Application Case Study of Mobile Computing to Decrease Paperwork at "Neighborhood Stabilization Program (NSP)" Construction Site

Dr. Tulio Sulbaran, University of Southern Mississippi

He received his Ph.D. in Civil Engineer from Georgia Institute of Technology with concentration in Construction Management with a minor in Computer Engineering and strong statistical background. He has over 8 years of work experience in the A/E/C (Architecture, Engineering, and Construction) industry with office and field experience in scheduling, estimating and project management in the United States and several international locations including: Venezuela, Singapore, Brunei, Malaysia and Thailand.

Dr. Sulbaran is an accomplished teacher and has taught a variety of construction courses including: Construction Planning and Scheduling, Construction Project Management, Cost Estimating I, Project Control, Proposal Preparation and Project Implementation among others. Dr. Sulbaran received the prestigious John Trimmer Award for Excellence in Teaching in 2010. Dr. Sulbaran engages students in learning activities inside and outside the classroom continuously advocating hands-on experience and collaborative learning. He has been in the forefront of on-line teaching and he was one of the pioneers in delivering online courses in the School of Construction. He established the Study Abroad Program in Panama at the University of Southern Mississippi. Dr. Sulbaran led the effort to establish the newly created Master of Science in Logistics, Trade and Transportation (MSLTT) and he is currently leading the effort to put the MS LTT fully on-line to further the educational reach of the University.

Dr. Sulbaran has being very fortunate to have the best externally funded projects track record of the School of Construction. He has submitted as PI/Co-PI over 100 proposals and has been awarded over 40 externally funded projects totaling over 10 million dollars coming to the University of Southern Mississippi. Additionally, he has been collaborator in multi-million multi institution proposals with institutions in the United States and abroad. Dr. Sulbaran has received funding from several organizations such as: The National Science Foundation, Mississippi Department of Transportation, Transportation Research Board, Northrop Grumman, Mississippi Development Authority, Army Corp of Engineers, and Department of Health and Human Services among others. Dr. Sulbaran founded the Center for Logistics, Trade and Transportation and all of his projects have supported and benefit from talented graduate and/or undergraduate students from a variety of academic units in the University.

Dr. Sulbaran has been very prolific in the area of scholarship and research. He has authored over 60 peer-reviewed national/international publications, written several books and made over 100 professional presentations nationally and internationally. Dr. Sulbaran's manuscripts have been published in: The International Journal of Technology, Knowledge and Society; The International Journal of Virtual Reality, Journal of Marketing Education, Marketing Education Review Journal, IEEE- Frontier in Education, American Society of Engineering Education Proceedings among others.

Dr. Sulbaran has contributed significantly to his discipline through his service activities. His leadership on several key organizations has reflected very favorably on the University. Dr. Sulbaran is the first and only faculty of the University to hold a Board of Trustee position in the American Council for Construction Education. He is also the first and only faculty serving as the Editor for the Associated Schools of Construction proceedings. Dr. Sulbaran has served in multiple university committees such as: I-TECH Customer Service Council, CoST Research Award Committee, CoST Scholarship Committee, and SoC Accreditation Committee, among others.

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Abstract

Compared to other industries, Construction is one of the slowest industries to benefit from information technology (IT) implementation. Some companies, especially small companies, still prefer paper-based operations over web-based. This can be contributed to several reasons such as costs of training, software and so on. One of the fields in which IT can be applied is Management Information Systems (MIS) for construction sites. The focus of this paper is to discuss a web-based system that can improve Management Information Systems by decreasing paper-based processes on construction sites. The paper is based on a case study of the XYZ Contractor Company. This company is one of the two companies that worked on "Neighborhood Stabilization Program (NSP)" that was established for the purpose of stabilizing communities that have suffered from foreclosures and abandonment. This paper also introduces a possible approach to include Mobile Computing in the classroom to prepare construction Management students to utilize this technology in the field.

Keywords: Construction, Mobile, Information Technology, Case Study

Introduction

Construction is one of the most information dependent industries. Significant amount of information is required in the construction industry to complete the projects. Information in the construction industry includes: detailed drawings, cost analysis sheets, budget reports, risk analysis charts, contract documents, among many others. This information is not only generated at the beginning of the project but during the complete project life cycle leading to the generation and exchange of enormous amount of information even for a small-size construction project. This information is also exchange among a significant number of project participants including owners, designers, and contractors, among others. Thus, information technology (IT) becomes a vital tool for managing information. Electronic management of information, through the use of IT, is the most effective way to generate and exchange information. It allows users/managers to store and retrieve information easily, gain faster, complete and accurate response, and be better informed of the relevant issues. However, the effective use of IT in the construction industry relies on the ability to exchange and share information among the project participants.

Purpose

The main purpose of this case study was to propose and test a web-based system that could be implemented using mobile phones to gather data digitally instead of manually on construction site to improve information management and decrease paper-based processes in the construction site of the Neighborhood stabilization Program (NSP). The Neighborhood Stabilization Program is a house rehabilitation project administrated by the Mississippi Development Authority (MDA) funded by the Department of Housing and Urban Development (HUD).

The Neighborhood Stabilization Program (NSP) project was conducted in Jackson, Mississippi and the owner of the contract and Project Manager were located at University of Southern Mississippi in Hattiesburg. As in most construction projects, it was important to access time

sensitive information. Therefore, this research was conducted to show how information management can be improved between the parties of the project.

Research Methodologies

It is important to highlight that the issue of applying mobile computing in the construction sites is very complex involving multiple variables in a unique blend of the slow moving construction industry and the fast pace information technology industry. This project did not intend to provide a comprehensive analysis of mobile computing for construction but rather present a proposed solution for a particular case study.

Case studies as a research method have been used for many years across a variety of disciplines Robert K. Yin defines case study research method as an empirical inquiry that investigates a contemporary phenomenon within its real-life context; when the boundaries between phenomenon and context are not clearly evident; and in which multiple sources of evidence are used [1]. It is important to acknowledge that one of the major drawbacks of the case study method is that establishing reliability or generality of findings is very challenging.

The five step for the case study methodology used in this project were as follows:

Step 1: Determine and Define the Research Questions

The first step in case study research was to establish the focus of the project. The established focus was to "propose and test a web-based system that could be implemented using mobile phones to gather data digitally instead of manually on construction site to improve information management and decrease paper-based processes in the construction site of the Neighborhood stabilization Program (NSP)".

Step 2: Select the Cases and Determine Data Gathering and Analysis Techniques

During the design phase of case study research, the researcher determined what approach to use. The decision was made to gather data from two sources: 1- Internet and 2-A single real-life case (to examine in depth) using a structured interview to collect the data from the project participants. The data to be collected was mainly to be qualitative and descriptive without internal/external validity and/or reliability test for the following:

- The case study was XYZ Company. XYZ Company was a construction contracting company located in Jackson, MS that was under contract with the University of Southern Mississippi Hattiesburg Campus.
- The project was the Neighborhood Stabilization Program (NSP) in Jackson, MS.
- The questions were about paper-based works in construction site.

Step 3: Prepare to Collect the Data

It was anticipated that this case study research was going to generate a large amount of data from the two sources identified. Therefore, a systematic organization of the data was important. Researchers prepared a simple but robust system to categorize and sort the data collected.

Step 4: Collect Data in the Field

The researcher collected the data from the two sources identified as follows:

- *Internet Search:* In this phase a literature review was conducted about application of mobile in construction site.
- *Interview:* In this phase a list of questions was prepared. The questions were about 'company's background information' (name and type of company, experience in construction management, company size, average number of employees, annual income of company) 'current status' (current method of on-site information gathering, type of paper based information that they gather, types of paper based information which are gathered) and 'expectations from Mobile application in construction site'. These questions were asked from project Manager of IDS NSP to investigate types of paper-based works which are used in IDS NSP construction site daily.

Step 5: Evaluate and Analyze the Data
The researcher examined and interpreted the data collected to address the focus of the project.

Literature Review
Traditional documentation in Construction
In the past and perhaps still prevalent in many construction companies, paper documents were filed in a cabinet. When a particular document was needed for work or editing, clerical staff would have to search for the document then fax, mail, or transport the document to the recipient. Figure 1 shows the traditional paper-based documentation process for construction projects.

Write Report (Paper Documents)   Locate File in Cabinet   Search File in Cabinet   Fax to Recipient   Read Report
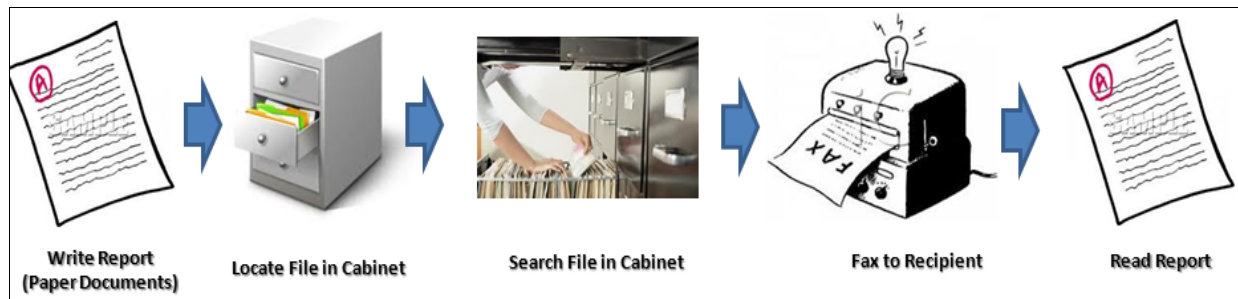
Figure 1: Traditional paper based documentation in Construction

The Evolving Use of the Internet in Construction
There have been three distinct stages of development for the use of information technology in the construction industry. The first phase occurred in the late 1970s. At that time, products were used to improve the efficiency of the manual processing of information at the operational level. The second phase of development saw the introduction of stand-alone packages in 1980s. The third phase of development began in the 1990s with the integration of stand-alone systems with strategic electronic platforms for real-time structured data exchange. The third phase facilitated supply chain relationships. The information that holds, manages, and uses data for a variety of management functions. The internet is the ideal vehicle to maintain these relationships [2].

Web-based documentation in Construction
Papers and documents can be converted into digital format for use by mobile computing devices at construction site. This would allow for a faster transfer of accurate data from document archive to end user. Figure 2 illustrates the flow of information, such as checklists, work orders, or change orders, from a construction site to a variety of users.
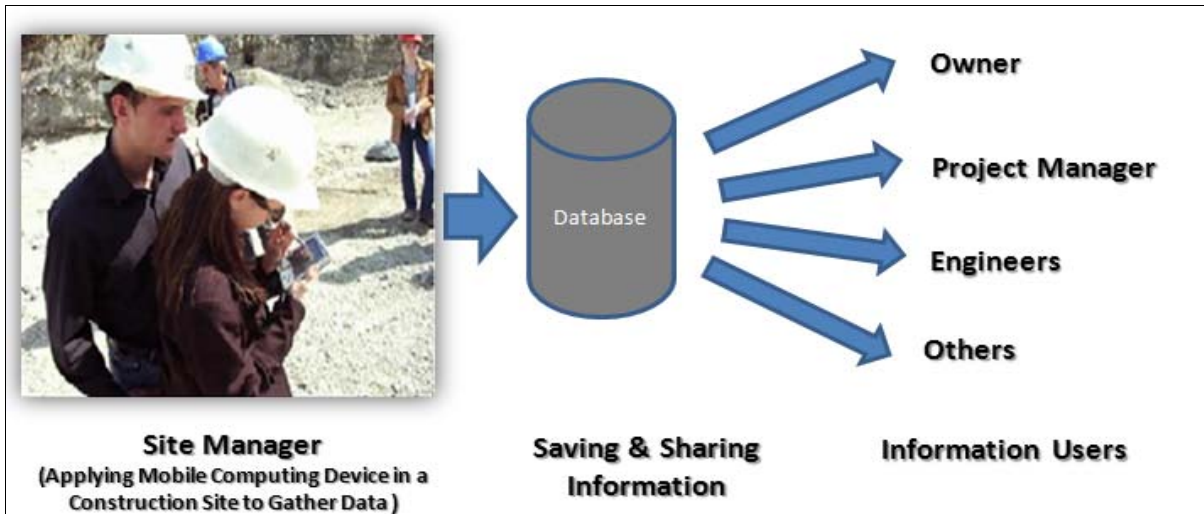
Figure 2: Web-based Information Management Flow

Mobile Computing devices in construction site

Mobile computing devices can be considered as important tools to decrease paper based works in construction sites. This section will list some of the computing devices that can be carried in construction sites.

IPhone: The iPhone can has a wide range of capabilities ranging from placing phone calls, browsing the internet, sending and receiving emails, and teleconferencing. The iPhone would be well suited for on-site personnel in the construction industry. The iPhone boasts an 8-megapixel iSight camera, which is of high digital quality. The 8-megapixel camera combined with the email capabilities would allow high resolution pictures to be viewed and sent. There are a wide variety of applications, or apps, available for download on the iPhone. Apps are available for purchase through the Microsoft Corporation and are frequently updated. The iPhone has the capability of opening a wide variety of documents to include: .jpg, .doc, .pdf, .ppt, .xls, etc. This means that users of the iPhone will have the capability of accessing all documents on-site. This prevents the need for personnel to seek out a computer to open important files [2]. A unique feature of the iPhone which would be of particular for communicating between on-site and office based personnel is the Face time capability of the phone. The Face time feature allows for digital teleconferencing on the go. In this way the iPhone would allow planners and managers to speak face to face with on-site personnel anywhere in the world as long as there is an available internet connection [7]. (See Figure 3)

Figure 3: iPhone 4 [5]

Blackberry: The blackberry is an adaptable smart phone for on-site personnel. The Blackberry is capable of internet access, sending and receiving email, and taking digital photographs. There are also a wide variety of existing applications for the construction field such as Constellation Homebuilding Systems, BuilderMT, ReportAway! ForFreshbooks, TeleNav Track, and Go Canvas.

Figure 4: Blackberry Smart Phone [7]

These apps are specific to the construction industry and provide a means of scheduling, cost tracking, monitoring quality production, and communicating with partners. Blackberries even have the capability of viewing on-site security cameras and viewing 3D CAD drawings. When all of these capabilities are combined, the Blackberry provides a high level of connectivity and cost mitigation for construction companies. Additionally, the solutions available from Blackberry can be integrated with existing located at the base of operations. These apps are available in an industry specific package through the Blackberry Company. The Blackberry Company provides solution packages for companies that will outfit anywhere from 1-250 employees. This allows the opportunity for companies to provide scalable smart phone services to their employees. Blackberry will work with customers to provide the right service for all situations. This would allow companies to adapt their smart phones services by project. The adaptability is the main advantage of utilizing the Blackberry smart phone for construction projects. [8] (See figure 4)

Android Platform: Samsung Smartphone operates on the android platform and is available in a variety of models. Top end Samsung models offer an 8-megapixel camera which provides high resolution photographs. They have the ability to browse the internet and send and receive emails. The android platform is Microsoft office compatible which means managers are able to utilize the smart phone without additional investment in software packages. Samsung smart

Figure 5: Samsung Smart Phone [10]

Phones are currently the top selling product in the global smart phone market. [9] Apart from internet connectivity the Samsung smart phones operating on the Android platform offer little

construction specific applications. The majority of apps available are for calculating items necessary for rafters, mulching, etc. While these apps are helpful to the actual laborer installing these items they do not offer connectivity for all parties responsible for a construction project. [10] (See Figure 5)

IPad and Tablets: There are a number of available tablets on the market that function as portable computers. These tablets have the ability to perform all of the functions of the previously discussed smart phones. The underlying difference in regular smart phones and their tablet counterparts is that tablets do not have the ability to place or receive phone calls without the use of third party software. Tablets would be a reliable method of replace laptop computers on construction sites but would have limited applications as a primary means of communication. (See Figure 6)

Figure 6: IPad [10]

Applications of Mobile in Construction Sites
On-site information management is vital for the success of construction projects. For instance, if a construction manager cannot access all pertinent information it could cause delays, increase costs, decrease labor utilization, and other potential problems [3].   Newton (1998) indicated that insufficient, inappropriate, or conflicting information contributes to 65% of contractors' reworks. Thus, improving information flow seems necessary, which can lead to easy monitoring, controlling, and accessing of project progress [4].
As shown in Figure 7, mobile devices can be very useful in collecting data from construction sites. Some examples of mobile applications in construction site are as following.

- ➤ **Web Search:** Conducting internet searches to locate required information quickly.
- ➤ **Digital photo:** Taking, saving and sending digital photos related to work progress or positioning of materials and equipment.
- ➤ **Drawings:** Review the digital drawings, details and instructions.
- ➤ **Manuals:** To review the manuals about methods of task completion, using equipment, etc.
- ➤ **Memos and notes:** Taking notes digitally
- ➤ **Checklist:** Fill out the forms and checklists digitally.
- ➤ **GPS:** Know the exact location equipment, workers, or status of earth work projects (cut/fill)
- ➤ **Contracts and specification**: To review contract roles and responsibilities on site.
- ➤ **Digital Films:** record digital films in construction site
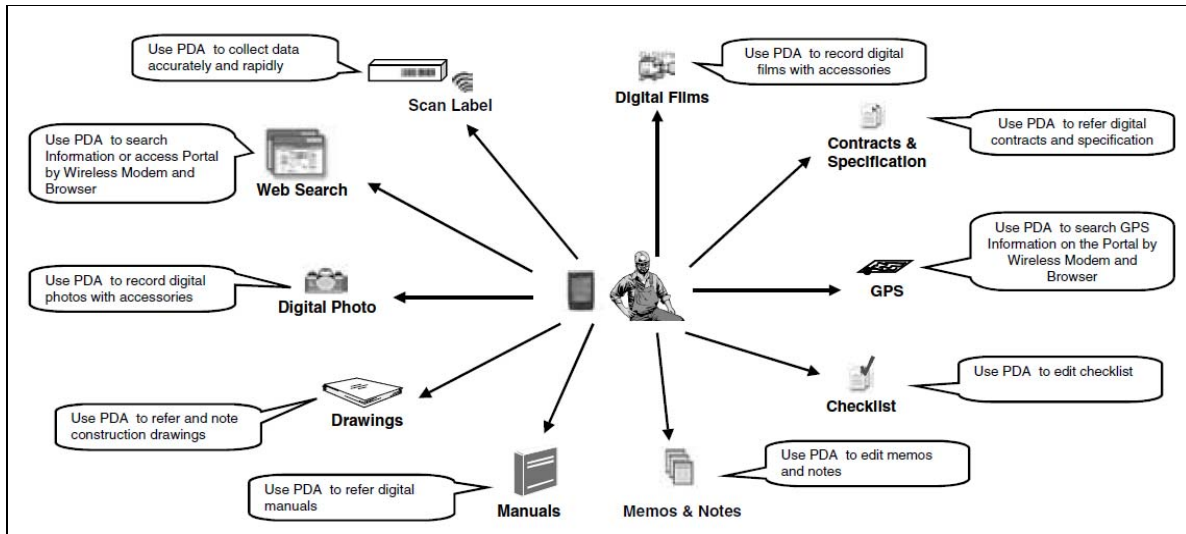- ➤ **Scan Label:** To gather data accurately and rapidly

Figure 7: Application of Mobile in Construction Sites [4]

Common Checklists and forms that are used in Construction site

As the Figure 7 showed, one of the applications of mobile in construction site is to fill out checklists and forms online (instead of manually) and making them accessible for Project Managers or parties. The checklist and forms which are used in any construction site can be categorized in the following fields:

1. Project Progress
2. Jobsite Record Keeping
3. Cost Management
4. Correspondence
5. Equipment Management
6. Material Management
7. Human Resource Management
8. Requests for Information
9. Contract Drawings
10. Safety
11. Quality Control Report

Case Study Results and Results Impacts

Neighborhood Stabilization Program (NSP) was established for the purpose of stabilizing communities that have suffered from foreclosures and abandonment. The program was created by the US department of Housing and Urban development (HUD). In order to start the project in Jackson, MS, University of Southern Mississippi proposed a grant to fund the entire project. The main contractor of the program is XYZ Company which is considered as a case study.

To achieve the objective of study, an interview with NSP project manager was conducted. During the interview, he was asked about the different paper-based activities and documents that were used on the construction site.

The interview was divided to four parts; background information, current status, expectations and barriers. The following describes the results.

Background information

The following lists responses related to Company's Background information:

- Name: XYZ
- Type of company: Contractor
- Experience in construction management: 5-9 years
- Company Size: Small
- Average employees per job: Less than10
- Average annual income of company: between $ 0.5-1 million

Current Status

The following lists the current status of XYZ Company about information gathering in construction site.

- Current Method of on-site information gathering in this company is paper-based.
- Type of paper based information that gathers is paper-based.
- Types of paper based information which are gathered are Project Progress, Safety Reports, Material Reports, Equipment Reports and Documentation of Reports.

Expectations about Mobile application in construction site

The following lists Expectations about Mobile application in construction site.

- ➢ Project Manager thinks that between computing devices such as I-Pad, I-Phone, Black Berry, PDA and Android the former (I-Phone) is more convenient for gathering data.
- ➢ The project manager prefers information such as Project Progress, Cost reports and Documentation of reports can be gathered internet based.

Barriers of using computing devices in construction site

The following lists barriers of using computing devices in construction site.

- ➢ The main barriers that Project Manager believed that is against the using web-based system for small companies such as M&P is complexity of software products to use and primary cost to buy.

The results cleared four aspects for converting paper-based to the web-based system:

1. Type of paper based works which were used by a small contractor company in a construction site should be converted to digital format.
2. Preferable type of mobile computing device in conducting web-based system that can handle requirements a small company for purpose of decreasing paper based works. As the result showed, the preferable type of hardware was I-phone.
3. Barriers against the web-based system such as cost and complexity of software products.
4. These three aspects were used for selecting the proper type of software which can be used by mobile phone in construction site. For this purpose, two products of Microsoft SharePoint and Google Drive were considered. Between these two, Google Drive met the investigated aspects more than Microsoft SharePoint. The reason is that Google Drive is a free online product (it is accessible for the people who have a Google account) and easy to use. On the contrary, Microsoft SharePoint is not free and is complex to use.

Mobile Computing in the Classroom

A significant number of professors in engineering lecture to a passive group of student [12] and traditional construction education is based on precise well-defined problems and formal definitions [13]. These classroom facts among many other facts make it very difficult for construction education to stay current and/or ahead of technological advances. However, as it was presented in this paper, there is currently a wealth of available mobile computing advances that could be immediately implemented in the field and in the classroom. Perhaps, faculty in construction courses such as: Estimating, Scheduling, Project Management, Safety among others could introduce the use of mobile computing in their classes to conduct task that traditionally are performed in paper based format. Table 1 below presents some example of activities that could be included in the classes to promote the use of mobile technology.

Table 1. Sample Construction Class and Example of Mobile Computing Activity

Sample Construction Class	Example of Mobile Computing Activity
Estimating	Instruct the student to prepare a quantity take-off spreadsheet of a simple building on campus. Then during few consecutive weeks, tell the students to document the simulated construction progress by measuring quantities, entering in the spreadsheet through their mobile devices, taking pictures embedding them in the spreadsheet and submitting from the mobile device to the professor as weekly construction progress.
Scheduling	Request student to use their mobile devices to access an online scheduling software such as Primavera/Oracle P6 v8 and document percentage complete of a simulated project
Project Management	Asked students to upload to their mobile devices a series of documents related to a simulated project such as specifications, contracts, schedule, cost estimate, sub-contractors, vendors, etc. Then each week simulate a situation where the students must access the information in their mobile devices and take the proper action.
Safety	Present the students with a mock-up scenario of a construction site violation with written description of the situation and pictures showing the unsafe practice. Then, tell the students to document the situation using their mobile devices and act according to OSHA standards.

Summary

The study reviewed the traditional documentation, evolving use of internet, and web-based documentation in the construction industry. Furthermore, some types of mobile computing devices were introduced. Since aim of this study was to investigate how paper based works can be decreased in Neighborhood stabilization program (NSP)'s construction site, an interview with project manager was conducted. The results of interview investigated required information that was necessary for converting paper based system to the web-based. Based on interview results, i-Phone as the hardware and Google Drive as software were selected.

Recommendations

The next step will be creating the digital forms in Google Drive and testing in a real environment to identify weaknesses and enablers.

Furthermore, in the next studies, other applications of Google Drive can be considered in improving management information system in construction.

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Appendix

Features of Google Drive

Google Drive is one of the newest online software products. In fact, Google Drive is the new version of Google Doc which already was installed on Gmail. The following list some features of this software.

- ➢ A powerful online software products
- ➢ Free access up to 5 GB for all users of Gmail service.
- ➢ In Google Drive, users can create or upload the documents, forms, drawing, Presentation and Spreadsheets.
- ➢ In Google Drive, users can work together at the same time with other team members on the same documents and see the changes that appear.
- ➢ Google Drive removes the need for sending bulky email attachments.
- ➢ By Google Drive, user can share files from a variety of applications (apps) directly.
- ➢ By Google Drive you can share files or folders with anyone that has a Gmail account.
- ➢ In Google Drive, user can define whether uploaded files can be viewed, edited, commented by another person or not.
- ➢ Comments can be replied and get feedback. This makes the file more collaborative.
- ➢ In Google Drive, text and objectives can be recognized in Scans and Images respectively.

This software provides a single infrastructure to upload and share digital forms, checklists, spreadsheets, drawings, schedules and other items that can decrease the paper-based activities on construction sites. This allows for better coordination and collaboration between on-site personnel and off-site managers. In other words, the paper- based forms can be converted into digital forms and used on construction sites by mobile computing devices. Then the Site Manager, Project Manager, and other parties with a mobile computing device such as iPhone can access these forms. In this scenario, the Site Manager can fill out the digital forms online (instead of current paper-based efforts) and other parties, such as Project Manager, can have access to the reports and information without delay.

User Guideline

The following lists steps for a user to use one of the Google Drive applications.

1. Go to www.google.com.
2. Go to Gmail.
3. Import User Name and Password.
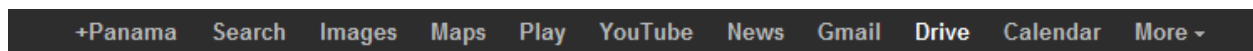3. Select "Drive" icon from black tool bar on the top of screen (See Figure 8).

Figure 8: Black tool bar on the top of screen

4. Click on "CREAT". A window will open that you can select the type of document you need create or uploaded such as Document, Presentation, Spreadsheet, Form, Drawing (See Figure 9).

Figure 9: Google Drive on I-Phone

If you choose "More", you will have access to more applications such as Auto CAD WS, Floor Planner and so on.

5. After opening one of the documents, you can select the team members that document should be shared with them. This will be possible by clicking on "Share" icon on the top right side of screen (See Figure 10).

Figure 10: Some Google Drive Applications that can be used in construction site