The Pennsylvania State University
5th Year Senior Thesis

Technical Assignment Three

Alternative Methods Analysis

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Somewhere, USA
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Executive Summary:

Technical assignment three is to identify area of the Data Center that is good candidates for research, alternative methods, value engineering and analysis for the thesis final proposal. This report contains information for the project team as well as a self-observation of the building.

The constructability issues that were faced during construction were the MEP systems and tying the new addition into the existing building. MEP was one of the main focal areas for the Data Center to stay on schedule. The MEP accounts for roughly 34 weeks of the schedule. To rectify this task, early coordination meetings were implemented into the schedule for easy flow construction during the MEP rough-in and fit-out stages of the Data Center. Tying the new addition into the existing was an issue that created a gap in the schedule's critical path. To rectify this issue, the trades worked overtime to get the schedule back on track.

Through an in-depth analysis of the constructability challenges, schedule acceleration and values engineering topics, the following areas were identified as for a detailed analysis of building technical systems and construction methods. These topics include: congested site/crane usage, LEED certification, architectural precast, occupancy – acoustical and vibrational isolation, and the use of 3D coordination. Each of these topics is discussed in detail later in this report. Each of these topics may provide insight into possible research topics for the spring thesis proposal.

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A. Constructability Challenges:

When the project team was interviewed, constructability challenge arose. This section lists the top three constructability challenges that the project team faced while constructing the Data Center. The topics are listed below in order of importance.

MEP Coordination:

MEP was one of the main focal areas for the Data Center to stay on schedule. The MEP accounts for roughly 34 weeks of the schedule. The mechanical system comprises of a combination between chilled water systems and glygol water systems. In the same respect, the electrical system comprises of a 2N electrical infrastructure with concurrent maintenance and three 2 MW generators that are located on the roof. For more information, please refer back to technical assignment one under building systems summary. Since the mechanical and electrical components where so complex, Turner and Sigma 7 set up coordination meetings to accelerate the construction as well as decrease the amount of future RFI's and change orders. Below in Image A.1 represents a breakdown of each meeting involved with the schedule. For the whole detailed schedule, please refer to technical assignment two.

47	**MEP Coordination**	**77 days**	**Mon 11/2/09**	**Tue 2/16/10**
48	**Underground Coordination**	**53 days**	**Mon 11/2/09**	**Wed 1/13/10**
49	DEVELOP U.G CONDUIT RUNS	5 days	Mon 11/2/09	Fri 11/6/09
50	OVERLAY PLUMBING ON COORD. DWG.	3 days	Mon 11/9/09	Wed 11/11/09
51	COORD. MEETING ON SITE	2 days	Thu 11/12/09	Fri 11/13/09
52	RE-DRAW COORD. DWG	3 days	Mon 11/16/09	Wed 11/18/09
53	SUBMIT COORD. DWG	39 days	Thu 11/19/09	Tue 1/12/10
54	REVIEW/APPROVE U/G COORD.	4 days	Wed 12/9/09	Mon 12/14/09
55	U/G COORD. DWG TO SUBS.	0 days	Wed 1/13/10	Wed 1/13/10
56	**Upper Slab O/H Coordination**	**77 days**	**Mon 11/2/09**	**Tue 2/16/10**
57	DEVELOP SHEET METAL BACKGROUND	54 days	Mon 11/2/09	Thu 1/14/10
58	OVERLAY SPRINKLER ON COORD. DWG	5 days	Fri 1/15/10	Thu 1/21/10
59	OVERLAY PLUMBING IN COORD. DWG	5 days	Fri 1/22/10	Thu 1/28/10
60	OVERLAY ELEC. ON COORD. DWG	5 days	Fri 1/29/10	Thu 2/4/10
61	COORD. MEETING ON SITE	2 days	Fri 2/5/10	Mon 2/8/10
62	RE-DRAW COORD. DWG	3 days	Tue 2/9/10	Thu 2/11/10
63	REVIEW/APPROVE UPPER SLAB O/H COORD.	3 days	Fri 2/12/10	Tue 2/16/10
64	SUBMIT COORD. DWG	1 day	Fri 2/12/10	Fri 2/12/10
65	UPPER SLAB COORD. DWG TO SUBS	0 days	Fri 2/12/10	Fri 2/12/10
66	**Lower Slab O/H Coordination**	**70 days**	**Mon 11/2/09**	**Fri 2/5/10**
67	DEVELOP SHEET METAL BACKGROUND	54 days	Mon 11/2/09	Thu 1/14/10
68	OVERLAY SPRINKLER ON COORD. DWG	3 days	Fri 1/15/10	Tue 1/19/10
69	OVERLAY PLUMBING ON COORD. DWG.	3 days	Wed 1/20/10	Fri 1/22/10
70	OVERLAY ELEC. ON COORD. DWG	3 days	Mon 1/25/10	Wed 1/27/10
71	COORD. MEETING ON SITE	2 days	Thu 1/28/10	Fri 1/29/10
72	RE-DRAW COORD. DWG	2 days	Mon 2/1/10	Tue 2/2/10
73	REVIEW/APPROVE LOWER SLAB O/H COORD.	3 days	Wed 2/3/10	Fri 2/5/10
74	SUBMIT COORD. DWG	1 day	Wed 2/3/10	Wed 2/3/10
75	LOWER SLAB COORD. DWG TO SUBS	0 days	Wed 2/3/10	Wed 2/3/10
76	**Under Raised Floor Coordination**	**26 days**	**Mon 1/11/10**	**Mon 2/15/10**
77	DEVELOP ELEC. CONDUIT RUNS	3 days	Mon 1/11/10	Wed 1/13/10
78	OVERLAY SPRINKLER ON COORD. DWG	5 days	Thu 1/14/10	Wed 1/20/10
79	OVERLAY PLUMBING IN COORD. DWG	5 days	Thu 1/21/10	Wed 1/27/10
80	OVERLAY HYDRONIC PIPING RUNS	5 days	Thu 1/28/10	Wed 2/3/10
81	COORD. MEETING ON SITE	2 days	Thu 2/4/10	Fri 2/5/10
82	RE-DRAW COORD. DWG	3 days	Mon 2/8/10	Wed 2/10/10
83	REVIEW/APPROVE UNDER RAISED FLR COORD.	3 days	Thu 2/11/10	Mon 2/15/10
84	SUBMIT COORD. DWG	1 day	Thu 2/11/10	Thu 2/11/10
85	UNDER FLOOR COORD. DWG TO SUBS	0 days	Thu 2/11/10	Thu 2/11/10

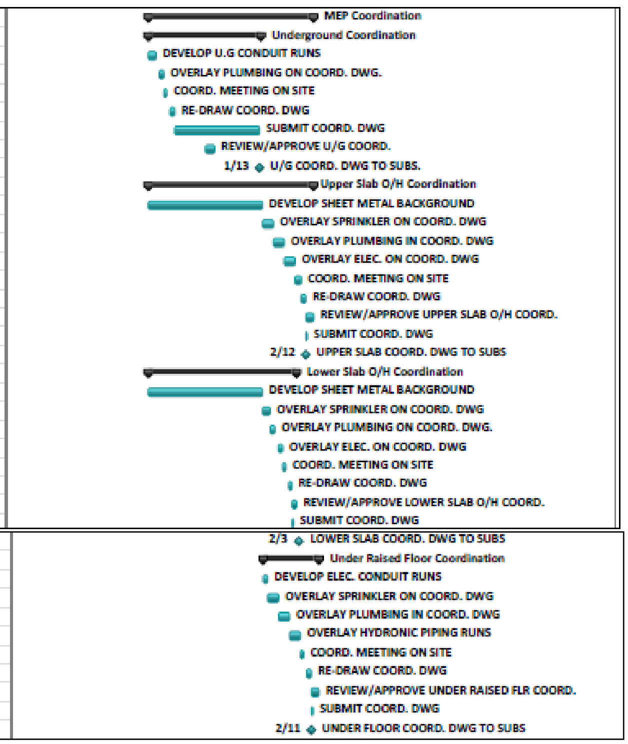
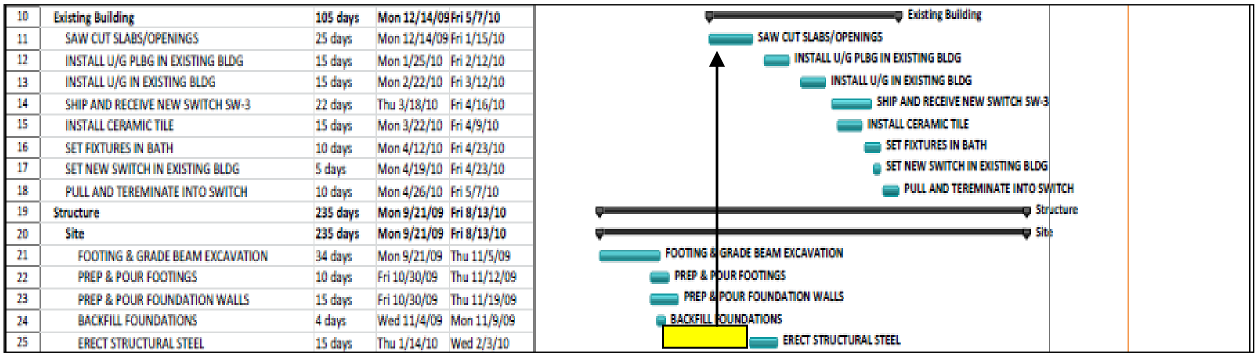


Image A.1 Coordination Meetings

The detailed schedule shows that the coordination meetings account for 77 days of the total schedule. This may be a problematic feature that will be discussed in section D of this report.

Tying the Building back into the Existing:

Another issue that arose was tying the new addition back into the existing building. There is a small, prevalent gap in the schedule that shows this constructability issue. Image A.2 shows the gap in the schedule that is represented in yellow and Image A.3 shows a detail to tie the building back into the existing.



10	**Existing Building**	**105 days**	**Mon 12/14/09**	**Fri 5/7/10**
11	SAW CUT SLABS/OPENINGS	25 days	Mon 12/14/09	Fri 1/15/10
12	INSTALL U/G PLBG IN EXISTING BLDG	15 days	Mon 1/25/10	Fri 2/12/10
13	INSTALL U/G IN EXISTING BLDG	15 days	Mon 2/22/10	Fri 3/12/10
14	SHIP AND RECEIVE NEW SWITCH SW-3	22 days	Thu 3/18/10	Fri 4/16/10
15	INSTALL CERAMIC TILE	15 days	Mon 3/22/10	Fri 4/9/10
16	SET FIXTURES IN BATH	10 days	Mon 4/12/10	Fri 4/23/10
17	SET NEW SWITCH IN EXISTING BLDG	5 days	Mon 4/19/10	Fri 4/23/10
18	PULL AND TEREMINATE INTO SWITCH	10 days	Mon 4/26/10	Fri 5/7/10
19	**Structure**	**235 days**	**Mon 9/21/09**	**Fri 8/13/10**
20	**Site**	**235 days**	**Mon 9/21/09**	**Fri 8/13/10**
21	FOOTING & GRADE BEAM EXCAVATION	34 days	Mon 9/21/09	Thu 11/5/09
22	PREP & POUR FOOTINGS	10 days	Fri 10/30/09	Thu 11/12/09
23	PREP & POUR FOUNDATION WALLS	15 days	Fri 10/30/09	Thu 11/19/09
24	BACKFILL FOUNDATIONS	4 days	Wed 11/4/09	Mon 11/9/09
25	ERECT STRUCTURAL STEEL	15 days	Thu 1/14/10	Wed 2/3/10

Image A.2 Detailed Schedule of Existing Work

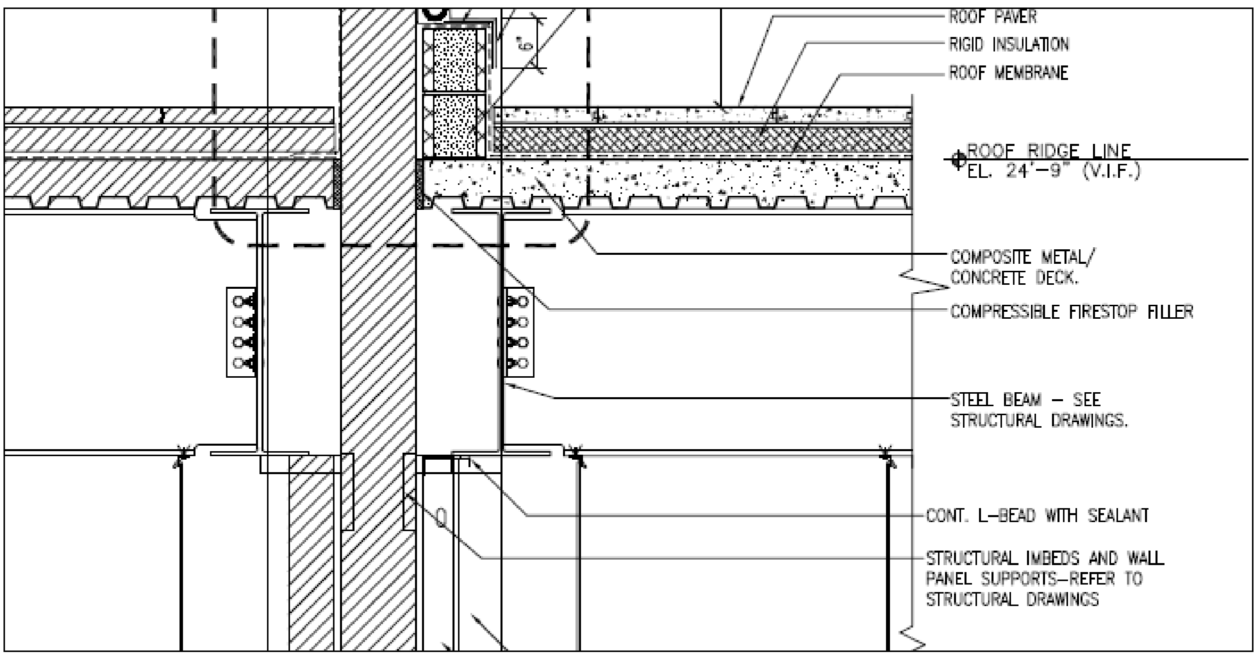


Image A.3 Detailed Section

To solve this issue the project team simply worked overtime for the Data Center to stay on schedule.

B. Schedule Acceleration Scenarios:

Critical Path:

The critical path for the Data Center is primarily related to the complex electrical and mechanical systems of the building. In Table B.1, shown below, represents the tasks that consist of the critical path throughout the construction for this project.

Superstructure	
Erect Steel	Place Concrete

Watertight Milestone	
Install Architectural Precast	Roof Complete

MEP		
Coordination	MEP Rough-in	MEP Fit-out

Finishes	
Install Sprinkler Systems	Drywall/Paint/Door and Hardware Complete

Commissioning Milestone	
Commissioning	Main Power on

The first task associated with the critical path is the superstructure. This phase of the project is less intensive than the other phases. There was very little to excavate and the steel erection phase lasted only roughly 15 days. Later, the concrete was placed for the composite beam structure and finished for the MEP, roof, and precast trades to mobilize onsite.

The precast and roof completion was next on the critical path. This involved the erection of all architectural precast to be completed. The roof is a composite structure, EPDM with concrete pavers to top it all off. This phase of construction need to be completed before the finishes and MEP rough-in and fit-out trades mobilize.

Acceleration Techniques:

The Data Center's schedule is very tight and some acceleration techniques were utilized to make construct this building in an efficient manner. Early coordination meetings were implemented into the schedule so there would be no delays during the MEP rough-in and fit-out. This insured a decrease in clashes between the mechanical, electrical, plumbing, and structural systems. Since the main driver for this building is the schedule, any trades would worked overtime when their task would fall behind schedule.

C. Value Engineering Topics:

During the project manager interview, there was no discussion one any value engineering topics. This section is purely topics that may be considered to value engineer into the Data Center.

Tilt-up Construction: Cast-in-place walls:

The Data Center's façade is made up of architectural precast panels. It might be possible to change the façade from the current precast to tilt-up cast in place. Some benefits to this type of façade are less congestion during truck deliveries and accelerate the superstructure phase. Some drawbacks are an increase in site congestion and less laydown area onsite.

D. Problem Identification:

In this section of the report, the following areas were identified as for a detailed analysis of building technical systems and construction methods. Each section has a detailed description of the problematic features that could be address through research and analysis.

Congested Site/ Crane Usage

The schedule is set up for multiple trades to be onsite at once. The site plan used for the Data Center may be problematic for this scenario. There is not sufficient lay out space for the steel, concrete, precast, and MEP trades. The usage of the crane may be problematic during the architectural precast erection. The MEP trades will need to use the crane to hoist the mechanical equipment to the roof and the precast trades will need the crane for erection of the architectural precast panels.

LEED Certification

The Data Center was not intended to be a LEED certified project. This is problematic because with this being a data center, the owner could possibly save a good amount of money through the performance of the building if spending more money upfront. Whether if it is the lack of interest, knowledge or time, the project team could have investigated the benefits of sustainability for this project.

Architectural Precast

The architectural precast poses a problem for the fact that there are no windows for this new expansion, the owner is losing opportunity to light his building with natural sunlight. This intern will reduce cost of the artificial lights needed inside the building as well as decrease the mechanical heat load in the building.

Occupancy/Acoustical and Vibration Isolation:

Phase two of the Data Center ties into the first phase of the major expansion on the south side of the building. Phase two includes a vast amount of mechanical equipment on the west side of the building. The acoustical isolation poses as a problem for undesirable noise coming for the mechanical equipment. In Figure D.2 shows section plans of the wall where phase two ties back into phase one. An acoustical study/research should be done to determine if undesirable sounds or sneaking into phase one of the Data Center.

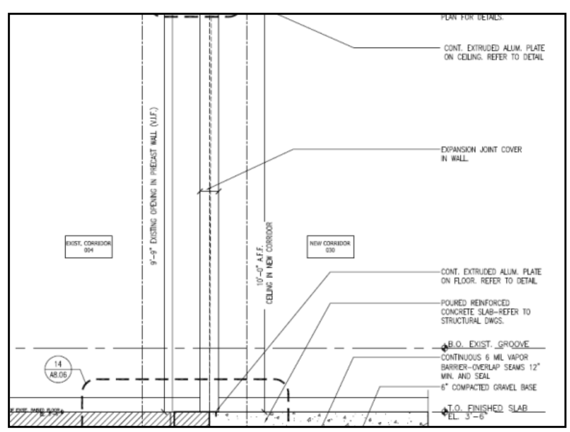
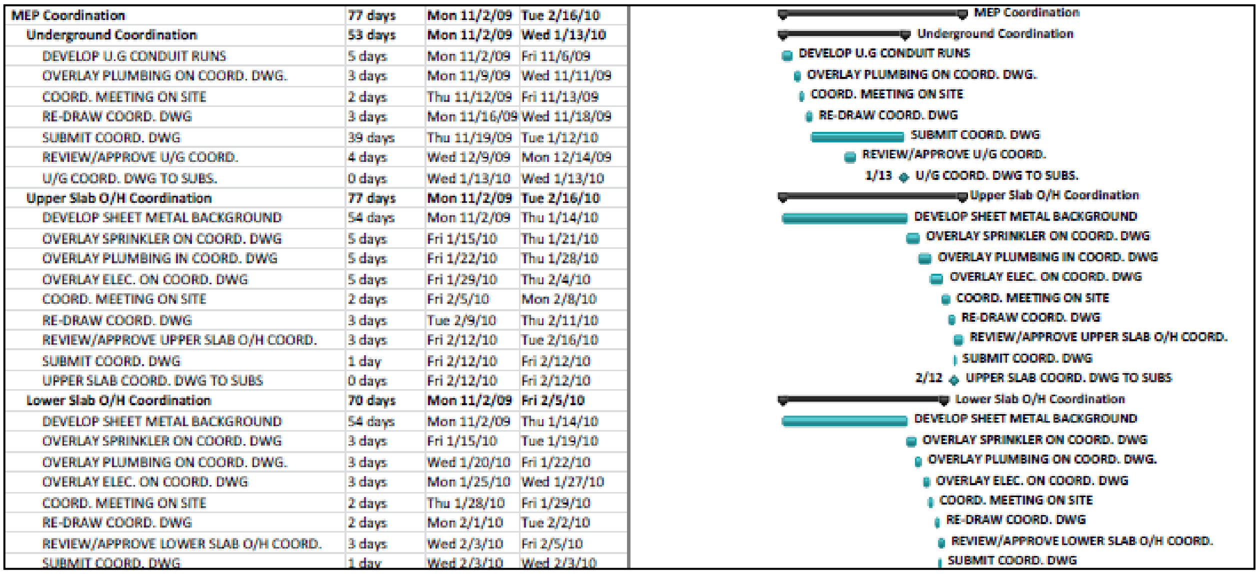


Figure D.1 Wall Section

Use of BIM/3D coordination:

The use of BIM and 3D coordination was not pursued for the Data Center. This is a problematic feature because the Data Center could have benefited drastically from BIM and 3D coordination. The schedule shows a portion of the coordination meetings for the whole project between Sigma 7 and Turner. This portion of the schedule is shown in Figure D.2. The whole detailed schedule can be found in technical assignment two.



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COORD. MEETING ON SITE	2 days	Thu 1/28/10	Fri 1/29/10
RE-DRAW COORD. DWG	2 days	Mon 2/1/10	Tue 2/2/10
REVIEW/APPROVE LOWER SLAB O/H COORD.	3 days	Wed 2/3/10	Fri 2/5/10
SUBMIT COORD. DWG	1 day	Wed 2/3/10	Wed 2/3/10

Figure D.2 Coordination Schedule

3D coordination could have been implemented shaving time and money for this project. The use of this coordination technique could have lowered the amount of time spent in coordination meetings shown above in Figure D.2.

E. Technical Analysis Methods:

This section of the report is based upon the list of the problematic features discussed in the previous section. This section includes analysis methods that are most worthy of future research and includes paragraphs of the description of each analysis.

Site Congestion:

Site congestion and crane usage was a concern stated in the previous section for the Data Center. This issue impacts the schedule, procurement, safety, and cost for this project. The lack of space for lay-down spaces can cause inefficient construction and an unsafe work environment.

This analysis will research the activity durations of all trades onsite. Then determine the most efficient progress to work. The schedule is set up with unreasonable overlaps between trades. These overlaps will be identified and rectified with techniques suggested.

The technique that could be used was mentioned in the last technical assignment and the PACE seminar: Latista and prefabrication to a different level.

Latista is a great tool for organization of materials onsite and procurement. A research study on the knowledge/experience of this tool would need to be conducted to figure out if preliminary classes would need to be held for the project team to learn this tool. Latista can directly help with the procurement process by having the information of what materials are onsite. Using this will decrease the congestion of materials onsite.

Prefabrication at a new level could be a technique to explore. With use of 3D modeling, research will need to be done to determine ways for prefabricating whole MEP systems. This will allow less material onsite but more pick times with the crane. This may impact the cost and schedule (procurement/prefabrication), therefore a construction research will need to be conducted to determine whether this technique is beneficial.

LEED Approach/Sustainable Techniques:

As mentioned. The Data Center did not pursue LEED Certification. However, this project could have utilized some sustainable techniques that could benefit financially in the future performance of the building. This analysis will need to conduct research the buildings illumination, water consumption, and waste management. This analysis has two sustainable techniques for exploration: Green roof and façade redesign.

The green roof technique will need to conduct a structural analysis of the building to see whether it is feasible to construct a green roof. A financial analysis must be researched to see how much this roof type will cost up front, cost for maintenance, and cost savings that the green roof will bring if constructed. Another study that may be appropriate for the construction of the green roof is a sound and vibration isolation analysis. The last section identified sound isolation to be problematic. The addition of a green roof may reduce any undesirable noise into the building.

A façade redesign is necessary for the fact that there are now windows included anywhere for this new addition. A cost analysis will need to be conducted for upfront cost, future savings, artificial light cost and heat savings. Client research will also need to be conducted to determine the reason for the lack of no windows. An architectural analysis will need to be conducted to determine optimal window placement. Lastly a construction analysis will need to be conducted to determine the effect of the schedule for the windows to be installed

Integration of 3D coordination:

As mentioned in the last section, the use of 3D coordination was not pursued for the Data Center. The schedule shows that MEP coordination meetings account for roughly 11 weeks of the project duration. The use of 3D models and clash detection can give insight to subcontractors on what will be needed onsite, which in term could decrease site congestion. Also, a good 3D model could essentially benefit the prefabrication/procurement process.

This analysis will need several items to research. The cost will need to be research for the BIM/3D coordination team and any RFI and change orders that could have been resolved using 3D coordination. The feasibility of the 3D coordination will need to be research to determine if all trades have/lacked experience to complete an actual 3D coordination clash detection. The schedule will need to be researched to determine if this analysis will decrease the duration of the coordination meetings.