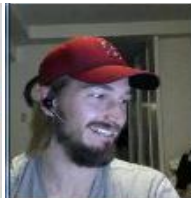
Sara
A

Lanxi
SE

Liyi
SE



Jordan
MEP

Arnaud
CM

Eline
CM

Carl
LCFM

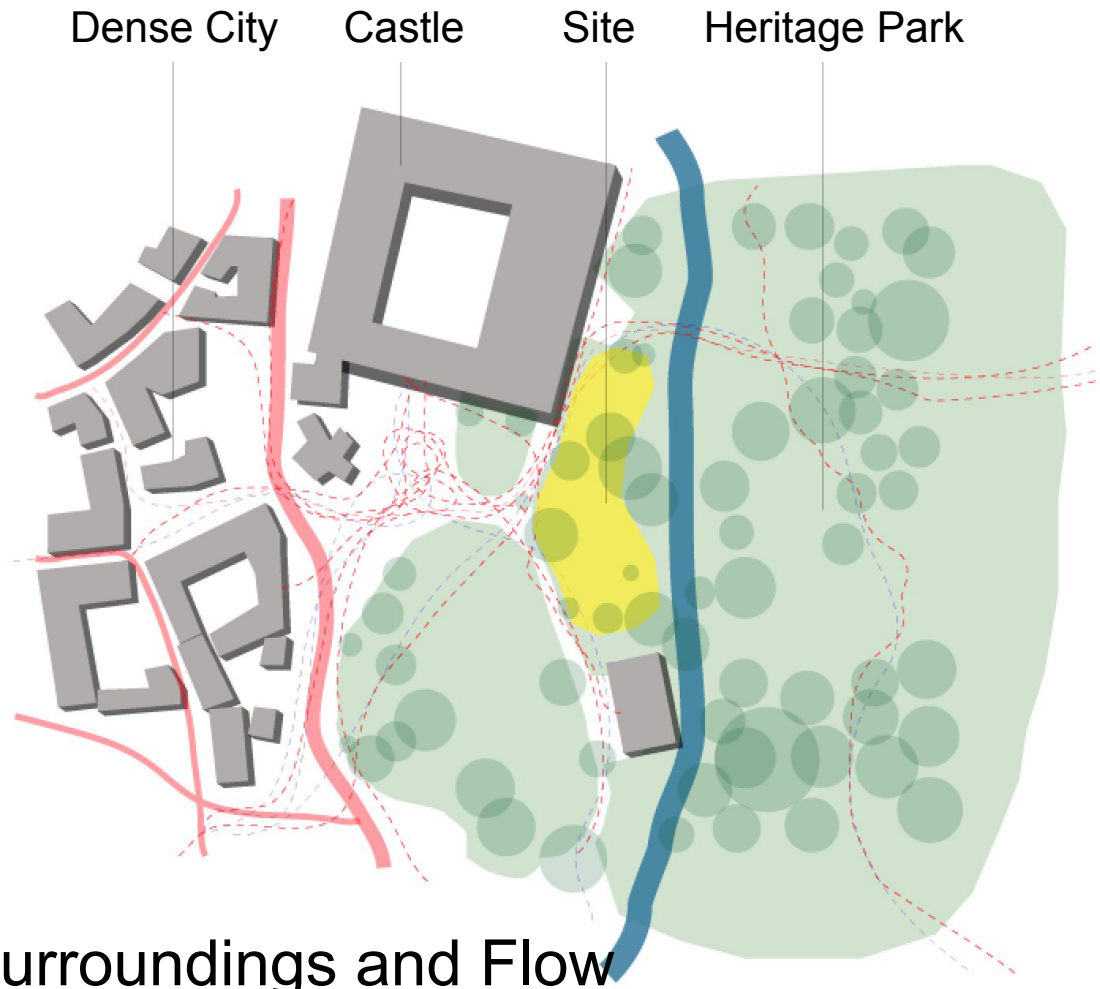
Team River
Winter Presentation

	Strategy
Architecture	Daylighting Passive Strategies Low VOC Materials & Finishes
Structural	Sustainable Timber Material Optimization
MEP	Thermal Comfort Underfloor Distribution Energy Efficiency
Construction	Dust Minimization
Life Cycle Financial	Consistent Filter & Equipment Maintenance

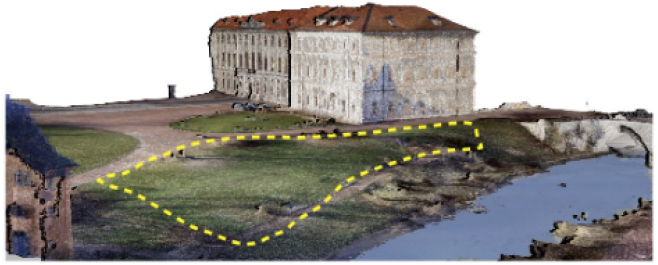
Air Quality Challenge



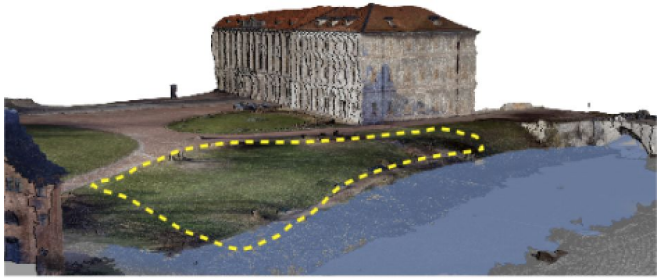
Weimar, Germany



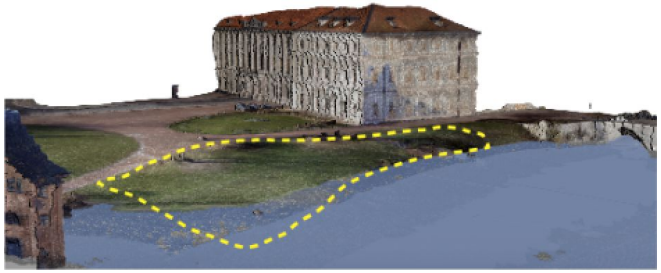
Site Surroundings and Flow



Normal water level



Worst flood last 100 years - 8’



Worst case future scenario - 12’

Potential Flooding Challenge

Source: http://www.ukrivers.net/climate.html 10 Feb 2016

Architect

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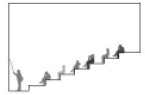
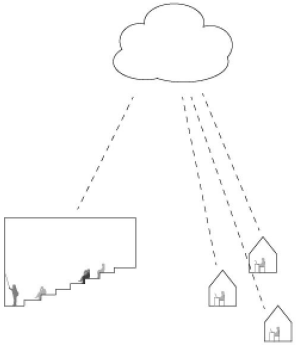
‘No Building’

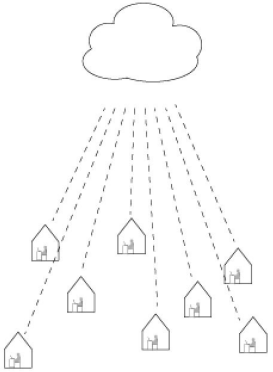
S.M.A.R.T



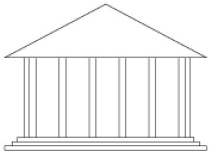
University 1960

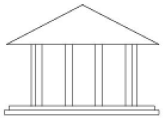


University 2016

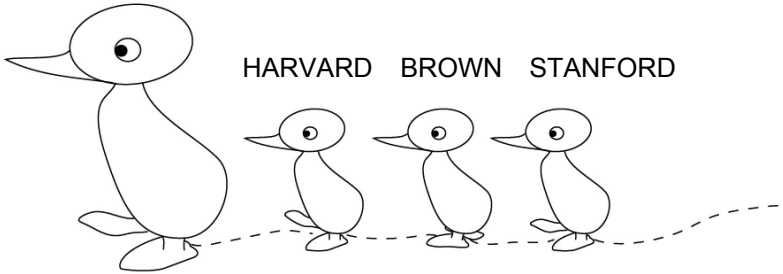


University 2070

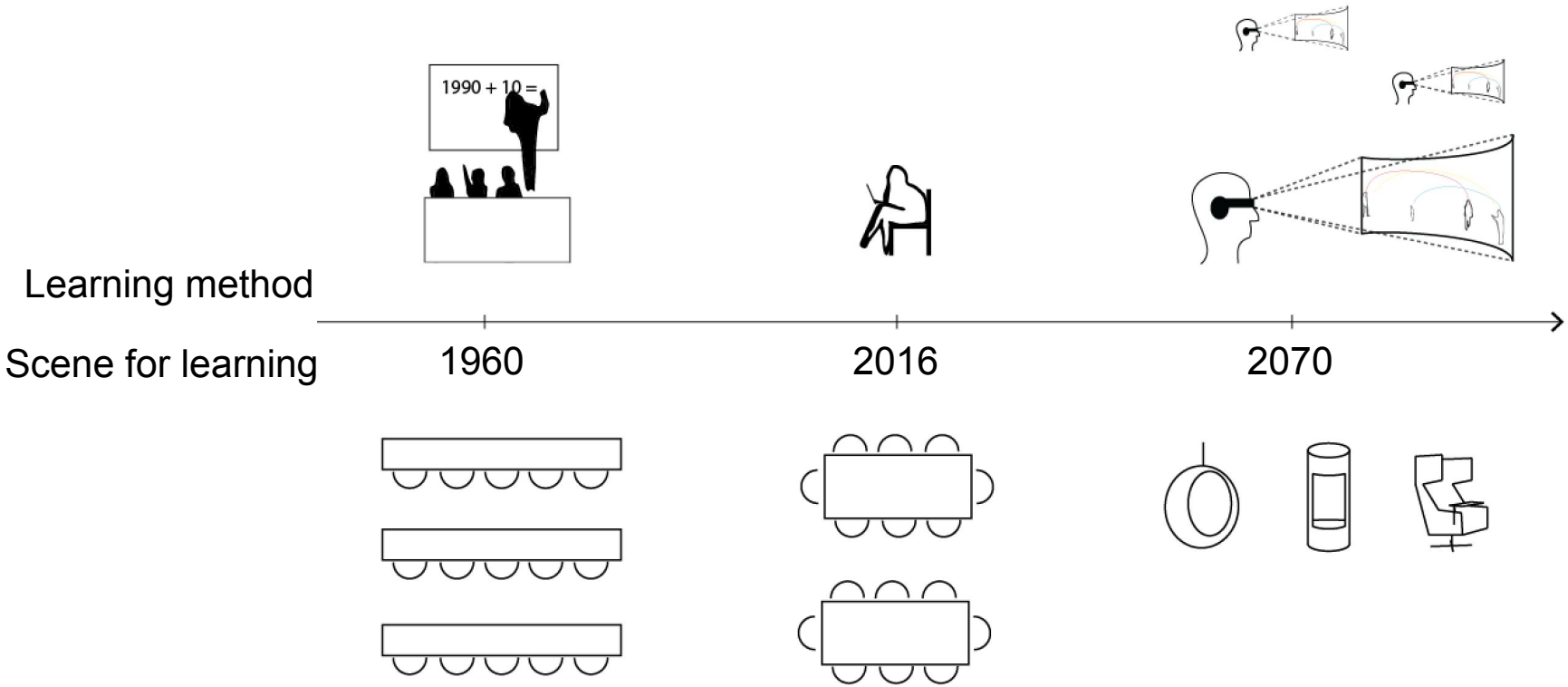




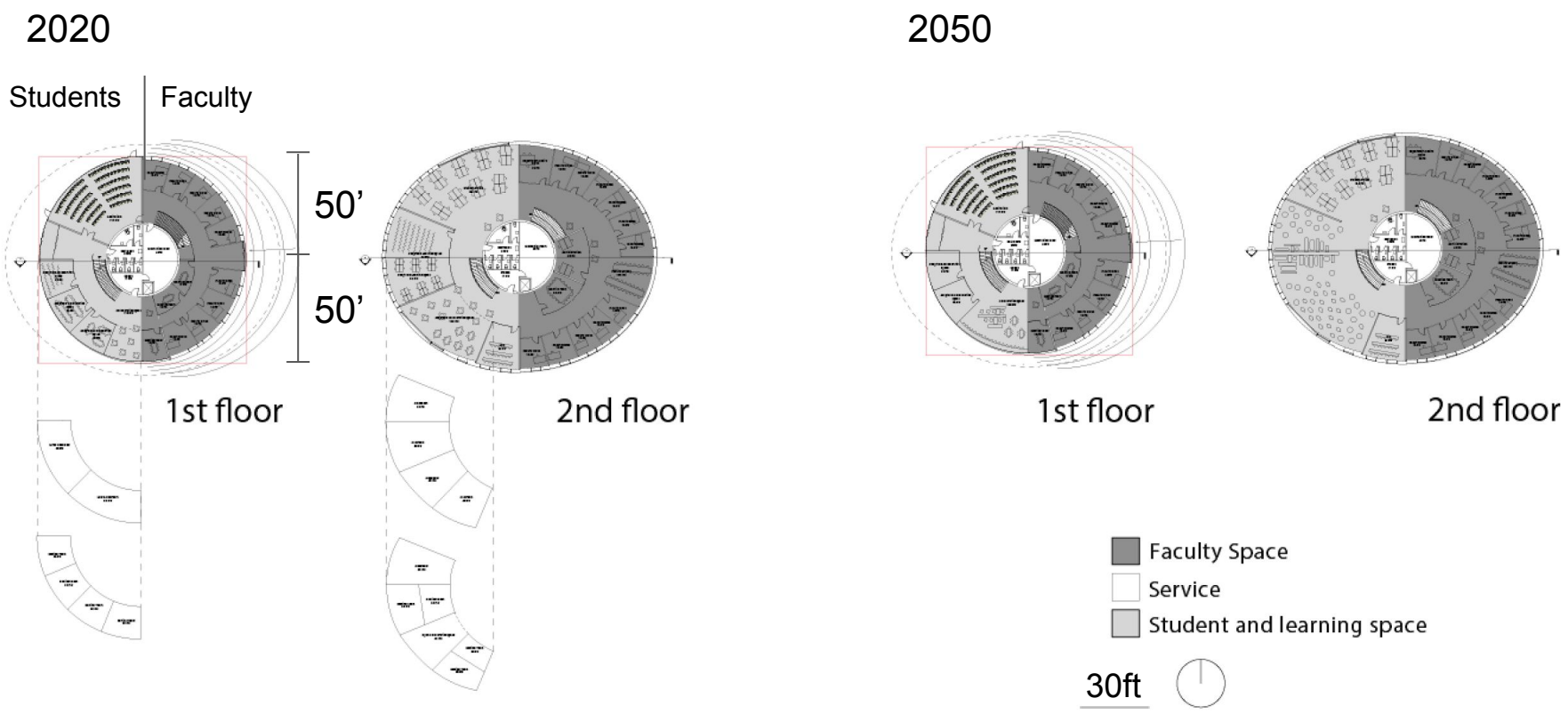
WEIMAR



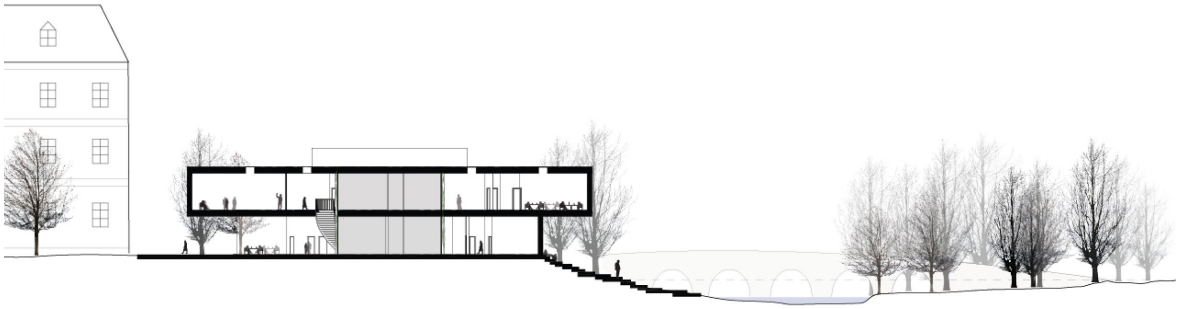
‘No Building’ Idea



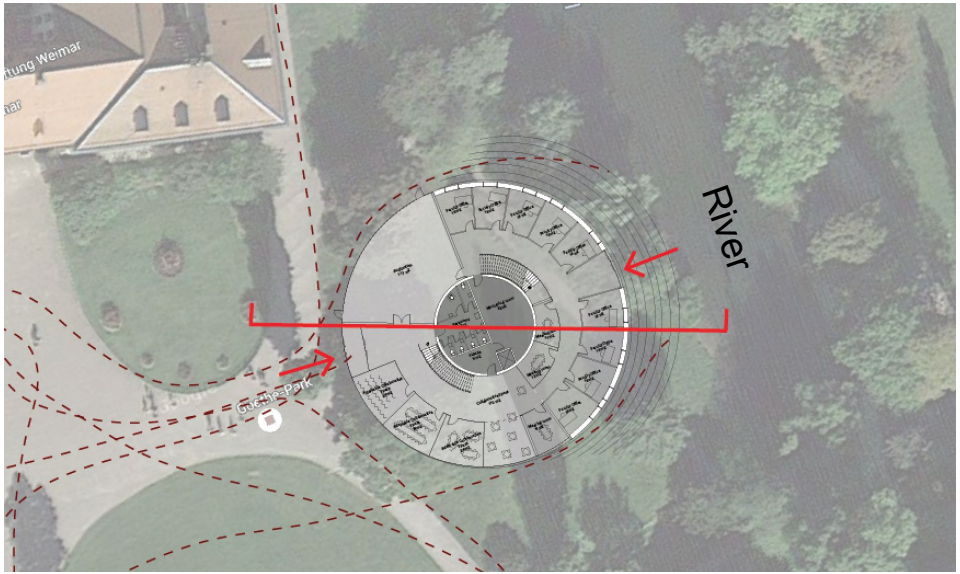
New ways of learning



Adaptable Spaces Reduce Floor Area by 40%

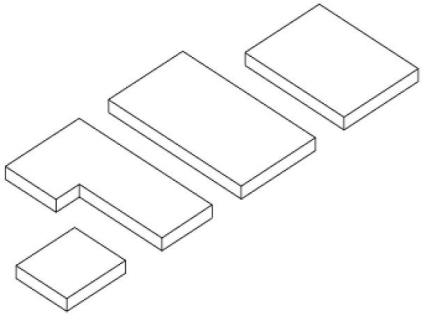


30’

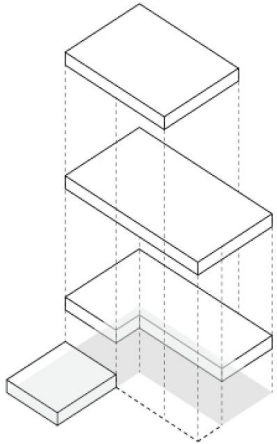


Integration in Urban Area

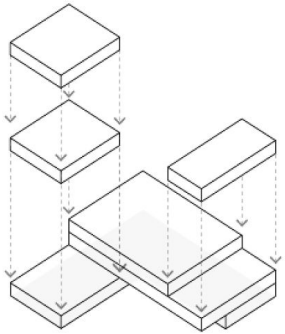
‘No Building’



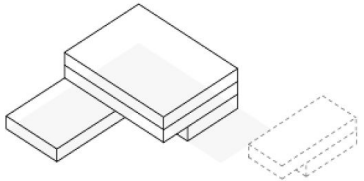
Clustered functions



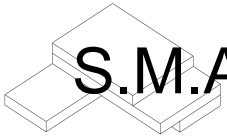
2020



2070: Add



2070: Remove



S.M.A.R.T Structurally, Mechanically, Architecturally & Resourcefully Thoughtful

Maslow's Hierarchy of Needs

Self actualization →

Individual →

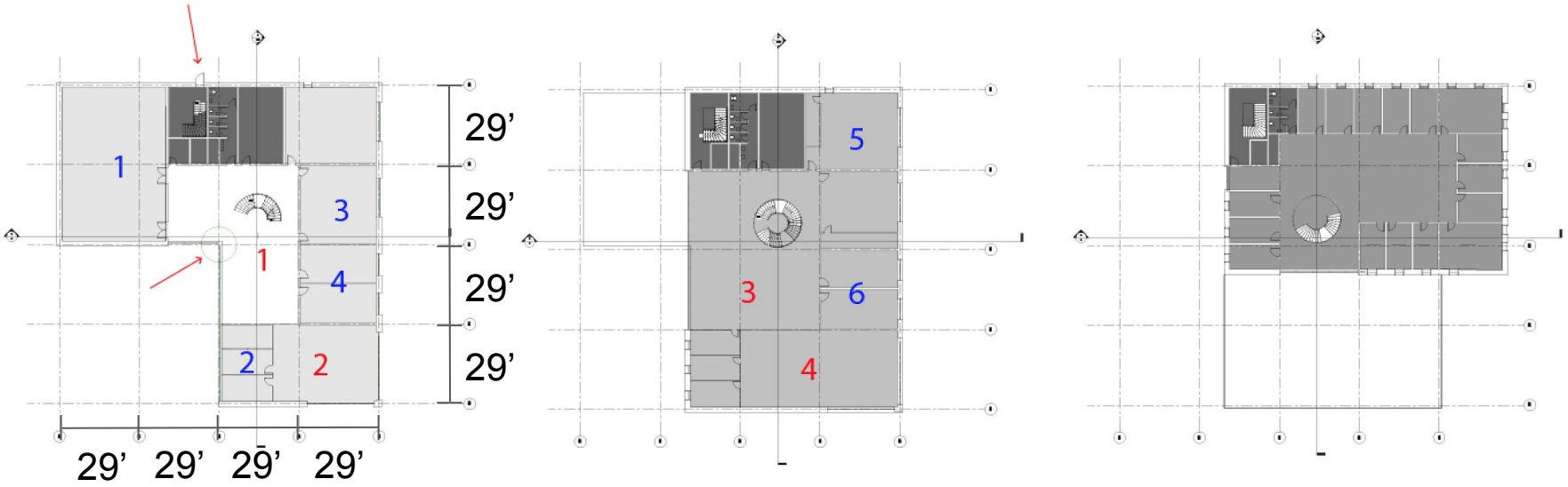
Social →

Mental →

Physical →

Architectural Needs of Learning

S.M.A.R.T Architecture



1st floor

2nd floor

3rd floor

30’

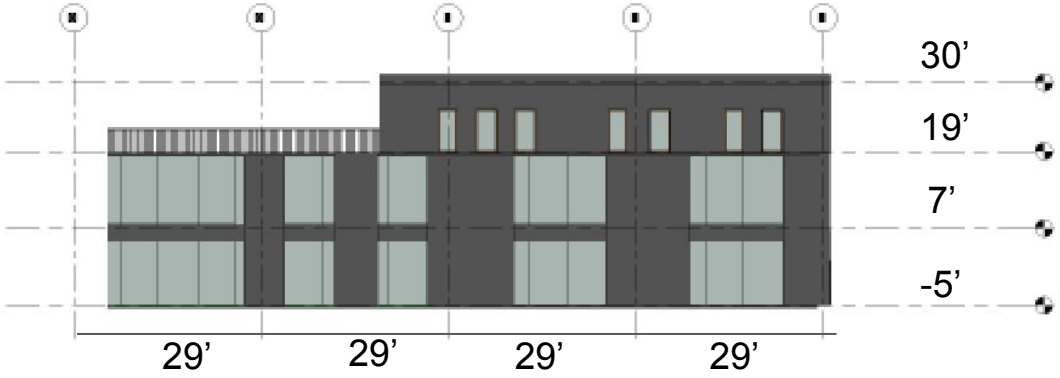
Shared Learning Space

Individual Learning Space

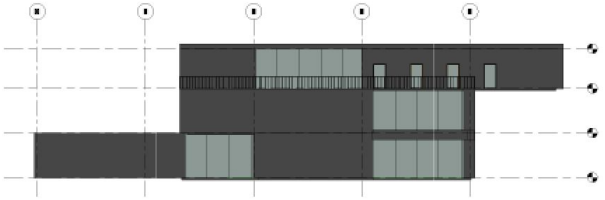
Faculty Space

Service

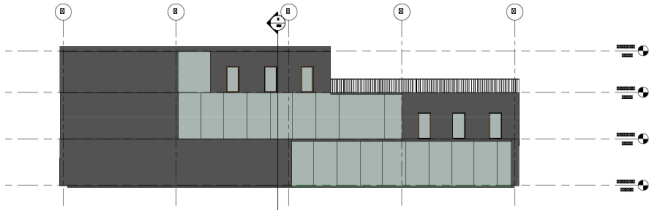
S.M.A.R.T Zone divided Floor Plans



East



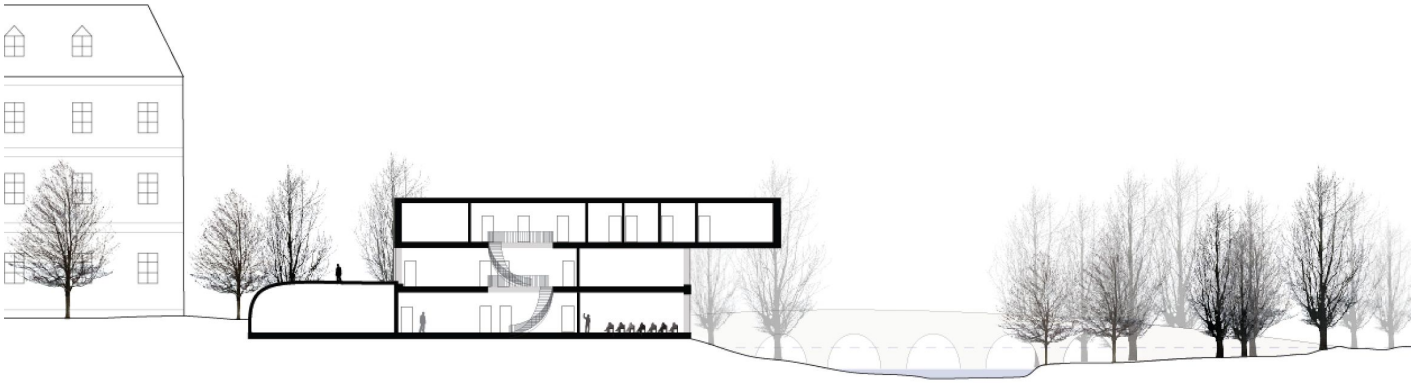
South



West

North

S.M.A.R.T Facades



30’

S.M.A.R.T in Context

S.M.A.R.T

Structural Engineers

‘No Building’

S.M.A.R.T

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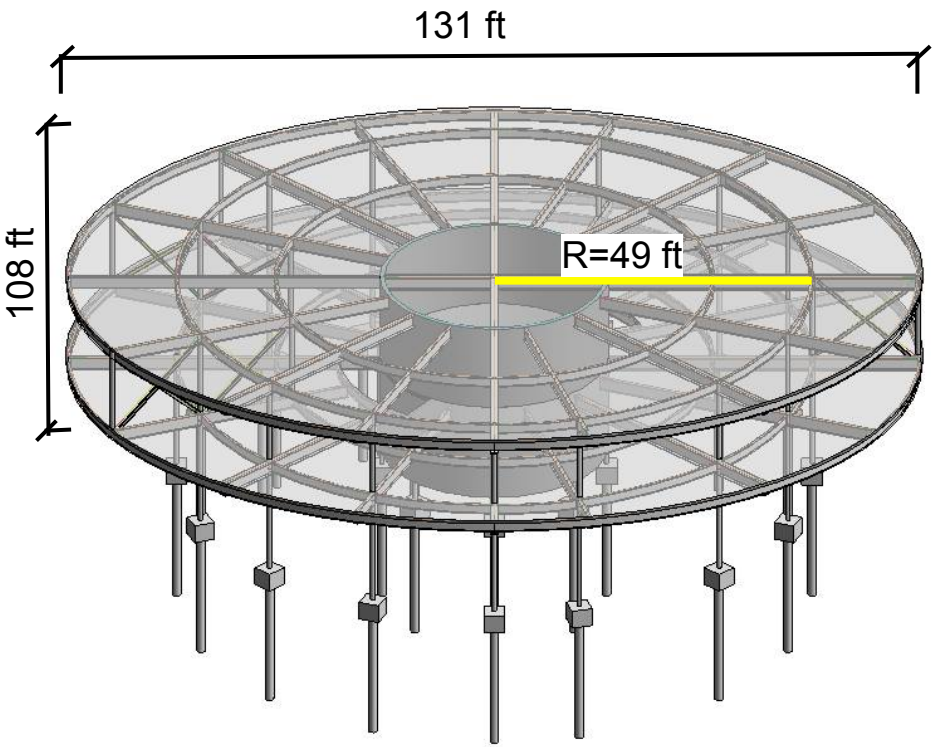
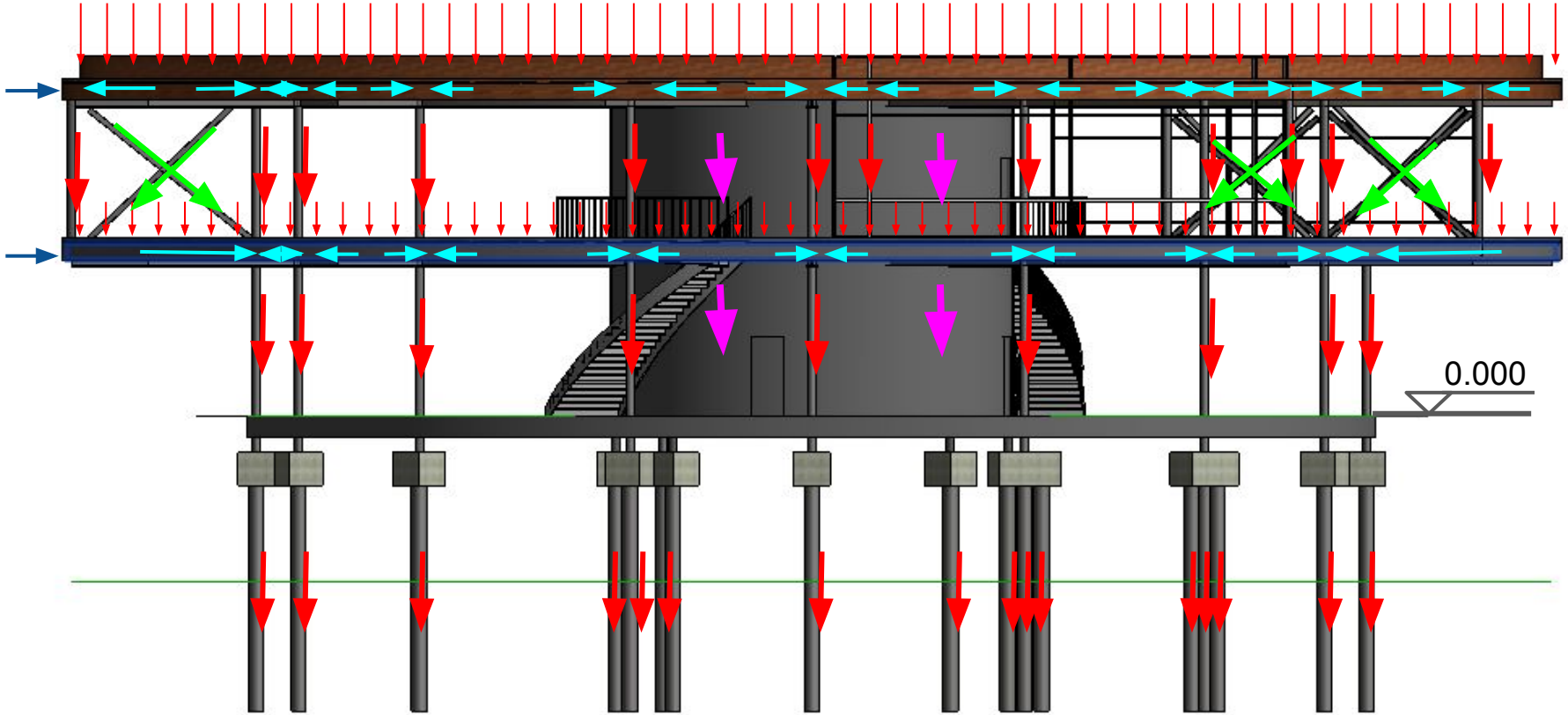


- **Steel frame + Composite Slab**
- **Concrete shear wall for lateral resistance**

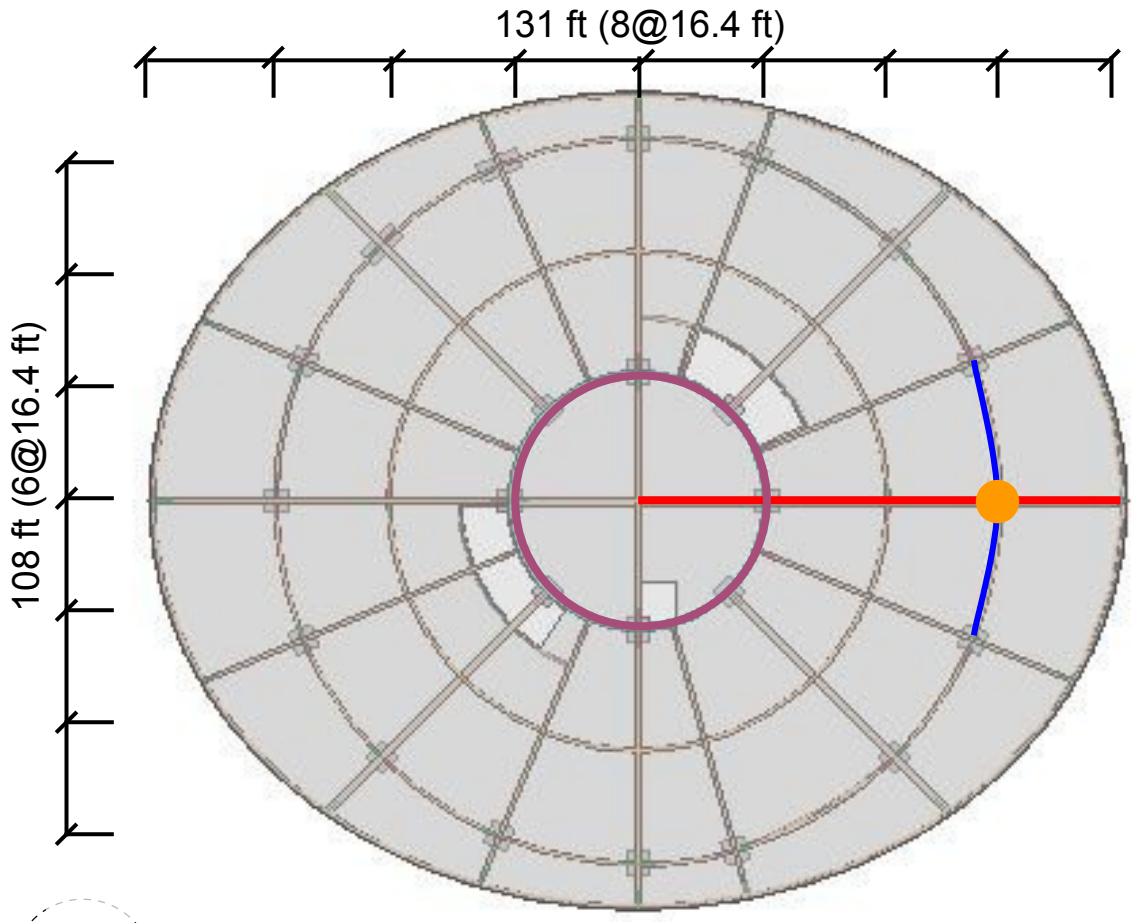
- **Glulam columns/beams + CLT slab**
- **CLT shear wall for lateral resistance**

‘No Building’ Concept



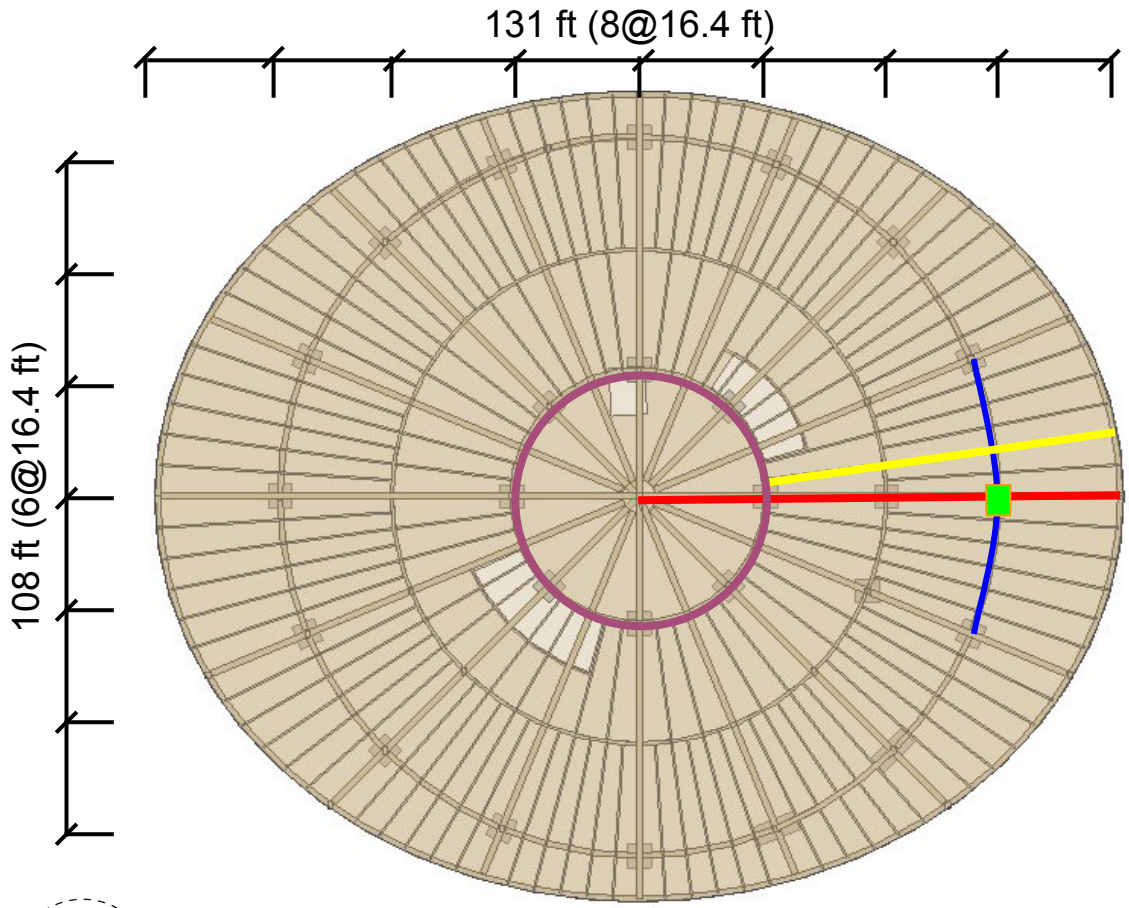
Wind Load: 0.65kN/m^2 (~13.6psf)

Load Path



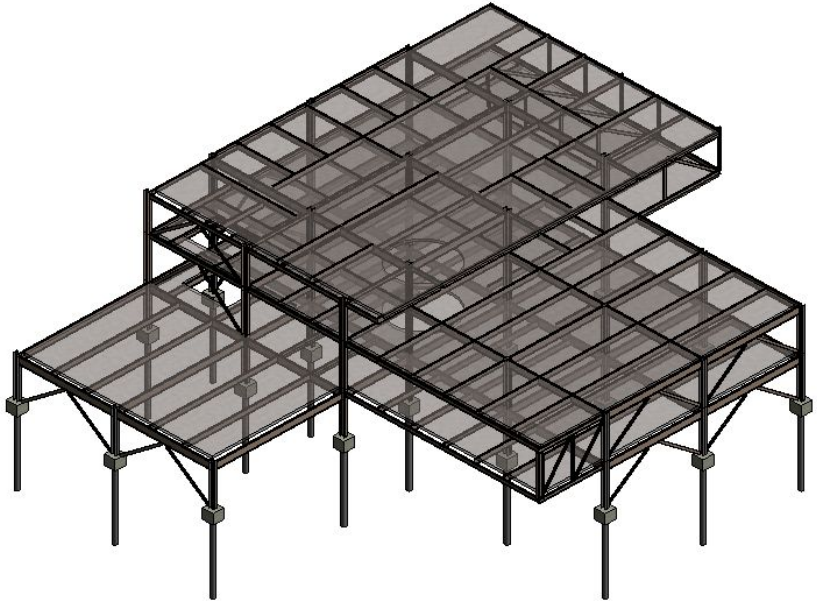
Member	Dimension
Concrete slab	6” thick
Steel girder (radial)	W24x55
Steel girder (circumference)	W18x35
Steel column	HSS 8.625x0.375
Concrete shear wall	8” thick

Steel/Concrete

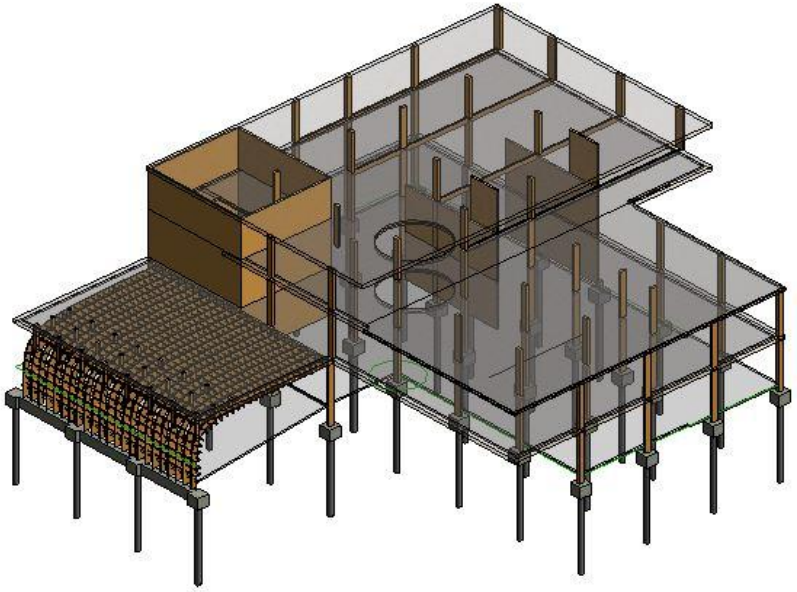


Member	Dimension
Timber slab	CLT 4” thick
Timber joist	Glulam 3.125 x16
Timber girder (radial)	Glulam 10.5 x33
Timber girder (circumference)	Glulam 8.75x24
Timber column	Glulam 8.75 x10.5
Timber shear wall	CLT 6” thick

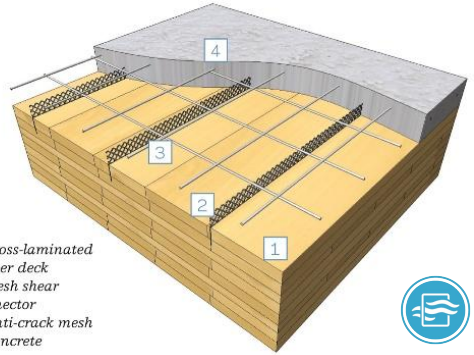
Timber



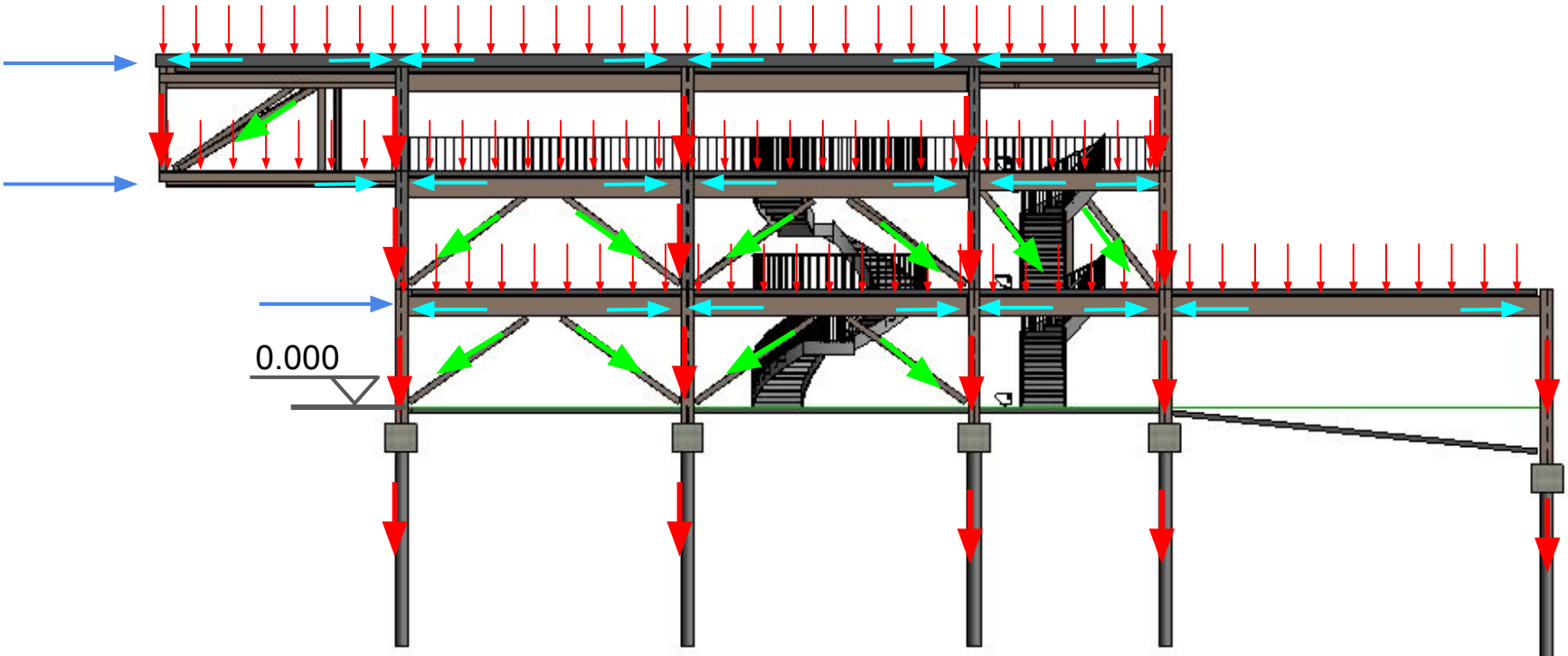
- **Steel frame + Composite Slab (concrete + metal deck)**
- **Steel braces for lateral resistance**



- **Glulam columns, beams + CLT shear wall + CLT-Concrete slab**
- **CLT shear walls for lateral resistance**

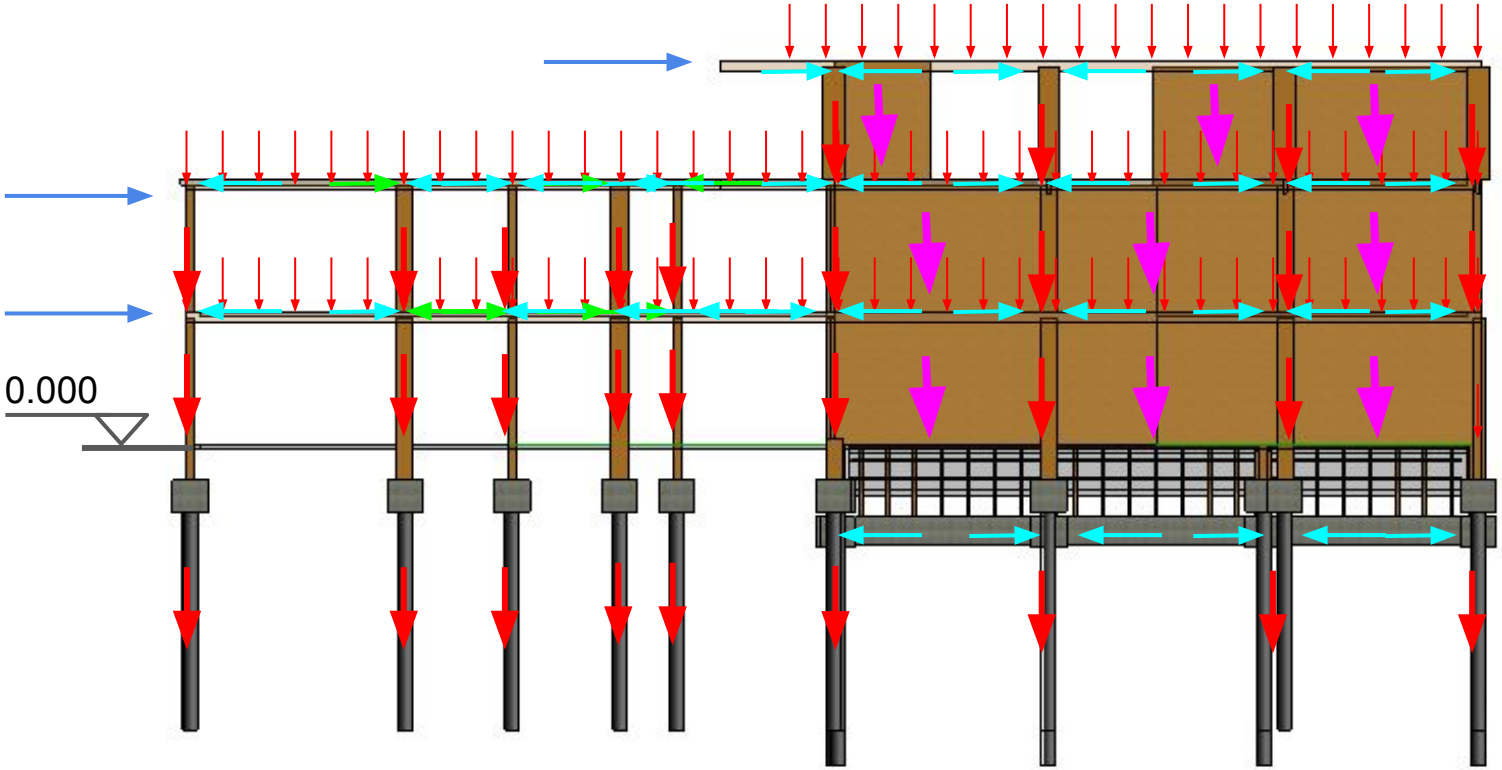


S.M.A.R.T Concept



North Elevation of the Steel + Concrete system

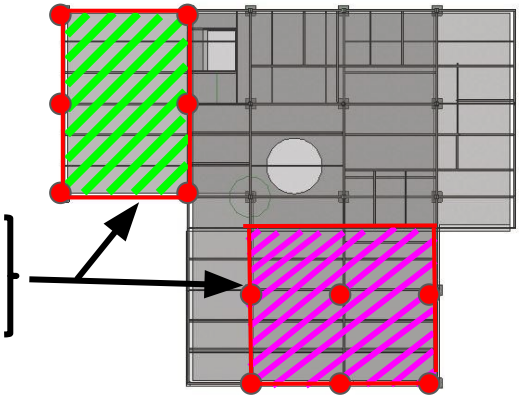
Steel/Concrete Load Path

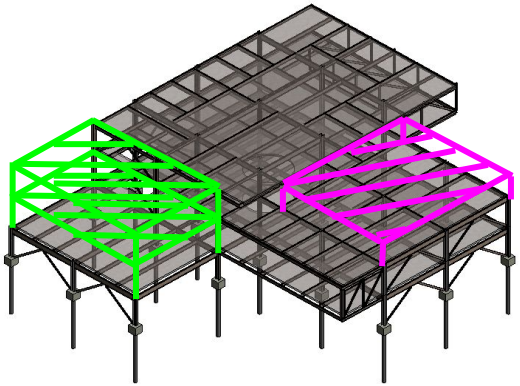


East Elevation of the Timber + Concrete system

Timber Load Path

- Frames overly designed for three floors
- Ready for adding boxes in the future



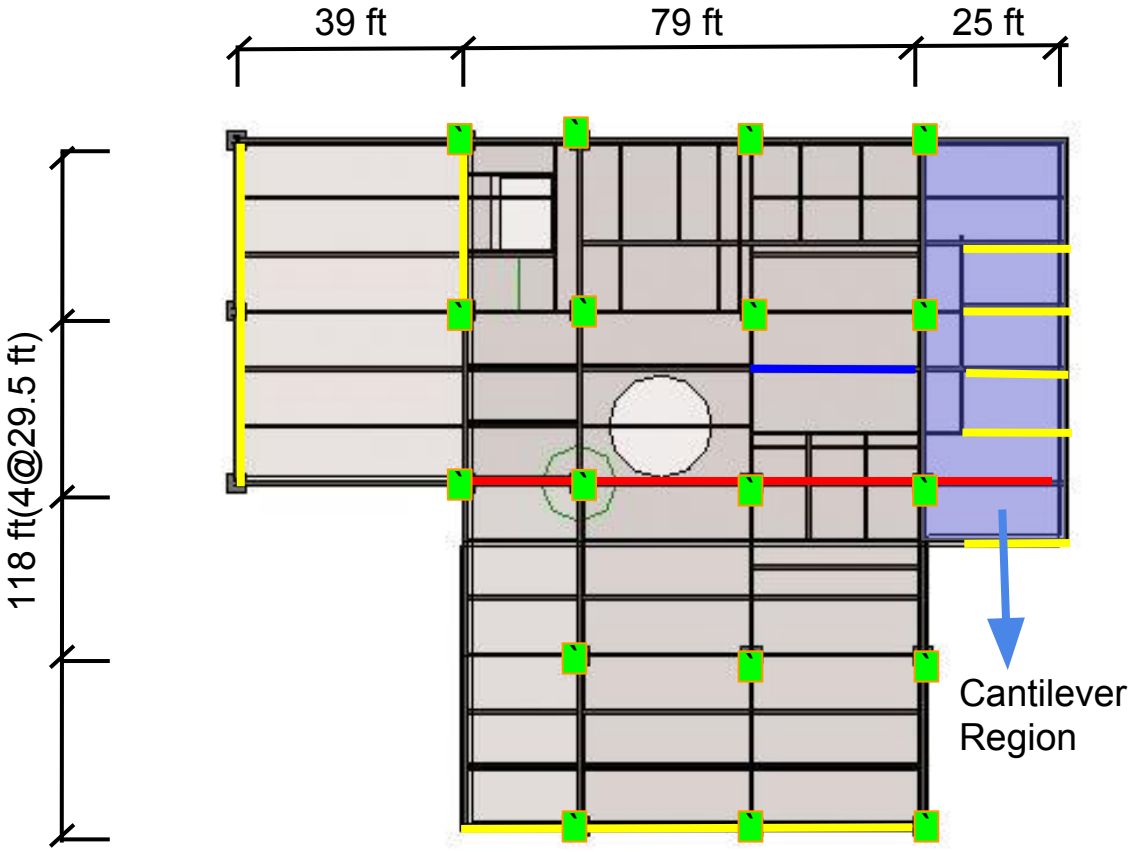


Possible connection ideas:

- Bolt connections for steel
- Mechanical connections for timber
- Easy panel connections for CLT slab

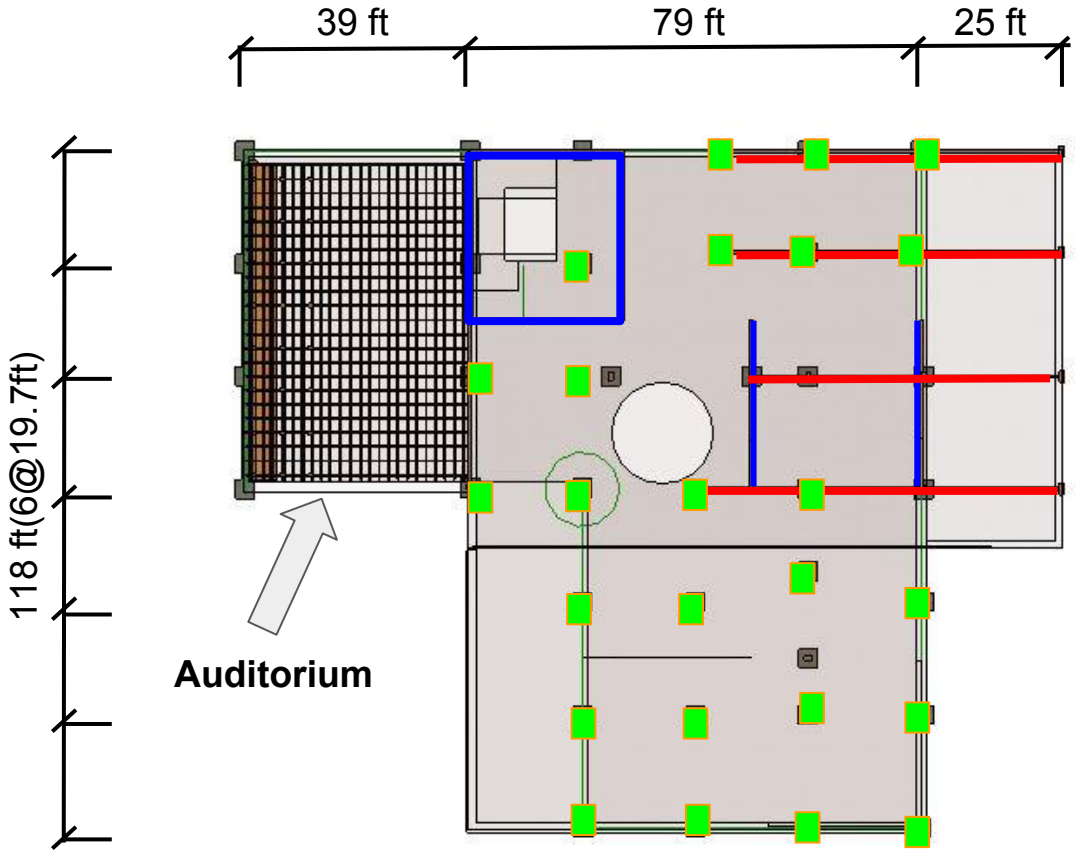
Easy to remove in the future!

S.M.A.R.T Adaptability - *Ready for the Future*

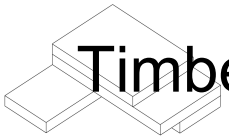


Member	Dimension
Concrete slab	6” concrete
Steel girder	W24x55
Steel beam	W18x35
Steel column	W14x99
Steel brace	W8x10

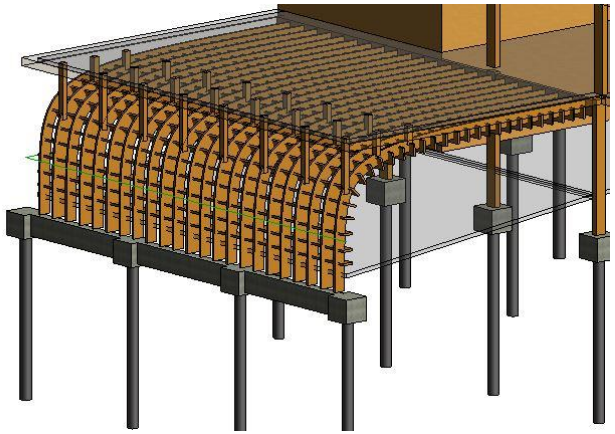
Steel/Concrete

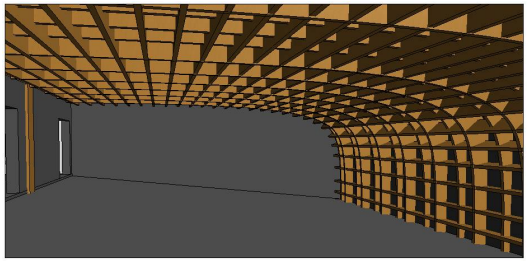


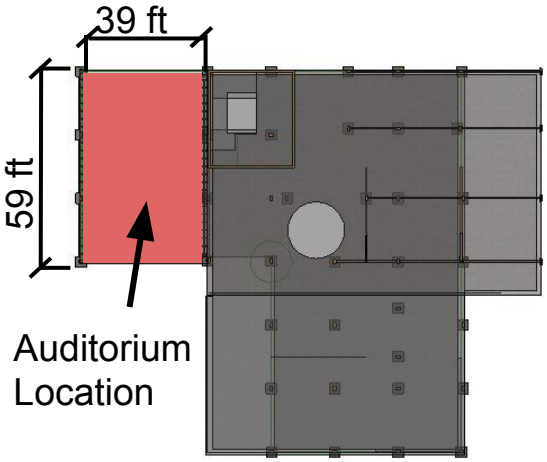
Member	Dimension
CLT-Concrete slab	4” concrete 8” CLT
Timber girder	Glulam 8.75 x24
Timber column	Glulam 8.75 x10.5
CLT shear wall	6” thick



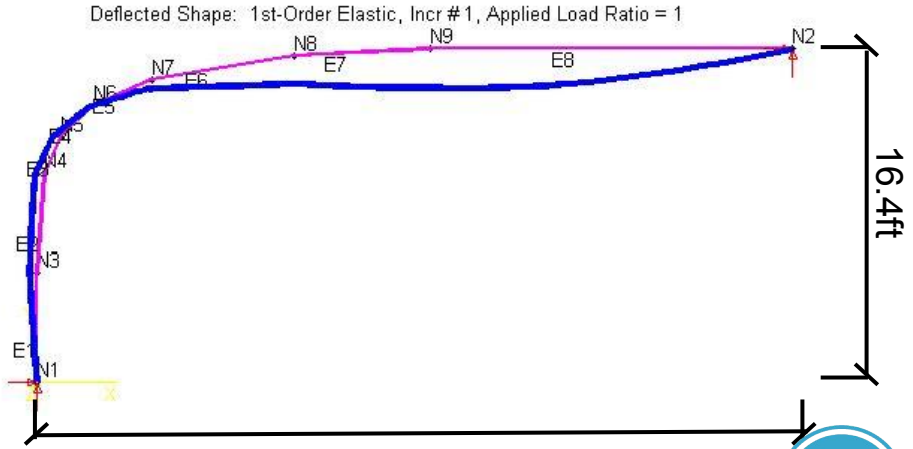
Timber





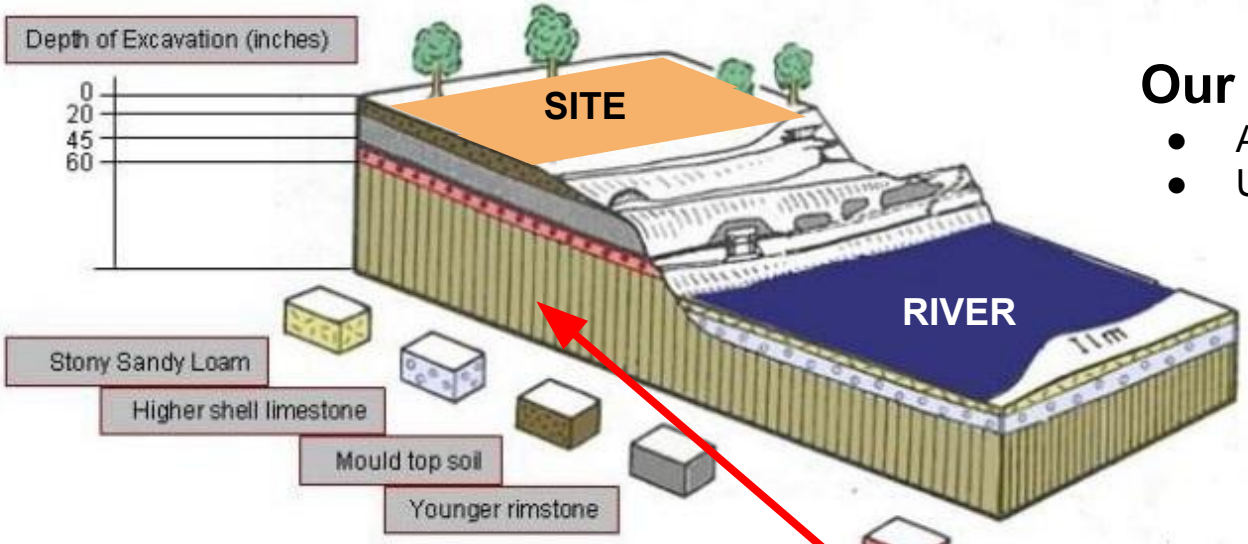


- **Arch. section**: Glulam 3.215”x18”
- **Arch. Spacing**: 2.5 ft



Timber Auditorium Solution

Soil Condition



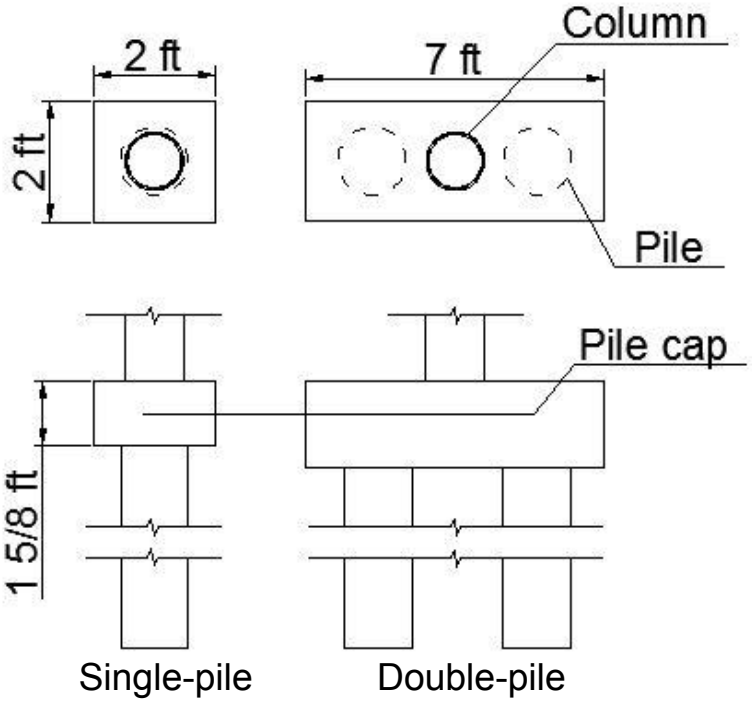
Our Solution:

- Avoid excavating too much
- Use pile foundations

'No Building' & S.M.A.R.T

Foundation Design

Single-pile/Double-pile cap



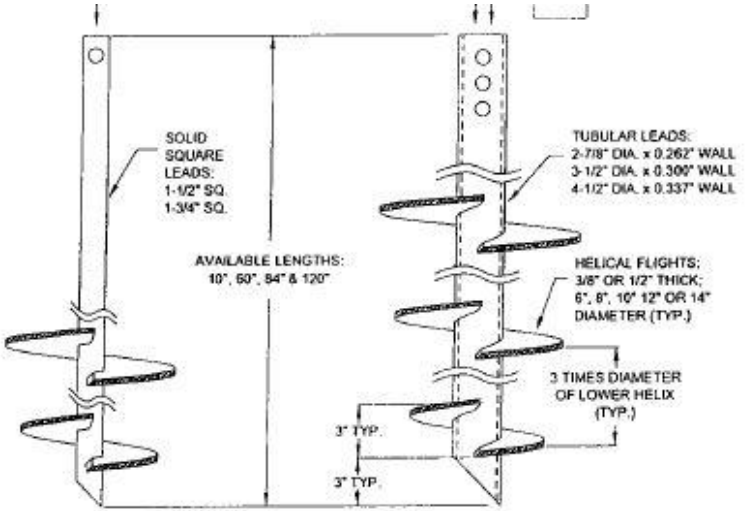
‘No Building’ & S.M.A.R.T

Pile Selection: Helical pile

- Length:10ft
- Size: shaft 2-7/8”, helical plate 10”
- Bearing capacity: 223 kips

Why choosing it :

- Smaller size
- Less noise (smaller environmental impact)
- Avoid dewatering (save money)



‘No Building’

S.M.A.R.T

Mechanical Engineer

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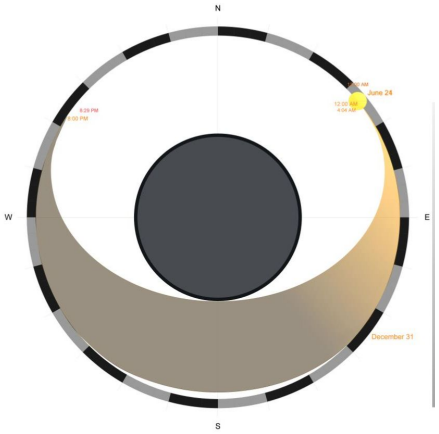
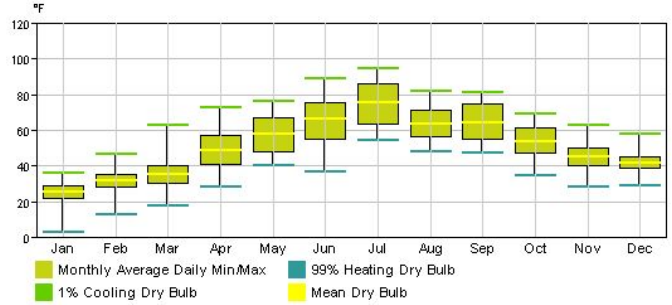
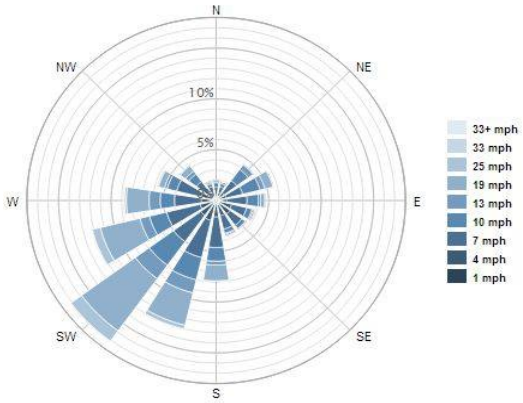
Sun



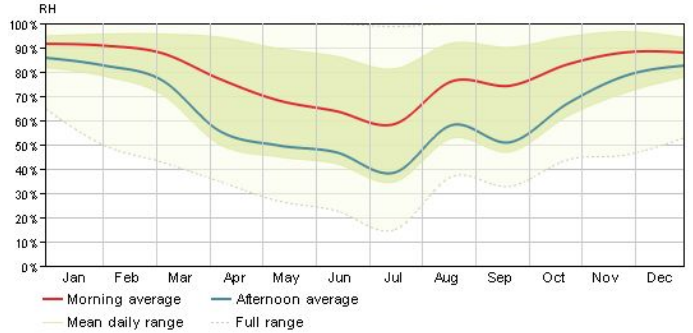
Seasons



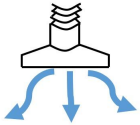
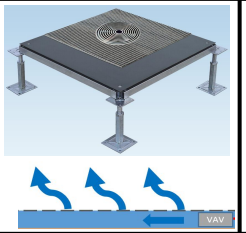
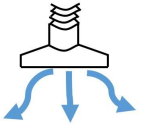
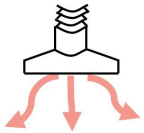
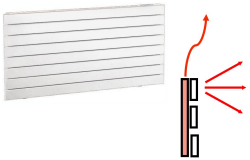
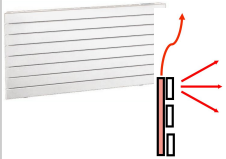
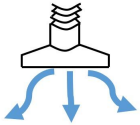
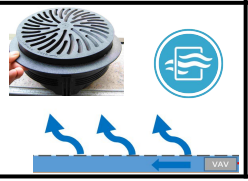
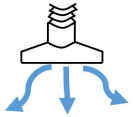
Wind



Humidity



Weather Challenges

	VRF Heat & Cool		UFAD + Radiant Heat		VRF + Radiant Heat	
	Primary	Secondary	Primary	Secondary	Primary	Secondary
Ventilation Dehumidification						
Heating						
Cooling						

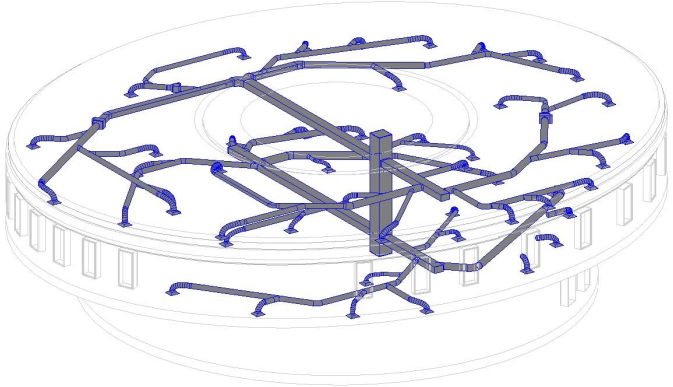
HVAC Equipment

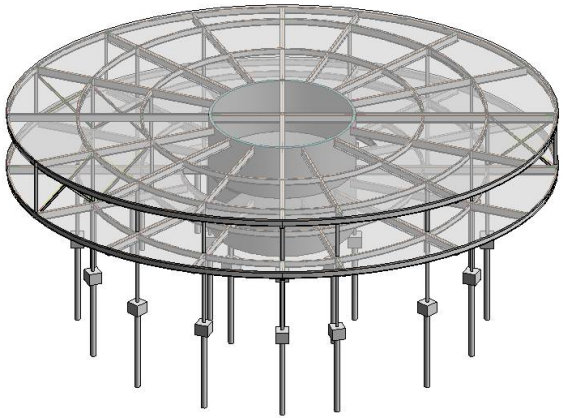
	VRF Heat & Cool	UFAD + Radiant Heat	VRF + Radiant Heat
Distribution Sizes	20” x 12” Supply 20” x 12” Exhaust	14” x 8” Exhaust 2” Pipe 12” Floor Supply Plenum	2” HHW Pipe 18” x 10” Supply 18” x 10” Exhaust
Pros	Lowest Overall First Cost Potential for net-zero carbon (all electric) Least Equipment Needed Smallest equipment rooms Least roof space required	Lower HVAC Costs - $1 to $2/SF Less Best Flexibility - Adaptable Floor Diffusers Best Indoor Air Quality - stratification Lowest Energy - Low friction (fan energy) Meets STV with minimal PV Very Quiet System	Excellent user control and comfort Least space requirements for ductwork Good energy efficiency
Cons	Highest Energy Consumption Most carbon emission (without onsite renewable generation) Costly PV to meet STV target	Higher Floor Cost - $7 to $8 More Most vertical height needed Highest maintenance costs Boiler emissions on-site	Higher upfront costs Unable to meet net-zero carbon with on-site boiler emissions

HVAC Decision Matrix

	VRF Heat & Cool	UFAD + Radiant Heat	VRF + Radiant Heat
Floor Sandwich Impact	20” x 12” AVERAGE	14” x 8” WORST 2” Pipe 12” Floor Plenum	18” x 10” BEST
Pros	Lowest First Cost Zero Onsite Emissions	Best Efficiency Best Air Quality Best User Control	Low Energy Cost Best Thermal Comfort
Cons	Highest Energy Cost	Highest First Cost Highest Maintenance	Average Annual Cost

HVAC Decision Matrix

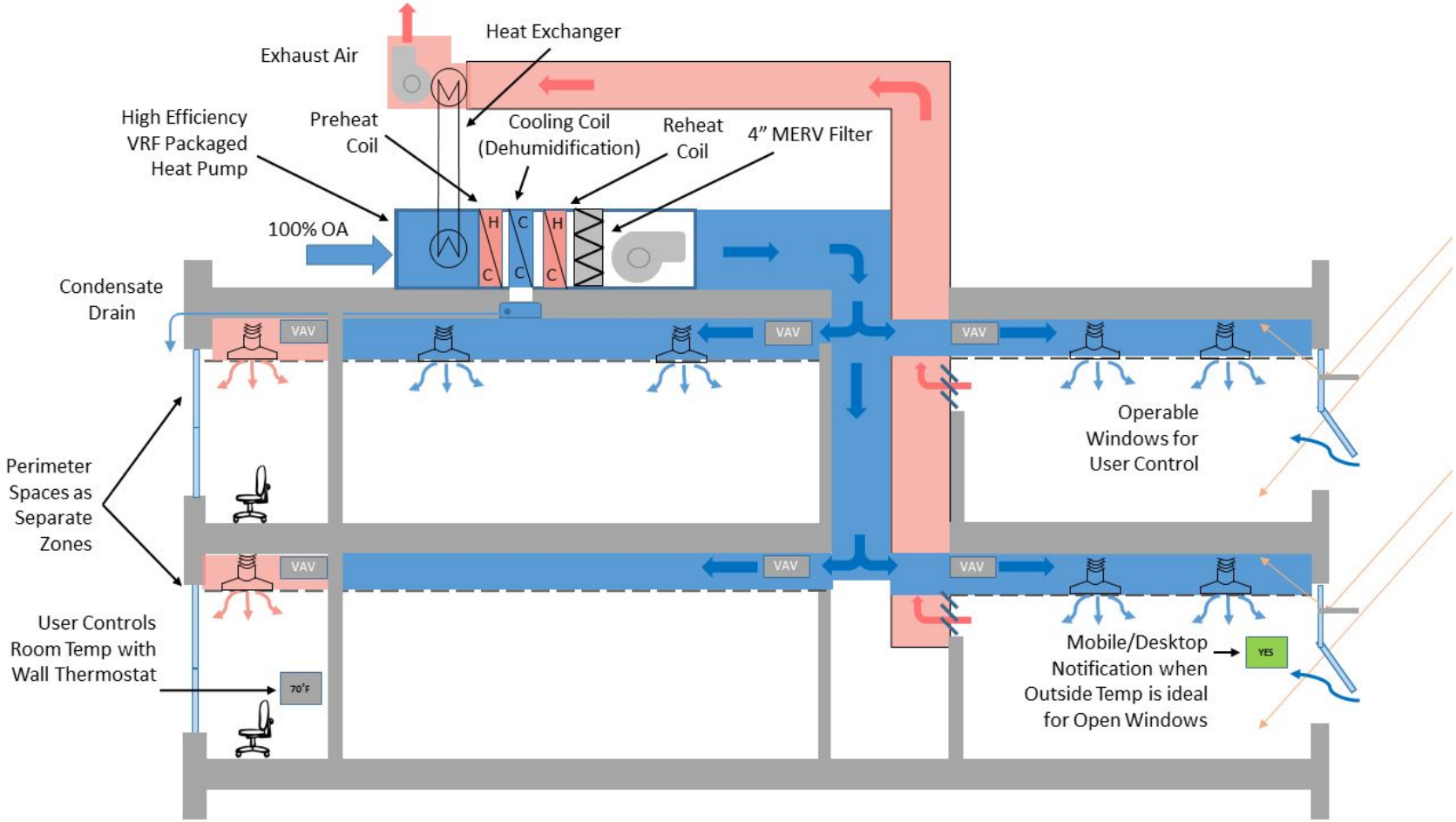




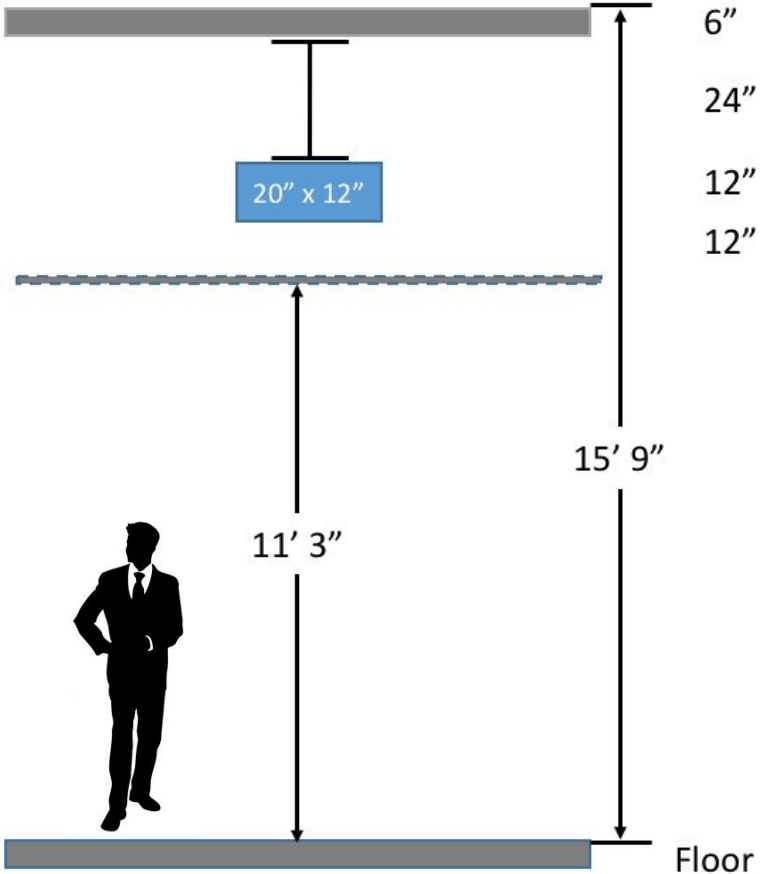
Packaged Heat Pump Unit

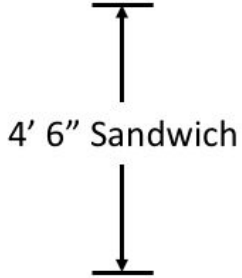
Ceiling Diffusers

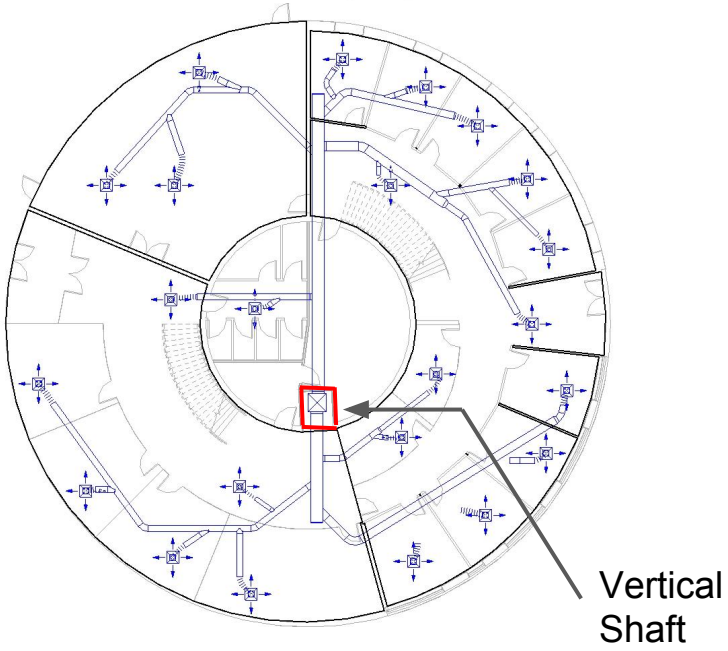
No Building Steel - VRF Heat & Cool



VRF Heat & Cool System Diagram

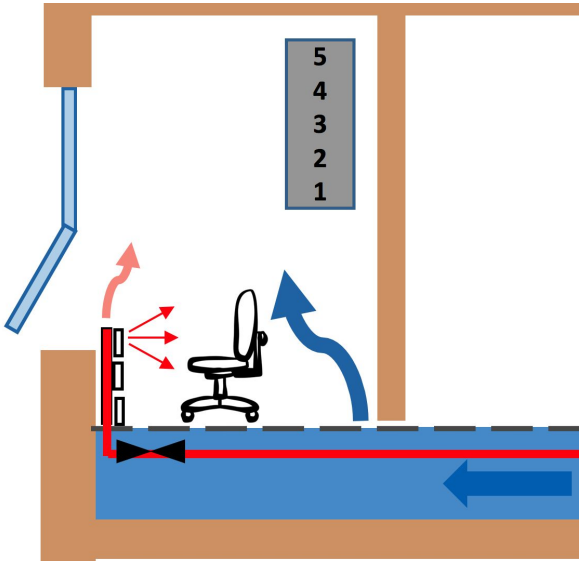






VRF Heat & Cool Floor Sandwich & Plan

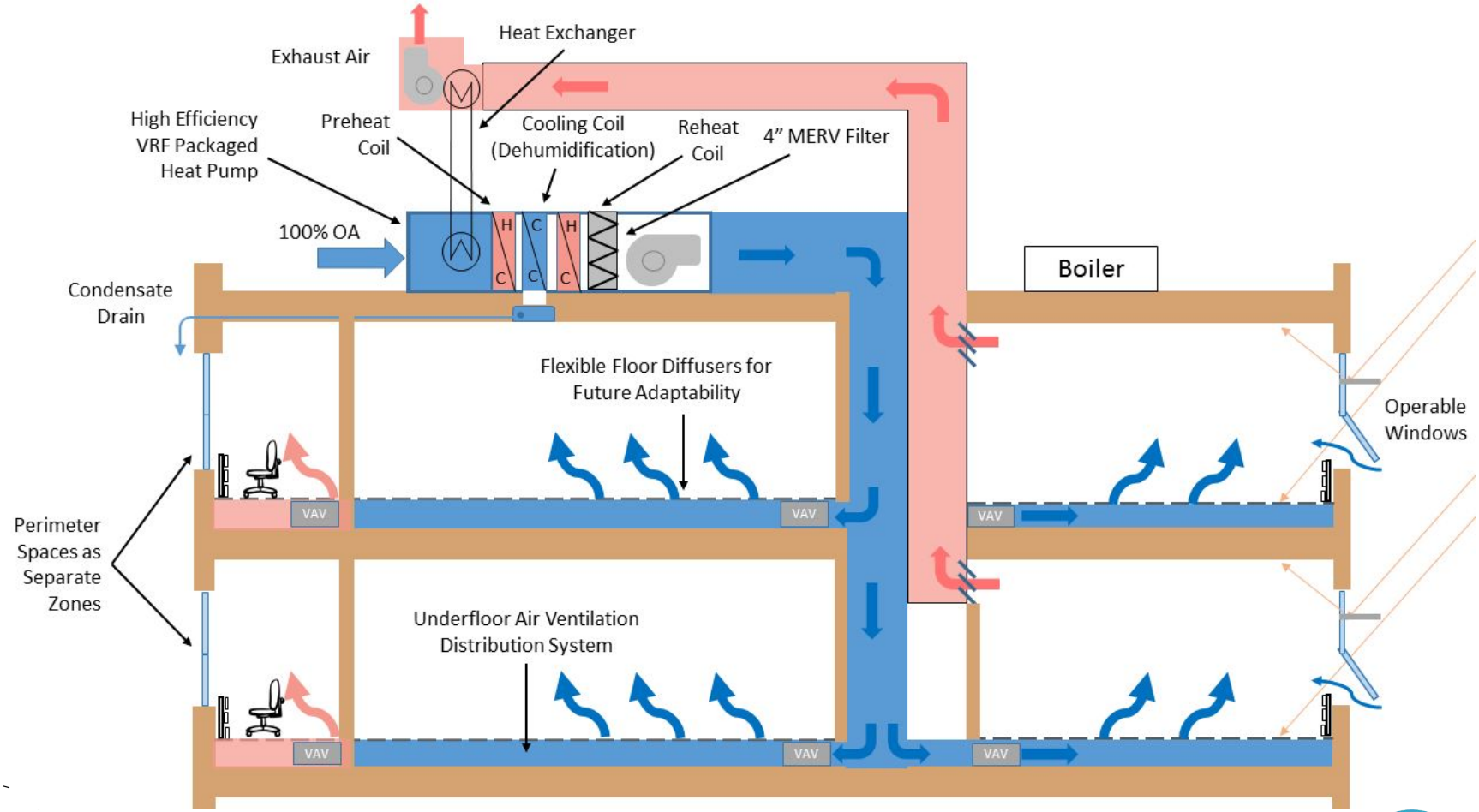
Packaged Heat Pump Unit



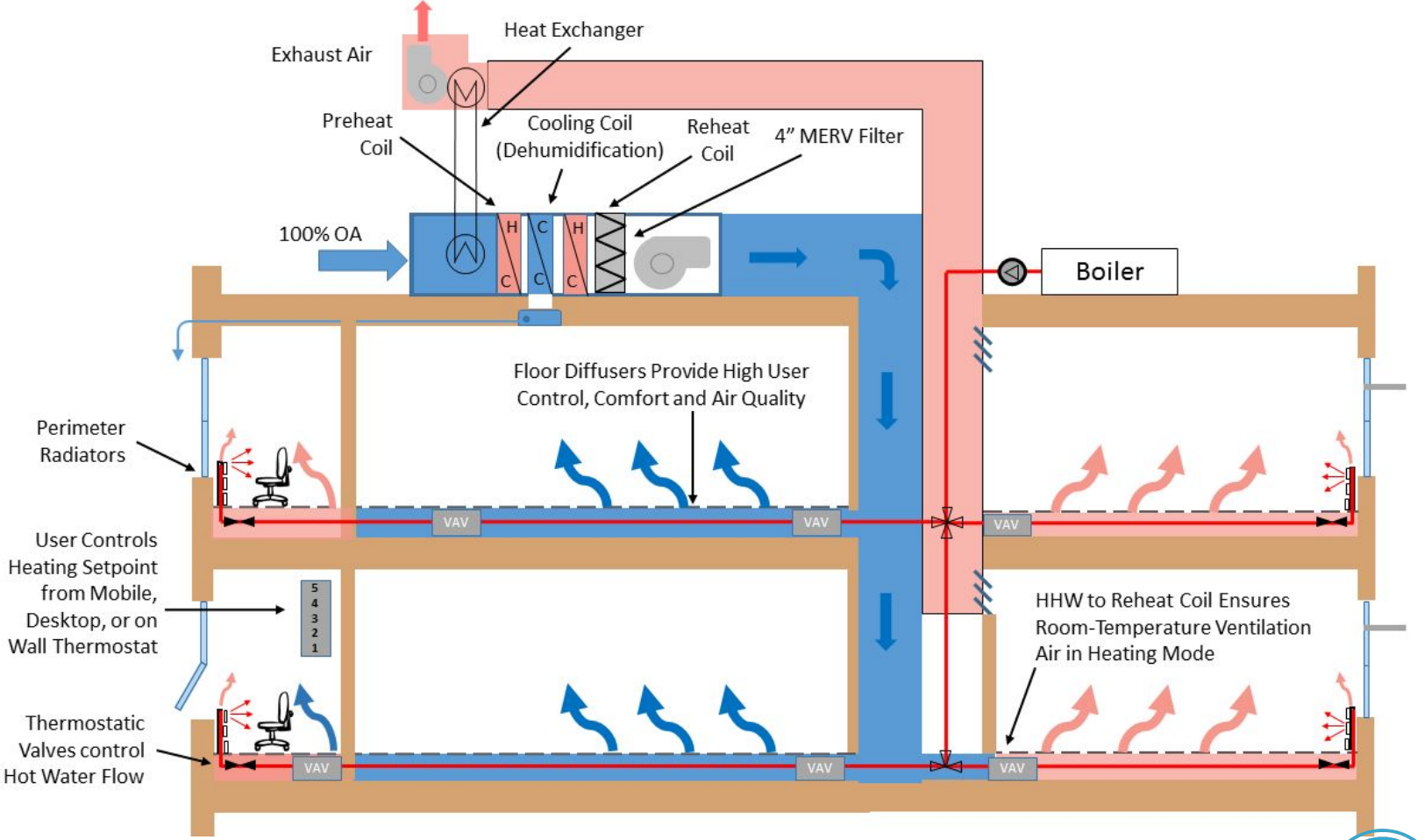
Underfloor Air Distribution

Perimeter Radiant Heat

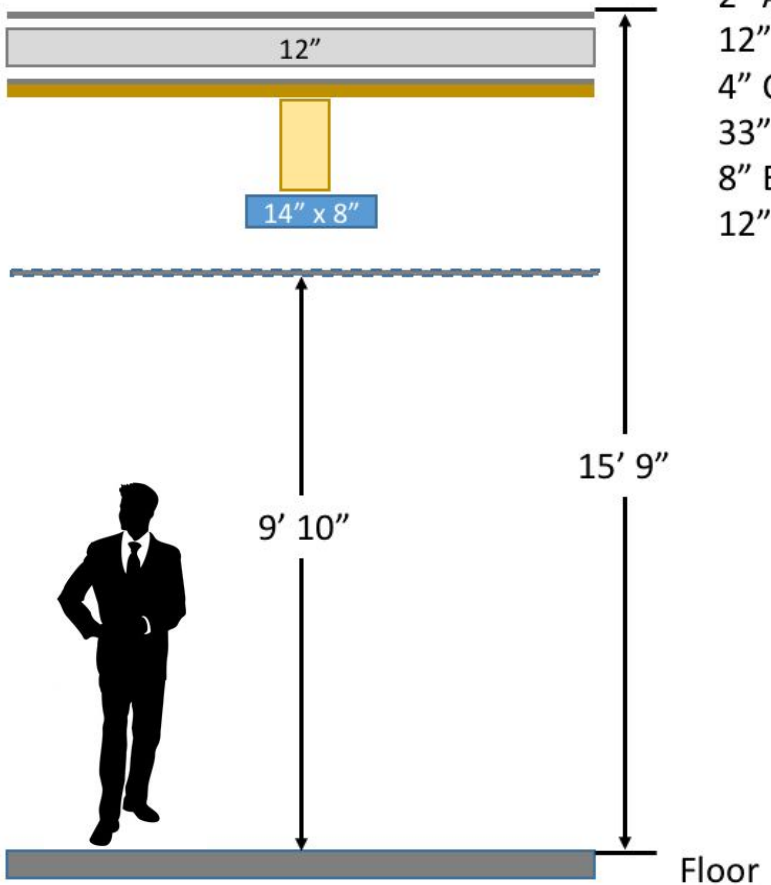
No Building Timber - UFAD + Radiant Heat



UFAD Ventilation



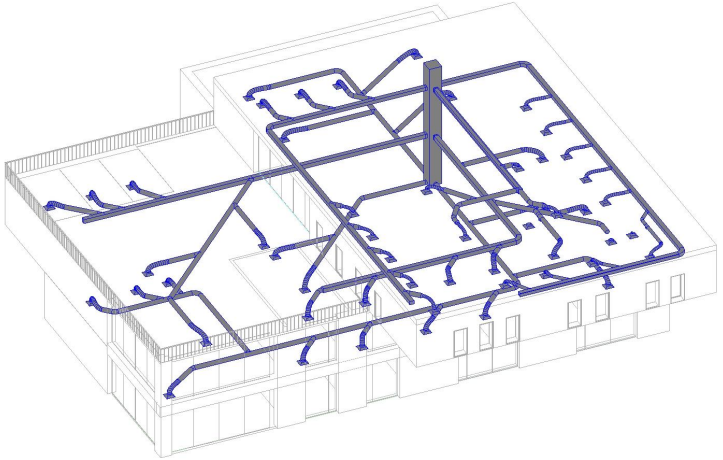
UFAD Thermal Comfort



2” Architectural Floor
12” Floor UFAD Plenum
4” CLT Slab
33” Glulam
8” Exhaust Duct
12” Space

5’11” Sandwich

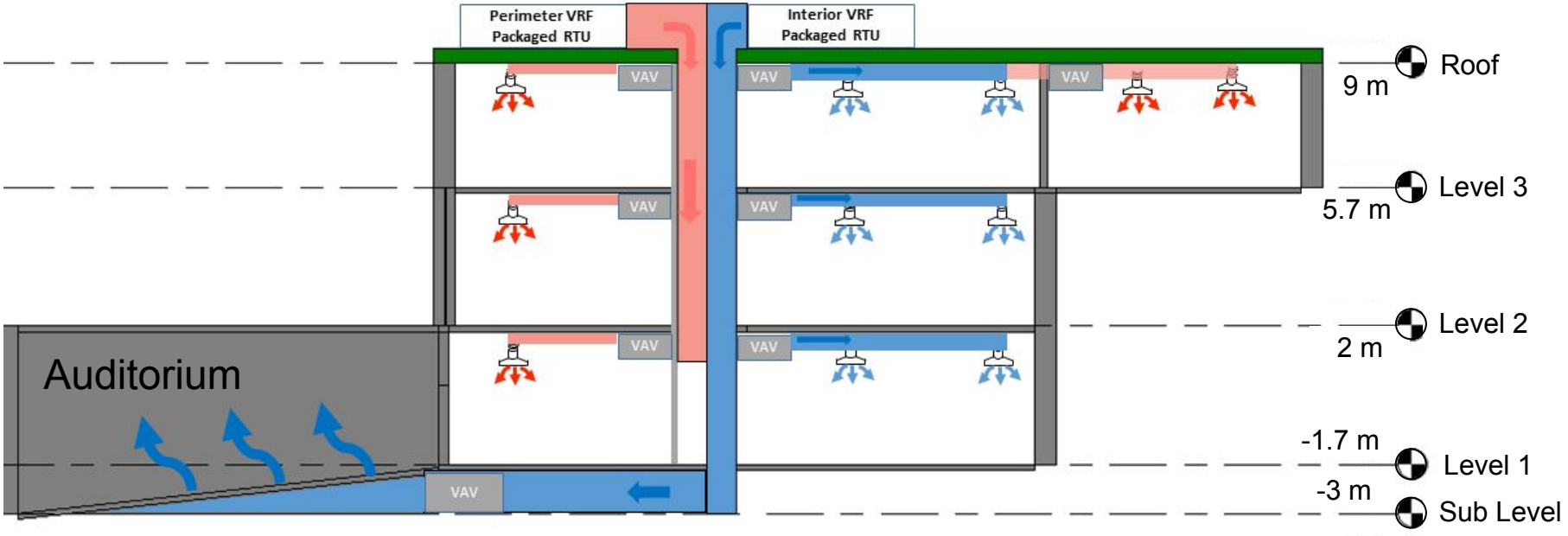
UFAD Floor Sandwich



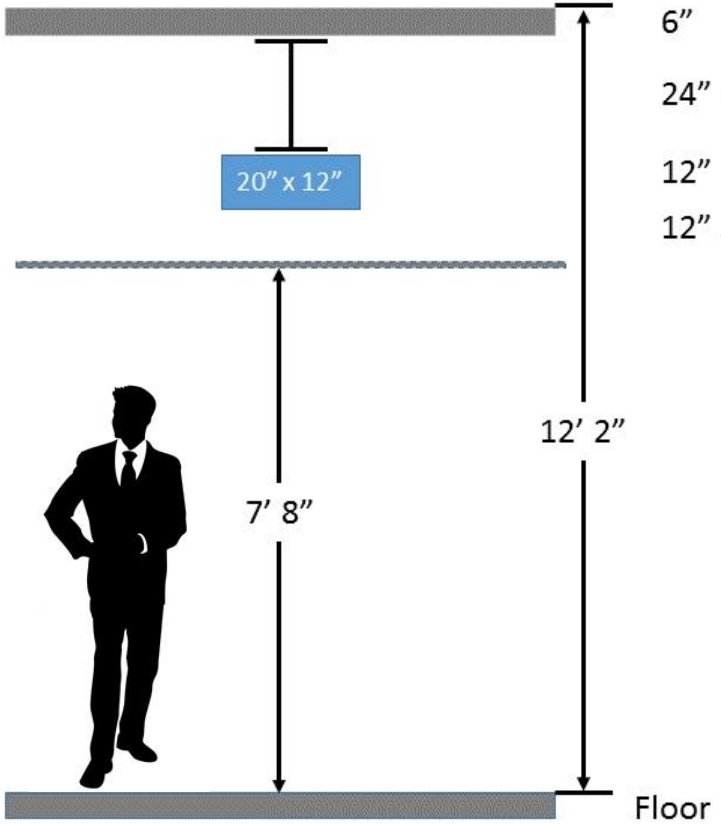
Packaged Heat Pump Unit

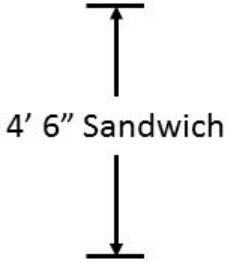
Ceiling Diffusers

S.M.A.R.T. - Steel - VRF Heat & Cool

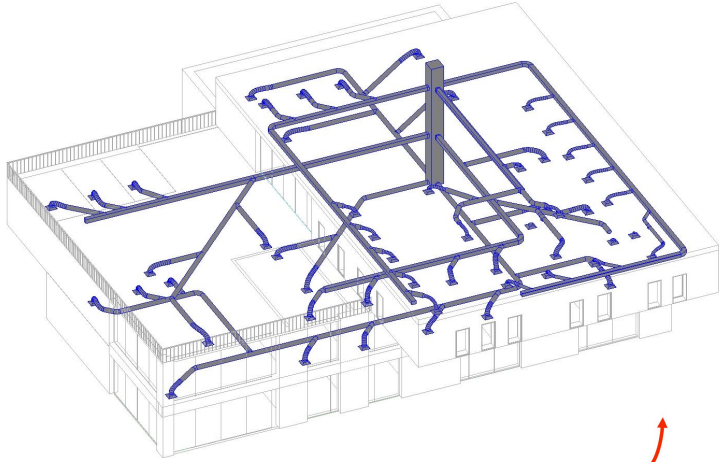


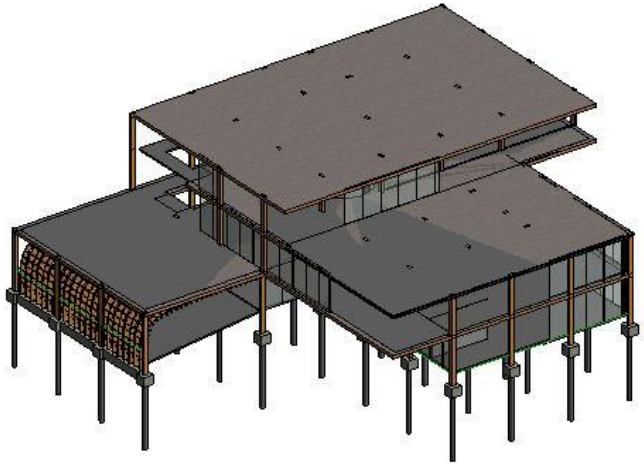
VRF Heat & Cool



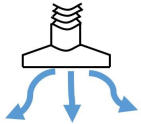


VRF Heat & Cool

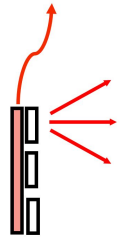




Packaged Heat Pump Unit

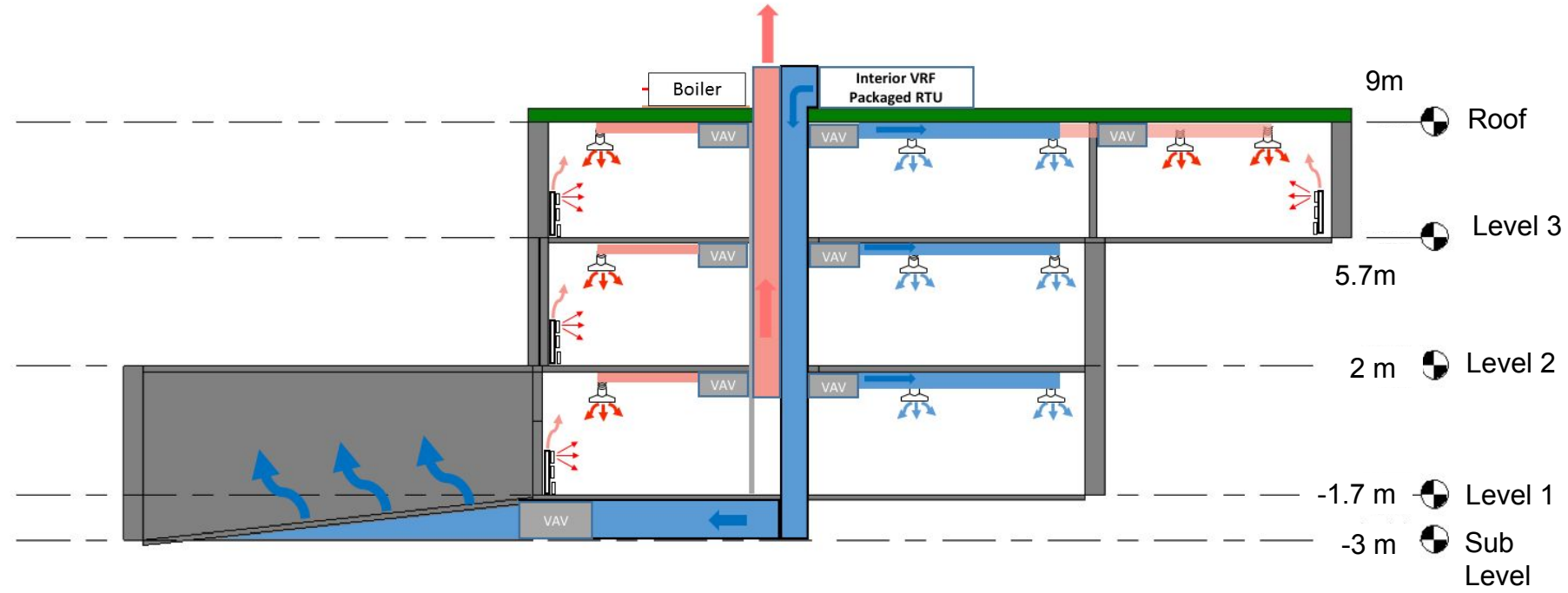


Ceiling Diffusers

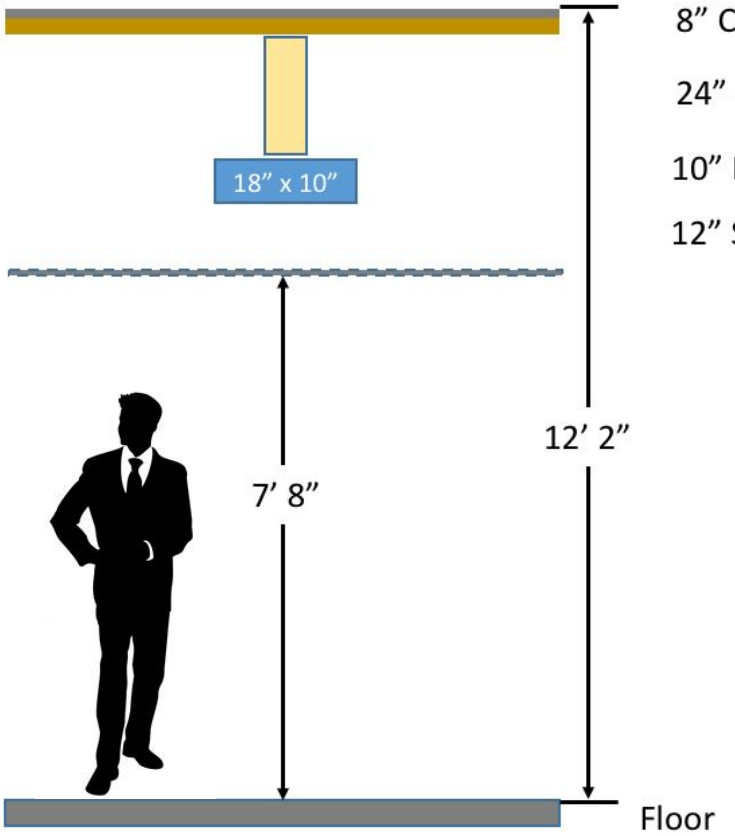


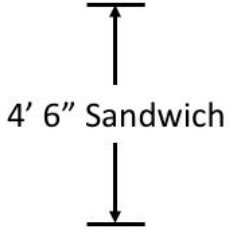
Perimeter Radiant Heat

S.M.A.R.T. - Timber - VRF + Radiant Heat

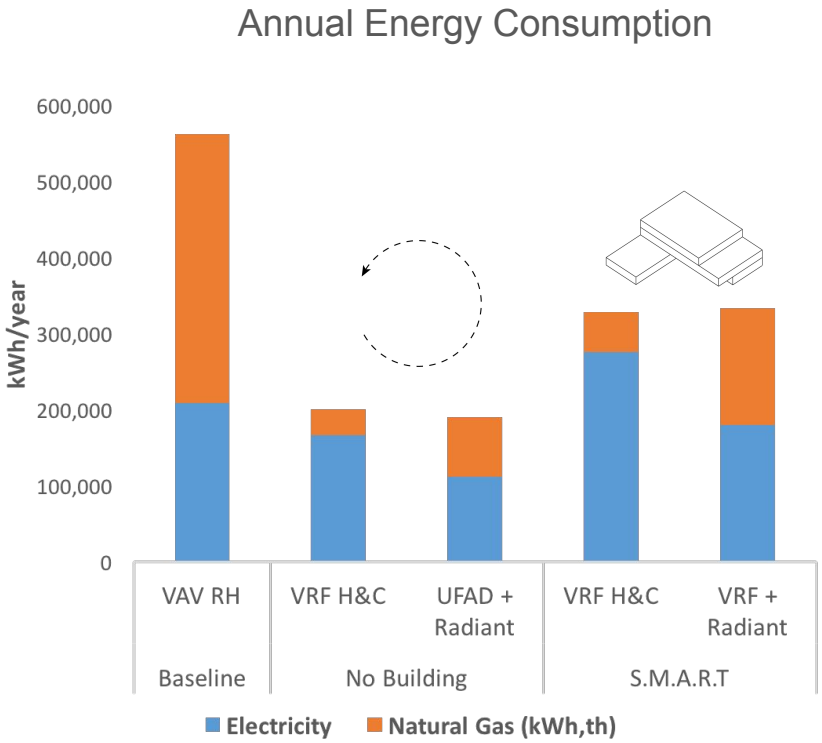


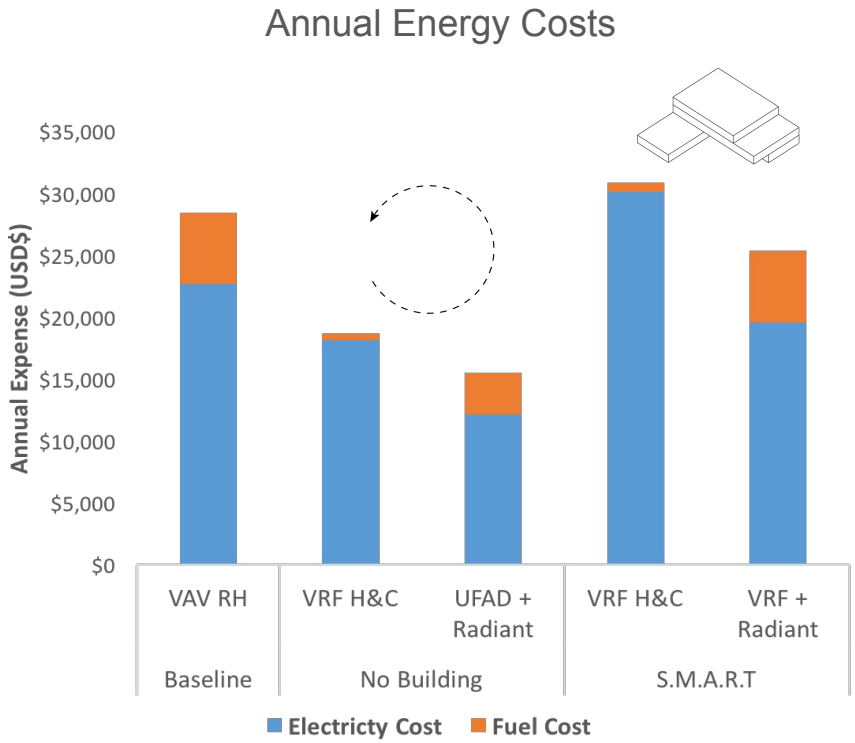
VRF + Radiant Heat



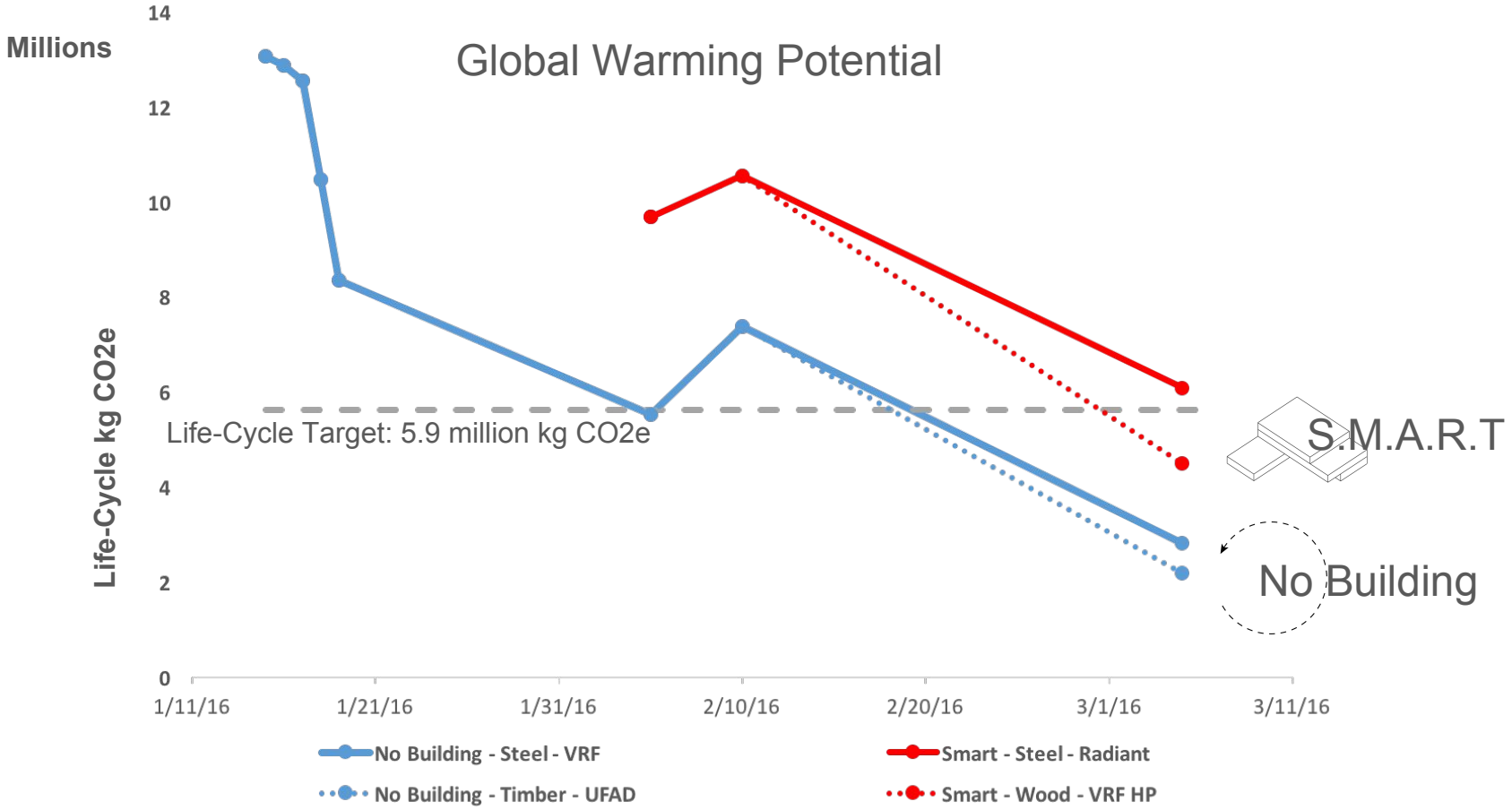


VRF + Radiant Heat





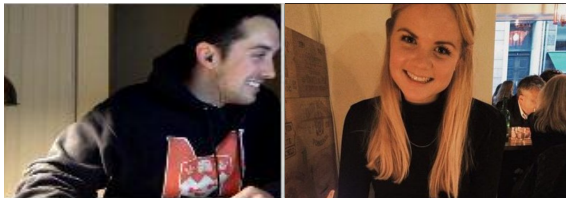
Comparing Energy Use of Design Alternatives



Sustainable Target Value Progression

‘No Building’

S.M.A.R.T



Construction Managers

A

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P

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L
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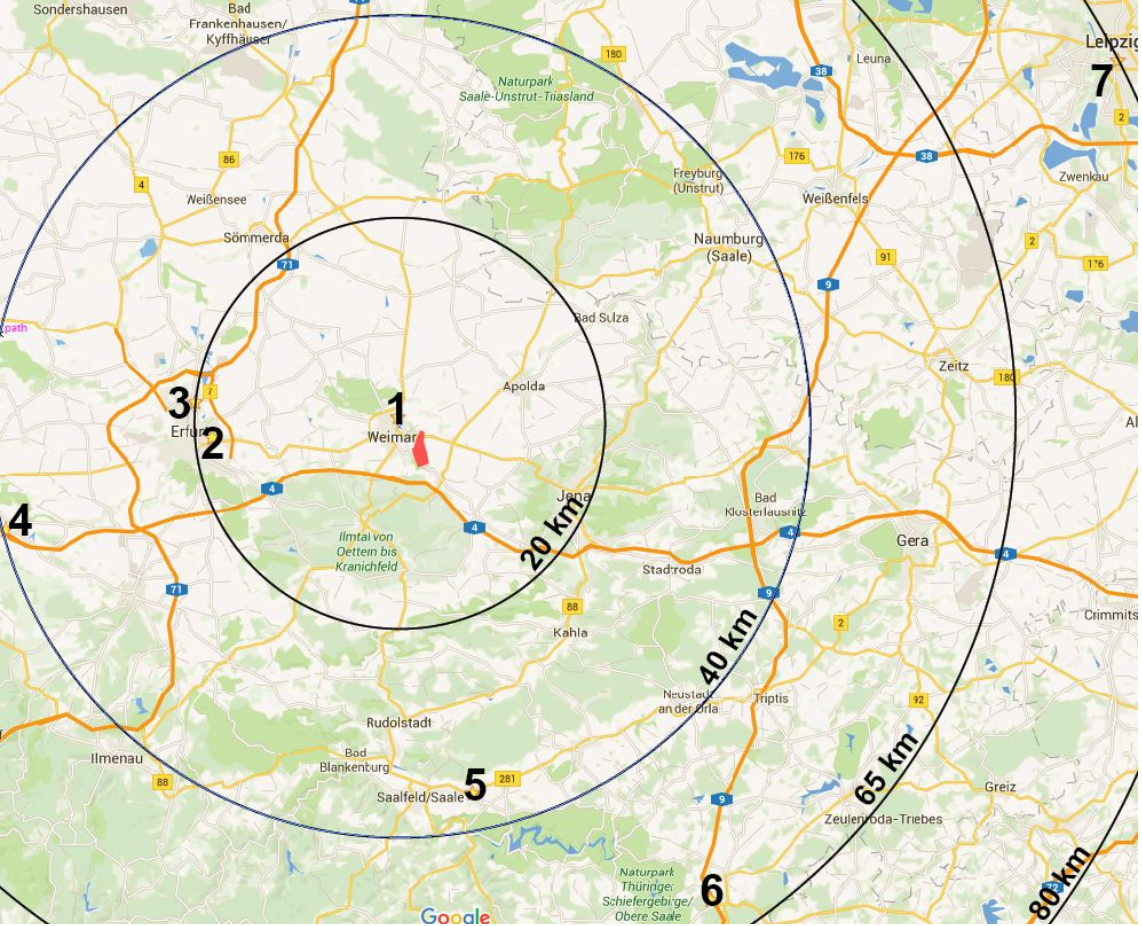
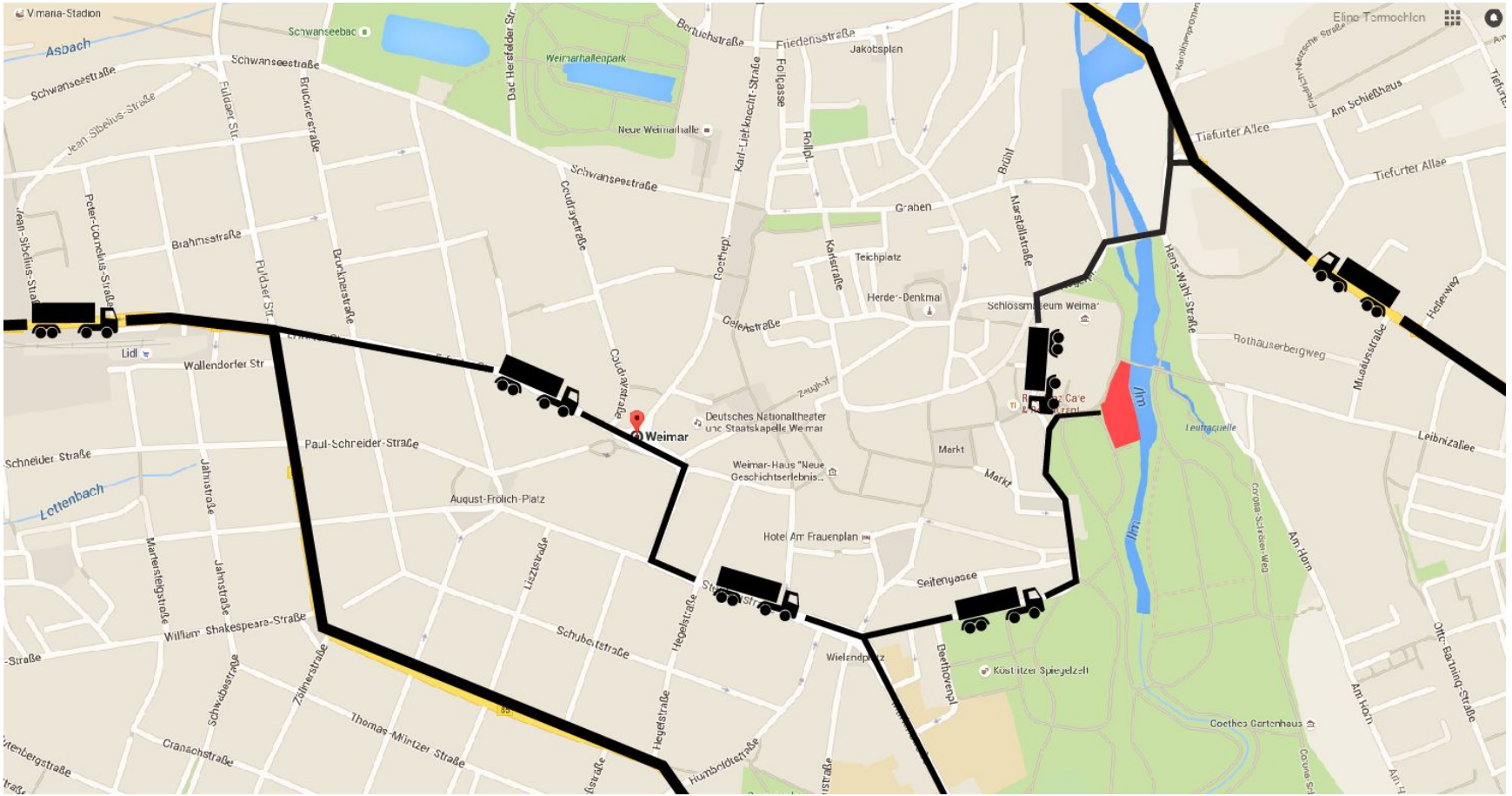
F
M

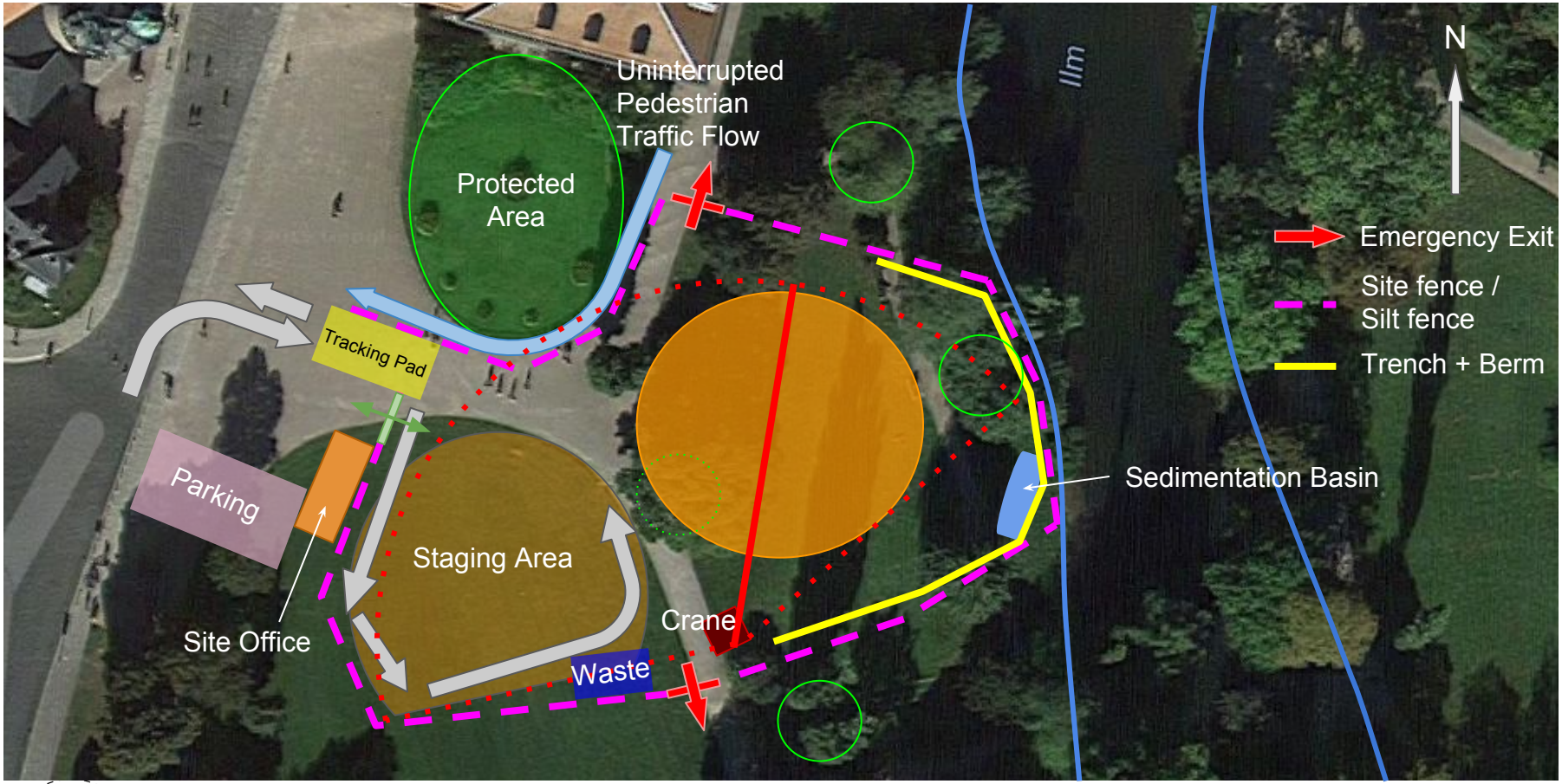


1. G&R
   Crane, Transport
2. Thyssen
   Steel, Cement, Systems
3. Loxan
   Rental Equipment
4. Thomas-Gruppe
   Concrete
5. Stahlwerk Thüringen
   Steel
6. RSP
   Excavation Equipment
7. FG
   Concrete

Map of Possible Suppliers with Distance to Site



Road Access to Site



Site Logistics

Site Logistics

POTAIN® by Manitowoc Igo T 85 A

Specifications

- **38 m Height (124.7 ft)**
- **45 m Radius (146.7 ft)**
- **6 t Max Cap.**
- **1.4 t Tip Cap.**

Supplier: Potain Cranes in Edersleben, Germany (65 km from site)

Price: $1,250 /week vs. $3,900 /week (Mobile Crane) vs. $925 /week (Tower Crane)

Critical Pick: 1.1 t load at tip (20 ft long W24x55)

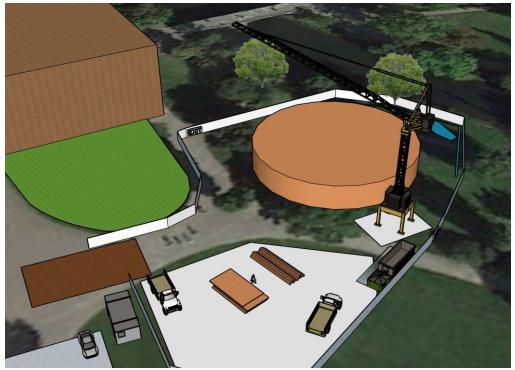
Selected Self-Erecting Crane

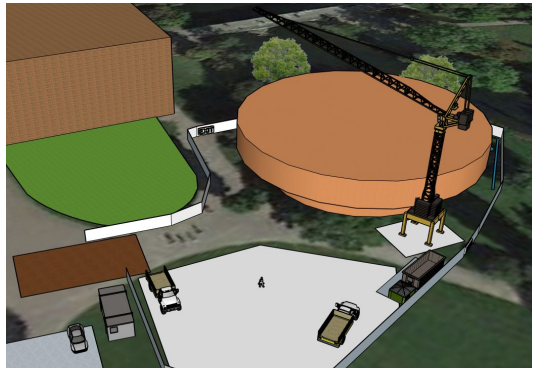
Steel/Concrete

Cast Concrete

Lab Finished

Timber

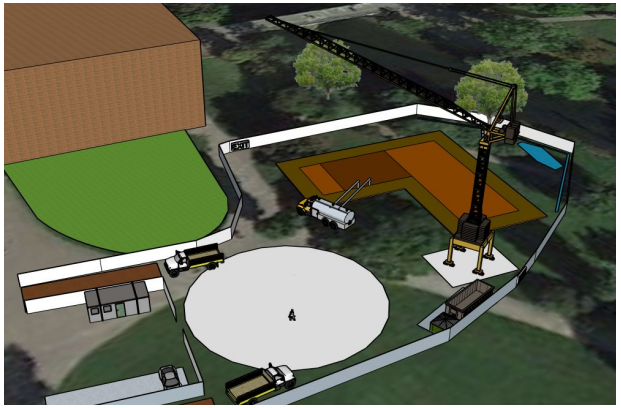




Building Finished

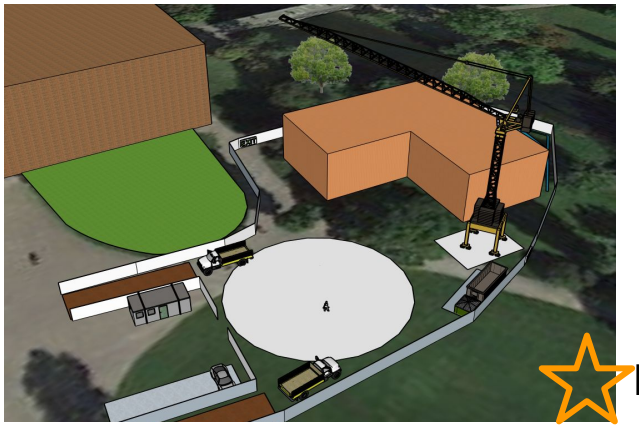
Critical Steps of Construction Process

Excavation



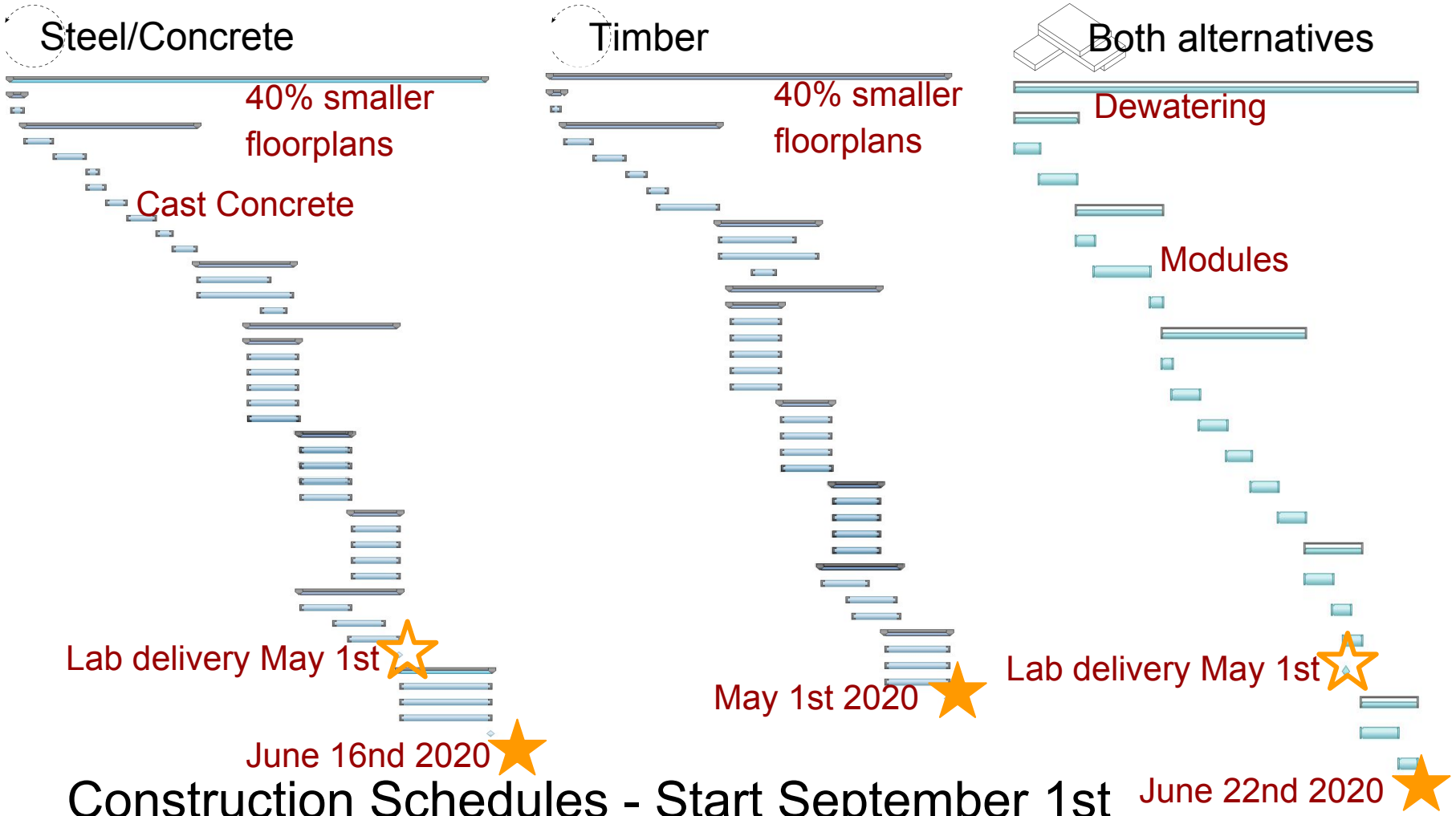
Dewatering

Modules



Lab Finished

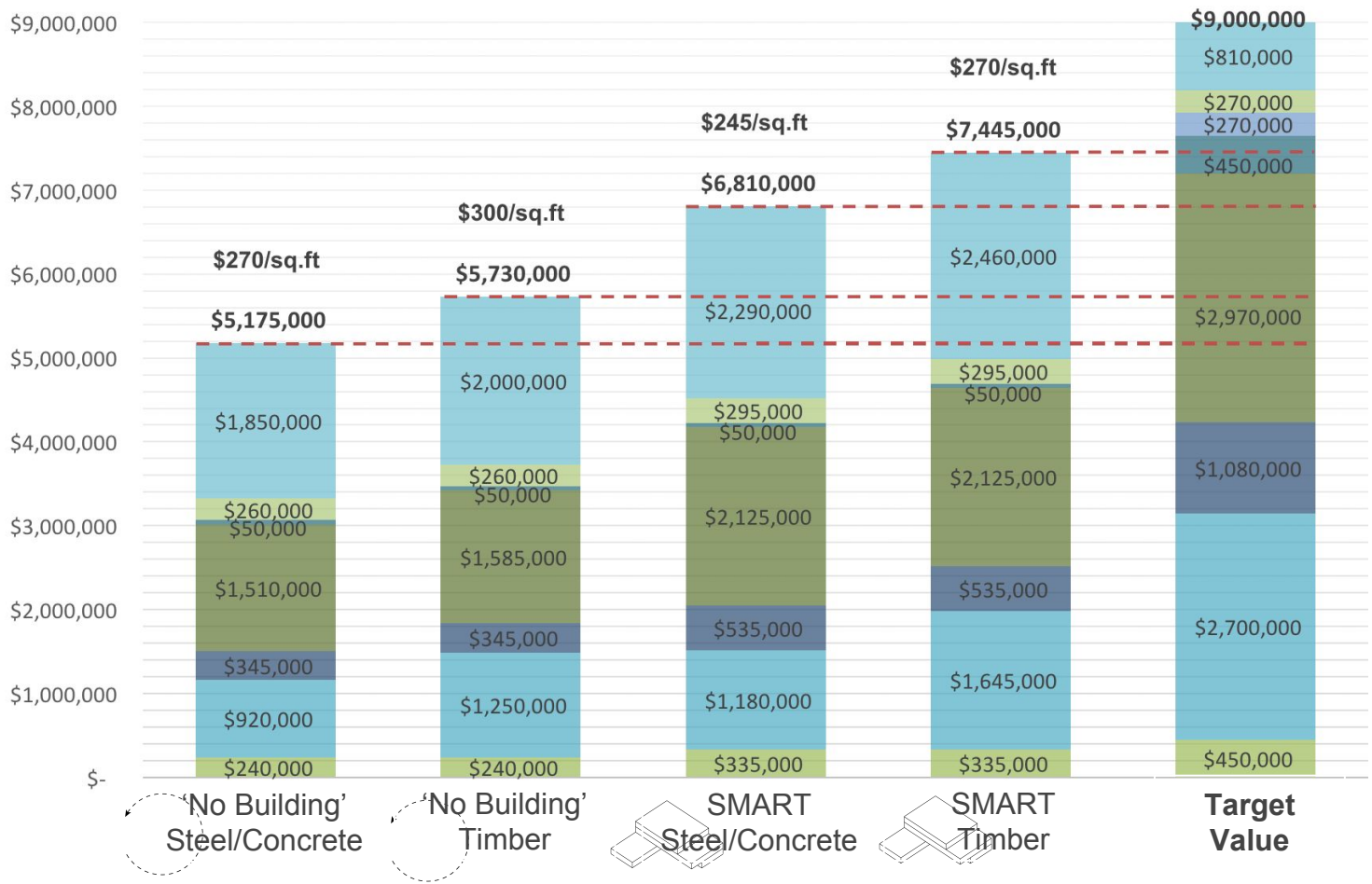
Critical Steps of Construction Process



Construction Schedules - Start September 1st

	Population	University	Density (per km²)	Construction Costs	Minimum wage
City of Weimar	65,000	Bauhaus	750	Average of $185/sq.ft for Building between 15k and 30k sq.ft (Local General Contractor)	$9.35 (€8.50)
	88,000	UC Santa Barbara	410	Average of $200/sq.ft for Building between 15k and 30k sq.ft (RS Means)	$10.00

RS Means - Comparable US City to Weimar, Germany

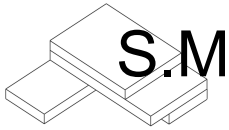


Target for 30,000 sq.ft: **$300/sq.ft**

Assumptions:
Construction Fees 25%
Insurance Fee 3%
Performance Bond 1%
Architectural Fees 9%,
Contingency 10%
LEED registration $3,500

'No Building' & S.M.A.R.T - TVD Comparison

‘No Building’



S.M.A.R.T

Life Cycle Financial Manager

A

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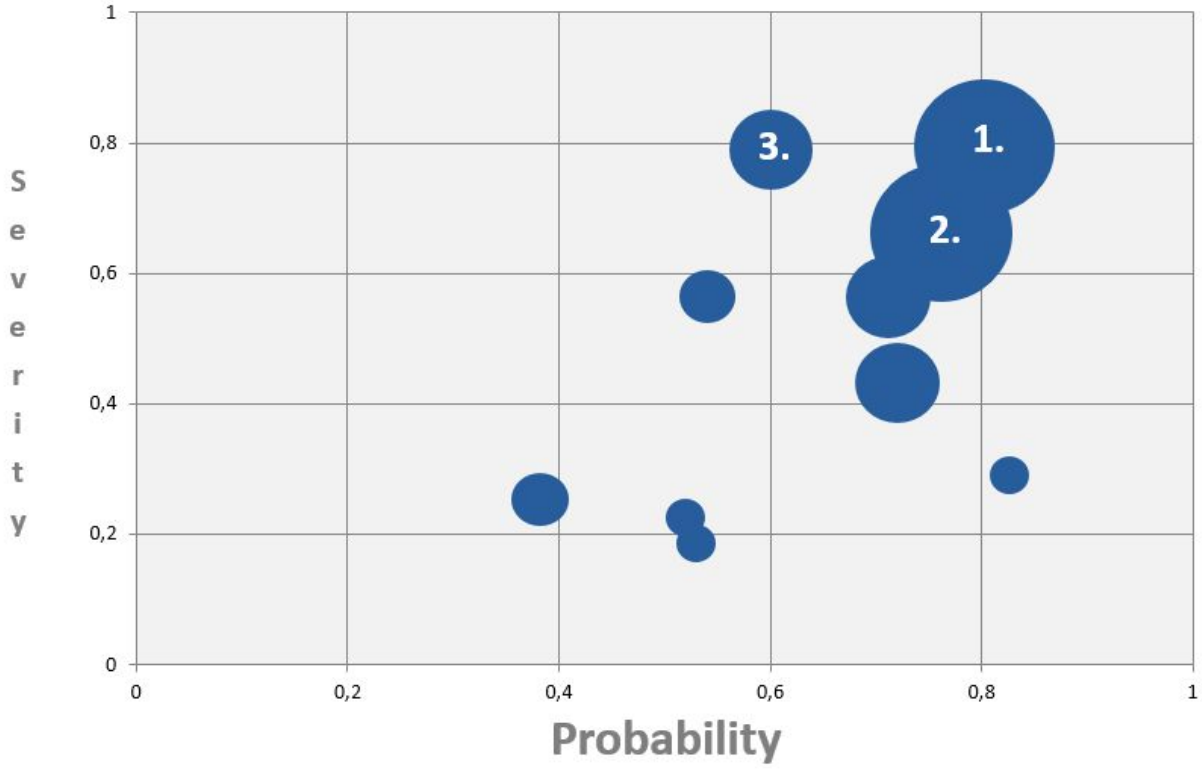
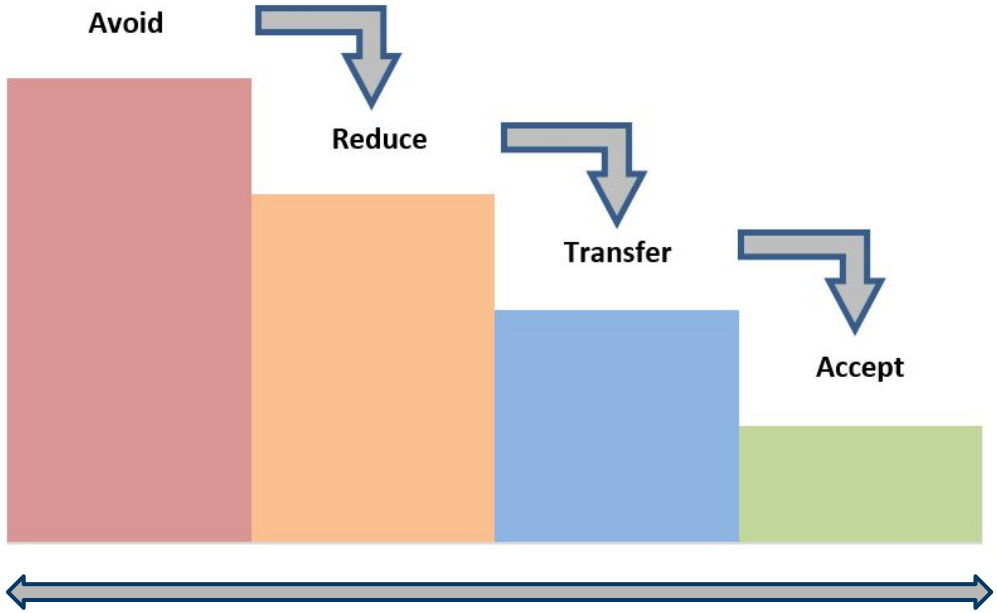
M

Risk Brainstorming

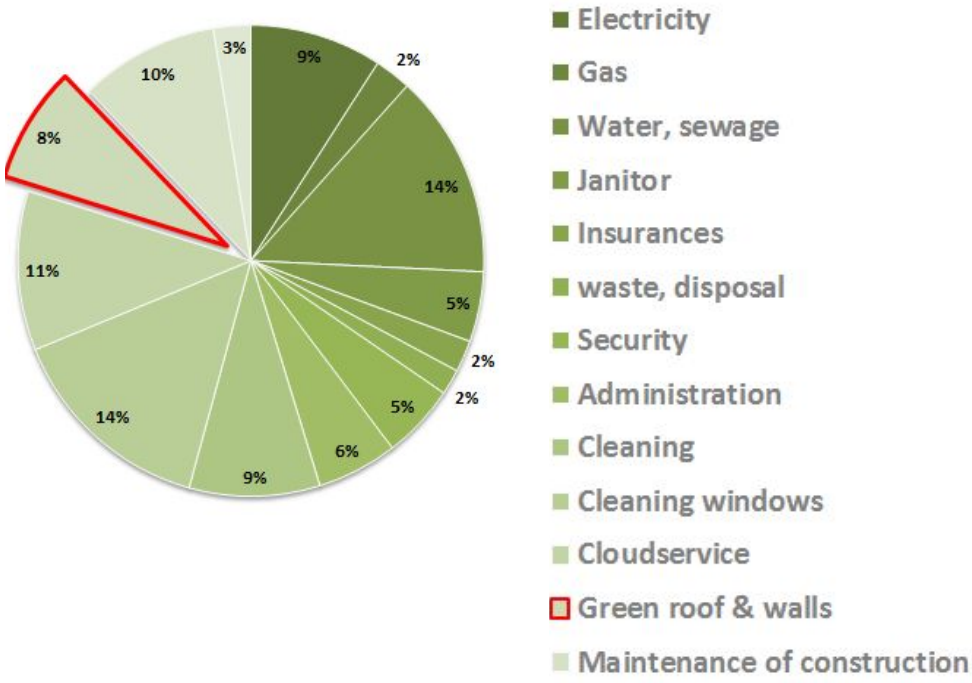


1. Flood risk
2. Vandalism and sabotage risk
3. High replacement costs because of cheap qualitiy materials

Risk Matrix

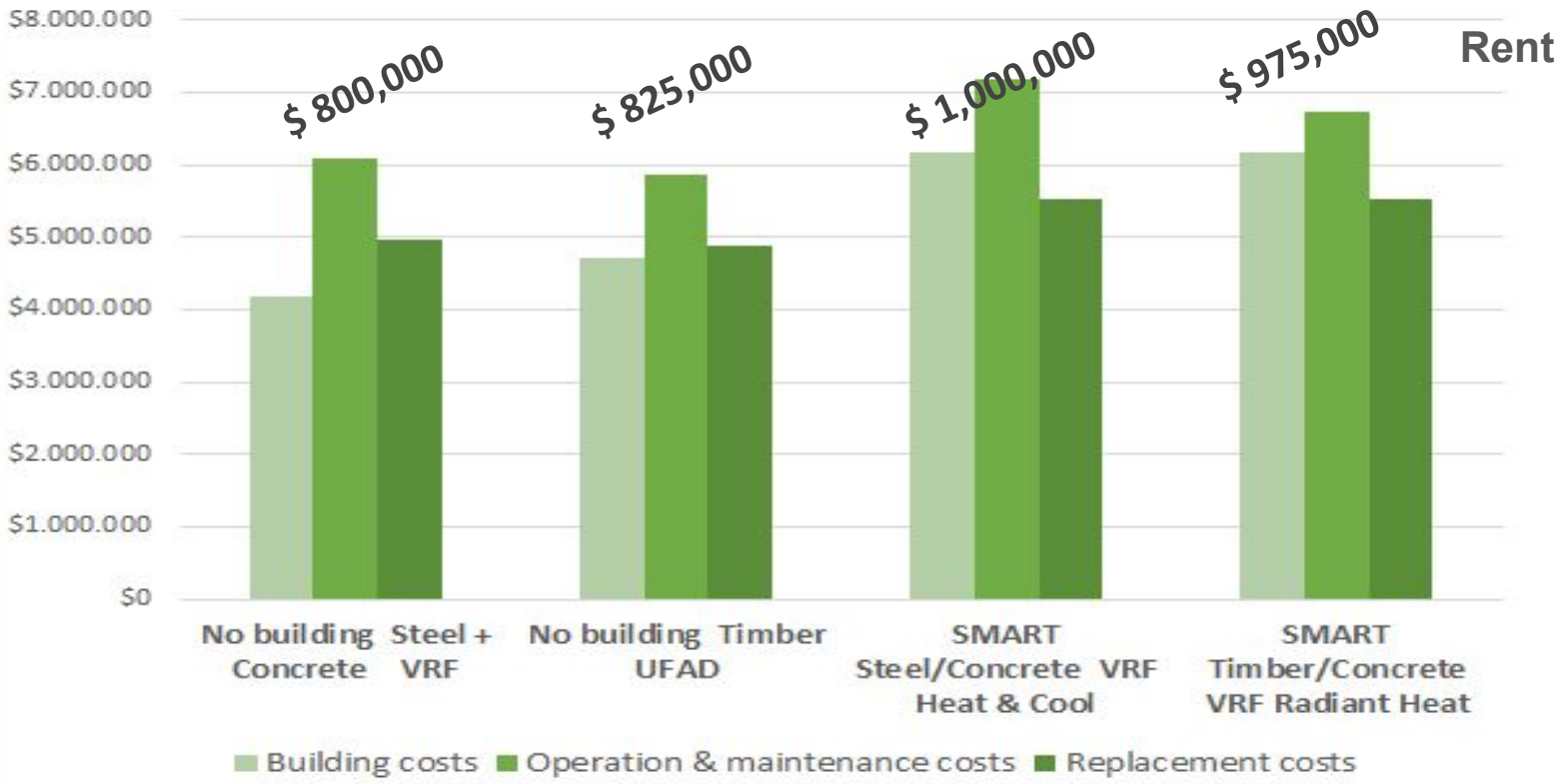


Risk Management & Strategies

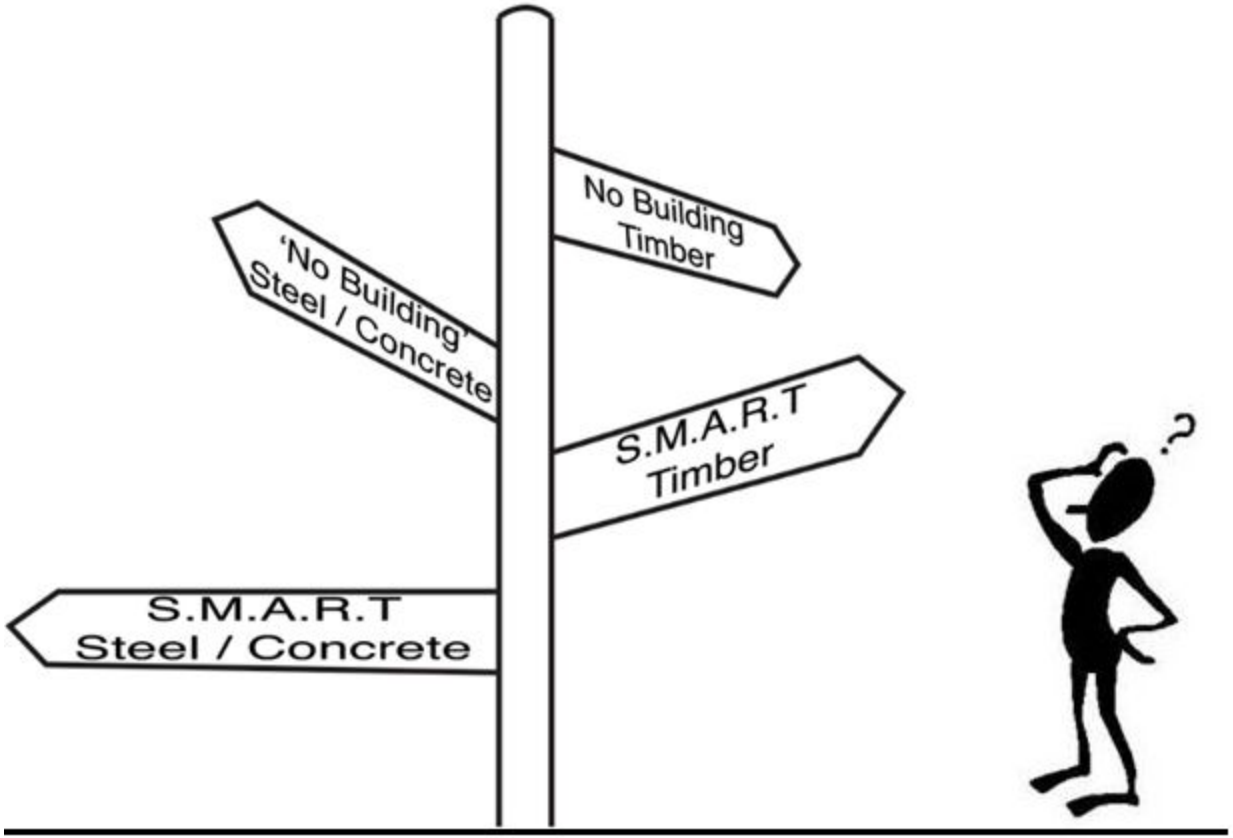


	Green Walls	Grey Walls
O+M (p.a.)	12,000$	1,100$
CO^2 - Reduction		
Improvement in Air Quality		
Habitat creation		
Aesthetic		

Operation & Maintenance Costs

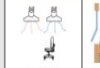
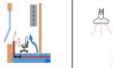


Life Cycle Cost Overview


No Building
Timber
'No Building'
Steel / Concrete
S.M.A.R.T
Timber
S.M.A.R.T
Steel / Concrete

Concept summary

	'No Building'	S.M.A.R.T
CONCEPT		
ARCH	 	 
STRUCT	 	 

MEP				
OM	 $ 5.164.530	 $ 5.617.057	 $ 6.794.263	 $ 7.428.694
LCFM	$ 781.000	$ 825 .000	$ 990.000	$ 968.000

Criteria catalog with definitions

Main Criteria	Sub Criteria	Definition	Ratingsystem
Environmental Quality	environmental impact by carbon	How is the carbon output from the building?	5= no CO^2 ouput; 1= over the required output from the STV
	environmental impact by ODP	How is the ODP (Ozone Depletion Potential) output from the building?	5=little or no ODP (kgCFC11e) output, 0=very high output
	water demand and sewage volume	How much water is being used in this design?	5 = little or no water (kg) output, 0=very high output
	primary energy consumption	How much energy will be used?	5=20 kwh/m²/a or lower, 1=greater than 40 kwh/m²/a
	environmentally-friendly material usage	How environmentally-friendly are the used materials	5= extremely friendly; 1=extremely bad
	land use/ space efficency	How is the ratio between the GFA and the assignable area?	AA/GFA => 0,8 = 5 points; 0,75 - 4 points; 0,7 - 3 points; 0,65 - 2 points; 0,6 or less - 1 point
Economic Quality	Life Cycle Cost - Rent	How much will we charge the occupants to use the space?	5=minimum, 0=1 mil/yr or more
	Flexibilty and adaptability of the building	How easy is a repurposing?	5 = extremely easy; 1 = not possible
Sociocultural and Functional Quality	Indoor air quality	How much natural air reaches the various areas of the building?	5=natural air maximized, 1=little or no natural air ventilation
	Comfort quality (thermal, acoustic, visual)	How is the comfort quality of the building	5 = extremely friendly; 1 = extremely bad
	User control	Which influence does the users have to regulate ventilations, temperatures, daylight and artificial light? And How easy is the using?	5 = very high influence, 1 = no influence
	Quality of outdoor spaces	How is the quality of the outdoor spaces?	5 = very high; 1 = very bad
	Public Access	Does the building offer a good public access?	5 = very high; 1 = very bad
	Design and Urban Quality	How does the building fit in the context of the surrounding buildings?	5 = very high; 1 = very bad
	Floodprotection	What is the potential damage level if/when a flood occurs?	5=no damage expected, 0=high amount of damage expected
	Adaptability of Technical Systems	How adaptable are the technical systems?	5 = very high; 1 = very bad
	Cleaning and Maintenance	How easy-to-clean are the surfaces and how is the quality of the used components?	5 = very high; 1 = very bad
	Deconstruction- and Disassembly- friendliness	How easy can the building deconstructed?	5 = extremely easy; 1 = not possible

Weighting

Main Criteria	Sub Criteria	Sara	Lanxi	Liyi	Jordan	Eline	Arnaud	Carl
Environmental Quality 25%	Environmental impact by carbon	2	4	6	4,5	4	3	4
	Environmental impact by ODP	3	2	5	0,5	1	1	2
	Water demand and sewage volume	2	3	2	4	2	3	3
	Primary energy consumption	3	6	6	8	6	7	7
	Environmentally-friendly material usage	8	5	3	6	6	7	4
	Land use/ space efficency	7	5	3	2	6	4	5
		Ok!	Ok!	Ok!	Ok!	Ok!	Ok!	Ok!
Economic Quality 25%	Life Cycle Cost - Rent	7	15	15	13	10	12	15
	Flexibilty and adaptability of the building	18	10	10	12	15	13	10
		Ok!	Ok!	Ok!	Ok!	Ok!	Ok!	Ok!
Sociocultural and Functional Quality 25%	Indoor air quality	4	6	6	8	5	8	7
	Comfort quality (thermal, acoustic, visual)	4	5	5	8	5	7	8
	User control	5	4	3	2	5	1	1
	Quality of outdoor spaces	4	3	3	4	5	3	3
	Public Access	2	3	3	1	2	2	1
	Design and Urban Quality	6	4	5	2	3	4	5
		Ok!	Ok!	Ok!	Ok!	Ok!	Ok!	Ok!
Technical Quality 25%	Floodprotection	5	5	6	5	4	3	4
	Adaptability of Technical Systems	6	3	6	8	4	3	5
	Cleaning and Maintenance	4	5	4	3	4	5	7
	Deconstruction- and Disassembly- friendliness	5	4	3	1	5	5	2
	Environmental Impact of Construction	3	5	3	5	4	4	6
	Schedule	2	3	3	3	4	5	1
		Ok!	Ok!	Ok!	Ok!	Ok!	Ok!	Ok!

Owner & member assessment

		No Building		S.M.A.R.T.		Weight in %	Sara: No Building		S.M.A.R.T.	
Main Criteria	Sub Criteria	No Building - Steel + Concrete - VRF	No Building - Timber - UFAD	S.M.A.R.T. - Steel + Concrete - VRF Heat & Cool	S.M.A.R.T. - Timber + Concrete - VRF + Radiant Heat		No Building - Steel + Concrete - VRF	No Building - Timber - UFAD	S.M.A.R.T. - Steel + Concrete - VRF Heat & Cool	S.M.A.R.T. - Timber + Concrete - VRF + Radiant Heat
Environmental Quality	environmental impact by carbon (Kg/m²)	Low impact from small footprint, no room for UFAD so slightly > Timber Life Cycle Impact (LCI): 3.3 million kgCO2e	Low upfront impact, UFAD sytem is lowest energy use LCI: 2.2 million kgCO2e	Highest impact due to energy intensive steel and larger annual energy use LCI: 5.2 million kgCO2e	Less impact than SMART Steel, but still high annual energy use LCI: 4.5 million kgCO2e	2	3	4	2	2
	environmental impact by ODP (Kg/m²)	Low impact 5/5	Low impact 5/5	Low impact 5/5	Low impact 5/5	3	3 1 2 4 5	5	5	5
	water demand and sewage volume (l/m²)	Best (5/5)	4	OK (3.5/5)	OK (3.5/5)	2		3	2	2
	primary energy consumption (up to 40 kwh/m2/a - Ideally 20 kW/h/m2/a)	(4.5/5)	Best (5/5)	Worst (3/5)	(3.5/5)	3	2	3	2	2
	environmentally-friendly material	Steel: repetitive usage; Recyclability;	Glulam & CLT; Pure Timber Structure; Renewable; Less engergy used; Less	Steel: repetitive usage; Recyclability;	Glulam columns; CLT+concrete slab; Renewable; Less engergy used; Less	8	3	5	3	5

Decision Matrix

A S E M E P C M **L C F M**

		No Building		S.M.A.R.T.	
	weights	No Building - Steel + Concrete - VRF Heat & Cool	No Building - Timber - UFAD	S.M.A.R.T. - Steel + Concrete - VRF Heat & Cool	S.M.A.R.T. - Timber + Concrete - VRF + Radiant Heat
Team	50%	377,36	421,29	328,64	365,43
Owner	50%	348,20	389,40	328,60	344,40
Total	1	**362,78**	**405,34**	**328,62**	**354,91**

Decision Matrix Results

Responds to Air Quality

- Arch: Smaller footprint → Fewer Emissions
- SE: Timber → Low embodied emissions
- MEP: UFAD → Low life-cycle emissions
  - High indoor air quality and thermal comfort + user control
- CM: Shorter construction period → Fewer emissions
- LCFM: Green walls → Low life-cycle emissions

‘No Building’

Communication with Team & Owners.

Owner updates & surveys.

Team & Owner Meetings

Meeting agendas, notes and presentations.

Coordination of meetings.

Project web for documentation handling.

Modelling and Storing of models.

Automatic update of quantities.

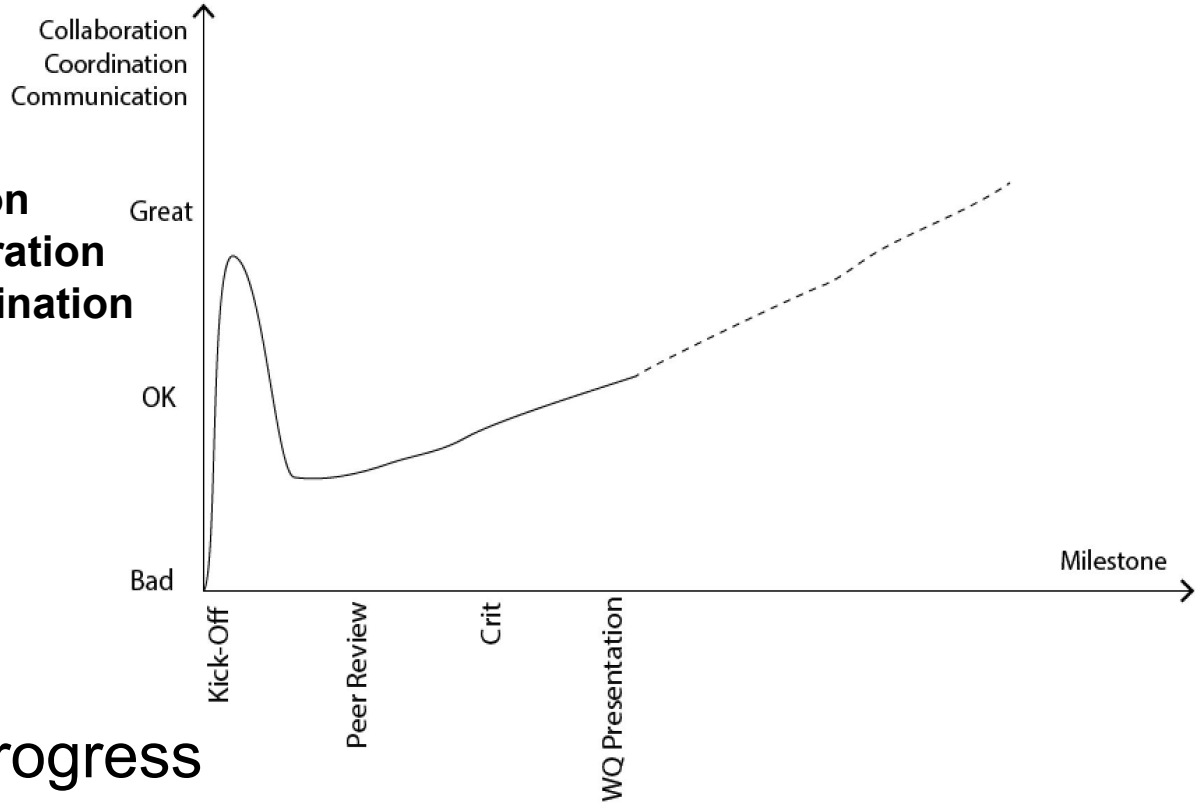
Team Process Tools

Team **CONTRACT**

‘’Timeliness - Honesty - Transparency - Trust’’

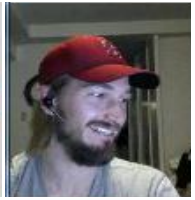
To improve

- Update → **Communication**
- Transparency → **Collaboration**
- Folder structure → **Coordination**
- Consistency
- Dependency



Team Process & Progress




Sara
A

Lanxi
SE

Liyi
SE

Jordan
MEP

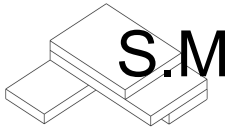
Arnaud
CM

Eline
CM

Carl
LCFM

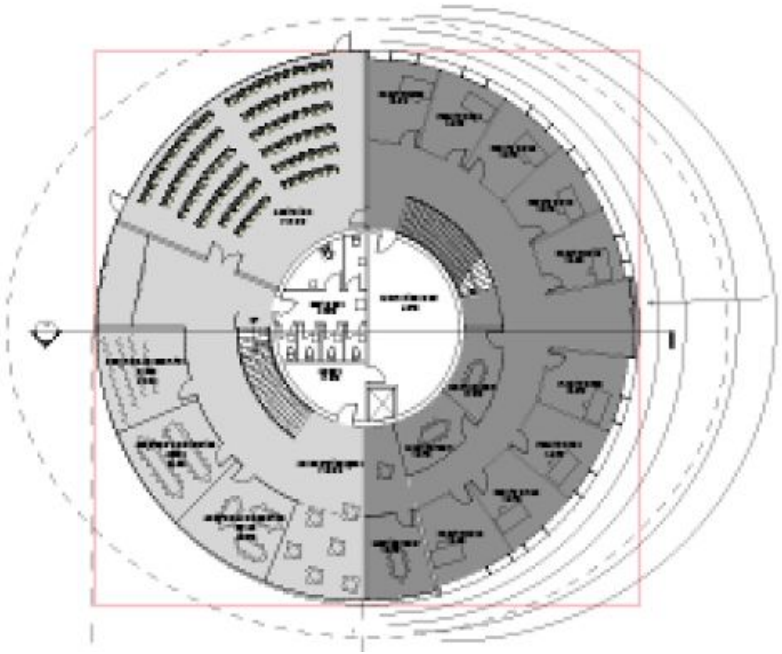

THANK YOU!
Questions?

‘No Building’

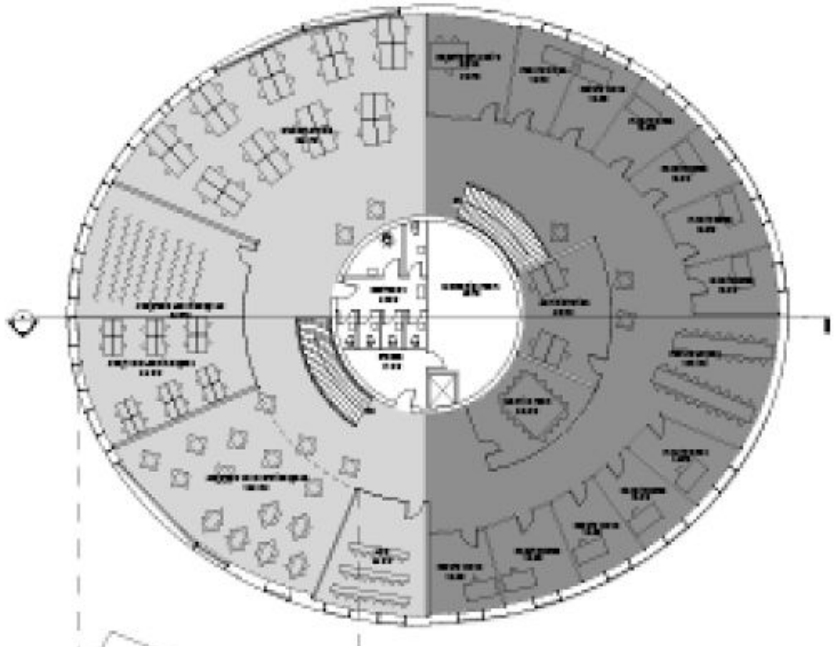


S.M.A.R.T

APPENDIX



1st floor



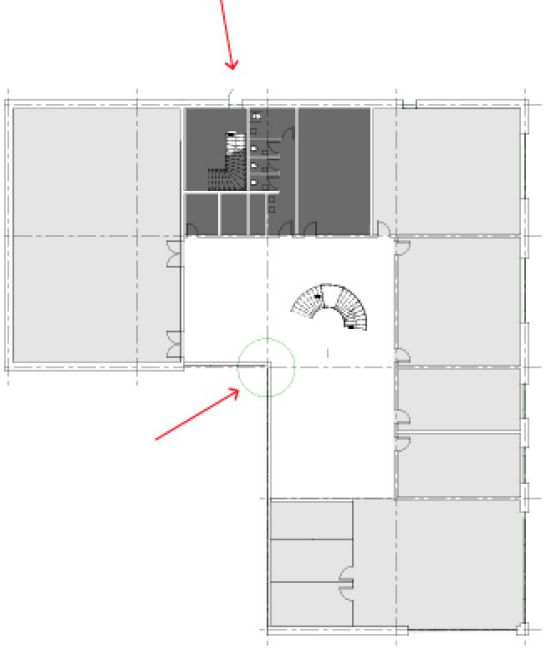
2nd floor

Faculty Space
Service
Student and learning space

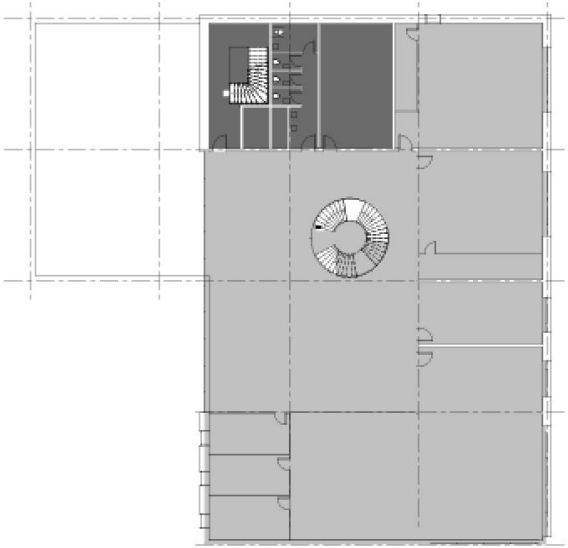
30 ft

‘No Building’

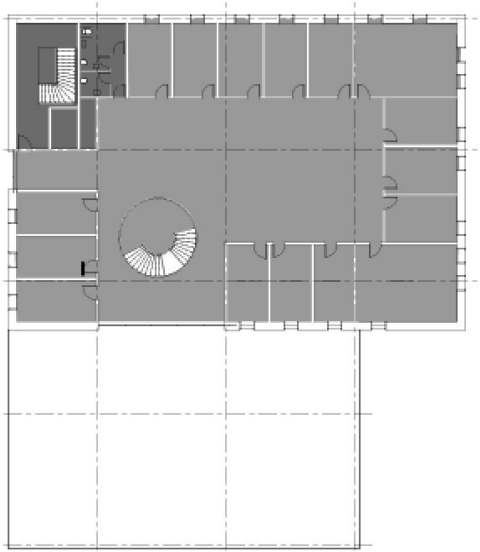
A
S
E
M
E
P
C
M
L
C
F
M



1st floor



2nd floor



3rd floor

Shared Learning

Individual Learning

Faculty

Service

30 ft

S.M.A.R.T

A

S

E

M

E

P

C

M

L

C

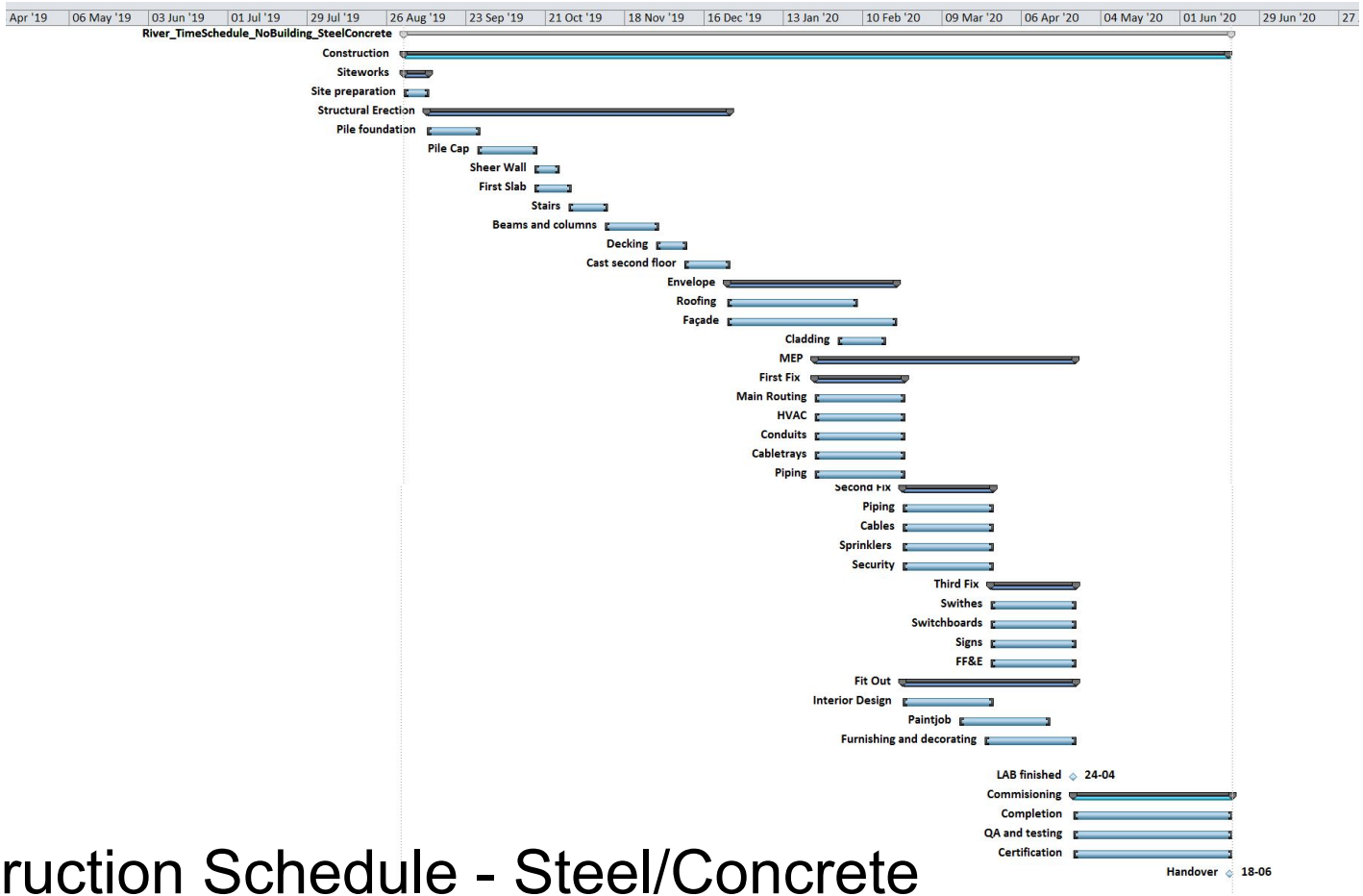
F

M

	VRF Heat & Cool	UFAD + Radiant Heat	VRF + Radiant Heat
Floor Sandwich Impact	20” x 12” AVERAGE	14” x 8” WORST  2” Pipe 12” Floor Plenum	BEST 
First Cost	Lowest 	Highest 	Average
Annual Cost	Highest 	Lowest 	Average
Indoor Air Quality	Good	Best 	Good
Thermal Comfort	Best 	Good	Good

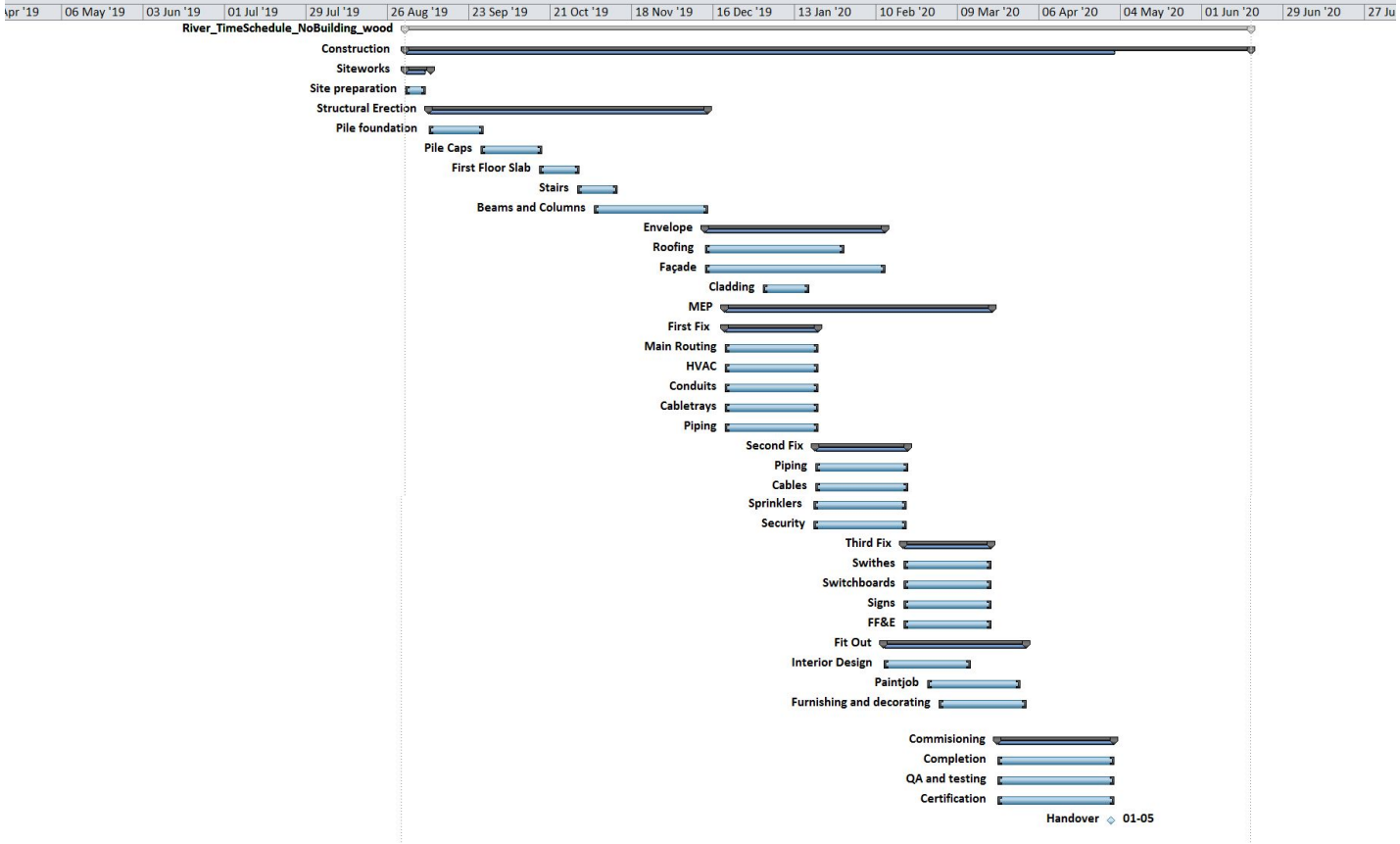
HVAC Equipment

Construction period: September 1st 2019 to June 18nd 2020.



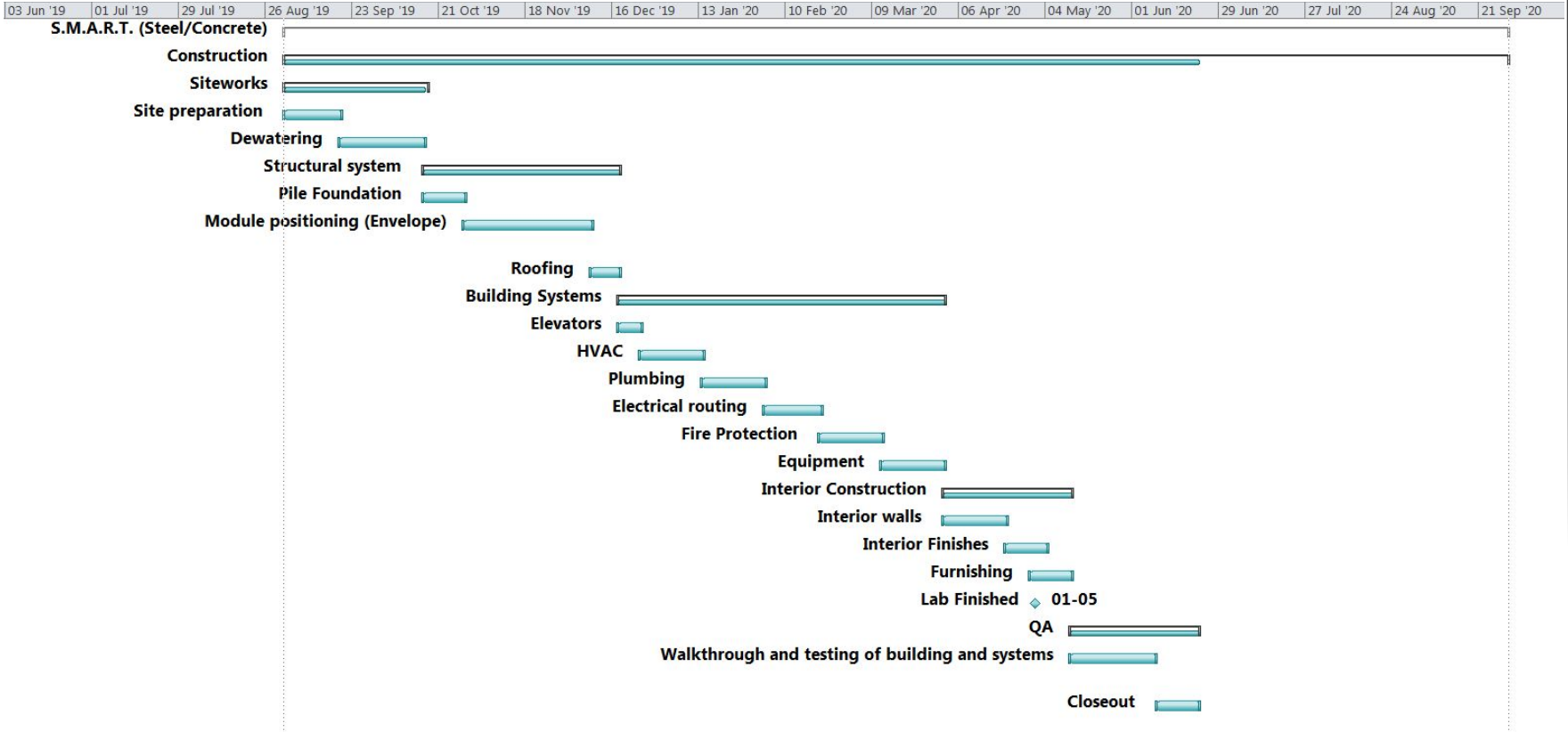
Construction Schedule - Steel/Concrete

Construction period: September 1st 2019 to May 1st 2020.



Construction Schedule - Timber

Construction period: September 1st 2019 to June 22nd 2020.



Construction Schedule - Both Alternatives