Tools for Managing a Construction Project
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Abstract

Government agencies and construction firms are hearing demands for greater accountability while doing their work with greater precision and at lower costs. Tax payers and their representatives want faster answers. Construction firms need to efficiently predict their income and their subcontractor payments. And change orders that are inevitable in any project need to be documented, approved and tracked to ensure proper payment.

We are better able to address these needs in this age of information technology. Better yet, we can adapt standard processes that have stood the test of time, while simultaneously applying automation that smoothes the procedures and facilitates better sharing of the information.

This paper is designed to provide guidance to all stakeholders working towards a successful transportation construction project and describes how automation and good business processes can augment their practices.

Once the pre-construction work (design, cost estimation, advertisement and tendering) is complete and the contract awarded, are we starting our construction phase with a blank sheet of paper? We shouldn't be! We don't want to waste any of the keystrokes that were previously used in the project lifecycle. We should automatically load the contracts and plans into the construction management system and derive the maximum benefit from our previous effort.

This paper reviews the following key functionality:
Track all labor and materials that make up each estimate / payment. Add change orders to a contract so that the new line items of material and labor are indistinguishable from the original contract. Have all daily work reports by inspectors and their supervisor approvals captured and kept in one system. Govern our construction processes using automated business rules that are enforced by the system. Over-ride the business rules, if needed, but keep those over-rides noted in the system.

Materials sampling, testing, and tracking are simplified. The materials are associated with a construction contract. The proper testing and approval of materials become a part of the criteria for an estimate / payment. Additionally, the tests are assigned to and test results accepted only from personnel with the proper material testing certifications. The material processes are governed by automated business rules that are enforced by the system. There is an ability to over-ride by management if needed, but those over-rides are noted in the system.

This paper looks at successful management practices and the application of automation to better administer construction projects. It outlines a comprehensive set of processes that provide a "closed loop" of construction activities and payments for those activities. The benefits of the paper point to consistency in process and results.

Introduction

Government agencies and construction firms are hearing demands for greater accountability while doing their work with greater precision and at lower costs. Prices for necessities in construction, especially fuel, continue to escalate at alarming rates. Agency personnel are caught in the middle with a strong desire to serve their citizens with well built roads and safe construction zones, coupled with the harsh reality of the soaring costs of construction.

Once projects are initiated, there is an increased interest in efficiency. Traffic disruptions are a common frustration among citizens - one that they are more likely to complain about. Getting traffic moving again and minimizing disruptions pays dividends to all agencies by keeping them out of the media and keeping the phones from ringing.

Tax payers and their representatives want faster answers. Agencies are faced with an increased need to produce regular auditable reports to increase accountability to these parties. Construction firms need to efficiently predict their income and their subcontractor payments. And, of course, change orders that are inevitable in any project need to be documented, approved and tracked, so that proper payments can be made.

Why automate?

As these needs multiplied, agencies began looking for new, innovative ways to meet them. Applying information technology was inevitable, but to what extent? We are better able to address these needs in this age of information technology, but should we just use basic, commercially available software tools and adapt them to our needs? Ideally, no. We should be able to apply the standard processes that have stood the test of time in road construction, while simultaneously applying automation that smoothes the procedures and facilitates better sharing of the information.

Automating processes benefits all stakeholders working towards a successful transportation construction project. Automation and good business processes can augment everyone's practices to streamline successful completion of projects.

A key to an automated approach to construction management is the avoidance of re-keying data and information. Why? With paper and pencil and re-keying of data, human error is bound to occur, costing agencies time and money. This happens as projects move from phase to phase (i.e. preconstruction to construction) and also within those phases (field collected data transferred to the main office). Once the preconstruction work is complete and the contract awarded, most agencies move into the next phase of construction and start with a blank slate. Ideally, we should automatically load the contracts and plans from preconstruction systems into the construction management system and derive the maximum benefit from our previous effort. Plus, we should be collecting data throughout the project into a single system – whether data is recorded in an office, on-site or in the field. The application of automation is key to better

administering construction projects and is especially helpful in determining payments for those projects.

Who are the stakeholders?

For any project, the ultimate stakeholder is the citizenry of our great communities. In between, we have many people to whom we must answer when getting a job done. We have our project engineers, materials engineers, a project manager, construction managers and inspectors. We must also constantly communicate with the ministry and fiscal authorities. The contractors are stakeholders too and vitally important to the success of the project.

When this group assembles into a team for each project, we can assume that all are interested in ensuring the integrity of the business process that governs a construction project. We also assume that all are interested in ensuring the integrity of the process, while holding the overhead it introduces to the project to a minimum.

While each project has its intricacies, there is a standardized administration of activities that must occur to successfully track a construction project and produce an accurate audit trail. We are fortunate to live in a time when technology has brought about integrated systems that keep all of these stakeholders, regardless of their level of involvement, informed and up-to-date.

Anatomy of an ideal system
What would the ideal system look like? In truth, it does not exist in today's marketplace; There is no single system that meets all of these requirements. While this listing of functionality sounds comprehensive, it is also both realistic and plausible given the state of technology and the expanding use of wireless and web technologies. The automation, security, and telecommunications are falling into place that enables a system like this to work. Much of the system and features described are based upon best practices in use in numerous transportation agencies in North America. This is a brief description of the key business processes the system must administer:

Handling of items

At the core, **items** are the building blocks of all construction projects. The successful system will have many capabilities built in for handling items and the inevitable changes in items that occur over the life of a project. The system can import all of the items, quantities, funding sources, budget caps, and prices that were developed from the engineers' estimate, proposal, and bid award. The system must be able to track all items in a construction project – those loaded from the awarded bid, and those later loaded because of change orders and force accounts. The funding sources for all items in the project must be identified; a means to assign priorities to the funding sources, per item or category is also a necessity. This allows some funding sources to be completely depleted before accessing the next favored funding source. If and when a change order is approved, all items in that change order, including all material items, become a part of the contract and administered in the system such that the items are indistinguishable from the

original contract. A force account can allow temporary additions of items to the contract, but the items must be approved via the change order process for payments to be approved. Again, all items must be able to be presented to the inspector whether they originate from the initial contract, from Force Accounts, or via Change Orders. The inspector must be able to readily track items by pointing and clicking; and the system must allow for extensive annotation per item if needed, including, besides text entry, digital photos. Examples items include construction materials, labor (personnel), equipment, etc.

Attachments

The ideal system will make the files of papers associated with a project obsolete. Electronic storage combined with interconnectivity will eliminate everything paper – from complex sets of plans to scraps with sketches on them. In the system, external documents and files (i.e. spreadsheets, PDFs, etc.) can be readily attached or referenced (pointed to such as a web address) and associated with project milestones and events.

Materials sampling and testing

The system must have robust capabilities for materials sampling, testing, and management, recognizing that this is an area of construction management that is complex, highly dependent on multiple conditions, and time consuming. Worst of all, it is extremely expensive and further disruptive to traffic to tear out and replace inferior material once installed. Therefore, we should do all that is reasonable to get the job done right the first time.

The system must present to the inspector the material items that must be sampled and stipulate conditions that must be met to successfully sample – amount, method(s) to collect, weather conditions, and if a particular certification is required of the sampler. Approved producer / suppliers of known materials are entered into the system to streamline the pre-approved materials. Start and stop dates of the certifications need to be included so materials are not inappropriately ordered or deemed accepted. Tracking the chain of custody of the material sample is required. The materials samples are tracked to know the contracts they impact, the tester to which they are assigned, which lab has the sample, which tests are to be performed, etc.; the system must be able to assist management in re-prioritizing the sample assignments – that way high priority work can be optimized in the labs. The software cannot speed up the testing, but it could assist in optimizing the use of the existing lab facilities and personnel. The system must know of the capabilities of all of the labs in the province, so that it can know which labs are able to conduct the necessary tests of the materials being collected. The system must assign test samples only to labs that meet certain criteria, such as the certification to perform the default tests and the custom tests called for in the contract / project. The system must know the capabilities of all of the personnel in the labs in the province, so that it can know which personnel are able to conduct the necessary tests of the materials being collected (user profiles). Start and stop dates of the certifications need to be included so work is not inappropriately assigned. The system must assign test samples only to lab

personnel (testers) that meet certain criteria, such as the certification to perform specified tests.   Test results of a material are immediately available to any user in the system – no reports need be produced and routed. Custom "contract specific" test and methods can be specified in the system and contract materials assigned to these tests in addition to or instead of the default tests

Daily Work Reports (DWRs)
DWRs, (or inspector daily reports (IDRs) or diaries) are the information lifeblood of a project. They provide the detailed information that allows project managers to assess and communicate up-to-date project status. The ideal system has a field tested and proven functionality for DWRs. In the system, DWRs are electronically accessible in the field via either wireless access or by checking out the contract items from the system until checking the items back in (once connectivity is re-established). DWRs must be inalterable once checked in for the day. The system must provide for checks and balances for requests and authorizations defined for the business processes. Specifically, it needs to allow, at a minimum, for these:

1. The reviews and approvals of DWRs must be performed by designated professionals such as a project or district engineer; sign offs are required to accept reported item quantities; sign offs are required to accept materials test reports.
2. Change orders must be reviewed and approved by all appropriate parties prior to inclusion in the contract. Stakeholders for the approval will include at least: the fiscal authority, project engineer, materials engineer (if materials are affected), and the contractor. Additional levels of review and approval can be added or removed depending upon the nature of the change order. For instance, there might be more or fewer thresholds set for the magnitude of the additional funds requested. Or there might be a need for the materials engineer to be involved in some approvals, but not others.
3. All items, including materials items, must be approved (tests accepted) to be included on an estimate / payment. Overrides are allowed, but the system restricts that override authority and requires an audit trail of parties making them. A reason(s) justifying the override is required.
4. All material items' test result reviews (acceptance and / or rejections) are conducted only by professionals with credentials appropriate to the materials. Overrides are allowed, but the system restricts that override authority and requires an audit trail of parties making them. A reason(s) justifying the override is required.
5. Access to view and having read / write access to information can be restricted by any number of criteria such as geographic boundaries (i.e. one region cannot see another region's contracts), contract specific (i.e. an inspector of a particular contract could be denied access to contracts to which he/she is not assigned), by professional type (i.e. a pavement engineer might not be allowed to access metals), etc.
6. The system accommodates Independent Assurance Sampling and Testing reviews of materials testing. The system allows for an independent set of tests to be performed and reviewed by only appropriate parties to compare the results.

Handling of data
All of the data involved in the system being described is maintained in one system for an integrated source of records and consistent navigation. All data about an estimate / payment and the supporting the detail is copied to a data warehouse that maintains all estimate data from current and previous projects. The data warehouse provides a means for numerous views of the data such as for trend analysis. All data regarding materials – starting with the samples taken, all the tests and test methods used, test results, and final acceptance or rejection of the material - is copied to a data warehouse that maintains all materials data from current and previous projects. The data warehouse provides a means for numerous views of the data such as for trend analysis and longitudinal studies.

Estimates / payments approved retain all details supporting the approval of the estimate. DWRs / IDRs involved, item quantities approved, materials accepted, funding sources per item, and any overrides. Keeping all of this information together within one system and accessible via a computer network makes for a system that is much easier to audit.

Read-only view for contractors
The ideal system will treat contractors as valued, trusted partners entitled to view most data on a project to ensure accurate records and timely payments. Through the system, a periodic read-only view of the estimate / payment approvals, including all approved item quantities, and those disallowed, is made available to the contractor(s) on the project. The purpose of this read-only view is to enable a thorough and transparent review and reconciliation of what is expected in a payment. If challenges are made, both parities can readily identify the items in question.

What are the benefits of an automated system?

The benefits of an automated, technology based approach to construction management are numerous and reach out to all project stakeholders.

At the highest level, the ministry would have one system of record for construction projects. This would aid any audits that must be performed, and enable the ministry to retain documentation on the decisions made during a project. It would automate the administration of the business processes of a construction project. The system would develop and enforce consistent processes and practices and this consistent use of processes and procedures would, over time, help achieve better or more predictable results.

For all stakeholders, information would be accessible online by appropriate parties, eliminating the need to search through paper file systems. Patterns of demand for constrained resources would be more readily seen and be able to be measured. Studies of data could be easily performed, such as the performance of one material when compared to another – for instance which performed better on tests, which is easier to test, etc.

Additionally, longitudinal studies could show advantages of one installation method of a material versus another.

This approach also enforces the various business rules, such as approvals and sign-offs for change orders as the system automates the administration of a construction contract. Over time, a ministry should be able to produce projects that complete much better when comparing estimated costs verses actual costs. Another benefit is the ability to respond much more rapidly to executive management when queried for information.

Such systems are not easy to adapt. However, the resulting increase in accuracy, communication and collaboration is extremely valuable, coupled with an extensive reporting and audit trail. Implementing such as system is a multi-phase project that impacts all levels of a transportation agency. The key to a successful roll-out is comprehensive planning, cohesive execution and constant communication with all involved parties.

Conclusion
As the demand for accountability grows, the need to implement automated, program-wide construction management systems grows as well. Stakeholders are requiring the communication, collaboration and accountability that are inherent in these systems. While the ideal system is not commercially available today, technology continues to move forward making the possibility more realistic. Detailed, customized systems for transportation ministries exist and are already in place in similar agencies. While implementing such a system can be a huge task, the payoff – to all stakeholders - is immeasurable.