

Penn State AE Senior Capstone Project Haitham Alrasbi **Construction Management Option Advisor: Dr. Chimay Anumba**

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



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

Size: 106,955 SF

Project Overview

THE SUSQUEHANNA CENTER **RENOVATION & ADDITION**

Project Location: Bel Air, MD

(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.

Introduction

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- 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 Analysis 4: Commissioning mechanical V.
- systems in the Susquehanna Center (Mechanical breadth)
- VI. Conclusion
- VII. Credits and Acknowledgments VIII.Questions and Answers



Project Overview

Before renovation



Nearing Completion

Introduction

- II. Analysis 1: Reduction of weather impact on the foundation schedule
 - I. Introduction
 - II. Analysis
 - III. Recommendations
- 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

#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



Introduction

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



PRECIPITATION YESTERDAY MONTH TO DATE SINCE JUN 1 SINCE JAN 1

#1: Reduction of weather impact in the foundation schedule

Forecasts from NOAA climatological report Check whether regularly

(]	EN)					
	0.00	MM	MM	0.11	-0.11	
9	(11.97)			(3.39)	8.58	
	17.07			11.28	5.79	
	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

Introduction

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

#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



Introduction

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

Problem: project because

Cost concern

#2: BIM use in the Susquehanna Center renovation project

Goal: Find whether BIM was worth implementing

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DITLONAL BUILDINGS

BIM was not used in the Susquehanna Center

Subcontractors lack BIM knowledge

Construction documents were not available in a **BIM friendly format**

(hoklife.com, 2012

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Introduction

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

#2: BIM use in the Susquehanna Center renovation project

Analysis: •3rd party •3rd party

- •Subcontractors lack knowledge •Offering BIM service Construction Manager/Owner/Designer •Training subcontractors
 - Construction Manager/Owner/Designer

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



Introduction

- II. Analysis 1: Reduction of weather impact in the foundation schedule
- III. Analysis 2: BIM use in the Susquehanna Center renovation project
 - I. Introduction
 - II. Analysis
 - III. BIM Uses
 - IV. BIM Cost analysis
 - V. Conclusion
- 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

#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	Х	CONSTRUCT	Х	OPERATE
	PROGRAMMING	Х	DESIGN AUTHORING		SITE UTILIZATION PLANNING		BUILDING MAINTENANCE SCHEDULING
	SITE ANALYSIS		DESIGN REVIEWS		CONSTRUCTION SYSTEM DESIGN		BUILDING SYSTEM ANALYSIS
		Х	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)
х	COST ESTIMATION		COST ESTIMATION		COST ESTIMATION		COST ESTIMATION
X	EXISTING CONDITIONS MODELING		EXISTING CONDITIONS MODELING		EXISTING CONDITIONS MODELING		EXISTING CONDITIONS MODELING

Introduction

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

#2: BIM use in the Susquehanna Center renovation project

BIM cost analysis:

BIM Prereq

Training sub

BIM Use

Existing Con

Cost Estimat

3D Coordina

Design Auth

TOTAL

uisites	Labor	Equipment	Total
ocontractors	\$4,800	-	\$4,800
	Labor	Equipment	Total
nditions Modeling	\$10,240	\$2,560	\$12,800
tion	\$8,100	-	\$8,100
ation	\$11,200	-	\$11,200
noring	\$36,160	\$10,300	\$46,460
	\$70,500	\$12,860	\$83,360

Cost	Project	BIM	Direct BIM	Net BIM	BIM ROI
(\$M)		Cost (\$)	savings (\$)	savings (\$)	(%)
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

Introduction

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

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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

Introduction

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

Conclusion: experience planning

#2: BIM use in the Susquehanna Center renovation project

*****BIM is worth implementing with a return of investment between 44% and 140%. Choose subcontractors that have prior BIM

*Analyze the ROI of BIM in the early stages of

Introduction

- 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)
 - Introduction
 - II. Analysis
 - III. Mechanical breadth
 - IV. Conclusion
- VI. Conclusion

VII. Credits and Acknowledgments VIII.Questions and Answers

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

#4: Commissioning mechanical systems in the Susquehanna Center

Picture taken 9-28-2012

Introduction

- 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)
 - Introduction
 - II. Analysis
 - III. Mechanical breadth
 - IV. Conclusion
- VI. Conclusion

VII. Credits and Acknowledgments VIII.Questions and Answers

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

#4: Commissioning mechanical systems in the Susquehanna Center

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

3" cement

Introduction

- 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)
 - Introduction
 - II. Analysis
 - **III.** Mechanical breadth
 - IV. Conclusion
- VI. Conclusion

VII. Credits and Acknowledgments VIII.Questions and Answers

#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 SEL	.ECT	ION				
	Total C	apacity	Sens Cap.	Coil Airflow	Enter	DB/W	B/HR	Leav	e DB/\ ∘⊏	NB/HR
	ton	IVIBN	IVIDN	cim	F	F	gr/ib	F	F	ang
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								

Introduction

- 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)
 - Introduction
 - II. Analysis
 - III. Mechanical breadth
 - **IV.** Conclusion
- VI. Conclusion

VII. Credits and Acknowledgments VIII.Questions and Answers

Conclusion: problems

#4: Commissioning mechanical systems in the Susquehanna Center

The cooling system in the pool area was not affected by the pool change of order Early involvement means early detection of

Potential savings if solution includes changes in the building system design

Introduction

- 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

Analysis 1: Reduct foundation schedule The construction tea ways in regards to cos techniques, and contr 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%

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

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

Introduction

- 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

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Introduction

- 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

foundation schedule impact renovation project

Questions and Answers

Conclusion

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

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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

Project Organizational Chart

♦ MEP:

Supplemental

- Owner: Harford Community College
 Architect :Hord | Coplan | Macht
 Construction Manager: Turner
 Civil: Site Resources, Inc.
- 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 HCM: (2) Architects	(1) week each
Cost Estimation	Turner / HCM	Turner: (2) Estimators HCM: (2) Architects	(3) weeks for estimators(1) week for architects
3D Coordination	Turner / HCM / Subcontractors	Turner: (2) Project Managers HCM: (1) Project Architect and (1) Architect Subcontractors: 1 from each sub = (3) + 1 = 4 total	(1) week each
Design Authoring	Turner / HCM / Subcontractors	Turner: (2) Project Managers HCM: (1) Project Architect and (1) Architect Subcontractors: 1 from each sub = (3) + 1 = 4 total	 (3) weeks for project managers (5) weeks for architects (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

Construction Templates - Project Alternative Alternative Description Default Construction Btu/h/le* F Slab 4"LW Concrete 0.73 Copy Boot 4"LW Conc 0.065 Delete Vall Frame Wall, 1" Ins 0.177384 Add Global Glass type U/factor Btu/h/le* F Skylight Single Clear 1/4" 0.95 0.95 Door Standard Door 0.2 Vindow Standard Door Vindow Vindow Standard Door Vindow Vindow Vindow Vindow Vindow Vindow Vindow Vindow Vindow <td< th=""><th>·</th><th></th><th>Jupplemental</th><th></th></td<>	·		Jupplemental	
Alternative Alternative Description Default Construction Ufactor Slab 4" LW Concrete 0.73 Copy Pattion 4" LW Conc 0.055 Delete Vial Frame Wall, 1" Ins 0.177984 Pattion 0.73° (Sop Frame) 0.387955 Add Global Vindow Single Clear 1/4" 0.95 0.95 Skylight Single Clear 1/4" 0.95 0.95 <t< td=""><td>Construction Templates - Project</td><td><u></u></td><td></td><td></td></t<>	Construction Templates - Project	<u></u>		
Description Default Construction U-factor But/ht%-FF Slab 4"LW Concrete 0.73 Copy Pool 4"LW Conc 0.065 Delete 0.177304 Delete Vall Frame Vall. 1"Ins 0.75" Gyp Frame 0.387955 Add Global Glass type U-factor Btu/ht%-FF Vindow Single Clear 1/4" 0.95 0.95 Skylight Single Clear 1/4" 0.95 0.95 Door Standard Door 0.02 0	Alternative 1	Apply	Internal Load Templates - Project	52
Alternative <t< td=""><td>Description Default</td><td>Close</td><td></td><td></td></t<>	Description Default	Close		
Construction Btu/h ft ⁶ ·F Slab 4" LW Concrete 0.73 Copy Partition 0.773 Partition 0.773 Delete Add Global Partition 0.75" Gyp Frame 0.387955 Add Global Orikitations Partition 0.75" Gyp Frame 0.387955 Add Global Vindow Single Clear 1/4" 0.95 0.95 0.95 0.95 0.95 0.95 0.95 0.95 0.95 0.95 0.95 0.95 0.95 0.95 0.95 0.95 0.95 0.95 0.95 0.95			Alternative Alternative 1	Apply
Slab 4" LW Concrete 0.73 Roof 4" LW Conc 0.065 Wall Frame Wall, 1" Ins 0.177984 Partition 0.75" Gyp Frame 0.387955 Add Global Add Global Workstations Partition 0.75" Gyp Frame 0.95 Glass type Ufactor But/hft**F Window Single Clear 1/4" 0.95 Skylight Single Clear 1/4" 0.95 Door Standard Door 0.2	Construction U-factor Btu/h-ft ^{e,} *F	New	Description Default	Close
Roof 4" LW Conc 0.065 Delete Image: Copy Image: Co	Slab 4" LW Concrete 0.73	Copy	People	
Wall Frame Wall, 1'' Ins 0.177984 Delete Density 320 sq ft/person schedule Cooling Only (Design) schedule Delete Partition 0.75" Gyp Frame 0.387955 Add Global Sensible 250 Btu/h Latent 250 Btu/h Delete Glass type Urfactor Shading Coeff Morkstation/person schedule Vorkstation/person schedule 1 workstation/person schedule Add Global Add Global Window Single Clear 1/4" 0.95 0.95 0.95 Use Lighting Lighting Lighting Lighting Lighting Vina the sin 2.3 Vira the	Roof 4" LW Conc 🔍 🔍 0.065		Type General Office Space	New
Partition 0.75" Gyp Frame Partition 0.75" Gyp Frame U-factor Btu/h:fê:*F Coeff Window Single Clear 1/4" 0.95 </td <td>Wall Frame Wall 1" Ins</td> <td>Delete</td> <td>Density 320 sq ft/person 👻 Schedule Cooling Only (Design) 👻</td> <td>Сору</td>	Wall Frame Wall 1" Ins	Delete	Density 320 sq ft/person 👻 Schedule Cooling Only (Design) 👻	Сору
I datability 0.75 dyp Hallie I datability 0.75 dyp Hallie I datability 0.75 dyp Hallie I datability 0.95 I workstation/person I uppe I uppe <td< td=""><td>Partition 0.75" Gup Frame</td><td>Add Global</td><td>Sensible 250 Btu/h Latent 250 Btu/h</td><td>Delete</td></td<>	Partition 0.75" Gup Frame	Add Global	Sensible 250 Btu/h Latent 250 Btu/h	Delete
Glass type U-factor Shading Window Single Clear 1/4" 0.95 Skylight Single Clear 1/4" 0.95 Opsile 0.95 Opsile 0.95 Skylight Single Clear 1/4" Opsile 0.95 Oppile 0.95			A	\dd Global
Window Single Clear 1/4" Skylight Single Clear 1/4" 0.95 0.95 Door Standard Door 0.2 0	Glass type U-factor Shading Blu/h-fi ^{g.} *F coeff		Workstations	
Skylight Single Clear 1/4'' Door Standard Door 0.2 0.2 Lighting Lighting Type Fluorescent, hung below ceiling, 100% load to space V(rea theorem 2.3 V(rea theorem 2.3 V(rea theorem 2.3	Window Single Clear 1/4"		Verisity 1 workstation/person	
Door Standard Door Image: Constraint of the standard Door	Skylight Single Clear 1/4"		Lighting	
Heat asis 23 Julias 8 w Saladda Liabta Midica Bida	Door Standard Door		Type Fluorescent, hung below ceiling, 100% load to space	
Heat gain [2.3 wrsq it Schedule Lights - Midlise Blog			Heat gain 2.3 W/sq ft Schedule Lights - Midrise Bldg	
Height Miscellaneous loads	Height		Miscellaneous loads	
Wall 27 ft underfloor plenum %	Wall 27 ft underfloor plenum %		Type Std School Equipment	
Fir to fir 27 ft Room type Conditioned Conditioned Conditioned Conditioned	Fir to fir 27 ft Room type Conditioned	-]	Energy 0.22 W/sq ft Schedule Cooling Only (Design)	
Plenum 0 ft	Plenum 0 ft		Energy Electricity	
meter Lacousty			meter 1-100 meter	
	Internet Airflow Themselver			
Internal Load Airflow Internostat Lonstruction Hoom Room			Internal Load <u>Airflow</u> <u>Ihermostat</u> <u>Construction</u>	oom

Supplemental

Alternative	Alternative 1	-	Appl
Description	Default	-	Close
Main supply		Auxiliary supply	
Cooling	To be calculated 💌	Cooling To be calculated 💌	New
Heating	To be calculated 💌	Heating To be calculated 💌	Copy
Ventilation		Std 62.1-2004/2007	Delet
Apply ASHR	AE Std62.1-2004/2007 No 💌	Clg Ez Custom 💌 🖉 %	Add Gk
Туре	Auditorium	Htg Ez Custom 💌 🖉 %	
Cooling	15 cfm/person 💌	Er Custom 💌 🖉 %	
Heating	15 cfm/person 💌	DCV Min OA Intake None 💌	[
Schedule	People - College 📃	Room exhaust	
Infiltration		Rate 0 air changes/hr 💌	
Туре	Neutral, Tight Const. 📃 💌	Schedule Available (100%)	
Cooling	0.3 air changes/hr 💌	VAV control	
Heating	0.3 air changes/hr 💌	Clg VAV min 30 % Clg Airflow 💌	
Schedule	Available (100%)	Htg VAV max 🛛 🛛 🛛 🏹 Clg Airflow 💽	1
		Schedule Available (100%)	[
		Type Default 💌	
		There a construction	Deere

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- III. Analysis 2: BIM use in the Susquehanna Center renovation project
- IV. Analysis 3: Alternative façade system (Architectural breadth) Not presented
- Analysis 4: Commissioning mechanical systems in the Susquehanna Center (Mechanical breadth)
- VI. Conclusion
- VII. Credits and Acknowledgments VIII.Questions and Answers

Supplemental

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 5 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 E. Motor Control Center – 1 each g. Generator - 1 each 150 amp 3 phase 480 volts h. Energy Management System 0 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 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.

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 Colleg 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 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 5.7 Agent shall verify and document that installed equipment performs according to manufacturer's recommendations.

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Introduction

- 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

Introduction

- 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

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