5th International/11th Construction Specialty Conference
5e International/11e Conférence spécialisée sur la construction

Vancouver, British Columbia
June 8 to June 10, 2015 / *8 juin au 10 juin 2015*

PROGRESS TRACKING OF MULTIPLE PROJECTS USING EMAIL AND VOICE

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Abstract: This paper introduces a framework developed to automatically track the daily progress details of multiple small/medium construction projects, simultaneously. The framework has been designed with several features: Geographic Information System (GIS); cloud-based email/IVR services; activity-initiated communication to relevant supervisors; flexible user-revised email/IVR surveys; multi-project status reporting; and input/output to Microsoft Project scheduling software. The paper discusses the components of the proposed framework and comments on the performance of a prototype system on multiple simultaneous projects. A case study was used to demonstrate the usefulness of the timely collected data to improve the visualization of progress status and schedule updates, as well as project control decisions. The system can also collect data about the worker-related factors (e.g., morale) on projects. The developed framework supports efficient management of multiple projects for small/medium contractors. The proposed framework facilitates efficient communication between site and head office, to help construction companies work more cost effectively within the competitive business of construction.

1 INTRODUCTION

Timely and efficient progress tracking is a key issue for project payments, early warnings, and corrective action planning. One of the biggest challenges facing construction managers is to keep track of all actions that take place on site in order to detect potential problems and to select appropriate corrective actions. Progress tracking is even much more challenging in the case of managing multiple projects, which is a common case in construction where small/medium companies get involved in many jobs at the same time. Because progress information of each project are scattered in many formats like daily site reports, minutes of meetings, and correspondences, schedule updates are often problematic and the management of multiple projects can become a nightmare, ending with delays, cost overruns, and lost business.

While the Construction Industry includes many large companies, statistics indicate that over two-thirds of construction firms in the United States have less than five employees (Halpin 2006). The majority of these small firms are specialty subcontractors working with the general contractor. For those small players, the simultaneous management of multiple projects is an everyday situation. As reported in the literature, up to 90% by value of all projects occur in the multi-project context (Payne 1995). Generally, these projects are small and do not, therefore, have the luxury of dedicated resources, but must share at least some resources with other projects.

Commercial scheduling tools can help planners produce realistic baseline schedules that are suitable for planning purposes (Gould 2005). Due to rapid growth in Information Technology (IT) (Chen and Romano 2003), many systems have recently incorporated high level of communication and collaboration tools.

Because 25% to 30% of total project work is always spent on communication and collaboration (Helbrough 1995), the surge in IT-related features undoubtedly brings great benefits to the management of projects. On the other hand, however, the core scheduling, tracking, and control functions of commercial software remained mostly unchanged over the past four decades. For example, existing software tools still do not have functions for time-cost trade-off analysis, automated tracking, or schedule optimization.

While the management of individual projects is difficult, it's even much more complicated in the case of multiple ongoing projects (Dooley et al. 2005). Commercial project management tools are not efficient to handle multiple projects, particularly when it comes to project control (Evaristo and Fenema 1999). Despite the high rate of utilization in the industry, research on the management of multiple projects is also very limited (Patanakul and Milosevic 2009). Recent work (e.g., Besikci et al. 2015) focuses on optimizing the planning and resource management before construction, and none focuses on progress tracking and control.

Among the key challenges in project control for individual and multiple projects is the inability to track and utilize sufficient progress details in an easy manner. Currently, schedules represent progress in terms of activities' actual start and finish times, and percentage complete, while keeping the important intermediate events (slow progress, rework, acceleration, etc.) hidden in other correspondences, daily site reports, or other paper-based documents. Thus, the low level of detail in progress tracking is considered inadequate to support corrective actions or the analysis of project delays (Hegazy and Menesi 2012). Without the mid-activity events of various parties recorded on the as-built schedule, forensic analysis of project delays becomes a complex task of sifting through mountains of scattered information and then trying to understand, a long time after the fact, how the progress events affected the schedule.

To enhance current project control for multiple projects, this paper proposes a new progress-tracking framework that has three key functions: (1) improved As-Built data representation; (2) user-defined system for email and voice tracking of progress and for verifying the quality of the progress data obtained; and (3) a visual reporting system to facilitate schedule analysis and corrective action planning. Each of these is discussed in the following sections.

2 AS-BUILT DOCUMENTATION ON THE SCHEDULE

As-built documentation has mainly been a manual process that is time-consuming and error-prone (Trupp et al. 2004), thus contributing to misunderstandings, incorrect assessment of project performance, and lack of early warnings. To facilitate project control decisions, enough details are required on how the progress events of all parties have evolved. Traditionally, the activities in existing commercial scheduling software, such as MS Project and Primavera, are represented as blocks of time (Left part of Figure 1). This representation, however, does not show the mid-activity events made by the various parties. As opposed to this representation, Hegazy and Menesi (2010) presented a rich representation of mid-activity events, called Critical Path Segments (CPS), as shown in Figure 1. In the figure, activity durations are divided into daily segments that can hold progress amount or other events made by any party on the specific timing of that segment, in addition to notes, hyperlinks to related documents, and explanations. Recording (or averaging) the progress percentage on the daily segments clearly conveys information related to speed of construction (actual vs. planned) and the evolution of events, not just the final status of each activity. The daily segments also can represent the events that are caused by the owner "O", the contractor "C", and/or neither "N" (e.g., weather). Rework amount is also represented as a negative percentage complete recorded on the relevant time segment. Such a generic activity representation clearly shows the evolution of all as-built events and allows a more granular level of detail at the segment level, which is general enough to facilitate corrective actions and schedule analysis. Due to its rich visualization and its usefulness for project control, the CPS representation has been used in this paper.

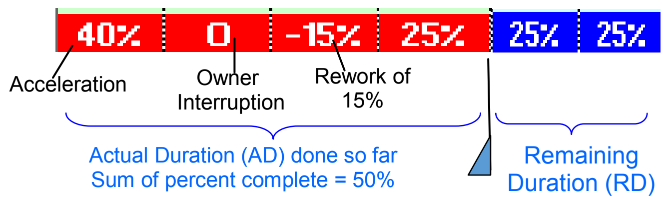
	Representation
Traditional (% complete = 50%)	Activity is a continuous bar of a given duration with no intermediate details 
<u>CPS:</u> <u>Mid activity events:</u> Interruption by owner = “O” Interruption by Contractor = “C” Neither (e.g., weather) = “N” Acceleration = high progress value Slow progress = low progress value Rework = negative progress value	Activity is a chain of separate daily time segments that show the timing of intermediate events 

Figure 1: Traditional versus CPS representation of progress events

3 FRAMEWORK FOR MULTI-PROJECT PROGRESS TRACKING

Since the daily CPS details may require a large effort to manually collect data from site, this paper automates the data collection process using low-cost email and interactive voice response (IVR) tools. In the literature, many researchers examined different information technology tools for site data collection (e.g., Trupp et al. 2004; McCullouch 1997; Liu 2000; Egbu and Boterill 2002; and El-Omari and O. Moselhi 2009). Among these tools, email and voice-based systems have rapidly grown over the years as technology advances fast. Recently, the use of voice has matured and has incorporated advanced features such as voice recognition and voice commands (Sunkpho and Garret 2000; and Reinhardt and Scherer 2000). Previous work by the authors (Hegazy and Abdel-Monem 2012) used email and Interactive Voice Response (IVR) to automatically collect as-built progress details for single projects, which is extended in this paper for multiple projects.
In order to track the progress of multiple projects simultaneously, the proposed framework integrates several components (as shown in Figure 2): progress database; Geographic Information System (GIS); dynamic survey creation; communication tools; visual location tracking; and reporting for single/multiple projects. These are as follows:

1. Database: at the core of the framework is a relational Microsoft Access database that includes information about projects (location, start date, finish date, etc.), company accounts (email address, IVR account, etc.), personnel (Supervisors’ emails and phones as well as the contacts of the person(s) responsible for answering any requests for information), activities’ daily tracking details (progress percentage, delay reasons, quality control issues, photos, attachments, etc.), and activities’ digital drawing files;
2. Geographic Information System (GIS): GIS has been incorporated so that all projects can be represented visually on a map system. such visual representation facilitates the management and tracking;

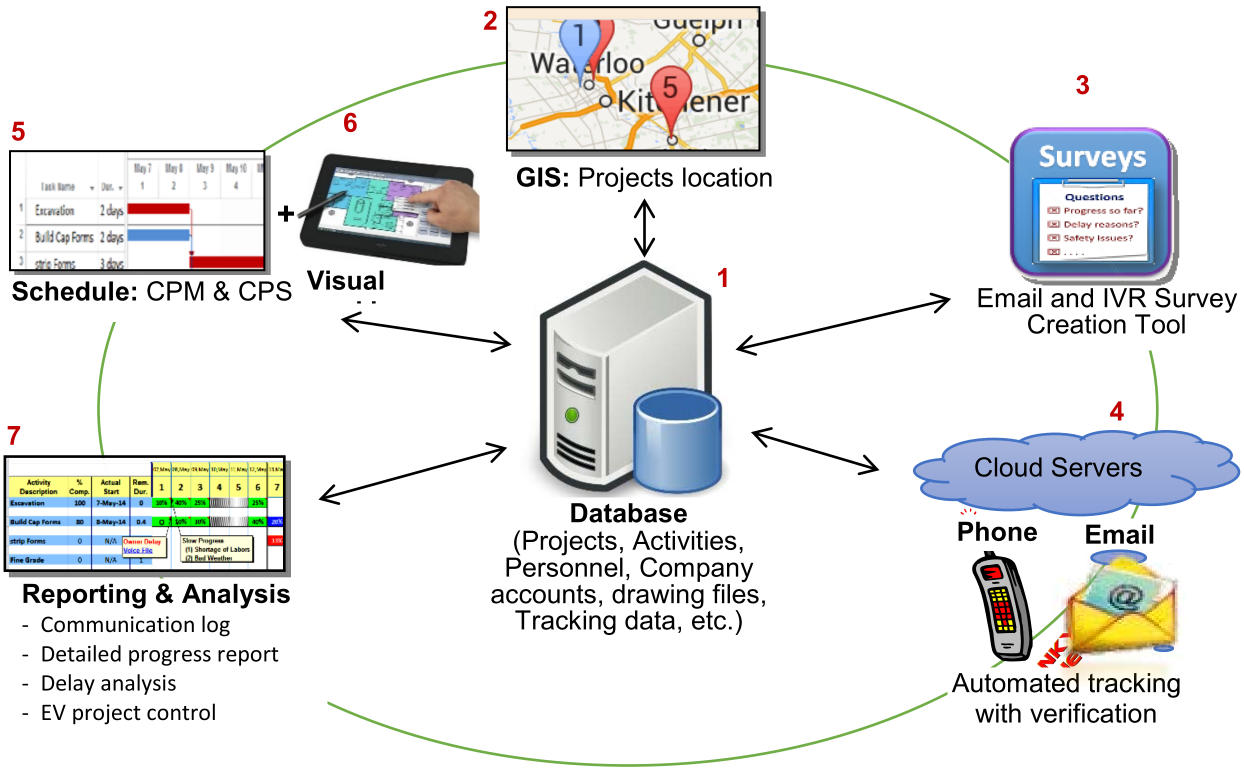


Figure 2: Multi-Project Progress-Tracking Framework

3. Survey Creation Tool: To collect progress details or any type of information, a survey creation tool (Figure 3) was developed to allow the user to easily customize pre-set questions an email or a voice (phone) survey. Survey questions are of two categories: typical progress queries (progress amount; events by different parties and their reasons; quality control/safety issues; and request for information); and other generic questions to be used for custom surveys (e.g., Yes/No; Multiple choice; and Comment message).

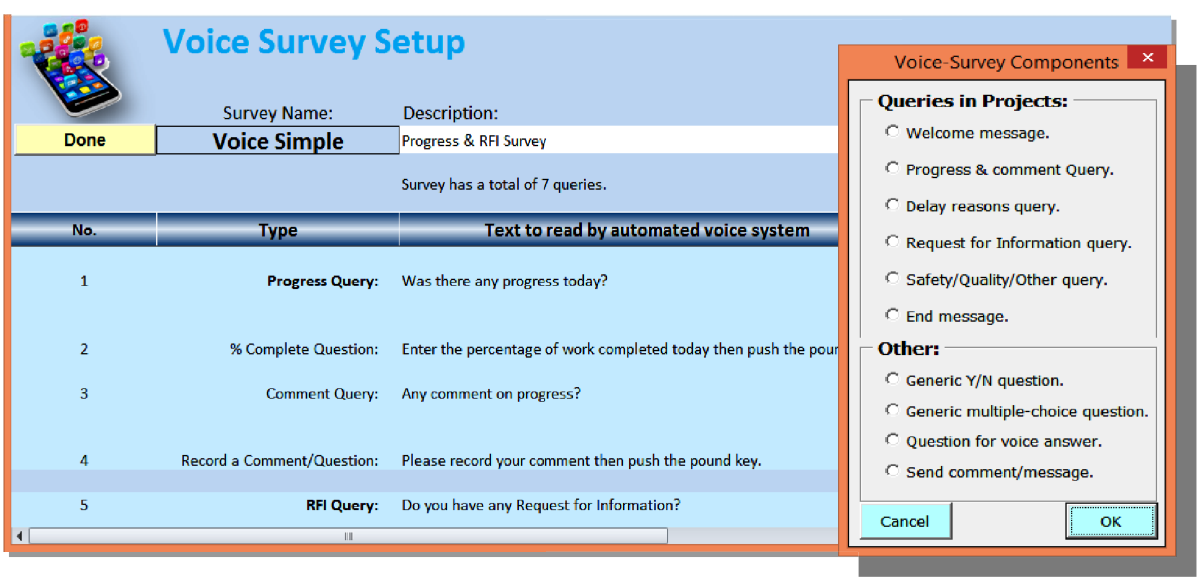


Figure 3: Add/Edit Interactive Voice Response (IVR) Survey.

The resulting custom IVR or email survey is dynamic in the sense that the sequence of questions is changed depending on the user's answer to a previous question (e.g., progress or delay). The customized surveys are saved in the system as templates to be used for tracking any project;

4. Communication tools: An IVR Cloud-Service, Ifbyphone server (ifbyphone 2012), is used to collect progress details by phone from multiple participants simultaneously, according to a selected IVR survey form. It has high quality voice, unlimited parallel calls, customizability, and flexible send/receive features. For email, Jotform cloud server (Jotform 2014) is used to send emails to multiple supervisors, according to any selected email form;
5. Scheduling tool: Microsoft Project scheduling tool has been used to prepare projects for progress tracking, including the activities, relationships, and costs;
6. Work location visualization tool: In addition to IVR and email communications, better visualization of progress location on related drawing files enables project managers to better visualize the evolution of progress. In the proposed framework, the activity is first associated with an appropriate CAD or image file that refers to the location of that activity. This file is always attached to the email survey form for progress tracking to allow supervisors to indicate the elements that have been completed to date and to record pictures, sound, etc.; and
7. Custom reporting tool: provides a log of all communications, an updated schedule, CPS progress report, and overall summary of projects' progress.

4 PROTOTYPE AND CASE STUDY APPLICATION

The developed system has been applied to a simple case study to track five projects simultaneously. The progress tracking process is shown in Figure 4. The main interface (top of Figure 4) shows the list of projects, the GIS map, and the setup options for company, projects, personnel, and surveys. The automated tracking process starts by the system identifying the running projects and the eligible activities for progress tracking. It then identifies their relevant supervisors and the predefined survey forms. The data collection process is all cloud-based to retrieve supervisor responses, verify responses, and update the schedule.

Project setup can be done through importing projects and all related information from MS Project as well as edit/add the date and time for progress tracking. Personnel can be added to the company personnel list of the supervisors who will respond to progress information requests and the persons who will respond to any request for information (RFIs).

To demonstrate the automated progress tracking process. Project 1 activities are used as an example. The project is expected to take 16 working days (22 days including weekends), starting from May 7th, 2014 and finish on May 28th, 2014. The developed system enables project activities to automatically request progress from their relevant supervisors, and all received information will be legibly visualized on the daily segments for each activity. The as-built tracking, as it applies to Project 1 summarized in Figure 4. Detailed step-by step process is as follows:

Identify Progressing Projects: for each project, the system checks tracking date, tracking time, project % complete, project start and project finish. If current date is larger than or equal tracking date then check if the project's percentage complete is less than 100% then starting progress tracking process for that project.**Identify progressing activities:** for each of progressing project (e.g., Project 1 in this case study) the process starts by automatically identifying the activities that are planned to start (their predecessors are completed), or continuing on the current progress date. In the case study, activities 1 and 2 are the ones to start on the first day of the project;

Identify progressing activities: For each progressing project (e.g., Project 1 in this case study), the system automatically identify the activities that are planned to start (their predecessors are completed) or continuing on the current progress date. In the case study, activities 1 and 2 of project 1 were planned to start on the first day of the project;

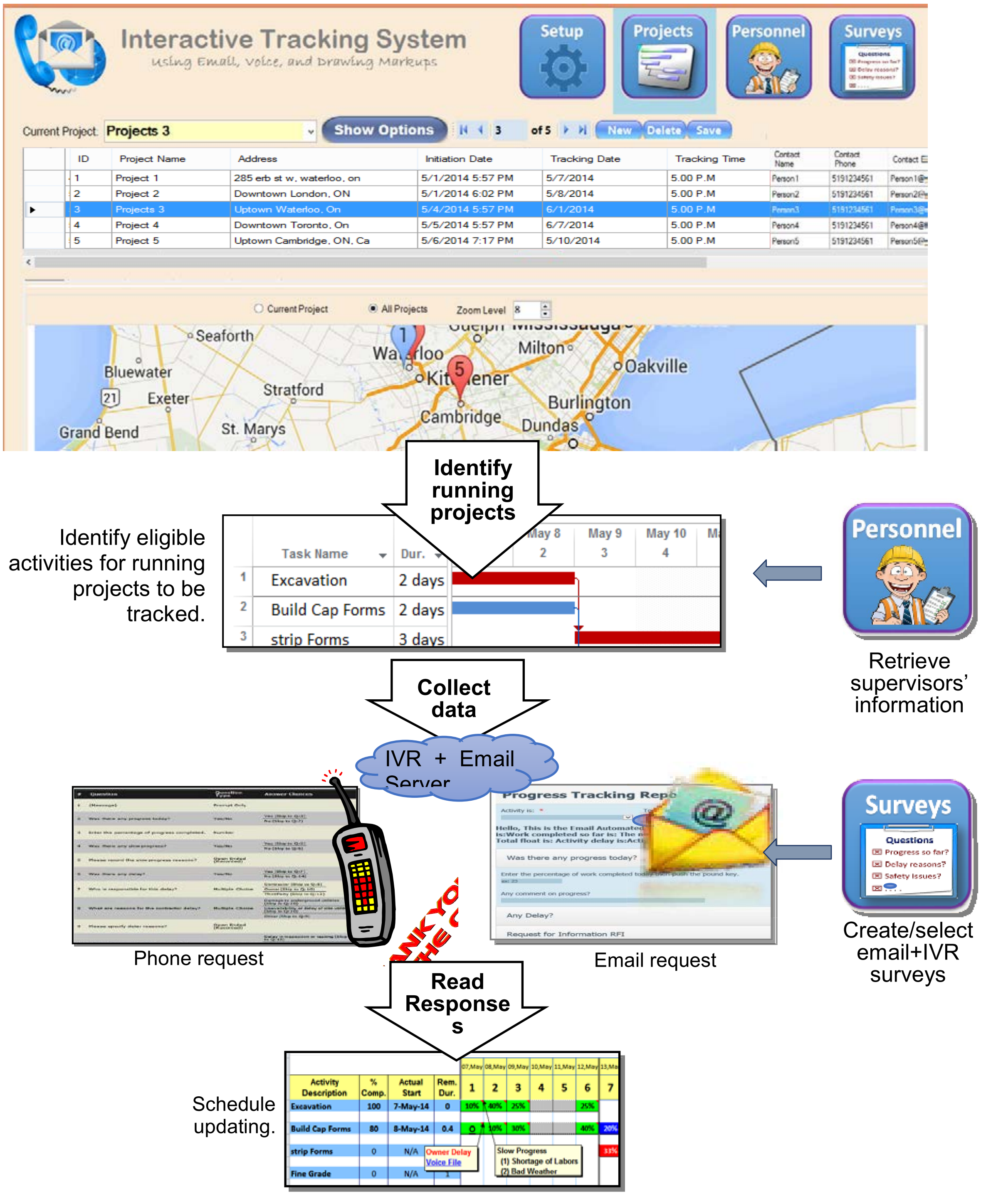


Figure 4: Multi-project progress tracking process

Retrieve the communication list and IVR/email surveys: Upon identifying the eligible activities, the system retrieves the pre-defined project communication list (middle columns of Figure 5) and loads the supervisor's contacts, email surveys, the index number to the related IVR surveys, and visual files of the current eligible activities;

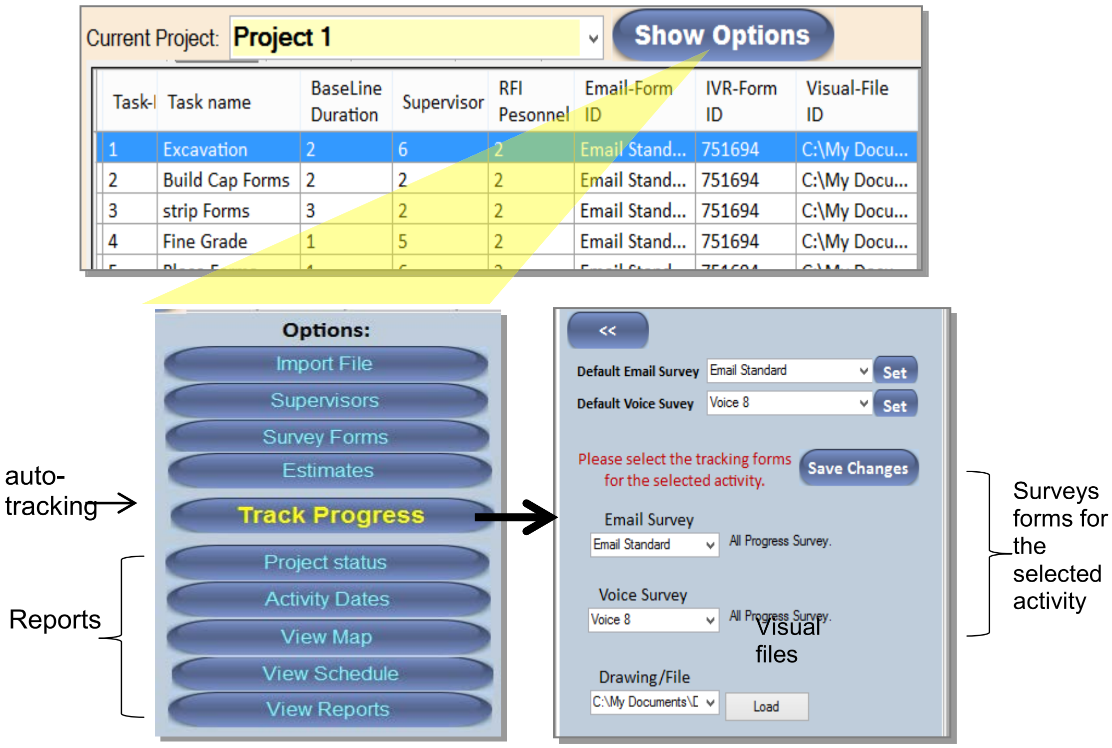


Figure 5: Assign IVR/email surveys, and visual files

Send Email/IVR progress request: In this step, according to the preset preference of each supervisor, the system automatically sends an email or a request to the IVR cloud-based service to initiates phone calls to the selected supervisors;

Read responses: Once the supervisor(s) reply to the phone calls or email requests, their responses, and any attachments, are collected by the cloud-based service and email system, which send these responses as email files to the project email account. The system then loads the latest email responses, saves the information into the project database along with other documents such as voice notes;

Update project information: Upon reading the new as-built information, the system updates the project schedule and saves all site events related to each activity, with any attached file(s) in the log of communications. In addition, two important reports are generated: an automated update to the MS Project file of the project with the cumulative percentage complete for each activity adjusted according to latest information; and a detailed CPS report of the schedule with the evolution of all as-built events, with all details shown as comments on their associated activities days. All visual files received with supervisor comments show the progress evolution for each activity. Such visual progress reports greatly facilitate understanding progress details, and facilitate decision makers' decisions. An example of a multi-project status update is shown in Figure 6 with the detailed CPS report of a sample project. The summery status of each project is also shown with color-coding to highlight the projects that have issues or require user attention; and

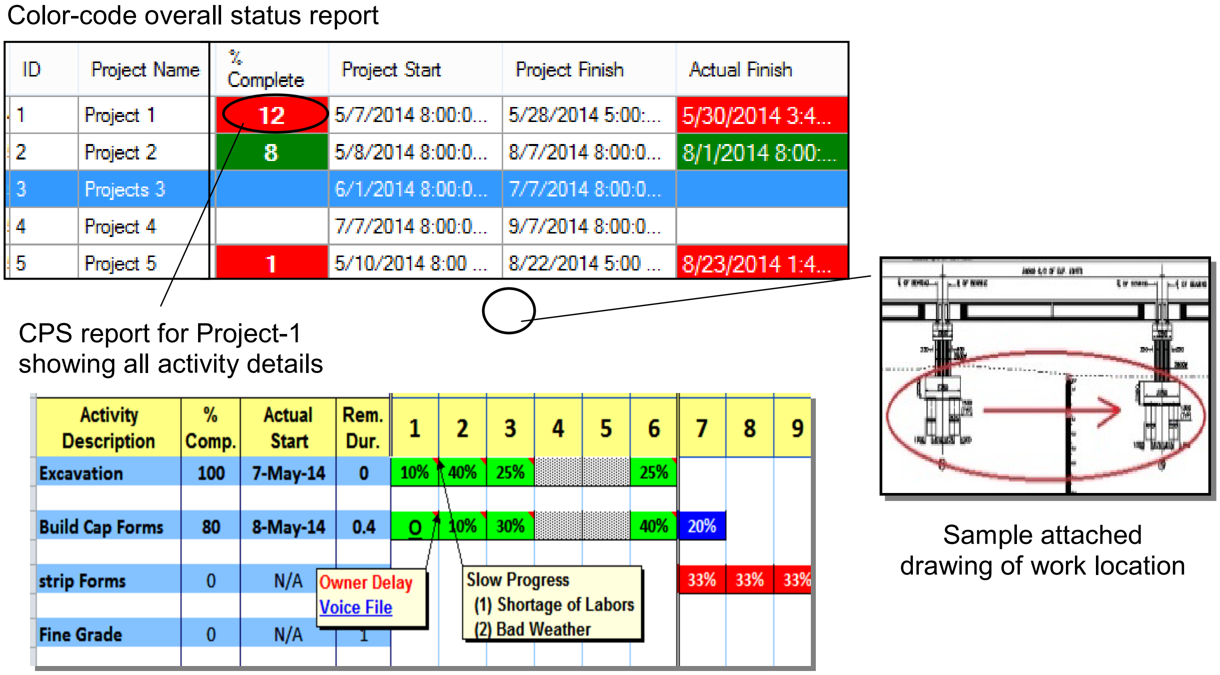


Figure 6: Sample multi-project status reports

Respond to RFIs: After updating the project schedule with received information, the system automatically checks if there are any requests for information (RFI), quality control issues, or safety issues. Accordingly, the system automatically forwards the RFI emails/voice message to the responsible person's email/phone predefined in the communication list. The answer to this RFI is then sent back automatically to the initiating supervisor.

5 CONCLUDING REMARKS

This paper proposed enhancements to the visual representation of a schedule, using time segments, to efficiently use the schedule as a decision support tool for project control. The proposed representation is coupled with an automated framework to legibly document full as-built events of multiple simultaneous projects directly on the schedule. The framework can accurately document all daily as-built detail using email and Interactive-Voice-Response (IVR) technologies. In addition, it allows supervisors to mark the elements accomplished for each activity, along with their location on digital plans. The visual progress files indicate the evolution of the progress of the activities, which helps project participants easily form a complete picture of the finished work to date. All the as-built details are thus saved automatically in a communication log and are attached to the relevant daily segments for each activity. The system has been uniquely designed for bidirectional voice/Email communication. It allows activity supervisors to initiate calls/Emails for progress updates; and allows eligible activities on the office server to automatically initiate contacts. In addition, the system automatically communicates any requests for information, and their responses, to the appropriate parties. The system's flexible feature of allowing custom site surveys to be generated and communicated using email and IVR are currently being utilized to collect a new layer of site information related to workers' stress level and morale. This information can be used to forecast realistic estimates of project completion time and cost, and can trigger warning signs. A prototype system has been applied to a simple case study to demonstrate its benefits. The paper contributes to improving multi-project tracking and control through enhanced bidirectional communication between site and head office to help construction firms collect timely and accurate as-built information for decision making.

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