

The e-revolution: how could e-applications change the traditional construction management approach in Puerto Rico

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Abstract

The construction industry is characterized by complex interactions between the different players (such as owner, architect, engineers, contractors, consultants, etc.) involved in a particular project. These interactions typically involve sharing of information and data for purposes such as clarifications, inspections, planning and to inform about how and when work will be performed. Typically, the documentation of the information shared in such interactions or meetings is paper-based which could require extra time in terms of office personnel, archiving clerks, office space and equipment. This process could be time consuming because dual entries will be required if the information will be enter into computer systems for archiving purposes. In addition, possible problems in information dissemination through fax and mail could be encountered. As a result, cost and time increases are typically associated with the current documentation and information dissemination processes. In recent years, several alternative approaches have been explored to shift from a traditional paper-based system to automated electronic-based systems. Some of these new approaches use the Internet (e.g., bank accounts); other approaches use mobile devices such as handheld computers to automate their processes (e.g., FedEx, UPS), with information transfer being accomplished through wireless connections. More recently, attempts have been made to apply these new approaches to the construction industry. However, to this date, none of these applications have been implemented in Puerto Rico primarily because they do not fit the needs and particularities of the local construction industry. It is believed that the construction industry in Puerto Rico has not accepted nor implemented these new technologies and they believe that the benefits for their business would be minimal. This paper presents an evaluation of the different applications developed, either in construction or other industries, to automate typical management processes in the context of Puerto Rico. In addition, it presents some alternatives for e-applications for the construction industry in Puerto Rico.

Keywords

Construction Management, Project Management, Information Technology, Automation, Puerto Rico

1. Introduction

The construction industry is characterized by complex interactions between the different players (such as owner, architect, engineers, contractors, consultants, etc.) involved in a particular project. These interactions typically involve sharing of information and data for purposes such as clarifications, inspections, planning and to inform about how and when work will be performed. Typically, the documentation of the information shared in such interactions or meetings is paper-based which could require extra time in terms of office personnel, archiving clerks, office space and equipment.

Figure 1 depicts the typical communication and information sharing between the parties involved in a typical construction project.

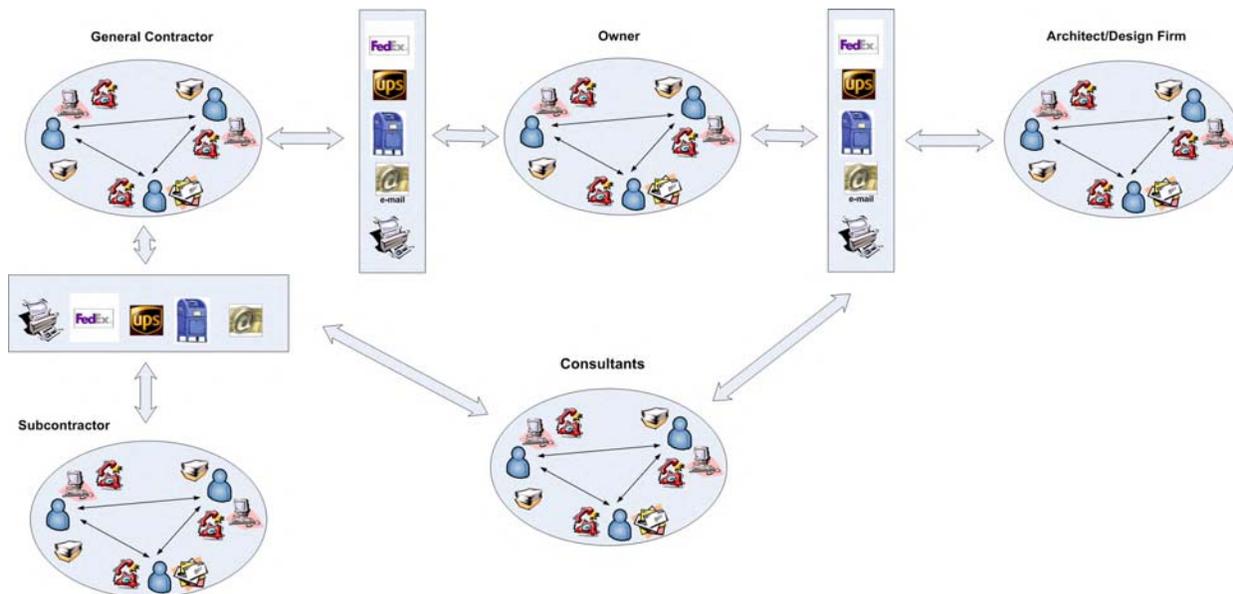


Figure 1: Typical Communication and Information Sharing in Construction

The communication between the general contractor (GC), the owner, the owner's representative, consultants and subcontractors uses typical mailing systems for information sharing. Problems that could arise include delays in the time when the documents are received or information cannot be delivered when needed (regular mail, UPS, Fedex), information not received or received incomplete (fax), among other problems. In addition, parties could argue that the information was not received on a timely manner.

e-construction

To tackle the management challenges typically encountered in a construction project, some companies have tried to automate the construction and project administration processes. The primary purpose of automation of construction and project management processes is to minimize double entry of recorded data, which in turn minimizes errors in data input. Other benefits include the reduction of paperwork, automatic generation of reports, and faster distribution of electronic data. Combined, these advantages translate into cost savings through decreased delays and reductions in labor time. The problem is that these systems do not fit the particular needs of the construction industry in Puerto Rico. However, there is an opportunity to develop a system customized to fill the needs of the Puerto Rican construction company. The following sections will describe areas that could be automated and possible benefits of adopting an automated approach.

Several applications have been developed to automate the construction project management and administration. These applications could be divided based on their functionality. Such systems include web-based systems, intranet and extranet and mobile computing.

Some companies have developed electronic website that allows automating construction and project administration. Among some of the developed web-based systems Constructw@re, Buzzsaw, Corecon, BuildIt Pro, EProject, Citadon and Primavera Expedition are included.

Corecon was designed for small to mid size AEC firms. This software offers a complete suite of applications to assist in estimating, managing projects and cost control. This application allows

communication with subcontractors and vendors anywhere, onsite or offsite. In addition, it allows quickly of organizing multiple bids, contracts, change orders and budgets. BuildIt Pro is a system that offers document organization, contacts, and schedule. It is not a cost estimating system, is only a system to organize all the documentation for a project in a simple way that offers the advantages of web based system to the users. EProject Enterprise offers a 100 % web based solution to help contractors make more accurate and more relevant business decisions by connecting the people who are involved in the project and the information and ideas that are critical to the success of every project. Citadon is web based collaboration, project management solution for distributed and project oriented organizations. The system enables the management and collaboration on all organizational and project documents. Also, it allows for automation of streamline business processes and communications within and across enterprises.

When one starts to analyze how long it took for some companies to implement web-based project management construction, it is easy to understand how difficult this process has been. The construction industry is resistant to change and the traditional way to meet with the people involved in a project was face to face and all the documentation and drawings was in paper. Companies continue operating the same way they have been operating for the last decades.

Web based project management for construction projects could be the ideal management process in Puerto Rico. The system could bring together all the project participants to a paperless management process. Moreover, the system could provide up to date, "real" time information to participants faster, because the information dissemination time gets reduced considerably.

e-bidding

In the construction world, bidding has been the traditional delivery method used by owners for the selection of a contractor. The main purpose of a bidding process is to select the contractor with the lowest price, but, at the same time, keeping in mind the owner's requirements with respect to quality and performance of the project being built. In addition, the qualifications of the contractor are a very important aspect to consider.

In the public agencies of Puerto Rico, the contract is awarded to the contractor that submitted the lowest bid, as long as all the bid requirements are fulfilled. In the private sector, the contractor with the lowest bid is not always selected.

Bidding procedures and requirements vary and have different requirements that are established by the owners. One of the challenges of a bidding procedure is the amount of paper-based forms that need to be revised, filled, and filed. This requires great amounts of time, which the contractor possesses very little when preparing a bid. Every time the contractor is preparing a bid, these forms are filled. Some of these forms do not vary if the contractor is preparing a bid for the same owner.

An electronic platform could be very useful for bids management in the construction industry. There are electronic applications, such as eBay, that could be used as models for developing a platform for construction. The volume of transactions, buy and sell, performed everyday on eBay gives an idea of the level of confidence and comfortability of users of this system. Similar to eBay, an electronic bidding platform should provide secure access to contractors, owners, architects, and other players involved in a construction bidding process through a username and password.

Bidding documents could be obtained through the electronic platform after paying a pre-determined fee. This will save time to contractors because they will not have to travel to the owner's office to purchase the documents. Moreover, the documents could be accessed from anywhere by using the Internet. Specifications could be uploaded in .pdf format while the plans could be uploaded in design web format (.dwf), a format that could be read by using a free viewer, AutoDesk DWF Viewer.

The idea of having a user's profile for contractors and owners could be very helpful. Evaluations of performance in previous projects could be included in such profile. By reading the profile information such as compliance with specifications and quality standards, attitude with relation to claims and re-work, work relationship with previous clients, subs, suppliers, type and magnitude of previous work could be available to the interested party. The contractor could have quick access to projects that are of his particular interest. The owner could upload addendums, answer questions electronically to all the bidders. This information could be available in the profile of the contractor, once the project is selected as one of his favorites. The contractor would be responsible to obtain documents through the Internet and the owners will have a record of the contractors that bought the documents. Bids could be grouped by agency, owner or type of construction, which will allow searching easily. The projects that will be bid in upcoming dates could be advertised on the main page with a link to all the project information.

Field automation of processes

Many different types of construction data are collected on a daily basis in the field basis. These different types of information can be classified as follows: project correspondence and memorandums, including RFIs, change order and submittal requests, quality control and assurance records, construction field activity and progress logs, resource and inventory logs, including tracking of labors, equipment, and materials.

Each of these categories of onsite data collection have been recorded through the use of paper forms, a method still used in the construction industry in Puerto Rico. Once all the information is collected, these forms are sent back to the office where they are manually processed by copying desired information from multiple forms into one form or even into a computer spreadsheet.

Time and cost saving could be achieved by automating the field data collection in the field. Important data could be sent directly to interested parties. Figure 2 illustrates a conceptual framework for automating the data collection process in the field.

The concept of automating the field data collection is easy to implement. Essentially databases are used to store the data collected by using electronic means. These data is distributed electronically to the parties interested as needed. A description of some automated data collection applications follow.

e-inspection

Inspection and maintenance data is generated on a daily basis, with the frequency of daily data generation being very high. Not only data is generated during the construction phase of a building, but, in addition, inspection data is generated when the building is being inspected for compliance purposes. Maintenance data is generated when the building is being repaired as well as when the equipment is being maintained.

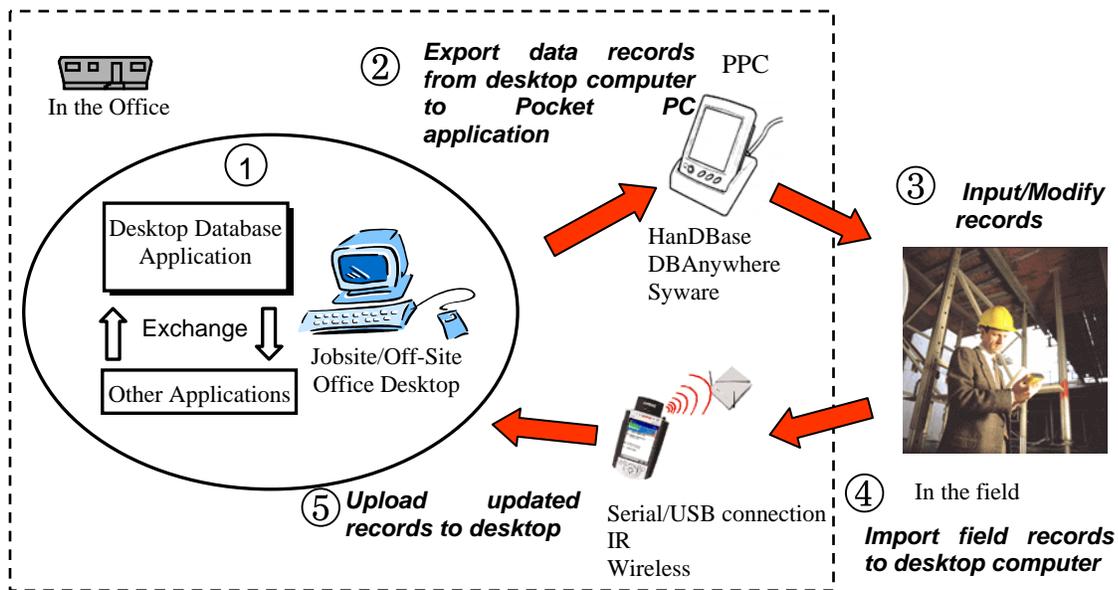


Figure 2: Automation of field data collection using PocketPC

Construction inspection data allows field personnel to monitor project performance with the ultimate goal of improving productivity and lowering costs. In addition, inspection allows for quality control and quality assurance, critical aspects for the overall success of the project. This quality control and assurance is vital for compliance not only with owner requirements, but also with federal and state regulations.

Current practices for data collection at the construction jobsite rely mainly on paper based forms to compile information. Recorded data is, therefore, manually sorted and filed. Time spent in collecting, filing, and distributing paper forms in this manual process raises many concerns. Not only is the clerical expense of the process very high, but also the organization and review of the information commands an inordinate amount of time by a project manager, of which most project managers possess very little.

With the introduction of improved portable technologies, a more feasible solution to the problem of dealing with vast amounts of data collected in paper forms can be developed. Portable databases can now be taken to the site using a portable computing device that can fit in the palm of the hand. Data can then be digitally recorded while being collected eliminating the use of paper forms. Using a wireless connection, the collected data can be transmitted in real time to the jobsite trailer PC or to other remote locations. The ability to transfer data directly from the handheld, while doing the inspection, accelerates the notification process of any possible problems encountered. Corrective actions could be taken more rapidly than using the current paper forms, because the data is transmitted instantly and electronically to the interested parties.

Software exists that allows storing a digital form of the construction drawings. This is very useful while doing an inspection. The inspector can view in the handheld device a graphical representation of the process being inspected, without the need of carrying a bulky amount of plans that could make the inspection process difficult. Typically, the inspection process is based on two dimensional drawings. It could be possible that the information in the plans could not be easily understood because of the limitations of a two dimensional drawing that can not represent depth. As a result, misinterpretations distribution of incorrect information and discrepancies could be often encountered in a project. These portable devices have the capacity of displaying 3D images, a feature that could be very useful, not only for inspection, but also it could allow the contractor to better visualize complex construction details. An example 3D view of a model displayed in a Pocket PC is depicted in Figure 3.

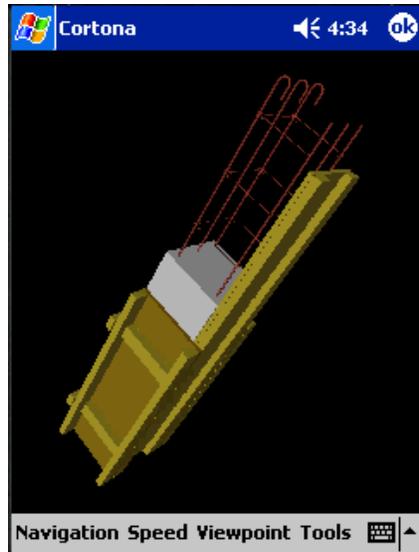


Figure 3: 3D view displayed in a Pocket PC

e-equipment records

Research efforts have concentrated in the collection of production data with the purpose of improving the operations. Production data refers to data related to the productivity of equipment or crews. Manual data collection methods fall short to collect accurate equipment production data in the amount of detail required to perform performance improvement studies. This is the reason why the collection of heavy equipment production data has been automated lately.

Collection of data related to equipment maintenance and usage is essential for equipment production and to avoid breakdowns. The acquisition of construction heavy equipment is a major investment for a construction because of the high prices of this equipment. Therefore, it is very important to keep maintenance and usage records to minimize breakdowns. This process could be automated and data related to equipment maintenance and usage could be store in a chip or tag that could be read by using a portable device. This will eliminate the need of keeping paper records of equipment maintenance and usage since all the information required will be stored in the chip or tag on the equipment. Whenever a maintenance worker wants information on the equipment, the chip or tag is scanned, and the information is displayed in the portable device.

e-procurement

The author performed research to automate the process of material requisition for the electrical contractor by using handheld devices, specifically Pocket PCs. The author developed electronic versions, in the Pocket PC, of the paper based forms currently used for material requisition. These electronic forms contain all the information in the paper forms considering the information sharing between forms.

The software used in the development was VisualCE from Syware. Figure 4 illustrates the application tree of the application, using Pocket PC screenshots, if the user wants to access the Material Database. In the Main Menu, the user selects Database Module, in the database Module the user selects Material Database, then the Material Database screen will appear. This module allows the user to add, delete, view or edit information about any type of material used by the company.

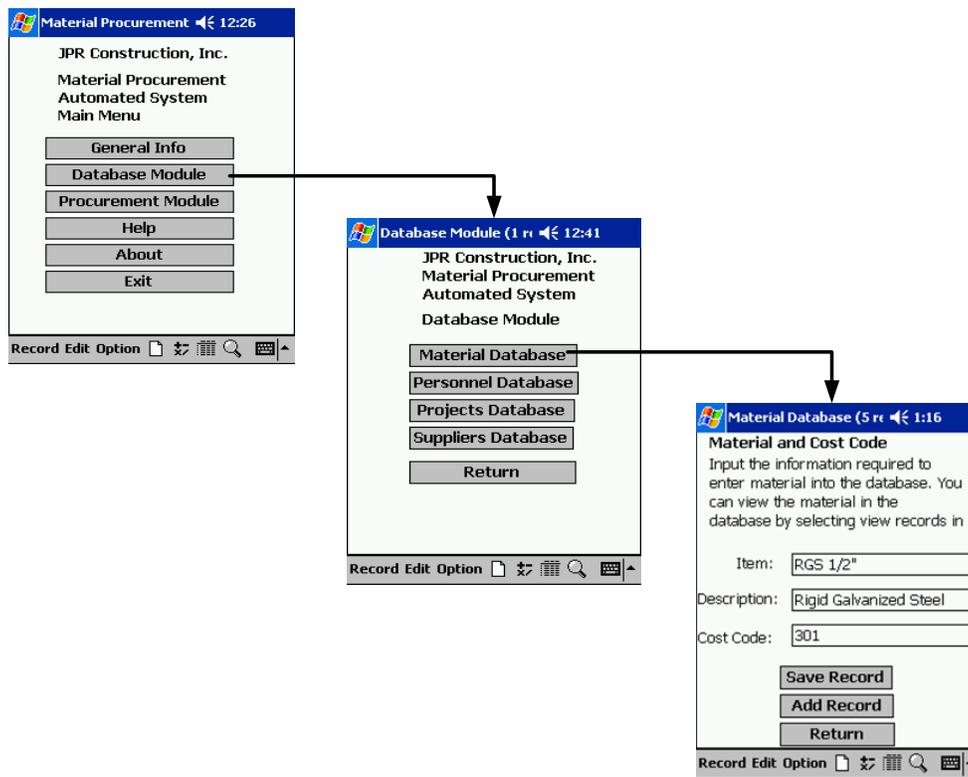


Figure 4: Application Tree on the Pocket PC

Other Applications

McCullough conducted research to demonstrate the use of pen-based computers into road maintenance operations. Notebooks or clipboards, handheld or slate and PDAs were considered for the study. Savings in the time needed for data collection were identified. In addition, the processing of information became simpler and the accuracy and quality of the data collected improved.

UPDATER™ is a handheld application that was developed for automating the collection process of schedule progress data in the field. UPDATER™ was intended to provide field personnel with a handy, compact, and mobile tool for schedule updating. UPDATER™ allows for downloading project schedule information from either Primavera Project Planner® (P3) or SureTrak Project Manager®. Once updated in the field, schedule information is uploaded to the scheduling software for review and generation of the new schedule.

WorkSafe International developed applications to conduct safety audits in the construction industry. The main purpose of these applications is to reduce the use of paper sheets and clipboards while performing safety inspections on the field.

Wickes Lumber developed a mobile version of their desktop application BuilderCentral. This program helps the contractor manage the entire construction process. Workers in the field can use the mobile application to view change orders, contracts, purchase orders, construction timelines, to dos, notes and prices of materials.

ToolTrac was developed by TAC Inc. The software component is a PC based application designed to interface with handheld units. The application was designed to track and manage tools, while minimizing manual entry at the warehouse.

TimeTrac was also developed by TAC Inc. to run on handheld units. It was designed to keep track of the hours worked by a company's personnel. The Conference Proceedings will be produced directly from the camera-ready manuscripts received from authors. Therefore the authors should try to produce their paper, as closely as possible to this model paper.

Field Data Recorder, an MS Access database application running on the Pocket PC platform, allows for recording field data related to environmental, geologic and drillhole data. This application was developed by RockWare Inc.

Cox et al. used the HandDBase software on the Pocket PCs to automate the construction field inspection process. They concluded that errors in data input and transmission could be reduced by automating the field data inspection process.

Construction education

Perdomo et. al. (2005) conducted research to address the impact of using 3D in teaching and its advantages over current approaches. The authors conducted a pilot study conducted with students from the Virginia Tech Architecture and Building Construction departments. The experiment investigated the advantages of 3D representation as compared to 2D drawings, in understanding construction assemblies and details. The authors also investigated the shortcomings of the traditional methods and compare the suitability of using 3D as a teaching aid. A new approach utilizing Pocket PCs via wireless connectivity, to allow students to access and view 3D models remotely, is depicted in Figure 5.

The authors concluded that that 3D modeling can be of great advantage for construction education.

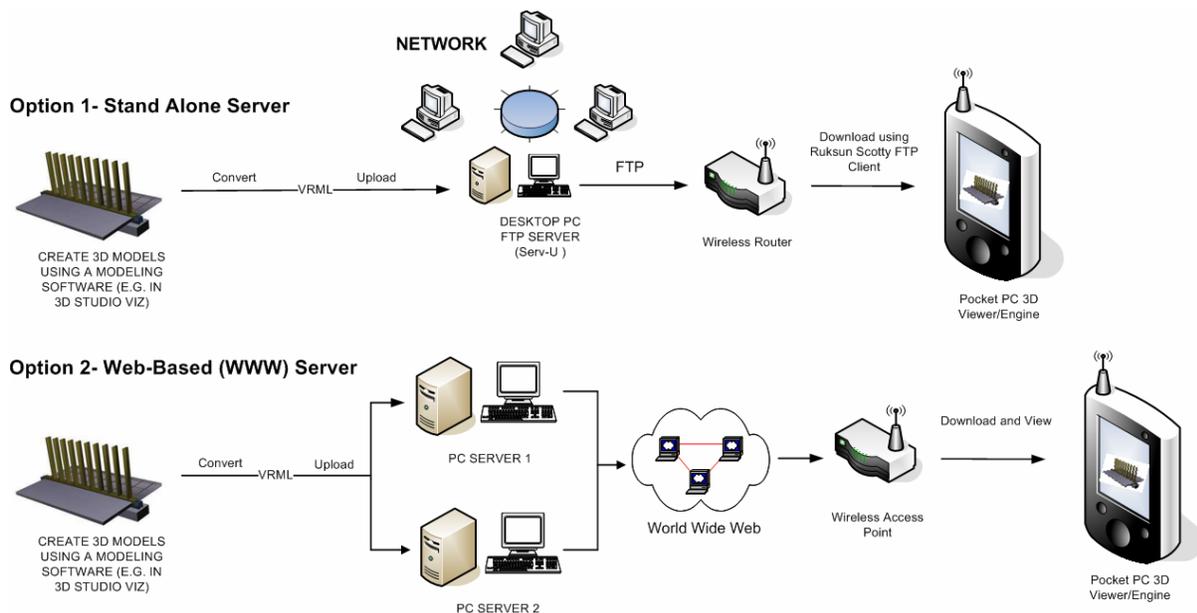


Figure 5: Framework for Wireless 3D Visualization in the Classroom Using the Pocket PC (Perdomo et. al. (2005))

Conclusions

The implementation of new technology is critical for the construction industry in Puerto Rico. At this moment, the use computer processes and technology is more apparent in the industry. Before implementing these tools, the contractor needs to analyze the value and return of the technology based on the company's operational plan, benefit expected, strategic competitiveness, technology and user orientation perspective. Most companies understand that there is a need to improve their communication system and include IT solutions. However, it has been more important to know the payback of all the resources that could be invested in setting such a system.

The construction industry, in general, not only in Puerto Rico, is very resistant to change. Implementation of new innovative methods is very difficult in such an environment. For the implementation of automated system there are some challenges that need to be addressed. There are some issues related to usability and personal issues.

- One issue is just facing the challenge itself.
- Another issue to consider when implementing change is management buyout and support.
- The time needed to learn the new tools and systems implemented could be of concern for the top executives.
- Field personnel are more resistant to change than top executives.

Challenges faced for automating data collection processes in the field not only deal with issues related to office and field personnel, but also with technological issues.

- The type of system selected has a tremendous impact on the overall implementation.
- Issues related to information storage and retrieval need to be considered. The information needs to be easily stored, retrieved by the user.
- The display capabilities are different with the type of equipment selected.
- The input of data is a major issue when considering the implementation of Pocket PCs.

The construction industry in Puerto Rico could greatly benefit from modifying its current approach to construction management and automating some of its processes. Paper based data collection in the field has been used in the construction industry for a long period of time. The use of paper based forms will continue until the construction personnel realize the benefits of automating the field data collection process. One of the advantages of automated field data collection over manual data collection includes the elimination of double entry of records, which minimizes errors while re-entering data for record generating purposes. Other benefits include the reduction of paperwork, automatic generation of reports, faster data distribution due to automatic generation of reports, and increase in efficiency in the overall process, which translate into cost savings due to reduction of labor time.

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