Identification of Late Deliverables and Their True Impacts to Industrial Construction Projects

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ABSTRACT
Given that a construction site is both temporary and unique, the outcome of every construction project is dependent upon having all of the proper resources delivered to the site at the appropriate time. Although construction supply chains, logistics, and materials management systems have been scrutinized in recent years, the full range of potential late deliverables has not yet been investigated. Furthermore, the true impacts of these late deliverables are much more far-reaching and less understood. This paper, part of a larger research project being developed by the Construction Industry Institute Research Team 300, describes the process followed to list and categorize common late deliverables to industrial construction sites using team knowledge, expert interviews, industry surveys, and in-depth case studies as well as a review of the existing literature on the topic. This information will serve as a starting point for an investigation into how these late deliverables impact the cost, schedule, quality, and safety performance of construction projects along with the effects on the organizations involved. The enumeration and classification of these project impacts, incorporating the perspectives of both owners and contractors, are also described in this paper.

KEYWORDS
Late Deliverables, Impacts, Construction Site

INTRODUCTION
The construction industry is an integral part of a country’s economy, yet it is an industry constantly plagued by poor cost, schedule, and safety performance, low profit margins, poor productivity, compromised quality, price escalation, and a lack of innovation worldwide (Yeo and Ning, 2004). Of the countless factors that lead to these performance issues, materials delivery and handling has been identified as a major concern for the industry. A significant amount of research has been conducted
within the field of construction supply chain management, materials management, stakeholder relationships, and work packaging in an attempt to improve the reliability of construction material delivery and coordination on site. However, supply chain materials represent only a fraction of the late deliverables to construction sites that can adversely affect the time, cost, quality, and safety performance of the industry. Very little existing research investigates the full spectrum of resources that must be in place for a project to succeed, and these resources are often poorly tracked throughout a project. Moreover, the broad impact of late deliverables to construction projects is even less understood.

Construction projects have multiple and often conflicting objectives that must be met for a project to be considered a success. Both the construction industry and a project’s goals are dynamic in nature, and success means different things to different people at different points in a project lifecycle (Chan and Chan, 2004). Typically, time and cost performance are the predominant criteria, but these are not the only indicators of project success or failure. In construction, safety and quality risks, although less often measured, are equally important in determining the outcome of a project. These make up the third and fourth set of objectives that must be managed appropriately for a project to succeed. A fifth set of objectives exists within the realm of the companies and individuals participating on a project. Each stakeholder, from the company involved to an individual laborer, has a set of objectives and expectations that contribute to and are derived from the project’s outcomes. These measures for a company can include the profit of the project, the opening of a new market or project capability, technology innovations, and an improved reputation or relationship. For the individual stakeholders, goals can include morale, working relationships, advancement in the company, or recognition. This organizational capacity, along with the aforementioned cost, schedule, quality, and safety goals of a project, comprise the five pillars of project performance being investigated as part of this research. Though the goals and objectives of individual and organizational stakeholders are both abundant and dynamic, they must be collectively managed for a project to succeed.

In order to aid the construction industry in successfully meeting these five pillars of project performance, the Construction Industry Institute (CII) has commissioned Research Team 300 to enumerate common late deliverables to the construction site for industrial projects. Further, the research team is challenged to both identify and describe, both qualitatively and quantitatively, the true impacts these late deliverables have throughout a project’s lifecycle. The final objective of the research team is to identify, where possible, leading indicators of late construction deliverables. This paper describes in detail the data gathering methods used by the research team in pursuit of these objectives.

LITERATURE REVIEW

This literature review contains an investigation into the types of late deliverables that affect the construction industry as well as how they have been shown to affect individual projects across all industries and sectors. The study of relevant literature reveals that there is great variety in potential late deliverables, and the impacts caused by each are similarly numerous and diverse. The impacts found in
a literature review are far-reaching and difficult to categorize, but the effects have been well documented in a range of studies covering different topics.

Early studies in construction motivation reveal that crews were demotivated by a lack of materials and tools, foreman were dissatisfied with poor working arrangements such as missing essential materials and equipment, and superintendents were frustrated by delayed architectural and engineering drawings to the site (Borcherding, 1972). From this, it can be deduced that field workers at all levels are dependent upon proper resource management not only for effective work and productivity, but also for job satisfaction.

Along with impacting crews, it is well known that late deliverables can lead to construction delays, and these delays are huge impediments to project success. Knowing this, significant amounts of research have investigated the various causes of construction delays, and several studies have explicitly drawn the link to late deliverables. One study examining the causes of construction delays in Hong Kong attempted to enumerate and rank the most significant factors that delayed building projects using interviews with contractors, clients, and consultants (Kumaraswamy and Chan, 1998). The top ten factors identified as delay causes in the study were ranked by a calculated relative importance revealing that four of the top ten hypothesized factors in the study can be directly associated with late informational or physical deliverables to the construction site. These include delays in design information (#3), lack of communication between consultant and contractor (#4), client-initiated variations (#7), and improper control of site resource allocation (#10). These four factors can all be attributed to a delayed delivery of necessary resources to the construction site (i.e. designs, correspondence, materials, equipment). Perhaps more importantly, of the four primary stakeholders identified (design team, project team, contractor, and client), each is responsible for one of these delay causes. Thus, it is both the opportunity and responsibility of each stakeholder to make resources available to the site at the appropriate times.

In assessing the risk to the construction schedule, it is easy to identify additional resources that, if not available at the right time, can delay the project. One study identified 85 specific risks to project schedules, with on-time delivery of resources and one of the highest risk factors for the procurement phase (Mulholland and Christian, 1999). A similar study into the causes of delay to large construction projects revealed 73 causes of delay for projects in Saudi Arabia (Assaf and Al-Hejji, 2006). Lateness and unavailability of resources made up 26% of the observed delay causes for the sample of projects. Of the 73 causes of delay, 19 are attributable to late deliverables, including late payments, designs documents and reviews, decisions by owners, engineers and consultants, site availability, materials, and permits along with shortages of equipment and labor. Of important note from the study is that every project stakeholder can cause delay through late delivery of required information, materials, or human resources (Assaf & Al-Hejji, 2006).

One specific late deliverable that can cause serious delays to a construction project is various permits, which can be internal or external to the project. One inquiry found that building permit approvals were the most critical cause of delay for a selection of 380 building projects in the state of Florida (Ahmed et al, 2002). The same research found that late fabricated materials were the third most common cause
of construction related delay. Perhaps more revealing is the identification of these two causes of delay as having an occurrence of greater than 50% in the sample of projects (Ahmed et al, 2002). Similarly, a study of 130 residential and small commercial projects also found that late materials and equipment were a major cause of delays along with notices to proceed being later to site (Al-Momani, 2000).

Beyond schedule delays, cost overruns are another impact that can hamper project success. Recently, a study into the causes of construction cost overruns in Malaysia found that the late delivery of materials was the tenth most significant factor faced by contractors, and the late delivery of equipment was the eleventh most common source of cost overruns (Rahman, Memom and Karim, 2012). Moreover, lateness of equipment was the highest ranked machinery-related cause of cost performance issues according to the contractors interviewed. However, beyond these causes of cost overruns that explicitly cite late deliveries, late resources may also cause several of the other factors found in the study. These include availability and shortages of materials and equipment along with delays in payments. The same study goes on to indicate that “late or irregular delivery or wrong types of material delivered during construction affect the utilization of other resources like manpower and machinery” and can lead “to poor productivity, time delay and cost overrun” (Rahman, Memom and Karim, 2012). Beyond the material and equipment deliverables, the study also cites labor absenteeism and shortages as top twenty causes of cost overruns, either of which could be attributed to late human resources, depending on the situation. Given that cost performance is one of the most tracked indicators of project success, it is important that the connection between these late items and cost performance is established.

It has also been shown that late deliverables can impact project quality, along with schedule and cost performance. A study in lean construction found that the “late delivery of drawings and materials which lead to contractors pressurizing for quicker response” might lower quality performance on fast track projects (Kumar, 2010). The same study found that although schedule buffers can help shield contractors from late deliveries, the “shielding is expensive, in both time and money.” Similarly, when management attempts to make up for delays by exerting pressure on crews to work faster, implementing overtime, and/or hiring additional crews, the short-term progress may improve but at the expense of several identifiable consequences (Ford, Lyneis and Taylor, 2007). Working faster or for longer hours increases the risk for quality errors and reduces productivity, and increasing staffing levels reduces short-term productivity while new crews are trained as well as long-term productivity from the inherent inefficiencies of a crowded worksite. Beyond these primary impacts, potential secondary “knock-on” impacts include out of sequence work, trade stacking, increased rework to fix errors, and organizational impacts to turnover and morale.

Other research into the procurement of engineered equipment, with its inherent time and schedule uncertainty, has revealed several different project impacts in comparison to late bulk materials. One investigation distinguished engineered equipment, in contrast to bulk materials, as major “capital equipment that will be assembled or installed to form an integral part of the constructed system or facility” (Yeo and Ning, 2004). Major engineered equipment is characterized by several risks that could provide insight into the root causes of late delivery. These risks include
long lead times, incorporation of complex or specialized technology, and lack of inventory buffers. These risks are compounded by the typical location on the critical path and one-of-a-kind nature. The research continued with a survey of industrial/process, building, and civil construction projects with significant engineered equipment requirements. The responses showed that major equipment made up about 36% of the overall procurement costs for the projects, 50% of that equipment was delivered just-in-time, and around 20% was delivered late. Results highlighted the importance of regular communication, expediting, and the necessity of on time delivery for project performance.

Beyond the physical construction materials and permits required to complete a project, informational deliverables can have an equally significant impact on a project’s success. Dr. Glenn Ballard of the Lean Construction Institute points out that, with the overlap of the design, procurement, and construction phases in EPC projects and lean construction, engineering has become a supplier to construction (Ballard, 1993). The engineering firm must provide drawings and specifications to procurement and construction teams in the same manner as external suppliers. Although these engineering deliverables are “critical inputs” to construction just like materials, one of Ballard’s studies of an industrial project found that, on average, “more 30% of engineering deliverables were behind schedule.” In addition, the average number of days beyond the scheduled delivery milestones was 56 days, but this project still finished on schedule. Ballard also found the root causes of engineering delays were inadequate materials, non-standardized processes, poor goal setting, and an inability to understand or manage risks on the project. Further, the construction phase “was usually able to absorb the late and out-of-sequence delivery of drawings and materials, but at a tremendous cost” (Ballard, 1993). However, beyond these cost and schedule impacts, no other pillars were investigated.

Significant research has been performed in the fields of construction material management and construction supply chain management. Late deliverables can have substantial impacts on materials management on the construction site. As shipments arrive out of order, material handling may increase and flexibility to accommodate changed work sequences becomes a necessity. In a case study examining a delayed shipment of steel, researchers noted the haphazard unloading of the late shipment with no regards for the construction sequence and, when construction resumed, material handling and the required time increased significantly (Thomas, Sanvido and Sanders, 1989). The storage area became crowded with steel and the condition continued for several days until the erection process was back on track. Meanwhile, the erection crews were forced to demobilize while waiting for the steel to arrive and, upon remobilization, had to work in very crowded and difficult conditions.

Another research project investigated how material delivery and availability can impact small and medium sized construction projects. The most common problems with materials for the projects studied included interruption to the work schedule, rework from having the wrong or out-of-order materials, and double handling because of inadequate materials (Donyavi and Flanagan, 2009). These main problems were an effect of materials being delivered at the wrong time and the lack of information provided for materials arriving on site, among others. Additional
issues experienced include material deterioration during extended storage periods, expenses associated with crews lacking proper materials, and lost items on or off site.

RESEARCH METHODOLOGY

This review of existing literature provided the research team with a starting point from which to begin creating a more comprehensive list of both late deliverables and subsequent effects. In order to further develop the list of potential late deliverables and their effects to construction sites, several data gathering methods were employed. These included case studies with Construction Industry Institute (CII) member companies, surveys of construction industry professionals, and interviews with both research team members and other construction experts.

Interviews

Several interviews were conducted with construction industry experts at various companies that included both owner and contractor organizations. These interviews were not conducted in relation to any particular project, but rather to gather information from the many years of combined experience of the interviewees, who represented several different levels within their respective organizations from construction and project managers up to company executives. The goal of the interviews was to create a starting point from which to build the database of late deliverables and impacts. Using the knowledge of past late deliverables to construction sites, the research team was able to synthesize a first draft of categories to encompass the list of late deliverables. Interviews were also used to create a list of actual and theoretical impacts of late construction deliverables, and these impacts were then synthesized into categories of similar impacts to be refined further.

Industry Surveys

A second research tool introduced for data collection was a survey of construction industry members. The survey was administered in two mediums: the first during an interactive presentation of the research project and the second online for distribution to construction industry members.

Interactive Presentation Survey

The first round of the survey was completed very early in the research project at the 2012 Construction Users Roundtable (CURT) National Conference as an interactive presentation. The outline of the research project was presented with audience questions interspersed throughout. For example, questions asked about how often late deliverables affected construction projects, how often each of the five pillars was impacted, what are the most common late deliverables, and how late deliverables impact planning, management efforts, and labor. The answer choices were not quantitative but rather perception-based. With these responses, the research team was able to further refine the research targets and to gain insight into the industry member’s thoughts on late deliverables and the research effort.

Online Survey

After revisions and the addition of new questions, the survey was made available online and distributed to CII and CURT member companies. The survey questions were developed by the research team to gather information about late
deliverables and consequent impacts from the respondent’s past experiences. Each respondent was asked to consider a single past project when answering the questions in the survey so relationships between specific late deliverables and their subsequent impacts could be retained. Questions covered general project information such as delivery method, contract type, project sector, and overall cost as well as specific information regarding the use of front-end planning, stage-gate processes, and similar company-specific information. The survey then moved into the types of late on the project and the subsequent impacts along with how these effects were handled by the project team. The information from the online survey was then combined with that of the interviews and literature review to create a more comprehensive list of late deliverables and impacts and begin to define categories of each.

**Rating Survey**

A third survey was distributed among CII member companies and at the 2013 CURT National Conference with the purpose of ranking the various types of late deliverables and impacts with respect to commonality and severity. This survey consisted of five questions, with the first being whether the respondent worked for a owner, contractor, or engineering company. The next four questions were based on a one to four scale, and the respondent rated the commonality and severity of each type of late deliverable and impact from late deliverables that the team had developed. Using the 240 responses, the average commonality and severity of each late deliverable and impact category was developed for owners, contractors, and overall.

**Case Studies**

Case studies were also employed to investigate late deliverables to construction sites. As part of the data collection, the research team has conducted two types of case studies: ‘mini’ case studies and in-depth case studies.

**‘Mini’ Case Studies**

Much like the online industry survey, ‘mini’ case studies were used to help expand and validate the categories of late deliverables and impacts. The research team conducted a breakout session at the CURT Winter Member Meeting in February 2013, and attendees were asked to complete a questionnaire similar to the online industry survey. Participants were again asked to consider a single project affected by a late deliverable and to list specific impacts to the project. Additional questions regarding contingencies, replanning, the critical path, progress monitoring, turnover, and other related topics were also included, mostly asking for yes or no responses.

**In-Depth Case Studies**

The primary method for data collection was in-depth case studies of recently completed or near complete construction projects, which were selected based on several criteria. The primary criterion for the case study selection was to fulfill each late deliverable category. Other secondary criteria were used to maintain variety in the nine case studies selected, and this, as well as the primary late deliverable categories fulfilled, is shown in Table 1 for each case study.
Table 1: In-Depth Case Study Development Criteria

<table>
<thead>
<tr>
<th>Sector</th>
<th>Location</th>
<th>Site</th>
<th>Cost</th>
<th>Late Deliverable Category Fulfilled</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mining</td>
<td>Northeast</td>
<td>Greenfield</td>
<td>$47.0 MM</td>
<td>External Permits</td>
</tr>
<tr>
<td>Oil &amp; Gas</td>
<td>Southeast</td>
<td>Brownfield</td>
<td>$14.5 MM</td>
<td>Engineering Documents, Approvals and Responses</td>
</tr>
<tr>
<td>Oil &amp; Gas</td>
<td>Asia</td>
<td>Greenfield</td>
<td>$1.56 B</td>
<td>Fabricated Materials</td>
</tr>
<tr>
<td>Oil &amp; Gas</td>
<td>Southwest</td>
<td>Brownfield</td>
<td>$51.0 MM</td>
<td>Engineered Equipment</td>
</tr>
<tr>
<td>Power</td>
<td>South</td>
<td>Brownfield</td>
<td>$827 MM</td>
<td>Construction Equipment; Engineering Documents</td>
</tr>
<tr>
<td>Process</td>
<td>Midwest</td>
<td>Brownfield</td>
<td>$58.6 MM</td>
<td>Human Resources; Engineering Documents</td>
</tr>
<tr>
<td>Process</td>
<td>Southwest</td>
<td>Greenfield</td>
<td>$1.00 B</td>
<td>Bulk &amp; Fabricated Materials; Prefabricated Assemblies</td>
</tr>
<tr>
<td>Process</td>
<td>Southeast</td>
<td>Brownfield</td>
<td>$56.7 MM</td>
<td>Utilities and Infrastructure</td>
</tr>
<tr>
<td>Power</td>
<td>Southwest</td>
<td>Brownfield</td>
<td>$120 MM</td>
<td>Project Execution Planning; External Permits</td>
</tr>
</tbody>
</table>

Each in-depth case study was comprised of several interviews with project team members along with an investigation of relevant project schedules, cost breakdowns, safety reports, change orders, and other project documents. A minimum of three interviews were conducted for each case study with project team members at various hierarchical levels as well as across company divisions, which allowed for varying perspectives and areas of expertise to expand and validate the information gathered during the case study. Standardized cost and schedule data was also gathered along with any pertinent safety information (recordables, near misses, first aids) and quality documents (non-conformance reports, field change notices). This information was supplemented with project team knowledge to create a narrative surrounding each late construction deliverable and its true impacts on the project.

**FINDINGS**

By combining the literature review knowledge with the team’s research, late deliverable categories and the project impact categories have been developed and finalized as shown in Table 2. Through the case studies and industry surveys, the research team concluded that these categories incorporate all of the potential late deliverables and impacts to construction sites, and each has been defined to provide further distinction between each and ensure the lists are comprehensive. Furthermore, these categories are force ranked using the product of the severity and commonality rating from the rating survey.

Table 2: Late Deliverable and Project Impact Categories

<table>
<thead>
<tr>
<th>Late Deliverable Categories</th>
<th>Project Impact Categories</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Engineering Documents/Approvals</td>
<td>1 Scope Changes</td>
</tr>
<tr>
<td>2 Engineered Equipment</td>
<td>2 Productivity</td>
</tr>
<tr>
<td>3 Fabricated Materials</td>
<td>3 Engineering/Design Work</td>
</tr>
<tr>
<td>4 External Permits</td>
<td>4 Work Resequencing</td>
</tr>
<tr>
<td>5 Prefabricated Assemblies</td>
<td>5 Overtime and Shift Work</td>
</tr>
<tr>
<td>6 Project Execution Planning</td>
<td>6 Critical Path Management</td>
</tr>
<tr>
<td>7 Human Resources</td>
<td>7 Commissioning/Start-Up</td>
</tr>
<tr>
<td>8 Utilities &amp; Infrastructure</td>
<td>8 Rework</td>
</tr>
<tr>
<td>9 Bulk Materials</td>
<td>9 Craft Levels/Density</td>
</tr>
<tr>
<td>10 Construction Equipment</td>
<td>10 Downtime</td>
</tr>
<tr>
<td>11 Project Risk Changes</td>
<td>23 Damage, Degradation, and Loss</td>
</tr>
<tr>
<td>12 Indirect/Overhead Costs</td>
<td>24 Training Resources</td>
</tr>
</tbody>
</table>

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Beyond the encompassing list of late deliverable and impact categories created, the research team has made several additional observations thus far. To begin, the team has noted the full range of impacts from late deliverables is rarely understood or tracked on construction projects. Although cost and schedule are consistently tracked on all projects, ties to the quality, safety, and organizational impacts were less often revealed in interviews and required additional research to uncover these relationships. Given the dependence of construction projects on all project pillars, it is essential that both individuals and companies understand the impacts of late deliverables throughout the entire project lifecycle.

Furthermore, the research team discovered through the multiple interviews and case studies that knowledge of the impacts of late deliverables is not uniform among those stakeholders and individuals involved on construction projects. To begin, late deliverables affected owner and contractor organizations differently and the knowledge gathered from each, though in many ways similar, had unique aspects. Although common themes among owners and contractors were found, the research team also observed that the impacts noted differed between contractor companies and between owner organizations. Finally, the research revealed that individuals at different levels and positions within a single company focused on specific impacts of late deliverables. For example, most project team members, when interviewed, were predominantly focused on their responsibility within a project. For example, while the project controls manager had detailed insight into specific cost and schedule impacts and the safety manager could recall specific safety risk changes, a project executive who has less knowledge in these more specific aspects could provide greater insight into the internal and external organizational impacts. By gathering all of these complimentary views from various companies and industry professionals into one knowledge base, the research team believes that companies will be able to more fully understand the true impact of late deliverables and improve project team alignment helping ensure project success.

CONCLUSIONS AND FURTHER RESEARCH

Thus far, CII Research Team 300 has created an encompassing list of late deliverable categories as well as categories of the resulting impacts. These categories were created through a literature review, interviews with construction experts, industry surveys, and project case studies. Using the same method, the team was also able to validate the existing categories as the research progressed; categories evolved, and a clear definition of each was drafted. With this knowledge and a set of standardized definitions for the categories, the team now proceeds into the second half of the research project. It is the goal of this research to create an encompassing list of impacts caused by late deliverables. A database will be formed linking the late deliverables with their observed impacts along with the pillars affected. The final piece of the database will be a set of leading indicators developed by the team and tied to each late deliverable, along with a force ranking of each late deliverable and impact by its commonality and the severity of its impact to a project. The ultimate goal of the research team is to develop a graphical tool for industry use with this data. Then, an owner and a contractor will test a prototype allowing the research team to gain feedback and make any improvements before the research project is finalized.
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