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Proposal
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CityCenterDC | Parcel 1

Washington, D.C.

Executive Summary

CityCenterDC is a multi-building development in the heart of Washington, D.C. With all six buildings under construction simultaneously, the project team must coordinate multiple schedules and crews. While each building is assigned a specific project team, the emphasis lies in the overall progress of the development. This creates the opportunity to explore alternative solutions and techniques regarding the improvement of construction processes in Office Building 1. This proposal outlines the construction analyses, breadths, and master's topics integration, that will be pursued during the Spring 2013 semester.

The typical floor layouts of Office Building 1 create the opportunity to implement a Short Interval Production Schedule (SIPS), specifically to the mechanical or electrical rooms. These rooms carry a level of complexity, along with limited space, which would benefit from a detailed and organized work sequence. This analysis will investigate the impact of coordinated crews and tasks in an effort to increase the efficiency and productivity, as well as quality of work, of the spaces.

Analysis 2 will focus on the impacts a virtual mockup will have on the quality and productivity of work in the previously mentioned mechanical and electrical rooms. Models will be readily available to the project team to utilize on-site. Accurate representations of the systems and work sequences will reduce the problems that may arise during the installation of the complex spaces. In addition, the effects of the virtual mockups will be taken into consideration while creating the SIPS.

The core and shell structure of Office Building 1 allows the option for easily reconfigurable floor layouts during the lifespan of the building. The current electrical system is not designed for easy adaptability to such changes. The purpose of Analysis 3 is to redesign the electrical distribution system using SnakeBus technology. This system gives tenants the flexibility to rearrange floor layouts with ease. In addition to the electrical redesign of the system, a construction breadth will be performed to analyze the constructability and savings from the system.

The final analysis explores the impacts of a raised floor system. The current mechanical system requires adjustment of the VAVs with any new floor layout. The implementation of a raised floor system would give the tenants more control and options in respect to a dynamically changing layout. Constructability issues will be addressed along with cost and schedule savings. A mechanical breadth will determine the most efficient mechanical system for the raised floor system.

All results of the analyses will be compared to the original techniques or systems. Feasibility studies will also aide in the determination of the appropriateness of the implementation of the proposed systems. Knowledge acquired through master's level courses will be applied to Analysis 1 & 2. The following proposal outlines each of the analyses and steps that will be taken to complete them.

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Analysis 1 – Implementation of SIPS at Core

Problem Identification

Office Building 1 of the CityCenterDC development is a 12-story core and shell structure. Floors 3-11 are typical, and among others, include an electrical room, mechanical room, restrooms, and elevator shafts. The complexity and limited space in these rooms creates the potential for schedule delays. It is hard for more than two crews to physically fit into one of these spaces, let alone perform their work side by side. Without properly coordinated crews and a detailed construction plan, the project team carries the risk of delaying the project and incurring additional costs. In addition, Office Building 2 is a mirror image of Office Building 1. This creates even more incentive to explore optimization solutions.

Background Research Performed

The repetitive layout of Office Building 1 creates the opportunity to explore the effects of utilizing a Short Interval Production Schedule (SIPS). By creating a SIPS, crews and tasks can be broken down and detailed to a greater extent. Coordination of each crew can then be used to optimize the work and ensure there is a logical flow. This will eliminate the inconvenience of having several crews in one area. Because each crew will be working in a designated space, for a designated time, they will be able to manage and control their processes better. This will in turn increase the quality of the work, as each crew will be assigned to a particular task which they will perform multiple times. In order to aid in the learning curve, the crews will be presented with virtual mock ups, explained in Analysis 2.

While the existing schedule is organized to resemble SIPS for the core work, it does not designate crews, durations, and specific tasks. If any delays or schedule adjustments must be made, the crews simply move onto another building of the development. This is not an efficient approach to address such an issue, as it creates additional opportunities for problems to arise. Also, the crews that currently perform the work do not necessarily work on all floors of the building, as they may be reassigned to another building. This impacts the quality of the work and creates a learning curve for each new member. With all of this taken into account, the implementation of SIPS has the promise to address the present issues.

Potential Solutions

The results of my analysis will yield the following potential solutions in regard to the implementation of SIPS on Office Building 1:

- Recommend implementing SIPS as a value adding tool that creates potential for schedule acceleration, cost savings, improved quality, and crew balancing.
- Consider SIPS as an alternative, as calculated savings equal, but do not outweigh those of original strategy, i.e. no value added.
- Do not recommend implementation of SIPS as it does not produce any savings or has the potential for losses compared to original strategy.

Methodology

The following steps will be taken to properly complete this analysis:

- Research implementation techniques of SIPS on other projects, i.e. case studies.
- Investigate if and how many of current project team members have experience with SIPS in the past.
- Develop a sequence of work and balance crews with consideration to project schedule
- Evaluate potential risks and create a risk management plan
- Evaluate feasibility of implementing SIPS for Office Building 1
- Explore the associated savings or losses (schedule, cost, quality, etc.)

Expected Outcome

It is believed that the implementation of SIPS for Office Building 1 will accelerate the current schedule, produce a more reliable plan, and improve the quality of work. One of the owner's top priorities is schedule acceleration, as their income from leasing depends on it. With the detailed coordination of crews and tasks, the completion dates will be more predictable than the current schedule. The quality of work will also increase because crews will have specific tasks they will repeat on every floor. In addition, virtual mock ups will be provided (see Analysis 2) to crews to ensure proper installation of systems.

Analysis 2 – Core Electrical or Mechanical Room Mock-Up

Problem Identification

The electrical and mechanical closets on each floor of Office Building 1 carry a certain level of complexity. The limited amount of space in addition to the equipment and supporting systems create for a difficult and mistake prone working environment. Any mechanical or electrical room is subject to thorough inspection, and if there are issues, they must be addressed. These issues can take considerable amounts of time to fix, and with closets on every floor of Office Building 1, such mistakes could cause for significant schedule delays. It is vital for these rooms to function properly, as the tenants comfort and ability to work can be compromised otherwise. Once again, floors 3-11 are typical for Office Building 1 (and Office Building 2). As a result, mechanical and electrical closets are also identical, with the minor exception of some piping sizes. It is important to the project team to find a solution to control and assure the timely and successful completion of all closets.

Background Research Performed

The project currently relies on skilled laborers to ensure the proper installation of the electrical and mechanical closets. While experienced individuals are great assets for such tasks, more control is needed to ensure the quality and proper installation. As explained in Technical Report 2, CityCenterDC's use of BIM was limited to clash detection. The BIM efforts that exist were taken on by the mechanical subcontractor, as the project did not include an allowance for BIM. Because these closets affect the mechanical contractor the most, I propose the implementation of a virtual mock up. This mockup can be created using 3D modeling software. It can then be sequenced to produce a 4D model. This model can then be given to the crews via tablets. They would proceed to use these tablets as aides in construction the rooms. Having such a guide will not only increase the quality of the product, but also guarantee proper installation. There is also a potential for schedule acceleration with such a mock up, as the crews will have the steps and procedures readily available to them on site. The virtual mockups can be used as a tool in conjunction with SIPS to increase productivity and quality. The durations and tasks in the SIPS will take into account the effects a virtual mock-up could have.

Potential Solutions

The results of my analysis will yield the following potential solutions in regard to the implementation of virtual mockups for the electrical or mechanical closets in Office Building 1:

- Recommend implementing virtual mock ups as a value adding tool that creates potential for improved quality, proper installation, reduction of re-work, and schedule acceleration.
- Consider virtual mock ups as an alternative, as calculated savings equal, but do not outweigh those of original strategy, i.e. no value added.
- Do not recommend implementation of virtual mockups as it does not produce any savings or has the potential for losses compared to original strategy.

Methodology

The following steps will be taken to properly complete this analysis:

- Research success of virtual mock ups on other projects.
- Investigate if and how many of current project team members have experience with virtual mockups.
  - Project management team as well as field employees
- Calculate costs necessary to implement a virtual mock up, i.e. tablets, personnel, time, etc.
- Quantify savings a virtual mock up could produce
- Evaluate feasibility of implementing a virtual mock up.

Expected Outcome

It is believed that the implementation of a virtual mock-up will be received well by all employees and have the potential to improve quality of the closets, reduce the amount of mistakes and rework, and in conjunction with SIPS, accelerate the schedule. While it will be difficult to quantify the savings, comparisons from case studies will produce estimations. Implementing virtual mock-ups will also help the involved parties enhance their technological knowledge and experience. This will in turn be an aide for the team in future projects, as they will have significant experience with it.

Critical Industry Research

One of the leading topics of discussion in the construction industry is the effective use of BIM on a project. While BIM is being incorporated more and more into complex projects, the extent to which it helps versus the resources and time it consumes are questioned. Some project teams incorporate BIM just because they are required to in the contract, but do not necessarily utilize it effectively. Certain tools such as clash detection are widely accepted to be very beneficial. The goal of my research is to explore the effectiveness of virtual mock-ups for projects. I will conduct interviews with both professionals who have used virtual mock-ups and those who haven't. This will produce a correlation between the anticipated, desired, and achieved results of virtual mock-ups. The subjects of my interviews will be both general contractors and subcontractors. I will also research case studies involving virtual mock-ups. The results of this research will benefit project teams considering the implementation of virtual mock-ups, as well as raise awareness of the capabilities a virtual mock-up can have on a project.

Please refer to Appendix B for sample interview questions.

Analysis 3 – Electrical Branch Redesign

See Appendix A for Construction Breadth

Problem Identification

The core and shell layout of Office Building 1 was chosen because of the intended use of the space. With an open floor plan, the tenants can arrange and rearrange their layout as often as they desire. This concept creates an additional problem that is often over-looked. A rearrangement of desks and equipment also requires a rearrangement of the electrical power supply for that furniture. A traditional overhead branch system is brought down from the ceiling and taken to the permanent receptacle locations. The open floor plan of Office Building 1 has very columns where the branch can drop down. Therefore, if the layout does not concentrate around these locations, a visually unappealing solution would have to be presented to bring down the wire. If there is ever a rearrangement, the entire branch system would need to be redone, which is both a time consuming and labor intensive process. Consequently, the design and type of electrical distribution system could determine the costs that could arise at a later time, for the tenant or the owner of the building.

Background Research Performed

Exploring options that other similar projects and spaces have undertaken, I came across a unique solution. SnakeBus, a relatively new concept to the market, is an easily customizable electrical distribution system. Beneath the 3" raised floor structure, is a customizable buss bar. This bar can be configured to move in any direction, at 90 degree angles. There are multiple tap in points on the buss bar, where floor boxes can be connected. These floor boxes can include receptacles and even data jacks. What makes this system particularly appropriate for this layout is the fact that these boxes and tap in points can be moved and adjusted very easily. There is no need for rewiring, simply un-tap at one point, move the box to the desired location, and tap it in there. SnakeBus was designed to anticipate such dynamically changing floor spaces. There is also no compromise to quality. My analysis will revolve around designing such a system for a typical floor, sizing it, and making sure all codes and regulations are met.

Potential Solutions

The results of my analysis will yield the following potential solutions in regard to use of a SnakeBus system:

- Recommend implementing SnakeBus as a value adding tool that will aide in the customizability of the space and save rearrangement costs in the future of the spaces.
- Consider SnakeBus as an alternative, as calculated savings equal, but do not outweigh those of original system design, i.e. no value added.
- Do not recommend SnakeBus as its upfront cost exceeds the savings the system could have.

Methodology

The following steps will be taken to properly complete this analysis:

- Research and familiarize myself with all components of the SnakeBus system
- Research reviews of already installed system, i.e. case studies
- Design a system to match load and code requirements
- Evaluate feasibility of implementing SnakeBus system

Expected Outcome

It is believed that the upfront cost of the SnakeBus system will be higher than the upfront cost of the original system, but the lifetime savings will be lower. The customizable SnakeBus system is therefore more suitable for the nature of this space. There will be a learning curve associated with the installation, but the owner is very familiar with raised floor systems, so they will have knowledge to help the contractors. Utilizing this system will keep rearrangement costs at a minimum for the owner or the tenant. They will have full control in respect to the desired location of their furniture and equipment.

Analysis 4 – Raised Floor

See Appendix A for Mechanical Breadth

Problem Identification

As described in Analysis 3, the office space requires customizable design of systems. In addition to the electrical system, the mechanical system of Office Building 1 is also not designed for a dynamically rearranging floor layout. The VAVs of the overhead distribution system require adjustment with every reconfiguration of the floor layout. This would require specialists to adjust the systems when needed. If the systems are not adjusted, the comfort of the tenants is compromised. Once again, this poses both comfort issues for the tenants and future rearrangement costs.

Background Research Performed

Dynamically changing floor layouts are common to working environments, especially the so-called “cubicle farms.” After researching various techniques to accommodate the mechanical and electrical systems in such an environment, I came across a raised floor solution. The developer of CityCenterDC then informed me that they were very experienced with raised floor systems. They have used them in many other projects and are comfortable with idea. Shifting to a raised floor system of course impacts floor height among others, and will need to be one of the major topics of analysis. A raised floor system for this project could solve the issue with customizability for the floor layout. Both the mechanical and electrical systems could be stowed away in the raised floor, allowing for easier access for maintenance and adjustment. Another consideration is the fire protection system in the ceiling and the way that will be dealt with. Constructability is always an issue with a raised floor but in this case, with an experienced owner, many of the issues could be addressed early.

Potential Solutions

The results of my analysis will yield the following potential solutions in regard to use of a SnakeBus system:

- Recommend implementing raised floor system as a value adding tool that will aide in the comfort, customizability of the space, and save rearrangement costs in the future of the spaces.
- Consider raised floor system as an alternative, as calculated savings equal, but do not outweigh those of original system design, i.e. no value added.
- Do not recommend raised floor system as its costs exceeds the savings, due to either installation or incorporation issues.

Methodology

The following steps will be taken to properly complete this analysis:

- Research various types of raised floor system and their effectiveness
- Compare costs of both systems, both upfront and long term
- Evaluate any schedule impacts
- Constructability review with contractors and owner
- Research and evaluate which system has higher customer satisfaction
- Feasibility to incorporating such a system with current design

Expected Outcome

It is believed that a raised floor system would be better suited for this building. While the upfront costs of the raised floor may exceed the upfront costs of the original system, lifetime cost will be lower and value would be higher. The analysis will yield quantitative results about the potential savings of the system. In order to resolve the non-quantitative aspect of value, research and interviews will be performed to determine which system tenants are more satisfied with. It is believed that the incorporation of such a system will serve the space better and yield a higher level of satisfaction to both the owner and the tenants.

Conclusions

The project team for CityCenterDC put a strong emphasis on the timely completion of Office Building 1. Upon substantial completion of the building, the owner will be able to officially sign a lease with the tenant. At this point the owner will start receiving revenue from the tenant, and begin the fit-out process. As such, schedule savings would speed up both the tenant move-in and revenue exchanges. My analyses revolve around shortening the schedule in an efficient manner that also improves the quality of the product. Analyses 1 & 2 concentrate on creating a more productive and efficient schedule while ensuring the systems are installed with a higher level of quality. Analyses 3 & 4 pertain to creating a more suitable system for the designated spaces as well as reducing lifetime costs. It is believed these analyses will produce beneficial and desirable results for the owner, project team, and future tenants.

Appendix A

Breadth Topics & MAE Requirements

Breadth Topics

Construction Breadth

The implementation of a SnakeBus electrical distribution system will be explored as an opportunity to increase the customizability of a dynamically changing floor layout. Calculations will be performed to match the current load and code requirements. The feasibility of implementing SnakeBus will greatly depend on the value added through this system. A construction breadth will be performed to evaluate the impacts this system has on cost, schedule, and constructability. The upfront and lifetime costs of both systems will be compared to determine the more cost effective system. Constructability issues will be investigated to identify any potential schedule impacts. A raised floor system also has requires coordination of floor-to-ceiling heights. As such, an analysis will be performed to ensure all height requirements are met. At the conclusion of the analysis, a comparison between the traditional and SnakeBus systems will be presented. Based on the results, the project team and owner will be able to make an accurate assessment of the appropriateness of the system.

Mechanical Breadth

Due to the limited adaptability for a shifting floor layout of the current mechanical and electrical distribution systems, a raised floor system's implementation will be investigated. While the current mechanical system would require adjustments to the VAV boxes per any reorganization of the floor layout, a raised floor system would easily adapt to such changes. A mechanical breadth will be performed to analyze the different under-floor mechanical systems. Factors such as quality, efficiency, cost, and construability will be compared among the different systems. Based on the results, the most appropriate system will be recommended. A comparison to the original system will then be performed to quantify the differences between the two systems.

MAE Requirements

The knowledge acquired through various MAE 500 level courses pertains to several of my technical analyses. More specifically, concepts from AE 570 Production Management will be incorporated into Analyses 1 & 2. AE 570 revolves around the use of production management to efficiently manage projects. One of the thoroughly covered subjects in the course is SIPS. As mentioned before, this technique will be implemented for the core electrical or mechanical rooms. I will revisit the fundamentals and tools learned in the class and apply them to Office Building 1. In addition to SIPS, the course covered several production tracking and optimization techniques. These will aide in the development of the virtual mock-up implementation plan, and alongside with SIPS, work towards increasing productivity of various processes and shortening the schedule of the project.

Appendix B

Sample Interview Questions

Interview Questions

For previous users of virtual mockups

1. What project have you used virtual mockups for?
2. How effective were the mockups?
3. Did you notice a significant improvement in quality of productivity?
4. What were you looking to get out of the mockup?
    a. Did you achieve this result? Explain.
5. What types of resources were necessary to implement virtual mockups?
6. Did you use tablets or keep it in the trailer?
7. Did field crews find it beneficial?
8. If you used virtual mockups again, what would you change, or what would you like to see different?
9. Would you use virtual mockups again?
10. Compared to physical mockups, which would you say is more beneficial?
    a. Which would you prefer?

For those who have never used virtual mockups

1. Are you familiar with the concept of virtual mockups?
2. Would you be willing to use virtual mockups on a project?
3. What would you expect to gain from virtual mockups?
4. Do you think project teams would be open to the implementation of virtual mockups?
5. How would you alter you work plan if virtual mockups were present?

Appendix C

Senior Thesis Timetable

			Milestone 1 1/28/13		Milestone 2 2/11/13		Milestone 3 3/1/13				Milestone 4 3/25/13	Andy Penev CityCenterDC Dr. Messner			
Proposed Thesis Semester Schedule															
January 2013 - April 2013															
1/7/13	1/14/13	1/21/13	1/28/13	2/4/13	2/11/13	2/18/13	2/25/13	3/4/13	3/11/13	3/18/13	3/25/13	4/1/13	4/8/13	4/15/13	4/22/13
MEP Room Schedule								Spring Break		MCAA Convention		Final Report - April 3	Faculty Jury Presentation - April 8-12		Senior Banquet - April 26
Revise Proposal or Update	Create SIPS & Quantify Results														
		Virtual Mockup Interviews													
			Model, Implementation Plan, Results												
					Electrical Redesign										
						Construction Analysis of SnakeBus System									
										Presentation					
								Research, Analysis, and Feasibility of Raised Floor System							
										Mechanical System Selection (Breadth)					
												Complete Report			
													Jury Present.	ABET Assessment	
														Update CPEP & Report	

Milestone		Analyses & Breadths
1	SIPS Analysis Complete	SIPS
2	Virtual Mockup Analysis & Model Complete	Virtual Mockup
3	Electrical Redesign Complete	SnakeBus (CM Breadth)
4	All Analyses Complete	Raised Floor (Mech. Breadth)