Photo courtesy of Steven Holl Architects

The Performing Arts Center

New Jersey, U.S.A.

Turner

Techincal Assignment 3: Exploring project challenges and opportunities

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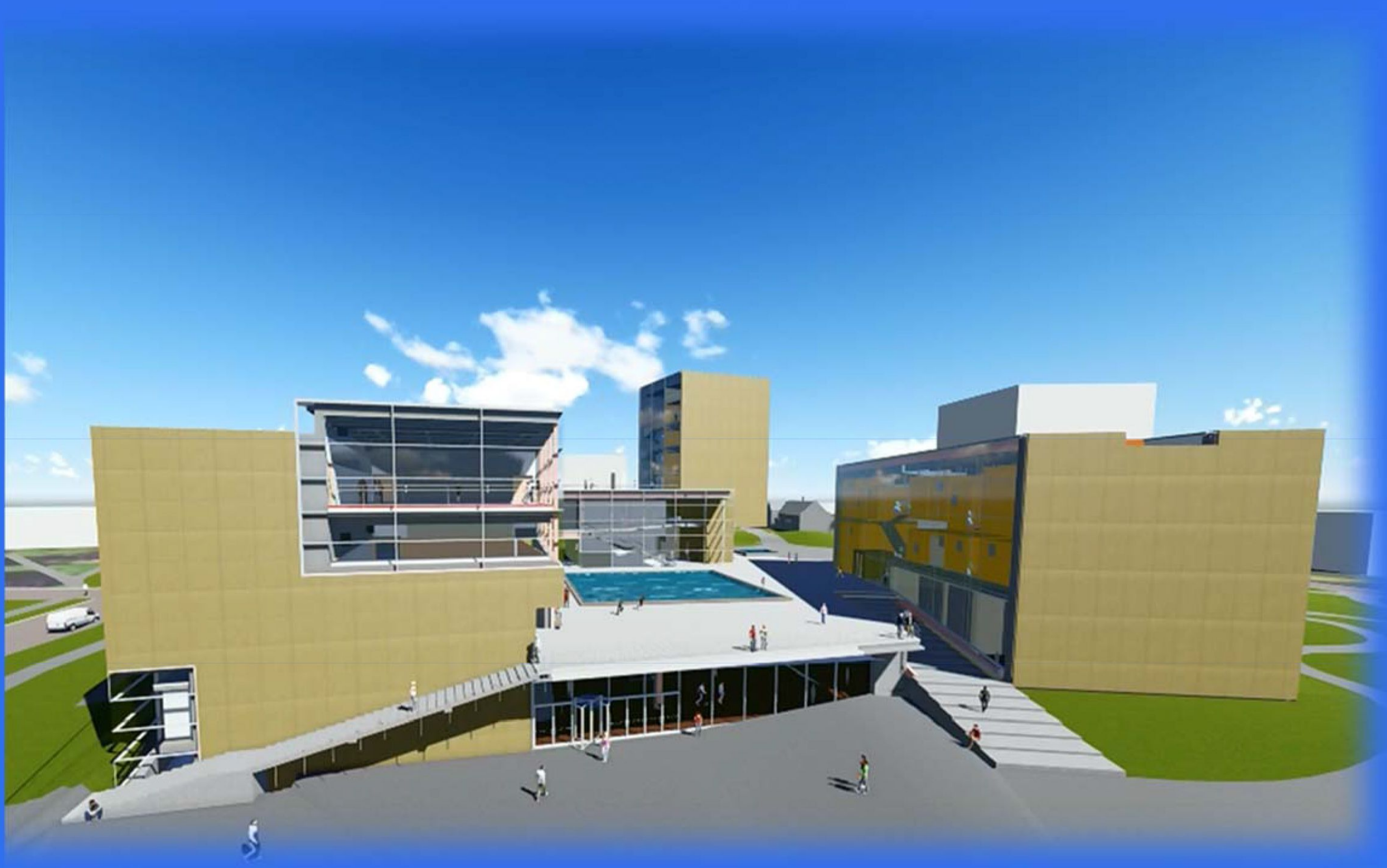

Photo courtesy of Turner Construction Co.

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Executive Summary

The unique design and complex construction of the Performing Arts Center presents obstacles even for a highly experienced project team. Nevertheless, the architects, engineers, contractor and owner are able to continuously find resolution in the face of tough decisions. This project will be remembered as a precedent where innovative, sustainable design has surpassed expectations to make this an unbelievable project for the University, its faculty, students and surrounding population. Furthermore, the construction techniques conceived to build the radial façade walls and architectural concrete finishes have been untested until this project. Even after construction, plans for facility management integration using a smart building information model offer opportunity for exploration for enhanced building performance. This project has seen its challenges and solutions through design and construction, however the opportunities do not end there. This document serves to analyze these project management challenges and solutions, but explore opportunities to improve project lifecycle experience.

In order to analyze project challenges and solutions, a project management staff personnel was interviewed, the Penn State University PACE Roundtable Conference was leveraged for bleeding edge industry focus, an industry professional representing both design and construction provided feedback, and industry practices were explored from a building information modeling and sustainability approach. During the Turner interview, overall trends concluded that constructability reviews early and often with the entire stakeholder team are the best solution to preventing communication issues. Furthermore, it was discovered that the owner prioritizes the schedule and safety of its students and faculty over opportunities for enabling faster processes. Through the PACE Roundtable, further research focused on the post BIM era and collaboration in the construction field. Conversations with an industry professional, Andy Rhodes of Southland Industries, illustrated alternatives for mechanical system design and prefabrication. Furthermore, the University will be using building information modeling on a much higher level for this project, serving as a case study for future jobs. Finally, a LEED evaluation was made for the Performing Arts Center based on its performance compared to the Penn State University LEED Policy.

Through the examination into the projects challenges and solutions, opportunities to improve design, construction and operation have become evident. From a design standpoint, sustainable initiatives may focus on a more comprehensive renewable energy solution, less impact to the atmosphere, utilizing local and sustainable materials and resources, indoor environmental quality and sustainable site benchmark standpoint. An alternative, highly efficient mechanical system for an acoustically designed facility is a dedicated outdoor air system (DOAS) in combination with a fan-powered induction system (FPTU). For the remaining portion of the project, it will be feasible to increase subcontractor collaboration by engaging them on a personal level outside the job site and illustrating a "one team" mentality rather than a "us vs. them", traditional approach. Finally building information modeling offers opportunity for facility management techniques and automated construction.

Project Manager Interview:

This interview took place on November 9th, 2015. To find key answers on overall project challenges, feedback was collected related to schedule, client requirements, design management, value engineering and delivery method. Overall trends illustrated that due to a CM-At-Risk delivery method, Turner Construction Company was involved in a significant portion of the project, from preconstruction through construction. Preconstruction itself lasted for 5 years with a heavy focus on resolution of constructability issues. Major project challenges have been related to unexpected schedule alterations. During a complex project where construction begins before drawing documentation is finalized, changes occur frequently causing communication challenges where solutions and answers need to be found quickly.

Project Management Services:

Preconstruction:

The University selected Turner for Preconstruction Services during the design phase. Throughout the 5 year preconstruction process, Turner's priority was to provide any advice that the University needed. Although the services have focused on constructability review decisions and working with the surrounding township, preconstruction services have spanned to logistics planning, phasing design, and scheduling. Due to the unique circumstances of this project, including being located on a major road at the interface of campus and town, much of the advice and consultation was focused on working with the surrounding township. This has been essential so that construction impacts the local population minimally.

During logistics planning, Turner has offered solutions related to optimal site access, material deliveries, and on-site equipment including hoists. During the preconstruction period, Turner designed an eleven-stage site logistics plan that started with earthwork mobilization of the entire enabling site and concluded with the landscaping and unveiling of the Performing Arts Center. In the logistics plan, construction phasing, material delivery allocation and general conditions are illustrated for every three months of the project. This has been valuable to the owner, Turner and subcontractors in visualizing the changes of the site and how it may impact construction and external operations.

Master schedules have been developed including resource-loaded schedules that offer visual projections of material and manpower availability. These have been developed in accordance with the University's highly prioritized guidelines to align with the schedule on a macro scale and micro scale in the form of university schedule and daily road operations, respectively.

Major Project Challenges:

Schedule Challenges & Solutions

From preconstruction through construction, most of the project challenges have been related to schedule and design management. From a schedule standpoint, the major challenge has been getting the structure ready for the glass and glazing systems. For much of the enclosure phase, roof structure and wall-roof connections have lagged behind schedule expectations. This can be attributed to design management and constructability changes, weather impacts and unfamiliar forms of construction such as board formed architectural concrete. The level of difficulty to implicate board forms to create architectural concrete finish was highly underestimated. When the board forms are on both sides of a wall, this surpasses schedule expectations drastically. Before any windows and curtain wall system is attached, the structure needs to be complete. In order to resolve this delay in schedule, other construction tasks have begun early including mechanical system construction in the basement and throughout the building in the form of radiant heat systems. Furthermore, temporary enclosures have been built to ensure dry conditions where necessary. While this prevents moisture, the interior spaces still need to be conditioned from a fully functional mechanical system for millwork and hardwood floors to be installed safely. The costs associated with schedule delay are remediated by the re-sequencing of work so that mechanical system installation takes place. While mechanical system construction was expected to occur after building enclosure, these costs and tasks can be swapped with the now delayed enclosure system construction. In addition, the costs associated with temporary enclosure systems prove viable since it is made up in the form of labor and manpower expenses. Using temporary enclosures can keep the subcontractors onsite at the expected manpower quantity and duration so that additional expenses are not incurred with additional man-hours to the contract.

Client Driven Delivery

Throughout preconstruction and construction, Turner works to produce the best overall experience and product for the University. To ensure safety and mitigate impact to the surrounding area, the University presents constraints related to scheduling and phasing of work. These restrictions are generally related to the student schedule and the overarching University schedule. Turner needs to improvise for the day-to-day schedule changes for when deliveries and construction trucks are restricted to roadway travel. However, overarching phasing schedule requirements have been built into the master schedule. These include exam periods, University-wide reunions, etc.

In order to create a great end product, Turner ensures that every element of construction retains the priority of quality. Turner is constantly communicating with the University to protect and ensure preservation of high priority elements through wall protection or wooden floor covering. While this is additional to the budget, it is important so that the University gets the building as it was designed. For example, hardwood floors will be put down a year before the building is finished. These need to be protected to ensure quality while construction still occurs. Other systems that need to be protected include glass and glazing systems and board form concrete walls. For the board form architectural walls, corners need to be protected.

Future Solutions – Constructability Reviews Early & Often

Many of the communication challenges and late, costly changes can be resolved through earlier constructability reviews. In future projects, the project management team envisions performing constructability reviews earlier and more often. It is important to meet with the owner, architect and main subcontractors early on to analyze the drawings based on constructability. On this job, construction started before the constructability reviews were completed. As a result, Turner has been facing difficulties since questions arise late and create hurried, emergency situations where answers come last minute. As a result, changes and RFI's are demanded on the day of construction, which is unfair to the owner, contractor and designer. Project management is focused on how they can collaborate with the designers or engineers to get answers way ahead of time when solutions and improvements can be implemented easier and more cost effectively. This can be improved by holding constructability reviews way in advance.

Delivery Method Benefits & Challenges

The CM-At-Risk Delivery Method has proven fruitful for the collaboration of the University and Turner. The University uses this delivery method because they have full control of the budget and have close ties to the contractor from design through construction. This enables the owner to stay heavily involved through every decision making process. In addition, this has allowed the job to start sooner. In a lump sum or cost plus delivery method, the drawings need to be finalized before construction can begin. For this scenario, delays can be minimalized since construction can begin as documents and drawings are finalized.

Value Engineering:

For every decision that is made by the owner, value-engineering solutions are proposed by Turner's project team and reviewed by the architect. The main area of value engineering has been alternative structural elements that were post-tensioned. These changes are based on simplifying the structure and enabling the overall facility to be more constructible. The ideas are not based on creating a cheaper building, but a higher quality and simpler building. Another example of value engineering is that beech wood flooring sourced from Germany has been changed to a material that is closer in proximity and more accessible. From the University's standpoint, there is little constraint related to cost or cutting schedule timeline. Therefore, value-engineering ideas related to faster and easier solutions are not considered.

Critical Industry Issues – PACE

The 24th Annual PACE Roundtable took place on November 3rd, 2015 at The Pennsylvania State University. The main discussions were based around "Innovation in New Directions", "Enabling Through Technology", and "Project Team Integration". The event offered a mixture of industry professionals, Penn State Architectural Engineering faculty, graduate students and undergraduate students in which research and professional practices were deliberated upon. After evaluation of the breakout sessions, "Post BIM – Challenges and Opportunities", and "Driving Collaboration into the Field" were determined to be the most relevant industry issues and ones that are relevant to alternative solutions for The Performing Arts Center.

Post BIM – Challenges and Opportunities:

This breakout session focused on what will happen next as BIM becomes 'the norm' in construction. Three focuses of this topic include the limitations in the information fabric and BIM compliant world, scaling to an urban level and Smart City design standard, and how will technological development enrich construction workflows. The most important question to consider is how these technologies will impact and be adopted into company and project strategy.

At this point in time, the largest limitation in leveraging the information fabric and the potential of BIM is due to the disconnect between industry stakeholders, divided software technologies and standardization of BIM datatype exchange process. The first roadblock in the way of leveraging BIM effectively is that the stakeholders of the AEC industry are isolated between company barriers. Although IPD and Design-build delivery methods encourage collaboration from a contractual standpoint, it is still difficult for true collaboration to take place. Since stakeholders are on different teams, variances exist in the model on a coordination and information exchange basis. Henry Beck, managing director of The Beck Group, focuses on "leveraging a much larger pool of resources to significantly improve the delivery process" (What the AEC Industry Can Learn from Steve Jobs). In this approach, an integrated enterprise can be formulated to create long-term collaboration and integration between team members where all the stakeholders are within the same company. The trust between an architect, contractor and design engineer will grow from project to project. Furthermore, the teams can actually innovate because it becomes cost effective for the entity to invest in its own research and development, innovation teams and technology.

The wide array of software platforms has created a world where interoperability and data exchange is challenging. While the goal is to have all the information and geometry of a building readily available, The National BIM Standard states that " The industry, however, does not yet have the open standards and infrastructure in place to capture, organize, distribute, and mine that information" (National BIM Standard). At this point, each project and company can vary greatly in the standards to author, organize and distribute modeling data. Voytek Pniewski states "In order to effectively support the use of information, organizations need to be able to represent their project data in a common, interpretable form, which provides a facility of an accurate exchange of data among different computer systems and platforms" (Building Information Modeling (BIM) Interoperability Issues in Light of Interdisciplinary).

Beyond what was discussed related to Smart Cities at the PACE Roundtable, London's Year In Infrastructure Conference awarded Singapore as the world's first smart nation. Singapore has developed a virtual model "to be the source of authoritative information about Singapore for use by government. The purpose is to enable advanced energy sustainability solutions, manage high population density, enabling smarter communications, and mobility" (Smartnation-Forbes). "The current priority is a 3D model of buildings including below and above ground infrastructure" (Geoff Zeiss). Singapore is creating this model through oblique imagery, airborne laser scanning, and terrestrial scanning and then combined in a consolidated repository. The model is based on the standard, CityGMK and is at a level of detail (LOD) ranging between 1-3. Many issues have been related to integrating BIM model Industry Foundation Classes (IFC) into the CityGML standard.

Construction has drastic steps it can take to enable a more streamlined workflow from the design and construction model to a physical structure. One of the main ways that the workflow can be enhanced is by eliminating the manual process of exchanging design files and drawings to shop drawings to the labor force performing construction. Moreover, the rote, human tasks that occur on the field can be replaced with computers and automated machinery. Solutions can be developed that largely eliminate the human factor of construction. For instance, the Semi-Automated Mason (SAM) developed by Construction Robotics is a robot that bricks three times the rate as a mason journeyman.

Figure 1: Semi - Automated Mason laying brick at Fort Lee Barracks Job in Virginia

The robot is able to lay flat wall series of bricks "using a set of algorithms, a handful of sensors that measure incline angles, velocity, and orientation, and a laser. The laser is rigged up between two poles at the extreme left and right sides of the robot's work space, and moves up and down the wall as work progresses to act as an anchor point for the robot" (MIT Technology Review). Whereas a human can lay 300 bricks a day, SAM can lay up to 1,200 bricks a day. As a result, "one human plus one SAM equals the productivity of having four or more masons on the job" (MIT Technology Review). In the case the business strategy is evident on every level except for perhaps an ethical standpoint. As technology becomes more prevalent, issues related to union resistance will be a barrier to implementation within company and project strategy.

Driving Collaboration into the Field:

During this PACE Roundtable discussion, it was determined that the industry has implemented Lean and Integrated Project Delivery (IPD) initiatives on a project management level, but the next question will be how these platforms can resolve to the foreman level and below. The key point in this conversation was that it is imperative to achieve buy in from all stakeholders in the field if collaboration is going to be achieved. In order to achieve this, the selection process needs to reward subcontractors that are team players, a human connection needs to be developed between subcontractors early in the project lifecycle, a give and take connection needs to be established with the project management team, and subcontractors should promote coordination and construction so that everyone wins.

First, the selection process of subcontractors needs to be reevaluated so that team players are selected before low bidders. The general contractor needs to realize that although this upfront number may represent a higher "bid", the project experience will most likely be less painful and eventually cheaper since less changes and adversarial situations will arise.

After that, the human and team connection needs to be developed between subcontractors so that the "us vs. them" mentality breaks down. This is the most basic element in establishing collaboration. If the subcontractors only see each other as companies building and getting a fee for their work, the work will continue in silos without collaboration or more often than not, with adversarial relationships. Therefore, it is important to break down these communication walls by enabling friendly interaction outside of the construction site. If preliminary meetings or events can occur where the subcontractor teams can touch base and realize that they share similar, "human" interests, these barriers disappear at a faster rate. For instance, if the project management can help a mason and ironworker realize that their kids player soccer together, an immediate bond is formed which may lead to positive relations on the jobsite. The key is in enabling the human factor and finding a common understanding.

Finally, on-site collaboration can occur when the project team eliminates the "Us vs. them" view of project management versus field staffing. Many times when a project manager tells a subcontractor that their work is behind or the "numbers are not met", the subcontractor can take this personally and become defensive. If management can illustrate that "our" work is behind and that he wants to help the subcontractor in any way to get him back on track, the subcontractor will react more positively. Moreover, by getting the subcontractors in the big room and letting them schedule with the project management staff, the schedule becomes a collaborative entity rather than a project management tool.

Feedback from PACE Industry Roundtable

The critical issues presented at the PACE Roundtable and then further researched upon were discussed with Andrew Rhodes, Senior Design Engineer for Southland Industries. Andrew was a great source to discuss the issues related to "Driving Collaboration into the Field" since Southland Industries prefers collaborative delivery through contractual and non-contractual means. One of the greatest points that came out of the discussion was that eliminating the "Us vs. them" mentality, creating the human connection and working collaboratively can be successful even in "plan-spec" contractual arrangements. Andy is a proponent of getting subcontractor teams in the big room as early as possible and letting them make preconstruction decisions with the project management team. This promotes teamwork early on and creates a single team approach. Furthermore, he champions the idea of showing the subcontractors that the project management team is there to help them with whatever they need. Using the approach that it is "our" issue not the subcontractor issue can go a long way in construction. Andrew also provided insight into how the Performing Arts Center can redesign its systems and promotes alternative methods. This information can be referenced in *Performing Arts Centers | Next Level Solutions.*

Performing Arts Centers | Next Level Solutions

On the Performing Arts Center, aspects of these initiatives from the PACE Roundtable can be implemented to improve construction from schedule, cost and quality perspectives. Through the discussion with Andrew Rhodes, ideas were generated related to alternative mechanical system deployment as well as prefabrication efforts for M. E. P. systems. Collaboration techniques can also be leveraged on the field. Moreover, automated construction and Smart Buildings techniques can be leveraged as solutions.

The Performing Arts Center is heated and cooled through a geothermal system consisting of a ground-coupled heat pump system consisting of heat pumps, circulating pumps and a ground coupled heat ex-changer to enable the closed loop system. The glycol heats and cools the spaces using primarily radiant heat and VAV boxes for additional control. After review it was determined that radiant heating and cooling is an optimal system in a performing arts center because of its low acoustical impact to the surround environment. However, an alternative could be to leverage a dedicated outdoor air system (DOAS) in combination with a fan-powered induction system (FPTU). The FPTU is a direct substitution for the variable air volume boxes where the air is conditioned and mixed with outdoor air, then diffused back into the space. This system is extremely efficient from an energy usage standpoint. Furthermore, dew point sensors can be implemented on the sensible water loop so that the building automation control system can understand when to raise the temperature so that the dew point is never reached inside the building.

Another solution that can be considered for the Performing Arts Center is to design a pre-fabrication system focused on mechanical, electrical and plumbing equipment. For corridors and straight runs where large-scale duct and conduit are run close to each other, a rack can be designed to hold these components. If there is a scenario where the same services are run from point "A" to point "B", then this design is a no-brainer because it can eliminate onsite constructability issues and prevent labor on the job. Similar solutions can be offered in bathrooms where carriers and piping can be located in the wall that separates men and woman.

Solutions that can be derived from the PACE Roundtable include automated construction and Smart Buildings techniques. Automated construction can be leveraged on the exterior portion of this job. Although the finish is not mortar or brick, the repeating Lecce limestone tile offers the ability for a mechanical tool to improve the construction efficiency process. On the Arts Tower, Dance and Theater Building and Music Building, the walls are generally straight runs. This is where automated tools excel. An automated robot could lift the lecce limestone panels and bring it to the proper GPS coordinate and height. Then, a mason could install the panels successful the façade system. In the similar way that the semi-automated mason enables a faster brick laying process, this would aid workers by expediting the material movement process.

The University has a goal to leverage the data and geometry within the building information model for facility management once construction is complete. Therefore, there is an opportunity for SMART Buildings design ideologies to take place to enable a better building experience. The as-built model is proposed to a high level of detail for major maintenance components including mechanical equipment. To take advantage of the model, sensors can be built into the mechanical system so that during a failure or error, the model indicates which air handler, piping or VAV box has an issue. To remediate the error, the component can be visualized in the model and the data can be pulled in form of an operation manual or serial number. This will lead to faster maintenance since the University can find which component has an issue and how it can be fixed through the data loaded in the model.

Building Information Modeling Use Evaluation

For the Performing Arts Center, this project serves as a case study in which building information modeling is leveraged at a much higher level than previous jobs. One of the University's main goals is to obtain an as-built model with a high level of detail. Naturally the model is transferred from design through operation. Based on University and project team goals, the following potential BIM uses were identified. In summary, the goals represent a high level of detail for the facility management system, improving constructability, enhancing communication, visually communicating design intent and achieving above premium LEED certification.

Projected BIM Goals:

Table 1: BIM Goals & potential uses

PRIORITY (HIGH/ MED/ LOW)	GOAL DESCRIPTION	POTENTIAL BIM USES
High	Enhance efficiency & communication between engineering staff and superintendents	3D Control & Planning, Design Reviews
High	Increase field productivity	Site Utilization Planning, 3D Control & Planning
High	Eliminate design clash & coordinate models	3D coordination (design)
High	Coordinate systems between Turner and subcontractors during construction	3D Coordination (Construction),
High	Integrate As-Built model for facility management system	Asset Management, Record Modeling
High	Align project phasing with campus logistics/schedule	Phase Planning
High	Generate design and construction drawings directly from model	Design Authoring
Med	Adopt Prefabrication for M.E.P. equipment	Digital Fabrication
Med	Present model and design decisions visually to owner	Design Reviews
High	Ensure system constructability for enclosure, joint intersection	Construction System Design
High	Achieve premium energy sustainability level beyond LEED	Facility Energy Analysis, Building System Analysis
Med	Monitor construction progress compared to projections	4D Scheduling
Med	Automated construction of façade	3D Control and Planning, Digital Fabrication

After the development of goals, specific BIM Uses were pinpointed to reach these goals throughout the project. To achieve a successful facility management model, asset management and record modeling was chosen. This will be imperative to store operations, product manuals, equipment specifications and equipment performance information and allow the as-built model to be effective in facility management. Due to the University's high priority for the building efficiency, both Facility Energy Analysis and Building System Analysis were chosen to ensure high-energy performance from design through operation. During construction the University has tight constraints on site logistics and phasing. Therefore, the model can be leveraged for optimal site utilization planning and phase planning. Due to the complex geometries of the façade and many structural components, construction system design or virtual mockups can be leveraged to visualize and check constructability. To enable a higher level of collaboration and communication between the overall project team, design reviews and 3D Control and Planning were selected. Since Turner used BIM 360 Glue, 3D Control and Planning will be useful to check construction against the construction model. Specific locations can be pinpointed through GPS control so the subcontractor knows where they are in the building related to the model. This

Table 2: BIM Uses throughout the project the lifecycle

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

can also increase field productivity.

Actual BIM Uses:

For Turner Construction and the University, this project serves as a precedent for future implementation of building information for the lifecycle of buildings. While industry standard use cases include 3D coordination of systems, more forward thinking use cases include the ability for subcontractors to leverage the model onsite using iPads and Autodesk 360 Glue. When a subcontractor needs to visualize the model and compare it with construction, this process becomes effortless. Markups can then take place on the spot and be refreshed to the project servers and updated on all machines. Furthermore, virtual walkthroughs allow the owner and designers to see parts of the building before it is actually constructed. While the walkthroughs occur in conference rooms on a projector, a greater level of visual and immersive experienced could be leveraged through a Unity rendering engine with an Oculus Rift or Immersive Display. One of the greatest applications for the model will be throughout operation in the facility management stage. The as-built model will be handed off to the University operations so that it can be leveraged for an enhanced facility management process. Turner has worked with the owner and designers to enable a model of a high level of detail so that specific elements can be accessed for operation manual, specification numbers, manufacturer contact information and troubleshooting information for when a component needs to be replaced or fixed.

Sustainability Implementation

While LEED is a current energy precedent, the University is not pursuing LEED certification. The Performing Arts Center is pursuing an energy benchmark of 50 percent less energy than any current energy standards. This can be completed through the reduction of carbon emissions inherent to design, construction and operation. Features that will provide for an industry leading sustainable building include geothermal heating and cooling, enhanced envelope performance, green roof system, displacement and mixed mode ventilation, and radiant heating and cooling. Passive strategies include shading, natural ventilation and the combination of natural sunlight and thermal mass. (BNIM).

Although The Performing Arts Center's energy goals are not oriented toward LEED Certification directly, these sustainability guidelines still apply for the facility. LEED™ stands for Leadership in Energy & Environmental Design. The system evaluates environmental performance throughout the building's life cycle. For this project, sustainability focus has been placed on the LEED guidelines of creating a sustainable site, minimizing energy usage and atmospheric impact, sustainable material selection, indoor environmental quality and innovation processes. To compare the Performing Arts Center to LEED Certification, Penn State University's LEED Policy 2011 will be leveraged. To reference the Penn State University Lead Policy, please see Appendix B: Summary of OPP LEED Policy 2011 Update.

The Penn State LEED Policy prioritizes the level of implementation of sustainable elements in its facilities. In order to customize the LEED process for Penn State University's (PSU) facility design, construction and operation, the credit classification system is broken down into priority classes: Mandatory for all PSU projects, Significant Effort required during lifecycle, Minimal Effort necessary and credit not required.

Based on the comparison of The Performing Arts Center's LEED Project Checklist and Penn State's LEED Policy, the project excels in meeting Penn State's mandatory and significant effort LEED project guidelines. It is an interesting comparison because The University's guidelines for the project must be fairly similar to Penn State's policy. Therefore, for many of the places where Penn State placed priority on an item, The Performing Arts Center meets this point credit. Since the University's goals for sustainable performance are not oriented with achieving a specific LEED certification, the most recent level of certification is acceptable. While the Performing Arts Center may focus on energy performance, it could achieve a broader scale of LEED accreditation.

Alternative LEED Proposal Strategy:

Since the project goals are highly focused on implementing eco-friendly and renewable resource strategies, the Performing Arts Center should realistically achieve Gold or Platinum accreditation through the LEED system. In order to achieve LEED Gold, it is proposed that this project is designed, constructed and operated to achieve at least 60 LEED accreditation points. In order to achieve 60 points, it is essential that the project lifecycle reaches its potential from an energy and atmosphere, materials and resources, indoor environmental quality and sustainable site benchmark standpoint.

In order to meet the project goals of a high performing energy building, energy and atmospheric LEED initiatives need to be enhanced. The project excels in the area of energy and atmosphere from an optimization, commissioning, and commissioning. Based on the LEED project checklist, the project could improve on green power, and overall on-site renewable energy initiatives. This is extremely surprising due to its onsite geothermal heating and cooling, passive and natural design strategy. However, this lack of accreditation can be explained by failing to provide 35% of the building's electricity through renewable systems.

Another major goal of this project is to reduce carbon and enhance the ventilation. Both of these contribute to the indoor environmental quality of the facility. The Performing Arts Center creates indoor environmental quality through a phenomenal thermal comfort design approach, low-emitting materials and controllable systems. However, in order to achieve a more sustainable interior environment, outdoor air delivery monitoring needs to be leveraged to maintain design requirements. Furthermore, indoor chemical and pollutants need to be controlled through design capabilities.

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Dear Friends of PACE,

The PACE Roundtable has a mixed format that will include two break-out sessions in which critical industry issues will be discussed, intermingled with a special industry panel with some unique insights into Enabling the Workforce, both in the field and in young, future leaders.

Break-Out 1 & 2:	Attendees will break into groups that examine specific topics in: 1) Innovation in New Directions; 2) Enabling through Technology; and, 3) Project Team Integration.
Research Topics:	Attendees will break into small groups, coupling industry members with students to allow the students to explore the ways they can capture one of the topics to research.
Panel:	Four leading industry members will hold a discussion and Q&A session on Enabling the Workforce – Hiring and Retaining Young Leaders.

The main discussion topics, identified through The PACE Roundtable, are:

	A. Innovation in New Directions	B. Enabling Through Technology	C. Project Team Integration
Round 1	**Session 1A:** Innovation in Safety	**Session 1B:** Post BIM – Challenges and Opportunities	**Session 1C:** Distributed Leadership vs. Centralized Decisions
Round 2	**Session 2A:** Automating Design Analysis	**Session 2B:** Technology in Construction: The new 'norm' of construction competencies	**Session 2C:** Driving Collaboration into the Field

After the Roundtable, students will conduct research on the topics raised during the discussion and present their results at our PACE Research Seminar and Awards Banquet. Please plan on attending this important event!

Sincerely,

Robert M. Leicht

Robert M. Leicht; Assistant Professor of Architectural Engineering
Director, the Partnership for Achieving Construction Excellence

WEDNESDAY NOVEMBER 3RD - AGENDA

7:30 a.m. Continental Breakfast
Ballroom C

8:15 a.m. Introduction and Kick-Off
Ballroom C

8:30 am Keynote Presentation:

Life after the BIM Revolution

Professor Robert Amor
Chair, Department of Computer Science
The University of Auckland, New Zealand

9:30 a.m. **BREAKOUT SESSION I**

1-A: Innovation in Safety — Ballroom A
Facilitator – Dr. Somayeh Asadi

1-B: Post BIM – Challenges and Opportunities — Ballroom B
Facilitator – Dr. Robert Amor

1-C: Distributed Leadership vs. Centralized Decisions — Ballroom DE
Facilitator – Dr. Robert Leicht

10:30 a.m. Morning Coffee Break
Shared Break Main Level

11:00 a.m. Panel Discussion: Enabling the workforce: Hiring and retaining Young Leaders
Facilitator:
John Bechtel, Assistant Director, Design and Construction, Penn State OPP
Panelists:
Sue Klawans, Director of Operational Excellence and Planning, Gilbane Building Company
John O'Keefe, President and CEO of Atkinson Construction, Clark Construction Group, LLC
Jessica Baker, PE, Senior Design Engineer, Southland Industries
Abigail Kreider, Project Engineer, Barton Malow Company

12:00 p.m. Lunch - *Faculty Staff Club (Lower Level)*

Wednesday November 3rd - Agenda

1:00 p.m.	**Breakout Session 2**	
	2-A: Automating Design Analysis *Facilitator – Ehsan Mostavi and Dr. Somayeh Asadi*	Ballroom A
	2-B: Technology in Construction: The new 'norm' of construction competencies *Facilitator – Kathryn Davies and Fadi Castronovo*	Ballroom B
	2-C: Driving Collaboration into the Field *Facilitator – Dr. Robert Leicht*	Ballroom DE
2:00 p.m.	Afternoon Coffee Break *Faculty Staff Club*	
2:30 p.m.	Focus Groups – Developing Student Research Topics	
3:30 p.m.	Summary and Adjourn	

VISITING PACE FELLOW

ROBERT AMOR, PHD, PROFESSOR
DEPARTMENT OF COMPUTER SCIENCE

Robert Amor is a Professor of Computer Science at the University of Auckland, New Zealand. Prof Amor undertakes research in the field of Construction Informatics, with a passion for the application of beneficial computer science techniques to the Architectural, Engineering and Construction industries. Achieving interoperability is his core research interest and to achieve this he investigates integrated environments which covers information modelling (e.g., BIM), process modelling, user interaction, implementation frameworks, information mapping, and communication strategies. Since 2003 he has coordinated the working group W78 (IT for Construction) for the International Council for Research and Innovation in Building and Construction (CIB - which comprises 500 international research organizations). He is also a founding member of CIB's priority theme on Integrated Design and Delivery Solutions (2009). He is the Editor-in-Chief for the Journal of Information Technologies in Construction (ITcon). He has been Primary Investigator on a number of major national and international research projects and successfully bid for approximately $6 million in research funding internationally and in New Zealand.

ENABLING THE WORKFORCE: HIRING AND RETAINING YOUNG LEADERS

The US construction industry has noticeably rebound with continuing growth in nonresidential construction through this summer and early fall. The consistent growth occurring throughout the market is shifting focus (slightly) from winning projects to the new challenges of finding the workforce necessary to complete the current backlog of construction. Building upon these recent challenges, this panel will explore the implications of the surge in construction opportunities, specific to the hiring and retention of young graduates seeking project management track positions. The hiring, development, and retaining of young engineers is critical to the success of any company. The new generation of graduates has different expectations, desires, and behaviors than previous generations which pose both opportunities and challenges for firms hiring them. Bringing together a panel with diverse backgrounds, the discussion will explore the perspectives ranging from recent graduates to company leaders.

July 2015 Construction Starts

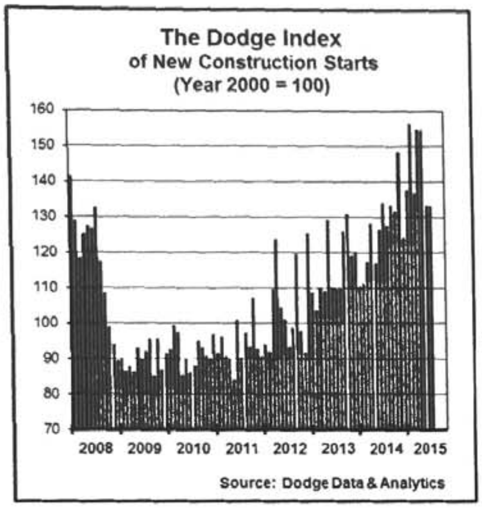


Figure 1: Index of construction growth since 2008 (Dodge Analytics, July 2015).

Notes

Innovation in New Directions - Session 1-A:

Innovation in Safety

Facilitator: Dr. Somayeh Asadi **Ballroom A**

Questions

- What challenges are we seeing in making our jobsites incident free?
- What are some strategies for building an incident –free culture and behavior?
- What are your current methods of assessing or training for safety?
- What innovative techniques/practices does your firm employ to improve safety performance?
- Where is the current emphasis for safety? Techniques, practices, management?
- How can technology be utilized to improve workers' situational awareness and help them consciously recognize hazards on jobsites?
- What areas of safety are ripe for use of technology or innovative approaches, based on success in other areas of construction?

Notes

Enabling Through Technology - Session 1-B:

Post BIM – Challenges and Opportunities

Facilitator: Dr. Robert Amor **Ballroom B**

Questions

- As BIM becomes 'the norm,' what limitations do we expect to continue, even in a BIM compliant world?
- Can there be improvements to the *information fabric* we work within?
- How does it scale to urban scale/Smart City requirements?
- What further change do we expect to see in BIM-enabled practices?
- How will emerging / future technologies offer innovation, or disruption, to our current processes and workflows? (Cloud computing; Internet of things; Big data; Sensor rich environments; Drones; Location-aware devices)
- How do we align for technological disruption coming with emerging technologies?
- How do we plan / approach the study and potential adoption of technologies within our company and project strategies? How flexible can/should we be?

Notes

Project Team Integration - Session 1-C:

Distributed Leadership vs. Centralized Decisions

Facilitator: Dr. Robert Leicht **Ballroom DE**

Questions

- What comes to mind when you hear the term "Distributed Leadership" ?
- To what extent are we seeing leadership roles distributed within teams?
- How are these interactions, particularly in integrated teams, changing from traditional leadership models in construction?
- What opportunities do the use of distributed leadership models in design and construction teams offer?
- What challenges are emerging in the sharing of information, clarity of roles and responsibilities, and process for meeting commitments?
- How does the shift to building integrated teams influencing the process for making decisions in the design and construction phases of projects?
- What tensions need to be balanced to enable distributed teams and leadership to function effectively, while still maintaining the appropriate involvement and input from key stakeholders and overall project leaders?

Notes

- What is distributed leadership?
  - different companies involved, voices of all companies important
  - shared risk between companies
  - responsibility of field vs. office
- Decision Making not sole responsibility of leader
- Shared Resources between firms
- Develop trust within teams
- owners perspective → step back from leadership
  - IPD → lays out decision making process
  - enables collaboration

- every team member has a role to play
  - ↳ how do we organize teams?
- "Know your role, do your job"
- who should do what?
- Decision by who owns the risk
  - ↳ change who owns it
- To receive full benifit → need new contract
- Collaboration under traditional methods
  - ↳ emerging leaders
- How do you learn to be IPD + think that way
- Hold each other accountable
  - ↳ trust
- How to relate to people
  - ↳ emotional intelegence
- Stop + analyze process
- Balance between risk + value

Research Questions

- Training for IPD teams
- What is the decision making process
- How were decisions made
- Decision making frameworks
- who leades decisions → expert?
- Before/After of Key Goals

Innovation in New Directions - Session 2-A:

Automating Design Analysis

Facilitator: Ehsan Mostavi and Dr. Somayeh Asadi **Ballroom A**

Questions

- What comes to mind when we say "Automating Design Analysis"?
- What is the current state of automated design analysis being used amongst architects and engineers?
- Does automating building design analysis provide opportunities to help deal with inefficiencies associated with the building design process?
- What current tasks could be improved or facilitated through automated analysis?
- How could automating design analysis provide opportunities to more fully integrate disciplines in an efficient, design flow?
- What opportunities exist to automate building design data transfer between building disciplines?
- How could automating design analysis ultimately improve high-quality design services?
- How could it potentially be a detriment to providing consistent, high-quality design services?
- What opportunities exist for more seamlessly interfacing design and construction activities through the use of automated design analysis?

Notes

Enabling Through Technology - Session 2-B:

Technology in Construction: The new 'norm' of construction competencies

Facilitator: Kathryn Davies and Fadi Castronovo **Ballroom B**

Questions

- What are the current level of construction competencies – in gen x, baby boomers and in between
- Students – what are you currently being taught? What would you like to see?
- Where is the industry currently trending, in terms of directions of technology adoption and skill development?
- What role / level of involvement do we expect construction personnel to play in using models over the next 10 years?
- Where do we see the industry in 10 years in terms of technology competencies?
- What other changes are needed to create these opportunities?
- What competencies and skill sets related to technology planning and management are sustainable, regardless of the modeling tools or technology of the moment?

Notes

Project Team Integration - Session 2-C:

Driving Collaboration into the Field

Facilitator: Dr. Robert Leicht **Ballroom DE**

Questions

- What is the current model, or level, of collaboration we see amongst field personnel?
- To what extent, and in what ways, do we expect to see field personnel sharing information and working collaboratively?
- Do we know of any examples of teams or projects that were able to create a high performing collaborative field team?
- What benefits do we expect from having our foremen and field personnel working more collaboratively?
- What challenges or limitations are limiting the current levels of collaboration in the field?
- How could greater levels of collaboration for field staff be enabled?
- What barriers, contractual or behavioral, are creating these limitations?
- How does technology influence the sharing of information and collaboration amongst field personnel (e.g. mobile devices, modeling, etc.)

Notes

- ± 40% of cost comes from the field
- What is the current baseline
  - ↳ allow field workers input in surveys, etc
  - ↳ pull planning in field w/ subs
    - form trust
- "Colocation trailers" / BIM Box
- Sharing Points of View → "US vs. Them"
- Foreman meetings / Daily Huddle
  - ↳ look aheads
- Everyone working toward the same goal
- Accountability for commitments
- Do we provide them with the resources needed?

Research Questions

- Technology in foreman's hands
- Project size vs. what tech. is best
  - scalable concepts
- what would enhance collaboration in the field
  - colocation / last planner
- How do you get everyone on board? How do you deal with troublesome players
  - avoid picking them in the first place
- How do you evaluate subs after a job?
- How does the young person respectfully become the teacher.

- Challenges
  - Info Transparency
  - Open Enviornment
- Procurement
  - Trades
  - Supply Chain
- -Office "Norm" talk
  - ↳ domino effect
- Difference between coordination + collaboration
- What needs to be done + why is it important?
- What is "the field".
- Short term goals as well as long term
- Get buy-in from the foreman
  - ↳ moves down to crews
- Find the right people for the job
- Conserve local ties.
- Influence by Technology
  - ↳ bottom up, facilitate input
  - ↳ generation on communicate
    - know how to approach them w/ technology

The 24th Annual PACE Roundtable

STUDENT FORM

Student Name Melissa Consiglio

Session 1: Topic:

Research Ideas:

1)

2)

Session 2: Topic: Collaboration in the field

Research Ideas:

1) Colocation

2)

Session 3: Topic: Safety

Research Ideas:

1) Making people more accountable for safety through psychology

2) What impact does removing cell phones have on safety

STUDENT FORM

Industry Member: ______________________

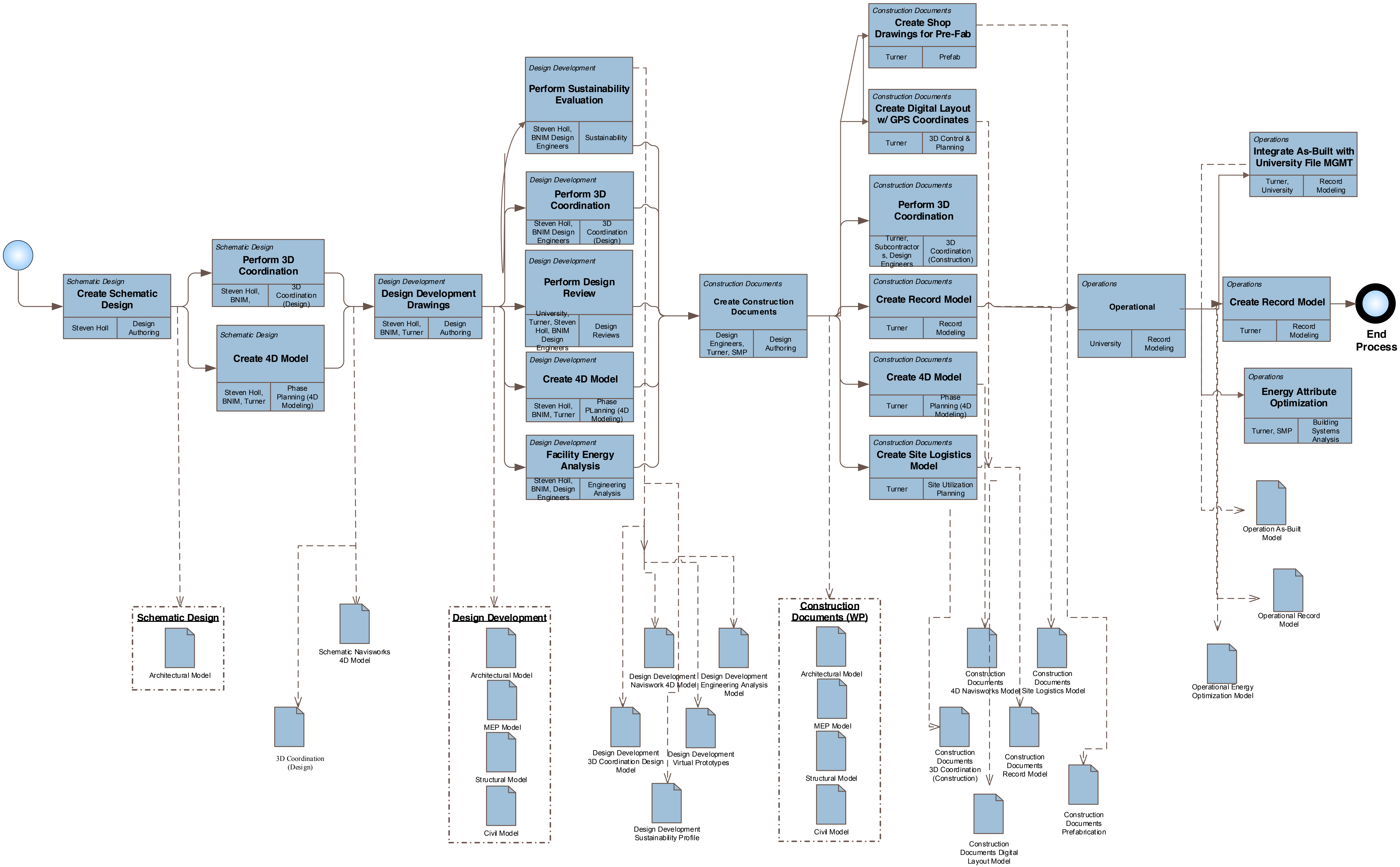
Key Feedback:

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

Suggested Resources:

What industry contacts are needed? Is the information available?

Developed with the BIM Project Execution Planning Procedure by the Penn State CIC Research Team.
http://www.engr/psu.edu/ae/cic/bimex



LEED 2009 for New Construction and Major Renovations

Project Checklist

Last Updated: September 2013

Y	?	N			
21	5		**Sustainable Sites**	Possible Points:	26
Y			Prereq 1	Construction Activity Pollution Prevention	
1			Credit 1	Site Selection	1
5			Credit 2	Development Density and Community Connectivity	5
1			Credit 3	Brownfield Redevelopment	1
6			Credit 4.1	Alternative Transportation—Public Transportation Access	6
1			Credit 4.2	Alternative Transportation—Bicycle Storage and Changing Rooms	1
	3		Credit 4.3	Alternative Transportation—Low-Emitting and Fuel-Efficient Vehicles	3
2			Credit 4.4	Alternative Transportation—Parking Capacity	2
	1		Credit 5.1	Site Development—Protect or Restore Habitat	1
1			Credit 5.2	Site Development—Maximize Open Space	1
1			Credit 6.1	Stormwater Design—Quantity Control	1
1			Credit 6.2	Stormwater Design—Quality Control	1
1			Credit 7.1	Heat Island Effect—Non-roof	1
1			Credit 7.2	Heat Island Effect—Roof	1
	1		Credit 8	Light Pollution Reduction	1
2	1	7	**Water Efficiency**	Possible Points:	10
Y			Prereq 1	Water Use Reduction—20% Reduction	
		4	Credit 1	Water Efficient Landscaping	2 to 4
		2	Credit 2	Innovative Wastewater Technologies	2
2	1	1	Credit 3	Water Use Reduction	2 to 4
12	6	17	**Energy and Atmosphere**	Possible Points:	35
Y			Prereq 1	Fundamental Commissioning of Building Energy Systems	
Y			Prereq 2	Minimum Energy Performance	
Y			Prereq 3	Fundamental Refrigerant Management	
8	3	8	Credit 1	Optimize Energy Performance	1 to 19
		7	Credit 2	On-Site Renewable Energy	1 to 7
2			Credit 3	Enhanced Commissioning	2
2			Credit 4	Enhanced Refrigerant Management	2
	3		Credit 5	Measurement and Verification	3
		2	Credit 6	Green Power	2
5	3	6	**Materials and Resources**	Possible Points:	14
Y			Prereq 1	Storage and Collection of Recyclables	
		3	Credit 1.1	Building Reuse—Maintain Existing Walls, Floors, and Roof	1 to 3
		1	Credit 1.2	Building Reuse—Maintain 50% of Interior Non-Structural Elements	1
2			Credit 2	Construction Waste Management	1 to 2
		2	Credit 3	Materials Reuse	1 to 2

Y	?	N			
			Materials and Resources, Continued		
1	1		Credit 4	Recycled Content	1 to 2
1	1		Credit 5	Regional Materials	1 to 2
	1		Credit 6	Rapidly Renewable Materials	1
1			Credit 7	Certified Wood	1
7	6	2	**Indoor Environmental Quality**	Possible Points:	15
Y			Prereq 1	Minimum Indoor Air Quality Performance	
Y			Prereq 2	Environmental Tobacco Smoke (ETS) Control	
	1		Credit 1	Outdoor Air Delivery Monitoring	1
		1	Credit 2	Increased Ventilation	1
1			Credit 3.1	Construction IAQ Management Plan—During Construction	1
1			Credit 3.2	Construction IAQ Management Plan—Before Occupancy	1
1			Credit 4.1	Low-Emitting Materials—Adhesives and Sealants	1
1			Credit 4.2	Low-Emitting Materials—Paints and Coatings	1
1			Credit 4.3	Low-Emitting Materials—Flooring Systems	1
	1		Credit 4.4	Low-Emitting Materials—Composite Wood and Agrifiber Products	1
	1		Credit 5	Indoor Chemical and Pollutant Source Control	1
	1		Credit 6.1	Controllability of Systems—Lighting	1
1			Credit 6.2	Controllability of Systems—Thermal Comfort	1
1			Credit 7.1	Thermal Comfort—Design	1
	1		Credit 7.2	Thermal Comfort—Verification	1
	1		Credit 8.1	Daylight and Views—Daylight	1
		1	Credit 8.2	Daylight and Views—Views	1
4	1	1	**Innovation and Design Process**	Possible Points:	6
1			Credit 1.1	Innovation in Design: Acoustic Control	1
		1	Credit 1.2	Innovation in Design: Pilot Credit	1
1			Credit 1.3	Innovation in Design: Exemplary Performance	1
	1		Credit 1.4	Innovation in Design: Exemplary Performance	1
1			Credit 1.5	Innovation in Design: Green Cleaning / Education / ...	1
1			Credit 2	LEED Accredited Professional	1
1	2	1	**Regional Priority Credits**	Possible Points:	4
		1	Credit 1.1	Regional Priority: EAc1 (40%) / EAc2 (1%)	1
1			Credit 1.2	Regional Priority: SSc4.1 / SSc5.1	1
	1		Credit 1.3	Regional Priority: SSc6.2	1
	1		Credit 1.4	Regional Priority: WEc2	1
52	24	34	**Total**	Possible Points:	110

Certified 40 to 49 points Silver 50 to 59 points Gold 60 to 79 points Platinum 80 to 110

2011

THE PENNSYLVANIA STATE UNIVERSITY

LEED POLICY 2011 UPDATE

01/2011

TABLE OF CONTENTS:

OVERVIEW

This document prioritizes the implementation of sustainable elements in the design of University facilities in accordance with the *United States Green Building Council's Leadership in Energy and Environmental Design® (LEED) Reference Guide for Green Building Design and Construction: Version 3.0* document. LEED for *New Construction* shall be used as the rating system in the application of this policy document. This policy shall be used in conjunction with Penn State's Office of the Physical Plant (OPP) *Design and Construction Standards*, to guide design consultants in the implementation of requirements to attain LEED® certification for campus projects.

This document also reinforces the fundamental idea of the LEED® process, which calls for an integrated, holistic approach to building design; one that yields energy-efficient, comfortable, healthy, and ecologically-responsible facilities. Implementation on future projects in agreement of this document will aid prevention of random pursuit of credits to achieve a higher score.

In order to customize the LEED® process for Penn State and focus on issues that are most important to the University, a committee was formed with broad representation across the University's operational groups. Individuals included represent the following areas:

- Engineering Services – MEP design
- Architecture
- Landscape
- Storm Water Management
- Transportation/Parking
- Purchasing
- Project Management
- Maintenance
- Janitorial
- Health and Safety

CRITERIA APPLIED

The following issues are integrated within all reviewed sustainable design metrics and important to Penn State, therefore they are key drivers for classification of each credit. Identified issues are listed below in no particular order:

- Energy conservation
- Natural resources conservation
- Prevention of environmental degradation
- People's health, well-being and comfort
- Total cost of ownership

CREDIT CLASSIFICATION DEFINITIONS

MANDATORY- credit compliance is required on all Penn State University construction projects. Credits may be inherently achieved through current campus layout, location of new construction, or typical OPP construction methodology. However, if not already present, credit achievement must be completed prior to project completion.

SIGNIFICANT EFFORT- proof of serious attempts at credit achievement must be completed and proven to reviewing OPP personnel. If compliance is not achieved, failure reasoning must be demonstrated by design professional and accepted by The Pennsylvania State University.

MINIMAL EFFORT- investigation of possible credit compliance must be completed and approved by The Pennsylvania State University. If credit requirements are beyond a project's programmatic requirements, documentation must be completed; however, no additional efforts or resources will be dedicated towards it.

NOT PURSUED- credits will not be pursued on Penn State University construction projects and documentation will not be required.

ADDITIONAL PROVISIONS

1. While not specifically addressed by this document, it should be obvious that all prerequisites are mandatory.
2. While each credit is addressed specifically as it relates to University renewal projects, it is evident that a number of credits will be impacted by broader campus-wide initiatives and institutional commitments. These credits will fall into the "mandatory" category, for example: *transportation and parking issues, storm water issues, wastewater issues, etc…*
3. This document is directed to the design professionals of a specific project, and the level of effort assigned to a particular credit refers to the effort required from that professional within the scope of that specific project. It does not reflect the importance that the University attaches to the issue addressed by that specific credit outside the scope of the project. For example: *Alternative Transportation: Public Transportation Access, is classified in this document as "minimal effort." This means that the design professional for the specific project will exert nominal efforts in achieving this credit because typically a site for the project is established prior to the involvement of a professional and that is a determining factor in attaining this credit. The University puts forth a great deal of effort in providing public transportation to its constituents and addresses the issue globally.*
4. This policy applies to all projects exceeding a Total Project Cost of ***$ 5,000,000***, including new construction and/or substantial renovation. Differences inherent between

new construction and renovation projects are addressed in the specific description for each credit.

5. This policy applies to all Penn State University campus locations. If local circumstances dictate specific requirements, these are addressed in the specific description for each credit.
6. If the design team for a project, including the OPP Project Leader, feels that there is a compelling reason to waive a *mandatory* credit or entire project certification, they will submit the request and supporting documentation to the PSU LEED® Committee. The appropriate members of the Committee will then formulate a recommendation and submit it to the Associate Vice President for Physical Plant, who will make the ultimate decision and inform the project team.

PROJECT NAMING GUIDIANCE

The design professional is required to verify the exact naming format with the PSU Project Leader prior to project registration. This is necessary to ensure consistency across all PSU LEED Projects.

United States Green Building Council's Leadership in Energy and Environmental Design® (LEED) Reference Guide for Green Building Design and Construction: Version 3.0

SUSTAINABLE SITES

SS Credit 1.0: Site Selection ***MINIMAL EFFORT***
Typically, site selection is addressed at the campus master planning level and is established by the University prior to beginning of design.

SS Credit 2.0: Development Density and Community Connectivity ***MINIMAL EFFORT***
Channel development to urban areas with existing infrastructure, protect greenfields and preserve habitat and natural resources.

SS Credit 3.0: Brownfield Redevelopment ***MINIMAL EFFORT***
Rehabilitate damaged sites where development is complicated by environmental contamination and to reduce pressure on undeveloped land.

SS Credit 4.1: Alt. Transportation: Public Transportation Access ***MINIMAL EFFORT***
Typically site selection is addressed at the campus master planning level and is established by the University prior to beginning of design. Public transportation is addressed globally and is

typically outside the purview of individual projects. In addition, local public transportation circumstances may be dealt with differently in the various Penn State locations.

SS Credit 4.2: Alt. Trans.: Bicycle Storage & Changing Rooms ***SIGNIFICANT EFFORT***
At University Park, the University provides bicycle racks as part of its inter-modal transportation system and will continue to do so. If it makes programmatic sense to provide the necessary changing facilities in a project, we will do so but not require it. At locations other than University Park, local circumstances related to bicycle use will dictate implementation of this credit

SS Credit 4.3: Alt. Trans.: Low Emitting and Fuel Efficient Vehicles ***MINIMAL EFFORT***
This credit may be accomplished by implementation of comprehensive University policies dealing with parking and/or transportation at each location. It is not addressed by individual projects.

SS Credit 4.4: Alt. Transportation: Parking Capacity ***MINIMAL EFFORT***
This credit may be accomplished by implementation of comprehensive University policies dealing with parking and/or transportation at each location. It is not addressed by individual projects.

SS Credit 5.1: Site Development: Protect or Restore Habitat ***MINIMAL EFFORT***
This is addressed at the campus master planning level.

SS Credit 5.2: Site Development: Maximize Open Space ***SIGNIFICANT EFFORT***
It is important to maximize the efficient use of land (a finite resource). This will help with storm water infiltration and provide natural areas for informal use.

SS Credit 6.1: Stormwater Design: Quantity Control ***MANDATORY***
Regulatory compliance generally results in achieving this credit.

SS Credit 6.2: Stormwater Design: Quality Control ***SIGNIFICANT EFFORT***
Storm water can have a significant impact on existing natural water resources. It is imperative that the quality of storm water be as high as possible before it leaves a project site.

SS Credit 7.1: Heat Island Effect: Non-Roof ***MINIMAL EFFORT***
Current design standards for exterior pavers do not comply with the requirements of this credit making it very difficult to attain. It is also not of significant impact when judged against our primary criteria.

SS Credit 7.2: Heat Island Effect: Roof ***SIGNIFICANT EFFORT***
Current roofing materials technology (including vegetated roofs or high SRI roofs) makes this a worthwhile credit to pursue; however, careful analysis of longevity, performance, cost and maintainability must be performed.

SS Credit 8.0: Light Pollution Reduction ***NOT PURSUED/SIGNIFICANT EFFORT***

University Park: ***NOT PURSUED***
Current Penn State design standards for exterior light fixtures at University Park do not comply with the requirements of this credit.

Non-University Park locations: ***SIGNIFICANT EFFORT***
Many municipalities require compliance. The benefit of pursuing this credit must be based on the circumstances particular to each campus.

SS Credit 9.1: Tenant Design and Construction Guidelines
Only applicable to Core and Shell Projects; to educate tenants about implementing sustainable design and construction features in their tenant improvement build-out.

SS Credit 9.2: Site Master Plan
Only applicable to School Projects; to ensure that the environmental site issues included in the initial development of the site and project are continued throughout future development caused by changes in programs or demography.

SS Credit 10.0: Joint Use of Facilities
Only applicable to School Projects; to make the school a more integrated part of the community by enabling the building and its playing fields to be used for nonschool events and functions.

WATER EFFICIENCY

WE Credit 1.0: Water Efficient Landscaping: Reduce by 50% or No Potable Water Use or Irrigation ***MINIMAL EFFORT***
Current landscape design goals dictate attainment of this credit; all projects should attempt to remove all permanent irrigation requirements.

WE Credit 2.0: Innovative Wastewater Technologies ***MINIMAL EFFORT***
While we do implement a number of wastewater reduction initiatives such as use of low flow fixtures, and some dedicated gray water riser systems, achieving this point would require a higher level of commitment and potential benefits do not justify the investment at this point.

WE Credit 3.0: Water Use Reduction: 30%-40% Reduction
This is attainable with current technology but will require consideration of multiple water-saving strategies including ultra low-flow or waterless urinals, no-touch or spring-loaded faucets and dual-flush toilets. It should be explored on a case by case basis.

30% ***SIGNIFICANT EFFORT***
35% ***MINIMAL EFFORT***
40% ***MINIMAL EFFORT***

WE Credit 4.0: Process Water Use Reduction
Only applicable to School Projects; to maximize water efficiency within buildings to reduce the burden of municipal water supply and wastewater systems.

ENERGY AND ATMOSPHERE

EA Credit 1.1-1.21: Optimize Energy Performance

University Park within the footprint of the central heating and cooling plants:
1 -10 ***MANDATORY***
11-19 ***NOT PURSUED***

Non-University Park locations:
1 -10 ***MANDATORY***
11-19 ***MINIMAL EFFORT***

CREDIT REQUIREMENTS: This is a key goal identified in the initial charge establishing the requirement to get LEED® certification. As clarification to the initial charge, the goal is to achieve 30% energy savings over the "most recent" applicable version of the ASHRAE 90.1 standard for new construction. Additionally, refer to the Division 01 Performance Requirements Section of the University's Design and Construction Standards for guidance in achieving optimized energy efficiency.

The Compliance shall be achieved using the "OPTION 1. Whole Building Energy Simulation" method. In implementing this credit, it is important to note that the design team will be required to validate their envelope design vis-à-vis alternate concepts. Computer generated whole building energy simulations should be performed in a basic shoebox format early in the design to influence decisions. Energy simulations should increase in detail with the design until the design is complete and the final simulation is performed for credits. It should also be noted that expectations for this credit will vary between new construction and renovation projects.

Projects located at University Park within the footprint of the central heating and cooling plants must use the "Option 1 Streamlined" approach from the "Treatment of District or Campus Thermal Energy in LEED®" Document. It is undesirable to have each building design team simulate the performance of the central heating and cooling plants. Utility rates shall be those provided by OPP-Engineering Services.

EA Credit 2.1-2.7: On-Site Renewable Energy ***SIGNIFICANT EFFORT***
Due to the pace of technological advances in this field, every effort should be made to utilize new technologies that help reduce the consumption of fossil fuels.

EA Credit 3.0: Enhanced Commissioning ***MANDATORY***
We already do this in an effort to attain the most efficient systems and operation. Future PSU contracts for new building commissioning services will include the scope of work required by the Enhanced Commissioning credit.

EA Credit 4.0: Enhanced Refrigerant Management ***MANDATORY***
At University Park the central chilled water plant already complies. A calculation documenting the central plant refrigerant management will be provided by PSU for all buildings connected to the central plant. Individual systems at University Park and at other locations should be designed to meet this requirement and documentation provided by the design consultant.

EA Credit 5.1: Measurement and Verification - Base Building ***NOT PURSUED***
We cannot justify implementing the specific strategies required to accomplish this credit, including staffing commitment. Accountability of building energy consumption is valuable and can be accomplished in other ways that are more manageable but will not satisfy the requirements of this credit.

EA Credit 5.2: Measurement and Verification - Tenant Submetering ***NOT PURSUED***
To provide for ongoing accountability of building electricity consumption performance over time.

EA Credit 6.0: Green Power ***MANDATORY***
The University has made a commitment to the use of renewable energy in the form of Renewable Energy Certificates. It will be necessary to implement a documentation process as we continue to add LEED® certified projects.

MATERIALS AND RESOURCES

MR Cr. 1.1: Bldg Reuse: Main. 55-95% of Exist. Walls, Floors & Roof ***MINIMAL EFFORT***
Master planning, programmatic and aesthetic decisions will take precedence regarding the scope of reuse of existing facilities.

CREDIT REQUIREMENTS: Maintain the existing building structure (including structural floor and roof decking) and envelope (the exterior skin and framing, excluding window assemblies and nonstructural roofing materials). Hazardous materials that are remediated as a part of the project must be excluded from the calculation of the percentage maintained.

55% = 1 point
75% = 2 points
85% = 3 points

MR Cr. 1.2: Maintain Interior Nonstructural Elements ***MINIMAL EFFORT***
Master planning, programmatic and aesthetic decisions will take precedence regarding the scope of reuse of existing facilities.

CREDIT REQUIREMENTS: Use existing interior nonstructural elements (i.e. interior walls, doors, floor coverings, and ceiling systems) in at least 50% of the completed building, including additions. If the project includes an addition with square footage more than 2 times the square footage of the existing building, this credit is not applicable.

MR Cr. 2.1: Construction Waste Mgmt: Divert 50-75% from Disposal ***MANDATORY***
The University has made a broad commitment to recycling in general. At this point it is reasonable to expect from construction managers a waste collection and removal process that accomplishes this.

MR Credit 3.0: Materials Reuse: 5%-10% ***MINIMAL EFFORT***
Potential benefit may not justify level of effort.

MR Cr. 4.0: Recycled Content: 10-20% (post-consumer+½ pre-consumer)
This is achievable given the amount of recycled material currently being used in basic construction products such as steel, carpeting, etc...

CREDIT REQUIREMENTS: Use materials with recycled content such that the sum of the postconsumer recycled content plus ½ of the preconsumer content constitutes at least 10% or 20% based on cost, of the total value of the materials in the project. The minimum percentage materials recycled for each point threshold is as follows:

10% = 1 point ***MANDATORY***
20% = 2 points ***SIGNIFICANT EFFORT***

The recycled content value of a materials assembly is determined by weight. The recycled fraction of the assembly is them multiplied by the cost of assembly to determine the recycled content value.

Mechanical, electrical and plumbing components, and specialty items such as elevators cannot be included in this calculation. Include only materials permanently installed in the project. Furniture may be include if it is included consistently with MR Credit 3: Materials Reuse through MR Credit 7: Certified Wood.

MR Cr.5.1: Regional Materials: 10-20%Extracted, Processed & Manufactured ***MANDATORY***
We are conveniently located within a 500-mile radius of sources for numerous building materials. The challenge for this credit is the documentation.

MR Credit 6.0: Rapidly Renewable Materials ***MINIMAL EFFORT***
At this point our facilities do not lend themselves to the use of these materials to the extent required.

MR Credit 7.0: Certified Wood ***MANDATORY***
The type of wood products we typically use in our buildings lends itself to achieving this credit.

INDOOR ENVIRONMENTAL QUALITY

IEQ Credit 1.0: Outdoor Air Delivery Monitoring ***MANDATORY***
This is a very important strategy that helps control the amount of ventilation, thus reducing the potential waste of energy to temper outside air. It requires very careful design to be effective and cost efficient.

IEQ Credit 2.0: Increased Ventilation ***NOT PURSUED***
Good air quality is mandated by prerequisite 1. Additional ventilation requires energy to condition and the benefit does not justify the effort.

IEQ Cr. 3.1: Construction IAQ Management Plan: During Construction ***MANDATORY***
This is an important strategy in addressing the health and well being of building occupants.

IEQ Cr. 3.2: Construction IAQ Management Plan: Before Occupancy ***MANDATORY***
This is an important strategy in addressing the health and well being of building occupants.

IEQ Credit 4.1: Low-Emitting Materials: Adhesives and Sealants ***MANDATORY***
This is an important strategy in addressing the health and well being of building occupants. Current industry standards make this relatively easy to attain.

IEQ Credit 4.2: Low-Emitting Materials: Paints and Coatings ***MANDATORY***
This is an important strategy in addressing the health and well being of building occupants. Current industry standards make this relatively easy to attain.

IEQ Credit 4.3: Low-Emitting Materials: Carpet Systems ***MANDATORY***
This is an important strategy in addressing the health and well being of building occupants. Current industry standards make this relatively easy to attain.

IEQ Cr. 4.4: Low-Emitting Materials: Composite Wood & Agrifiber Products ***MANDATORY***
This is an important strategy in addressing the health and well being of building occupants. Current industry standards make this relatively easy to attain.

IEQ Cr. 4.5: Low-Emitting Materials: Furniture and Furnishings
Only Applicable to School Projects. To reduce the quantity of indoor air contaminants that are odorous, irritating, and/or harmful to the comfort and well-being of installers and occupants.

IEQ Cr. 4.6: Low-Emitting Materials: Ceiling and Wall Systems
Only applicable to School Projects. To reduce the quantity of indoor air contaminants that are odorous, irritating, and/or harmful to the comfort and well-being of installers and occupants.

IEQ Credit 5.0: Indoor Chemical and Pollutant Source Control ***MANDATORY***
This is a relatively easy requirement to address and has substantial impact on the well-being and comfort of occupants as well as the maintainability of a facility. Strategy to be reviewed by PSU OPP Environmental, Health, and Safety Division.

IEQ Credit 6.1: Controllability of Systems: Lighting ***MANDATORY***
Current practice makes it reasonable to expect achieving this credit.

IEQ Credit 6.2: Controllability of Systems: Thermal Comfort ***SIGNIFICANT EFFORT***
This is an important goal with significant benefit to the well-being and productivity of occupants; considerable thought must be given to the relationship between programmatic demands, cost, and benefit of the occupants.

CREDIT REQUIREMENTS: Design heating, ventilating and air conditioning (HVAC) systems and the building envelope to meet the requirements of ASHRAE 55-2004, Thermal Environmental Conditions for Human Occupancy (with errata but with addenda). Demonstrate design compliance in accordance with the Section 6.1.1 documentation.

IEQ Credit 7.1: Thermal Comfort: Design ***SIGNIFICANT EFFORT***
This requires humidification and de-humidification that is not part of our standard practice. We can reach adequate comfort levels without this requirement.

IEQ Credit 7.2: Thermal Comfort: Verification ***MANDATORY***
The documentation required to achieve this credit is incorporated into the bond inspection process. Design professional to coordinate with PSU Project Leader.

IEQ Credit 8.1: Daylight and Views: Daylight ***SIGNIFICANT EFFORT***
This is a very worthwhile goal with a potentially significant benefit to the well being of occupants; however, in some instances it may not be achievable without programmatic compromise.

CREDIT REQUIREMENTS: 75% of regularly occupied spaces must achieve daylighting for 1 point.

Option 1: *Simulation-* demonstrate through computer simulations that 75% or more of all regularly occupied spaces achieve daylight luminance levels of a minimum of 25 footcandles and a maximum of 500 footcandles in a clear sky condition on September 21st at 9 a.m. and 3 p.m.; areas will luminance levels below or above the range do not comply.

Option 2: *Prescriptive* for side-lighting daylight zone

Option 3: *Measurement*

Option 4: *Combination*

IEQ Credit 8.2: Daylight and Views: Views ***MINIMAL EFFORT***
Same reasoning as previous credit but harder to achieve; requirements are very prescriptive.

CREDIT REQUIREMENTS: Achieve a direct line of sight to the outdoor environment via vision glazing between 20 inches and 90 inches above the finish floor for building occupants in 90% of all regularly occupied areas. Determine the area with direct line of sight by totaling the regularly occupied square footage that meets the following criteria:

- In plan view, the area is within sight lines drawn from perimeter vision glazing
- In section view, a direct sight line can be drawn from the area to perimeter vision glazing

The line of sight may be drawn through interior glazing. For private offices, the entire square footage of the office may be counted if 75% or more of the area has a direct line of sight to perimeter vision glazing. For classrooms and other multi-occupant spaces, the actual square footage with a direct line of sight to perimeter vision glazing is counted.

IEQ Credit 9.0: Enhanced Acoustical Performance
Only applicable to School Projects; to provide classrooms that facilitates better teacher-to-student and student-to-student communications through effective acoustical design.

IEQ Credit 10.0: Mold Prevention
Only applicable to School Projects; to reduce the potential presence of mold in schools through preventative design and construction measures.

INNOVATION AND DESIGN PROCESS

ID Credit 1.0: Innovation in Design ***SIGNIFICANT EFFORT***
The University supports exceptional efforts beyond the requirements set forth in the LEED Green Building Rating System.

ID Credit 2.0 LEED® Accredited Professional ***MANDATORY***
The inclusion of a LEED® accredited professional in the design team is standard procedure.

ID Credit 3.0: The School as a Teaching Tool
Only applicable to School Projects; to integrate the sustainable features of a school facility with the school's educational mission.

REGIONAL PRIORITY

RP Credit 1.0: Regional Priority ***MINIMAL EFFORT***
To provide an incentive for the achievement of credits that address geographically specific environmental priorities.

SUMMARY of OPP LEED Policy 2011 Update

Sustainable Sites

Credit Number	Credit Name	Credit Classification	Credit Description
1.0	Site Selection	Minimal	Picking an appropriate site that is suitable for new construction
2.0	Development Density and Community Connectivity	Minimal	Channeling construction to urban areas, protecting greenfields, connecting with the community
3.0	Brownfield Redevelopment	Minimal	Developing Brownfield or documented contaminated locations
4.1	Alt. Transportation: Public Transportation Access	Minimal	Having appropriate proximity to bus stops and other public transportation
4.2	Alt. Transportation: Bicycle Storage & Changing Rooms	Significant	Providing Bike racks and changing rooms to encourage biking to work
4.3	Alt. Transportation: Low Emitting and Fuel Efficient Vehicles	Minimal	Providing preferred parking for fuel efficient and low emitting vehicles/incentives to share rides in these vehicles
4.4	Alt. Transportation: Parking Capacity	Minimal	Parking lot sizes and limiting. Also providing preferred parking for carpooling
5.1	Site Development: Protect of Restore Habitat	Minimal	Limiting site development and disturbance/restoring previously developed sites
5.2	Site Development: Maximize Open Space	Significant	Providing a vegetated open space adjacent to the building equal to the footprint
6.1	Storm water Design: Quantity Control	Mandatory	Reducing impervious covering to limit disruption of natural hydrology/increasing on site filtration
6.2	Storm water Design: Quantity Control	Significant	Managing storm water runoff to reduce pollution
7.1	Heat Island Effect: Non-Roof	Minimal	Providing shade from structures covered with materials with at least an SRI of 29 or solar panel shading
7.2	Heat Island Effect: Roof	Significant	Effectively eliminating the heat island effect with "green" roofs or SRI 78 material for low slope
8.0	Light Pollution Reduction*	Not Pursued / Significant	Minimizing building to site light, reducing sky-glow, improve nighttime visibility
9.1	Tenant Design and Construction Guidelines		[Only applicable to core and shell projects] Educate tenants about implementing sustainable design and construction
9.2	Site Master Plan		[Only applicable to school projects] Ensure any environmental changes are changed in the Master Plan.
10.0	Joint Use of Facilities		[Only applicable to school projects] Make the school a more integrated part of the community.

Water Efficiency

Credit Number	Credit Name	Credit Classification	Credit Description
1.0	Water Efficient Landscaping: Reduce by 50%	Minimal	Reduce potable water consumption by 50% from midsummer baseline/ using other sources for irrigation
2.0	Innovative Wastewater Technologies	Minimal	A higher level of commitment than following the usual wastewater reduction initiatives.
3.0	Water Use Reduction: 30-40% Reduction	Varies	This is attainable with current technology but will require consideration of multiple strategies.
4.0	Process Water Use Reduction		[Only applicable to school projects] Maximize water efficiency within buildings to reduce the burden of municipal water.

Energy and Atmosphere

Credit Number	Credit Name	Credit Classification	Credit Description
1.1-1.21	Optimize Energy Performance	Varies	Perform a whole building energy simulation. Various levels of energy cost savings percentages will get you various points.
2.1-2.7	On-Site Renewable Energy	Significant	Use on-site renewable energy to reduce the cost of running the building systems.
3.0	Enhanced Commissioning	Mandatory	Implement or contract a commissioner to further commission the building
4.0	Enhanced Refrigerant Management	Mandatory	Eliminate Refrigerants all together/ minimize as much as possible
5.1	Measurement and Verification - Base Building	Not Pursued	Develop a measurement and verification plan that will cover 1 year of post-construction occupancy minimum
5.2	Measurement and Verification - Tenant Submetering	Not Pursued	Develop a measurement and verification plan that will cover 1 year of post-construction occupancy minimum
6.0	Green Power	Mandatory	Engage in at least a 2-year renewable energy contract to provide at least 35% of buildings electricity

Materials and Resources

Credit Number	Credit Name	Credit Classification	Credit Description
1.1	Bldg Reuse: Main. 55-95% of Exist. Walls, Floors & Roof	Minimal	Maintaining existing building structure and envelope minimum of 55%
1.2	Maintain Interior Nonstructural Elements	Minimal	Using existing interior nonstructural elements in at least 50% of the complete building, not applicable if addition is double the original size
2.1	Construction Waste Management: Divert 50-75% from Disposal	Mandatory	Recycle or salvage nonhazardous construction and demolition debris. Minimum of 50% recycled/salvaged for minimum points
3.0	Materials Reuse: 5-10%	Minimal	Use salvaged, refurbished or reused materials the sum of 5% or 10 % based on cost of the total value of materials on project
4.0	Recycled Content: 10-20% (post-consumer+1/2pre-consumer)	Mandatory/Significant	Use materials with recycled content such that 10-20% of total cost of all materials includes these materials
5.1	Regional Materials: 10-20% Extracted, Processed & Manufactured	Mandatory	Use materials that have been harvested recovered manufactured within 500 miles of the project site for 10-20% of total cost of all materials
6.0	Rapidly Renewable Materials	Minimal	Use rapidly renewable materials and products for 2.5% of the total value of all building materials and product used on project
7.0	Certified Wood	Mandatory	Use a minimum of 50% of wood based materials and products certified with Forest Stewardship Council for wood building components

Indoor Environmental Quality

Credit Number	Credit Name	Credit Classification	Credit Description
1.0	Outdoor Air Delivery Monitoring	Mandatory	Install permanent monitoring systems to ensure that ventilation systems maintain design minimum requirements.
2.0	Increased Ventilation	Not Pursued	Provide additional outdoor air ventilation to improve indoor air quality and promote occupant comfort, well-being and productivity
3.1	Construction IAQ Management Plan: During Construction	Mandatory	Develop and implement an IAQ management plan for the construction and preoccupancy phases of the building
3.2	Construction IAQ Management Plan: Before Occupancy	Mandatory	Develop and implement an IAQ management plan after all finishes have been installed and the building has been completely cleaned out
4.1	Low-Emitting Materials: Adhesives and Sealants	Mandatory	Reducing quantity of indoor air contaminants that are odorous, irritating and/or harmful to the comfort and well-being of occupants
4.2	Low-Emitting Materials: Paints and Coatings	Mandatory	Paints used in the building must comply with the VOC standards set by Green Seal Standards
4.3	Low-Emitting Materials: Carpet Systems	Mandatory	All flooring must comply with standards to ensure the reduction of indoor air contaminants.
4.4	Low-Emitting Materials: Composite Wood & Agrifiber Products	Mandatory	Composite wood and agrifiber products used interior must contain no added urea-formaldehyde resins.
4.5	Low-Emitting Materials: Furniture and Furnishings		[Only applicable to school projects] Reduces the quantity of indoor air contaminants
4.6	Low-Emitting Materials: Ceiling and Wall Systems		[Only applicable to school projects] Reduces the quantity of indoor air contaminants
5.0	Indoor Chemical and Pollutant Source Control	Mandatory	Design to minimize and control the flow of contaminants in the building.
6.1	Controllability of Systems: Lighting	Mandatory	Provide individual lighting controls for 90% minimum of the buildings occupants. Also provide adjustments for group spaces
6.2	Controllability of Systems: Thermal Comfort	Significant	Provide individual controls for 50% minimum of the building occupants. Described in ASHRAE Standard 55-2004
7.1	Thermal Comfort: Design	Significant	Provide permanent monitoring system to ensure building performance meets comfort standards of Credit 7.1
7.2	Thermal Comfort: Verification	Mandatory	Achieve Credit 7.1. Provide permanent monitoring system to ensure building performance meets comfort standards of Credit 7.1
8.1	Daylight and Views: Daylight	Significant	Provide occupants with a connection between indoor and outdoor spaces through the introduction of daylight and views into occupied areas
8.2	Daylight and Views: Views	Minimal	Achieve direct line of sight to the outdoor environment via vision glazing in 90% of occupied areas
9.0	Enhanced Acoustical Performance		[Only applicable to school projects] Provide classrooms that facilitate better communications between teachers and students through acoustical design
10.0	Mold Prevention		[Only applicable to school projects] Reduce the potential of mold in schools

Innovation and Design Process

Credit Number	Credit Name	Credit Classification	Credit Description
1.0	Innovation in Design	Significant	Achieve significant measureable environmental performance using a strategy not addressed in LEED 2009
2.0	LEED Accredited Professional	Mandatory	At least 1 principal participant of the project team shall be a LEED A.P.
3.0	The School as a Teaching Tool		[Only applicable to school projects] Integrate the sustainable features within the school.

Regional Priority

Credit Number	Credit Name	Credit Classification	Credit Description
1.0	Regional Priority	Minimal	Earn 1-4 of the 6 Regional credits. No more than 4 credits may be earned.