PENNSTATE
Department of
Architectural Engineering

eStudio
ARCHITECTURAL ENGINEERING
SENIOR THESIS PORTFOLIO

# THE SUSQUEHANNA CENTER
# RENOVATION & ADDITION
# BEL AIR, MD

**Penn State AE Senior Capstone Project**


**Haitham Alrasbi**
**Construction Management Option**
**Advisor: Dr. Chimay Anumba**


HARFORD COMMUNITY COLLEGE

Turner
Construction
Company

hord | coplan | macht

## Presentation Outline

I. **Introduction**
   I. **Project Overview**
   II. Before and after renovation
II. Analysis 1: Reduction of weather impact in the foundation schedule
III. Analysis 2: BIM use in the Susquehanna Center renovation project
IV. Analysis 3: Alternative façade system (Architectural breadth) *Not presented*
V. Analysis 4: Commissioning mechanical systems in the Susquehanna Center (Mechanical breadth)
VI. Conclusion
VII. Credits and Acknowledgments
VIII. Questions and Answers

# Project Overview

## THE SUSQUEHANNA CENTER RENOVATION & ADDITION

- Project Location: Bel Air, MD
- Size: 106,955 SF
  (58,640 SF Addition & 49,159 SF Renovation)
- Cost: $26.7M after $1.65M VE savings
- Dates of Construction: 5/23/11-12/6/12
- Delivery Method: GMP, CM-at-Risk

- Objective:
  Find the best cost effective solutions for specific problems happened during the Susquehanna Center renovation and addition project.

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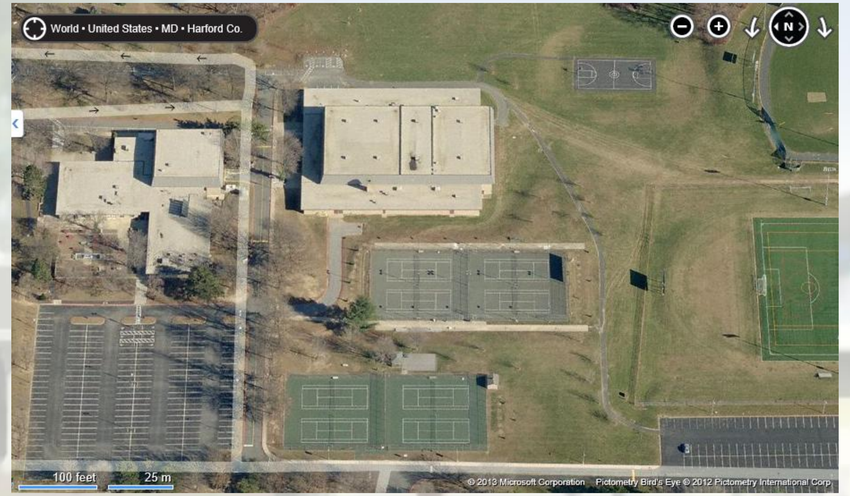
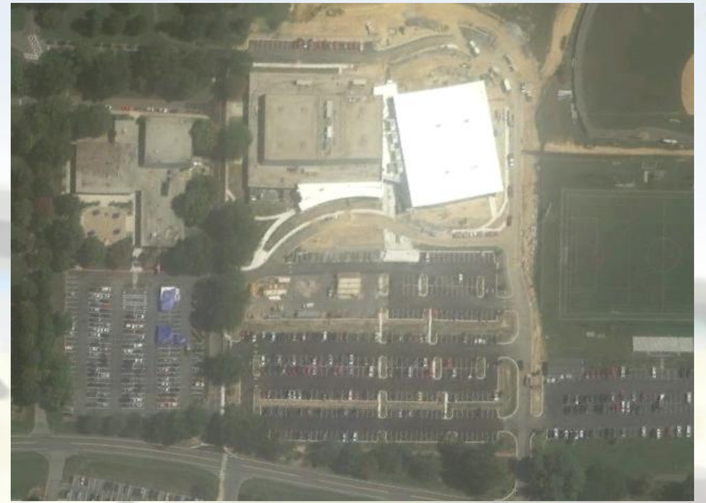
# Project Overview




Before renovation



Nearing Completion

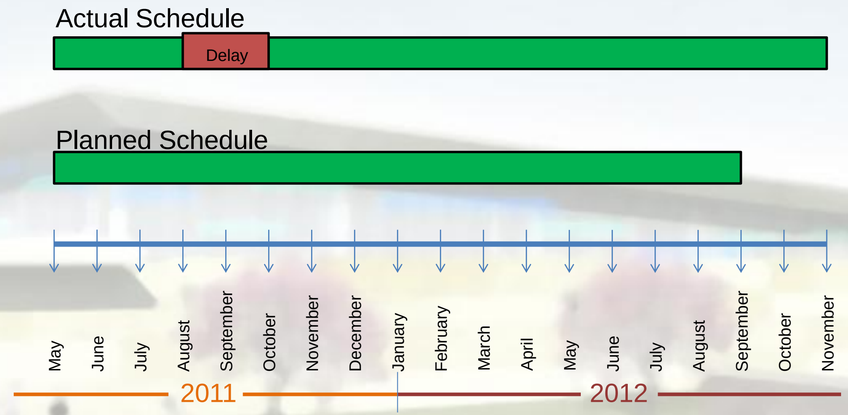
## Presentation Outline



# #1: Reduction of weather impact in the foundation schedule

**Problem:**
Rainfall during the foundation phase pushed the schedule about two months back

**Goal:**
Find the most cost effective ways to minimize the weather impact



## Presentation Outline



# #1: Reduction of weather impact in the foundation schedule

Analysis:

- Schedule
  - Forecasts from NOAA climatological report
  - Check whether regularly

| PRECIPITATION (IN) | | | | | |
|---|---|---|---|---|---|
| YESTERDAY | 0.00 | MM | MM | 0.11 | -0.11 |
| MONTH TO DATE | 11.97 | | | 3.39 | 8.58 |
| SINCE JUN 1 | 17.07 | | | 11.28 | 5.79 |
| SINCE JAN 1 | 33.18 | | | 27.37 | 5.81 |

- Physical techniques
  - Direct: e.g. physically cover the site
  - Indirect:
    - Drainage
    - Overtime/weekends
    - Concrete accelerators
- Contract
  - Clear weather responsibility
  - Negotiation

## Presentation Outline



# #1: Reduction of weather impact in the foundation schedule

Recommendations:

- The construction team followed the best ways possible to minimize weather impact
- Checking weather regularly is critical
- Evaluate all means possible to recover from weather damage (e.g. concrete accelerators, working overtime, etc.)
- Understand the contract very clearly

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# #2: BIM use in the Susquehanna Center renovation project

**Problem:**

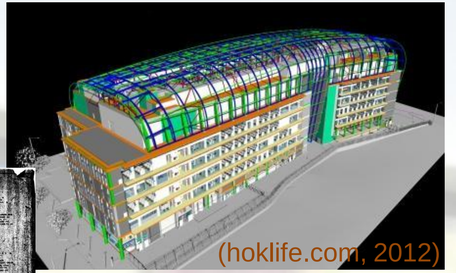
BIM was not used in the Susquehanna Center project because

- Subcontractors lack BIM knowledge
- Construction documents were not available in a BIM friendly format
- Cost concern

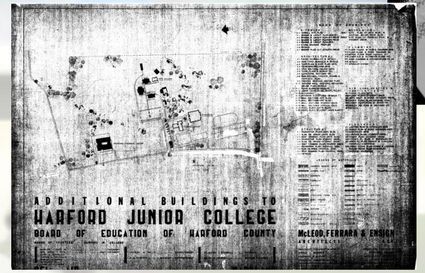
**Goal:**

Find whether BIM was worth implementing

$ $ $



(hoklife.com, 2012)

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# #2: BIM use in the Susquehanna Center renovation project

Analysis:

- Subcontractors lack knowledge
  - Offering BIM service
    - Construction Manager/Owner/Designer
    - 3rd party
  - Training subcontractors
    - Construction Manager/Owner/Designer
    - 3rd party

- Construction Documents format problem
  - Convert available CDs
  - 3D scan the building
    - Existing Conditions Modeling

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# #2: BIM use in the Susquehanna Center renovation project

BIM Uses:
- Existing Conditions Modeling
- Cost Estimation
- 3D Coordination
- Design Authoring

BIM prerequisite:
- Train subcontractors

3. BIM Uses:

| X | PLAN | X | DESIGN | X | CONSTRUCT | X | OPERATE |
|---|---|---|---|---|---|---|---|
| | PROGRAMMING | X | DESIGN AUTHORING | | SITE UTILIZATION PLANNING | | BUILDING MAINTENANCE SCHEDULING |
| | SITE ANALYSIS | | DESIGN REVIEWS | | CONSTRUCTION SYSTEM DESIGN | | BUILDING SYSTEM ANALYSIS |
| | | X | 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 | | | | |
| | | | SUSTAINABLITY (LEED) EVALUATION | | | | |
| | | | CODE VALIDATION | | | | |
| | PHASE PLANNING (4D MODELING) | | PHASE PLANNING (4D MODELING) | | PHASE PLANNING (4D MODELING) | | PHASE PLANNING (4D MODELING) |
| X | COST ESTIMATION | | COST ESTIMATION | | COST ESTIMATION | | COST ESTIMATION |
| X | EXISTING CONDITIONS MODELING | | EXISTING CONDITIONS MODELING | | EXISTING CONDITIONS MODELING | | EXISTING CONDITIONS MODELING |

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# #2: BIM use in the Susquehanna Center renovation project

## BIM cost analysis:

| BIM Prerequisites | Labor | Equipment | Total |
|---|---|---|---|
| Training subcontractors | $4,800 | - | $4,800 |
| **BIM Use** | **Labor** | **Equipment** | **Total** |
| Existing Conditions Modeling | $10,240 | $2,560 | $12,800 |
| Cost Estimation | $8,100 | - | $8,100 |
| 3D Coordination | $11,200 | - | $11,200 |
| Design Authoring | $36,160 | $10,300 | $46,460 |
| **TOTAL** | **$70,500** | **$12,860** | **$83,360** |

| Cost ($M) | Project | BIM Cost ($) | Direct BIM savings ($) | Net BIM savings ($) | BIM ROI (%) |
|---|---|---|---|---|---|
| 54 | Progressive Data Center | 120,000 | (395,000) | (232,000) | 140 |
| 82 | HP Data Center | 20,000 | (67,500) | (47,500) | 240 |
| 16 | GSU Library | 10,000 | (74,120) | (64,120) | 640 |
| 47 | Aquarium Hilton | 90,000 | (800,000) | (710,000) | 780 |
| 88 | Mansion on Peachtree | 1,440 | (15,000) | (6,850) | 940 |
| 30 | Ashley Overlook | 5,000 | (135,000) | (130,000) | 2600 |
| 58 | 1515 Wynkoop | 3,800 | (200,000) | (196,200) | 5160 |
| 47 | Raleigh Marriott | 4,288 | (500,000) | (495,712) | 11560 |
| 32 | NAU Sciences Lab | 1,000 | (330,000) | (329,000) | 32900 |
| 14 | Savannah State | 5,000 | (2,000,000) | (1,995,000) | 39900 |

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| 32 | NAU Sciences Lab | 1,000 | (330,000) | (329,000) | 32900 |
| 14 | Savannah State | 5,000 | (2,000,000) | (1,995,000) | 39900 |

| | Direct BIM Savings ($) | Net BIM savings ($) | BIM ROI (%) |
|---|---|---|---|
| Minimum | **120,000** | **36,640** | **44** |
| Maximum | **200,000** | **116,640** | **140** |

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# #2: BIM use in the Susquehanna Center renovation project

Conclusion:

- BIM is worth implementing with a return of investment between 44% and 140%.
- Choose subcontractors that have prior BIM experience
- Analyze the ROI of BIM in the early stages of planning

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# #4: Commissioning mechanical systems in the Susquehanna Center

**Problem:**

Limited commissioning scope of work, which led to identify the pool leakage problem late in the construction phase

**Goals:**

- Modify the commissioning plan in a cost effective way to help identify problems earlier
- Determine how it could effect the mechanical system

Picture taken 9-28-2012

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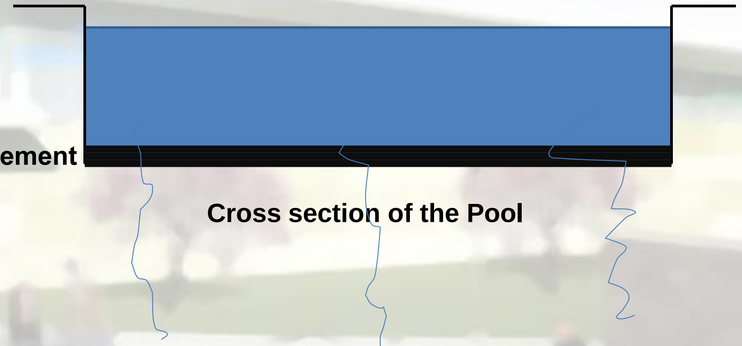
# #4: Commissioning mechanical systems in the Susquehanna Center

Analysis:

Current commissioning plan:
- Installation checklist
- Mechanical equipment inspection
- Automation system commissioning
- Track errors using android tablets

Proposed commissioning plan:
- Early involvement
- Assistance in developing the mechanical design
- Pool commissioning services




Cross section of the Pool

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# #4: Commissioning mechanical systems in the Susquehanna Center

Analysis:
Trane Trace™700 model
Input:
Slab U-value: 0.73 Btu/hr-sq ft$^2$°F
Roof U-value: 0.065 Btu/hr-sq ft$^2$°F
Wall U-value: 0.178 Btu/hr-sq ft$^2$°F
Room dimensions: 117' x 67' x 27'
Density: 320sq ft/person

**COOLING COIL SELECTION**

| | Total Capacity | | Sens Cap. | Coil Airflow | Enter DB/WB/HR | | | Leave DB/WB/HR | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | ton | MBh | MBh | cfm | °F | °F | gr/lb | °F | °F | gr/lb |
| Main Clg | 15.4 | 184.9 | 131.2 | 5,318 | 76.0 | 63.6 | 68.7 | 53.8 | 51.8 | 54.4 |
| Aux Clg | 0.0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Opt Vent | 0.0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| *Total* | 15.4 | 184.9 | | | | | | | | |

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# #4: Commissioning mechanical systems in the Susquehanna Center

Conclusion:

- The cooling system in the pool area was not affected by the pool change of order
- Early involvement means early detection of problems
- Potential savings if solution includes changes in the building system design

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# Conclusion

❖Analysis 1: Reduction of weather impact on the foundation schedule

The construction team chose the most effective ways in regards to cost, schedule, physical techniques, and contract to minimize weather impact

❖Analysis 2: BIM use in the Susquehanna Center renovation project

BIM use in the Susquehanna Center was estimated to have a ROI of 44% to 140%

❖Analysis 4: Commissioning mechanical systems in the Susquehanna Center

•Cooling system was not affected by the new commissioning plan
•Early involvement helps detecting problems early which could mean potential savings in different aspects in project

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# Acknowledgements


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Chang Liu
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Adam Karlheim
Julanda Alriyami
Mohammed Allawati
Haitham Alabdali
Abdulaziz Alalyani
Omanis at Penn State

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# Questions and Answers

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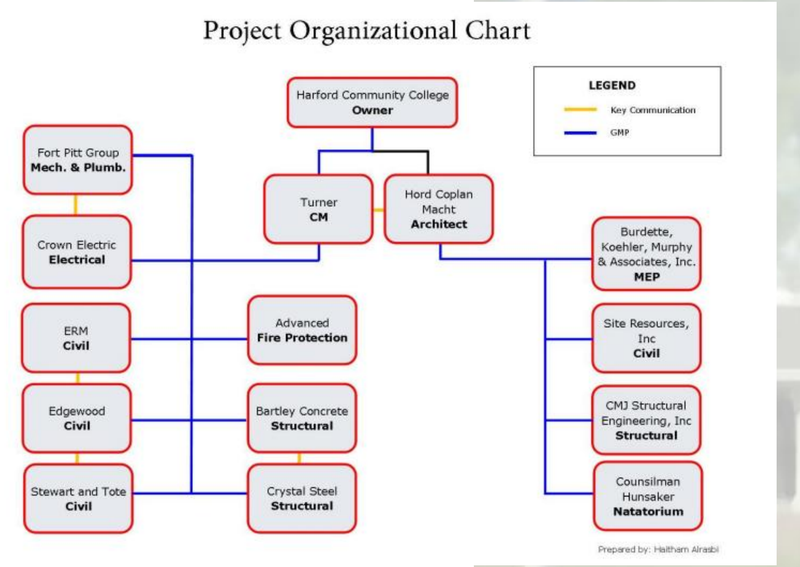



- Owner: **Harford Community College**
- Architect :**Hord | Coplan | Macht**
- Construction Manager: **Turner**
- Civil: **Site Resources, Inc.**
- MEP:

**Burdette, Koehler, Murphy & Associates, Inc.**

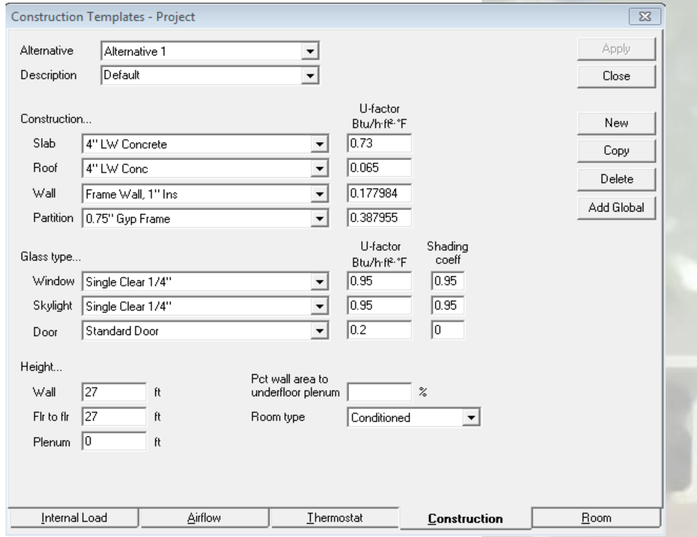
- Structural: **CMJ Structural Engineering, Inc.**
- Natatorium: **Counsilman Hunsaker**

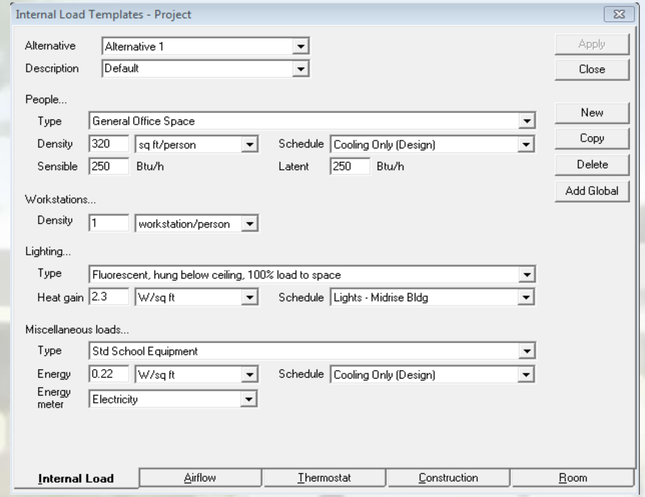
**2. BIM Use Staffing:**

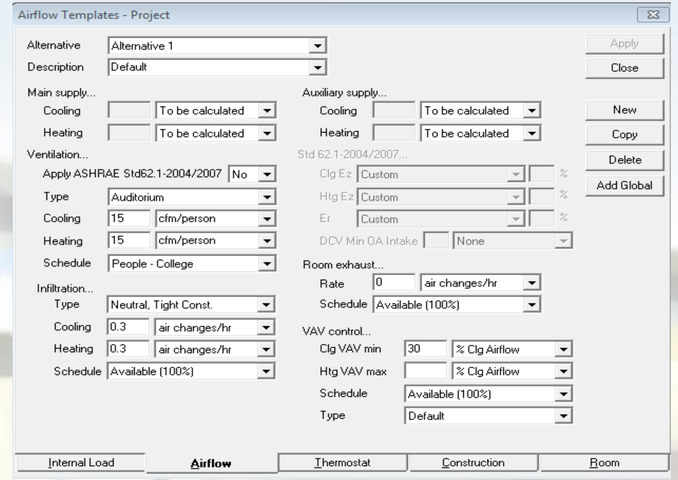
| BIM Use | Organization(s) | Staff Required for BIM Use | Worker Duration |
|---|---|---|---|
| Existing Conditions Modeling | Site Resources, Inc / HCM | Site Resources, Inc: (1) Surveyor and (1) Civil Engineer<br>HCM: (2) Architects | (1) week each |
| Cost Estimation | Turner / HCM | Turner: (2) Estimators<br>HCM: (2) Architects | (3) weeks for estimators<br>(1) week for architects |
| 3D Coordination | Turner / HCM / Subcontractors | Turner: (2) Project Managers<br>HCM: (1) Project Architect and (1) Architect<br>Subcontractors: 1 from each sub = (3) + 1 = 4 total | (1) week each |
| Design Authoring | Turner / HCM / Subcontractors | Turner: (2) Project Managers<br>HCM: (1) Project Architect and (1) Architect<br>Subcontractors: 1 from each sub = (3) + 1 = 4 total | (3) weeks for project managers<br>(5) weeks for architects<br>(4) weeks for subs |

| BIM Use | Organization(s) | Number of Total Staff for BIM Use | Estimated Worker Hours | Location(s) | Lead Contact |
|---|---|---|---|---|---|
| Existing Conditions Modeling | Site Resources, Inc / HCM | 4 | 160 | Jobsite | Site Resources, Inc |
| Cost Estimation | Turner / HCM | 4 | 320 | Office and Jobsite | Turner |
| 3D Coordination | Turner / HCM / Subcontractors | 7 | 280 | Accessible from anywhere | Turner |
| Design Authoring | Turner / HCM / Subcontractors | 7 | 1280 | HCM office, Turner offices, and jobsite | HCM |

# Supplemental



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# Supplemental

### Current Commissioning Plan

5.1 The commissioning agent shall assist the project Architect and Owner in developing commissioning specifications.
5.2 Agent shall provide commissioning services for the renovation and expansion of the Susquehanna Center which contains the athletic facility located on the main campus of Harford Community College. Construction of this project is anticipated to begin in May 2011 and be completed within eighteen (18) months.
a. Area – Existing Building: 52,444 GSF; Addition: 54,511 GSF
b. Tentative construction schedule:
Existing building (Phase 1) – May 2011 – May 2012
Addition (Phase 2) – May 2011 – August 2012
5.3 Agent shall develop a Commissioning Plan which shall provide for a systematic process of ensuring that all building systems perform interactively according to the design intent and the owner's operational needs.
5.4 Agent shall provide commissioning services to include the following equipment:
a. Boilers - Low Pressure Hot water – 4 each
b. Variable Air Volume Boxes - 15 each (locations to TBD by HCC)
c. Chiller - 205 ton unit – 1 each
d. Pumps – 5 each hot water and 2 each chill water
e. Roof Top Units – 8 each ranging in size from 7 to 18,000 CFM
f. Motor Control Center – 1 each
g. Generator – 1 each 150 amp 3 phase 480 volts
h. Energy Management System
i. Lighting
j. Energy Recovery Wheels - 7,000 CFM each
k. Exhaust fans – 7 each
5.5 Agent shall provide verification that all mechanical and electrical equipment is installed according to manufacturer's recommendations.
5.6 Agent shall insure that installing contractors perform a documented functional checkout of all equipment.
5.7 Agent shall verify and document that installed equipment performs according to manufacturer's recommendations.
5.8 Agent shall verify and document that installed equipment performs as designed by the engineering firm.
5.9 Agent shall verify and document that the building automation system functions as designed.
5.10 Agent shall verify that the owner's personnel are trained on all equipment.
5.11 Agent shall provide a summary report detailing all commissioning work.

### New Commissioning Plan

5.1a The commissioning agent shall assist the project Architect and Owner in developing commissioning specifications.
5.1b Agent shall assist the project MEP contractor in developing the mechanical design.
5.2 Agent shall provide commissioning services for the renovation and expansion of the Susquehanna Center which contains the athletic facility located on the main campus of Harford Community College starting from the design phase. Design of this project is anticipated to start June 2010. Construction of this project is anticipated to begin in May 2011 and be completed within eighteen (18) months.
a. Area – Existing Building: 52,444 GSF; Addition: 54,511 GSF
b. Tentative construction schedule:
Existing building (Phase 1) – May 2011 – May 2012
Addition (Phase 2) – May 2011 – August 2012
5.3 Agent shall develop a Commissioning Plan which shall provide for a systematic process of ensuring that all building systems perform interactively according to the design intent and the owner's operational needs.
5.4 Agent shall provide commissioning services to include the following equipment:
a. Boilers - Low Pressure Hot water – 4 each
b. Variable Air Volume Boxes - 15 each (locations to TBD by HCC)
c. Chiller - 205 ton unit – 1 each
d. Pumps – 5 each hot water and 2 each chill water
e. Roof Top Units – 8 each ranging in size from 7 to 18,000 CFM
f. Motor Control Center – 1 each
g. Generator – 1 each 150 amp 3 phase 480 volts
h. Energy Management System
i. Lighting
j. Energy Recovery Wheels - 7,000 CFM each
k. Exhaust fans – 7 each
5.4b Agent shall provide commissioning services prior and after pool restoration to the pool – 27.22 sq ft.
5.5 Agent shall provide verification that all mechanical and electrical equipment is installed according to manufacturer's recommendations.
5.6 Agent shall insure that installing contractors perform a documented functional checkout of all equipment.
5.7 Agent shall verify and document that installed equipment performs according to manufacturer's recommendations.
5.8 Agent shall verify and document that installed equipment performs as designed by the engineering firm.
5.9 Agent shall verify and document that the building automation system functions as designed.
5.10 Agent shall verify that the owner's personnel are trained on all equipment.
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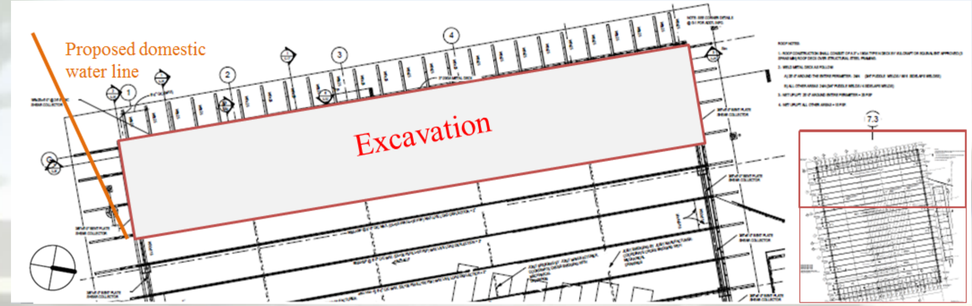
II. Analysis 1: Reduction of weather impact in the foundation schedule
III. Analysis 2: BIM use in the Susquehanna Center renovation project
IV. Analysis 3: Alternative façade system (Architectural breadth) *Not presented*
V. Analysis 4: Commissioning mechanical systems in the Susquehanna Center (Mechanical breadth)
VI. Conclusion
VII. Credits and Acknowledgments
VIII. Questions and Answers

# Supplemental



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# References


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