

Construction Option Thesis Requirements:

Fall 2012

Department of Architectural Engineering

AE 481W: Senior Thesis

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Summary

This document provides a detailed description of the Construction Capstone Project requirements. You are expected to familiarize yourself with the assignments and submit your thesis deliverables on the assigned dates.

Key Dates / Grading Percentage for Technical Assignments:

25%	Tech 1: Construction Project Management	September 17
25%	Tech 2: Cost and Schedule Analysis	October 12
	<i>PACE Roundtable Meeting (Attendance required)</i>	<i>November 6</i>
20%	Tech 3: Methods Analysis	November 12
	<i>Proposal Presentations</i>	<i>Nov 29 & Dec 1</i>
30%	Final Thesis Proposal	December 7

Grading

Electronic copies of each report are to be submitted to your via Turnitin.com, with a paper copy submitted to Professors Parfitt & Holland to be distributed to your advisor. You are also required to electronically post your report per the thesis requirements. Due dates are fixed and final.

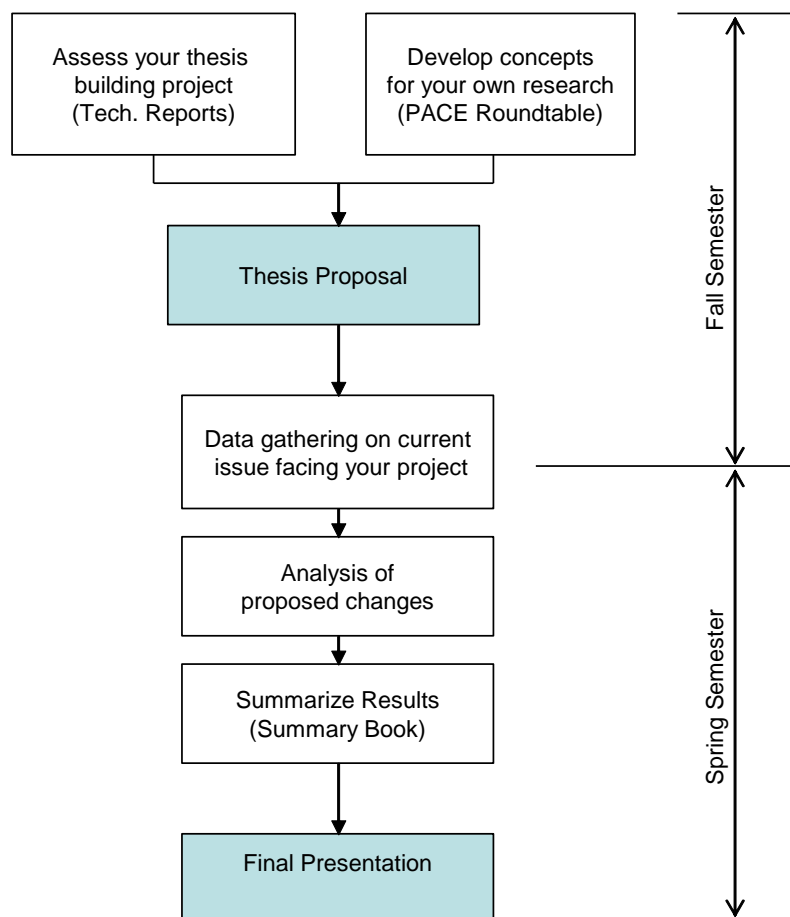
Corrections to Graded Reports:

Once you receive your returned reports with comments, you are responsible for making appropriate corrections to your assignments and reposting the corrected version on your eStudio website along with re-submitting it to Turnitin for confirmation and to help instructors track changes.

Thesis Process

Objectives:

- Gain a working understanding of the technical and construction issues on your thesis building.
- Develop a thesis proposal that defines areas of investigation to be completed in the Spring Semester.
- Gather data through industry sources on key relevant issues facing the building industry and your project, and on the technical systems analysis you perform to identify potential improvements on your project.
- Develop and produce a concise and professional oral and written presentation of your results.



Technical Assignment 1: Construction Project Management

This portion of your Fall Thesis is intended to familiarize you with the conditions under which your building is constructed and the scope of work. This background will provide you with the opportunities and constraints that affect the design and construction process. Note that some of this information was required in your Building Statistics section posted to your eStudio portfolio. You can directly copy any information posted to your building statistic, if appropriate, to this technical assignment.

(10) *Executive Summary / Table of Contents / Professional Document*

Prepare a one page summary of the key findings in this assignment, and questions you have about how the contractual arrangements, construction schedule, and budget might affect your thesis research. Highlight any distinguishing requirements, e.g., the project is LEED rated, or any unusual techniques that were employed to meet the demands of the project, e.g., unique delivery methods or information technology solutions. Your document should also include a table of contents, cover page, and be written as a professional technical report.

(10) *A. Project Schedule Summary*

Produce a one-page summary schedule of your project using MS Project, Primavera, or Excel. Include the design phase, and procurement of construction services on the schedule. Your schedule should illustrate when the major phases of construction occur (Sitework, foundations, superstructure, enclosure, finishes, and occupancy). Any key milestones and phasing relationships should be illustrated. Do not exceed 25-30 activities. Show activity names, durations, and start and completion dates in the left margin of the schedule. Make sure the schedule is easy to read and follow. Briefly describe in a written section the key elements of the foundation, structural and finish sequences.

(10) *B. Building Systems Summary*

Complete the “building systems summary” form at the back of this assignment describing the key aspects of the design and construction for your project. Include goals set by the project team to achieve LEED Certification, and any unique green building project features.

(15) *C. Project Cost Evaluation*

Evaluate the costs of the building systems by performing the following tasks:

- Report the actual building Construction Cost (CC) and CC /SF. Do not include land costs, sitework, permitting, etc.
- Report the Total project Costs (TC) and TC cost / SF.
- Report major Building Systems Costs and Cost /SF (May place emphasis on option). This should include as a minimum the mechanical system, electrical system, and structural system.
- Produce a Square Foot estimate for your building using R.S. Means data, and attach a reference from the source you use for cost information. Include your assumptions and any revisions to the standard square foot data.
- Prepare Assemblies cost estimates for the MEP systems employed on your project
- Briefly compare and discuss the differences between your estimates and the actual project costs.

(30) **D. Site Plans**

(10) Existing Conditions (See checklist)

Obtain the site plan(s) used by the contractor and develop a site layout drawing for the temporary facilities (general conditions items) on your project. Develop **your own** version of the site plan on CAD, PowerPoint, or Revit. Show locations of parking, access roads, hydrants, utility locations, neighboring buildings (with height of structure), traffic and pedestrian patterns. (3D/4D site plans are typically very effective visualization tools, and are encouraged, but are not required.) Your site plan should look professional.

(20) Site Layout Planning

Using the existing conditions plan created above, develop scale site plans for each critical phase of construction e.g. excavation, superstructure, or finish phase of the project (minimum of 3). Show locations of ramps, fences, temporary facilities, cranes, hoists, etc. Provide descriptions of the key features of the site layout, and critique the layout used by the contractor. Submit each site plan on 11x17 (min) sized paper and be sure to specifically reference the plans and changes in the descriptions.

(5) **E. Local Conditions**

List any preferred methods of construction in the region, availability for construction parking, available recycling and tipping fees, and type of soil/subsurface water condition.

(5) **F. Client Information**

Describe the owner of the project. Why are they building this facility e.g. mission critical, growth, relocation, etc.? What are the cost, quality, schedule and safety expectations for the project? Identify examples of their actions to support your descriptions. What sequencing issues are of interest to the owner? Are there any joint, dual, or phased occupancy requirements? What are the keys to completing the project to the owner's satisfaction?

(10) **G. Project Delivery System**

Define briefly how the project is being delivered, e.g., design-bid-build, design-build, construction management, etc, and why that approach was chosen. Produce an organizational chart for your project that demonstrates the following for each major project player (Owner, Architect, Engineers, Contractors, and **Specialty Contractors related to your option**, e.g. steel erector, HVAC contractor, electrical contractor etc:

- Role in project
- Name of Firm
- Key Contact (if available)

Your chart should also include the **types of contracts** held between different players and any other interesting relationships, e.g. joint ventures, LLC, or key communication lines. You can place the contract types on the lines within the organization chart. Include a paragraph describing in detail the essence of the contractual agreements between parties, with an emphasis on the construction contract terms. How was a contractor selected? What bonds and insurance are required? Assess the appropriateness of the contract types and delivery systems for the project.

(5) **H. Staffing Plan**

Develop an organizational chart describing how the CM/GC staff is assigned to the job. Briefly describe the structure of the project management and supervision staff.

Technical Assignment 2: Cost and Schedule Analysis

This section of your thesis will allow you to analyze the key features of the project that affect project execution. You will determine important schedule attributes and the costs of a key building system.

(5) ***Executive Summary / Table of Contents***

(20) ***A. Detailed Project Schedule***

Develop a more detailed construction schedule for your project by trade. This is the schedule you will use for your cost loading. Your schedule should reflect how the project was built, including phasing and structural sequences, and make distinctions between MEP rough-in, distribution, and finishes. Each project will be different; however do not exceed 200 activities.

(25) ***B. Detailed Structural Systems Estimate***

Following the detailed estimating format provided, develop a detailed estimate for a typical bay (or logical module) of the system you have chosen for your estimating analysis. If you do not choose an alternate system you should estimate the cost of the scope of work for the superstructure. Complete this calculation by providing the cubic yards of concrete and/or tons and number of pieces of steel, etc. Include foundations, slab on grade, elevated decks, columns, roof slabs, and flatwork. (Show calculations) Using a Square foot method, extrapolate this section to provide an estimate of the labor, material, and equipment costs for the entire system. If you select an alternative system which is approved by your faculty consultant, provide effective overall ratios for evaluating your detailed estimate, e.g., \$/sf for exterior enclosures, \$/sf for electrical, etc.

(10) ***E. General Conditions Estimate***

Develop a General Conditions Estimate for the project. Include all project and staffing costs. Do not include home office overhead. Include monthly fees and unit costs so you can reflect the impact of schedule changes on general conditions costs. Be sure to address temporary utilities. Keep in mind that any schedule savings you propose will require a calculation in G.C. savings.

(20) ***Building Information Modeling Use Evaluation***

Develop the BIM use list and Level 1 Process Map how BIM was used on your project. Summarize the BIM uses implemented and the process which were used, including whether models were transferred from design to construction, and identify any plans related to use for turnover to the owner. Provide a critical evaluation of both the appropriateness of the BIM uses and the process for implementation.

(20) ***Constructability Challenges***

Describe and include drawings / sketches of the top three unique and/or challenging constructability issues on the project. How did the actual site team overcome these challenges? Discuss these challenges with your project team.

Technical Assignment 3: Alternative Methods Analysis

This section of your investigation will allow you to begin to identify areas of the project that are good candidates for research, alternative methods, value engineering, and schedule compression. These will form the basis for your final thesis proposal.

(5) *Executive Summary / Table of Contents*

(20) *LEED Evaluation*

Develop a LEED strategy for your project using the most up to date LEED Point System based on the Penn State approach. Briefly summarize the results and analyze the appropriateness of each point category. Provide an overall critical evaluation – is your project pursuing the appropriate level of certification in order to meet the client’s needs and project goals?

Project Manager Interview:

(15) *Schedule Acceleration Scenarios*

Describe the critical path of the project schedule. What are the biggest risks to the project completion date? What are key areas that have potential to accelerate the schedule if needed? What would be the costs and techniques?

(15) *Value Engineering Topics*

Describe key areas of value engineering that were implemented on the project. How did these correlate / detract from the goals of the owner? What ideas for value engineering were considered but not implemented?

(15) *Critical Industry Issues*

Briefly summarize the results of the sessions that you attended during the PACE Roundtable Meeting. What surprised you about the discussion at this meeting? What issues might affect or be applied on your project? Who are the key contacts that you met that might be able to advise you in your area of interest?

Your observations:

(15) *Problem Identification and Technical Analysis options:*

Identify several problematic features of your thesis project that could be pursued through a detailed analysis of technical building systems and construction methods. Describe how you would complete your analysis, along with any research needed, on the building systems. What types of design and construction analyses will be required?

Presentation

(15) *Proposal Presentation*

In a 5 minute presentation, summarize your project and the analysis areas you intend to pursue for your spring proposal. You may use a maximum of 5 slides, one to introduce your project, and four to explain the analyses you would like to pursue (one slide per topic). Bring a print copy of your slides for each of the thesis advisors (4 copies).

Final Proposal for Spring Thesis Project

Your final thesis proposal should include the following items:

- Cover page
- Executive summary
- Table of Contents
- Analysis descriptions (four (4) analyses topics minimum)
- Conclusions
- Appendix 1 – Breadth Studies

Technical Analysis Descriptions:

You should have **at least 4 analyses topics** identified for your proposal. For each analysis topic, clearly define the problem (or opportunity) supported by: 1) background research performed, 2) the potential solution(s), 3) the steps that you will perform to achieve your technical analysis / research, and your expected outcome. It is important that you perform a preliminary analysis to analyze the viability of your potential solutions prior to completing your proposal.

Critical Issues Research Methods

One of your analysis topics will be a *critical industry issue*. Identify a critical issue you wish to pursue through your research based on your experience, interests, and experience at the PACE Roundtable meeting. Include a **problem statement** that identifies the challenges facing the industry in this topic. State the **goal of your research**, e.g. who will be the audience, who will benefit, etc. State specific measurable research steps, such as literature review and expert interviews, and summarize results. Describe the sources of outside information you will require. Provide a draft of the data collection tool that you will use (survey questions, interview format).

Demonstration Breadth – Embedded Requirements

The demonstration of breadth in Architectural Engineering should be accomplished in one or more of your 4 analyses topics. You are required to illustrate your breadth skills in at *least two option* areas outside of construction, e.g., structural, lighting, electrical, mechanical, or acoustics. This can be accomplished by identifying an analysis which requires a more detailed breadth study to successfully complete the analysis. Then, you should allot a larger percentage for either (1) Value Engineering Analysis **or** (2) Constructability Review, whichever is most appropriate for your breadth study. You will also need to submit a separate one page document which clearly defines your breadth areas as an appendix to your proposal. This document will also be submitted separately for review by Prof. Parfitt and Prof. Holland. For ideas regarding breadth analyses, please reference the eStudio website in the ‘Breadth Proposal Ideas section (available from the home page). ***Note:** Breadth proposals will be rejected if they do not include sufficient construction content and motivation. Breadth requirements are expected to be achieved through well-round analysis of the project through the lens of the construction industry*

Proposal Requirements

Submit a proposal that describes your intentions for your Thesis Investigation to be conducted in the Spring Semester. Include the specific systems and methods you will use to perform each analysis, and your initial ideas for cost, schedule, and process improvements. Demonstrate the source of your ideas e.g. PACE, AE 473, classmates, project contacts, etc. Clearly identify the breadth analyses that you will do within the analysis areas. Remember that these should not be a separate, individual analysis, but instead, embedded into one of the construction analysis areas. The proposal should be written as a professional document and include an executive summary and table of contents.

Core Thesis Investigation Areas

You should plan to distribute your effort among different analyses you propose for the spring. Note that you need to perform at least 2 breadth studies. These should be integrated into the analysis areas.

You will be required to complete a more detailed analysis of your project and propose changes to the existing building process and systems you are studying. Your proposal should be organized by analyses that you plan to perform. You should have 3 or 4 analyses. Within each analysis, the following core areas of investigation can be addressed. A detailed description of these areas is included in the following section.

1. Critical Issue Research
2. Value Engineering Analysis
3. Constructability Review
4. Schedule Reduction / Acceleration Proposal

Note that not every analysis area will cover every core area, but you should make you cover each of the four core areas within your analyses. The four core areas are further defined below:

1. *Critical Issues Research*– Investigate a current issue facing the construction industry. Some examples include risk analysis, contracting strategies, new technology, or green buildings. How will you address this issue on your project? Perform independent research which should include a literature review, along with independent research such as surveys, interviews, experiments, or other research methods.
2. *Value Engineering Analysis* – Assess the goals/priorities of the owner and the design scheme. Identify potential areas to save costs and/or schedule time that will not infringe upon the intent of the design. Provide three value engineering ideas including estimates of cost savings and impact on schedule time. Provide suggestions to ADD value to the building, not simply reduce cost through lower quality.
3. *Constructability Review* – Review the structural system (or other appropriate system) in terms of constructability, e.g. steel staging, concrete formwork, precast / post-tensioned members. Evaluate the integration of the structural system and mechanical systems, e.g., plenum height, riser locations, and position of mechanical floors. Determine potential areas for prefabrication for structural elements, facade and mechanical systems. Identify alternative design schemes that would ease coordination problems.
4. *Schedule Reduction / Acceleration Proposal* – Determine the costs of reducing the project schedule by 10-15% of its planned duration. Choose an area of the project that has presented challenges and frustrations to the contractor. Present a detailed plan to achieve this time savings, and a detailed estimate of the costs. Consider the need to implement this plan late in the project as a method to get back on schedule in the event of unforeseen delays.

Building Systems Summary

Yes	No	Work Scope	If yes, address these questions / issues
		Demolition Required?	Types of materials, lead paint, or asbestos?
		Structural Steel Frame	Type of bracing, composite slab?, crane size / type / location(s)
		Cast in Place Concrete	Horiz. And Vert. Formwork types, concrete placement methods
		Precast Concrete	Casting location, connection methods, crane size / type / location (s)
		Mechanical System	Mech. room locations, system type, types of distribution systems, types of fire suppression
		Electrical System	Size/ capacity, redundancy
		Masonry	Load bearing or veneer, connection details, scaffolding
		Curtain wall	Materials included, construction methods, design responsibility
		Support of Excavation	Type of excavation support system, dewatering system, permanent vs. temporary

Assemblies Estimating Checklist / Format Guide

	Show all appropriate assemblies for your selected system
	Modify assemblies as appropriate to match your project conditions
	Clearly show the summary of your estimate in a condensed format, categorized by CSI Unifomat II
	Add appropriate markups and modifications to standard estimating manual data
	Include overall units for easy comparison of your estimate results to similar projects, e.g., \$/cy for concrete, \$/ton for steel, \$/sf of façade for enclosure
	Submit a copy of your takeoff notes with the summary
	Clearly define any assumptions

Detailed Estimating Checklist / Format Guide

	Perform detailed takeoff of one system (show takeoff notes)
	Price items with standard estimating manual or database
	Include clear summary of results organized by CSI Masterformat
	Add appropriate markups and modifications to standard estimating manual data
	Include overall units for easy comparison of your estimate results to similar projects, e.g., \$/cy for concrete, \$/ton for steel, \$/sf of façade for enclosure
	Clearly define any assumptions

Site Plan Checklist

<u>Version 1 (Tech. 1) Existing Conditions</u>	
	Used CAD, Revit, Visio, or PowerPoint (or some other drawing package)
	Building Perimeter is clearly identifiable (darkest line weight)
	Include building height on building footprint (either is # of stories or elevation)
	Clear labels of existing and temporary facilities
	Property line / boundaries of construction site are clearly shown
	North Arrow
	Existing and new utilities are shown – water, gas, electrical, communications
	Fire hydrants and temp. light location are shown
	Construction fences and overhead protection (if required) are shown
	Pedestrian / traffic flow is shown with directional arrows on roads / walkways
	Use appropriate font size. Make sure all text is readable, and important text is a larger size.
	Professional title block with building title, drawing title, date and your name
	Adjacent buildings with name or address and building height (# of stories or elevation)
<u>Version 2 (Tech. 1) Construction Site Plan - Add these details to your site plan(s)</u>	
	Include appropriate items from Version 1 based on the phase of construction
	Temp. Power transformer
	CM and subcontractor office trailers and tool trailer locations
	Crane locations and limits of crane shown for lifting capacity
	Entrance and exit to site (can one-way traffic be used?)
	Temporary support of excavation systems and limits of excavation
	Loading docks, material hoists, personnel hoists, temporary elevators (if used)
	Dumpsters, portable toilet, material storage sheds
	Clearly note the phase of construction in the title block
<u>Optional – (depending on you project conditions and your research topic)</u>	
	Parking for construction personnel
	4D version of site plan including structure and neighboring buildings
	Neighboring buildings or landmarks
	Vicinity Map with directions to / from site for construction vehicles
	Foundation Excavation – ramp, soil retention system construction

BIM PROJECT GOALS / BIM USES

Describe how the BIM Model and Facility Data are leveraged to maximize project value (e.g. design alternatives, life-cycle analysis, scheduling, estimating, material selection, pre-fabrication opportunities, site placement, etc.) Reference www.engr.psu.edu/bim/download for BIM Goal & Use Analysis Worksheet.

1. MAJOR BIM GOALS / OBJECTIVES:

State Major BIM Goals and Objectives

PRIORITY (HIGH/ MED/ LOW)	GOAL DESCRIPTION	POTENTIAL BIM USES

2. BIM Use Analysis Worksheet: ATTACHMENT ERROR! REFERENCE SOURCE NOT FOUND.ERROR! REFERENCE SOURCE NOT FOUND.

Reference www.engr.psu.edu/bim/download for BIM Goal & Use Analysis Worksheet. Attach BIM Use analysis Worksheet as Attachment Error! Reference source not found.Error! Reference source not found..

3. BIM Uses:

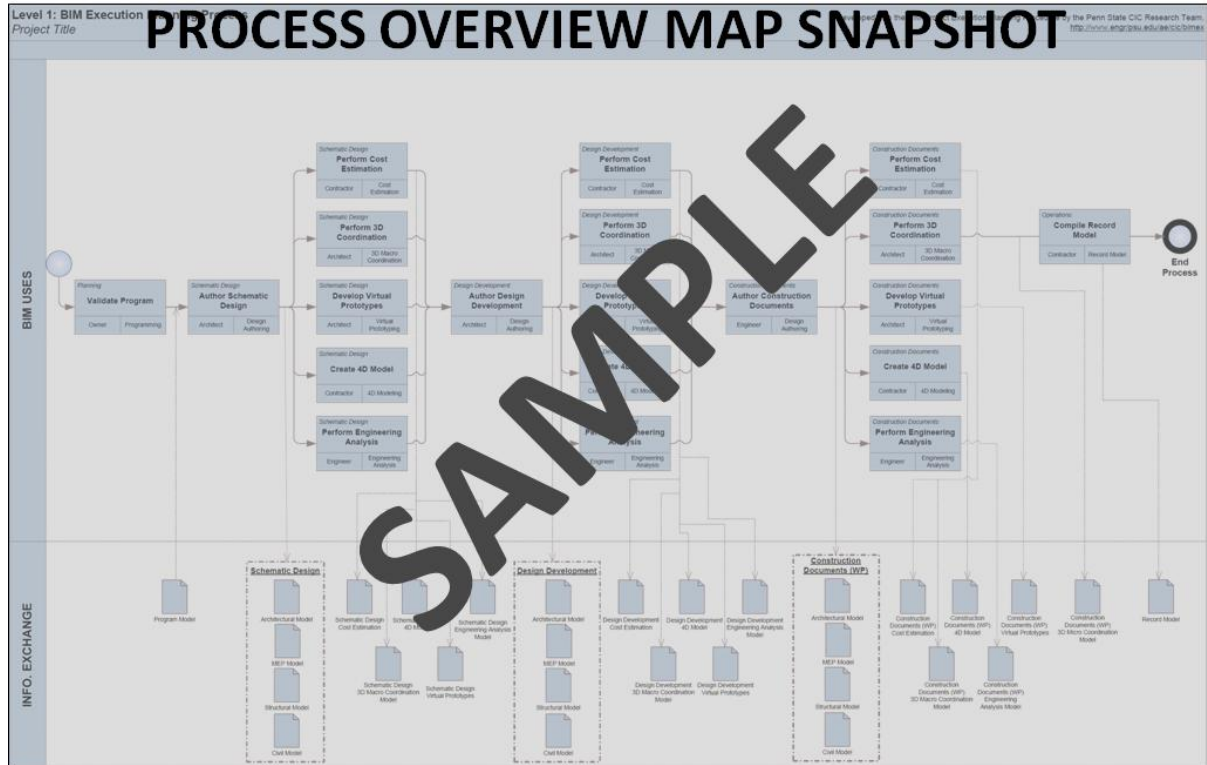
Highlight and place an X next to the additional BIM Uses to be developed by the use of the BIM model as selected by the project team using the BIM Goal & Use Analysis Worksheet. See BIM Project Execution Planning Guide at www.engr.psu.edu/BIM/BIM_Uses for Use descriptions. Include additional BIM Uses as applicable in empty cells.

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

BIM PROCESS DESIGN

Provide process maps for each BIM Use selected in section D: Project Goals/BIM Objectives. These process maps provide a detailed plan for execution of each BIM Use. They also define the specific Information Exchanges for each activity, building the foundation for the entire execution plan. The plan includes the Overview Map (Level 1) of the BIM Uses, a Detailed Map of each BIM Use (Level 2), and a description of elements on each map, as appropriate. Level 1 and 2 sample maps are available for download at www.engr.psu.edu/BIM/download. (Please note that these are sample maps and should be modified based on project specific information and requirements). Please reference Chapter Three: Designing BIM Project Execution Process in the BIM Project Execution Planning Guide found at www.engr.psu.edu/BIM/PxP

1. LEVEL ONE PROCESS OVERVIEW MAP



2. LIST OF LEVEL TWO – DETAILED BIM USE PROCESS MAP(s):

The following are examples. Modify for specific project. Some Process Maps may need to be removed, while some process maps may need to be added.

- Existing Conditions Modeling
 - Cost Estimation
 - Phase Planning (4D Modeling)
 - Programming
 - Site Analysis
 - Design Reviews
 - Design Authoring
 - Energy Analysis
 - Structural Analysis
 - Lighting Analysis
 - 3D Coordination
 - Site Utilization Planning
 - 3D Control and Planning
 - Record Modeling
 - Maintenance Scheduling
 - Building System Analysis
- [Delete unused or add additional process maps from list]