APPLICATION OF LEAN CONSTRUCTION CONCEPTS TO MANAGE THE SUBMITTAL PROCESS IN AEC PROJECTS

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ABSTRACT

Office processes are repetitive, common to multiple projects, involve multiple specialists, and are necessary to support the work of trades. Not much attention has been given to the management of office-related processes in the Architecture, Engineering, and Construction (AEC) literature despite their importance in supporting core activities in this industry. Anecdotal evidence provided by industry practitioners and research carried out by the authors suggest that these processes lack transparency (e.g., actual durations are unknown, indicators are not used to manage the process) and suffer from low reliability, that is, planned times do not reflect the reality and are often underestimated. Aiming to address this gap in the literature, this paper presents a two-phase study carried out to investigate the submittal process in a construction company using Lean Construction concepts and tools. The study revealed that durations used to manage the submittal process are unreliable and often do not match what is indicated in schedules and contractual requirements. Actual lead times to process a submittal are variable and root causes for their variability are not properly understood, consequently unreliable durations continue to be used to prepare schedules. The authors suggest that by using the method and variables presented in this paper for the submittal process, companies can take the first step to map this and other administrative processes in order to visualize the chain of tasks necessary to process information in their offices. This method provided transparency to the process managed and allowed the management team to identify areas that needed improvement in the process.

KEYWORDS: Submittal, Project Management, Lean Construction, Office activities

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INTRODUCTION

The process of preparing, submitting, and the resulting steps until the approval of the submittal is called the submittal process. The purpose of this exchange of information is to ensure that designers’ intentions and requirements are implemented in the construction process. The designer issues design documents that become part of the contract documents, but the design does not have the level of detail that construction requires, as their main intention is to express the design concept (Atkins and Simpson 2008). Consequently, during the construction phase, the general contractor (GC) and the Subcontractors work with suppliers to define and detail the products that will be used to satisfy the specifications set forth by the design team. Documents containing product information (e.g., shop drawings, samples, and product data) are then sent to the Architect and project consultants for review and approval.

Submittals are a contractual requirement addressed in the General Conditions of the Contract for Construction (e.g., AIA 2001-2007; EJCDC 2007). The Standard General Conditions of the Construction Contract issued by the Engineers Joint Contract Document Committee indicates that no payments should be made to the GC until the schedule of submittals is submitted for approval (EJCDC 2007). Submittals are of extreme importance as specific construction processes cannot start until their corresponding submittals have been approved. Submittals may include different types of documents, i.e., shop drawings, product data, samples, reports, manuals, and warranties. Some of these documents are sent to the design team as part of the project’s record, others need to be approved by the design team before the material or equipment represented in the submittal is installed or built in the project, i.e., shop drawings, samples, and product data (Atkins and Simpson 2008). The coordination of the submittal process depends on the contractual and working relationship of the teams assigned to the project and is very much related to the delivery method adopted (Fisk and Reynolds 2010).

Anecdotal evidence provided by industry practitioners and research carried out by the authors of this paper indicate that office-related processes, in particular, the submittal process lacks transparency (e.g., actual durations are unknown, indicators are not used to manage the process) and suffers from low
reliability, that is, planned times do not reflect the reality and are often underestimated. In order to study the submittal process and the underlying causes of these problems, the authors developed a two-phase case study and used Lean Construction concepts as the theoretical basis to define variables of analysis, interpret results, and draw conclusions about the process investigated. The paper initially discusses the importance of managing the flow of documents in AEC projects and how Lean Construction concepts can be used to improve their visibility and performance. The two-phase case study is presented and results are analyzed in light of Lean concepts. Finally, conclusions and recommendations are presented.

MANAGING THE FLOW OF DOCUMENTS IN AEC PROJECTS

Documents are required in any project, and their management is necessary regardless of the type of delivery method used. Intervening parties in construction projects constantly exchange information and documents related to payment, procurement, RFIs, submittals, and change orders amongst others. Processes are set up not only to keep track of a company’s records but also to manage legal and contractual documentation, and communication among different parties (Fisk and Reynolds 2010). The submittal process, for instance, supports the work developed by numerous specialists (project engineers, designers, estimators, etc.) and staff who is often times dispersed in different departments of an organization or even different organizations.

In general, office-related activities that process project documentation are repetitive, and improvements achieved at the office level will be capitalized on for other projects as well. However, regardless of their direct contribution to the overhead costs of a project, office-related activities in construction are often mismanaged (Kim and Ballard 2002), lack proper planning, or are buffered with extra resources to account for variability within these office processes (Kemmer et al. 2009; Chin 2010). Still, the authors know of few studies that have dealt with how document-related processes are managed and analyzed from a “production system” standpoint using performance indicators to evaluate the flow of information and documents exchanged between different parties in a project (e.g., Garret and Lee 2010).
LEAN CONSTRUCTION CONCEPTS APPLIED TO THE MANAGEMENT OF DOCUMENTS IN AEC PROJECTS

The concepts and practices that support the Toyota Production System (Ohno, 1988) became the basis of what is currently known as Lean Production. The translation of Lean to construction, commonly referred to as Lean Construction (LC) has focused on three main aspects of production: transformation, flow, and value (Koskela 2000).

Transformation activities alter the shape or form of resources, and are the ones traditionally considered by construction managers (e.g., schedules and estimates focus on the transformation: placing concrete, painting walls). Flow activities (transportation, waiting/inventory, inspection) are necessary for production but may or may not add value to the production from the client’s point of view. Flow activities have been traditionally overlooked by managers, resulting in the waste of resources assigned to production (Koskela 2000). Management of value from the client perspective is another tenet of LC since activities exist to fulfill the demand of a client; accordingly, activities must directly contribute or support value generation to match the client’s demands. Defining value is also essential to understanding waste, in other words, resources are used but do not contribute to the delivery of what the client expects and might also generate failure demand, that is, rework to fulfill an order (Seddon 2008). Ultimately the definition of value and the value stream (including value-adding and non-value adding activities necessary to deliver a product) takes front stage when Lean concepts are used.

LC principles used to improve the design and operation of production systems include: reduce lead times, increase transparency (i.e., a system’s ability to communicate with people), reduce the share of non-value-adding activities, reduce variability of inputs and outputs, balance improvement of flow and conversion activities, amongst others (Koskela 2000). Even though such principles are commonly used to improve production systems, they can also be used to improve office-related activities.

The reduction of lead times in construction processes and supply chains has been discussed by numerous research papers. Arbulu (2002) studied the supply chain of pipe supports to improve their
capability to design, procure, fabricate, and deliver products without delays. Yu et al. (2009) investigated activities in a residential project with the goal of designing a stable flow of work for the trades involved, thus reducing the original process lead time by 50%. Regarding the management of documents in construction firms, Kemmer et al. (2009) investigated how to reduce approval times for payment by redistributing workload among staff and rescheduling activities, whereas Garret and Lee (2010) mapped the flow of electronic submittals. Studies on lead time reduction are usually based on the method proposed by Rother and Shook (2003) which uses a combination of standard symbols and indicators to translate the value stream performance into a more visual and comprehensive format. However, VSM needs to be adapted before it can be used to study construction processes. The direct measurement of activities times is not always possible and researchers rely on recording, planned and original, starting and end dates from computer-based tracking systems (Yu et al. 2009). A similar approach to collecting data was adopted in this research and is described later in the paper. Process mapping was used as part of this research; however, due to space limitations this paper does not present the maps developed.

One of the most notably recognized examples to stabilize the flow of inputs and outputs in construction is the Last Planner System™ (LPS™) described by Ballard and Howell (1998). The system has been used over the years by field personnel to promote the diligent screening of tasks, to identify their necessary inputs, and to provide resources to assure a continuous flow of tasks (i.e., make ready process). Additionally, the LPS™ promotes a systematic analysis of causes of problems that halt processes, as suggested by Ohno (1988), to avoid their repetition and consequent interruption of processes. The LPS™ and its basic tenets can be used to manage the flow of information in office-related processes by promoting early identification of resources to complete tasks and the causes of problems that delay their completion, and by promoting collaboration among different parties (e.g., Reginato and Graham 2011).

Authors suggest that implementing Lean principles to nonproductive processes represents a leverage point for companies aiming to minimize waste and increase value to the client. However,
companies usually focus their efforts on production tasks and fail to map and study office activities; thus not having a complete picture of the entire organization (Keyte and Locher 2004).

RESEARCH METHOD

The approach used to conduct the research was the case study method, appropriate to answer why and how types of questions (Yin 2009). The study was carried out in two phases and in two different companies. In Phase 1, preliminary studies were conducted at companies A and B (January 2010 to May 2010) to understand how the submittal process worked in construction projects. Phase 2 (May 2010 – November 2010) comprised the development of an in-depth case study in Company A, which agreed to continue serving as a volunteer for the study. Only the results obtained from Company A are presented in this paper due to space limitations. The research includes two different projects, one as a Pilot in Phase 1 and a second during Phase 2, as will be explained later.

Limitations

The projects were located in Southern California and were both built for a non-profit organization and used design-bid-build delivery. The case studies were limited to the set of data provided by Company A and some of its partners during the Case Study. The authors point out the well-known limitation of case studies as a means to advance research, since they are not designed to allow for statistical generalization. Rather, case studies allow for analytic generalization, meaning that researchers can use a similar research protocol to extend the study to similar populations and expect similar findings (Yin 2009).

Company A

After a first contact was established with Company A, its managers showed interest in participating in a research in which the submittal process could be studied. Company A has worked in the new building construction and building renovation market in Southern California for over 90 years. The company also offers construction management and preconstruction services, design-build services, and structural concrete. The Pilot case study was conducted on a residential project that had been completed when the study started. The submittal process was managed on site by the construction team, and
according to a top manager of the company the team ran the process smoothly without major problems; however, the process lacked a streamlined and standardized procedure (Pestana and Alves 2011).

The Phase 2 case study project was a $54 million, 12-story, mixed-use, high-rise building structure, with a total construction floor plan area of 33,000 SQ FT. The time of the case study coincided with the time the project was being built, so that current data reflecting the actual flow of submittals at the site was collected in real time (rather than forensically in the Pilot). The Owner contracted directly with the Architect, the Mechanical and Plumbing Engineer, the Structural and Civil Engineer, other Engineers and Consultants, and the General Contractor (GC). The GC contracted with the Subcontractors, suppliers, and fabricators. The Architect coordinated the design work, but the GC often contacted the consultants.

Research Validation

A mixed approach was used to collect qualitative and quantitative data throughout the research. Tactics used to address research validation include: construct validity, internal validity, external validity, and reliability studies (Yin 2009). Construct validity was addressed through the definition of measures to study the concepts and the use of multiple sources of evidence, the use of a pilot case study to define the indicators and refine the data collection method, triangulation, and the review of the case results by key informants in both cases at Company A. Triangulation is used to view a phenomenon from different angles and to reduce or eliminate bias from a single source. The authors used quantitative and qualitative methods simultaneously, in one single phase, to cross-validate findings and to overcome weaknesses of one method or the other (Creswell 2003). For instance, different people involved with the project were interviewed to address how the submittal process was managed. Data provided by Company A was collected and analyzed, and then presented to the Company A’s management team for discussion. Direct observation of meetings was also used to assure that the researchers had a first-hand account on how submittals were managed. The combination of data obtained from different sources and angles of observation allowed the researchers to draw a more comprehensive picture of the submittal process, which would not be possible if a single source of data had been used.
For the Pilot Case Study quantitative data was provided by the company, consisting of archival records of the submittal process in the form of spreadsheets that were used as a submittal schedule (submittal log). Qualitative data was collected through semi-structured interviews with members of Company A. The main categories of indicators (types of submittals, lead times, cycle times), and the method to collect data were defined (Pestana and Alves 2011). According to Lucko and Rojas (2010), pilot studies serve to adjust the instrument used for data collection and help the construct validity, that is, make sure that researchers are measuring the right indicators to explain the phenomenon being studied.

The case study, centered on the work of the GC’s construction team, used data collected on weekly field visits to the site during a six-month period. Internal validity, related to the definition of a causal relationship, was addressed through inspection and analysis of multiple sources of evidence, particularly direct observation and open-ended interviews, and reviews of case results. By directly observing activities the first author could observe the subtleties related to the management of submittals at the construction site. The researcher could record actual times spent on preparation of submittals, problems with the use of data management system and with the submittals, as delivered by subcontractors. During the field visits, quantitative data was collected through the analysis of the submittal log for the project. Qualitative data was collected through the following: analysis of reports generated by document management software used to plan and control administrative processes; copies of submittals, transmittals, direct observation of the management of submittals; and open-ended interviews with managers of the companies involved with the project (Project Engineer, Project Manager, Assistant of the Project Manager, and Superintendents), the Architect (Project Manager) and the Subcontractor (Project Manager). Copies of the submittals (kept on-site and on two internet FTP servers) were accessed to verify the contents of the submittals and to categorize the main causes of problems.

External validity, that is, definition of the universe to which the research findings can be generalized, was addressed through the use of an initial phase of the research work that dealt with two Pilot case studies and a subsequent in-depth case study. Reliability, related to the documentation of the
research method so it can be replicated, was addressed through triangulation (i.e., use of multiple sources
of evidence to build a convergent line of inquiry), extensive description of the research phases and the
structure of the data collection, accompanied by a clear indication of a description of study limitations
(see Pestana 2011 for additional details).

Types of data collected & analyzed

Using the sources of evidence described, three major categories of data were collected during the
study: time data, quality data, and procedural data. Time data included actual dates which reflect when an
event actually took place, and planned dates which were introduced into the submittal log at the beginning
of the project. Quality data reflected the approval status (Approved, Approved as Noted, Revise &
Resubmit, Rejected, For Record, and Waiting) that was determined in two different phases of the
submittal process. The first phase was the GC’s review period – during this phase a submittal marked as
Approved, Approved as Noted or For Record had no or only minor notes, and was released to the
Architect for approval. A submittal marked as Revise & Resubmit had major problems and could not be
sent to the Architect before being revised and resubmitted for the GC’s review. A submittal marked as
Rejected was no longer needed. A submittal marked as For Record was sent to the Architect to add to
their files. The second phase was the Architect’s or the A/E’s team review period. During this phase any
submittal the Architect or the A/E marked Approved, Approved as Noted or For Record might have only
minor notes, but was returned to the GC and then to the Subcontractor. Revise & Resubmit documents
had major problems and needed additional work. In these cases the submittal was sent back to the GC
who then sent it to the Subcontractor to revise and resubmit, after which the entire review cycle started
again until the submittal was Approved or Approved as Noted. A submittal marked Rejected was no
longer needed. Submittals marked as Waiting represented submittals within the GC’s review period.

The nominal data reflected the type of submittal delivered for approval (e.g., shop drawings,
samples, or product data). In the Case Study, submittals were categorized as ordinary submittals when
they did not have special needs; special submittals, which have special needs (e.g., long lead items); and
particular submittals including submittals with items for which design was not clear. The procedural data reflected the party responsible for the approval of the submittal (e.g., Architect, Structural Engineer).

Findings of the Pilot Case Study were presented to the GC’s construction team, who provided comments which were later addressed in the analysis of the case study. The data analysis focused on review cycle times, approval status, and variability within indicators. In an attempt to identify patterns, and following the indication of the GC Project Manager (PM), data was first analyzed for the entire process and then analyzed separately by variables within each category: quality, nominal, and procedural.

For the Case Study, “swimlane diagrams” were developed to illustrate the exchange of information and hand-offs between different participants of the project. These diagrams serve as a basis to visualize the exchange and categorization of activities (value adding, non-value adding, and waste) which contribute to a product’s lead time. The diagrams are not discussed in this paper due to space limitations, but they can be found in the work of Pestana (2011).

PILOT CASE STUDY

The first task of the Pilot case study was to develop a map of how Company A managed their submittal process. Based on information provided by Company A’s managers, the submittal process started when the GC prepared the submittal schedule (or submittal log), where the specification sections, due dates, and responsible parties were represented. There was no contractual relationship between the Subcontractors (suppliers and fabricators) and the owner; the Subcontractors submitted the submittals to the GC for approval. Ideally, the GC reviewed each submittal, approved it, and sent it to the A/E who approved it, and sent it back to the GC. Once the A/E reviews were completed and the submittals approved, the GC would send the submittal back to the respective contractor. Figure 1 illustrates the timeline for this process as described by the managers. The shaded stars correspond to the due dates that were set by the Project Engineer (PE) on the submittal log at the beginning of the construction phase.
For this case, the submittal log was built on an MS Excel spreadsheet and contained different types of information. The submittal log listed all the submittals indicated in the specification book for the project, and key information: Architect- or A/E-allowed review time, estimated delivery lead time (to deliver a product or service once the Subcontractor received the approved submittal), due date each submittal was required to be submitted, and the date the submittal was required on site.

The submittal review process would start once a Subcontractor sent a submittal to the GC for review. In an interview, the GC’s PE stated that during this period (ideally 3 to 5 days) the GC’s team reviewed submittals based on project plans and specifications to ensure that no time was wasted by sending an incorrect or incomplete submittal to the Architect. During the review process, the GC’s construction team would select a category for each submittal. The possible categories for this project were: Approved, Approved as Noted, Revise & Resubmit, Rejected, and For Record.

Next, the submittal was sent to the Architect and review was completed either exclusively by the Architect or with the help of consultants, ideally within 14 days. Once the Architect or the A/E review was complete, the submittal was sent back to the GC. Provided that the A/E stamped the submittal Approved or Approved as Noted, no resubmission was necessary. In some cases the submittal was categorized as Approved as Noted but it had so many notes and corrections that the Subcontractor was asked to submit a clean copy for record. Finally the GC distribution time was estimated as 3 days, totaling an estimated lead time of 20-22 days.

**Analysis of Indicators**

This section initially presents an analysis of collected indicators followed by a series of potential explanations for their behavior. Using the MS Excel spreadsheet provided by the GC, the authors organized the existing data into different types of variables for analysis. The goal of this analysis was two-fold, make the process transparent to those involved with the management of submittals (i.e., the indicators would provide a good representation of how well the process operated) and investigate how
reliable the estimates provided by the GC’s team were after all these indicators had served as a basis for planning and integrating the flow of submittals with those of on-site construction operations.

Time indicators were analyzed considering the entire project and each type of variable, as discussed before: quality, nominal, and procedural. After that, quality indicators were calculated, e.g., % of submittals approved, % of submittals that needed to be revised and resubmitted. Table 1 presents a summary of the results (mean and median) obtained for the time indicators. This analysis was only performed for the variables that were representative of processes that had a Planned Lead Time of 11 days (93% of the data). It is worth noting that although the subsequent discussion focuses on the median values, the mean values are also shown for each time indicator to provide some information on the degree of asymmetry of the distributions of the time indicators.

Insert Table 1 about here

The analysis of indicators revealed that submittals were often delivered later than required on site (based on the submittal log), and lead times of the submittal process seemed to be almost unpredictable revealing the low reliability of the durations used to manage the process. The results presented in Table 1 reveal that the median Lead Time 1 (30 days) is about 1.5 times higher than the Estimated Lead Time (22 days) for all submittals, and almost three times the Planned Lead Time (11 days).

On average, submittals required more time to be distributed than to be reviewed by the GC (CT3 > CT1). According to the GC’s team this should not occur. Nevertheless, the team speculated that this could be related to the fact that in some cases the Architect for this project might have used submittals as a way to finish the design, leading to submittals where many notes had to be considered by the GC and eventually led to change orders.

The difference between planned (submittal log), estimated (indicated during interviews), and actual dates (collected evidence) reflects the additional time used by the GC to perform reviews and assure that the notes would be properly addressed by the construction team. These examples illustrate how the Distribution Cycle Time (CT3) is affected by the need to review and sometimes rework
documents returned by the Architect, respectively adding additional durations related to inspection and transformation of documents to CT3 and ultimately to the entire lead time.

The Distribution Time (CT3) for product data (6.5 days) was approximately the same time that of shop drawings (6.0 days). This contradicted what the PM had expected as shop drawings were assumed to have a longer lead time than product data since they are much more complex and may detail dimensions with low tolerances. The lead time of submittals sent to be reviewed by the A/E was lower than the lead time of submittals sent to the Architect only. The GC speculated that when the submittal had to be sent to the consultants, the Architect worked on it immediately, potentially to meet contractual deadlines. However, the data does not corroborate the GC’s explanation. Interestingly, the skew reduces for some LTs. Since the LT corresponds to a summation of CT the reduction in skew can be attributed to the relatively low correlation between different cycle times ($\rho_{CT1,CT2} = 0.096, \rho_{CT1,CT3} = -0.095, \rho_{CT2,CT3} = -0.156$) as well as the corresponding low correlation between CTs and LT1 ($\rho_{LT1,CT1} = 0.537, \rho_{LT1,CT2} = 0.559, \rho_{LT1,CT3} = 0.535$).

Figure 2 presents a summary of the results and allows a comparison between planned cycle times and lead times as defined in the submittal log; estimated cycle times and lead times, as described by the PM’s team; and the actual cycle times and lead times that were registered on the submittal log. Additional analysis revealed that for 75% of the sample (96 submittals), the lead time for each submittal approval required a period ranging between 0 and 45 days to be approved by the GC and the A/E.

**Insert Figure 2 about here**

Figure 2 shows that submittal activities took longer than planned and even longer than estimated and that the process had low reliability and did not perform as planned. Additional analysis revealed that 57% of the time the Subcontractor delivered submittals earlier than required to the GC, but 41% of the time the Subcontractor delivered submittals late to the GC. In 49% of the cases, submittals were distributed late to the Subcontractors.
These indicators suggest several explanations: a) the process is highly unreliable, as a result many scheduled dates are not met; b) scheduled dates are buffered and do not reflect actual dates when submittals are needed, therefore scheduled dates are not enforced; c) occurrence and duration of transformation and flow (inspection, distribution/transportation, waiting) activities are not well understood and consequently not accounted for during the scheduling process; d) even though the PM’s team acknowledged that they should consider their own review time in the submittal log, data shows that they did not consider it in the initial schedule.

Finally, the analysis of the quality indicator revealed that the majority of submittals, after the A/E review, were Approved as Noted (57.6%), followed by submittals Approved (35.4%), and Revise & Resubmit & Rejected (6.9%). This set of data did not have submittals For Record. If submittals are viewed as products (documents) crossing a production line, only about one third of them had a first pass yield and did not need rework (e.g., Approved), the other two thirds needed some sort of review. Without understanding the causes for variations in cycle times in the submittal process, the GC is left with schedules indicating durations that are not representative of what happens in practice. Potential solutions for the problem of unreliable durations include studies such as the one presented in this paper and working to assure the completeness of submittals, thereby increasing the number of approved submittals in the first pass. This is along the lines of what is proposed by the Last Planner System™ of production control (Ballard & Howell 1998): releasing assignments (in this case submittals) that have been checked for prerequisites is likely to yield better performance.

**Final remarks – Pilot Case Study**

The authors presented these results to the team in charge of the project analyzed during the Pilot Case Study and its participants were reluctant to trust the indicators, which had been obtained from the Excel spreadsheet they had provided to the authors. The team had a different, tacit understanding about how the submittal process ran in the project analyzed. The team’s tacit understanding (perception) of the submittal process was that it ran smoothly and without delays occurring between tasks; the data revealed
otherwise. Members of the team mentioned that at times submittals would sit on someone’s desk for several days, for no (apparent) specific reason, before being sent to the next interested party or being returned late to Subcontractors (adding waiting times to the final lead time). Additionally, data revealed that only about one third of submittals were approved on a first pass, with the other two thirds requiring additional work to be approved. Two important findings resulted from the Pilot study. Firstly, the tool used to manage the process had data which were not transformed into indicators to proactively manage the process; the tool lacked transparency. Secondly, estimates used to build the submittal log and manage the process were unreliable. With a baseline method to study the submittal process and preliminary results at hand, the authors started the investigation of an ongoing project managed by the same team.

**CASE STUDY**

Data collected during the case study focused on how the GC’s construction team managed the process to ensure timely review and distribution of submittals and how the GC kept track of the work performed by the A/E teams. In this design-bid-build project, like in many others, the designer could not know in advance the product or the system the GC would adopt to build the project. Through the submittals, the GC and Subcontractors completed the information necessary to build the project by detailing drawings and dimensions, checking for physical conformance, and presenting to the designer information about how products interfaced with adjacent systems. The submittal log was a contractually required document that had to be presented to the A/E team for approval. The PE used the information listed on the project specification book to prepare the submittal log during the pre-construction phase. Then the submittal log was input into the submittal register, both were modules of software which centralized the submittal information by linking project documents and files to the submittals. The software was adopted by the GC to facilitate the management of submittals. In previous projects (e.g., Pilot Study project) the submittal process was tracked with an Excel spreadsheet.

The due date for each submittal was determined by the PE after retrieving information from the project’s schedule and assigning to each item a submittal lead time. The project’s schedule dictated when
a Subcontractor, fabricator or supplier needed to provide materials, equipment, and service. The submittal total lead time was determined by considering the delivery lead times and the A/E review time, i.e., 14 days for A/E review plus 2-3 days (buffer) for review by the PE or the Architect PM. The Delivery Lead Time reflected the time that a Subcontractor, fabricator or supplier needed to provide materials, equipment, or service after receiving the approved submittal. This estimate was based on the construction team experience. The PM’s team review times were not explicitly considered. Nevertheless, the total lead time had buffers (2 to 3 days) that allowed for those reviews to be performed.

The submittal process involved the work of different teams working on the project, i.e., vendors, Subcontractors, GC, and the A/E teams. To ensure Subcontractors’ project managers (PMs) had all the information necessary to prepare submittals, the GC construction team collaborated with them by facilitating meetings between the GC PM, the Architect PM, and the design team when necessary.

**Analysis of indicators**

Indicators for this case study were categorized into four groups: time indicators, i.e., cycle times (CTs) and lead times (LTs); quality indicators, i.e., relative percentage of submittals Approved, Approved as Noted, Revise & Resubmit, Reject, and “For Record”; nominal indicators; and problem indicators. Three main types of submittals were defined based on major characteristics of each document during the review process: ordinary, special, and particular (as previously discussed). Among the time indicators, the time for a Subcontractor to deliver a submittal revision (CT4) was collected in the Case Study, differently from the Pilot Case Study when this indicator was not included in the analysis. The type and frequency of problems detected by the A/E were also collected and analyzed.

Analysis of due dates vs. actual delivery dates on the submittal register revealed that most packages were submitted without considering the due dates originally planned, similar to what had been evidenced in the Pilot Case Study. Between May and November 2010, Subcontractors submitted 60 packages for approval with a total of 297 items. The number of items in each package varied between 1
and 35. Out of 60 submittal packages, 8 (13%) were submitted on the due date, 22 (37%) were submitted earlier, and 21 (35%) were submitted late. For 9 packages (15%) there was no information.

Table 2 shows a summary of cycle times (CTs) and lead times (LTs) for different submittals tracked during the case study period. The Architect/Engineer Review Time (CT2) was higher for Approved as Noted and Revise and Resubmit than for Approved. The data suggests that submittals with problems increase the cycle times of specific tasks and ultimately the entire process due to the increase in flow activities. Even though CT2 for particular submittals was high, during meetings the Architect/Engineer would approve part of the submittal package so the subs and the GC could work. The approval of parts of the submittals was not assessed in this study because the GC only kept records of the time when the submittal package (as a whole) was approved. This suggests that the way submittals are grouped in packages (batching rules) directly influences the total lead time for submittals in the event packages are approved as a whole only.

Insert Table 2 about here

The time a Subcontractor took to revise a submittal (CT4) at times was very long, suggesting that submittals were submitted earlier than needed or that the Subcontractor was aware of buffered durations in the submittal log. Finally, it is worth noting that the GC Distribution Time (CT3) decreased from a median of 6.0 days in the Pilot Case Study to 0 days in the Case Study. The authors did not work with the team to implement changes in the process, but the data suggests that the visibility provided by the swimlane diagrams and the indicators collected for the entire process contributed to the decrease in cycle times for the different activities performed and ultimately the entire lead time for the process.

Furthermore, most packages with problems detected by the A/E (44 out of 60) contained more than one problem. The most common problems found by the A/E were: missing information (27 packages, 61%); wrong information (15 packages, 34%); incomplete (12 packages, 27%); and other problems (16 packages, 36%). Missing information referred to items such as Requests for Information (RFIs) and Architect’s Supplemental Instructions (ASIs) that the Subcontractor did not acknowledge in
the package, and requests for confirmation of details. These cases show that whenever the Subcontractor prepared the submittal without all the information required, this either resulted in more items requiring resubmission at a later stage or the addition of RFIs and ASIs to the submittal package.

Finally, the software used to manage submittals helped automate the process, which once used Excel spreadsheets manually set to support similar functions. However, the automation of the process did little to improve the quality of submittals and their approval times because it inherited managerial practices which were in place before the software was implemented. Batching practices used to group submittals in packages and proper screening of submittals to improve their quality seem to be more important to improve the performance of the process as whole. Routines based on the Last Planner System™ could be put in place to promote the screening of submittals to improve their quality through the correct identification of information and resources needed, and to address the root causes of problems to avoid their repetition.

CONCLUSIONS

Like any other process required to deliver a project, the submittal process needs to be planned and controlled during the life of a project; making the process’ attributes visible is a first step towards properly managing it. The study revealed that many assumptions related to the submittal process, which are used as the basis to generate construction schedules, require a careful review. The submittal log, established in the beginning of the project, is defined as a contractual document and as a tool to manage the process. A comprehensive list is virtually impossible to set, as it is required in advance of the construction phase and without the input of the ones who will prepare the submittals.

Indicators used to build the log do not reflect the reality. Additionally, because the submittal log does not allow a visual reading of the real indicators of the process and the flow of information (lack of transparency), it does not help control the submittal process. The schedule for the delivery of the submittals was not accomplished in 70% of the cases in the Case Study. The submittal delivery time was buffered to account for low reliability of the Subcontractors, but this practice caused more variability. The
schedule was dictated by the GC, and it is likely that the Subcontractors ignored the GC’s planned schedule for the submittals because they knew that due dates were buffered.

Two main types of waste were identified in the submittal process. Time waste reflected as the time spent by the PM’s team to set up an inadequate submittal log, and failure demand waste reflected by the percentage of submittals that were Rejected or Revise & Resubmit, requiring additional work to be approved. Value enabling work was reflected by the high number of submittals that are Approved as Noted, which ultimately required minor adjustments before being ready to be distributed to subcontractors. Lack of information, a result of poor communication, was identified as a major source of failure demand. Furthermore, Subcontractors’ vendors who prepare the submittals are not on site. As such, the vendors do not know what is happening on site at specific times because construction projects are fast and dynamic.

The use of Lean Construction principles (i.e., increase transparency and focus control on the entire process) were used in this study to map the process and collect indicators about its performance so that wasteful practices and problems could be properly identified and targeted in future initiatives. The study revealed that the inspection of submittals performed by the GC and the upfront coordination with subs (i.e., matching submittals to the A/E review needs, creating value demand) reduced failure demand and consequently the share of non-value adding activities (e.g., waiting, rework).

Companies usually track field productivity and other indicators but forget to track office-related performance, which accounts for overhead costs and can make or break businesses during tough times. The authors suggest that, using the method and variables presented in this paper, companies take the first step and map their administrative processes to visualize the chain of tasks necessary to process information at their offices. Once the process and its variations are mapped, indicators should be defined and tracked against current estimated values used for scheduling purposes. Results might be used to drive improvements at the company level (e.g., development of realistic/reliable schedules) and at the industry level (e.g., start a conversation about the way specification books are defined).
Finally, the results of the study presented are limited to the management of the submittal process, which was selected based on the fact that submittals are part of AEC projects and their importance to support field activities. However, the relevance of such study and its results could be amplified if the scope of processes covered could be expanded to include the impact the submittal process and other office-related processes have on the performance of design, shop, and field operations, and ultimately on scheduling decisions. Such study could provide additional theoretical contributions regarding the management of AEC office-related processes, and engineering project-based organizations alike.

PRACTICAL IMPLICATIONS

The study revealed the need to improve the transparency of office-related processes by making them directly observable through the use of indicators, and working to improve their reliability through the identification lead time variation causes. Much attention is devoted to the transformation activities and their automation; however, flow activities (transportation, inspection, and waiting) need attention as they also impact process lead times and might result in distorted estimates used to develop (unreliable) schedules. Finally, the findings suggest that the software used in the Case Study inherited the problems of the process (batching practices and managerial routines) when it was managed using Excel; the problems were simply automated with a new tool and flow activities remained unchanged. This highlights the need to balance improvements in transformation and flow activities, and the importance of screening documents for problems to avoid rework and variability in the flow of work, which result in higher lead times to complete the approval process.

ACKNOWLEDGEMENTS

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REFERENCES


Lump Sum Bidding for Building Projects.” 47th ASC Annual Conference Proceedings. University of
Nebraska-Lincoln, Omaha, 8pp.

Version 1.3., June 2003

Seddon, J. (2008). Systems thinking in the public sector. The failure of the reform regime...and a
manifesto for a better way, Triarchy Press, Axminster, UK


Construction Using Value Stream Mapping.” Journal of Construction Engineering and Management,
135(8), 782-790
Table 1: Submittal process actual cycle times and lead times (days) – Pilot Case Study

<table>
<thead>
<tr>
<th>Submittals</th>
<th>Time</th>
<th>GC Review CT1&lt;sup&gt;a&lt;/sup&gt; (days)</th>
<th>A/E Review CT2&lt;sup&gt;b&lt;/sup&gt; (days)</th>
<th>GC Distrib. CT3&lt;sup&gt;c&lt;/sup&gt; (days)</th>
<th>Lead Time LT1&lt;sup&gt;d&lt;/sup&gt; (days)</th>
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<tr>
<td>Estimated</td>
<td>Mean</td>
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<td>14</td>
<td>3</td>
<td>20-22</td>
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<td>Project (total = 124)</td>
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<td>Approved (total = 47)</td>
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<td>Approved as Noted (total = 70)</td>
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<tr>
<td>Quality</td>
<td>Mean</td>
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<td>15.7</td>
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<td>Product Data (total = 42)</td>
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<td>Median</td>
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<tr>
<td>Nominal</td>
<td>Mean</td>
<td>7.9</td>
<td>14.7</td>
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<td>Procedural</td>
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<td>Median</td>
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<td>10</td>
<td>6</td>
<td>25</td>
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Legend:
- <sup>a</sup>CT1 – Cycle Time 1 (GC Review Time)
- <sup>b</sup>CT2 – Cycle Time 2 (A/E Review Time)
- <sup>c</sup>CT3 – Cycle Time 3 (GC Distribution Time)
- <sup>d</sup>LT1 – Lead Time 1 (LT1 = CT1 + CT2 + CT3)
Table 2: Summary of cycle times and lead times – Case Study

<table>
<thead>
<tr>
<th>GC Approv. Status</th>
<th>Total submittal packages (unit)</th>
<th>A/E Approv. Status</th>
<th>Submittal packages (unit)</th>
<th>CT1&lt;sup&gt;α&lt;/sup&gt; (days)</th>
<th>CT2&lt;sup&gt;β&lt;/sup&gt; (days)</th>
<th>CT3&lt;sup&gt;γ&lt;/sup&gt; (days)</th>
<th>LT1&lt;sup&gt;δ&lt;/sup&gt; (days)</th>
<th>Submittals resubmitted (unit)</th>
<th>CT4&lt;sup&gt;ζ&lt;/sup&gt; (days)</th>
<th>LT2&lt;sup&gt;η&lt;/sup&gt; (days)</th>
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<td></td>
<td></td>
<td></td>
<td>µ</td>
<td>m</td>
<td>µ</td>
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Legend:  
A – Approved; AAN – Approved as Noted; RR – Revise and Resubmit; Wait. – Waiting; µ - mean; m - median  
<sup>α</sup>Cycle Time 1 (GC Review Time)  
<sup>β</sup>Cycle Time 2 (A/E Review Time)  
<sup>γ</sup>Cycle Time 3 (GC Distribution Time)  
<sup>δ</sup>Lead Time 1 (LT1 = CT1 + CT2 + CT3)  
<sup>ζ</sup>Cycle Time 4 (SC Review Time)  
<sup>η</sup>Lead Time 2 (LT2 = LT1 + CT4)  
*Work in progress  
**No data  
***Particular submittal had been submitted but not returned when the final data set was collected  
N/A – not applicable (Approved submittals by definition are not resubmitted/revised)