



TOWSON TIGER ARENA

TOWSON, MD

Derek Stoecklein | Construction Management Option

Advisor: Ray Sowers





Project Background

- Overview
- Location
- Site Planning

Fabric Duct System



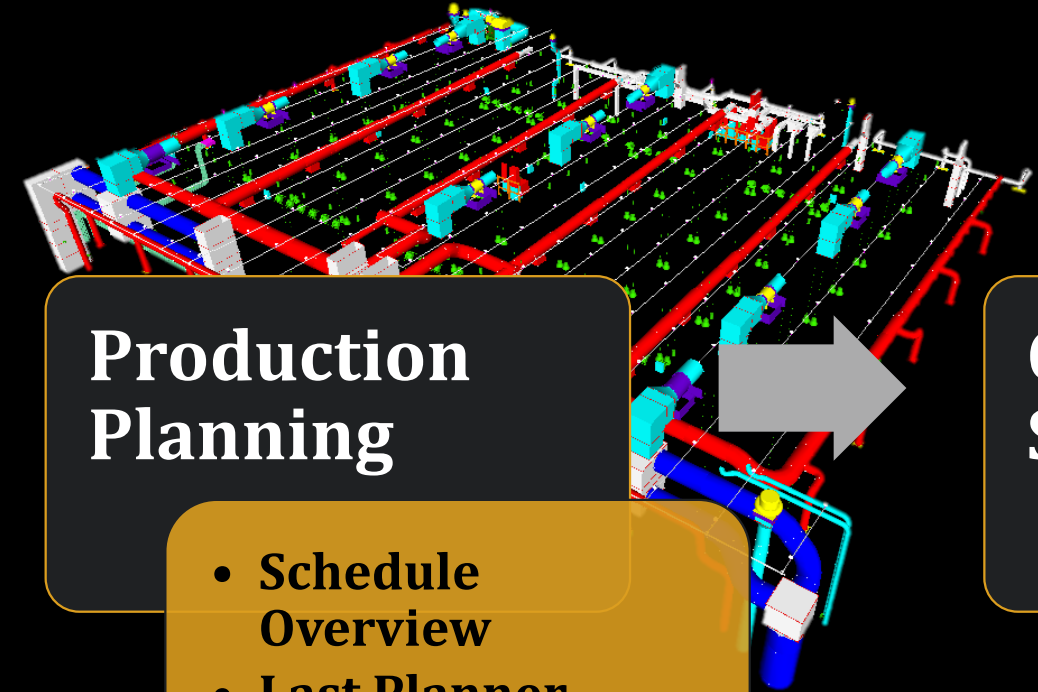
- Existing System
- Load Calculations
- DuctSox Design
- Comparison

Prefabricated Terra Cotta



- Existing System
- Designed Panels
- Delivery and Connection Details
- Comparison

Production Planning



- Schedule Overview
- Last Planner
- Implementation

Cisco StadiumVision

- Technology at Home
- StadiumVision Overview
- Application at Towson
- Case Studies



Presentation Outline

- I. Project Background
 - I. Overview
 - II. Location
 - III. Site Planning
- II. Fabric Duct System
- III. Prefabricated Terra Cotta
- IV. Production Planning
- V. Cisco StadiumVision
- VI. Conclusion/Recommendation
- VII. Acknowledgments



Building: Towson Tiger Arena

Building Location: Towson University; Towson, MD

Building Size: 120,000 SF

Number of Stories: 4 Stories

Occupancy Type: Sports, Entertainment

Project Cost: \$56 Million

Construction Duration: 18 Months

Project Delivery Method: Design-Bid-Build

Contract Type: Guaranteed Maximum Price (GMP)

Sustainable Design: LEED Gold

Owner: Towson University

Construction Manager: Gilbane Building Company

Architect: Hord | Coplan | Macht

Associated Architect: Sasaki Associates

MEP Engineer: James Posey Associates

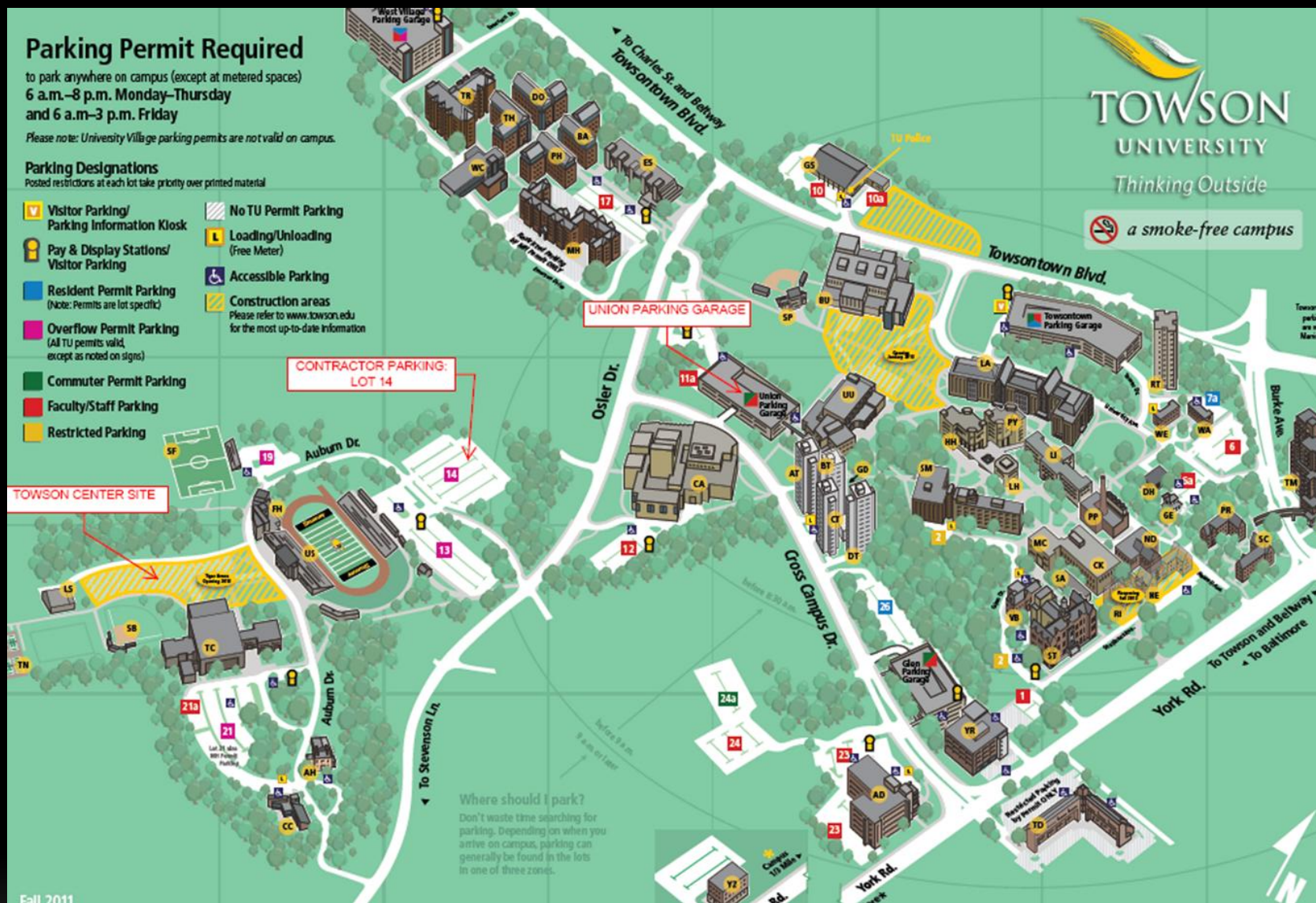
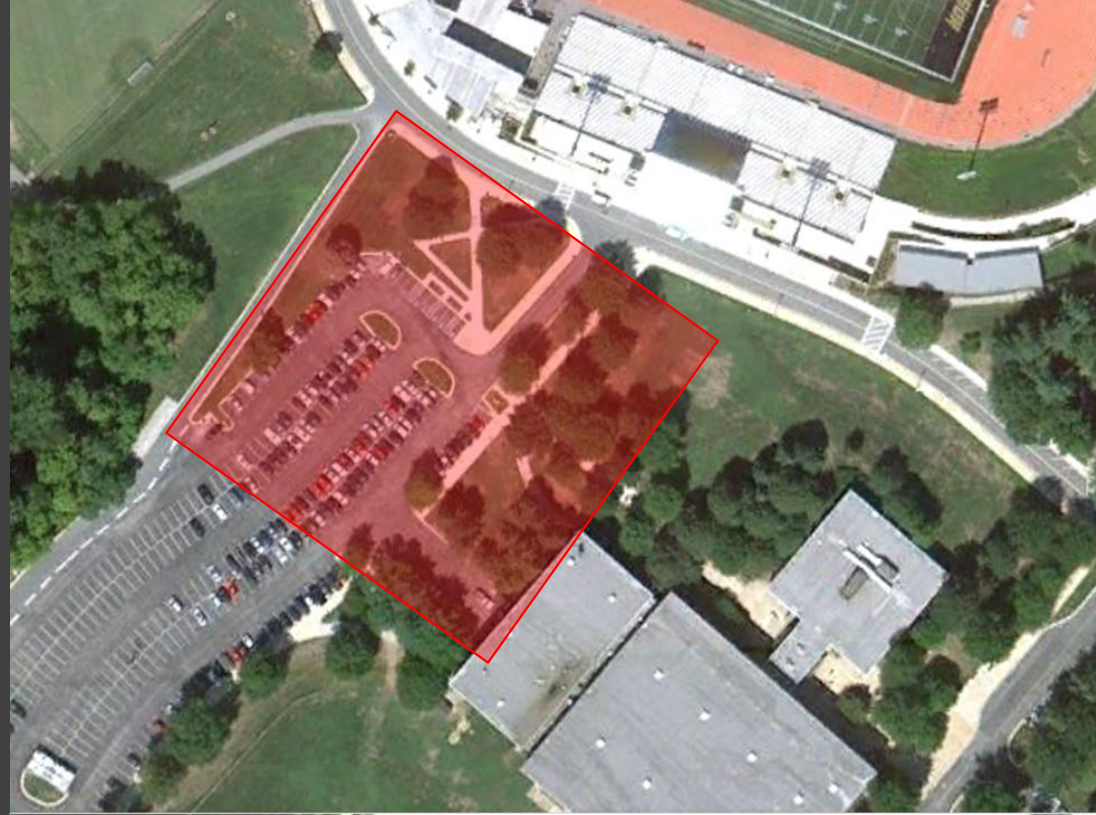
Structural Engineer: Faisant Associates

Civil Engineer: Site Resources, Inc.

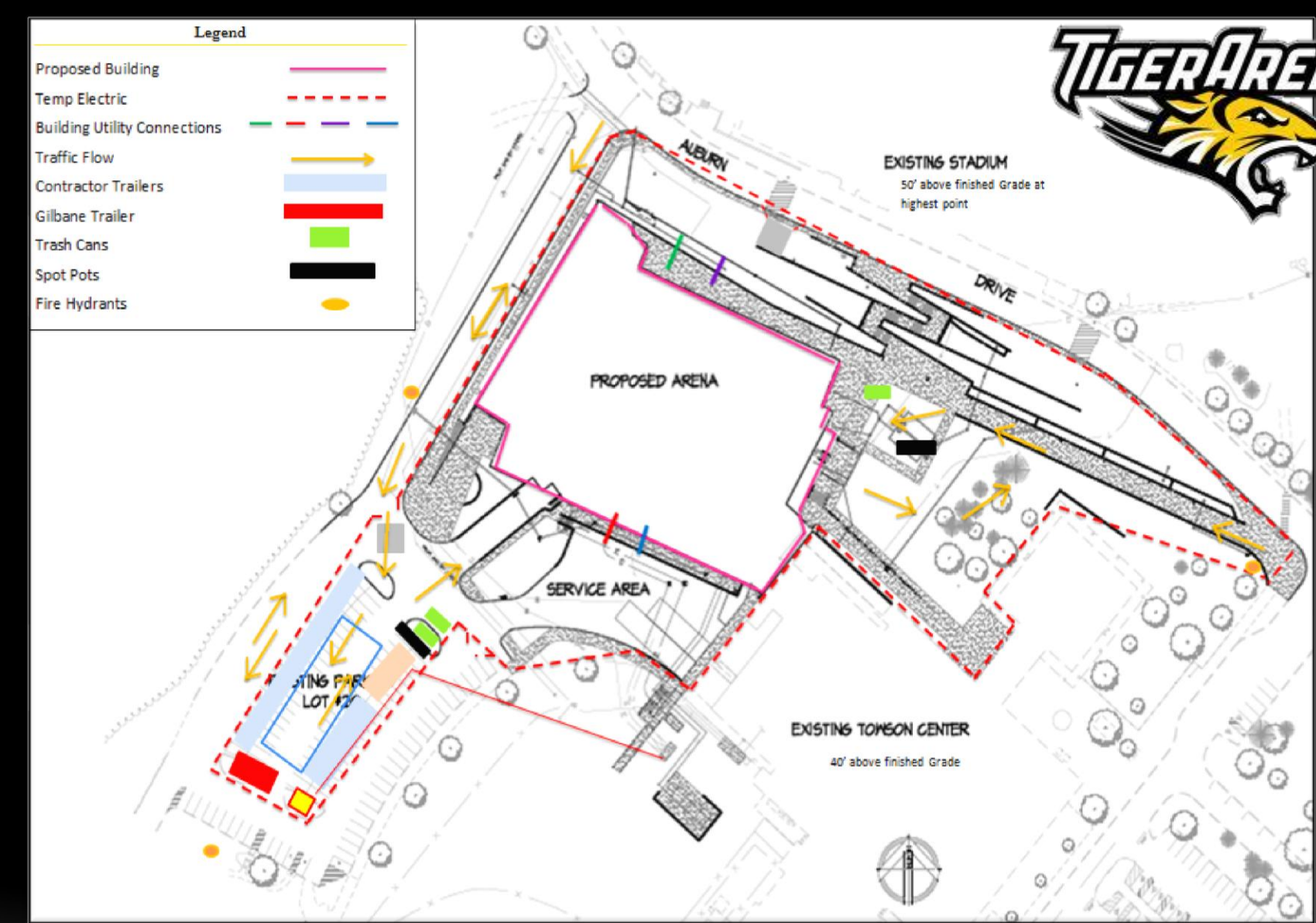


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Location and Site Planning



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ANALYSIS I: DUCTSOX SYSTEM

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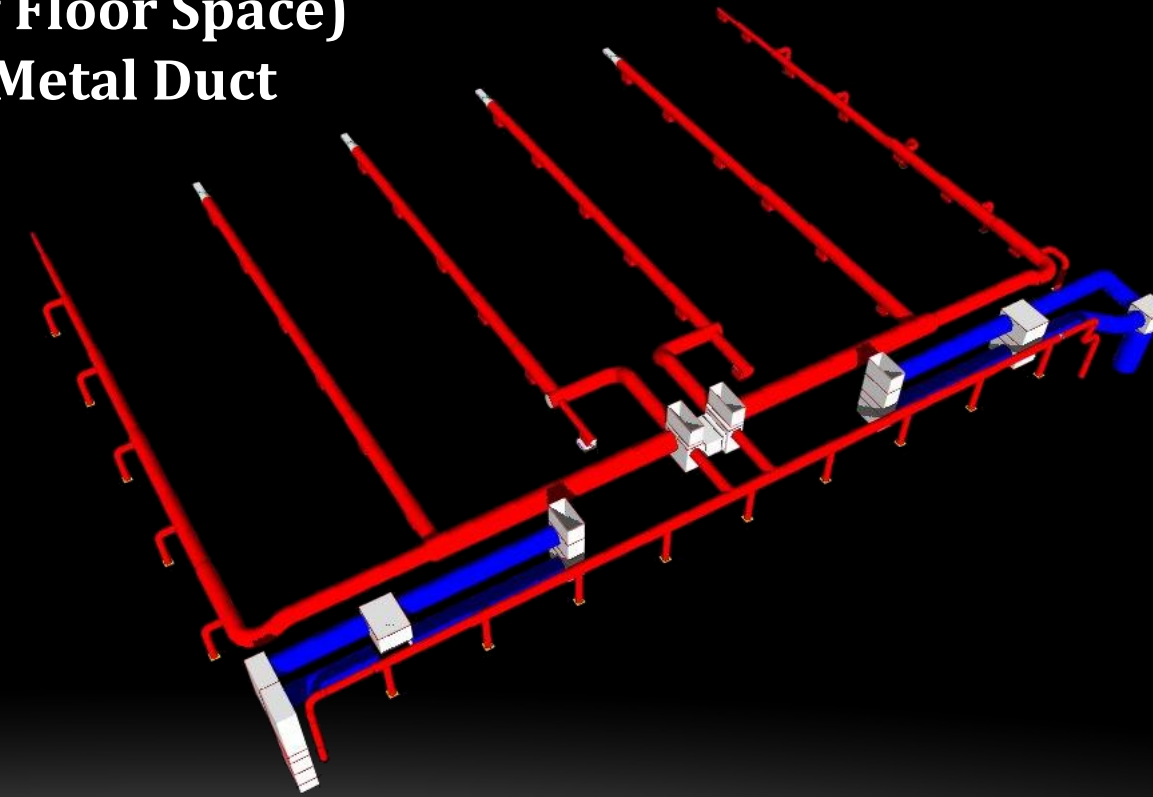
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- II. Fabric Duct System**
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System Overview

- (2) 47,000 CFM Rooftop Units = 94,000 CFM
- Single Zone Variable Air Volume (VAV) with a CO2 reset
- 2,635,720 CF (Volume of Space)
- 43,340 SF (Area of Floor Space)
- Traditional Sheet Metal Duct
 - 14" to 62" Dia.

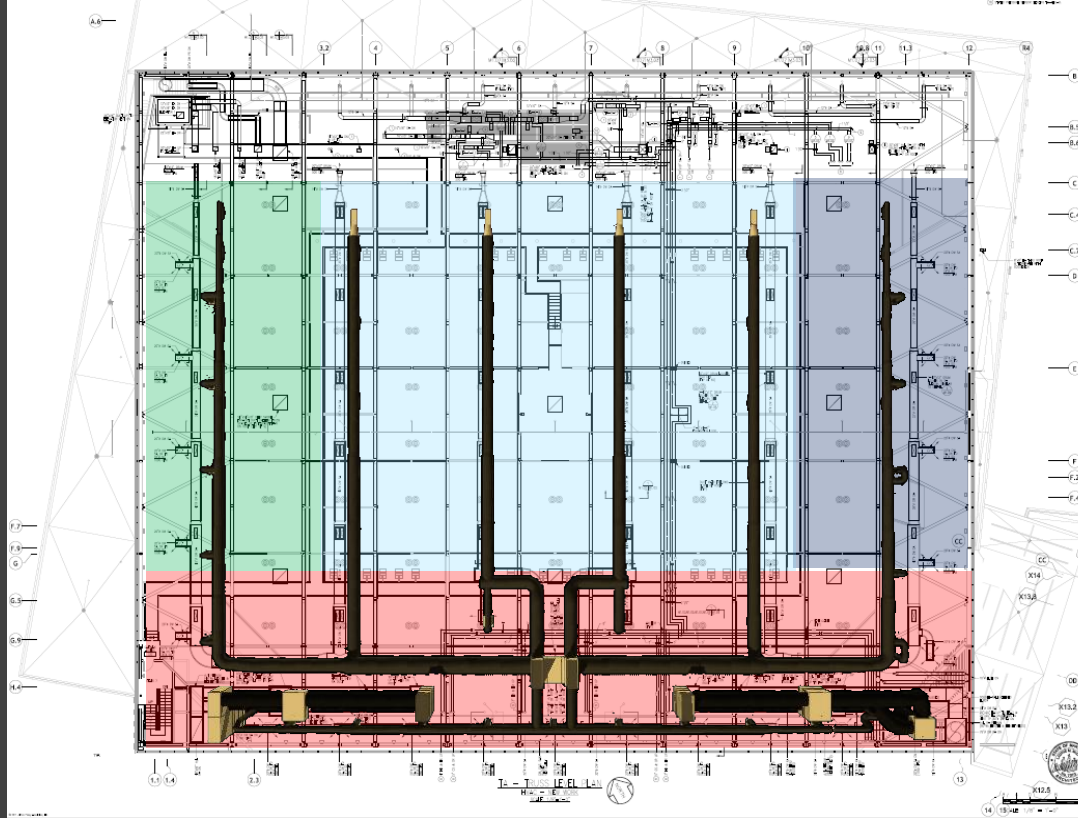


Existing System



Presentation Outline

- I. Project Background
- II. Fabric Duct System**
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 - II. Load Calculations**
 - I. Mechanical Breadth**
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Load Calculation (Mechanical Breadth)

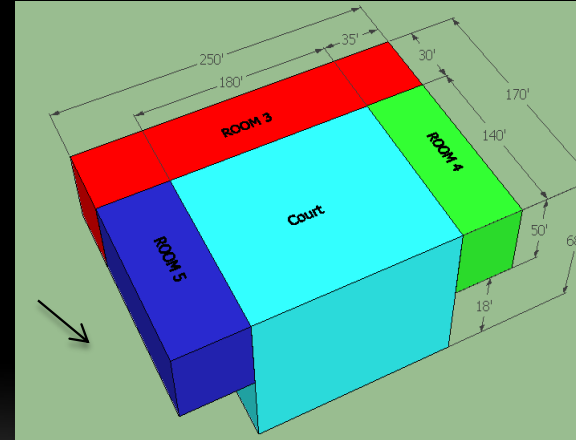
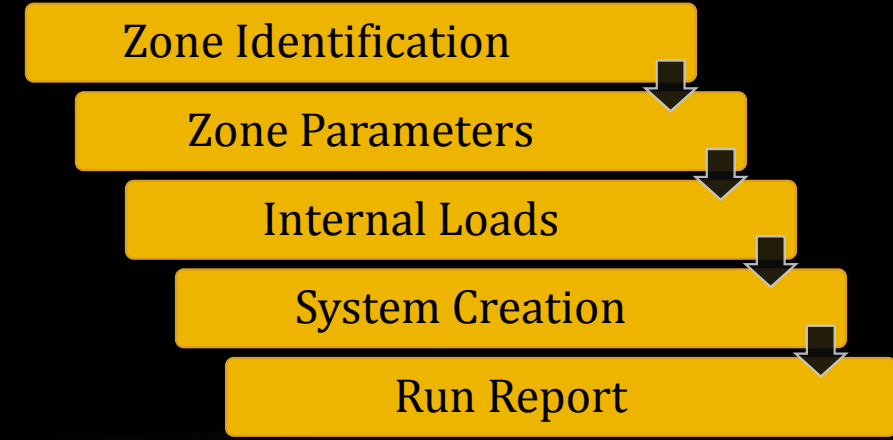
1. Ventilation Loads (ASHRAE Standard 62.1)

45,312 CFM

1. Heating and Cooling Loads (Trace)

87,041 CFM Cooling

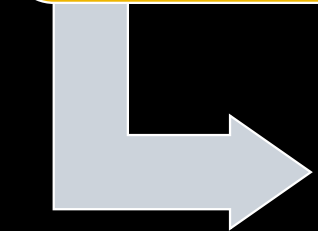
26,830 CFM Heating



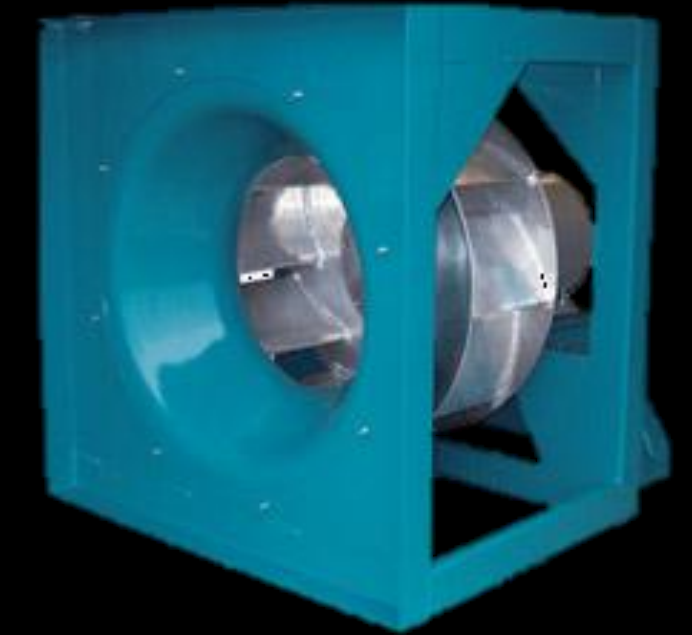
Original Output of AHU 8 – 9	94,000 CFM
Total Calculated Demand	87,041 CFM
Difference	6,956 CFM



EPFN-490

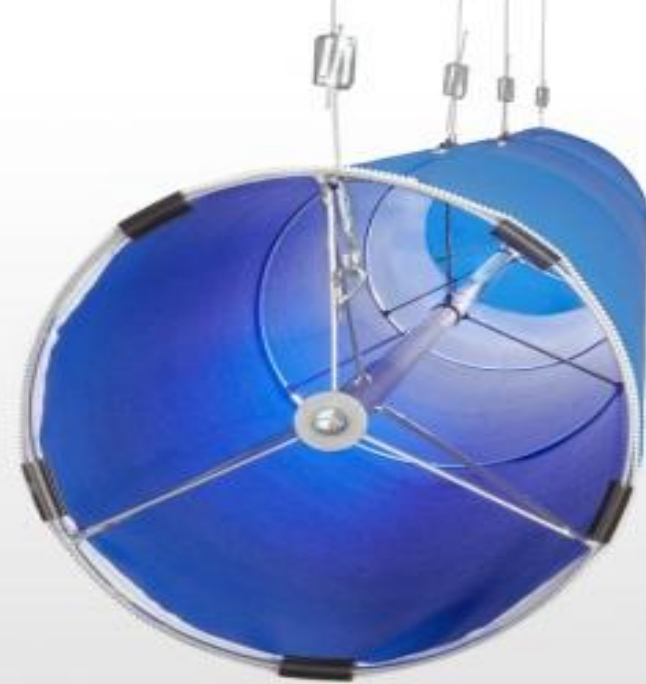


EPFN-445

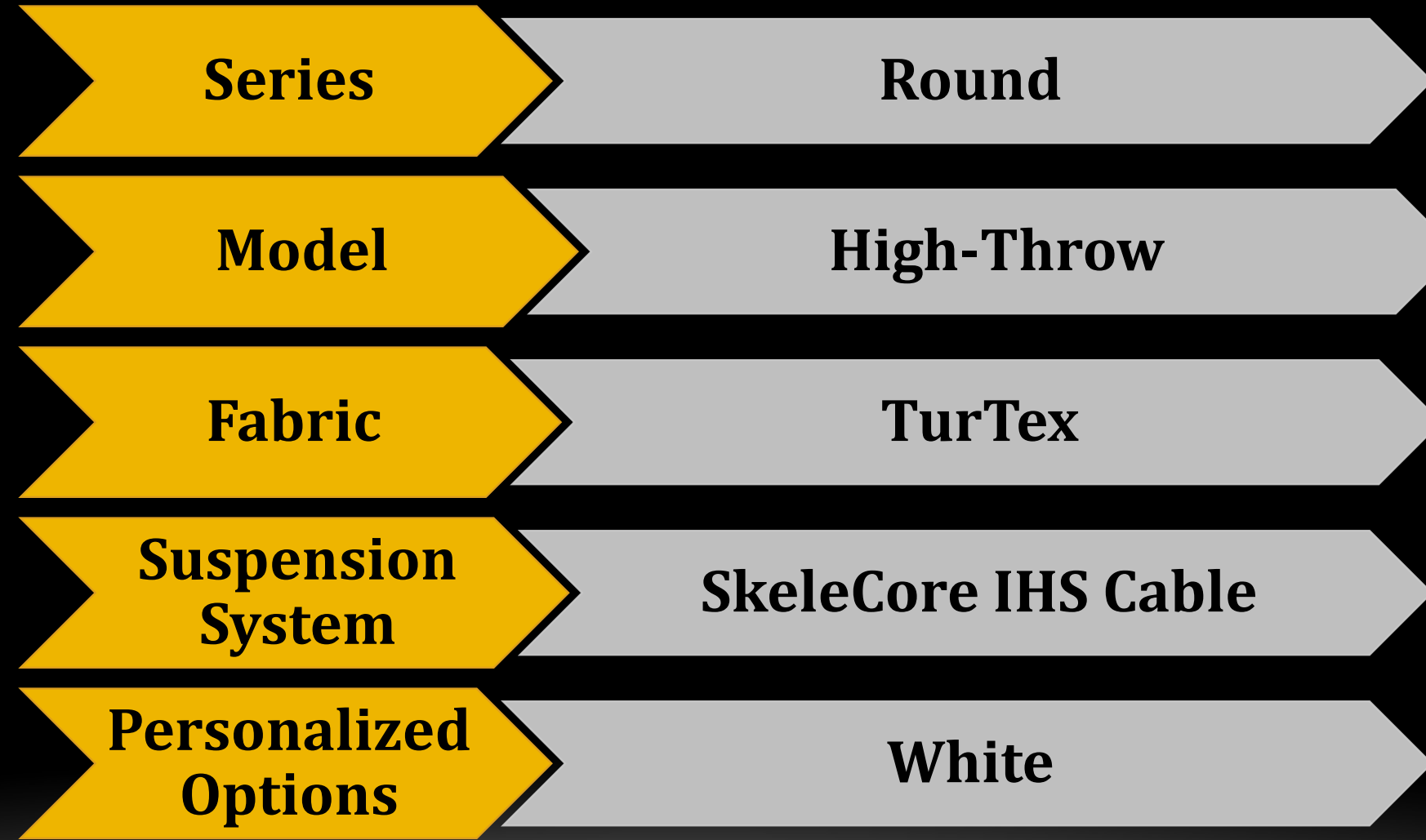


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DuctSox System Selection Process



Design Layout

- (2) 46" Dia. x 101' L = (2) Duct Sections Ea.
- (4) 32" Dia. x 144' L = (4) Duct Sections Ea.
- (2) 32" Dia. x 118' L = (3) Duct Sections Ea.
- (2) 32" Dia. x 24' L = (1) Duct Section Ea.
- (1) 32" Dia. x 17' L = (1) Duct Section Ea.

(29) Total Fabric Duct Sections

32	5,585	6,702	7,819	8,936
34	6,305	7,566	8,827	10,088
36	7,069	8,482	9,896	11,310
38	7,876	9,451	11,026	12,601
40	8,727	10,472	12,217	13,963
42	9,621	11,545	13,470	15,394
44	10,559	12,671	14,783	16,895
46	11,541	13,849	16,157	18,466



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Schedule Comparison			
Standard Fabrication & Deliver			
DuctSox	4 Weeks	Savings	
Sheet Metal Duct	8 Weeks	4 Weeks	
Complete Ductwork Installation			
DuctSox	14 Days	Savings	
Sheet Metal Duct	70 Days	56 Days	
Painting			
DuctSox	0 Days	Savings	
Sheet Metal Duct	30 Days	30 Days	

Total Time Savings		
Description	Days	
Fabrication	20	
Installation	56	
Others	30	
Days	106	
Weeks	21.2	
Months	5.3	
*86 Days on-site labor		

Price Comparison			
Material Cost			
DuctSox	\$37,310.00	Savings	
Metal Duct Total	\$455,000.00	\$ 417,690.00	
Sheet Metal Duct	\$375,000.00		
Sheet Metal Insulation	\$50,000.00		
Paint Metal Duct	\$30,000.00		
Labor Cost			
DuctSox Total	\$ 28,568.00	Savings	
Metal Duct Total	\$375,000.00	\$ 346,432.00	
Sheet Metal Duct	\$265,000.00		
Sheet Metal Insulation	\$50,000.00		
Paint Metal Duct	\$60,000.00		



Total Cost Savings to Towson	
Description	Savings
Material	\$417,690.00
Labor	\$346,432.00
CM Fee (2%)	\$15,282.44
Subtotal	\$779,404.44



Comparison

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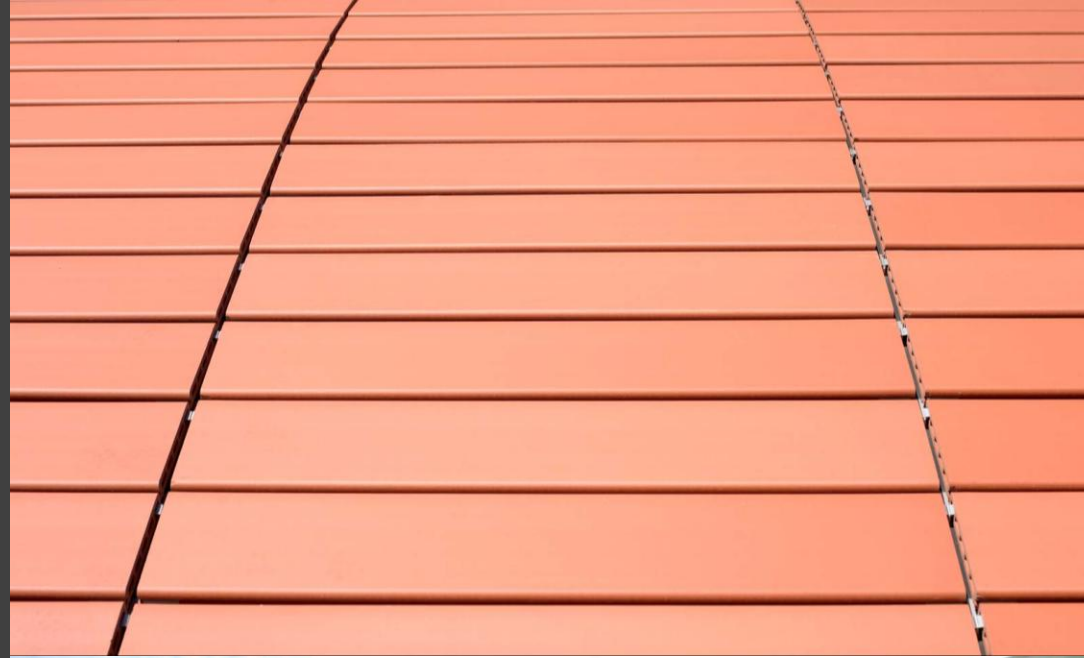
ANALYSIS II: PREFABRICATED TERRA COTTA PANELS

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Presentation Outline

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- III. Prefabricated Terra Cotta**
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 - II. Prefabricated Panel Design
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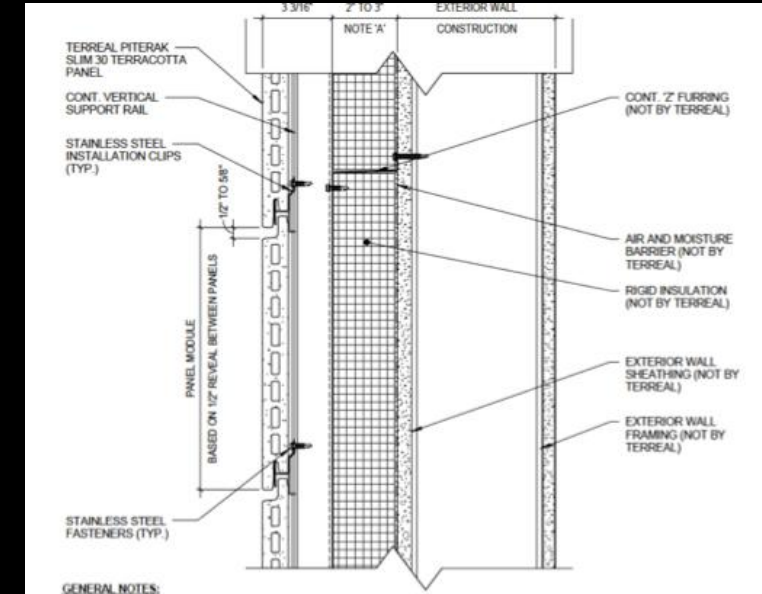
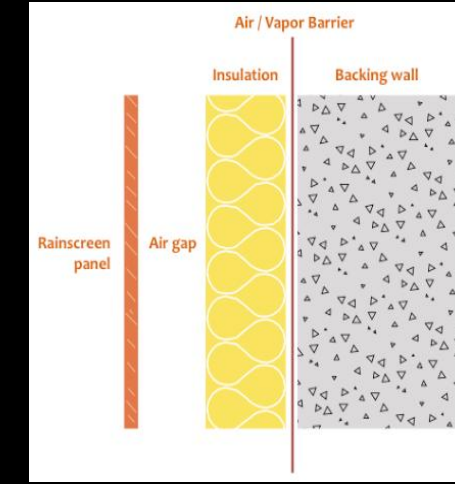
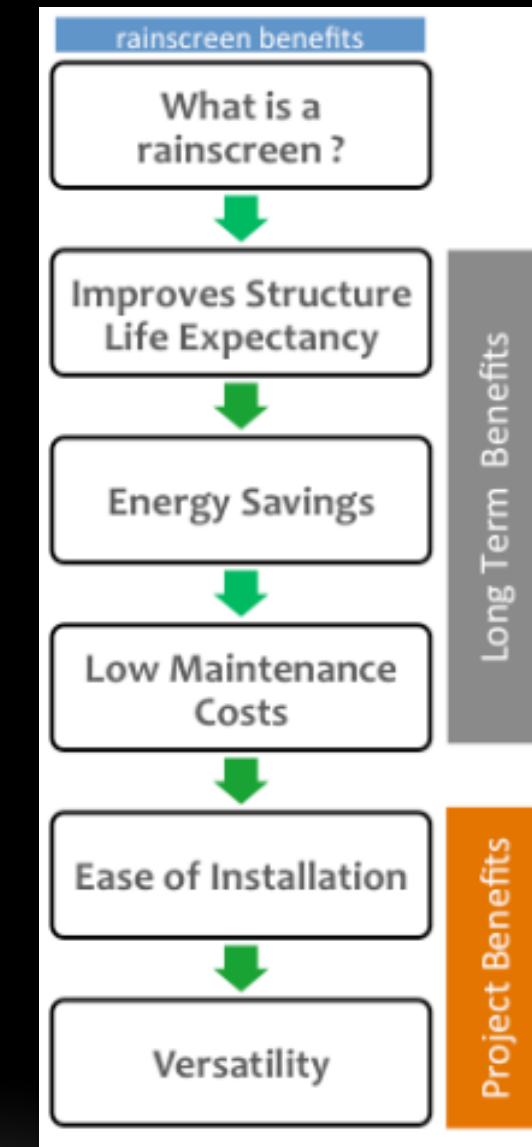


What is a Terra Cotta Rainscreen?

- Wall panel made from clay
- Hung on structural sub-framing system
- Sub-framing mounts to primary structural wall system
- Clay panels and sub-framing components create cavity in facade
- Pressure equalized



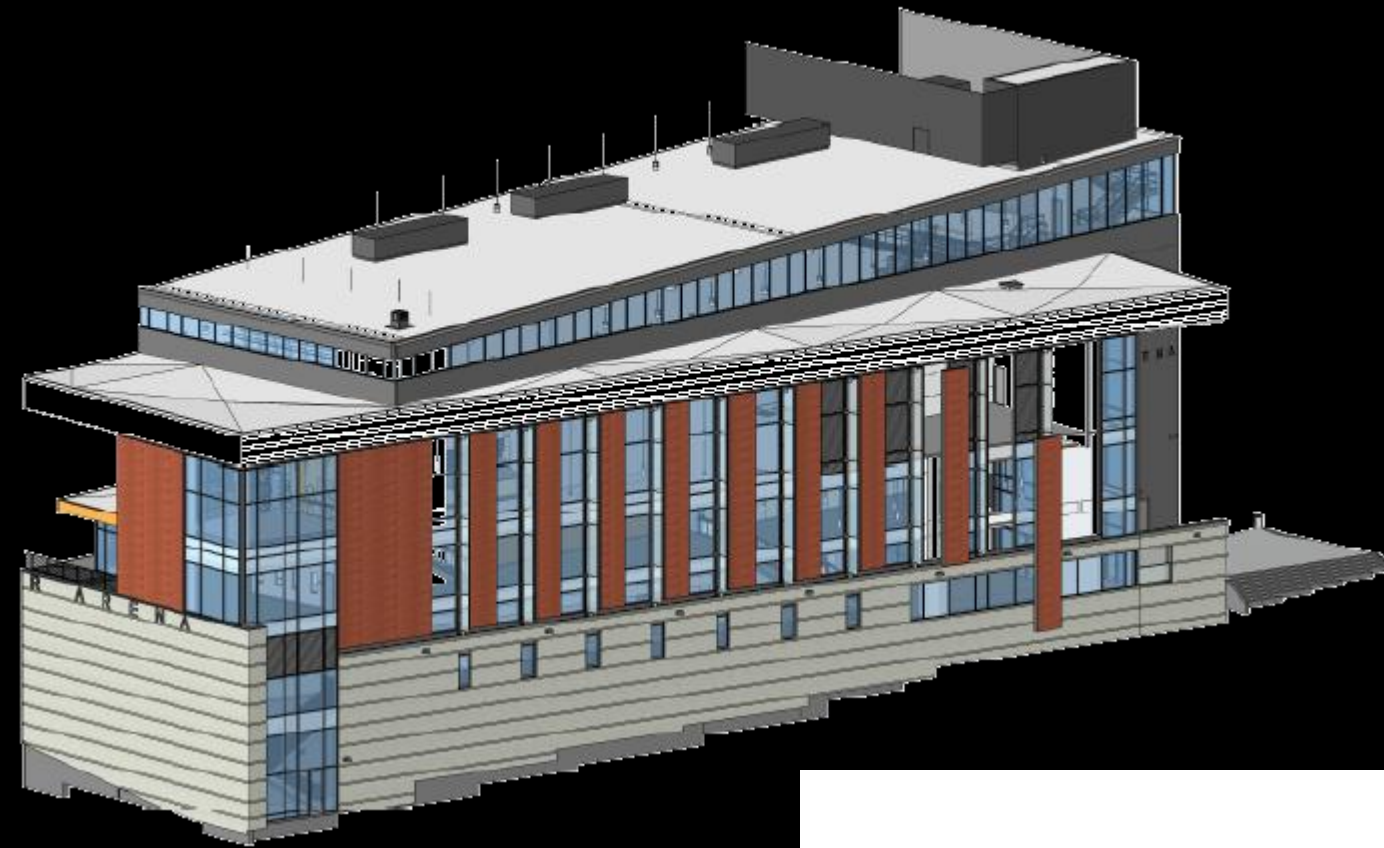
Terra Cotta Rainscreen



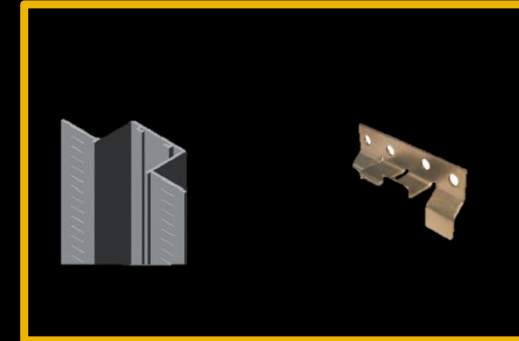
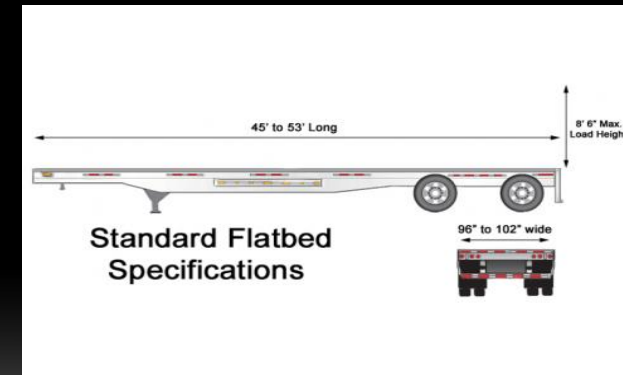
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Panel Sizes
Width: 5' -4"
Height: 20' to 37'



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6015 SF of Terra Cotta

Stick-Built System

\$65.60 SF

171 Days On-Site Labor

Prefabricated System

\$70.00 SF

24 Days On-Site Labor

Overall

\$46,113 Increase

4 Months On-Site Labor Decrease

Comparision

Cost & Schedule Comparison		
Description	Duration (Days)	Cost
<u>Prefabricated</u>		
TOTAL	119	\$674,510
<u>Stick-Built</u>		
TOTAL	211	\$628,397
<u>Delta</u>		
TOTAL	92	\$46,113



R-Value Comparison ft ² ·°F·h/Btu			
Description	R-Value	Thickness	Subtotals
<u>Existing System</u>			
FOAMULAR 250 Rigid Foam Insulation	5 per inch	3"	15
GlassRoc Exterior Sheating	.51 per SF	5/8"	0.51
		Total	15.51
<u>Prefabricated System</u>			
Optimo Smooth Insulated Metal Panel	7.5 per inch	3 5/8"	27.19
		Total	27.19

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ANALYSIS III: PRODUCTION PLANNING OF THE TRUSS PHASE MEPFP

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Presentation Outline

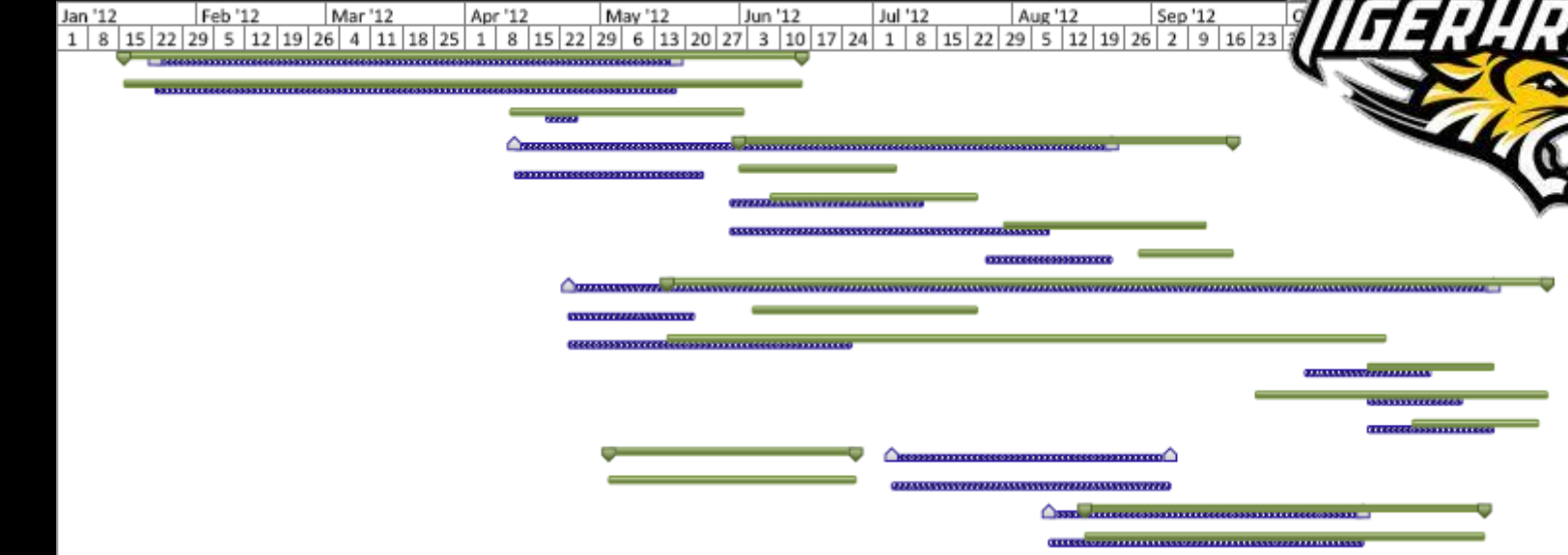
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Baseline Schedule vs. Actual Schedule

Actual Starts vs. Baseline Analysis	Actual Start Dates				
	Task	Actual Duration	Baseline Start	Actual Start	Delta
	Sprinkler RI @ Trusses	39	7/5/2012	5/3/2012	45
	Storm Rough In Truss Lvl	25	4/12/2012	6/1/2012	36
	HVAC Pipe RI @ Trusses	32	5/30/2012	6/8/2012	7
	Comm Conduit/Cable tray	36	4/24/2012	6/4/2012	29
	Conduit/Wire Truss Lvl	114	4/24/2012	5/16/2012	16
	Duct Rough In	33	5/30/2012	7/30/2012	43
	Duct Insulation @ Trusses	15	7/26/2012	8/29/2012	35
	Paint @ Trusses/Deck	63	8/9/2012	8/17/2012	6
	Lighting @ Truss Level	20	10/5/2012	10/19/2012	10
	Fire Alarm Devices and Test Truss Level	21	10/19/2012	10/29/2012	6
	Electrical Devices @ Truss Level	47	10/19/2012	9/24/2012	19

Actual Starts vs. Baseline Analysis	Actual Finish Dates				
	Task	Actual Duration	Baseline Finish	Early Finish July	Delta
	Sprinkler RI @ Trusses	39	9/4/2012	6/26/2012	50
	Storm Rough In Truss Lvl	25	5/23/2012	7/5/2012	31
	HVAC Pipe RI @ Trusses	32	7/11/2012	7/23/2012	8
	Comm Conduit/Cable tray	36	5/21/2012	7/23/2012	45
	Conduit/Wire Truss Lvl	114	6/25/2012	10/22/2012	85
	Duct Rough In	33	8/8/2012	9/12/2012	25
	Duct Insulation @ Trusses	15	8/22/2012	9/18/2012	19
	Paint @ Trusses/Deck	63	10/17/2012	11/13/2012	19
	Lighting @ Truss Level	20	11/1/2012	11/15/2012	10
	Fire Alarm Devices and Test Truss Level	21	11/15/2012	11/25/2012	6
	Electrical Devices @ Truss Level	47	11/8/2012	11/27/2012	13



Common Construction Productivity Challenges

- Poor or incomplete design and documentation
- Client scope change during construction
- Mistakes during construction
- Delays in decision making or instructions
- Poor planning and communication
- Weather
- Labor skills, availability or disputes
- Incorrect material types or quantity

Schedule Analysis

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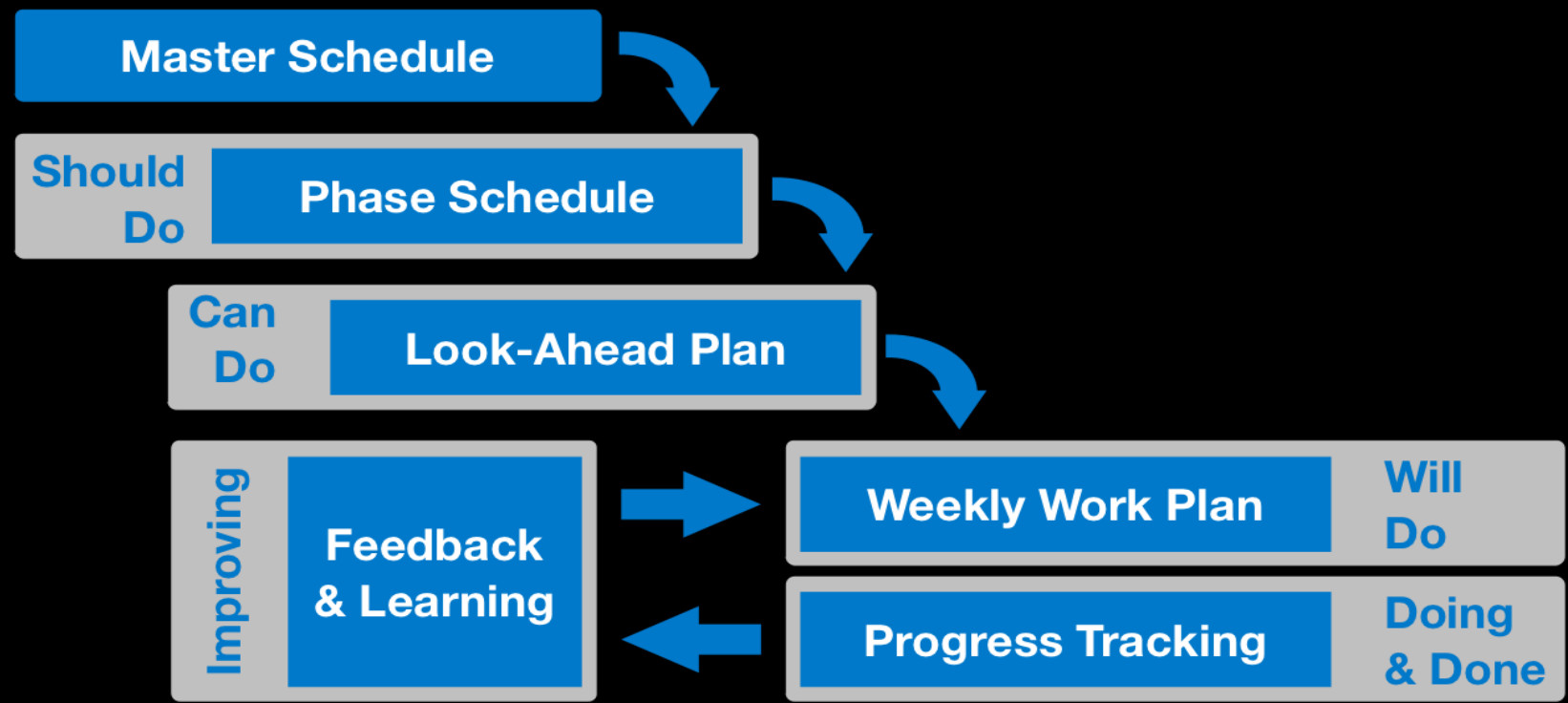


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The Last Planner System



Measure progress and remedy issues

4 Levels of Planning

- 1. Master CPM Schedule**
 - Feasibility
 - Long Lead Items
 - Milestones
- 2. Phase Schedule**
 - Pull planning
- 3. Look-Ahead Plan**
 - Detail Tasks
 - Screen Tasks
 - Workflow Plan
- 4. Weekly Work Planning**

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IV. Production Planning

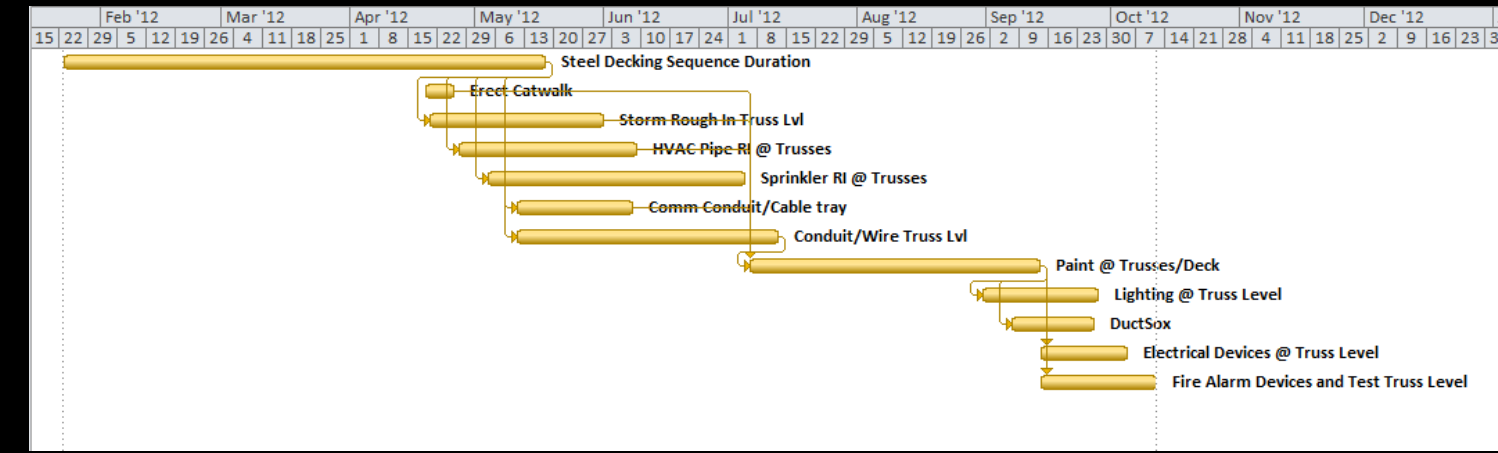
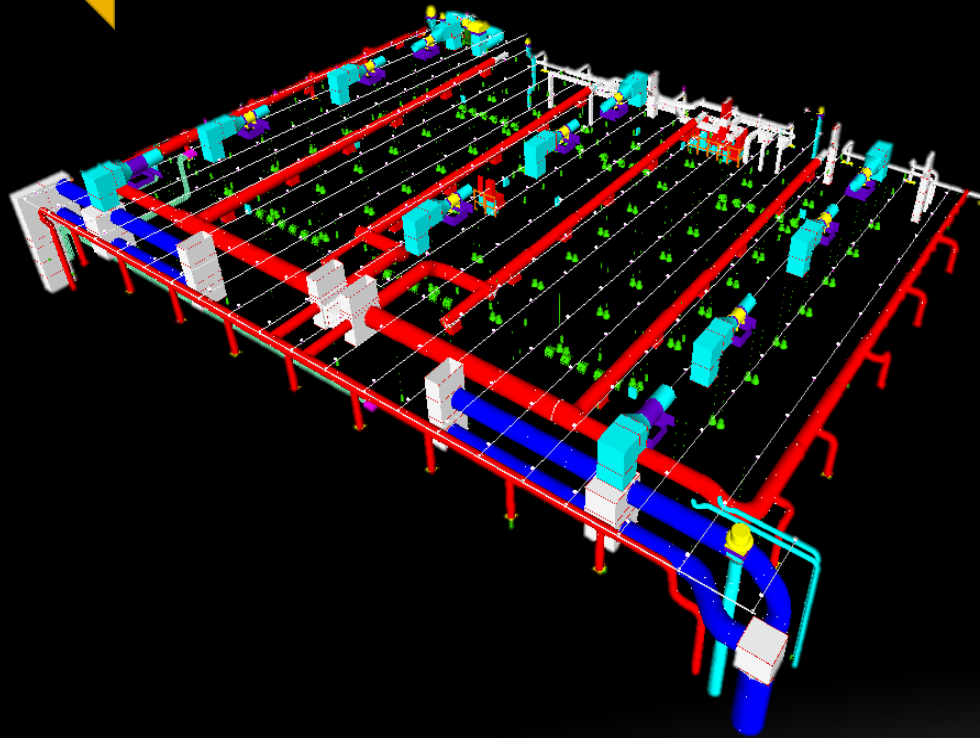
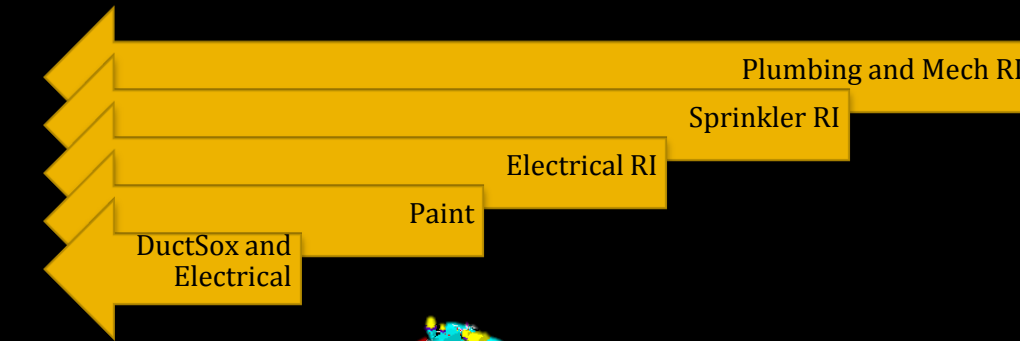
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Name	Duration: Re-Seq	Duration: Actual	Duration: Diff	Start: Re-Seq	Start: Actual	Start: Diff	Finish: Re-Seq	Finish: Actual	Finish: Diff
Kinsley - Steel	84 days	109 days	-25d	Mon 1/23/12	Mon 1/16/12	5d	Thu 5/17/12	Thu 6/14/12	-20d
Steel Decking Sequence Duration	84 days	109 days	-25d	Mon 1/23/12	Mon 1/16/12	5d	Thu 5/17/12	Thu 6/14/12	-20d
Erect Catwalk	15 days	38 days	-23d	Thu 4/19/12	Wed 4/11/12	6d	Wed 5/9/12	Fri 6/1/12	-17d
DenverElek - Mechanical	114 days	78 days	36d	Fri 4/20/12	Fri 6/1/12	-30d	Wed 9/26/12	Tue 9/18/12	6d
Storm Rough In Truss Lvl	30 days	25 days	5d	Fri 4/20/12	Fri 6/1/12	-30d	Thu 5/31/12	Thu 7/5/12	-25d
HVAC Pipe RI @ Trusses	31 days	32 days	-1d	Fri 4/27/12	Fri 6/8/12	-30d	Fri 6/8/12	Mon 7/23/12	-31d
Duct Rough In		33 days			Mon 7/30/12			Wed 9/12/12	
Duct Insulation @ Trusses		15 days			Wed 8/29/12			Tue 9/18/12	
DuctSox	14 days			Fri 9/7/12			Wed 9/26/12		
BK Truland - Electrical	110 days	140 days	-30d	Fri 5/11/12	Wed 5/16/12	-3d	Thu 10/11/12	Tue 11/27/12	-33d
Comm Conduit/Cable tray	20 days	36 days	-16d	Fri 5/11/12	Mon 6/4/12	-16d	Thu 6/7/12	Mon 7/23/12	-32d
Conduit/Wire Truss Lvl	45 days	114 days	-69d	Fri 5/11/12	Wed 5/16/12	-3d	Thu 7/12/12	Mon	-72d
Lighting @ Truss Level	20 days	20 days	0d	Fri 8/31/12	Fri 10/19/12	-35d	Thu 9/27/12	Thu 11/15/12	-35d
Electrical Devices @ Truss Level	15 days	47 days	-32d	Fri 9/14/12	Mon 9/24/12	-6d	Thu 10/4/12	Tue 11/27/12	-38d
Fire Alarm Devices and Test Truss Level	20 days	21 days	-1d	Fri 9/14/12	Mon	-31d	Thu 10/11/12	Sun 11/25/12	-31d
NFP - Sprinkler	44 days	39 days	5d	Fri 5/4/12	Thu 5/3/12	1d	Wed 7/4/12	Tue 6/26/12	6d
Sprinkler RI @ Trusses	44 days	39 days	5d	Fri 5/4/12	Thu 5/3/12	1d	Wed 7/4/12	Tue 6/26/12	6d
NLP - Painting	50 days	63 days	-13d	Fri 7/6/12	Fri 8/17/12	-30d	Thu 9/13/12	Tue 11/13/12	-43d
Paint @ Trusses/Deck	50 days	63 days	-13d	Fri 7/6/12	Fri 8/17/12	-30d	Thu 9/13/12	Tue 11/13/12	-43d



Truss MEPF - Baseline Duration

4/12/2012 - 11/15/12

156 Days

Truss MEPF - Actual Duration

5/3/2012 - 11/27/12

149 Days

**Not including overtime*

Truss MEPF- Re-Sequenced "Phased Schedule" Duration

4/12/2012 - 10/11/12

126 Days

Difference of **33 Days** from Actual Completion

= \$354,629 GC Savings

Last Planner System Implementation

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ANALYSIS IV: CISCO STADIUMVISION

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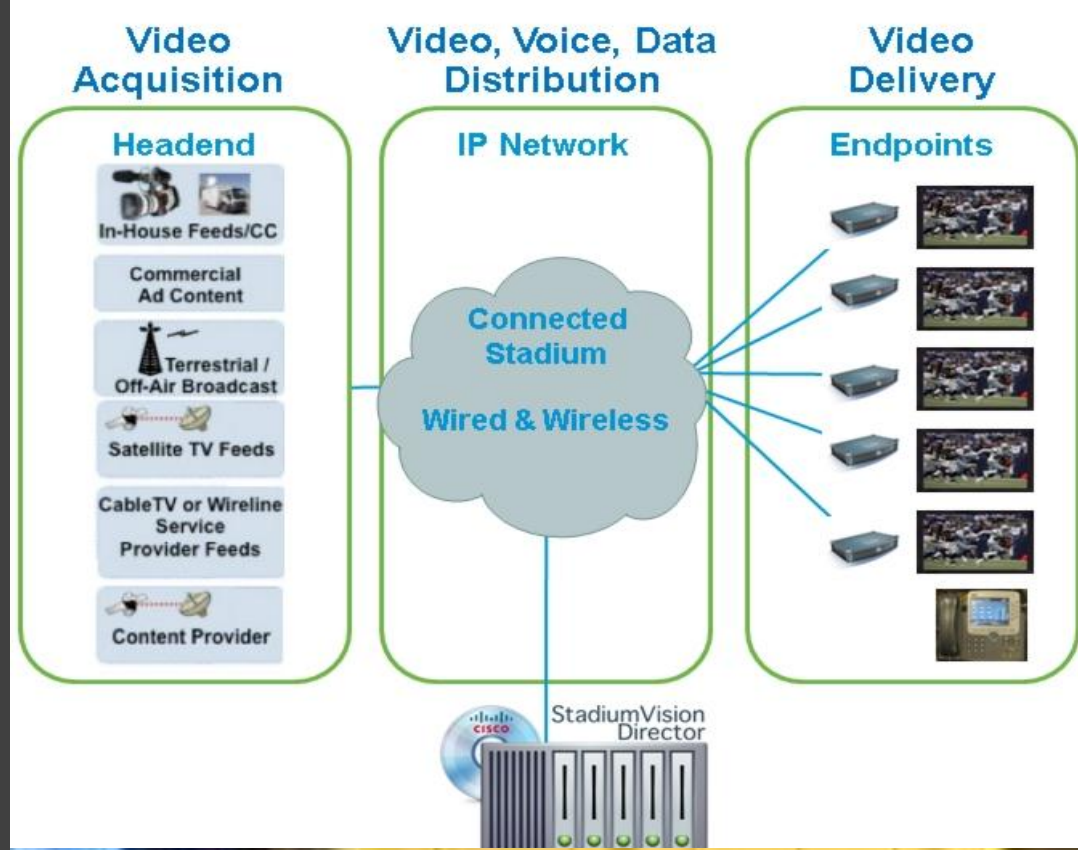
The Comfort of Home

- Lazyboy
- Technology
- Cost Effective



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The Ultimate Experience

- Video Feeds Options
- Sales
- Player Stats
- Directions
- Wi-Fi
- Big Board Interaction
- Suite Features



StadiumVision Overview

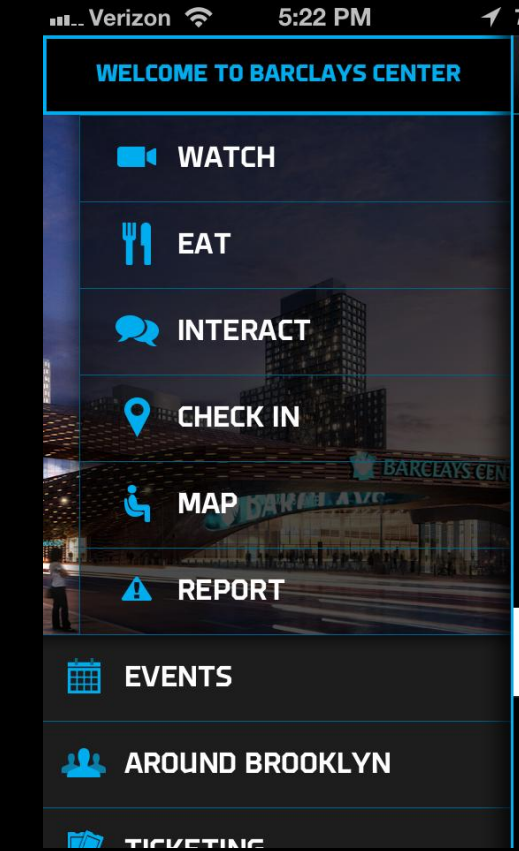
StadiumVision Director

StadiumVision Mobile

Connected Stadium



“Meeting the demands of a new generation of fans”



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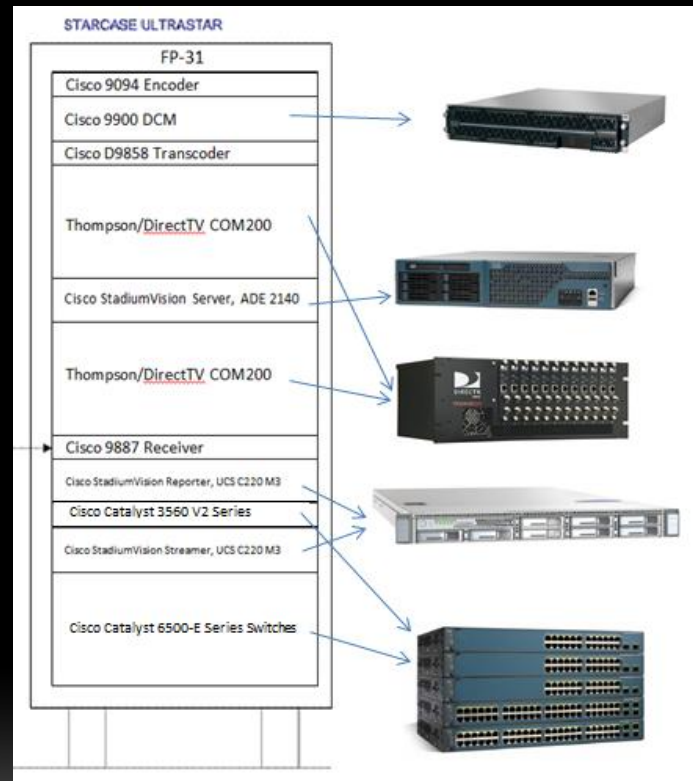
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Revenue Generation for Towson

- Advertisements
- Point of Sale
- Merchandise
- Promotions
- Purchasing



Tiger Arena StadiumVision Components

Required Rack Equipment v. 3.0	Rack Slot	Amount	Max Power (W)	Power Req. (W)
Cisco 9094 Encoders	1	1	60	60
Cisco D9858 Transcoder	1	1	110	110
Cisco 9887 Receiver	1	1	200	200
Cisco 9900 DCM (Digital Content Manager)	2	1	350	350
Catalyst 3560/3750 Ethernet Switches	1	1	130	130
Catalyst 6504 Switch (Video Distribution System)	5	1	113	113
Thomson/DirectTV COM200	5	2	320	640
Cisco StadiumVision Server, ADE 2140	2	1	600	600
Cisco StadiumVision Reporter	1	1	650	650
Cisco StadiumVision Streamer	1	1	650	650
Rack Total	20	11	-	3503
Adjusted Power (.95 PF)				3687

Rack Details

11 Components
3,687 VA Output
3,840 VA Capacity
120 V, Single-Phase 20A



RP1C

WIRING SCHEDULE: PANEL RP1C																
120/208 VOLTS				3PHASE 4 WIRE				100 AMP MAINS				SURFACE MOUNTED				
CIRC/UIT	POLE	DESCRIPTION	WIRE/CONDUIT	BREAKER	POLE	AMP	A0	B0	C0	CIRC/UIT	POLE	DESCRIPTION	WIRE/CONDUIT	BREAKER		
1	1	CUH-TA-1 (VESTIBULE 124)	#12-3/4" C	1	20					2	2	HAND DRYER MEN'S 131	#8-3/4" C	1 20		
3	3	REC FAN ASSIST 134,135,137	#8-3/4" C	1	20		1.0	1.4		4	4	HAND DRYER MEN'S 131	#8-3/4" C	1 20		
5	5	REC EVENT MGMT 133, 134	#8-3/4" C	1	20				0.8	6	6	REC MEN'S 131	#8-3/4" C	1 20		
7	7	REC WOMEN'S 132	#8-3/4" C	1	20	0.8	0.8			8	8	REC RECEPTION 125, CORR	#10-3/4" C	1 20		
9	9	HAND DRYER WOMEN'S 132	#8-3/4" C	1	20				1.4	10	10	REC PRESS RM 127	#12-3/4" C	1 20		
11	11	HAND DRYER WOMEN'S 132	#8-3/4" C	1	20					12	12	REC PRESS RM 127	#12-3/4" C	1 20		
13	13	REC PRESS ROOM 127	#12-3/4" C	1	20	0.8	1.0			14	14	REC AVA PRESS RM 127	#12-3/4" C	1 20		
15	15	REC PRESS ROOM 127	#12-3/4" C	1	20			0.8	0.5	16	16	REC METAL DETECTOR 125	#12-3/4" C	1 20		
17	17	REC EVENT STAFF 121	#12-3/4" C	1	20				0.6	18	18	REC METAL DETECTOR 125	#12-3/4" C	1 20		
19	19	REC EVENT STAFF 121, CORR 114	#12-3/4" C	1	20	0.8	0.5			20	20	REC EWC 125	#12-3/4" C	1 20		
21	21	REC SECURITY 122, CORR	#12-3/4" C	1	20			0.8	0.8	22	22	REC AVA SECURITY 122	#12-3/4" C	1 20		
23	23	REC PRODUCTION 129	#10-3/4" C	1	20				0.8	24	24	REC PRODUCTION 129	#10-3/4" C	1 20		
25	25	REC PRODUCTION 129	#10-3/4" C	1	20	0.8	0.8			26	26	REC PRODUCTION 129	#10-3/4" C	1 20		
27	27	REC PRODUCTION 129	#10-3/4" C	1	20				0.8	28	28	REC PRODUCTION 129	2#10-#10	2 20		
29	29	REC PRODUCTION 129	#10-3/4" C	1	20				0.8	30	30	REC PRODUCTION 129	G-3/4" C	1 20		
31	31	REC PRODUCTION 129	2#10-10G-3/4" C	2	20	1.0	1.0			32	32	REC PRODUCTION 129	2#10-#10	2 20		
33	33						1.0	1.0		34	34		G-3/4" C	1 20		
35	35	REC PRODUCTION 129	2#10-10G-3/4" C	2	20			1.0	0.8	36	36	REC PRODUCTION 129	#10-3/4" C	1 20		
37	37							1.0	0.4	38	38	REC TV PRESS ROOM 127	#12-3/4" C	1 20		
39	39	CISCO STADIUM VISION RACK	3#10-10G-3/4" C	2	20			1.9		40	40	SPARE		1 20		
41	41								1.9	42	42	SPARE		1 20		
CONNECTED LOAD =							36.6	KVA		5.5	5.9	7.7	5.5	7.3	4.7	
DEMAND LOAD =							27.1	KVA			11.4	12.2	12.0			
MIN AIC RATING =							10,000	AMPS SYMMETRICAL								

Towson Application

Derek Stoecklein | Construction Management Option

Presentation Outline

- I. Project Background
- II. Fabric Duct System
- III. Prefabricated Terra Cotta
- IV. Production Planning
- V. Cisco StadiumVision**
 - I. Technology at Home
 - II. StadiumVision Overview
 - III. Towson Application
- IV. Case Studies**
- VI. Conclusion/Recommendation
- VII. Acknowledgments



“The value that we are receiving from Cisco Stadium Vision far outweighs just a financial investment. We can easily justify it financially, but the value to our brand is immeasurable. We can demonstrate to sponsors and fans that they gain a far better experience, and there is not a more effective way to do it.”
– David Peart, Senior Vice President of Sales and Service, CONSOL Energy Center

CONSOL Energy Center, PA
200% increase in advertisers

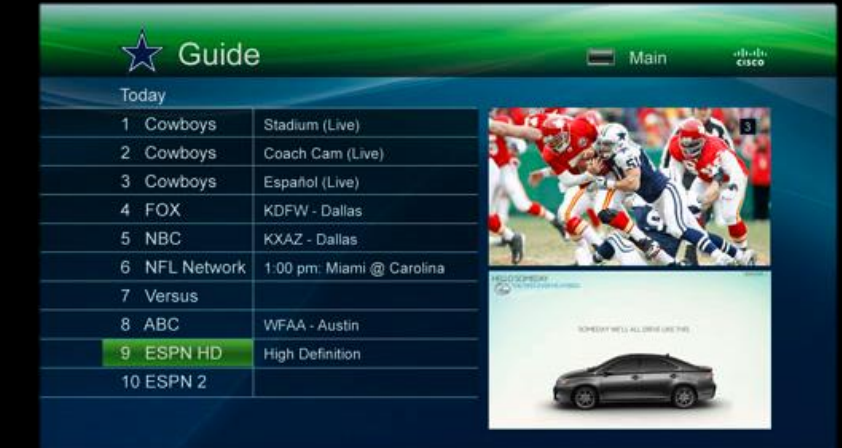
300% increase in advertisement and sponsorship revenues

80% of fans retaining the digital content they viewed



Staples Center, LA
9% increase in concession revenue

400% increase in pilot promotions revenue



“Cisco solutions are helping us use our new home to deliver the biggest and best experience in the world of sports and entertainment.”
– Jerry Jones, Owner and General Manager, Dallas Cowboys



Presentation Outline

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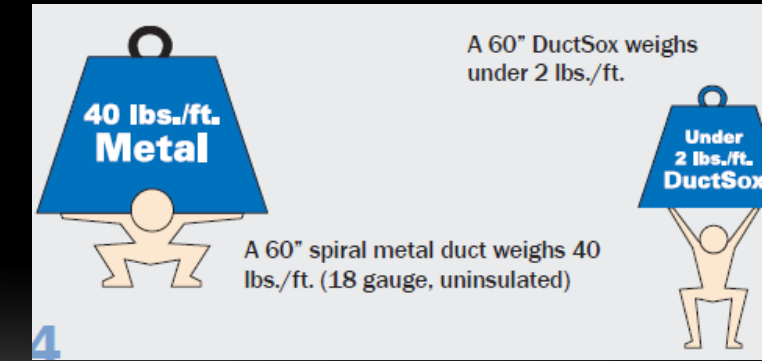
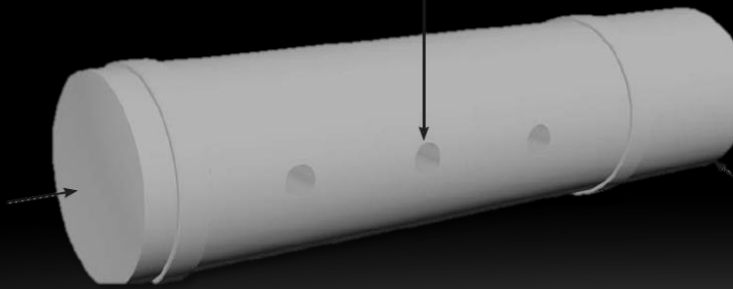
DuctSox

On-Site Schedule Savings: 86 Days

Towson Savings: \$779,404

25% More Efficient than Sheet Metal

Reduction in AHU Fan Size



Conclusion & Recommendations

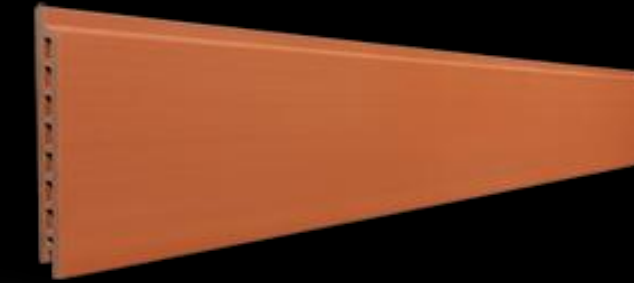
Prefabricated Terra Cotta

On-Site Schedule Decrease: 4 Months

Towson Cost: (\$46,113)

Improved R-Value: 27.19 > 15.15 ft²·°F·h/Btu

Improved Safety, Quality, and Logistics



Derek Stoecklein | Construction Management Option



Presentation Outline

- I. Project Background
- II. Fabric Duct System
- III. Prefabricated Terra Cotta
- IV. Production Planning
- V. Cisco StadiumVision
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 - II. StadiumVision Overview
 - III. Towson Application
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VI. Conclusion/Recommendation

VII. Acknowledgments

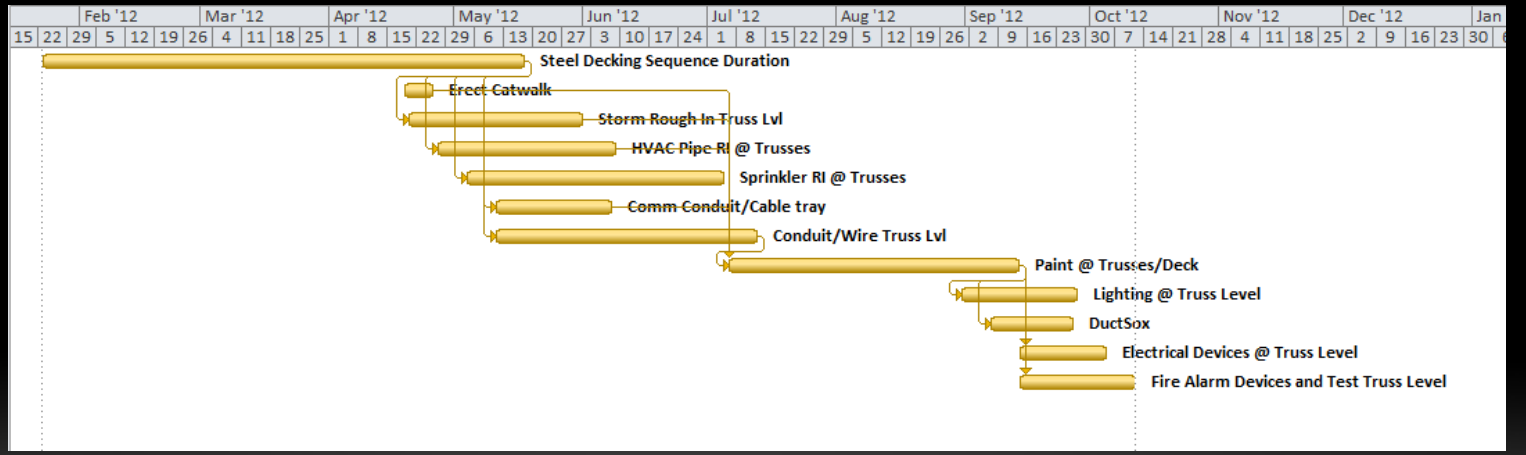


Last Planner System

Schedule Decrease: 33 Days

GC Savings: \$354,629

Improved Safety and Logistics



Conclusion & Recommendation

Cisco StadiumVision

Revenue Generation Potential

Creating the Ultimate Experience

Cost and Schedule Increase



Derek Stoecklein | Construction Management Option



Academic Acknowledgments

Penn State Architectural Engineering Faculty

Ray Sowers

Dr. Craig Dubler

Industry Acknowledgments



Special Thanks

Stephanie Fuss

Family and Friends



Acknowledgments

Derek Stoecklein | Construction Management Option



Questions?

Derek Stoecklein | Construction Management Option



Questions?

Derek Stoecklein | Construction Management Option

APPENDIX SLIDES

Derek Stoecklein | Construction Management Option



Schedule Comparison			
Standard Fabrication & Deliver			
DuctSox	4 Weeks	Savings	
Sheet Metal Duct	8 Weeks	4 Weeks	
Complete Ductwork Installation			
DuctSox	14 Days	Savings	
Sheet Metal Duct	70 Days	56 Days	
Painting			
DuctSox	0 Days	Savings	
Sheet Metal Duct	30 Days	30 Days	

Total Time Savings		
Description	Days	
Fabrication	20	
Installation	56	
Others	30	
Days	106	
Weeks	21.2	
Months	5.3	
*86 Days on-site labor		

Price Comparison			
Material Cost			
DuctSox	\$37,310.00	Savings	
Metal Duct Total	\$455,000.00	\$ 417,690.00	
Sheet Metal Duct	\$375,000.00		
Sheet Metal Insulation	\$50,000.00		
Paint Metal Duct	\$30,000.00		
Labor Cost			
DuctSox Total	\$ 28,568.00	Savings	
Metal Duct Total	\$ 375,000.00	\$ 346,432.00	
Sheet Metal Duct	\$265,000.00		
Sheet Metal Insulation	\$50,000.00		
Paint Metal Duct	\$60,000.00		

Total Cost Savings to Towson	
Description	Savings
Material	\$417,690.00
Labor	\$346,432.00
CM Fee (2%)	\$15,282.44
Subtotal	\$779,404.44

Internal Load Calculations

People : 5000

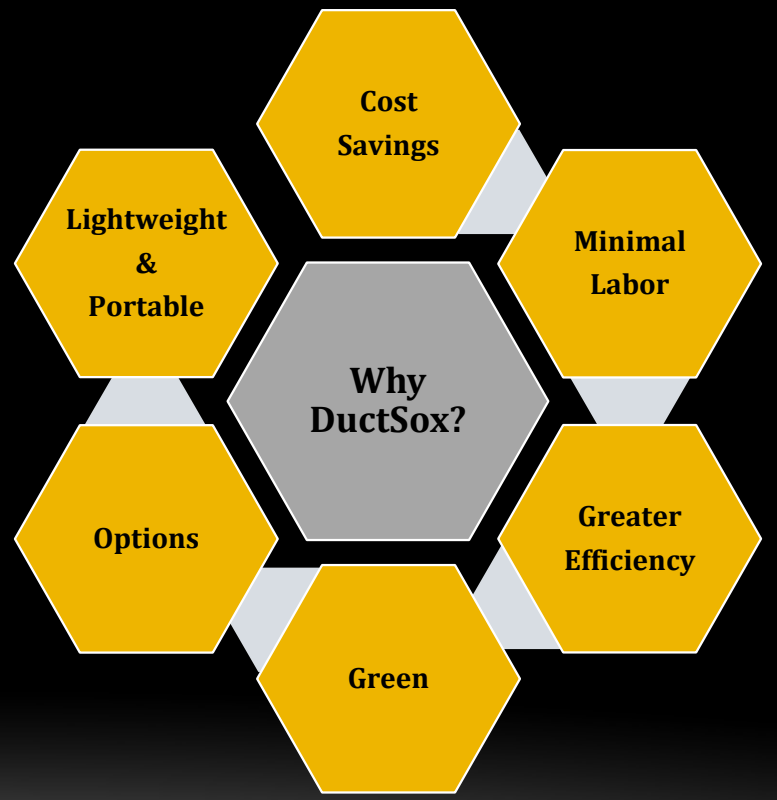
Total Lighting Load = 2.03 W/SF
 $97.9\text{KVA} * 0.9 \text{ Power factor} = 88.11 \text{ kW}$
 $88.11 \text{ KW} / 43340 \text{ SF (SF of applied area)} = 2.03 \text{ W/SF}$

Misc. Loads = 0.73 W/SF
 $21.2 \text{ kVA} * 0.9 \text{ Power Factor} = 19.08 \text{ kW}$
 $19.08 \text{ kW} / 26040 \text{ SF (applied to court area only)} = 0.73 \text{ W/SF}$

Design Layout

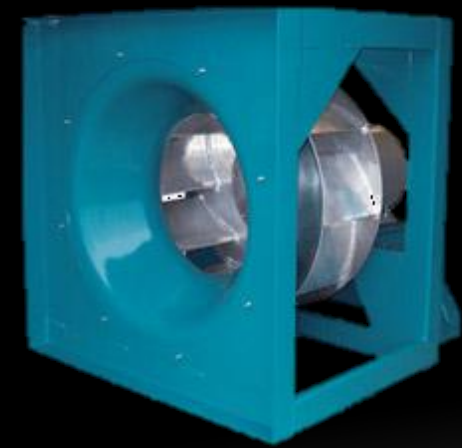
- (2) 46" Dia. x 101' L = (2) Duct Sections Ea.
- (4) 32" Dia. x 144' L = (4) Duct Sections Ea.
- (2) 32" Dia. x 118' L = (3) Duct Sections Ea.
- (2) 32" Dia. x 24' L = (1) Duct Section Ea.
- (1) 32" Dia. x 17' L = (1) Duct Section Ea.
- (29) Total Fabric Duct Sections**

32	5,585	6,702	7,819	8,936
34	6,305	7,566	8,827	10,088
36	7,069	8,482	9,896	11,310
38	7,876	9,451	11,026	12,601
40	8,727	10,472	12,217	13,963
42	9,621	11,545	13,470	15,394
44	10,559	12,671	14,783	16,895
46	11,541	13,849	16,157	18,466



445 EPFN (9-Blade, Arr. 1 and 4)		Wheel Diameter: 44.50"												Fan Efficiency Grade = FEG85							
CFM	1" SP		2" SP		3" SP		4" SP		5" SP		6" SP		7" SP		8" SP		10" SP		12" SP		
	RPM	BHP	RPM	BHP	RPM	BHP	RPM	BHP	RPM	BHP	RPM	BHP	RPM	BHP	RPM	BHP	RPM	BHP	RPM	BHP	
12000	403	2.47																			
13800	423	2.84																			
15600	440	3.25	560	6.49																	
17400	461	3.68	574	7.17																	
21000	507	4.69	610	8.70	700	12.97															
24600	558	5.92	652	10.42	735	15.24	812	20.30	886	25.69											
28200	612	7.37	697	12.37	775	17.69	846	23.24	914	29.07											
35400	727	11.20	798	17.20	865	23.49	929	30.06	989	36.88	1046	43.92	1101	51.13	1154	58.44	1205	65.81	1256	73.55	
42600	848	16.57	907	23.31	966	30.73	1022	38.28	1077	46.14	1129	54.12	1179	62.36	1226	70.57	1272	79.18	1318	87.76	
48900	972	23.71	1024	31.37	1074	39.50	1124	48.16	1173	57.06	1220	65.99	1266	75.14	1311	84.56	1354	94.06	1396	103.76	
57000			1144	41.50	1188	50.39	1233	60.00	1276	69.79	1319	79.90	1361	90.09	1402	100.39	1443	111.03	1482	121.61	
64200			1267	54.06	1307	63.90	1346	74.08	1386	84.95	1424	95.87	1463	107.31	1500	118.56	1537	130.03			

MAXIMUM RPM: CLASS I = 944 CLASS II = 1202 CLASS III = 1545 Outlet Area = 15.38 ft² Max. BHP = 38.36 x (RPM / 1000)³



ANALYSIS I: DUCTSOX

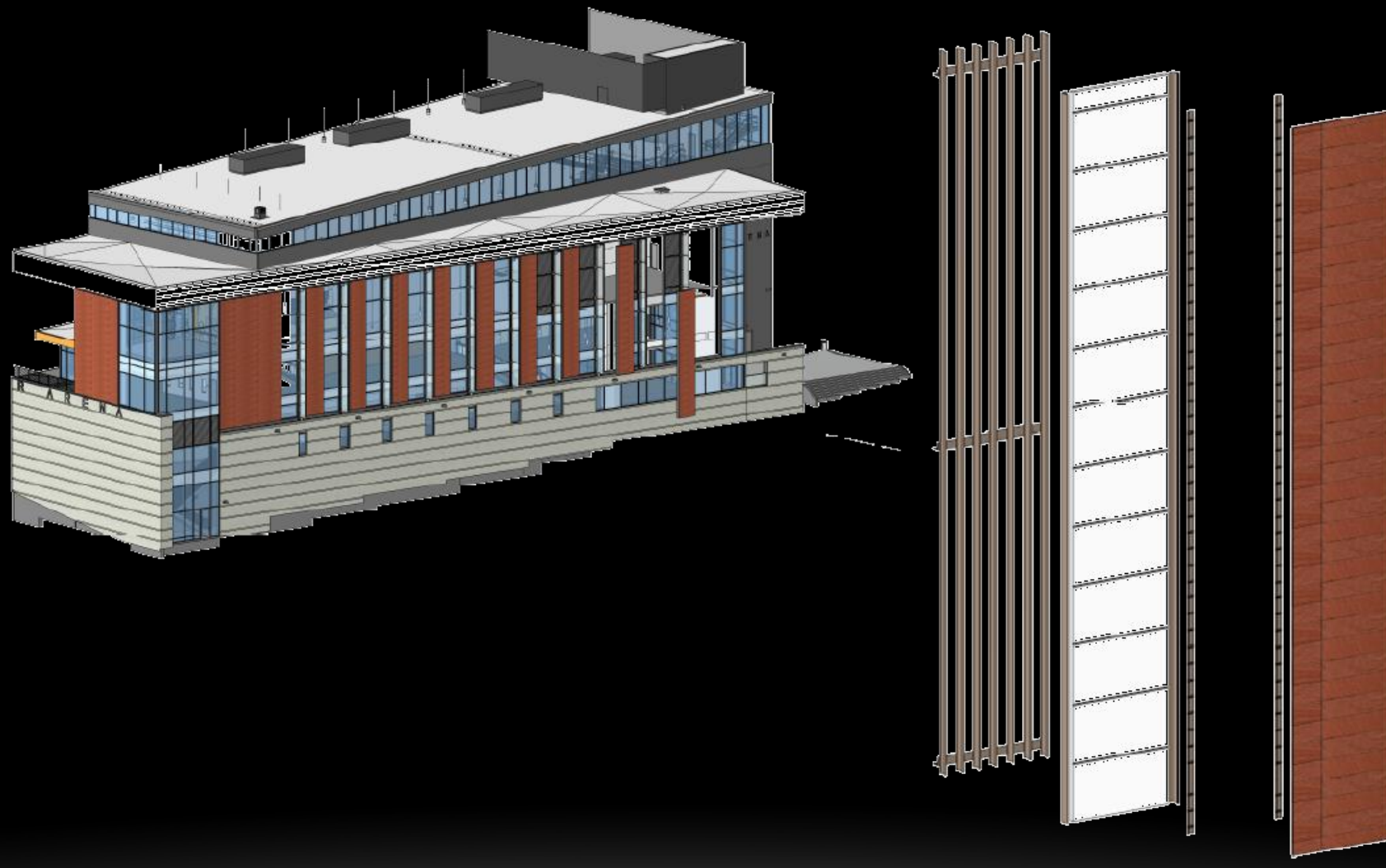
Panel	Width	Height	SF	# of TC Panels
1	11'-0"	37'	413	74
2	5'-8"	37'	210	37
3	5'-8"	37'	210	37
4	5'-8"	37'	210	37
5	5'-8"	37'	210	37
6	5'-8"	37'	210	37
7	5'-8"	37'	210	37
8	5'-8"	37'	210	37
9	5'-8"	37'	210	37
10	5'-8"	37'	210	37
11	11'-0"	37'	413	74
12	11'-0"	37'	413	74
13	5'-8"	20'	113	20
14	5'-8"	20'	113	20
15	5'-8"	20'	113	20
16	5'-8"	20'	113	20
17	5'-8"	20'	113	20
18	11'	20'	220	40
19	11'	20'	220	40
20	11'	20'	220	40
21	-	-	193	40
22	11'	8'	88	16
23	11'	30'	333	60
24	11'	30'	333	60
Total	5301			951

* Terra Cotta Dimensions: 5' W x 1' H

Prefabricated Panels		
Task	Duration	Cost
Terra Cotta Fab and Del	40	\$250,000
Prefab and Del Panels	35	\$211,800
Installation of Panels	24	\$158,850
Punchlist / Closeout	-	\$6,700
Stick Built Sections	20	\$47,160
Total	119	\$674,510

**Prefab and Del Panels & Installation = 70\$ SF, assumed
40\$ for material and 30\$ for labor*

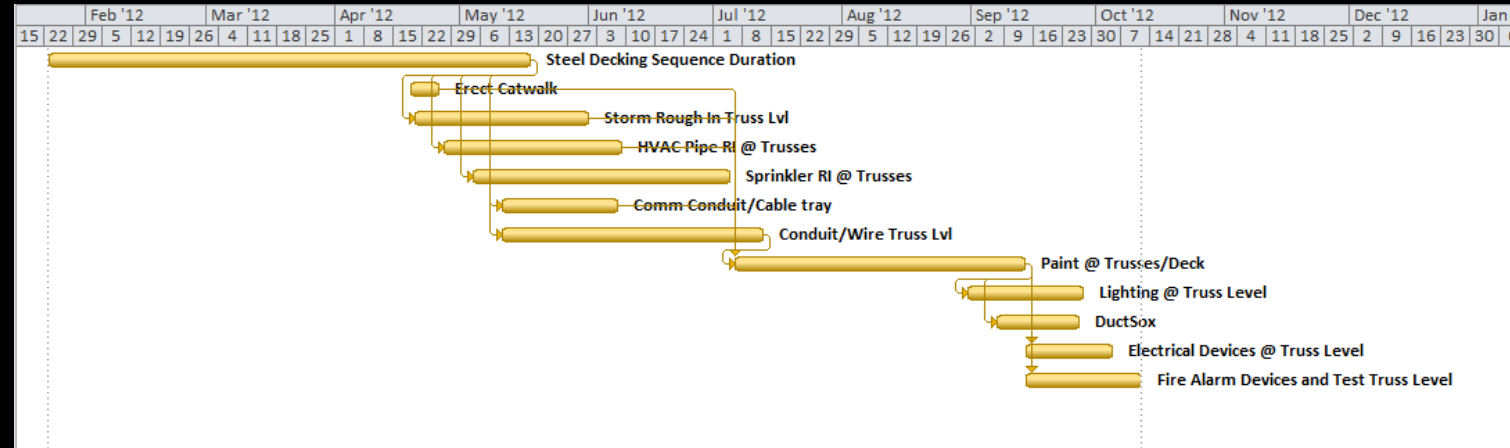
Tiger Arena Terra Cotta Cost		
Task	Duration	Cost
Terra Cotta Fab and Del	40	\$250,000
Layout	17	\$23,000
Framing	47	\$106,025
Sheathing	24	\$52,800
Air Barrier	38	\$114,872
Installation of Panels	45	\$75,000
Punchlist / Closeout	-	\$6,700
Total	211	\$628,397



Schedule Comparison	
Existing System	211
Fab and Del Terra Cotta	40 Days
Complete Installation	171 Days
Prefabricated System	119
Fab and Del Terra Cotta	40 Days
Shop Fabrication	35 Days
Installation	24 Days
Stick Built Section	20 Days

R-Value Comparison ft ² ·°F·h/Btu			
Description	R-Value	Thickness	Subtotals
Existing System			
FOAMULAR 250 Rigid Foam Insulation	5 per inch	3"	15
GlassRoc Exterior Sheathing	.51 per SF	5/8"	0.51
		Total	15.51
Prefabricated System			
Optimo Smooth Insulated Metal Panel	7.5 per inch	3 5/8"	27.19
		Total	27.19

ANALYSIS II: PREFABRICATED TERRA COTTA



		Baseline/July Comparison							
	7	Task	Duration	Baseline Start	Early Start July	Delta	Baseline Finish	Early Finish July	Delta
June	A1420	Sprinkler RI @ Trusses	44	7/5/2012	5/3/2012	63	9/4/2012	6/26/2012	70
July	A1290	Storm Rough In Truss Lvl	30	4/12/2012	6/1/2012	50	5/23/2012	7/5/2012	43
July	A1660	Comm Conduit/Cable tray	15	4/24/2012	6/4/2012	41	5/21/2012	7/23/2012	63
July	A1360	HVAC Pipe RI @ Trusses	15	5/30/2012	6/8/2012	9	8/7/2012	7/23/2012	15
July	A1350	Conduit//wire Truss Lvl	34	4/24/2012	5/16/2012	22	6/25/2012	8/20/2012	56
July	A1390	Duct Rough In	50	5/30/2012	7/3/2012	34	7/10/2012	9/12/2012	64
June	A1670	Duct Insulation @ Trusses	20	7/26/2012	8/20/2012	25	8/22/2012	9/18/2012	27
July	A1700	Paint @ Trusses/Deck	50	8/9/2012	9/4/2012	26	10/17/2012	11/13/2012	27
July	A1690	Lighting @ Truss Level	20	10/5/2012	10/30/2012	25	11/1/2012	11/28/2012	27
July	A2720	Fire Alarm Devices and Test Truss Level	20	10/19/2012	11/13/2012	25	11/15/2012	12/12/2012	27
July	A1680	Electrical Devices @ Truss Level	15	10/19/2012	11/15/2012	27	11/8/2012	12/7/2012	29

Truss MEPF - Baseline Duration
4/12/2012 – 11/15/12
156 Days

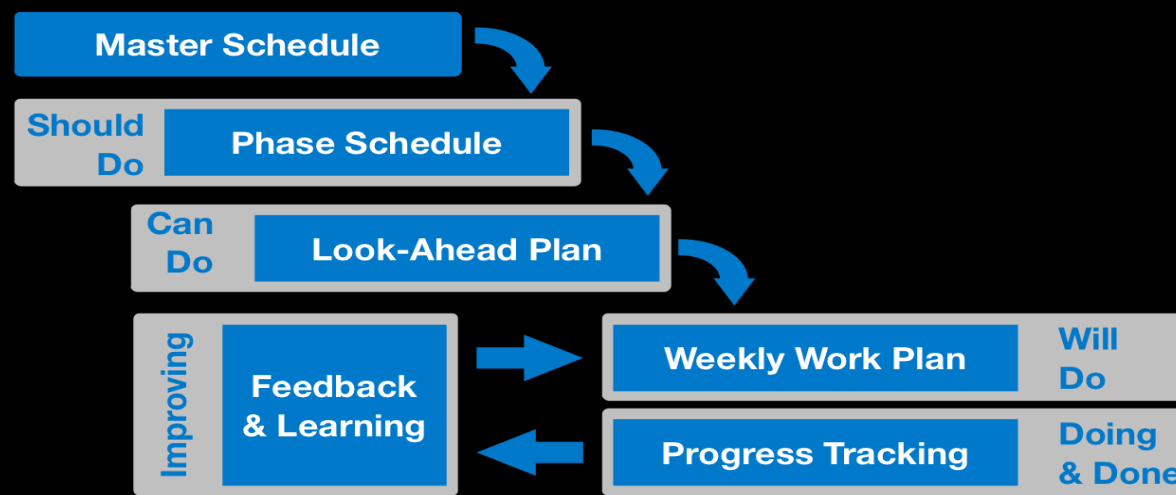
Truss MEPF - Actual Duration
5/3/2012 – 11/27/12
149 Days

**Not including overtime*

Truss MEPF- Re-Sequenced "Phased Schedule" Duration
4/12/2012 – 10/11/12
126 Days

Difference of 33 Days from Actual Completion
= \$354,629 GC Savings

Name	Duration: Re-Seq	Duration: Actual	Duration: Diff	Start: Re-Seq	Start: Actual	Start: Diff	Finish: Re-Seq	Finish: Actual	Finish: Diff
Kinsley - Steel	84 days	109 days	-25d	Mon 1/23/12	Mon 1/16/12	5d	Thu 5/17/12	Thu 6/14/12	-20d
Steel Decking Sequence Duration	84 days	109 days	-25d	Mon 1/23/12	Mon 1/16/12	5d	Thu 5/17/12	Thu 6/14/12	-20d
Erect Catwalk	15 days	38 days	-23d	Thu 4/19/12	Wed 4/11/12	6d	Wed 5/9/12	Fri 6/1/12	-17d
DenverElek - Mechanical	114 days	78 days	36d	Fri 4/20/12	Fri 6/1/12	-30d	Wed 9/26/12	Tue 9/18/12	6d
Storm Rough In Truss Lvl	30 days	25 days	5d	Fri 4/20/12	Fri 6/1/12	-30d	Thu 5/31/12	Thu 7/5/12	-25d
HVAC Pipe RI @ Trusses	31 days	32 days	-1d	Fri 4/27/12	Fri 6/8/12	-30d	Fri 6/8/12	Mon 7/23/12	-31d
Duct Rough In		33 days			Mon 7/30/12			Wed 9/12/12	
Duct Insulation @ Trusses		15 days			Wed 8/29/12			Tue 9/18/12	
DuctSox	14 days			Fri 9/7/12			Wed 9/26/12		
BK Truland - Electrical	110 days	140 days	-30d	Fri 5/11/12	Wed 5/16/12	-3d	Thu 10/11/12	Tue 11/27/12	-33d
Comm Conduit/Cable tray	20 days	36 days	-16d	Fri 5/11/12	Mon 6/4/12	-16d	Thu 6/7/12	Mon 7/23/12	-32d
Conduit/Wire Truss Lvl	45 days	114 days	-69d	Fri 5/11/12	Wed 5/16/12	-3d	Thu 7/12/12	Mon	-72d
Lighting @ Truss Level	20 days	20 days	0d	Fri 8/31/12	Fri 10/19/12	-35d	Thu 9/27/12	Thu 11/15/12	-35d
Electrical Devices @ Truss Level	15 days	47 days	-32d	Fri 9/14/12	Mon 9/24/12	-6d	Thu 10/4/12	Tue 11/27/12	-38d
Fire Alarm Devices and Test Truss Level	20 days	21 days	-1d	Fri 9/14/12	Mon	-31d	Thu 10/11/12	Sun 11/25/12	-31d
NFP - Sprinkler	44 days	39 days	5d	Fri 5/4/12	Thu 5/3/12	1d	Wed 7/4/12	Tue 6/26/12	6d
Sprinkler RI @ Trusses	44 days	39 days	5d	Fri 5/4/12	Thu 5/3/12	1d	Wed 7/4/12	Tue 6/26/12	6d
NLP - Painting	50 days	63 days	-13d	Fri 7/6/12	Fri 8/17/12	-30d	Thu 9/13/12	Tue 11/13/12	-43d
Paint @ Trusses/Deck	50 days	63 days	-13d	Fri 7/6/12	Fri 8/17/12	-30d	Thu 9/13/12	Tue 11/13/12	-43d



ANALYSIS III: LAST PLANNER SYSTEM

Last Planner Savings to Towson	
Description	Savings
General Conditions	\$354,629.55

**General Conditions = \$214,927 a month, savings will be calculated after production planning of truss activities is complete. Ref. Analysis 3 for GC Savings*

WIRING SCHEDULE: PANEL RP1C

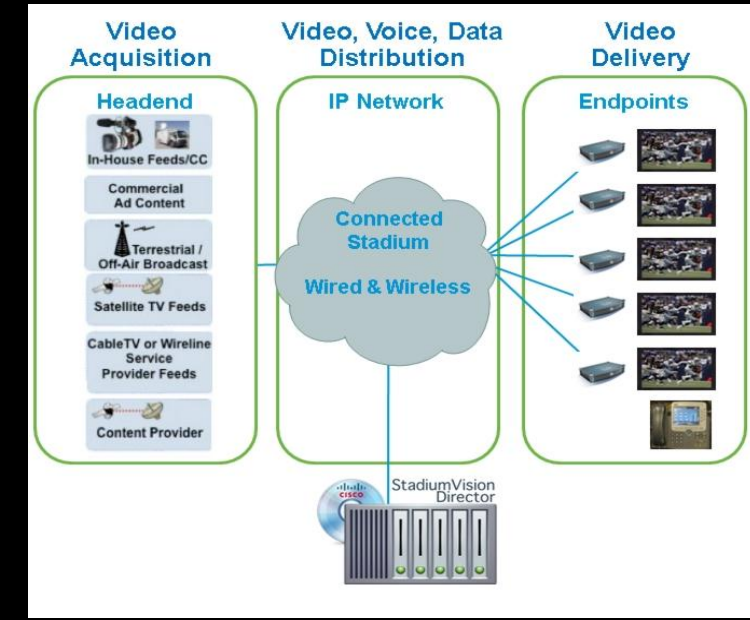
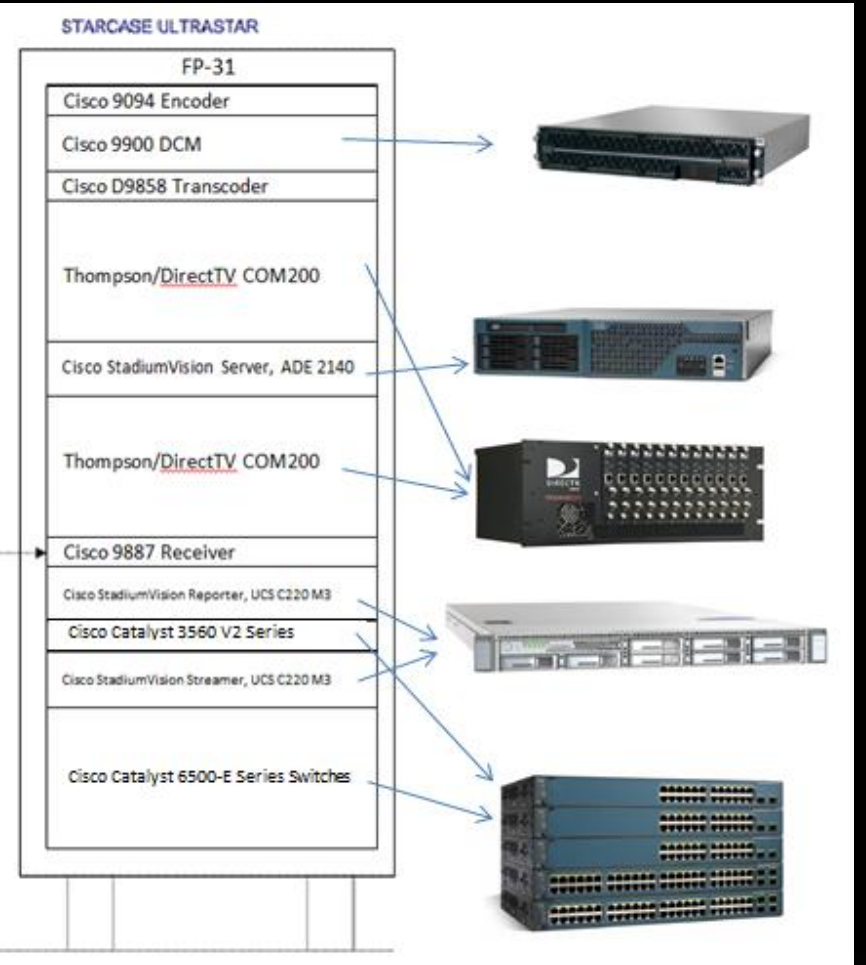
120/208 VOLTS		3PHASE 4 WIRE				100 AMP MAINS				SURFACE MOUNTED				
CIRC-UIT	POLE	DESCRIPTION	WIRE/ CONDUIT	BREAKER POLE	AMP	AØ	BØ	CØ	CIRC-UIT	POLE	DESCRIPTION	WIRE/ CONDUIT	BREAKER POLE	AMP
1	1	CUH-TA-1 (VESTIBULE 124)	#12-3/4"C	1	20	0.3	1.4		2	2	HAND DRYER MEN'S 131	#8-3/4"C	1	20
3	3	REC FAN ASSIST 134,135,137	#8-3/4"C	1	20		1.0	1.4	4	4	HAND DRYER MEN'S 131	#8-3/4"C	1	20
5	5	REC EVENT MGMT 133, 134	#8-3/4"C	1	20			0.8 0.8	6	6	REC MEN'S 131	#8-3/4"C	1	20
7	7	REC WOMEN'S 132	#8-3/4"C	1	20	0.8	0.8		8	8	REC RECEPTION 125, CORR	#10-3/4"C	1	20
9	9	HAND DRYER WOMEN'S 132	#8-3/4"C	1	20		1.4	0.8	10	10	REC PRESS RM 127	#12-3/4"C	1	20
11	11	HAND DRYER WOMEN'S 132	#8-3/4"C	1	20			1.4 0.8	12	12	REC PRESS RM 127	#12-3/4"C	1	20
13	13	REC PRESS ROOM 127	#12-3/4"C	1	20	0.8	1.0		14	14	REC AVR PRESS RM 127	#12-3/4"C	1	20
15	15	REC PRESS ROOM 127	#12-3/4"C	1	20		0.8	0.5	16	16	REC METAL DETECTOR 125	#12-3/4"C	1	20
17	17	REC EVENT STAFF 121	#12-3/4"C	1	20			0.6 0.5	18	18	REC METAL DETECTOR 125	#12-3/4"C	1	20
19	19	REC EVENT STAFF 121, CORR 114	#12-3/4"C	1	20	0.8	0.5		20	20	REC EWC 125	#12-3/4"C	1	20
21	21	REC SECURITY 122, CORR	#12-3/4"C	1	20		0.8 0.8		22	22	REC AVR SECURITY 122	#12-3/4"C	1	20
23	23	REC PRODUCTION 129	#10-3/4"C	1	20			0.8 0.8	24	24	REC PRODUCTION 129	#10-3/4"C	1	20
25	25	REC PRODUCTION 129	#10-3/4"C	1	20	0.8	0.8		26	26	REC PRODUCTION 129	#10-3/4"C	1	20
27	27	REC PRODUCTION 129	#10-3/4"C	1	20		0.8 1.0		28	28	REC PRODUCTION 129	2#10#10	2	20
29	29	REC PRODUCTION 129	#10-3/4"C	1	20			0.8 1.0	-	30		G-3/4"C		
31	31	REC PRODUCTION 129	2#10#10G-3/4"C	2	20	1.0	1.0		32	32	REC PRODUCTION 129	2#10#10	2	20
-	33						1.0 1.0		-	34		G-3/4"C		
35	35	REC PRODUCTION 129	2#10#10G-3/4"C	2	20			1.0 0.8	36	36	REC PRODUCTION 129	#10-3/4"C	1	20
-	37					1.0	0.4		38	38	REC TV PRESS ROOM 127	#12-3/4"C	1	20
39	39	CISCO STADIUM VISION RACK	3#10#10G-3/4"C	2	20		1.9		40	40	SPARE		1	20
-	41							1.9	42	42	SPARE		1	20
CONNECTED LOAD =					36.6	KVA					MAIN BREAKER 100 AMPS			
DEMAND LOAD =					27.1	KVA					NOTE: PROVIDE SEPARATE NEUTRAL FOR EACH CIRCUIT			
MIN AIC RATING =					10,000	AMPS SYMMETRICAL					LOCATION SECURITY 122			

Table 250.122 Minimum Size Equipment Grounding Conductors for Grounding Raceway and Equipment

Rating or Setting of Automatic Overcurrent Device in Circuit Ahead of Equipment, Conduit, etc., Not Exceeding (Amperes)	Size (AWG or kcmil)	
	Copper	Aluminum or Copper-Clad Aluminum*
15	14	12
20	12	10
60	10	8
100	8	6

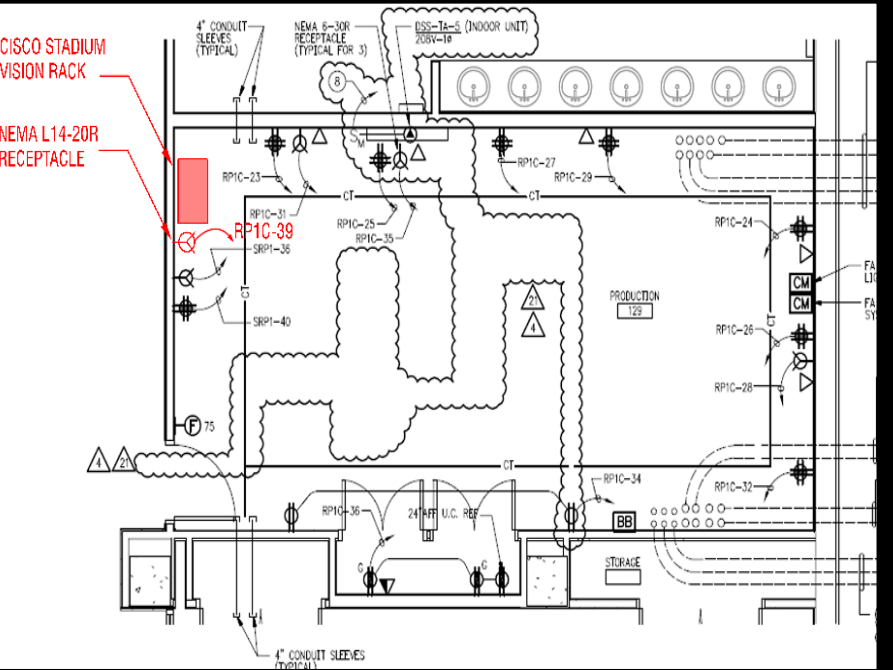
Size	Temperature Rating of Conductor. [See Table 310.104(A).]					Size	
	60°C (140°F)	75°C (167°F)	90°C (194°F)	60°C (140°F)	75°C (167°F)		90°C (194°F)
AWG or kcmil	Types RH, TH, TW, UF		Types TBS, SA, SIS, FEP, FEPE, MI, RHH, RHW-2, THHN, THHW, THWN, THWN-2, XHHW, XHHW-2, USE, ZW	Types RH, TH, TW, UF	Types RH, TH, TW, THHN, THHW, THWN, THWN-2, XHHW, XHHW-2, USE	Types TBS, SA, SIS, THHN, THHW, THWN-2, RHH, RHW-2, USE-2, XHH, XHHW, XHHW-2, ZW-2	AWG or kcmil
	Copper		Aluminum or Copper-Clad Aluminum				
18	—	—	14	—	—	—	—
16	—	—	18	—	—	—	—
14**	15	20	25	—	—	—	—
12**	20	25	30	15	20	25	12**
10**	30	35	40	25	30	35	10**
8	40	50	55	35	40	45	8

Trade Size	Wire Size (THWN, THHN)		Conductor Size AWG/kcmil																			
	14	12	10	8	6	4	3	2	1	1/0	2/0	3/0	4/0	250	300	350	400	500	600	700	750	
1/2	EMT	12	9	5	3	2	1	1	1	1	1	1	1									
	IMC	14	10	6	3	2	1	1	1	1	1	1	1									
	GRC	13	9	6	3	2	1	1	1	1	1	1	1									
3/4	EMT	22	16	10	6	4	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	IMC	24	17	11	6	4	3	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	GRC	22	16	10	6	4	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1



Rack Details
11 Components
3,687 VA Output
3,840 VA Capacity
120 V, Single-Phase 20A

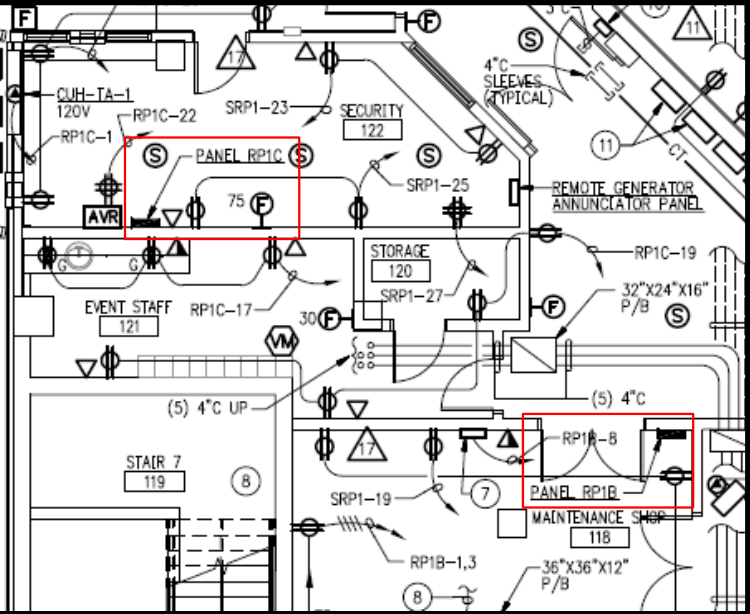
Device	Power Requirements
Cisco D9900 DCM	350 W (max); 110 to 240V AC
Cisco D9094 Encoder	60 W (max) ; 100 V AC
Cisco D9887 Receiver	200 W (max); 95 to 135 / 180 to 265 V AC
Cisco D9858 Transcoder	110 W (max); 110 to 240V AC
Cisco Spectra QAM Demod	8 W; 48V AC
3rd Party Set-top Box	Varies – 15-20 W; 110 to 240V AC
DirecTV COM200	320 W (max with redundant PSU); 110 to 240V AC
Catalyst Switches	PoE is not required. Power supplies for switches should be sized accordingly.



Specifications for 40 Amp Units 208V-120V

AC Voltage Input:	200 to 230V
AC Voltage Output:	100 to 115V
Frequency:	60 Hz
Load Capacity:	UL Rated 33Amps max - (5) 16 Amp circuits
Circuit Breaker:	(5) 20 Amp UL489 Listed circuit breakers
Output Receptacles:	NEMA 5-20R
Product Warranty:	2 years
Power Cable - AWG Length & Plug Type:	12/4 5/4" Type, L14-20P, 120, (3.6m)
With Local Ammeter Readout:	0-20 Amp 4-digit display +/- 0.2A LCD with backlighting
With Remote Ammeter Readout:	0-30A 3-digit display +/- 0.2A Remote LCD with backlighting

40A Power Commander Power Distribution Units			
Catalog No. 4B44B2-2 Twenty-four (24) 20A sample outlets in two banks of 12. Black housing. Length: 48" [1.2m] Width: 1 1/2" [38mm] Depth: 2 7/8" [73mm]	Catalog No. 4B50B2-2 Thirty-six (36) 20A sample outlets in two banks of 18. Black housing. Length: 70" [1.8m] Width: 1 1/2" [38mm] Depth: 2 7/8" [73mm]	Catalog No. 4B53B2-2-AM Eighteen (18) 20A sample outlets in two banks of 9. Two lighted LCD digital ammeters. Black housing. Length: 54" [1.4m] Width: 1 1/2" [38mm] Depth: 2 7/8" [73mm]	Catalog No. 4B43B2-2-RAM Eighteen (18) 20A sample outlets in two banks of 9. Two lighted remote LCD ammeters. Black housing. Length: 48" [1.2m] Width: 1 1/2" [38mm] Depth: 2 7/8" [73mm]



ANALYSIS IV: CISCO STADIUMVISION