Technical Assignent 3

The Apartment Building
East Coast, USA

B. Kerem Demirci | Construction Option | Advisor: Dr. Messner | 11.14.14

Source: JMAV

EXECUTIVE SUMMARY

The Apartment Building is a high-end apartment building located in a historic metropolitan city on the East Coast. It consist of ten stories above grade, amounting to 151,158 SF. The building also has a two story, 62,250 SF underground parking garage.

Technical Assignment Three begins the investigation of possible areas that may be good candidates for research, alternate methods, value engineering and schedule compression. This report includes a summary of an interview with the project manager, a BIM use evaluation as well as a summary of key topics and ideas discussed at the 23rd annual PACE Roundtable.

An in depth interview was held with the project manager, Adam Harrison. During this interview, topics regarding schedule, value engineering and constructability were discussed. The critical path on the Apartment Building began with the removal of an existing storm water management tank, followed by the installation of a new tank. From here the critical path moved to site excavation and then to the concrete structure. Once the concrete structure was complete, exterior brick and masonry were on the critical path followed by drywall, finishes and punchlist. There were many risks to the schedule on the construction of the Apartment Building. The main risks were winter weather and unforeseen conditions. The project gained a 30 day extension due to weather and unforeseen conditions. The majority of the value engineering done on this project dealt with alternative materials. By selecting alternative materials and even removing some design elements, the contractor was able to add value to the project and reinforce the owner's goals. The main constructability concerns on this project were the site constraints and the support systems for excavation that was needed as well as the unforeseen conditions that were encountered during excavation.

A BIM Execution Plan was created and suggested potential BIM uses that would benefit the project and owner. Some of these BIM uses include existing conditions modeling, engineering analysis, 3D coordination and site utilization planning.

The PACE Roundtable was attended to proctor discussion on relevant industry topics while promoting interaction between students and industry members. The session attended were IPD and the New Project Manager, New Global Drivers, and Incentivizing Team Performance. Following these presentation, a small group session was held with John O'Keefe, the president of Atkinson Construction, to delve into the Apartment Building and help discuss possible areas for research. Some possible areas of research include market evaluation, SIPS scheduling, architectural flexibility and implementing BIM.

CONTENTS

PROJECT MANAGER INTERVIEW

Adam Harrison, the project manager on the Apartment Building, was interviewed to help identify areas that would be good candidates for research, alternative methods, value engineering and schedule comparison.

SCHEDULE ACCELERATION SCENARIOS

CRITICAL PATH

The critical path for the construction of the Apartment Building began with the demolition of an existing storm water management tank followed by the installation of a new storm water management tank. This had to be done before any excavation could occur, which was next on the critical path. Following excavation, the concrete structure was on the critical path. Once the structure was complete, exterior work, which included brick and masonry, was on the critical path until the 6th floor was complete. Exterior work dropped off the critical path at the 6th floor because this is where the building steps back and the footprint decreases. Drywall follows the critical path up through the 6th floor and drops off the critical path.

SCHEDULE RISKS

The main schedule risks for the Apartment Building fall into two main categories: unforeseen conditions and weather. Because of these two risks, JMAV was about to obtain a schedule extension of 30 days.

The primary unforeseen conditions were related to the site and earthwork. Preliminary geotechnical research was completed prior to construction. However, boring samples are only accurate at the spot where they were taken. The true makeup of the site was not properly predicted based on the boring samples. For example, two corners of the site turned out to be clay, which was not shown on the geotechnical report and had to be remediated. Aside from soil composition, other unforeseen conditions included undocumented pipes and materials. The city in which the Apartment Building is located is an old historic town that had many pipes and miscellaneous objects in the ground that were undocumented. For example, where the new sanitary main tie in point, an existing railroad track and ductbank were found. Clashes with existing objects such as these require the rerouting or redesign. To help better understand the existing conditions and mitigate clashes, as-built drawings were obtained from the neighboring buildings.

Weather is always a risk to any construction project because it is unpredictable. On the Apartment Building, the majority of the concrete work and the beginning phases of masonry were initially scheduled to occur in the winter. However the winter weather was harsh and caused some delays. According to the weather tracking log created by JMAV, between November and March, poor weather conditions affected 26 days of construction. Heavy rain impacted activities such as pouring concrete and sanitary work. Cold temperatures resulted in shutting down the concrete plant which in turn made concrete unavailable. Snow accounted for delays in installation of rebar, and transportation of materials. High winds even caused the tower crane to be shut down.

Date	Weather	Notes	Number of Days Affected
2/13/2014	Snow (5.9 in.) Hi 39 F / Low 27 F	Snow removal on 2/14 and batch plant closed. Delayed formwork for G level pour #4 and rebar installation for G level pour #2	2
2/15/2014	Rain (.07 in.) Hi 40 F / Low 31 F	Due to snow from earlier in the week, could not get material from plant.	1
		Total Weather Days - February 2014	**4**

Figure 1: Actual Weather Tracking Example

In order to mitigate the effects of a harsh winter, JMAV implemented several solutions. Since a new gas line was being installed in the building, temporary heaters were hard piped into the new gas line, as opposed to propane heaters. Also, accelerants were added to the concrete to make pouring possible on the cold days.

Although winter weather had a significant impact on the schedule, there were benefits to pushing the schedule. Masonry was scheduled to begin in the winter but was ultimately pushed back due to the weather delays. This turned out to be beneficial because many possible problems were avoided. For example, if masonry work began in the winter, the work areas would have to conditioned to allow proper curing of the mortar.

SCHEDULE ACCELERATION

In order to account for some of the delays caused by winter weather and unforeseen conditions, JMAV accelerated various activities. Since the storm water management tank was the first item on the critical path, JMAV decided to install both ends of piping concurrently. This cost more in that an additional crew was needed but this accelerated the installation of the tank. Originally

the concrete floors were to be poured in two pours. Instead this was cut down to one pour per floor which allowed one floor to be completed per week.

Due to the complex brick and masonry exterior that utilized many different types of materials, it was difficult to get into a productive rhythm. If a short interval production schedule (SIPS) was created for the exterior and accounted for the installation of various materials, the installation would be able to get into a rhythm more quickly. This method of scheduling can also be applied to finishes, another critical path item.

VALUE ENGINEERING TOPICS

VALUE ENGINEERING IMPLEMENTED

The main value engineering that was used on this project dealt with materials and their alternatives.

Cast Iron Risers: Initially the owner requested that cast iron risers were to be used for storm piping to help reduce vibration and sound. The contractor suggested that PVC be used instead which resulted in a savings of about $38,000.

Slab Edge Cover: Metal slab edge covers were specified at balconies. The contractor suggested to remove the slab edge covers and replace with painted concrete. This resulted in $25,000 cost savings.

Rust Orling Architecture produced the original interior design for the building. During construction, the owner hired a new interior designer, Linowes Design Associates Inc. This design change during construction had an impact on material procurement. Some of the materials chosen for the new design were to be procured from Japan. JMAV worked to select materials that could be found locally and were more readily available, thus mitigating the effect on the construction schedule.

VALUE ENGINEERING AND OWNER GOALS

The value engineering that was done on this project essentially reinforced the goals of the owner. The goal of the owner is to make the building a successful investment with high rate of return. The contractor's value engineering suggestions helped the owner decide if certain costly items that were designed would allow a higher premium rent for the units or if that money could be used towards amenity spaces.

CONSTRUCTABILITY CHALLENGES

TOWER CRANE

The tower crane was originally planned to be erected on the East side of the building, as seen in Figure 2. The air rights agreement with the neighboring building was cleared for the tower crane at this location. There was discussion to move the tower crane to the West side of the building due a conflict with pouring a concrete oil interceptor pit. However, the owner was unable to clear the air rights agreement with the neighboring building for the new tower crane location. The neighboring building wanted more compensation for clearing their air rights. The crane had to remain at its original location on the East side of the building. The issue of pouring the oil interceptor pit still remained. To remediate this constructability issue, the oil interceptor pit was rotated 90 degrees. At this point in the project, rakers were already installed in that area so the oil interceptor pit had to be coordinated with the rakers.

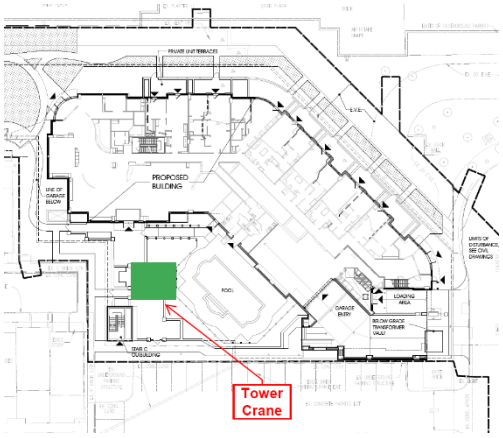


Figure 2: Actual Tower Crane Location

UNFORESEEN CONDITIONS

As with any construction project, unforeseen conditions can cause significant cost, schedule and constructability impacts. The best method of mitigating the effects of unforeseen conditions is to conduct extensive preliminary research. However, there is no way to completely eliminate unforeseen conditions, especially during excavation. As mentioned earlier when discussing schedule risks, the city in which the Apartment Building is located is an old historic town that had many pipes and miscellaneous objects in the ground that were undocumented.

When the new underground utility lines for the Apartment Building were installed at the designed elevation, clashes with the existing unforeseen objects were common. For example, where the new sanitary main tie in point, an existing railroad track and ductbank were found. Clashes with existing objects such as these require the rerouting or redesign. To help better understand the existing conditions and mitigate clashes, as-built drawings were obtained from the neighboring buildings. Installation work for these new pipes become less efficient and more complex whenever an unforeseen condition is encountered.

SITE CONSTRAINTS

The constrained site that the Apartment Building sits on, accounted for various constructability issues. During excavation, some piles were drilled instead of driven in areas that were in close proximity to neighboring buildings, as seen in Figure 3, in order to reduce vibration that could disturb the neighboring buildings and their occupants. On the East side of the building, existing condominiums were located tight against the site. Initially tiebacks were planned to be used to support excavation in this areas. However, due to the close proximity of the underground parking garage for the condominiums, underpinning and internally supported rakers were used. On the West side of the building there is an existing 16 inch diameter water line that branches from a water tower nearby. Piles were to be driven in this area and were located a mere two feet from the water line. This required great precision and accuracy to ensure the pile did not penetrate the water line, which would cause damage to the site, schedule delays and have a high cost impact.

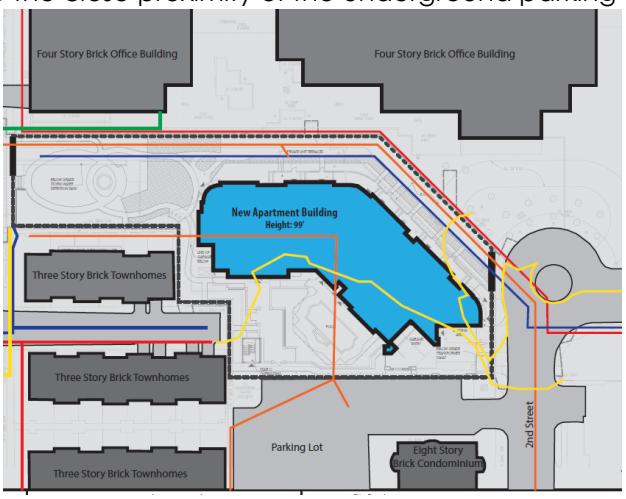


Figure 3: Apartment Building and Neighboring Buildings

MECHANICAL/ PLUMBING SUBCONTRACTOR TERMINATION

On this project, the plumbing and mechanical subcontractor was a design-build entity. Towards the latter half of the construction, it was revealed that the subcontract was having financial issues. JMAV, as a proactive measure, decided to terminate the contract with the design-build subcontractor before they failed. A new plumbing and mechanical subcontractor was brought on board to complete the remainder of the project. This affected the efficiency and production of the project since the new subcontractor was unfamiliar with the project and took time to get to speed. The caveat of terminating the design-build subcontractor is that when design question arose, the designer is part of the design-build contractor. An agreement was made with the original design-build subcontractor that they would still be responsible for responding to RFI's and answering design related questions. Although an agreement was made, the RFI turnaround rate was decreased which ultimately affects field productivity.

BIM USE EVALUATION

BIM OVERVIEW

As defined by the National Building Information Modeling Standards Committee, Building Information Modeling (BIM) is a, "digital representation of a physical and functional characteristics. A BIM is a shared knowledge resources for information about a facility forming a reliable basis for decisions during its life-cycle; defined as existing from earliest conception to demolition." BIM is a process, not just a tool. It is the processes of effectively exchanging information between all disciplines to help proctor planning, design, construction and operation decisions.

BIM uses are only as effective as the plan used to implement the information exchanges. The BIM Project Execution Planning Guide (BIMex), is a guide developed by Penn State to provide a structured procedure for implementing BIM on a project.

Figure 4: Penn State's BIM Project Execution Planning Guide

According to Penn State's BIM Execution Planning website, the five most frequently used BIM uses are 3D coordination, design reviews, design authoring, construction system design, existing conditions modeling. There are roughly 25 various BIM uses that are identified in the BIM Execution Planning website.

A BIM Execution Plan was created for the Apartment Building based on potential BIM uses that would be beneficial to the overall project. Penn State's BIM Execution Planning Guide was used to create the plan. Note that this plan is a shorted version of the Penn State BIM Execution Planning Guide, refer to Appendix 1.

CURRENT BIM USES

Currently, on the Apartment Building, BIM was used primarily in the design phase of the project. In the design phase, architect and structural engineer designed the building in 3D in Revit. This 3D model was then used to create the construction documents used for construction. The 3D model was not transferred to the contractor and minimal BIM uses were utilized in construction of the building. The main reason BIM is not a main focus of this project, is that there is significant cost involved to implement various BIM uses. Because of cost, traditional methods of construction were used. As an educational exercise, various BIM uses will be suggested and the benefits will be discussed.

SUGGESTED BIM USES

Based on feasibility, cost and overall benefit to the owner, the following BIM uses in Table 1 were selected.

Table 1: Suggested BIM Uses

X	PLAN	X	DESIGN	X	CONSTRUCT	X	OPERATE
	PROGRAMMING	X	DESIGN AUTHORING	X	SITE UTILIZATION PLANNING		BUILDING MAINTENANCE SCHEDULING
	SITE ANALYSIS		DESIGN REVIEWS		CONSTRUCTION SYSTEM DESIGN		BUILDING SYSTEM ANALYSIS
		X	3D COORDINATION	X	3D COORDINATION		ASSET MANAGEMENT
		X	STRUCTURAL ANALYSIS		DIGITAL FABRICATION		SPACE MANAGEMENT / TRACKING
		X	LIGHTING ANALYSIS		3D CONTROL AND PLANNING		DISASTER PLANNING
		X	ENERGY ANALYSIS		RECORD MODELING	X	RECORD MODELING
		X	MECHANICAL ANALYSIS				
			OTHER ENG. ANALYSIS				
			SUSTAINABLITY (LEED) EVALUATION				
			CODE VALIDATION				
	PHASE PLANNING (4D MODELING)		PHASE PLANNING (4D MODELING)	X	PHASE PLANNING (4D MODELING)		PHASE PLANNING (4D MODELING)
	COST ESTIMATION	X	COST ESTIMATION	X	COST ESTIMATION		COST ESTIMATION
X	EXISTING CONDITIONS MODELING		EXISTING CONDITIONS MODELING		EXISTING CONDITIONS MODELING		EXISTING CONDITIONS MODELING

Planning Phase:

In the planning phase, it is suggested to implement existing conditions modeling. Since the site that the Apartment Building is being built on was once a high school field and is located in a historic city, modeling the existing conditions on the surface and below the surface can help mitigate some of the unforeseen conditions that were encountered during construction. This enhanced documenting of the site and increased accuracy would have impact on design decision such as structure and support of excavation. By doing this research in conjunction with the geotechnical engineer, less unforeseen conditions will arise and remediation is much less expensive during design as compared to during construction.

Design Phase:

Since a 3D model had already been produced by Rust Orling, the BIS use of design authoring is a given. A 3D model, Revit in this case, helps improve design visualization, quality control, and collaboration between all disciplines. From this 3D model, various analysis by each engineering discipline can be completed to determine the best system for the Apartment Building. The analysis

tools are less expensive than the design authoring software that was already used on this project. Engineering analysis can help drive down the lifecycle cost of the building while improving quality and performance. Since the contractor, JMAV, was brought on early to the project. Cost Estimation and 3D coordination are two BIM uses that would be very feasible to implement while having tremendous benefits. As the design progresses, JMAV can use the 3D model to complete quantity takeoffs and track the cost of the project. Cost estimation can be completed at regular intervals or at each main phase of design: schematic, conceptual, and design development. The contractor can then do a cost trending analysis of the design as it develops and implement some value engineering to reach the owners performance, schedule and cost goals. Since the contractor is already involved early on in the project, 3D coordination, or clash detection can have many benefits. As the design is developed by each discipline, the contractor can go through the process of clash detection by overlaying each disciplined 3D model. Clashes between building systems can then be solved while still in the design phase. It is much less costly to solve clashes in the design phase compared to in the field.

Construction Phase:

During the construction phase of the project, the BIM uses are primarily headed by the contractor, JMAV. By transferring the 3D design model that was created in the design phases in to construction, many beneficial BIM uses are possible. The suggested BIM uses are site utilization planning, 3D coordination, phase modeling and cost estimation. Since the construction site for the Apartment Building is tight due to the neighboring existing buildings, site utilization planning can be used to efficiently plan out the site layout for each phase of construction in a visual manner. This planning will minimize site congestion, improve safety, and minimize spatial conflicts between trades. 3D coordination, which was used in the design phase, can also be used during construction. This is the last chance to catch clashes between building systems prior to installation in the field. 3D Coordination can increase productivity, decrease cost, and ultimately decrease schedule. Cost estimation should be continued from the design phase into construction to help minimize the chances of a budget overruns. Change orders are inevitable on any project. By having a 3D model that can easily be changed, cost estimates can be quickly generated by reducing the time of quantity takeoffs. Lastly phase planning, more commonly known as 4D modelling should be used. Phase planning is the method of integrating the construction schedule with the 3D model. This is a valuable visual tool that can be used to help all project stakeholders understand the construction sequence. A 4D modeling can be used a first attempt at construction. Clashes, space conflicts and schedule waste can be caught prior to construction.

Operational Phase

Similar to as-built drawings that are handed over to the owner once the building is construction, a 3D model that accurately depicts the building can be turned over along with the 2D as-built drawings. This 3D model can be used for future renovations and improvements to the building as well as visual tool to help the owner gain a better understanding of the building systems for facilities and operational purposes.

LEVEL 1 PROCESS MAP

In order to properly implement BIM uses into a project, a plan of information exchanges, sequencing and responsibility must be developed. Below is the Level 1 BIM Execution Planning Process. An enlarged Level 1 Process Map can be found in the BIM execution plan in Appendix 1.

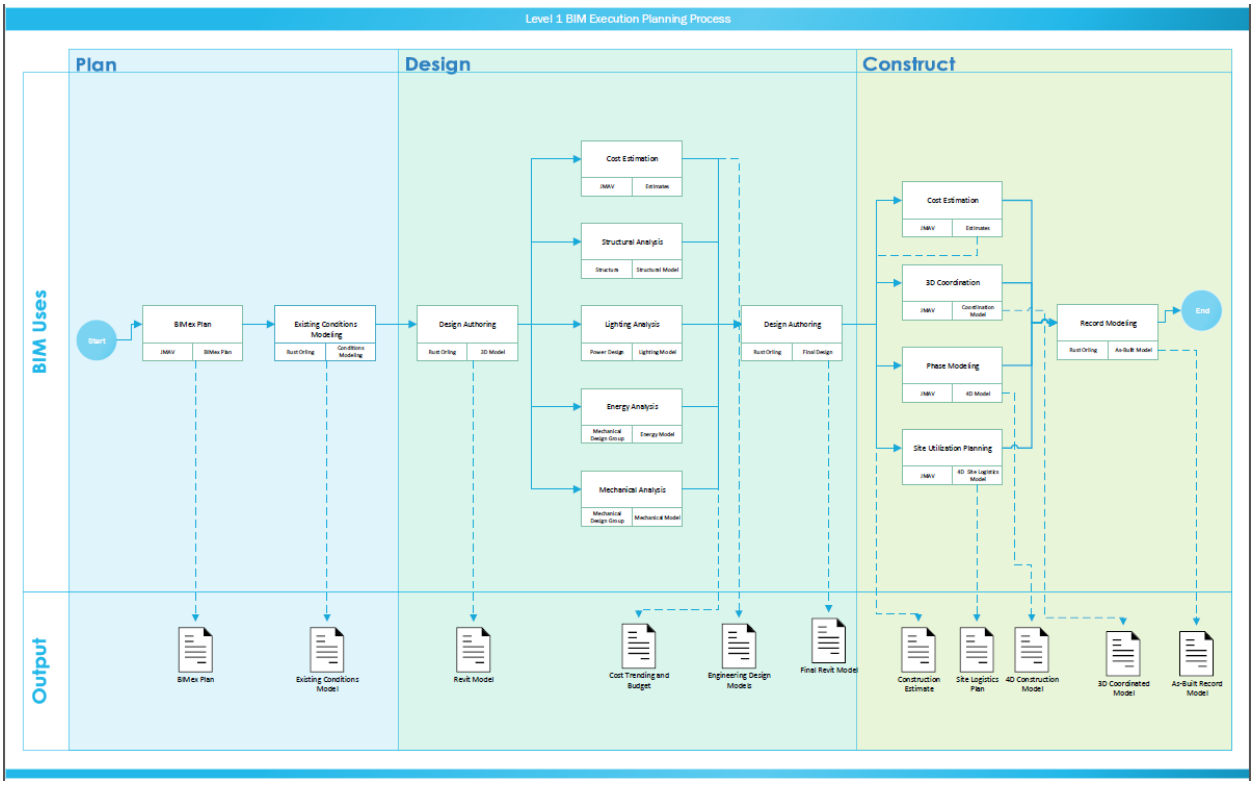


Figure 5: Level 1 BIM Execution Planning Process

LEVEL 2 DETAILED BIM PROCESS MAP

Detailed process maps for each suggested BIM use can be found in the BIM execution plan in Appendix 1.

CRITICAL INDUSTRY ISSUES

At the 23rd annual PACE Roundtable, various sessions relating to various facets of the construction industry were attended. The purpose of attending these sessions was to delve into conversation regarding construction topics and extracting possible research ideas for the Apartment Building. Three main sessions were attended. The topic of the first panel session was "IPD and the New Project Manager. From here several breakout sessions were held. The breakout session attended dealt with the topics of the opportunities and challenges of new global drivers and incentivizing team performance. Below is a summary of the various sessions. The student forms and notes can be found in Appendix 2.

PANEL DISCUSSION: IPD AND THE NEW PROJECT MANAGER

Speakers: Ken Lindsay, Chris Dierks, Kendall Nielsen

Facilitator: Dr. Leicht

To kick off the PACE Roundtable, a discussion relating to one of the more prominent advances to the construction industry was held, Integrated Project Delivery (IPD). As IPD and IPD-like delivery are becoming more a prevalent delivery method in industry, the role of the project manager is beginning to evolve. The panel for this discussion was comprised of three people that work for companies that are leading the IPD movement.

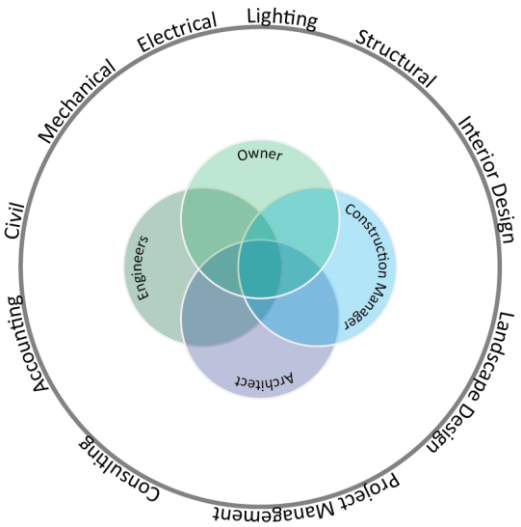


Figure 6: IPD

As IPD is becoming a more popular project delivery method, the roles and responsibilities of the traditional project manager are beginning to change. Project managers are now beginning to get involved earlier in the project, as early as the beginning of the design phase. Early involvement of the project manager gives the initial designers constructability and cost input. Owners prefer to keep the same project manager who was brought on early through the construction of the project since the project manager will have a better understanding of the dynamics of the team and project. With IPD, teamwork and the group setting is highly emphasized. In order to succeed with the delivery method, the team must work as a cohesive unit that is productive, efficient, flexible and driven. This puts extra responsibility on the project manager to proctor this collaborative environment. The ideal IPD project manager must have strong leadership skills and

have the capability to bring out the best out of all the experts on the project. Currently in school, the curriculum is heavily weighted on the technical side of construction and design. As IPD and the collaborative environment becomes more popular, it is important that students get more educated in the soft skills such as communication, organizational leadership and behavior.

BREAKOUT SESSION 1A: NEW GLOBAL DRIVERS – OPPORTUNITIES AND CHALLENGES

Facilitators: Dr. Messner, Dr. Rowlinson

The conversation began with a discussion on the global sourcing of products and materials then expanded into a discussion about why companies even expand globally and the repercussions associated with doing so, for example safety.

As construction companies are becoming more global in their reach and size, global sourcing of materials are becoming more popular. Through this globalization, product and materials can now be acquired internationally at completive quality and prices. There are risks associated with procuring materials and products abroad. The main risk is timely delivery since the product is coming from a further distance. More logistics and communication are needed to ensure timely delivery. It is commonly thought that quality is a major risk, however it is no longer a large risk since foreign suppliers and manufacturers have adapted ASTM standards. Another risk is the cultural and environmental differences between countries. Some countries have different power distances and cultural differences that can impact the construction process that is considered normal in the United States. However competency is there. Another risk is the chance of receiving counterfeit goods. This is not a large problem but it does exist. An example that was given, was a counterfeit water pump that looked identical to its brand name counterpart.

As the conversation developed, the topic switched from global sourcing of products and materials to the global expansion of companies. Companies expand internationally not just for the sake of doing so, but when there is opportunities in their niche markets. Companies first establish their niche in the domestic market then expand to areas where their experience is needed. John O'Keefe, mentioned that Clark Construction was asked to be the construction manager for Disney in their project in China since they have much experience with Disney's theme parks.

A large difference in the construction industry between countries is safety. Safety standards widely vary internationally. Steve Rowlinson, a professor at the University of Hong Kong, has much experience with the construction industry in China, Australia, and Indonesia. He mentioned that

in China, workers are paid at a piece-rate, meaning that workers get pain for the quantity of product they install. This promotes a production only mindset, minimizing the importance of safety.

BREAKOUT SESSION 2C: INCENTIVIZING TEAM PERFORMANCE

Facilitators: Dr. Leicht

Incentives are a common method of rewarding teams for good performance. This discussion evaluated common forms of incentives that are currently being used and other forms of incentives than can be used to promote good performance.

The discussion started off with a brainstorming session to determine what drives current employee behavior. The list consisted of items such as: team buy in, team dynamic, peer pressure, organizational culture, satisfaction, recognition, price, reputation, and respect. Ultimately the purpose of incentives is to promote performance. Although there are many factors that drive behavior and performance, the most common form of incentives is monetary.

Common project incentives include shared saving clause and "playing for tips". Both of these incentives work in a GMP contract. In a shared saving clause, the owner and contractor agree to divide the savings if the project comes under budget. In "playing for tips" the contractors costs are covered and the owner conducts walks every pay period to determine what fee the contractor deserves, this fee is ultimately the contractor's profit margin. On smaller scale, the monetary incentives for project team members include yearly bonuses and feedback and performance reviews at the end of the project.

Monetary incentives are generally liked by employees and project teams but does not buy commit by the team. The team ends up playing games to earn this monetary reward. There are other types of incentives, other than monetary, that promote team buy in. Some examples include social infrastructure, peer pressure in a group setting. Colocation is a way of improving the team dynamic by breaking down silos and promote face to face interaction. One example of peer pressure used by a company that attended the session, was the idea of gold stars. Gold stars were posted on a wall whenever a team member exceed expectation.

The conversation ended with topic of durations of these different types of incentives. Most incentives are aligned with the end of the project. It can be tiring for team members to have the same goal for two years. Short term goals are more manageable and give team members a sense of progress. A good analogy was made to students and grades. Students prefer to have grade updated given by teachers consistently throughout the semester so progress and performance

measured and analyzed. If a teacher gave one final grade at the end of the semester with no updates along the way, the student will feel overwhelmed and out of the loop. Short term goals are updates are vital to ensure performance throughout the duration of the project.

FEEDBACK FROM INDUSTRY ROUNDTABLE

At the last session of the PACE Roundtable, a small group session was attended with an industry member to further generate research opportunities and ideas for the Apartment Building. The industry member was John O'Keefe, the current president of Atkinson Construction. O'Keefe is also a former vice president of Clark Construction and has experience working in Clark's residential sector. O'Keefe provided his insight from his own experience to help identify opportunities for research and improvement for Apartment Building. The sections below summarizes some of the topics that were discussed.

QUALITY CONTROL AND TURNOVER

In any residential project, quality of construction is vital. If quality is not up to standards during construction, the punchlist and closeout duration of the project will be exponentially increased. This can impact the revenue and profit from the apartment units if turnover is delayed. Quality control through procedure and supervision is essential to help mitigate punchlist items and the closeout duration of the project. Since the Apartment Building is a phased turnover, quality and phasing is even more pivotal. In a phased turnover, construction and occupancy is mixed and can create several issues. Some of the major issues include vertical transportation, indoor air quality and egress. Also, major building systems must be complete before the first phase of turnover. Finishes can completed later, so in essence the building has to be further along that it would seem.

Due to the repetitive nature of construction and turnover of the Apartment Building, the construction must follow an assembly line approach, especially with finishes. A method that Clark uses to manage the assembly line is a finish matrix. This matrix is essentially a SIPS (short interval production schedule) schedule that has line items for every finish activity and designated when and where each crew should be doing work. The schedule should follow five work days per week. If at the end of the work week, the subcontractor is behind, they are obligated to perform weekend work to get back on the SIPS schedule by the next Monday. A common problem than can throw the SIPS schedule off is if a material delivery is missed, this has a domino effect on the whole schedule and can ultimately postpone turnover of the building. O'Keef's advice to mitigate this issue, is to always order extra material and store material in warehouses even though this goes

against the lean concept of just-in-time delivery. In addition when material is taken from other rooms or floors of the building it must be stringently tracked and more material should be ordered. Another important consideration is who should be working on the punchlist items. It is important that the punchlist crew is different than the production crew. Pulling the production crew from their production task will ultimately effect the SIPS schedule.

A possible research idea for the Apartment Building would be to create a detailed SIPS schedule for the interior finishes and exterior brickwork as well as a 4D model to help visualize the schedule.

Resources: John O'Keefe, Dr. Leicht

MARKET EVALUATION

BMPI, the owner of the Apartment Building, is a private developer that is building the Apartment Building as a long term investment. In order to maximize their return on investment it is vital to evaluate the market. This evaluation is typically done by a third party consultant. A market evaluation can help determine the following items:

- Size of units
- Demand of different unit types
- Appliances
- Amenities
- Condominiums vs Apartment

A research opportunities is to see if JMAV does market research in-house and reanalyze the market to see if there are areas where profit for BMPI can maximized.

ARCHITECTUAL FLEXIBILITY

Branching off this idea of market evaluation, the interior spaces of the Apartment Building should be flexible in order to adapt to the changing market. The concrete structure is ideal for flexibility since the interior spaces can be more easily altered compared to a stick build apartment building.

A possible area of research could be an architectural redesign of the units to promote easy conversion of units to various sizes based on the market needs.

BIMUSES

Since the Apartment Building has much repetition between floors, it could be beneficial to implement certain BIM Uses like 3D clash detection to help mitigate and resolve clashes early on the lower floors of the building.

Currently, the Apartment does not utilize any BIM technology and uses 2D clash detection to solve issues. A possible research area would be to delve into acquiring a 3D model from the architect and analyzing the cost and schedule impact of implementing 3D clash detection.

APPENDIX 1: BIM EXECUTION PLAN

BIM EXECUTION PLAN

The Apartment Building
East Coast, USA

B. Kerem Demirci | Construction Option | Advisor: Dr. Messner | 11.14.14

Source: JMAV

BIM PROJECT EXECUTION PLAN

VERSION 2.0

FOR

THE APARTMENT BUILDING

DEVELOPED BY

B. KEREM DEMIRCI

TABLE OF CONTENTS

SECTION A: BIM PROJECT EXECUTION PLAN OVERVIEW

Reason For BIM Project Execution Plan:

Building Information Modeling (BIM) is an established collaboration process that begins during the planning phase through operation. BIM is a tool that will help produce a complete, efficient, responsible building while being on budget and on schedule. The primary purpose of the Building Information Modeling (BIM) Project Execution Plan is to incorporate and standardize BIM in the design of the Apartment Building. Through this plan, BIM uses will be defined and an overall project schedule will be created to successfully integrate various facets from planning to design and through construction.

SECTION B: PROJECT INFORMATION

1. **Project Owner:** BMPI
2. **Project Name:** The Apartment Building
3. **Project Location and Address:** East Coast, USA
4. **Contract Type / Delivery Method:** GMP
5. **Brief Project Description:** The Apartment Building is a high-end apartment building located on the East Coast. It consist of ten stories above grade, amounting to 151,158 SF. The building also has a two story, 62,250 SF underground parking garage. Ten of the units are designated affordable housing for 40 years which allows the maximum zoning height restriction to increase from 77 feet to 99 feet. The ground floor houses amenities such as a lounge, business center, and fitness room. An additional club room is located on the fifth floor. Accessible terraces are located on the fifth and eighth floor and include gas grills, gas fire pits, and water/gas features.
6. **Project Schedule / Phases / Milestones:**

PROJECT PHASE / MILESTONE	ESTIMATED START DATE	ESTIMATED COMPLETION DATE	PROJECT STAKEHOLDERS INVOLVED
Conceptual Design	2/1/11	7/1/12	BMPI, JMAV
Design Development	7/1/12	2/11/13	BMPI, JMAV
Construction	2/11/13	2/11/13	BMPI, JMAV

SECTION D: PROJECT GOALS / BIM USES

1. MAJOR BIM GOALS / OBJECTIVES:

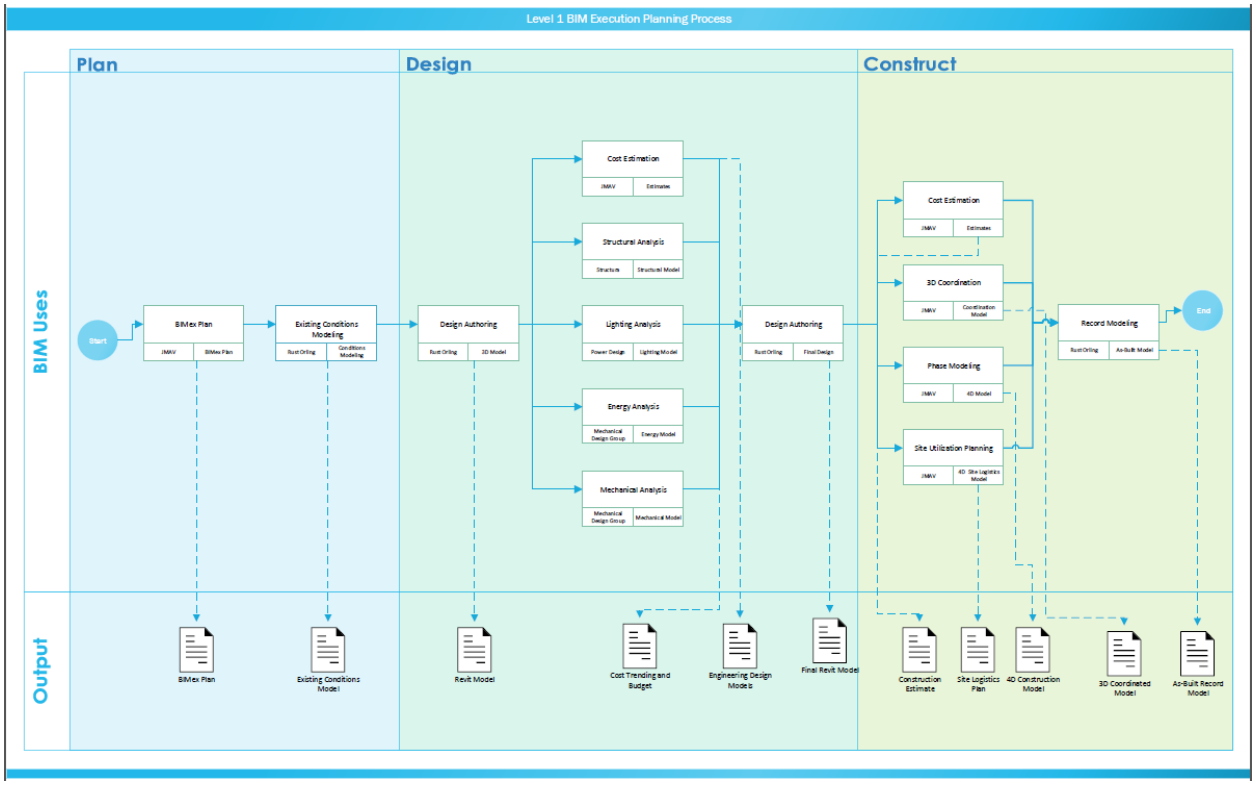
PRIORITY (HIGH/ MED/ LOW)	GOAL DESCRIPTION	POTENTIAL BIM USES
High	Effectively create and maintain the project budget	Design Authoring, Design Reviews, 4D Modeling
High	Effective phasing, scheduling and construction	Site Utilization Planning, 4D Modeling, Cost Estimation
Med	Meet LEED requirements	Sustainability Evaluation, Energy Analysis
High	Seamless integration and communication between all design disciplines	3D Coordination, 4D Modeling
High	Promote a high level of quality in design and construction	Design Authoring, Design Reviews

2. BIM USES:

X	PLAN	X	DESIGN	X	CONSTRUCT	X	OPERATE
	PROGRAMMING	X	DESIGN AUTHORING	X	SITE UTILIZATION PLANNING		BUILDING MAINTENANCE SCHEDULING
	SITE ANALYSIS		DESIGN REVIEWS		CONSTRUCTION SYSTEM DESIGN		BUILDING SYSTEM ANALYSIS
		X	3D COORDINATION	X	3D COORDINATION		ASSET MANAGEMENT
		X	STRUCTURAL ANALYSIS		DIGITAL FABRICATION		SPACE MANAGEMENT / TRACKING
		X	LIGHTING ANALYSIS		3D CONTROL AND PLANNING		DISASTER PLANNING
		X	ENERGY ANALYSIS		RECORD MODELING	X	RECORD MODELING
		X	MECHANICAL ANALYSIS				
			OTHER ENG. ANALYSIS				
		X	SUSTAINABLITY (LEED) EVALUATION				
			CODE VALIDATION				
	PHASE PLANNING (4D MODELING)		PHASE PLANNING (4D MODELING)	X	PHASE PLANNING (4D MODELING)		PHASE PLANNING (4D MODELING)
	COST ESTIMATION	X	COST ESTIMATION	X	COST ESTIMATION		COST ESTIMATION
X	EXISTING CONDITIONS MODELING		EXISTING CONDITIONS MODELING		EXISTING CONDITIONS MODELING		EXISTING CONDITIONS MODELING

SECTION F: BIM PROCESS DESIGN

1. LEVEL ONE BIM PROCESS OVERVIEW MAP: ATTACHMENT 2



2. LIST OF LEVEL TWO – DETAILED BIM USE PROCESS MAP(S): ATTACHMENT 3

a. Existing Conditions Modeling
b. 3D Coordination
c. Structural Analysis
d. Lighting Analysis
e. Energy Analysis
f. Mechanical Analysis
g. Cost Estimation
h. Site Utilization Planning
i. Phase Modeling

SECTION G: BIM INFORMATION EXCHANGES

1. BIM USE REQUIREMENTS

BIM USE	REQUIREMENTS	SENDER	RECEIVER
EXISTING CONDITIONS MODELING	3D modeling of existing conditions from photos, measurements, and topography.	Rust Orling, Ubran Ltd.	All parties
DESIGN AUTHORING	BIM authoring tool	All parties	All parties
3D COORDINATION	Detailed 3D model from all disciples	Rust Orling, Ubran Ltd. Mechanical Design Group, Structura, Power Design Inc.	JMAV
STRUCTURAL ANALYSIS	Detailed 3D model and building loads	Structura	All parties
LIGHTING ANALYSIS	Detailed 3D model, room usage, day lighting study	Mechanical Design Group	All parties
ENERGY ANALYSIS	Detailed 3D model, developed mechanical system design, utility rates	Mechanical Design Group	All parties
MECHANICAL ANALYSIS	3D model for load calculations	Mechanical Design Group	All parties
COST ESTIMATION	Building takeoffs and cost data	JMAV	All parties
SITE UTILIZATION PLANNING	Existing conditions modeling, site analysis, traffic and pedestrian flow	JMAV	All parties
PHASE PLANNING (4D MODELING)	Detailed 3D model from all disciplines, CPM schedule	JMAV	All parties

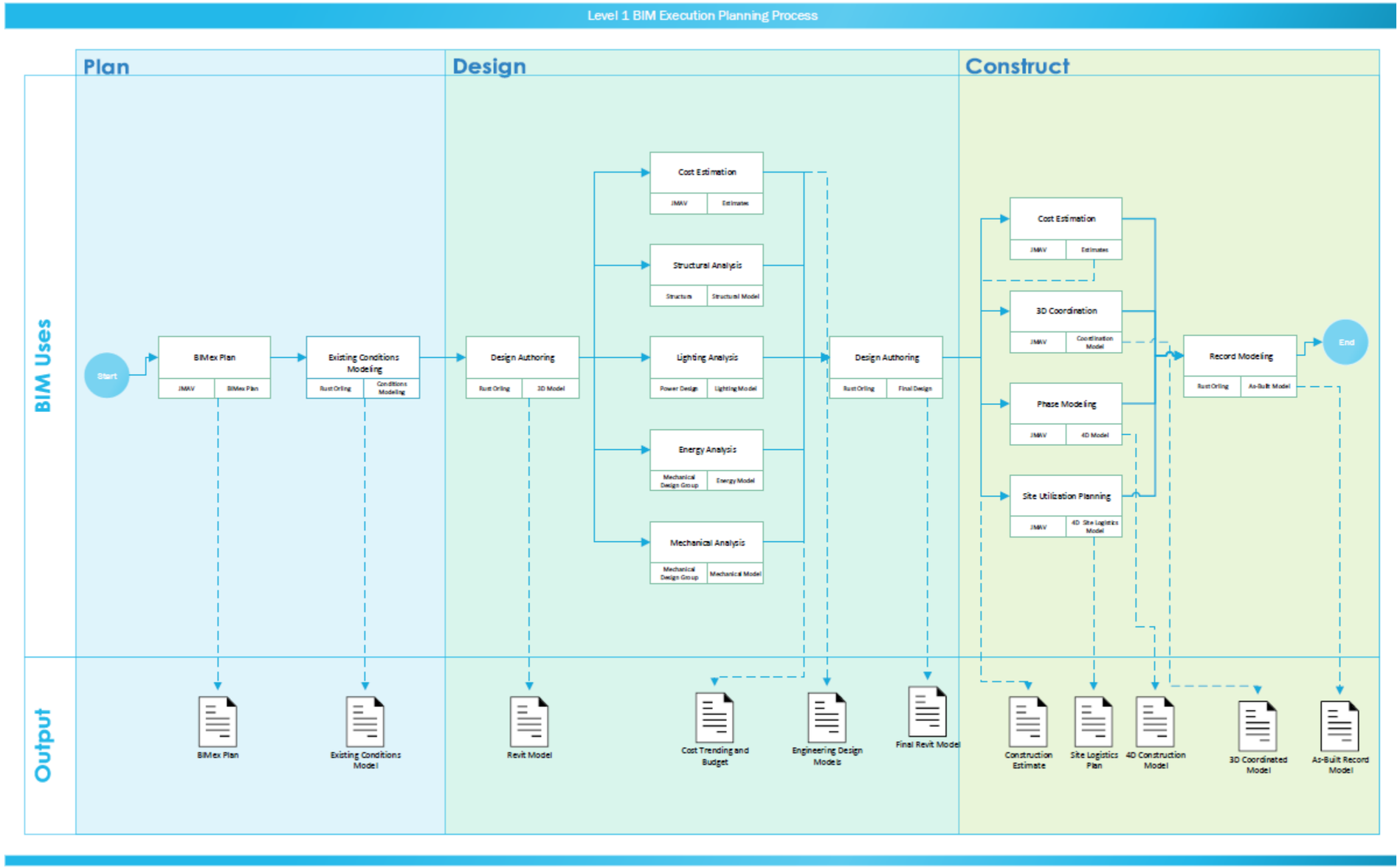
SECTION O: ATTACHMENTS

1. BIM USE SELECTION WORKSHEET [FROM SECTION D]

Priority (1-3)	Goal Description	Potential BIM Uses
1- Most Important	Value added objectives	
1	Effectively create and maintain the project budget	Design Authoring, Design Reviews, 4D Modeling
1	Effective phasing, scheduling and construction	Site Utilization Planning, 4D Modeling, Cost Estimation
2	Meet LEED requirements	Sustainability Evaluation, Energy Analysis
1	Seamless integration and communication between all design disciplines	3D Coordination, 4D Modeling
1	Promote a high level of quality in design and construction	Design Authoring, Design Reviews

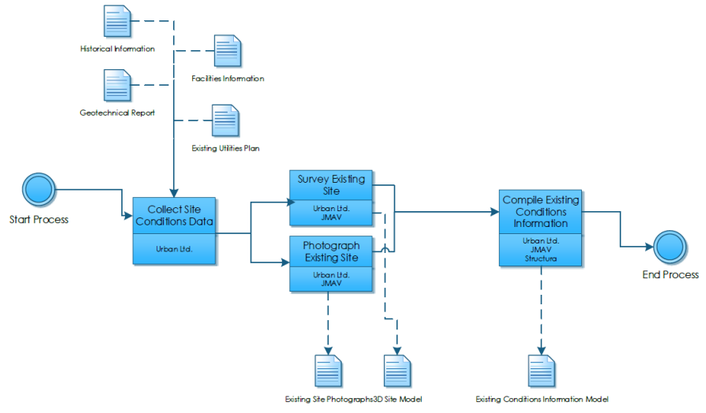
BIM Use	Value to Project	Responsible Party	Value to Resp Party	Capability Rating			Additional Resources / Competencies Required to Implement	Proceed with Use
	High / Med / Low		Med / Low	Scale 1-3 (1 = Low)				YES / NO / MAYBE
				Resources	Competency	Experience		
Cost Estimation	High	JMAV	High	2	2	2		**Yes**
4D Modeling	High	JMAV	High	3	1	1	Requires training and software	**Yes**
Site Utilization Planning	Med	JMAV	Med	3	2	1	Requires training and software	**Yes**
3D Coordination (Construction)	Med	JMAV	Med	1	1	1	Requires training and software	**Yes**
Engineering Analysis	High	Power Design Inc.	High	3	3	2	Requires training and software	**Yes**
		Mechanical Design Gr	High	3	3	2	Requires training and software	
		Structura	High	3	3	2	Requires training and software	
Site Analysis	Med	Urban Ltd	High	3	3	2		**Yes**
Design Reviews	Med	Rust Orling	Med	2	3	2		**No**
		BMPI	High	2	2	2		
		Contractor	Med	2	2	2		
3D Coordination	High	Rust Orling	High	3	2	1	Requires training and software	**Yes**
		Engineers	High	3	2	1	Requires training and software	
		JMAV	High	3	2	1	Requires training and software	
Existing Conditions Modeling	Med	Rust Orling	High	3	2	2		**Yes**
Design Authoring	High	Rust Orling	High	3	2	2	Requires training and software	**Yes**
		Mechanical Design Gr	High	3	2	2	Requires training and software	
		Structura	High	3	2	2	Requires training and software	
		Power Design Inc.	High	3	2	2	Requires training and software	

2. LEVEL 1 PROCESS OVERVIEW MAP [FROM SECTION F]

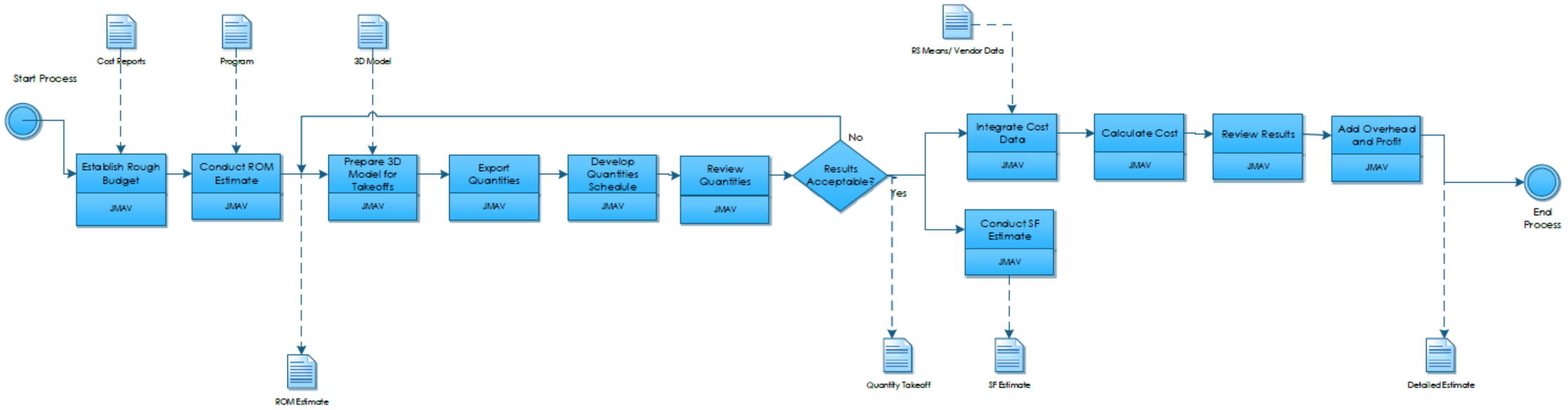


3. LEVEL 2 DETAILED BIM USE PROCESS MAP(S) [FROM SECTION F]

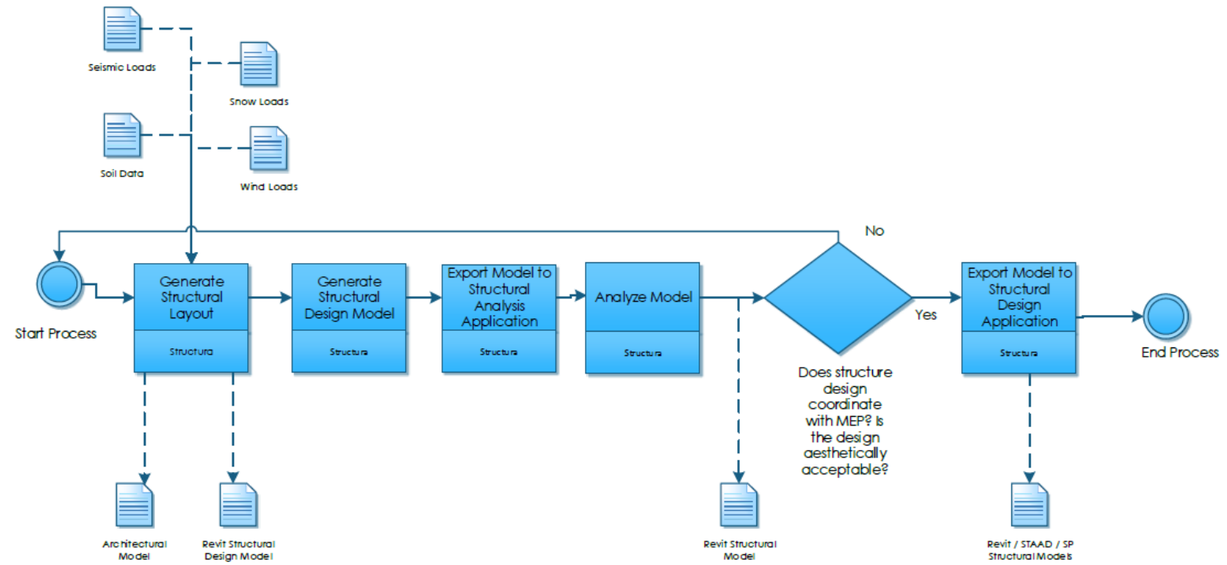
EXISTING CONDITIONS MODELING



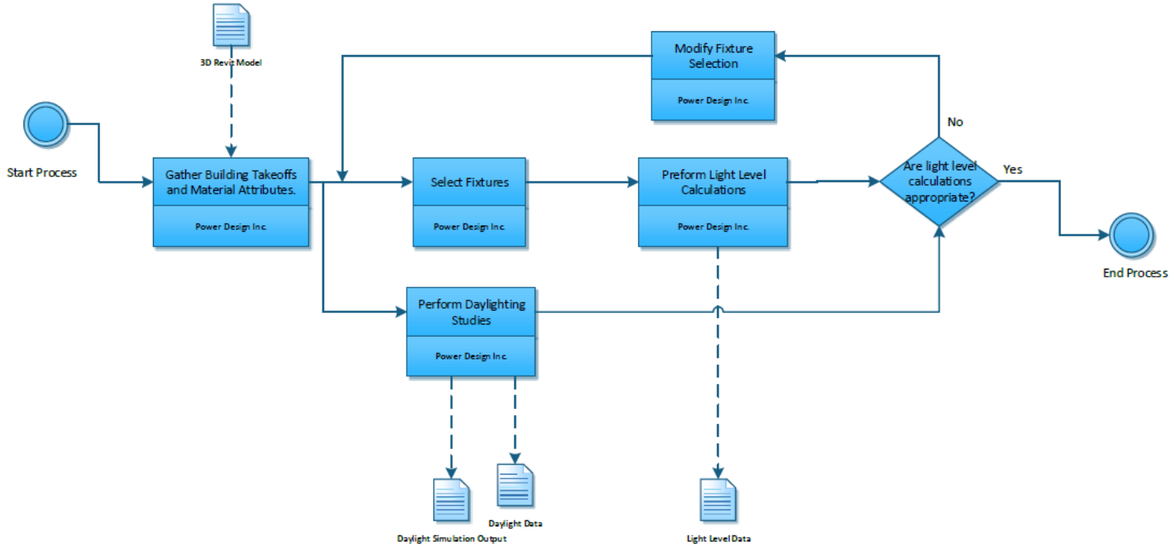
COST ESTIMATION



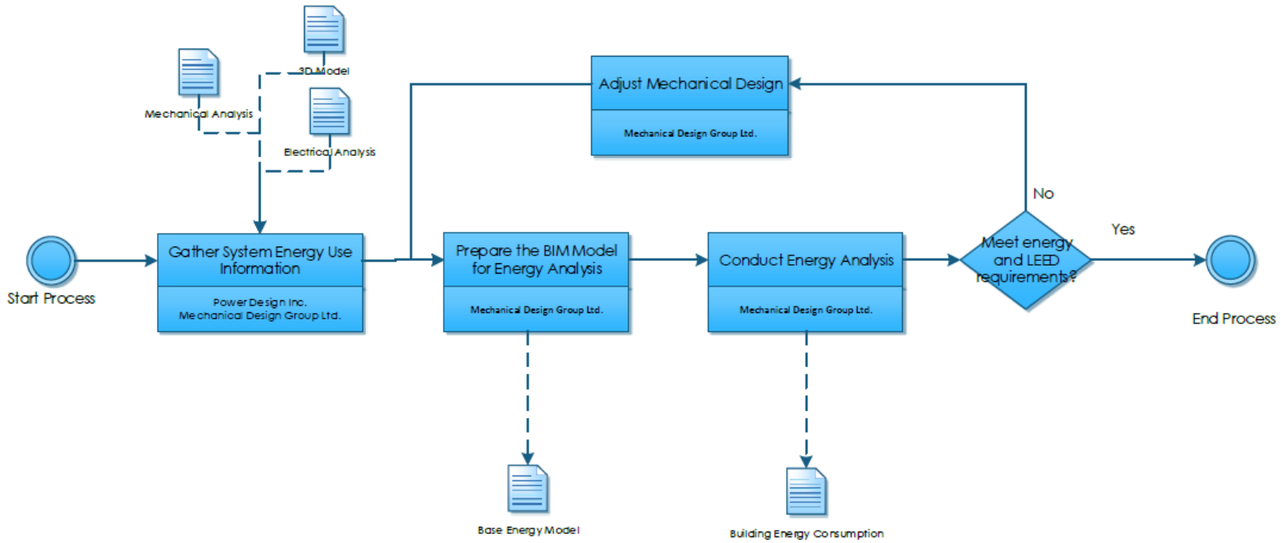
STRUCTURAL ANALYSIS



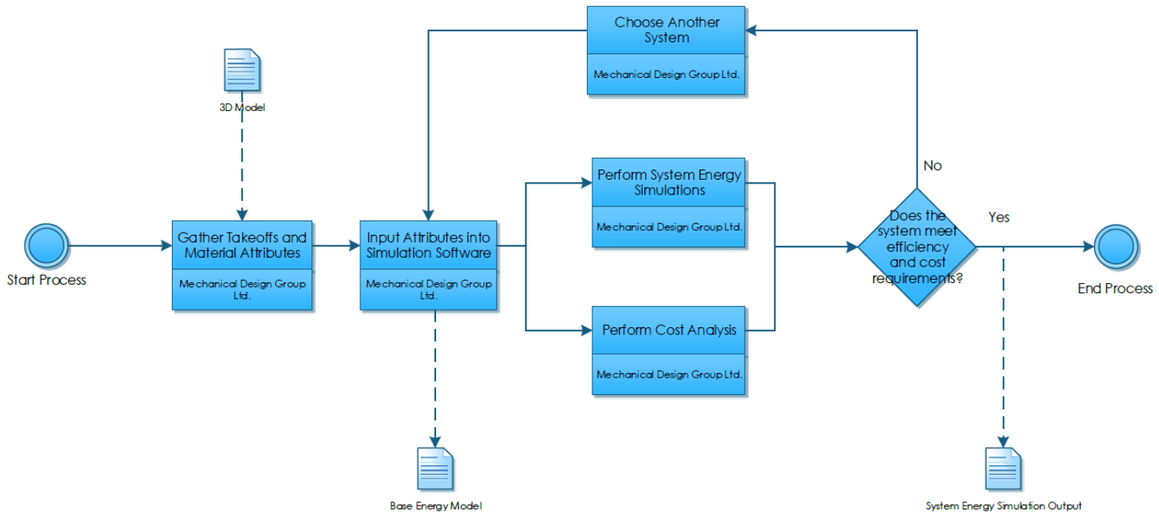
LIGHTING ANALYSIS



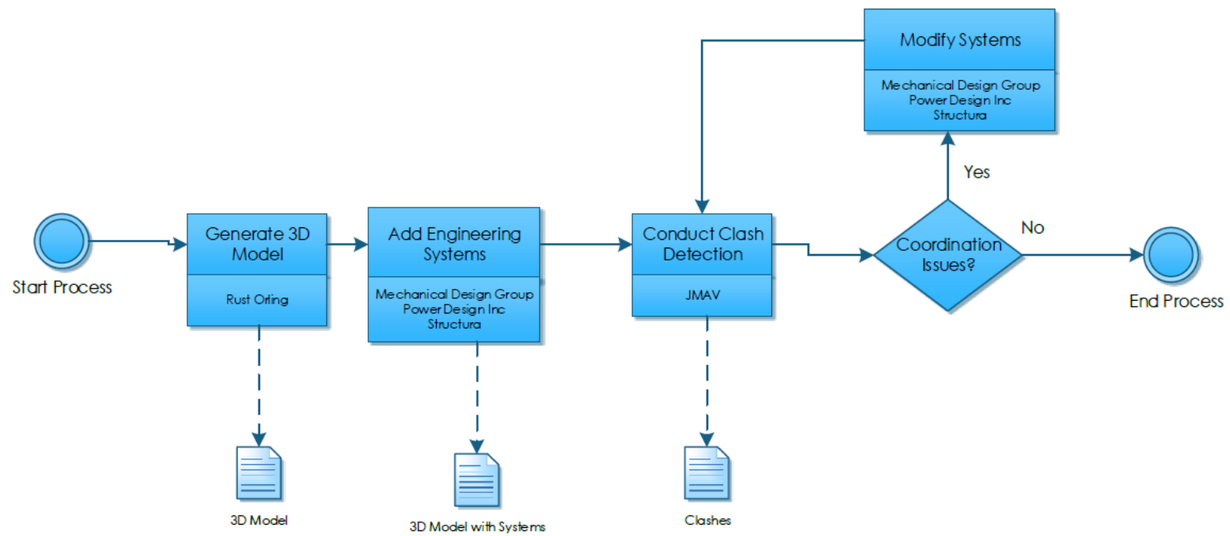
ENERGY ANALYSIS



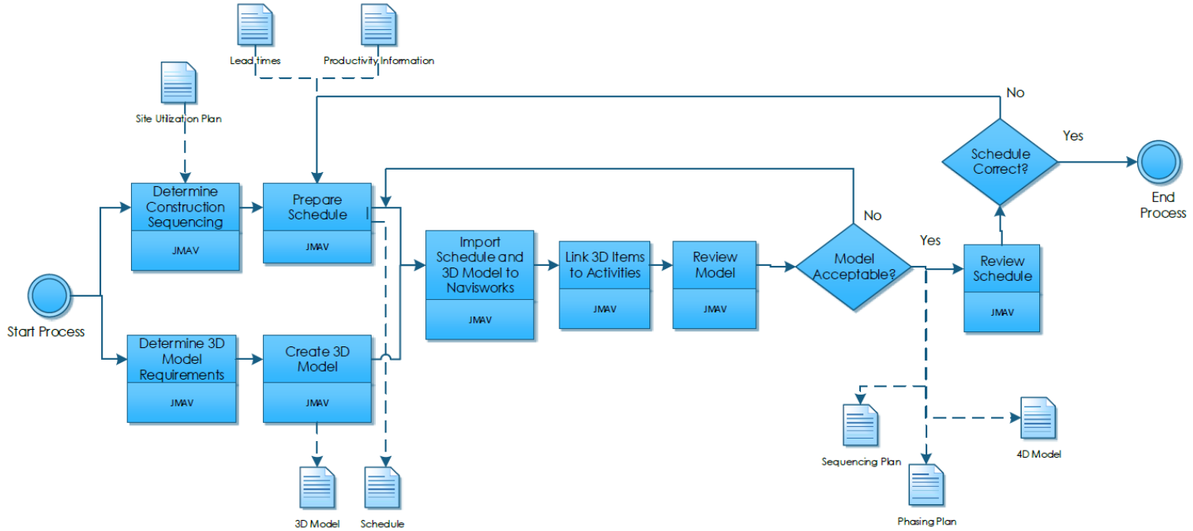
MECHANICAL ANALYSIS



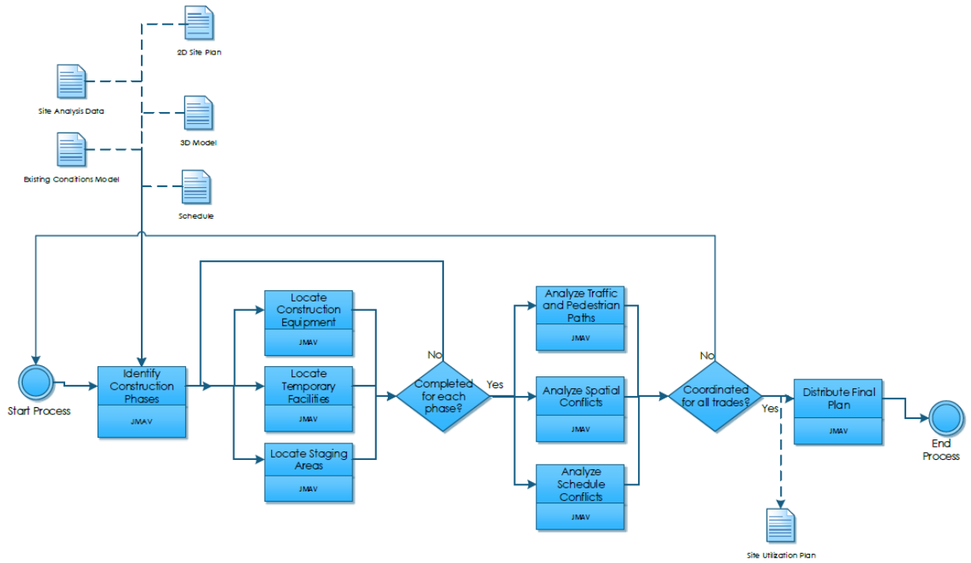
3D COORDINATION



PHASE MODELING



SITE UTILIZATION PLANNING



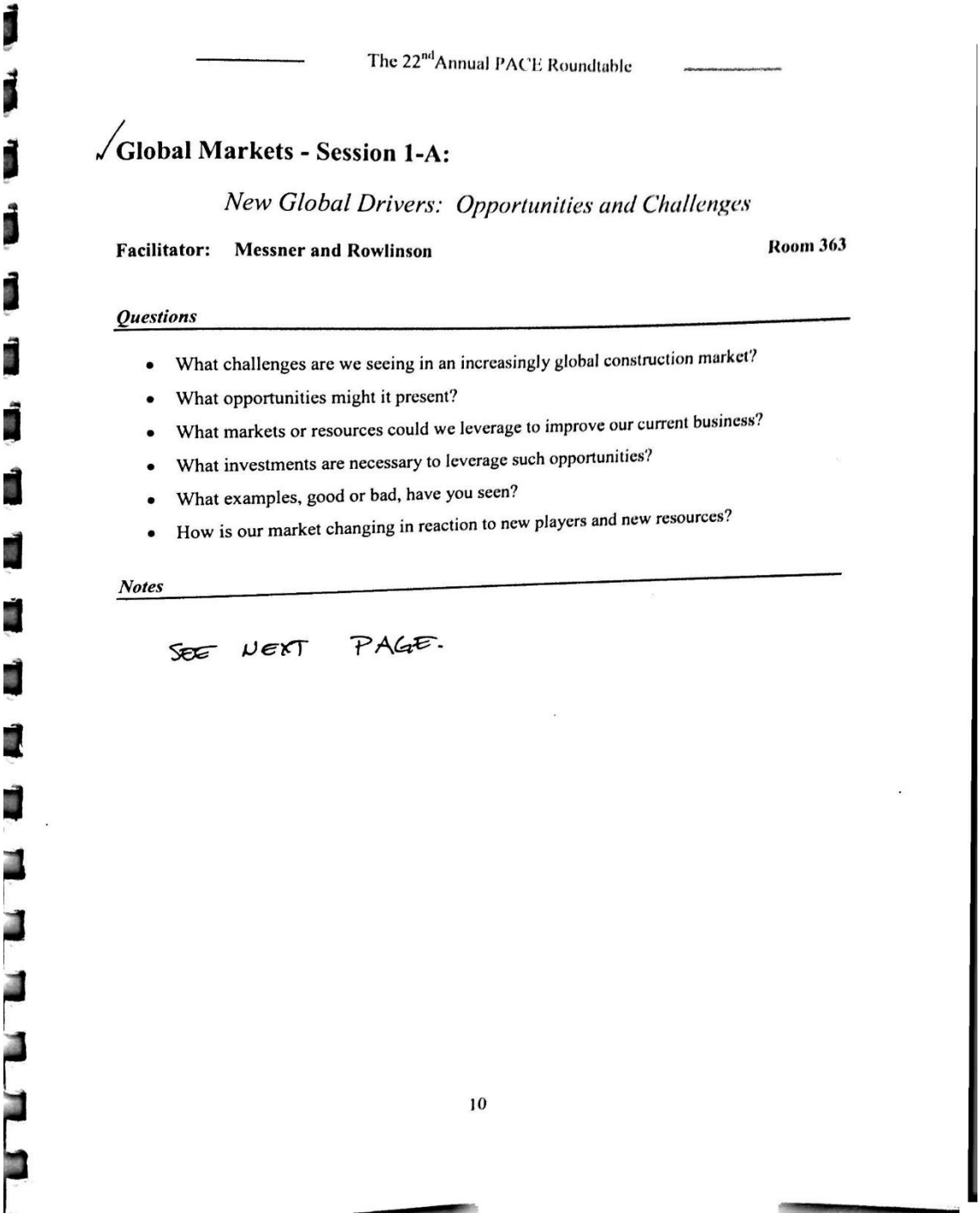
APPENDIX 2: PACE ROUNDTABLE STUDENT FORMS AND NOTES

PANEL DISCUSSION: IPD AND THE NEW PROJECT MANAGER

Panel Discussion: IPD and the New Project Manager

- Speakers: Ken Lindsay (Southland), Chris Dierks (DPR), Kendall Nielsen (Mortenson)
- What are the changing roles of project managers
  - beginning to get involved earlier in the project
  - owners are beginning to involve project managers earlier and prefer to have the same project manger stay for the life of the project
    - better understand dynamics of the team and project
- What individual traits are ideal for this changing project manager role
  - strong leadership skills
  - capability to bring the best out of all expects on project
  - ability to mesh team together
  - school is focused on technical and tactical solution, lack of organizational behavior skills
  - what courses should the AE program be offering to teach these skills
    - organizational leadership
    - behavior
    - communication
    - soft skills
- How do teams deal with personnel changes during a project?
  - try to avoid it
  - at the beginning establish ground rules for execution so that someone coming in can easily pick it up
  - don't rely on one person to do too much
- What can younger team member expect?
  - better understanding of process
- What kind of formal education do your superintendents and foremen have on these integrated projects?
  - typically trade school
  - conduct games that help teach them processes
- Cash flow
  - expect the front end of the project to be heavy
  - management is expensive
- How do you make big decisions?
  - most appropriate party should make the decision
  - decisions are collaborative and are made formal by a designated champion who owns the process
- Ideal owner's PM
  - must manage many early meetings
  - most important player in setting up environment where you break down silos
  - must be involves, if not, teams will retract back into silos
  - big time commitment
  - must keep morale high
- Metrics and goals
  - last planner
  - rfi tracking
  - failed inspection tracking
- What are some tools to improve team building
  - workshops

BREAKOUT SESSION 1A: NEW GLOBAL DRIVERS – OPPORTUNITIES AND CHALLENGES



The 22nd Annual PACE Roundtable

Global Markets - Session 1-A:

New Global Drivers: Opportunities and Challenges

Facilitator: **Messner and Rowlinson** **Room 363**

Questions

- What challenges are we seeing in an increasingly global construction market?
- What opportunities might it present?
- What markets or resources could we leverage to improve our current business?
- What investments are necessary to leverage such opportunities?
- What examples, good or bad, have you seen?
- How is our market changing in reaction to new players and new resources?

Notes

SEE NEXT PAGE.

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Breakout Session 1A: New Global Drivers - Opportunities and Challenges - Messner and Rowlinson

- Summary
  - Global sourcing of materials
    - construction industry is becoming global, materials as well
    - competitive quality and price
    - risk involved with globally sourced materials
      - quality
        - no longer a quality risk since ASTM standards are met
      - delivery
        - main risk
  - Globally, the culture and environment is different and can impact the typical process that the US is used to
    - power distance, cultural differences
    - competency is there
  - Counterfeit materials coming from international market
    - CII did a study
  - Product vs Raw material
    - stone is a material that has always been imported because it can't be found anywhere else. not much of a quality issue
  - Why do companies move internationally?
    - establish niches in domestic market and expand to areas where experience is needed
    - companies go global not for just any reason, must have expertise
  - Safety
    - safety standards vary internationally
    - e.g. china, workers are paid by piece rate and a production mindset.
  - Safety incentive program
    - pros - workers will work harder to be safe
    - cons - will stop reporting
- Issue that apply to my project
- Research Ideas
  - Look into foreign material/ systems used on Braddock, do an comparison with alternatives
    - metrics
      - cost
      - process
      - delivery
      - quality
  - Look into labor force. For educational purpose analyze how the project would be different if it was constructed in another country
    - What would JMAV have to do in order to pursue a project in another country
- Key contacts
  - Steve Rowlinson
  - John o'keefe

BREAKOUT SESSION 2C: INCENTIVIZING TEAM PERFORMANCE

The 22nd Annual PACE Roundtable

Integrated Processes - Session 2-C:

Incentivizing Team Performance

Facilitator: Leicht **Room 365**

Questions

- What incentivizes you personally to see a job succeed?
- What are the "incentives" which currently drive team behavior on projects?
- Where are the tensions in how we currently align risk and incentives?
- How important are contractual penalties? Are they aligned to make jobs successful?
- How important are contractual incentives?
- What are some examples of good and bad incentives?
- How does an owner "set the bar" for incentives?

Notes

SEE NEXT PAGE.

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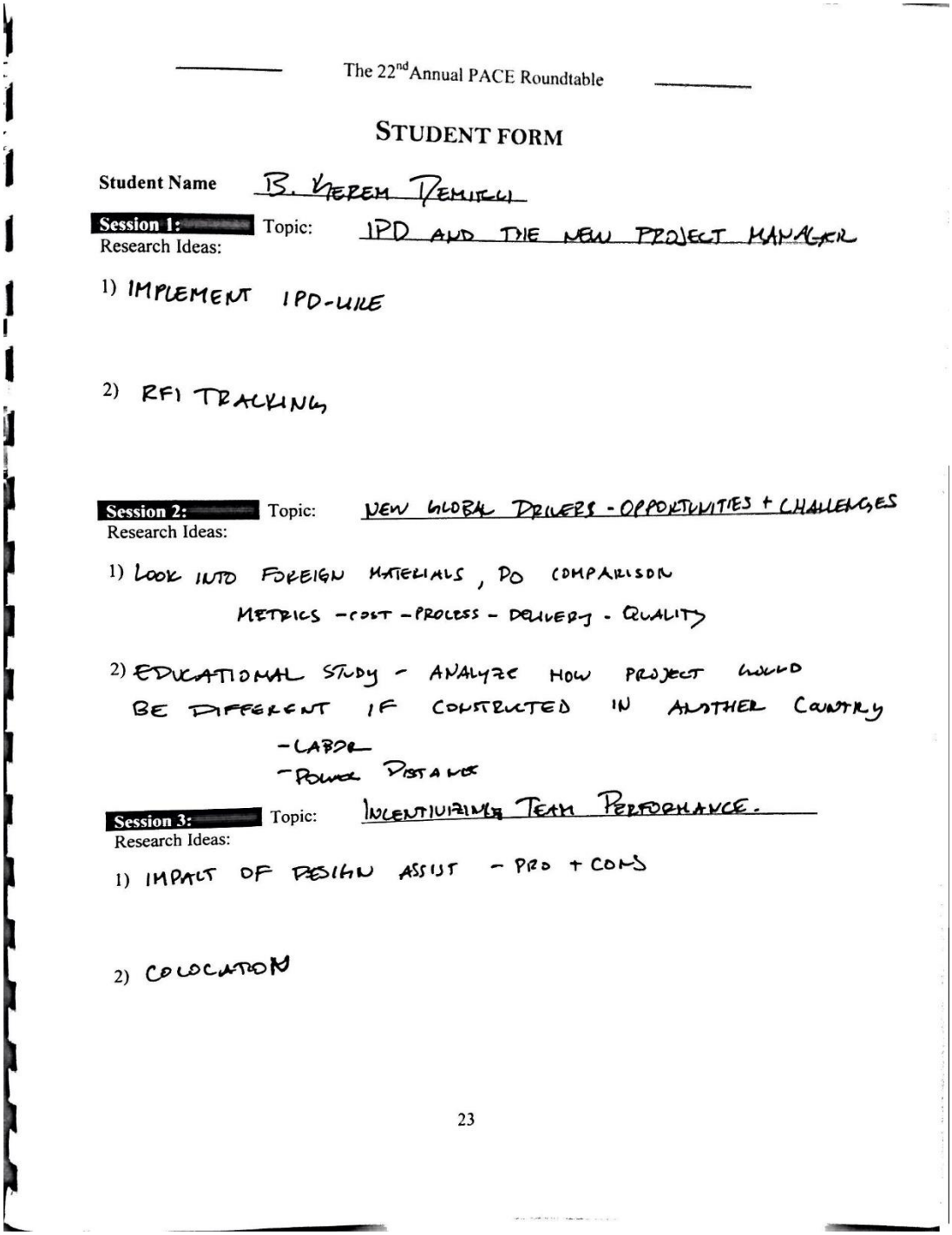
Breakout Session 2C: Incentivizing Team Performance - Leicht

- Summary
  - What incentivizes and drives what we current behavior
    - Team buy in
    - Team dynamic
    - Peer pressure
    - Organizational culture
    - Satisfaction
    - Recognition
    - Pride
    - Reputation
    - Respect of trades
  - How do we add fun?
    - Colocation and team dynamic
    - Break down silos
    - Face to face vs email
    - For ever tough conversation into many fun, effective, progressive conversations
  - Incentive for challenging jobs
    - Stronger sense of satisfaction
  - What metrics define successful incentives
  - Examples of bad incentives
    - Safety incentive
      - People stop reporting incidents
    - Metrics may drive wrong behavior
  - Common monetary incentives
    - Feedback and performance reviews
    - Yearly bonus
    - Shared saving clause
    - Play for tips
      - GMP contract
      - Contractors costs are covered and owner walks ever pay period and determines the fee that is deserved (contractor profit margin)
    - Can't really buy commitment
    - End up playing games
  - Other types of incentive
    - Gold stars - peer pressure in a group setting
    - Social infrastructure
  - Misalignment of incentives
    - Company drivers vs owner drivers
    - Who to please?
    - IPD is an attempt to align company with the project
  - Negative incentives
    - Liquidated damages
  - Duration of incentives
    - Most incentives are aligned with the end of the project but that is tiring to have the same goal for two years
    - Short term goals are more manageable and let you know where you stand
      - Topping out party
      - Safety lunches
  - Where should students study?
    - Look into IPD
      - Co location and team environment
    - Owner engagement effort and impact on IPD environment
    -
- Issue that apply to my project
  - Impact of design assist, pros and cons
  -
- Key contacts
  - Rob Leicht

STUDENT FORM: RESEARCH IDEAS



The 22nd Annual PACE Roundtable

STUDENT FORM

Student Name B. YEREM DEMIRCI

Session 1: Topic: IPD AND THE NEW PROJECT MANAGER
Research Ideas:

1) IMPLEMENT IPD-LITE

2) RFI TRACKING

Session 2: Topic: NEW GLOBAL DRIVERS - OPPORTUNITIES + CHALLENGES
Research Ideas:

1) LOOK INTO FOREIGN MATERIALS, DO COMPARISON
METRICS - COST - PROCESS - DELIVERY - QUALITY

2) EDUCATIONAL STUDY - ANALYZE HOW PROJECT WOULD BE DIFFERENT IF CONSTRUCTED IN ANOTHER COUNTRY
- LABOR
- POWER DISTANCE

Session 3: Topic: INCENTIVIZING TEAM PERFORMANCE.
Research Ideas:

1) IMPACT OF DESIGN ASSIST - PRO + CONS

2) COLOCATION

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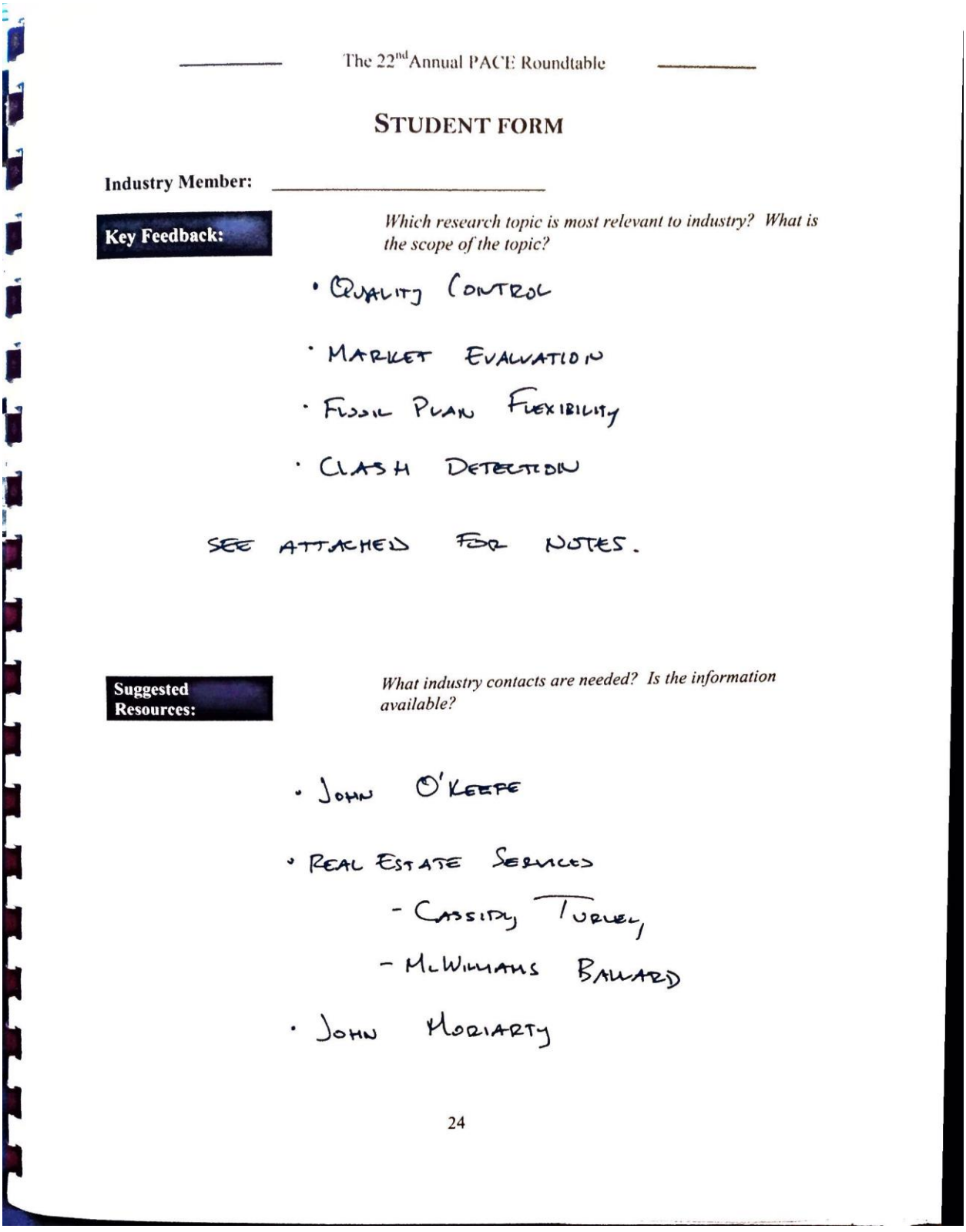
INDUSTRY FEEDBACK



The 22nd Annual PACE Roundtable

STUDENT FORM

Industry Member: _____

Key Feedback:

Which research topic is most relevant to industry? What is the scope of the topic?

- QUALITY CONTROL
- MARKET EVALUATION
- FLOOR PLAN FLEXIBILITY
- CLASH DETECTION

SEE ATTACHED FOR NOTES.

Suggested Resources:

What industry contacts are needed? Is the information available?

- JOHN O'KEEFE
- REAL ESTATE SERVICES
  - CASSIDY TURLEY
  - MCWILLIAMS BALLARD
- JOHN MORIARTY

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Feedback from Industry Roundtable - John O Keefe - Atkinson Construction

- John used to be head of Clark's residential
- Concrete is more expensive than stick built but it has more value down the road
- Post-tension concrete is more flexible in layout for the long term
    - floors can be removed etc. Cant be done with stick built
- Concrete usually have masonry skin and structural studs
- Can't build higher than 4 floors with stick build
- Subcontractor community is different for stick build vs concrete
    - subcontractors used to stick build is more used to residential construction that may not adapt well to metropolitan construction.
    - will need to be trained

Owner Builder

- more wholistic approach approach
- in it for the long run and the return
- changes are more easily done

Research Ideas

- Acoustical analysis
- Quality control
    - phased turnover
        - mixing construction and occupancy
            - Issues
                - vertical transportation
                - IAQ
                - egress
                - systems have to be complete before 1st phase of turnover
                - finishes can happen later
                - building has to be further along than you
            - must have a system like an assembly line
            - punchlist guys must be different than production works
            - SIPS Schedule
            - "Finish matrix"
                - installation of drywall
                - cabinets
                - ---
                - ---
                - --
                -
                - --
                - .
                - .
            - Make 4D model
            - scheudle for 5 days, if behind than weekend work is a must
            - subs are responsible, to be back on schedule by monday
            - *Just in time delivery analysis
                - cons
                    - once you miss a delivery SIPS schedule goes down the drain
                - should order extra material
                - material tracking, when you take material from other room and re order
                - store material in warehouse
- Evaluate the market
    - size of the units

- appliances
- what type of units are popular
- amenities that are bringing in money
- more on the developer side...
- how to maximize income for the developer!
- longer the building is in construction the more money is costs up front
- condo vs apartment
  - sell vs rent
- resources
  - McWilliams Ballard
  - Cassidy Turley
  - call dc developers
  - companies that do the marketing analysis - give advice to owner what units look like and sells
  - marketing and sales consultant
  - see if moritarty does this in house

◦ Architectural floor plan flexibility
- market changes so layouts should be flexible
- redesign layout?
- architectural breadth

◦ Implement 3D clash detection
- repetitive layout
- look into cost of obtaining 3D model
- cost of BIM guy

◦ Sustainability
-