

ELECTRONIC CAPTURE OF ENVIRONMENTAL DATA USING A TABLET PC MOBILE APPLICATION FOR DIRECT EXPORT TO A DATABASE

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ABSTRACT

The tracking of environmental samples and results, from the point of collection until final data storage/usage/disposition, is a critical activity that contributes to the success or failure of a project. On large sites (e.g., US Department of Energy, US Department of Defense, Superfund), where environmental samples have been collected for over 20 years, the present process combines manual data collection and entry, with database systems and one or more laboratory information management system (LIMS). The manual process conducted in the field requires the geologist, engineer, or field technician to complete and maintain several logbooks. After closure of a logbook, field data are hand entered into a database or computer.

Initial and subsequent manual data entry is an inaccurate, labor-intensive process. Problems that result include: inefficiency, inaccuracy, inconsistency and possible invalid interpretations. The “weakest link” is the manual field environmental data collection and entry process, because of the introduction of human errors.

In an effort to improve and streamline the environmental data collection process and reduce errors (increased quality) and costs, Bechtel Nevada Inc., Bechtel National Inc., and Idaho National Engineering & Environmental Laboratory, the BecGeoWorks team, have combined Tablet PC technology with an existing integrated data management system. This combination of a pen and tablet interface, disconnected networking, and a scalable enterprise database, is a major step towards a single source cradle to grave field collection and data management process.

INTRODUCTION

BecGeoWorks is a field deployable prototype application that utilizes a Tablet PC to allow field personnel to enter required information concerning an environmental sample in the field, thereby eliminating the manual data entry steps. Entering the information once directly into the tablet finalizes the process for the field staff and reduces human error. The ultimate goal is electronic capture of all information at the point of origin for export to a single repository for all environmental sampling related data.

DATA MANAGEMENT

Manufacturers in the 1970's learned that quality cannot be "inspected into a product" but is rather a function of the entire process. In a similar fashion, data management, cannot be an added on or segregated into a stand-alone process (Figure 1). True data management is integral at the beginning of the entire process. Data management is the key to the value, veracity, audit ability and defensibility of data from a project's inception until all deliverables are finalized and the data sets are archived for record retention .

Technology deployments have continued unabated, and have proliferated into every aspect of the government and commercial sectors, however even with all these advances, collection of environmental field data generally remains a manual, pen and paper process. One of the basic goals of the BecGeoWorks team was to identify technology that would allow for building a process that captures information at the source and seamlessly integrates with the existing database systems.



Notes: EDD – Electronic Data Deliverable
DQO – Data Quality Objective

Fig. 1 Data Management process

SITUATION

Bechtel wanted to streamline the process of gathering metrics associated with environmental field sampling, with a cost-effective, all-in-one solution that would combine the benefits of old fashion logbooks and laptop computers/PDA's (Personal Digital Assistant), providing an efficient and natural way to interact with data. The first phase of BecGeoWorks was to deploy a pilot Tablet PC application that would allow evaluation of hardware and software, plus the total effectiveness of the Tablet PC. Issues examined included:

- How does the Tablet PC change a sampler's approach to work in general? For instance, will field staff be able to work with the application in all of the varied conditions experienced at an environmental site.
- How viable is the Tablet PC for use by field workers? Will the learning curve be high? Will the habits of the past be overcome, such as wanting to keep manual logbooks? Will the Tablet PC be powerful enough to run the necessary applications/programs?

ELECTRONIC CAPTURE OF ENVIRONMENTAL DATA

A major factor, when deciding to deploy a computerized field logging system that replaces the current paper-based process, was identifying the requirements and specifications. Care was taken to scrutinize the process currently in use by the field staff and thoroughly describe all the existing forms and standardized paperwork needed for the process.

The new system to support the electronic capture of environmental data using a tablet pc, collecting data for direct export to an established database, should do the following:

- Mimic the present process used for collection of environmental data
- Allow expansion for additional functionality and/or new technology
- Be multi-user capable and enterprise ready
- Be ergonomic and intuitive
- Support multiple sample types
- Provide the user with several options for data entry
- Support multiple peripheral hardware devices (e.g., GPS, digital camera, bar code reader, RFID, wireless capability)
- Support all the functions of the current paper system
- Be data model compliant with the present environmental database
- Support requiring additional cross-checking and verification of data in the field
- By design be a system that helps end users perform their job
- Provide more consistent and better quality data at a lower cost, thereby improving client deliverables

Switching from a paper system to a computerized system requires careful design, planning and deployment. The requirements and wants of the field staff and end users must be considered. Their current computer skills, training and organizational or company culture must be factored into the deployment phase to ensure acceptance. Once all the requirements and specifications of

the current process are laid out, focus should then be given to the critical steps, and current processes that can be streamlined, automated, or consolidated.

REMOTE DATA COLLECTION

Tablet PC's

To meet these challenges, BecGeoWorks team chose Fujitsu ST4121 tablet PC. The ST4121 has a slate form factor with a high contrast TFT with Indoor/Outdoor (Reflective Front Light Viewable Display)

Development Platform

The Tablet PC runs Microsoft® Windows® XP Tablet PC Edition, providing the power of the Windows XP Professional operating system. In addition, Microsoft Visual Studio® .NET is being utilized to develop the pilot application. The .NET Framework is Microsoft's operating system product that provides prefabricated solutions to the windows programming environment.

With the Tablet PC, environmental samplers have choices on how to interact with the computer, allowing a work flow in a way that feels natural, matches skill strengths and is suitable to the field environment. The field staff has several methods of inputting data: keyboard, digital ink, and speech recognition. Staff can dictate notes directly to the Tablet PC, saving the notes and making them exportable in a format matching our data system. Others prefer the natural writing capabilities provided by the digital ink, while still others are more comfortable typing their notes using the keyboard.

Replication/Synchronization

There are a variety of data synchronization techniques for applications that have to operate in the Occasionally Connected Computing (OCC) environment. The technology that was appropriate for the given application was identified at an early design stage.

The issues considered in choosing a replication technique were: data synchronization, security, and manageability, how much data was to be cache on the mobile computer and the form of local data cache. Consideration was given to the need to synchronize changes back to the master data store on the server in a way that is both manageable and scalable.

The technique used for this application to synchronize data between the publisher (central SQL Server database) and the subscribers (a database on a client computer) is Merge Replication. Merge Replication has many advantages. It has excellent support for OCC, the features and functionality provided by SQL, good security and full merging capabilities. The security features handle authorization and client authentication.

Reusable Forms

At the DOE and DOD sites there are a wide range of field sampling requirements. Air, water, biota, radon, meteorological data all require different procedures, pre- and post-job check lists, field logs and sample note sections.

The BecGeoWorks tablet application has an extraordinary user interface that utilizes XML (eXtensible Markup Language) to reformat the application depending on the sample type.

Of the seven form tabs five are defined on the fly by an XML document that is matched to the type of sample that is being processed in the field at the time.

Tab 1 is defined by XML to contain a sample specific pre-job checklist.

Tab 2 is defined by XML to display the correct procedure for the sample type.

Tab 3 is a fixed format to facilitate data base entries.

Tab 4 is defined by XML to contain mapping / location information concerning the location where the sample is to take place.

Tab 5 is defined by XML to accept sample specific field notes in various formats.

Tab 6 is a fixed format for chain of custody (COC) entries and tracking.

Tab 7 is defined by XML to contain a sample specific post-job checklist.

XML is a markup language for documents containing structured information.

Structured information contains both content (words, pictures, etc.) and some indication of what role that content plays. The XML specification defines a standard way to add markup to documents.

Digital Ink

The Tablet PC represents a distinct evolution of the standard laptop computer by developers to create applications that permit users to input data with a digital pen as well as a standard keyboard or mouse. The Tablet PC has special screen which uses an active digitizer to enable field staff to write directly on the screen to control their PC and to input information as handwriting or drawing. This process, called inking, enables users to utilize "digital ink" in entering data into Windows applications; entries appear as natural-looking handwriting on the screen. Digitized handwriting can be converted to standard text through handwriting recognition, or it can remain as handwritten text. Inking also allows users to insert a sketch or drawing, jot down a chart, take free-hand notes, and annotate an existing document. Using a pen to input information into the Tablet PC is simply a more natural and productive way to work in the typical field sampling setting.

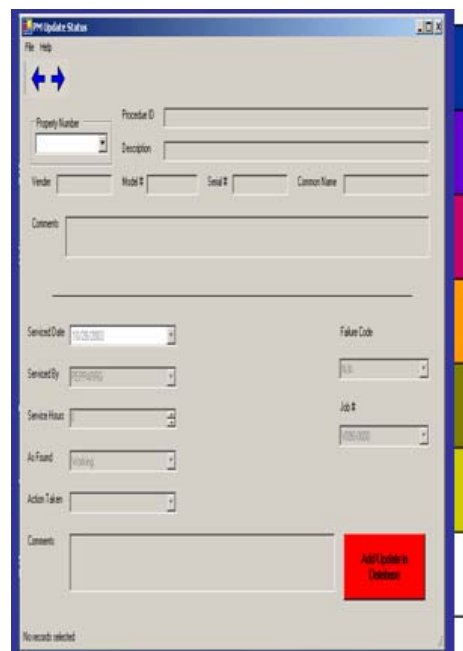


Fig. 2

Radio/Cell persistent connection

BecGeoWorks original configuration was to be utilized in the OCC environment. However this tablet PC application is purposely fashioned to be flexible enough in its underlying design to be utilized by any organization collecting environmental data and employing Bechtel Environmental Integrated Data Base Management System (BEIDMS) as their data warehouse.

Phase II of BecGeoWorks will support use of persistent database connections utilizing CDPD cell phone and spread spectrum radio technologies.

GPS,/Digital Camera, and/Bar Coder Reader

BecGeoWorks tablet application will support many hardware accessories. Included for example are GPS, digital camera and bar coder reader. By definition, environmental information and data are required to be georeferenced. The combination of Tablet PC and the latest GPS technology has made the collection of georeferenced data, and its entry to a data system, nearly invisible to the field scientist. BecGeoWorks will fully integrate GPS technology to georeference every sampling action.

In many situations a picture is worth a 1000 words. By including an integrated digital Camera, an image can be included in samplers' field notes whenever it is required. By integrating the camera into the application at the point of collection, the image is inserted into the sampling record in the field with no further action required. The benefits of using Barcodes for automated data collection are very simple: speed and accuracy. Entering barcode data is many times faster and more accurate than traditional manual keyboard entry; this translates into an increase in efficiency and near zero error rates.

CONCLUSION

The pilot version of BecGeoWorks deployed on Tablet PC's has exceeded goals. The data collection process for field personnel is now finalized in the field. This addresses the two principal objectives for BecGeoWorks, first to extend the data management process to the point of collection, and second to realize a reduction in the cost of field sampling.

By making it easier for field staff to fulfill their reporting requirements while in the field, the introduction of the Tablet PC will directly improve the quality and quantity of data collected.

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