

Integration of IT Platforms to Improve Change Order Efficiency in Construction

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Today's economy has been rough on businesses across many industries. Construction is no exception. Owners and contractors alike are in need of ways to mitigate financial risk on current and future projects. One of the prime contributors to late and over-budget projects in construction is change orders. These changes and the required approvals can be highly detrimental to project budget and schedule. Current approval processes are slow, linear, and require a heavy amount of manual distribution between team members. Incorporation of IT based solutions into this process were shown to improve and streamline the process model, minimize resulting approval timeframes, and increase project team member support in continued use of the solution. These positive results are critical to those in the construction industry today and support the need for construction business leaders to investigate the installation of these systems into their current and future projects. Additionally, this research will open the door to further and more in-depth studies of the effectiveness and efficiency of these systems
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Key Words: construction, technology, change order, efficiency

Introduction

Today's economy has caused owners and contractors alike to mitigate financial risk throughout the course of construction projects from start to finish. A critical component of construction projects that can heavily affect the bottom line is the process of discovering changes in the field or by Owner request, subsequently reviewing the budgetary and schedule related costs associated with these changes, and ultimately approving or rejecting the change. As most construction professionals can tell you, these change orders can often be the critical factor that turns a successful project into an unsuccessful one. It is increasingly important that these changes be communicated quickly and accurately to the Owner, design team, and contractors so that costs can be assessed and decisions made in a timely manner. Delays in this process can cause a negative ripple effect on both the budget and schedule goals for the project. It is clear that there is an immediate need to improve the process of change order approval.

Information Technology (IT) solutions may offer a key opportunity in increasing the efficiency of this process. As technology has evolved, in particular with the advent of the internet and electronic mail, means and methods of communication have expanded greatly. As is the case with most processes across different industries, change order processing has become more and more efficient with the use of electronic submittal of change order information to vested parties. While this advancement has done wonders in speeding the process along, it ultimately has only shortened the durations of transmittal that were present in the existing change order process. There is great opportunity and need for technology to be integrated into the process in a more centralized way. The goal of this research is to understand the effect implementing an IT solution into the change order process will have. Ultimately, the efficiency of change order approval will always be a critical factor in the performance of construction projects, and understanding the effect of IT solutions of those approvals is essential.

The installation of such IT solutions into the change order process was analyzed against the backdrop of an existing construction project in order to demonstrate their value and effectiveness. The construction project analyzed was a $23 million renovation of a medical educational facility in the Midwest. Renovations for this project vary from small minor cosmetic upgrades in selected areas to full gut and remodel of existing spaces. As can be expected in a renovations project, change orders resulting from field conditions, Owner directed changes, and deadline changes were abundant and totaled nearly 150 project-wide. This project presented a prime opportunity for analysis for the installation of IT solutions for improving the efficiency of the change order approval process.

Previous research on the topic has revealed several issues that must be taken into account when developing these IT solutions. IT solutions must be paired with a strong corporate or team culture and dedication to the installation and proper use of the given IT solution (Issa & Haddad, 2008). When viewed in this light, these IT solutions serve to assist the project team, not motivate them. Berente et al. (2010) describes that the installation of IT solutions, also called information and communications technologies, requires dynamic interaction from the project team in order to truly function. When a dynamic team is paired with a strongly embedded IT platform, the system can work to generate more project knowledge than in more traditional project communication structures. The analysis of the renovations project described above is meant to combine these theories against the backdrop of the change order process specifically, thereby filling the gap that exists in previous research. The resulting research supports that strong team culture, dedication to the IT solution, and dynamic interaction from team members are integral to the success of increasing change order efficiency. Construction leaders must make deliberate efforts to foster these aspects of their business, as an efficient change order system can keeps projects on time and on budget, and ultimately result in the overall success of these projects.

Though not extensively studied in this paper, Building Information Modeling (BIM) is an emerging technology that is at the forefront of construction today. This process integrates all necessary building information from all included building systems into a comprehensive and unified electronic model. Gal & Yoon (2008) delved into this subject, explaining the positive impact it has on the construction industry. BIM and its potential integration into the change order process is a topic that, though not detailed in this work, deserves mentioning when discussing IT solutions and construction and is a potential starting point for additional research.

The findings below represent the analysis of the current process in place for change order processing in the construction industry, potential IT based strategies that can improve this process, the resulting changes in the process once a strategy is implemented, and the resulting data and benefits once this new process has been implemented.

Methods and Approaches

Several approaches were used to assess the viability and effectiveness of IT implementation solutions in the change order approval process. These approaches were applied, where appropriate, to the medical educational facility renovations project described above. First, business process model analysis of both the current change order process and proposed IT based change order process was conducted in order to find specific areas for improvement. This process essentially breaks down the multitude of events, activities, and information exchanges into their individual parts and maps out the necessary sequences and relationships needed for the process to complete. Business process modeling was appropriate for this research topic as the change order process is one that involves many different events and information exchanges under many predetermined sequence constraints. Second, observational data was recorded using the base change order process and the proposed IT based process for analysis and comparison. This data was recorded through the creation and continued use of change order logs. Lastly, interviews were conducted with project team members to attest to the viability and effectiveness of a new IT based change order process.

Business Process Modeling

In order to evaluate and measure the improvement of a process, one must truly understand the base process itself. From there, he or she can understand what aspects have been changed, how they have been improved, and how these changes can increase overall process performance.

Appendix A depicts the process model of the traditional change order approval process as it stands in construction today. This process, though greatly assisted by the speed of email, is ultimately hindered by a long line of sequence flows and processes that are required to grant final approval. This process relies on a fairly linear sequence of events that can ultimately extend the time needed for all parties to properly review, question, and approve the change to be implemented by the contractor in the field. Appendix B depicts the change order process with the addition of a Web-based Project Management System (WPMS) geared specifically for change order processing. In this process, the WPMS acts as a central hub where the change order information is hosted, where it can be accessed by all necessary parties in parallel. Questions and concerns can be posted for the group, eliminating the need for direct follow up by email. The WPMS in this study is similar to several other online project management tools in existence, such as Submittal Exchange or Sharepoint. This WPMS is unique as it integrates the Owner into the process. In most instances, Submittal Exchange is used as a submittal review tool for the design team and select contractors only. Sharepoint, in the author's experience, has in the past integrated Owners but has been a far less interactive tool than a change order review tool would require. The proposed WPMS integrates change order information, Owner access, and interactivity to expedite the review and approval process. The inclusion of the WPMS, as can be seen in appendix B, decreased the number of sequence and communication lines needed to gain final change order approval. This decrease in the number of steps and follow-ups will potentially result in decreased total approval time of change orders. Review periods for the Owner are expedited due to the automatic compilation of architect and engineer questions and comments on the WPMS. Questions regarding scope are posted for the Owner to review, not held within potentially private correspondence. All relevant information is presented to the Owner in an organized manner, which reduces time in digging up needed information for review. This decrease in processing duration equates to less negative impact on the project schedule, and as such, less negative impact on the project budget.

The above described WPMS process differs from the current linear process of change order approval. Currently, change orders are first emailed separately to the Owner and the Architect. At this point, the architect must first review the change order to ensure it aligns with the scope change necessary for the project. Any questions are communicated via email directly to the contractor. Once the architect has completed his or her review of the change order, he must manually send out approval notices to the Owner stating the scope is correct. From there, the Owner must then assess the need for the given change and then review the costs associated with said change. Any and all questions are communicated to the contactor. At this point, any questions or issues will be dealt with via clarification or amendment to pricing. If and when the Owner is satisfied that the change is warranted and costs are appropriate, approval notices are manually sent to the team, communicating the change order has been approved and the contractors can move forward with completing the work. If the costs outweigh the benefits, the Owner may reject the change order. Team members are notified of the rejection. This process involves a heavy amount of manual emailing and distribution of information, and is completed in a very linear and drawn out process.

The IT solution proposed to improve this process is to remove the linearity of this process by installing a WPMS where the proposed change order information can be posted. Once this change is posted, all required parties are automatically informed that a new change order has been posted. From there, each party can download and review the document. Any concerns can be posted on the WPMS in order to encourage collaboration in sorting through issues, questions, and concerns, instead of individual questions pointed to certain members of the team. Need for manual distribution and approvals can be eliminated through the inclusion of online authorization forms. Not only would this process dramatically decrease the number of submissions and distribution steps for each of the parties, but it would encourage parallel processes in which different parties can review the information simultaneously. Another key benefit of this system is the automation of the assimilation and tracking of response times from individual team members. Automatic alerts can be sent at predetermined durations in order to keep all parties on predetermined approval windows. Also, the Owner review process itself is expedited due to the assimilation of team member comments, which allow the Owner to easily take others' feedback into account with their review. The Owner does not need to track individual correspondence for these questions and answers. The end results of this increased efficiency will be faster decision-making and minimal schedule delays on pending changes. All of these benefits serve to mitigate the financial risk involved in the change order process.

Observational Data

The above described process models were applied to one subproject of the larger renovations project analyzed in this case. This specific subproject contained thirty change orders to be reviewed and approved by the project team. Change order logs were produced to track and verify the results of each process model. These logs outline the key information in the change order approval process including change order number, work description, submittal dates, and approval dates. Appendix C depicts actual approval data from the subproject, which made use of the base process model for change order approval. Appendix D depicts projected approval data for the subproject, assuming the use of the WPMS process model. The reductions in these durations were estimated through the assumption of faster approval times due to centralized, shared information and parallel individual review periods instead of traditional linear based approval processes. Reduction rates were conservative and based on the overall reduction in sequence steps as shown in the base and WPMS process models. Through analysis and comparison of the resulting approval durations found on these logs, both on an individual team member basis and individual change order basis, one can see a drastic improvement in the efficiency of the approval process in the form of shorter approval durations. The data observed reports average approval time of 35.18 days using the base process (see appendix C) and 21.96 days average approval time using the WPMS process model (see appendix D). This translates into 13.22 days shorter approval duration on average, amounting to a 37.57% decrease in approval time. This decrease in time for these approvals will ultimately result in less negative impact to the schedule and budget.

Interview

Interviews of key construction team members for the medical educational renovations project were conducted throughout the research process to assess the enthusiasm and outlook of those this process will affect the most. As shown on the process model, owners are responsible for reviewing costs of these change orders. The senior project manager for the Owner responded positively regarding the implementationof a WPMS into the change order process, stating “change orders make or break a project. Integration of a centralized posting space for change order information is a great step forward in streamlining the approval process.” Similar support was found on the contractor’s side as well. The acting superintendent for the project voiced “superintendents depend on timely review and decision making when it comes to change orders to keep the construction crews running smoothly and efficiently. Adding a system that gets these decisions made faster will ultimately result in a more successful project.” As is shown above, there is a heavy amount of support for integration of IT solutions in the change order process.

Results

Value is added in two ways when incorporating the IT solution described above. The first improvement is the minimization of distribution channels. By incorporating a WPMS to host the change order information, approvals, and questions, time normally spent in the linear distribution process is minimized. This will decrease the total processing time of the proposed change order. The improved process model depicts a smaller quantity of sequence and message flow lines, and therefore reduces the overall steps needed to gain change order approval. The second value that is added by incorporating the WPMS is the development of a more integrated and collaborative review process. Change orders and the accompanying questions are posted in a centralized location, allowing all key members to provide valuable input that can ultimately hasten the approval process. The positive impact of these changes is depicted in the observational data that was gathered, and further verified by the support of real-life project team members. Overall, the integration of the IT based change order process solution was positive on all fronts, and outweighs the minimal additional startup or maintenance costs that may be incurred in the installation of this process.

Supporting Data

Benefits for the IT strategies described above can be supported by previous research, as well. Research articles regarding the need for integrated solutions in construction and the past performance of similar project management systems fortify the ideas and strategies as outlined above. Additionally, change order process logs reflecting the results of the base process model and WPMS model depict the real-world implications of an improved change order process.

Fischer and Kunz (2004) emphasized the issue that in construction, most decision making needs to occur through the interfacing of different disciplines and parties. The research problem at hand, that is, the efficiency of the change order approval process, follows the same issues that this article describes. IT solutions, the authors describe, can play an important role of an interfacing tool among all necessary parties in the construction project. With the proposed integration of a WPMS into the change order process, change order information and response times can be automatically logged between all parties. After this process has been in use for some time, response time trends can be analyzed for use in future projects, and can play a heavy role in understanding which parties expedite the approval process and which parties hinder it.

Previous support for IT integration into the change order process was also researched. A 2012 case study titled “Electronic Change Order Processing” exhibited North Carolina’s State Construction Office and its integration of a WPMS into the change order review process of a construction project. This case study examined the integration of a centralized web based hub where change order information was posted for all parties to view. The review and decision making process needed for change order approval in this case study was greatly aided by the integration of this system. This system both streamlined the change order approval process and recorded the associated response times from required parties. This information was used to more accurately predict the impact that change order review and processing will play on future projects. (Electronic Change Order Processing, 2010).

Change order approval is a continuous process in construction projects in which the distribution and tracking of change information, response times, issues, and approvals must be manually recorded and manually followed up on. As is exhibited in appendix C, one can see the multitude of items that must be tracked for each change order. Considering that larger projects can result in hundreds of change orders, this process of tracking change order information on the whole is quite laborious. The need for manual distribution and communication on issues and approvals ultimately results in longer durations between distributions and approvals. Appendix D depicts the same project with projected results assuming the integration of the WPMS. The WPMS automatically inputs change order information, questions, follow ups, and approvals. The resulting log takes less time to manage and results in shorter durations for response times, and ultimately, approval decisions.

Conclusion

Building owners today face an uphill battle in the fight to stay afloat financially. In construction projects, there is perhaps no greater threat to project budget and schedule than the occurrence of change orders. This process requires review and approval from several key project team members and for years has been an arduous and drawn out process that has cost owners and contractors time and money. The relative linearity of the current process and the need for a heavy amount of manual distribution of information are prime contributors to the extended duration of this process. The research presented in this article, which was set against the backdrop of a large medical educational facility renovation project, assessed the effect of integrating an IT based solution into this process. Business process modeling showed integration of the WPMS, which acted as a central “hub” for posting, reviewing, and approving or rejecting change orders, streamlined the process by removing the total number of sequence steps and information transfers as compared to the traditional approval process. After collecting actual change order data from the project in the form of approval durations and comparing to projected durations from the WPMS-integrated process, it was found that integration of IT platforms in the change order process significantly reduced the duration of the approval process. Qualitative data in the form of project member interviews also exhibited firm support in the installation of the WPMS into the change order process. The positive results of this research support the need for business owners and key players in the construction industry to look into the integration of these systems further. Additionally, the findings herein form a starting point for additional and more comprehensive studies on the integration of IT platforms into change order and other construction based processes.

References

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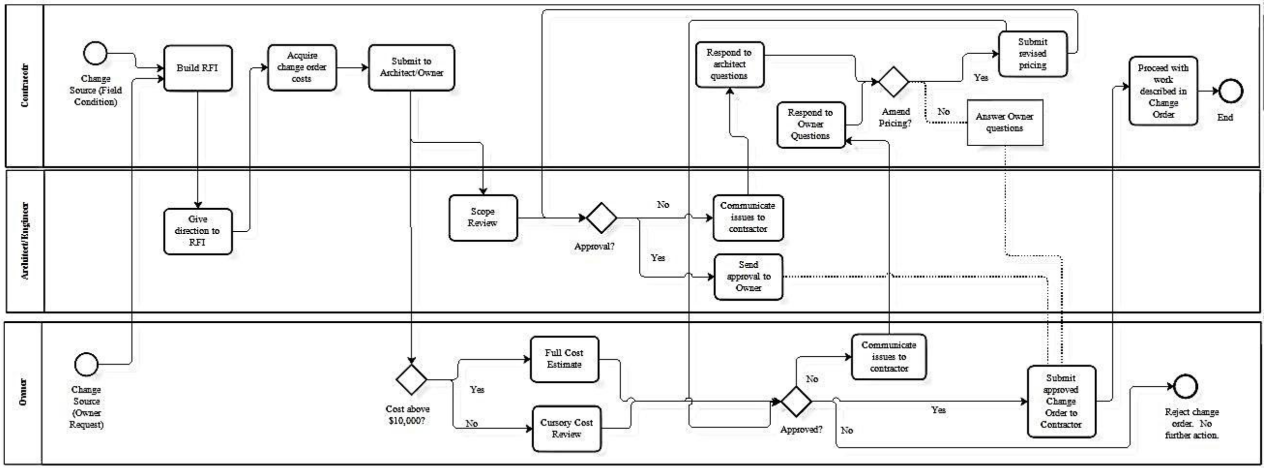
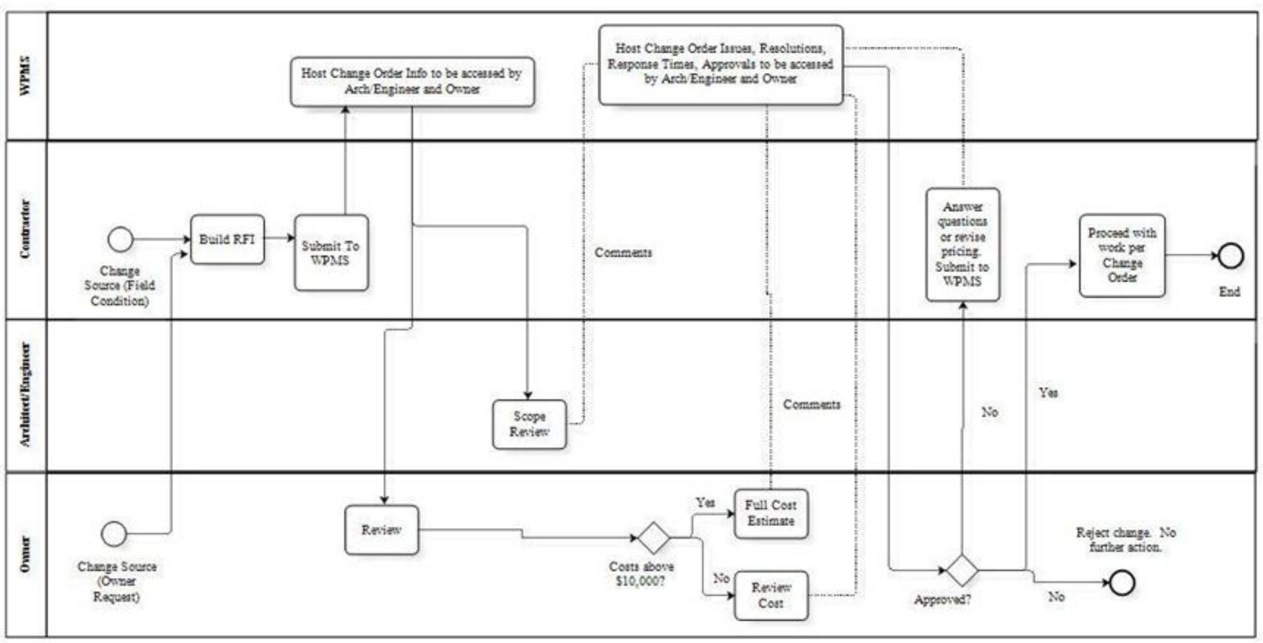
Appendix A

Change Order Base Model



Appendix B

WPMS Change Order Model



Appendix C

Base Model Change Order Log

CO#	Contractor	Description	Date	Cost	Arch App'd	OR App'd	Owner App'd	Sent	Approval Duration	Origin
001	GENERAL	Not submitted								
002	GENERAL	CB 5	05/30/12	$0	7/5/12	7/14/12	7/20/12	7/21/12	52	Owner
003	HVAC SUB	Changes to Reheat Coils and Associated Control Valves	05/30/12	$5,423	7/5/12	7/14/12	7/20/12	7/21/12	52	Owner
004	HVAC SUB	RFI#17 - HVAC Costs	05/30/12	$2,876	7/5/12	7/14/12	7/20/12	7/21/12	52	Owner
005	AV SUB	A/V & Speaker Raceways	05/30/12	$21,278	7/5/12	7/14/12	7/20/12	7/21/12	52	Owner
006	GENERAL	Paint Cord Reels	05/30/12	$3,949	7/5/12	7/14/12	7/20/12	7/21/12	52	Owner
007	AV SUB	IT Raceways	05/30/12	$6,169	7/5/12	7/14/12	7/20/12	7/21/12	52	Owner
008	ELEC SUB	Modify Fully Rated to Series Rated	05/30/12	$6,229	7/5/12	7/14/12	7/20/12	7/21/12	52	Contingency
009	GENERAL	Additional Clear Stone Required for Forklift Tracking Matt	05/30/12	$812	7/5/12	7/14/12	7/20/12	7/21/12	52	Contingency
011	WINDOW SUB	Mecho Roller Shades	06/28/12	$0	7/9/12	7/15/12	7/22/12	7/23/12	25	
012	HVAC SUB	Re Insulate Abated Piping - Anatomy	06/25/12	$6,584	7/9/12	7/15/12	7/22/12	7/23/12	28	
013	FLOOR SUB	RFI#52 - Extend Floor Tile to achieve Pitch for showers	06/25/12	$0	7/9/12	7/15/12	7/22/12	7/23/12	28	Contingency
014	ELEC SUB	Blank Covers on Existing Electrical Boxes to Remain	06/21/12	$0	7/9/12	7/15/12	7/22/12	7/23/12	32	Contingency
015	GENERAL	ODP Reduction	06/21/12		7/9/12	7/15/12	7/22/12	7/23/12	32	ODP
016	ELEC SUB	Minor Electrical Revs - Add (2) Duplex, (2) Clock and (2) Data	06/21/12	$1,604	7/9/12	7/15/12	7/22/12	7/23/12	32	Owner
017	DRYWALL SUB	CB #6, RFI 37 Bathroom Wall Extension and Light Cove	06/20/12	$0	7/9/12	7/15/12	7/22/12	7/23/12	33	Contingency
018	DRYWALL SUB	CB #9 Enclose Electrical Panels in Closets	06/20/12	$5,869	7/9/12	7/15/12	7/22/12	7/23/12	33	Owner
019	FLOOR SUB	PPG paint in lieu of Hallman Lindsay	06/21/12	$0	7/13/12	7/15/12	7/20/12	7/25/12	34	Contingency
020	DRYWALL SUB	CB 12 R1 - Finish Revisions and Locker Sloped Top	06/29/12	$2,679	7/13/12	7/15/12	7/20/12	7/25/12	26	Out of Scope
021	DRYWALL SUB	RFI#33 - Perimeter framing and insulation at exterior beam	06/25/12	$0	7/13/12	7/15/12	7/20/12	7/25/12	30	Field Condition
022	DRYWALL SUB	GWB Premium Time Worked Sat 6/16/12	06/25/12	$0	7/13/12	7/15/12	7/20/12	7/25/12	30	Field Condition
023	DRYWALL SUB	Drywall Patching at Rooms M2390, M2350, M2330	06/27/12	$0	7/13/12	7/15/12	7/20/12	7/25/12	28	
024	ELEC SUB	RFI#60 - Added Unistrut to Hang Light Fixtures A1/A2	06/28/12	$0	7/13/12	7/15/12	7/20/12	7/25/12	27	Contingency
025	ELEC SUB	Lighting Demolition @ East Corridor and Study Rooms	06/28/12	$0	7/13/12	7/15/12	7/20/12	7/25/12	27	Contingency
026	DRYWALL SUB	Patch GWB Walls at Study Rooms, Smoke Seal M2200	07/02/12	$0	7/20/12	7/22/12	7/26/12	7/30/12	28	Contingency
027	DRYWALL SUB	Top out existing walls in Air lock M2305	07/02/12	$0	7/20/12	7/22/12	7/26/12	7/30/12	28	Contingency
028	DRYWALL SUB	Furr Out East and West Walls at HA lab for plumbing rough in	07/02/12	$0	7/20/12	7/22/12	7/26/12	7/30/12	28	Contingency
029	ELEC SUB	Rework Existing Raceways	07/10/12	$0	7/20/12	7/22/12	7/26/12	7/30/12	20	Contingency
030	ELEC SUB	Support Existing FA Conduits @ South Lab Area	07/10/12	$0	7/20/12	7/22/12	7/26/12	7/30/12	20	Contingency
							AVERAGE DURATION		35.18	

Appendix D

WPMS Model Change Order Log

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013	FLOOR SUB	RFI#52 - Extend Floor Tile to achieve Pitch for showers	06/25/12	$0	7/9/12	7/10/12	7/12/12	7/15/12	20	Contingency
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023	DRYWALL SUB	Drywall Patching at Rooms M2390, M2350, M2330	06/27/12	$0	7/6/12	7/10/12	7/10/12	7/12/12	15	
024	ELEC SUB	RFI#60 - Added Unistrut to Hang Light Fixtures A1/A2	06/28/12	$0	7/6/12	7/10/12	7/10/12	7/12/12	14	Contingency
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029	ELEC SUB	Rework Existing Raceways	07/10/12	$0	7/16/12	7/15/12	7/17/12	7/21/12	11	Contingency
030	ELEC SUB	Support Existing FA Conduits @ South Lab Area	07/10/12	$0	7/16/12	7/15/12	7/17/12	7/21/12	11	Contingency
							AVERAGE DURATION		21.96	