equipped with macros. The program provides for surveying fieldbook note reduction, manual data entry, and automatic data import from total station devices. It performs volumetric calculations and produces profile templates. A screen image from this program is shown below.

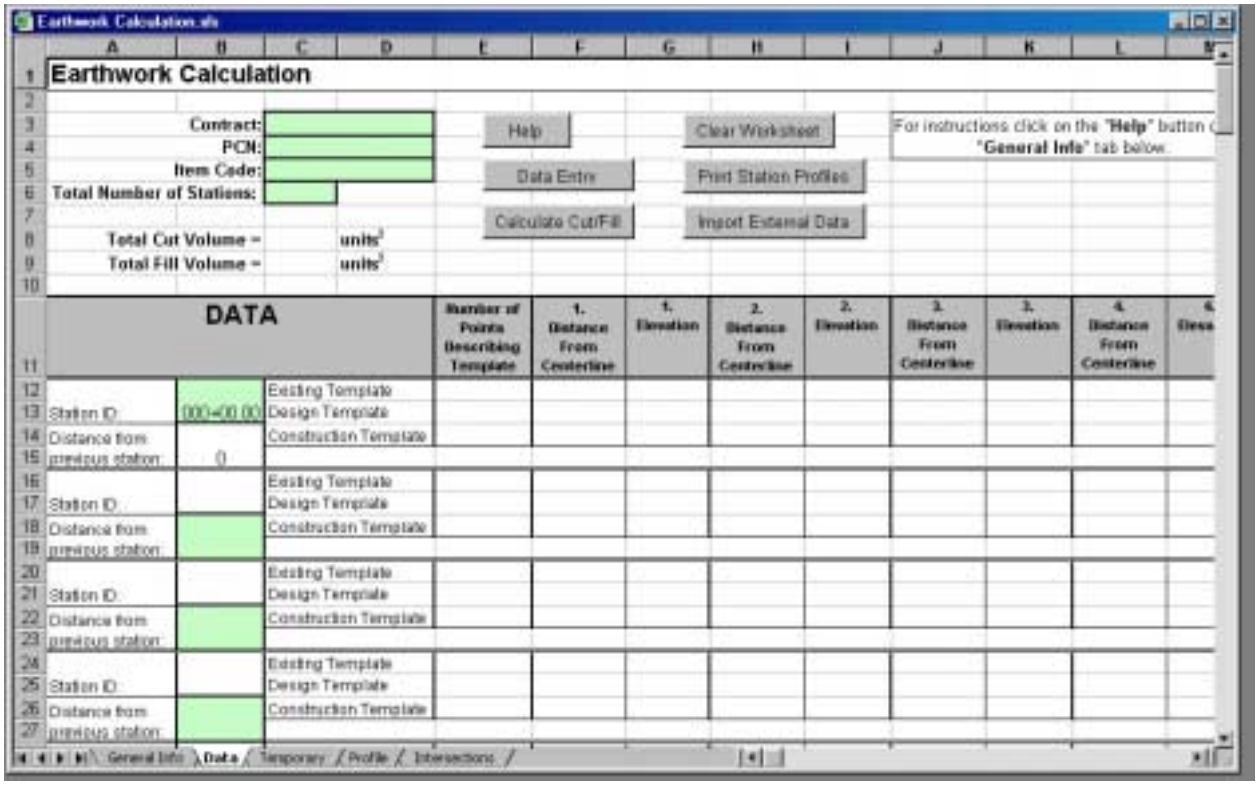

Figure 7 – Excel Earthwork Program

Field CAD Program

A field CAD program is needed for creating digital sketches or drawings. Inspectors and field engineers will use this tool to record field situations, as-built info, or for change order descriptions. This CAD capability will be used to supplement SiteManager data and will become a part of the digital construction record.

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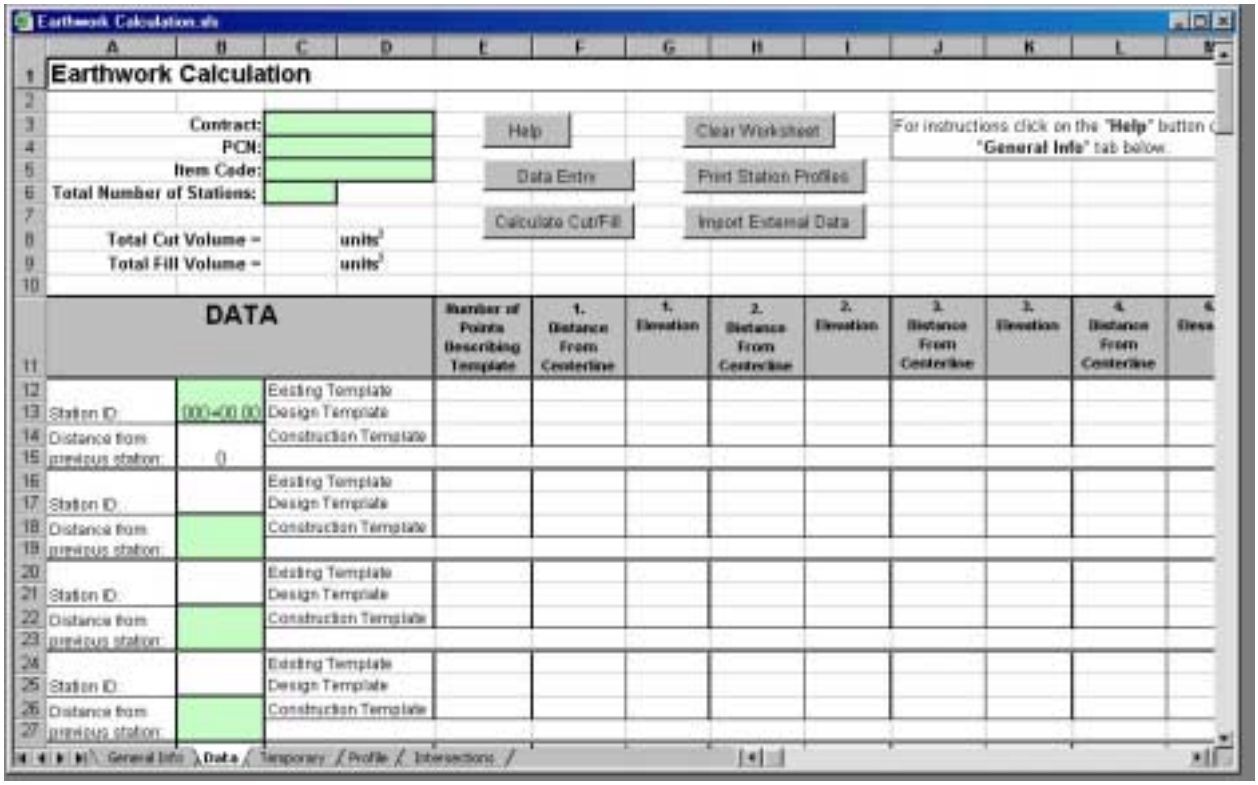

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So, after an Internet search and review of CAD programs currently on the market and considering the application and costs, one software was chosen and a trial version downloaded. The software downloaded is called DeltaCAD, Its internet address is www.dcad.com. The following are some of its main features.

- It can copy information into Word.

- Symbols can be created and saved into a library. Symbols can be considered as templates. Customized symbol libraries can be created and distributed that allow for quick drawing development. It is recommended that INDOT develop template libraries of typical drawing symbols. These will allow for some standardization in sketches and for faster completion.

- It does not have OLE capability. This is a major disadvantage and precludes from choosing it even though it's cost is $20. This capability is important because the need to copy into SiteManager.

Digital Camera Used as a Scanner

This test involved using a Kodak DC265 digital camera to collect images of documents that could possibly be scanned at the jobsite and saved in digital form. Three documents were tried, one a shipping bill, and two design drawing details. A combination of 9 different camera settings was tried for each document. The DC265 camera has three quality levels and three resolution levels. The quality levels are good, better, and best. The resolution levels are standard (768 x 512 pixels), medium (1152x768 pixels), and high (1536x1024 pixels). Comparing different cameras is difficult but the resolution setting numbers can be the basis for the comparison.

Each document was captured with the nine different settings. Results were interesting. Image size and quality are two factors that are important. The below table summarizes the test results. All files were saved as jpeg files (*.jpg)

Shipping Form – Quality level at Best

Resolution	Image size	File size	Results
1024x1536	14.22”x 21.33”	415K	Good quality
768x1152	10.67” x 16”	225K	Poor but legible
512x768	7.11” x 10.67”	152K	Not legible

Shipping Form – Quality level at Better

Based on the above settings, the image quality will only be good at the high-resolution setting. So that was the only one used.

Resolution	Image size	File size	Results
1024x1536	14.22” x 21.33”	226K	Good

Shipping Form – Quality level at Good

Based on the above settings, the image quality will only be good at the high-resolution setting. So that was the only one used.

Resolution	Image size	File size	Results
1024x1536	14.22” x 21.33”	155K	Good

Figure 8 – Shipping Form

Design Plan Detail – Quality level at Best

Resolution	Image size	File size	Results
1024x1536	14.22”x 21.33”	356K	Good quality
768x1152	10.67” x 16”	200K	Poor but legible
512x768	7.11” x 10.67”	139K	Not legible

Design Plan Detail – Quality Level at Better

Based on the above settings, the image quality will only be good at the high-resolution setting. So that was the only one used.

Resolution	Image size	File size	Results
1024x1536	14.22” x 21.33”	231K	Good

Design Plan Detail – Quality Level at Good

Based on the above settings, the image quality will only be good at the high-resolution setting. So that was the only one used.

Resolution	Image size	File size	Results
1024x1536	14.22” x 21.33”	148K	Good

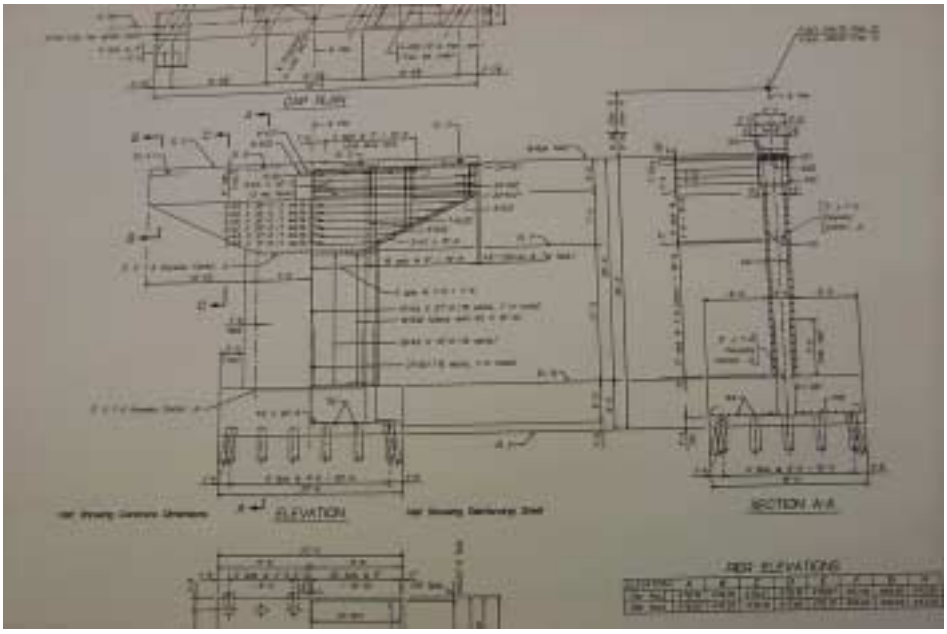

Figure 9 – Design Plan Detail

Conclusion

Looking at the results, the most efficient setting is high resolution and lowest quality level. The file size is optimized and the image is readable. At this setting the image size is large, 14.22” x 21.33”. This creates a problem for printing. If you reduce the image to fit on regular size paper (8.5x11), the image is not readable.

The file size (~ 150k) may seem large, but this is an image file. It is a fast way to capture this type of information, but transferring it into a computer system does take time. The images are saved onto a photo memory card. There are two ways to transfer the images.

One is to use a cable hookup, which requires transfer time of approximately 30 sec. per image. The other technique is to use a PCMCIA adapter that the photo card can be placed in and the computer reads the card as another drive. This is considerably faster and easier but it requires a PCMCIA port which are normally available only on laptops.

This can be an option for capturing documents into electronic form but probably not desirable when compared to a scanner. A flatbed color scanner can be purchased for less than $200 and is a better option because of the ease in converting this type of information in electronic form.

Internet Tools for Construction Data Management

The current status is one of transition. Established software development companies like Bentley, Autodesk, Microsoft are converting their products to be browser based. New developments are browser-centric as well. New Internet based companies are developing products for the construction industry. The web site http://extranets.cc is an excellent portal to these tools. A listing (dated April 7, 2000) shows more than thirty sites with developed tools or in development. Most of these products are targeting the building industry. Sites for purchasing materials, managing surplus materials, auctioning equipment and materials, managing drawings, facility management, bidding and procurement, creating as-builts are targeting this industry. There are generic project management tools for document management, project team communications, scheduling, managing subcontractors, and managing drawings, all which have application in the transportation industry. INDOT's workhorse will be the SiteManager tool which is not browser-based. As SiteManager is brought on-line, and managing projects and types of contracts change, these Internet tools may become appropriate. A printout listing of these Internet-based tools is shown in the Appendix.

Implementation

The driving force now and into the near future in construction data management is SiteManager. Jim Snyder and Rick Yunker are heading the phased implementation

effort. The efforts on this project have focused on tools to support and enhance SiteManager. Each has been described in this report and can be implemented.

One tool developed in this project was a earthwork analysis program. This analysis program can be used throughout the state and is designed to supplement SiteManager. Any new tools added should be built around the capabilities of SiteManager. It is recommended that these tools be browser based for accessibility and universality reasons.

One independent technology investigated is videoconferencing. This technology is a natural fit for INDOT operations with geographically separated offices and projects scattered throughout the state. The need for this type of communication and collaboration justifies the initial investment. Costs for regularly scheduled meetings were calculated and reports from other state DOTs indicate a good return on investment and a technology that can be very beneficial for the Department. This technology should be implemented.

INDOT has a very serious condition in the data management infrastructure that will cause problems and restrictions on future information technology tools. At each of the main hubs, central office and district offices, the internal data path capacity will be 100MB, while the connection between these locations is at 1.5MB. This is a serious bottleneck. With new data management tools Microstation CAD, Geographic Information System (GIS), Scheduling and Project Management System (SPMS), Client/Server Trns-port, Exor (Road and Bridge Inventory in Oracle), Electronic Records Management System (ERMS), and SiteManager rolling out within the next year, the current data path will become overloaded. Also, with new needs in the areas of videoconferencing, on-line training, and streaming video, the need for more capacity is here, now. The department needs to request a major upgrade in data path capacity between the central office and district locations and toll road.

Conclusions

This project investigated INDOT's data management needs in the construction management process. In the early stages it became evident that SiteManager will be the dominate centerpiece. As described earlier, it will be used on most projects and will allow contractors and consultants to participate in the electronic construction data management process. SiteManager will not be able to meet the entire site data management needs. It is recommended that off-the-shelf tools be used.

New information technology tools that are currently in the pipeline and will come rolling out within the next year will overload the current capacity of the data paths between the central office and the districts. And with potentially new applications in videoconferencing, delivering training on-line, and streaming video that provide benefits that far exceed their investment recommended, the Department needs to move quickly on upgrading these data paths to meet the current and future needs.

The project scope and direction changed during the project. The Study Advisory Committee provided the leadership for this. One lesson learned from this project is that in future studies like this where computer technologies are the main focus, the project scope should be more focused at the beginning. The reason being the quickly changing nature of computer technologies can create a proverbial endless search and chase. A guiding principle is to investigate technology families, determine which ones match best with the present and future needs, and describe solutions using a particular technology type.

DOT Video conferencing summaries

Alabama – Susan Lowery

Use the VTEL system. They will have one at each Division Office (9 total), at the Central Office, and at Materials & Test. The overall cost is more than $1,000,000. They are currently in phase I of implementation which sets up the system in two division offices and at a total of 5 locations. Phase II will complete the installation at all sites

Initially the system is being used for meetings with training as a future use of the technology. Phone lines are used. They are planning to use an Internet setup in the future.

Will send info on cost/benefit data.

Tennessee – David Doyle – 615-741-3576
Royce Jackson is the manager.

Use the VTEL system. They have 2 at the central office and one at each of the regional offices. At each regional office the installation is in the auditorium. They are using single 27" monitors and dual 35" monitors. They also have a smart board, a document camera, and a VCR to record a session.

The two units at the central office cost $80,000 ea. and each unit at the regional sites cost $60,000. The system costs about 50$/hr. to operate. They can interface into FHWA and with University of Tennessee. They are investigating a Internet point-to-point system run through a state WAN. Netmeeting worked well over the WAN.

Indiana – Shane Gamble

RFP is out for 5 sites, IGC, FW, Madison, Evansville, and Merrillville. The sites will be at the state police posts at these locations. The hourly use rate will be $30.

This will most likely not be convenient for INDOT because of the locations, with the exception of the one in IGC. Because of this accessibility problem, it will most likely not be used by INDOT. This is not a desirable option.

Illinois – Don Beard – 2127-785-2400

They are using VTEL equipment. They have 9 district offices, with one at the central office, a central office and one in Chicago. The installations are at he 8 outlying district offices and at the main office. The overall installation cost was $500,000 to $600,000.

They use it for Civil Rights hearings, disciplinary hearings, computer personnel meetings, bridge staff meetings, and training. The installations are used primarily by DOT personnel,

they get very little use from other agencies. Most people believe it is more productive and saves a considerable amount of time.

The interactive computer capability and white boarding is a nice capability to have.

Missouri – Dave Snider – 573-751-2856

They did a 90 trial of a system hookup between Jefferson City and St. Louis. The trial period went well and used it mainly for hearing meetings. In Missouri a company DTI has installed fiber optic cable along state highways. They are trying to negotiate with DTI to tie into this. They wish they had videoconferencing statewide with 10 districts and a central office requiring 11 installations. Each unit would cost between $20,000 - $50,000. They did a cost analysis and determined a 6 month payback for on the investment. A cost to benefit ratio of 2-3 to 1. They want this system first and a future point-to-point Internet system later.

Wisconsin – Jim McDonald – 608-264-7200

They have a statewide network consisting of 25 sites, central office, 8 district offices, 8 state police offices, and 8 BMV offices.

They are using the system primarily for meetings. A document camera is an important feature.

See email.

Pennsylvania – James Slaughter - 717-783-8823

They are using a PictureTel Venue 2000 double monitor system. The systems are setup at the 11 districts and 2 at the central office. They have a bridging services machine that can bridge up to 24 units. Each installation has a document camera, PC, and VCR. The initial cost was $700,000.

Each site has access to 3 ISDN lines. Each ISDN installation costs $1500. One line cost $0.32 per minute to operate. So three lines cost $0.96/ minute.

The payback period for the initial investment was 9 months. The savings came primarily from travel costs. The system is primarily used for meetings and training. Specific uses include design review sessions, meetings with FHWA, and meetings with consultants. It is not used for negotiating or personnel issues. Allowing community groups to use the facilities is fostering community partnership. Their facilities are used frequently and the response has been strong and enthusiastic.

Kentucky – John Stacksteder - jsacksted@mail.kytc.state.ky.us - 502-564-3280

Most of the major cities in the state have a publicly available videoconference center. Currently the centers have limited use so they have not experienced any problems in scheduling meetings. They use the facilities for monthly reviews by the design staff and other meetings. They have discussed developing their own videoconferencing centers but with the available centers and operating costs of $50/hr. they cannot be justified economically.

Equipment details and operation info can be obtained from Linda Mahone in the Information Systems office at 502-573-1578.

Iowa – David Cook – dcook1@max.state.ia.us - 515-239-1771

They are currently performing an internal analysis of their teleconferencing system. They are tracking the number of participants at each video session, staff hours avoided, miles avoided, and some other factors. They are also attempting to derive a productivity gain for each video session that is based upon several factors and a predetermined "average" per hour salary. These are some of the figures that will shortly be finalized and provided to the state legislature.

The Iowa DOT has 7 sites across the state with videoconferencing rooms. These are located at the Central Administration Complex in Ames, five regional transportation centers, and one is located in our Motor Vehicle Division based in Des Moines.

They use PictureTel's Concorde 4500 units with dual 27" monitors on moveable carts. The units at all 7 sites are the same so there is no confusion when employees use the units no matter which site they attend. Each video room also has a document camera and VCR. Each Concorde also has PictureTel's Limelight feature which is an auto-tracking system so participants don't have to manually change camera positions. Some of the units have a scan converter which allows video transmission of PC-based images (such as PowerPoint presentations) and electronic projection system images (such as DataShow projection presentations).

They also use PictureTel's LiveScheduler server system for our reservation & scheduling system. They have found it of immense benefit as the system will remotely dial the PictureTel Montage video bridge which then automatically activates and links the requested video sites. Video participants can simply walk into the room and the system activates for them at the designated time. At the designated end of the session, the system closes the conference; again with no action needed by meeting participants. They try to keep the system simple and as invisible as possible for participants.

During FY98 the Iowa DOT had 134 videoconference sessions and use appears to be growing. You should also realize that Iowa has the Iowa Communications Network (ICN) which provides a fiber-optic presence in all 99 counties. At present, there are over 600 full-motion (DS3) videoconference sites in the state with most of these located in K-12 schools, community colleges, and universities. There are also several full-motion videoconference sites in other state agencies. The Iowa DOT's compressed technology videoconference equipment frequently links into full-motion ICN-based videoconferences usually hosted by a state agency, e.g. training sessions hosted by the Iowa Dept. of Personnel or perhaps a state university.

PictureTel's compressed technology was chosen after reviews of several videoconferencing systems by an evaluation team composed of members from various areas of the DOT and from across the state. It was decided that the PictureTel compressed system met the Iowa DOT's needs based upon various factors. There was also realization that most of their "customers" would be internal DOT users and also consultants based in-state & out-of-state who used or planned to use compressed technology equipment due to their own business decisions.

The Iowa DOT has used the videoconferencing system for various team, office, divisional, & other types management meetings, CDL training, meetings with out-of-state consultants, construction & maintenance project reviews or coordination, various workshops, job position interviews, and the like. The variety & type of meetings are also increasing with videoconferencing's increased use and realization of benefits.

The system is becoming an integral part of the Iowa DOT as videoconferencing is becoming the first choice for meetings, especially when meeting members are widely dispersed or when information needs to be delivered in a timely fashion. It also allows more participants at informational meetings and in decisions.

Florida DOT – Elwin Broome – elwin.broome@dot.state.fl.us - 850-414-0138

They are currently looking into videoconferencing and investigating the different alternatives. One technology that have used is a Liveboard. This system is used in meetings and integrates document, videoconferencing, and multimedia presentations with an intuitive shared whiteboard to promote group collaboration. This technology is being used in training and conduct meetings that require sharing data.

North Dakota DOT – Gary Berreth – gberreth@state.nd.us - 701-328-4408

The North Dakota DOT has been involved with a multi-state video telecommunications system since about 1994. The initial system was a satellite based system with six DOT's and four universities. It's primary use was for training although it was also used as a face to face communication tool. The system had its good points and its bad points.

After about two and a half years of use and experimentation on improving the system, our group, more commonly known as TEL-8, decided that the system was not doing everything that we had envisioned it was supposed to do. We needed to step back and take a look at what we wanted the system to do again and investigate whether this technology or some other options should be pursued.

As a result of this review we have now converted from a satellite based system to a terrestrial based system. The new system includes five of the six original state DOT's and the original four universities. Although the system usage is still primarily for training its capability for other face to face usage has been enhanced considerably. We have purchased our own bridging equipment, developed formal training programs, developed university transportation related classes, scheduled regular information exchange programs for DOT's, scheduled NCHRP and TRB sessions, and expanded face to face communication sessions.

In short, the new system has been a very beneficial tool for us to use.

We have a system coordinator at NDSU in Fargo, North Dakota. His name is Doug Benson. His telephone number is 701-231-8388. Please feel free to contact him about details of equipment, operations, history of our group, annual reports on our systems, etc..

Wyoming – David Talley – dtalle@missc.state.wy.us –

Videoconferencing at WYDOT has been a very helpful tool and a positive experience for the agency. We are still learning how to best use the technology but what we have learned has encouraged to expand our use of it.

We got into videoconferencing through the "back door," some Federal monies allocated to the former FHWA Region 8 for experimentation using the technology. As a result, the DOTs in ND, SD, MT, UT, CO, and WY along with North Dakota State Univ, Utah State Univ, and the Univ of Wyoming became what is known as "Tel8."

Since 1995, Tel8 has been "practicing" with different ideas on equipment and programming. In 1998, we upgraded our equipment and switched from satellite transmission to terrestrial transmission. We currently use PictureTel equipment (the "winner" after an extended search process) and it has been "marvelous." Our system has been used primarily

for formal training---both technical and non-technical---, some graduate CE education, and just a bit of conferencing between states. We have also been able to sit in on things like the TRB or environmental and transportation conferences from North Carolina State University. As people become aware of the technology and its ease of use, we are finding more uses for it.

In dealing with upper management we had to overcome a slight "sticker shock" factor, but the savings in travel and subsistence costs easily won them over. The additional benefit of offering training opportunities that were previously out of the question due to cost was also a big plus.

If you would like more details on the management of such a system I suggest calling Doug Benson, Upper Great Plains Transportation Institute, NDSU, (701) 231-8388 or benson@plains.nodak.edu Doug is the Associate Director of Tel8 and can give the best perspective.