A Case Study of a Complex Project: Lewis and Clark Bridge Deck Replacement Project

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Successful management of complex transportation projects requires a fundamental change in how projects are planned, developed, designed, procured, and constructed. Project managers of complex projects must ultimately optimize the available resources with the technical performance needs of the project while operating under both known and unknown constraints. In order to better understand the key tools for successful delivery of complex projects, a case study for the Lewis and Clark Bridge Deck Replacement project was conducted to investigate techniques that were effectively used for complex project management. In order to understand the complexity issues and effective techniques, an extensive literature review and structured in-person interview with personnel involved in the Lewis and Clark Bridge project was conducted. Effectiveness of incentive clauses in contract documents, importance of public outreach, and usefulness of the public communication plan are some of the research findings. Practitioners may benefit from the research results describing issues in complex project management and effective tools to solve the problems associated with complex transportation projects.

Key Words: Complex Projects, Case Study, Project Management, Bridge Project.

Introduction

The problem with traditional project management cost and schedule control is particularly acute in large, complex projects, as noted in the final report of NCHRP Project 20-69: *Guidance for Transportation Project Management* (Marshall and Rousey, 2009). Results from this study indicate that of projects over $5 million in construction costs, less than 20% were on or under budget and only 35% were delivered on time. The study further identifies a number of factors that contribute to cost and schedule issues, including difficulty in obtaining the rights-of-way, utility conflicts, underground conditions, environmental and political issues, design problems, lack of accountability, inadequate protocols, and lack of coordination between project development phases. The study concluded that most of these issues can be mitigated by using effective project management protocols and procedures, specifically early and consistent coordination between departments and agencies responsible for these project tasks from the beginning of the project. The study demonstrates the need to train project managers to think of the project as an entire integrated system in addition to managing each of the individual phases.

The University of Manchester developed an excellent conceptual framework and synthesizing field study of the changing nature of project management in 2003, entitled “Rethinking Project Management” (Winter and Smith, 2006). The project brought together industry, government, and academic experts on the management of complex projects. The study aimed to identify the needs for project management research and to update the current practice by identifying the evolution of fundamental project management theories. The researchers applied a rigorous approach to this problem and developed a framework called “Five New Directions of Thought” to define the difference between routine project management and the management of complex projects in the 21st century. Direction 1 portrays the shift from a “life-cycle theory of projects and project management” to a “complexity theory.” Essentially, this change entails recognizing that projects are influenced by more external agents than just technical engineering and construction means and methods. The authors advocate developing multiple theories to account for multiple external influences, in contrast to current methods that treat external influences as risks. Following directly from the move to complexity theory, Direction 2 emphasizes a change from conceptualizing projects as a series of static, linear, and discrete events toward recognition of the interactive, interpersonal, and dynamic nature of modern projects. With the final Direction, Direction 5, the Winter and Smith (2006) report seeks to shift the practice from training project managers to use various analytical tools to inspiring project managers to be thoughtful, resourceful, and pragmatic in the application of their education and experience to managing complex projects.

However, managing complex systems has not traditionally been a centerpiece of educational programs, professional development, industry practice, or agency structures. This has led to calls for a special class of project managers who are specifically trained through new standards, training programs, and certification processes to manage complex projects (Whitty and Maylor, 2009).

One of the key underlying assumptions to this research is that the ability to successfully manage complexity is directly related to the ability to integrate the project team across the entire life cycle. The integrated project team must be able to meet both the task objectives associated with careful planning and execution of scope, cost, schedule, quality, and technical design issues while at the same time carefully managing the administrative and human relation tasks of contract compliance, stakeholder communication and negotiation, team member motivation, and labor recruitment and retention. The task and relational skills required from project managers will need to be active from the very earliest stages of the project through to construction completion. This includes recognizing that factors other than cost and schedule can be used to define project success.

Successful management of complex transportation projects requires a fundamental change in how projects are planned, developed, designed, procured, and constructed. Among the transportation network components, highway bridges are critical components of the nation's transportation network since a bridge controls the capacity of the system (Barker and Puckett, 1997). The research team investigated eighteen different projects to explore successful tools for successfully managing complex transportation projects. This paper presents a successful bridge project to identify techniques that were effectively used for project management of this complex bridge project.

The Lewis and Clark Bridge Deck Replacement project was selected for study because the project was regarded as a complex project that showed successful results. This project was included in the SHRP 2 R-04 research project on innovative construction technologies for rapid bridge renewal because the project team utilized innovative methods that yielded satisfactory results in the traditional cost, schedule, and technical management while also managing risk associated with external issues. The major reasons that the project was complex include 1) significant impacts on the surrounding communities, 2) significant impact on the road users, and 3) the newness of the delivery and procurement method chosen by the owner. The complexity issues and effective project management tools were implemented to solve those issues defined by the traditional three aspects of the project management (cost, schedule, and technical) as well as external issues (context), which are becoming more and more abundant on complex transportation projects. The paper presents the findings from the case study.

Research Objective and Methodology

The objective of the research was to identify complexity issues and effective techniques used to manage the complexity issues found on Lewis and Clark bridge deck replacement project. The case study methodology was utilized to fulfill this objective. By examining the case study project, the research team hoped to find lessons learned to identify effective techniques given the circumstances of the complexity issues.

Case studies can be utilized to look in-depth at a case to focus on attitudes, behaviors, meanings, and experiences by obtaining information from a number of different sources related to a project. Case study research in construction has encountered much criticism, including small sample size and unwarranted generalization of results, lack of trust of participants, and rigor of protocol (Taylor et al. 2009). To address these criticisms, the research team used a variety of methods, including using different sources of information, maintaining a chain of evidence, and searching for patterns among the data through data coding (Taylor et al., 2009; Yin, 2002). The primary input to the case studies was gathered through structured interviews with agency personnel, contractors, and consultants that have been part of teams involved with the identified projects. The structured interview outlines were developed similar to the method prescribed by the U.S. Government Accounting Office (GAO, 1991). The GAO method states that structured interviews can be used where "information must be obtained from program participants or members of a comparison group… or when essentially the same information must be obtained from numerous people for a multiple case-study evaluation" (GAO, 1991). Both of these conditions apply to this project. Therefore, the tool is appropriate for the research.

The process involves developing a questionnaire that is made available to each interviewee prior to the interview and then collecting responses in the same order using the same questions for each interviewee. The information was gathered by face-to-face interviews. Time is given per the GAO method to ensure that the interviewee understands each question and that the data collector understands the answer. Additionally, interviewees were also allowed to digress as desired, which allows the researchers to collect potentially valuable information that was not originally contemplated. The structured interview for this project was conducted with a person who was at the project management level of the Lewis and Clark Bridge Deck Replacement project. Through the interview mostly qualitative information was asked and sought such as issues that contributed to the sources of complexity on various aspects of project management (cost, schedule, technical, and context), tools the project team utilized to satisfy the issues, effectiveness of each tool, and major issues that had a particularly heavy impact on the final project. The output is used to present the agencies' perspective on various points analyzed.

Complexity Issues

The Lewis and Clark Bridge Deck Replacement project over the Columbia River between Washington and Oregon was completed in 2004. It is 5,478 feet in total length with 34 spans carrying 21,000 vehicles per day. The cost of the deck replacement was split evenly by both states. The original bridge was built in 1929 and at the time of construction, it was the longest and highest cantilever steel truss bridge in the United States. To extend the life of the existing bridge by 25 years, a full-depth precast deck replacement was designed and executed. Total funding from all sources for this project was $29.8 million. The final total value of the construction contract was $24 million. When the construction schedule required full closure of the bridge, funds were used for other services such as overnight ferry operations and Medical Emergency Helicopter (Medevac) service to address public needs.

The Lewis and Clark Bridge Deck Replacement project has been in development for many years. Original project planning, including public hearing and design, began in 1993 but was put on hold in 1994 because the project team could not acquire public consent. Project planning and design resumed in 2001. The project was advertised and the construction contract was awarded in 2002. The public consent acquirement process was completed in nine years.

The project delivery method for this project was design-bid-build (DBB). When the project planning began in 1993, innovative project delivery methods to accelerate project schedule such as design-build (DB) were not available. In 2001 when the project planning and design were re-discussed, the planning and preliminary scoping process for the project was too far along to be a good DB option. Therefore, DBB Best Value was the method of project delivery and procurement chosen by the owners, the Washington Department of Transportation (WSDOT) and the Oregon Department of Transportation (ORDOT). The Associated General Contractors of America defines Best Value as "a procurement in which qualifications, design (where applicable) and price or cost are weighted, and the qualifications and total construction cost of each competitor, including cost of the work, are applied against the relative weights of the other competitors, to identify the designer or constructor whose proposal represents the greatest value to the owner." The combination of the traditional DBB method of delivery with procurement through a method other than low bid is innovative in the transportation industry.

Cost Complexity

Public satisfaction was a major driver for this project to utilize a more complex construction strategy. The easiest and fastest construction could be achieved by full closure of the bridge during the entire project duration. However, the bridge was the only connection between Washington and Oregon within one hour driving distance along the border line of the states. Many of the Oregon-side residents commuted to Washington, and, there were very limited medical services available for the Oregon residents. If the bridge was fully closed, Oregon-side residents would have very limited medical services and commuting problems. Therefore, in order to reduce project impact on the traveling public and local communities, partial closure – single lane closure during the days and full night closure – was decided to be executed for the project. Under traditional means and methods, the partial closure would lead to long project duration. To avoid such a long project duration, accelerated construction was required, which could have potentially lead to dramatic increases in the project budget. In order to accommodate to accelerated construction under a controlled budget, an incentive contract was selected for the project. There were two types of incentives in the contract, bid incentive and early completion bonus. The bid incentive consists of the number of hours of single lane closure and the number of days of night closure. In addition, contract financial bonuses were given for early completion. This new type of project delivery method, incentive contract, was new to WSDOT and represented an innovative contracting method that was unfamiliar to local contractors increasing uncertainty inside.

The tradeoff between a higher value product with less public impact and higher project costs affecting the design method was another source of complexity. The project team had to continuously look for design solutions to reduce public impact without increasing the project cost too much even though project cost was not the project team's major concern.

There was no formal cost risk analysis for this project. Cost control was not the biggest concern of the project team, either. However, because of the uncertainty of the estimate formation and new technology to replace the deck, early identification of construction issues were keys for cost control.

Schedule Complexity

One source of schedule complexity is that construction needed to be done within a reasonable timeframe with limited traffic impact. Milestones drove the project delivery method and risk. The project team needed to meet early completion for milestones and contractually established times to open the bridge to public. Therefore, the project team had to manage the project schedule more in depth to make sure to meet bridge closure requirements even though contractors had schedule control responsibility. Before every closure, night or weekend, the project team demanded that the contractor submit a closure notice in advance.

Clear distribution of authority and responsibility of the participants was another source of schedule complexity. When promises to the public were publicized, through radio or websites and published to local papers regarding times the bridge would open for traffic, they had to be met. So, authority and responsibility of the participants must be unambiguous to respond to any kind of situation.

As there was no cost risk analysis, there was also no formal schedule risk analysis for this project. However, because of the importance of the bridge closure, schedule risk was the primary source of complexity.

Technical Complexity

Contract formation such as use of incentives and A+B bidding was a source of technical complexity for the WSDOT since they were new forms of delivery methods and contracting that the project team had never experienced before where A+B bidding is a form of Best Value selection which weighs project cost (A) and schedule (B) together.

Design of the project was executed by in-house design staff. The in-house design staff experienced difficulties because the project had a very complicated technical design and modeling did not accurately predict that the existing bridge would behave differently under construction than the design team anticipated. Complexity of technical design and constructability was an issue. In the design phase of the project, the method of concrete placement was changed from standard cast-in-place to precast, which made the whole process complex. Applicability of Self Propelled Modular Transporter (SPMT) for delivery and removal of deck units was dependent on site-specific constraints, and was discussed with SPMT suppliers in the early planning stage.

Existing conditions made the project more complex from a technical perspective. Given the historical nature of the bridge, one requirement was that the bridge must retain the same general look after construction. Additionally, the bridge was a 70 year old steel structure that had inaccurate as-built drawings. Technical requirements also included the water quality (construction over the water, rain drainage issue) which must be kept the same. The originally structure also served as a home for birds, bird nests were present that were protected by law.

The work shifts of the owner's traditional project team required restructuring because of the time constraints caused by night and weekend closure.

Early review and analysis of the structure resulted in development and public support for the precast option. The precast option had more risks to delivery, requiring significant effort to review constructability to make sure project elements could be built within the closure constraints committed to in the construction contract. Issues raised in review were used to develop management and contingency plan for use as the project was implemented.

The source of technical complexity from reviews and analysis in the design phase continued into the construction phase.

Finally, interpretation of contracts and tolerance of surveying accuracy resulted in issues between designers and contractors because some provisions of the incentive contract were new to both sides.

Context Complexity

Minimizing the impact on public drove design options. It took over eight years to get consent for how the bridge was to be constructed from public stakeholders. And the significant drive time associated with detours for bridge traffic initiated the complexity of the project from a context dimension. The owner had to seek solutions to minimize traffic impact. User benefits were the major driver to go to more complex construction strategies such as incentive contracts, which the owner had not experienced before, night and weekend full closure of the bridge, and precast deck replacement. When the bridge was fully closed, other services were prepared. Such services included Medevac medical service helicopter for emergency responders, and supporting funds for an existing ferry service to operate overnight.

The project was a very high-impact project to the small local community, which drew much public concern. Prompt notification of the public of the project and its progress, particularly those matters directly impacting the public was a challenge and made the project complex.

Effective Tools

A number of tools were identified in this case study for managing the afore mentioned issues. However, not all issues resulted in an effective management tool, the effective tools are presented.

Effective Tools for Managing Cost Complexity

Incentive provisions in the bid packages that were prepared during the planning and procurement phases helped to control cost and schedule during the construction phase. The project team's open attitude to contractor's ideas to build a job with innovative methods of using SPMTs led to permission to use technology new to WSDOT, saving $10 million from the internal estimate with even better quality (FHWA, 2008). Collaborative work with contractors in early stages helped to solve problems with less money and reduced impacts to structural design or public impact.

Effective Tools for Managing Schedule Complexity

Construction strategies utilized reduced the time that construction on the bridge impacted traffic. The contractor revised the placement procedure using SPMTs with a specially designed steel truss frame for lifting and transporting precast deck segments that enabled contractors to meet the scheduling constraints. The SPMTs moved the new panel to the top of the bridge, removed the old panel that crews had just cut out, and then lowered the new panel into place before taking the old panel off the bridge, as can be seen in Figure 1 (Federal Highway Administration, 2008). Again, by using the SPMTs construction time on the bridge could be reduced minimizing traffic impact on the public even though overall schedule for the bridge completion remained unchanged.

Figure 1: SPMTs transporting new deck panel from fabrication site adjacent to bridge.

Along with the new technology, partial and full closure was one technique used to manage timeline requirements.

Inclusion of early completion provisions in the bid packages helped to keep milestones. The contractor earned incentives by utilizing three weekend bridge closures; this is one less than allowed by the contract. A total of 143 single lane closures was utilized that was 30 less than allowed by the contractors. The incentive provisions worked well for keeping milestones by minimizing traffic impact, but it did not accelerate the overall schedule of the project. Also, the project team developed a 40-point checklist for surveying the size of deck panels to ensure that the deck replacement work could be done within an 8-hour work shift so that the bridge could open to the public on time.

The project team developed a protocol plan to manage preconstruction and construction strategy concerning timing of action, responsible personnel to act, backup plan, and tasks to do first. This protocol plan clarified authority and responsibility of the participant's effectively.

The project team set up a communication plan to reduce schedule delay risk due to miscommunication or late response between the project team members. Also, the project team trained contractors and internal personnel to notify problems early so that the problems could be solved in early stages, resulting in less money and less impact on schedule in most cases. One of the techniques the project team used for the early notification was using camera phones to send pictures of problem parts right away to let the personnel who had responsibility and authority access real time information to fix the problems.

Post-problem meetings were another technique used whenever the project team faced milestone problems. Along with preconstruction strategy before the construction, post-problem meetings made the deck replacement procedures faster and better.

Actively seeking solutions for contractors was a technique to facilitate schedule control. The project team actively involved and coordinated local authority, police, and ORDOT to minimize schedule impact from outside factors.

Effective Tools for Managing Technical Complexity

The contract team worked with the project management team in the procurement phase to write contracts and develop contract language to translate stakeholder concerns into contract requirements.

The project team went through each step of night closure work with contractors to make sure it was doable in an 8-hour work shift. The project team broke each task into pieces for constructability review, had specific reviews in advance, and prepared what-if plans The same techniques used in the design phase were used in construction phase.

A protocol plan was strengthened from an existing one for emergency situations in the owner's internal structure.

Collaborative teamwork for issue resolution focusing only on technical solutions (how to do this) was the first step for dispute resolution. Then, the matter of who would pay was discussed later. This required trust between all project partners

Effective Tools for Managing Context Complexity

The project team prepared several options concerning construction methods for the public to choose from to manage public needs and expectations. The project team used a small physical model of bridge, which worked well to explain the bridge construction process. Medevac and closure predictability of a two week-block were other tools used for managing public concerns. However, excellent public participation was the biggest success factor of the project because the project team could hear their concerns.

An extensive communication plan was accommodated for maintaining capacity, which represented planning decisions made by the owner such as lane closures, detours, and time of construction activities (i.e. nighttime, weekends, etc.). The communication plan included; 1) Daily basis updated website; 2) Live webcam; 3) Local papers with weekly calendar; 4) Phone line to public; 5) Highway Advisory Radio (HAR); and 6) Email and text alert (signup basis).

Conclusions

There were many factors fortifying the successful project management of the complex Lewis and Clark Bridge project. In order to understand the complexity issues and effective techniques through detailed case study, the research team conducted an extensive literature review and structured interview with personnel involved in the Lewis and Clark Bridge project. The following conclusions are drawn from the case study project.

- Incentive/disincentive clauses in the bid packages were effective to control schedule and control.
- The project management team’s open attitude to contractor’s ideas and collaborative work with contractors in early stages were keys to success.
- Using prefabricated elements reduced construction time on bridge allowing less impact on traffic while the overall completion schedule remained unchanged.
- Partial and full closure was successful to manage the timeline and to meet public’s needs.
- A well designed protocol plan concerning when, whom, what if, and task prioritization was the most important internal success factor.
- A communication plan reduced miscommunication and late responses.
- Post-problem meetings along with preconstruction strategies reduced the possibility of upcoming milestone problems.
- Active involvement and coordination of outside authorities minimized external impact on schedule.
- Contract team’s collaborative work with project management team in procurement phase reflected project team’s concern in the contract when the owner chose to utilize a new, innovative contract type.
- Extremely detailed review of constructability, time-on-task analysis, and what-if plans were prepared for night closure, and they were very successful.
- A flexible internal structure of the owner expedited the project processes.
- Development of a small physical model of the bridge helped the public understand how the bridge project works, and facilitated the public’s choice for construction methods.
- Extensive outreach effort to stakeholders’ needs and expectations was a major factor in project success.

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