Applying Mobile Technology to Data Collection for Environmental Characterization and Remediation, Beyond the Science – 15453

Kim Arrant, John Hackett
CB&I

ABSTRACT

The rapid advancements of our time bring us new methods of analysis that enhance the accuracy and sensitivity of measurement, improving the science used to solve problems and meet our objectives. What is often overlooked in our industry are the technology advancements that can dramatically improve the speed, accuracy and completeness by which those data can be collected, communicated, managed and reported. In addition, in the time used to generate and collect the analytical data, the technology collects, manages and reports other process data that can be used to better manage and facilitate our business process improving efficiency and communications as well as providing the information needed to track and manage cost and schedule. Good information management practices, including the use of innovative technology solutions like mobile data collection, are the drivers for project implementation. However, experience has highlighted key success factors that will maximize the level of success and benefit realized by the project. These factors include:

- A comprehensive, working knowledge of operational objectives;
- Detailed, documented process and data workflows;
- Effective technology selection and/or development (right tool for the job);
- Complete integration of the technology into day to day work practice accomplished through effective training and implementation planning.

Once this formula is in place, and executed consistently, it can be applied to any environmental investigation and/or remediation scenario. The proof is in the calculated return on investment and captured lessons learned for each project.

INTRODUCTION

With every day that passes, the impact information technology has on our day to day lives grows more and more significant. The interesting thing is that influence spans both our personal and professional lives, especially the science of mobile computing. The concept of mobile technology, whether it be accessing information, collecting information, or the devices and applications that enable it, become more accessible every day. It's becoming a way of life that one can no longer relegate to the "gadget freaks" or "technogeeks." We are exposed to the benefits in the simple things like finding our way to a new restaurant or checking the weather forecast when contemplating a walk. So how might we benefit when we walk onto the job site?

DESCRIPTION

CB&I has realized the true value of good information management in the execution of environmental characterization and remediation projects. While the project scope and objectives may be unique to a specific project or problem to be addressed or question to be answered, what all projects have in common is the need to collect significant amounts of data that can then be analyzed, evaluated, modeled, trended, and generally synthesized to inform the project objectives and bring the project team to the necessary

decisions and conclusions. While science brings us the analytical process, instrumentation, data evaluation tools and equations, information technology and good information management practices can provide us the means and methods necessary to capture, communicate, analyze and evaluate, and simply manage large amounts of usable data in an efficient, consistent and real time manner.

In collecting and working with data, it is important to ensure consistency in how it is generated. This is why very specific analytical methods are developed, documented and regulated. This drives consistency and continuity to how the analytical result is obtained, and it provides a level of confidence that it represents a specific condition for evaluation and action. Similarly, the methods used for capturing , organizing, storing and reporting those data points must drive standards and consistency to ensure the quality and accuracy of its use as well as maximize its availability to inform and support multiple objectives, maximizing its use and value to the project.

How does one ensure consistency and efficiency in the data collection, management and reporting process? What are the key elements in developing and implementing an approach that will drive these requirements?

Understanding the Requirements

The first and most important step in this process is to review the scope of the project or targeted task from the standpoint of the data that will need to be collected to meet the identified objectives and successfully satisfy the scope of work. This review should encompass all data/information needs including:

- What information/data are required to complete the necessary scientific evaluations and make necessary decisions in execution;
- End user/ customer required formats and methods for presenting and reporting various types data/information;
- All data sources, how they will be generated and the systems to be supported (inputs and outputs), and;
- How execution of the work will be operationally tracked and managed.

As a part of this review process, key stakeholders from the project team are identified to represent project operations. The stakeholders should be interviewed as an element of the initial requirements gathering effort as they bring a practical perspective of execution and actual field implementation needs and constraints to the review process. The stakeholders and their “buy in” are critical to drive consistent use and compliance in the field of the data collection tools and procedures developed and implemented.
A successful requirements gathering effort will facilitate and document a thorough and consistent working knowledge of the project objectives, data/information requirements, and the data and work flows of the process to be implemented.

Mapping the Process

It’s important to note that the process mapped to support these activities should not only provide direction and instruction as to how the procedure is to be executed, but will also indicate the data required and collected at each step. It should answer the “who, what, where, when and how” of the data collection aspect of the process.

Who will collect or capture the data? All data collection tasks and database solutions should have a clearly identified and communicated “owner.” The owner is responsible for the quality and accuracy of the data collected, as well as compliance with all data generation and collection methods employed.

What data are to be collected? The requirements evaluation will render a list of required data and information. The mapping of the process will indicate to the project team and define for the data owner at what step in the process those data are generated and captured.

When, or at what point in process execution are data collected? The process diagram should indicate very clearly the data to be collected with each step or activity of the procedure.

Where and how are the data to be input or remit to the system and using what application and device? The mapped data flow will indicate where and how the data are to be captured and any next steps, decisions or logical that must be executed or applied based on those results.

Tool Selection or Development

The requirements documentation, including the mapped process, provides the specifications against which the software and hardware technology solution analysis and selection will be evaluated and decided. Whether going to an off the shelf solution, or developing your own application, the requirements documentation serve as the documentation of what is needed. It is very important to keep in mind that a software application should never drive your requirements or business process, but rather should facilitate the requirements and process identified.

The Value of Mobile Computing

The next question to be answered is whether or not the process being supported or some portion thereof allows for, or would benefit from, mobile implementation. However, one must ask, do field conditions support the use of mobile devices? Do the project objectives include requirements for quick access to information or real time decision making? More often than not, the answer is "Yes."

Mobile data collection offers a number of functional advantages over the use of paper forms. Some of the benefits include:

- **Near real-time access and faster reporting**. Mobile data solutions save valuable time by eliminating the delays and cost of capturing data in writing, on paper, and completing separate data entry tasks later in the day or even shipping paper to offsite locations for data entry. These data entry efforts can be impaired by poor penmanship and form condition.
- **Better accuracy.** The use of mobile solutions can improve the accuracy of the data in a number of ways. One of the greatest advantages is that data can be collected and checked real time. Controls can be placed within the electronic forms to streamline data collection time using pick lists and valid values. These same controls also standardize the data enforcing specific values and nomenclature while verifying against valid result ranges or even historical data comparisons. This comparison allows the user to assess real time if the data entered makes sense based on previous results. As previously mentioned, mobile data collection eliminates the need for separate data entry tasks most often performed a significant amount of time after point of collection and by someone other than the person collecting the data originally. This lends itself greatly to the possibility of transcription errors, misinterpretations, and removes the value realized from data ownership. It is no secret that the most accurate and representative data are captured as close to the source generated as possible.
- Enables the collection of **Richer Data.** Mobile solutions, deployed from mobile devices, offer a greater variety of actions that better inform the data being collected. For example, many solutions provide the ability to take and annotate pictures, collect and display GPS coordinates on a map, even scan barcodes to increase accuracy and reduce data entry time.

- Enhanced **Data Security** from the standpoint of data loss. Paper forms are often damaged or misplaced. Data collected through a mobile solution is collected and synched back to the database as real time as data collections allow given the location of the work performed and available connectivity.
- **Environmental benefits** speak for themselves.

Realizing Maximum Benefit

The use of a flexible and robust database platform and reporting solution allows the end user to realize the maximum benefit and power of all the data collected…both directly and indirectly. Similarly, a thorough requirements analysis and mapping of the operations with regard to activity and the data to be collected, highlights opportunities to capture not only technical or scientific data but also to exploit those data from a production, task management perspective. It is important to see beyond the immediate need or objective and realize the information that is captured by default…whether it be an additional piece of data to be captured or an additional or innovative use of the data already being captured.

DISCUSSION

CB&I would like to demonstrate the power and value of mobile technology using examples or case studies of successful project implementation which will include calculated return on investment and lessons learned.

CASE STUDY 1 – Radiological Surveys

The Objective: CB&I received a high priority task order to conduct radiological scoping surveys in a housing area consisting of several hundred residences. Surveys were required to identify the degree of radiological impact to the residence so that an exposure assessment could be performed.

The Challenge: The survey protocol required 100% surveys of all floor area, with representative measurements collected every one square meter. Up to 18 different floor layouts were present in the surveyed residences. The aggressive schedule required up to six field teams surveying between 12 and 18 residences per day, with reporting to the customer by 10 AM the following day. Surveys using traditional survey form data collection and recordkeeping would not allow the schedule to be met.

The Solution: CB&I developed a master database of the expected floor plans and required survey measurement locations, along with a standardized data collection form that was deployed on a tablet-type field computer and provided to each survey team. Survey measurements were entered directly into the tablet form that was configured with survey-specific prompts, such as local background, instrument type, surveyed material, and technician ID. An algorithm in the form evaluated the recorded measurement against the project action levels, and, if elevated measurements were recorded, the user was prompted to collect additional information, including photographs, descriptions, and confirmation measurements with other instruments. The form stored data in a mapped display that allowed the user to track location and survey progress within the residence. When the survey was completed, the form directed the survey technician and team supervisor through a series of review screens before requiring a signature from each. Once closed, the survey for a specific residence was locked to editing to prevent tampering.

Following the completion of a survey, data were pushed to the remote database periodically during the work day. CB&I worked with the customer to develop a reporting format that briefly summarized the collected data for each residence in tabular and mapped formats on the first page, and then provided individual measurement data on subsequent pages. Once the format was established, the project database

allowed for one-click report generation. Reports for each residence were compiled the next day, given a final QC, and transmitted to the customer by the required time.

The Benefits: Collection of radiological survey data using the tablet-based system allowed for the elimination of paper survey documentation, and associated transcription and QC, reducing both labor costs and the reporting schedule. Due in part to the use of the tablet data collection, the field portion of the project finished five weeks ahead of schedule, a schedule reduction of over 25%.

Lessons Learned: During roll-out of any new system, minor bugs and errors are to be expected, but we provided for implementation time and support in the overall schedule. One particular lesson learned was that use of the standardized tablet forms allowed site supervisors to more easily identify discrepancies between the six field teams in terms of descriptive language, and quickly develop language to be used consistently for all the teams. For example, if portions of a survey cell were inaccessible due to an immovable appliance, some teams would state "30% of the cell was accessible", while other teams would state "70% of the cell was **in**accessible." By eliminating the data transcription step, we were able to focus efforts on data review and standardize descriptive language early in the survey and reporting process.

CASE STUDY 2 – Soil and Groundwater Sampling Events

The Objective: CB&I has historically, and continues to conduct a number of field sampling activities for the purpose of site characterization, compliance monitoring, etc. The overall objective being to verify the presence or absence of contaminants and delineate the extent of contamination present at that time.

The Challenge: To meet these objectives and provide accurate answers to these questions requires the collection of significant amounts of field data. The types of data collected include, but are not limited to

- sample data, to include the details of the sampling conditions
- sample location data, to advise the representativeness and quality of the sample collected
- analytical chemistry data, to include supporting instrument calibrations and quality control data
- field readings, to inform the environmental sampling conditions
- geologic data such as lithology, to document field and site conditions to inform the analysis of contaminant behavior and distribution

The challenge becomes how quickly, accurately, and effectively data can be collected and made available to the project team for analysis.

The Solution: CB&I has acquired and is now implementing an off the shelf mobile application in conjunction with a master database solution designed for the purpose of collecting, managing, evaluating and reporting the data itemized above. The mobile application is deployed on a tablet-type field computer and uses a formatted electronic data deliverable to export data collected in the field back to the central database. This format is similar to that used by the fixed-base laboratory when providing laboratory "EDDs," or electronic data deliverables, containing all chemistry data generated in sample analysis. The field mobile application is used to collect all field generated data and is transported using a field "EDD." The field generated data file is transmitted daily by uploading to the project website. From there, the file is run through a system validation process and imported into the project database.

While in the field, various reports and forms are generated electronically, such as:

- Sample chains of custody,
- Sample collection logs,

- Sample bottle labels,
- Soring logs,
- Well construction diagrams,
- Purge logs, and
- Field reading reports (pH, turbidity, temperature, etc.).

The project requirements (valid values, analytical parameter lists, limits of comparison, etc.) are setup in the central database prior to execution and pushed to the tablet application to drive consistency and real time data checks at the time of data entry in the field.

In addition to the data mentioned above, the devices are used to take and manage photos to inform the sampling activities as well as sketching capabilities to be used to highlight and markup maps and photos to further inform sampling conditions and locations.

The Benefits: The collection of sampling related field data using the mobile application allowed for the elimination of paper forms in the field, simplified the QC process by eliminating the need for a separate data entry step and potential transcription errors. As with Case Study 1, these benefits manifest themselves in lower labor costs both in the time to collect, enter, check and report the data and in the more immeasurable benefit of quicker access to more accurate information. Less time is spent with data errors. The number of instances of rework or data checks is practically eliminated, but if required, can be accomplished more real time while crews are still present in the field rather than requiring a remobilization of resources. One project example was able to reduce their crew by 2 FTEs when there was no longer a need for the review of paper forms and QC of hand entered data into the central database. Now, a data check is run from a QC report pulled from the database to verify completeness, etc. The data check is executed in less time resulting in a significantly reduced number of errors found. The number of errors are minimized by the use of data entry controls (pick lists, value limits, etc.) and the elimination of a “back office” data entry step.

It should be noted that paper copies of the forms mentioned can be generated for use in contract required hardcopy reports and any other instance where electronic versions do not fully meet the needs of the project.

Lessons Learned: What was soon realized in the implementation of this type of mobile field solution is the variety of uses for the data collected. While targeted specifically for technical purposes and capturing electronically what was previously documented by hand on paper, what was soon realized is that the information allowed for daily work planning, the measurement and use of production metrics and status tracking. For example, not only was it important to capture the sampling information and field parameters to inform a groundwater sample that was collected and sent to the lab for analysis, but from such data, reports could be run as needed to communicate completion data to the Project Manager or Field Site Supervisor. Data were made available to plan daily work assignments, analyze productivity, measure performance and proactively adjust resources accordingly.

A second lesson learned is the importance of ownership for the field data collection process. While technology facilitates operations and brings many benefits to the execution of the work, it still requires an administrator or owner to provide training and troubleshooting when needed, ensure consistency, in use, and full integration into the work process for 100% use and success. Even the best piece of software, if haphazardly, incorrectly or inconsistently used, will fail.

CASE STUDY 3 – Munitions Detection and Removal

The Objective: CB&I participates in a number of munitions response projects. These projects involve non-operational range lands that are suspect or known to contain unexploded ordnance (UXO), discarded military munitions (DMM), or munitions constituent (MC) contamination. Munitions response projects are response actions, including investigation, removal actions and remedial actions that address the explosives safety, human health or environmental risks presented by UXO, DMM, and MC. Operational range clearances are also performed by CB&I. While the approach to these two types of projects can be very different with regard to objectives, the basic work and data processes are almost identical and are supported by a single technology solution.

The Challenge: These projects require a field crew of trained UXO specialists to sweep the identified areas of concern, capturing potential points of concern, collecting spatial data to geographically inform the position of a potential concern and a myriad of other attribute data to inform the identity of the munition type, status, etc. Based on the information collected, decisions are made as to what action should be taken to address each finding. The process is very spatially driven and must be guided geographically to ensure the area has been fully evaluated….no stone unturned. The information about each anomaly collected must be complete and consistently captured to ensure all analyses and identifications are clear and accurate. In addition, data must be made available to the project team and client near real time for evaluation and to provide direction to the field team as to where digs are necessary. Additional data are collected during dig activities to further inform the identification of the munition and the action required.

As one would expect given the nature of these projects, accuracy, and thus QC, plays a significant part in the work and data flow for execution. There is no room for error in project execution.

The Solution: CB&I has developed a geographic information system (GIS)-based, mobile data collection field application that is deployed using a tablet-type field computer and global positioning system (GPS) unit. The solution also includes a desktop application that is used solely for real time QC of the collected data as it is pushed to the remote database and analyzed spatially using the GIS.

Land surveys are performed to establish the grid system and site boundaries. These data are used to build the spatial features in the database that will be used to geographically bound and direct the work to be performed as well as spatially measure and assess progress. The field data collection is initiated by selecting the feature to be addressed that day. Features are defined as points, polygons of various sizes and shapes, transects, trenches or bodies of water. Each feature is uniquely identified, and a project-specific list of attribute data are assigned for collection for consistency throughout the investigation. Additional data are required at an anomaly level if identified. The UXO specialist indicates the feature to be complete and then is required to sign off on the work performed.

The application includes the ability to take and manage photos as well as sketching capabilities to mark up and/or highlight photos and maps to further inform the findings.

The remote desktop portion of the application also deploys a map-based approach to work management (assigning teams to certain areas, creating “buffers” in GIS to create safety zones for the UXO specialists to also support work management). In addition, it supports a map-based review and edit of the data that can then be exported and signed off by UXO QC personnel.

Data are synched daily with the remote database and allows for daily work management, data review and evaluation in support of dig determinations, and to monitor and inform safety objectives.

The Benefits: Development and implementation of this application optimized operational efficiency for munitions response projects by providing real-time data acquisition, imposing data and information standards to the data collected, the process executed and the field teams completing the work. The application provided the project team a time and work management tool that allowed work to be planned, assigned and tracked visually using site maps with grid overlays. The desk top application and remote centralized database allowed for easy access to data as generated for review and editing while techs were in the field and issues could be rechecked and verified. Overall, the solution provided near real-time management visibility into data being collected as well as information to support scheduling/progress monitoring activities and reporting.

Measurable benefits of this application were manifested more significantly in the way work is performed driving standardization in process and reporting. However a direct correlation to reduced level of effort was noted. What was more noteworthy was the distribution of hours and time spent within the lifecycle of the project. **Figure 1** demonstrates the effect the implementation of overall information management procedures and mobile data collection have on the execution of the project throughout its life cycle. The hours noted in red represent an average number of hours spent on a daily basis collecting, reviewing and reporting data prior to the implementation of the mobile application versus the average number of hours represented in blue spent daily completing those same objectives after the technology and procedures were implemented. Not only do the numbers demonstrate a reduction in labor cost, but they also reflect a shift of behavior that imposes the requirements of planning and the benefit of better time spent on upfront planning.

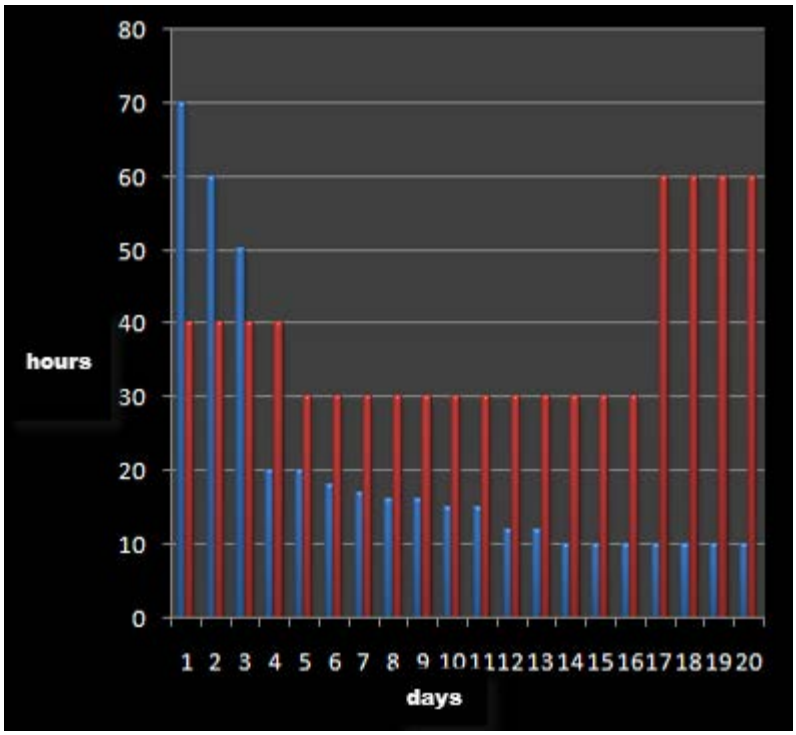

Fig. 1 – Level of effort comparison data - use of mobile application (blue) vs. manual execution (red)

Lessons Learned: In the evolution of this application through development and implementation, the value of integrating the spatial component into the solution was truly realized. Initial versions provided the field crew data entry forms that certainly succeeded in stream-lining the data collection process, but integrating the spatial component into the application enhanced its use by enriching the data collected and

its immediate use, better informing data checks, work management and even safety monitoring as the work progressed.

A second lesson learned in the implementation of this solution was the importance of hardware selection. This work is often performed in very rugged terrain. As the technology progresses, the problem is more easily addressed, but devices suitable for this work are often heavy and can be cumbersome. Also, it is very important in the requirements gathering phase of the project to determine the degree of accuracy or resolution required for the coordinate data so that GPS selection is done to meet the requirements and data quality objectives identified.

CONCLUSION

From the examples provided, one can easily see the key benefits of good information management and the use of mobile technology as well as the added value that is realized beyond the science or chemistry. Yes, accurate data are generated and captured to support good decisions as to the presence or absence of contamination and how it should be addressed. That is a given. But in doing so, information can be captured and used to manage one's process near real time ensuring consistency, completeness and accuracy. As seen in Case Study 1, the technology enables the field technician to track his progress while moving through a building survey while ensuring a consistent technical approach is followed through the use of built in decision points and alternatives. On the next level, as data are synched, the supervisor can monitor the number of surveys being completed on a daily basis, the anomalous readings collected and address any issues as they surface. He can be more agile in the management of the size and needs of his crew. For the project manager, implementation of a mobile solution can provide access to a set of integrated data and reports to support cost and schedule management and a summary of technical findings to monitor overall progress and results. Technology also can enable good collaboration and communication with all project stakeholders pushing the task to complete with team consensus… no surprises.

Each example decidedly demonstrates that the ever changing world of technology benefits our industry by not only improving the science but by improving our business.