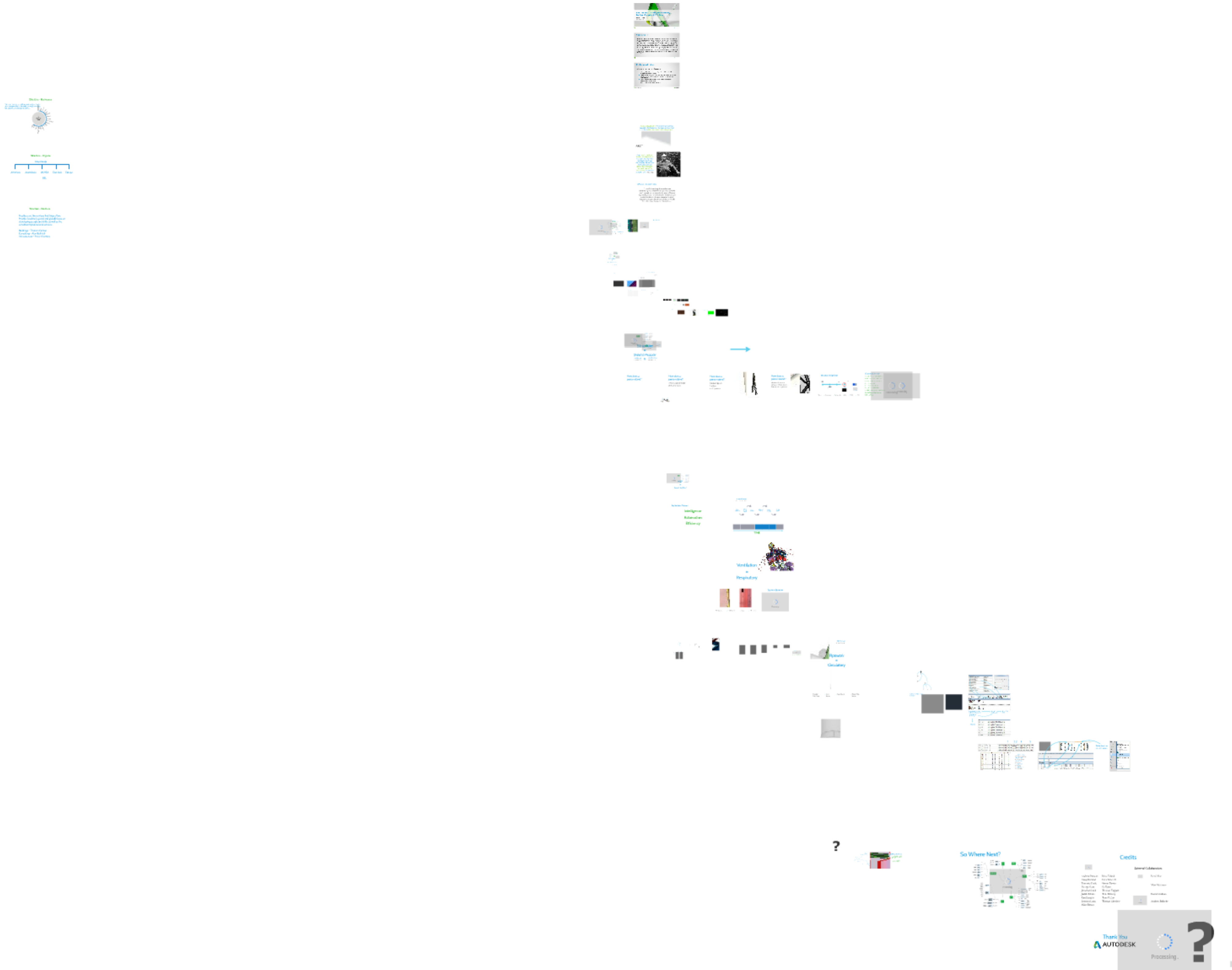


Intelligence
Automation
Efficiency
Ventilation
+
Respiratory
Pipework
+
Circulatory
?
So Where Next?
Credits
Thank You
AUTODESK
Processing...
?

Virtually Human: Modelling the Human Body Inside and Out Using BIM Platforms

Andrew Duncan
BIM Manager, Arup

Class summary

The study of human anatomy has traditionally been the domain of physicians, dentists, physiotherapists, nurses, paramedics, and other health professionals. What happens when you let building designers have a crack at replicating it? This class provides you with the opportunity to meet Project OVE, Arup's virtual human. OVE has a full structural skeleton and respiratory system. OVE sweats, gets hungry, and even has a heart. We are still working on the operating system but OVE has a huge brain that will act as the main control center when finished. However, OVE is also more than just an artificial replication of the human body. Creating an intelligent version of OVE required us to exploit the full potential of Autodesk® Revit®-based software as a state-of-the-art BIM (Body Information Modeling) tool.

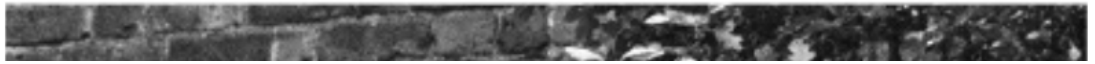
Key learning objectives

At the end of this class, you will be able to:

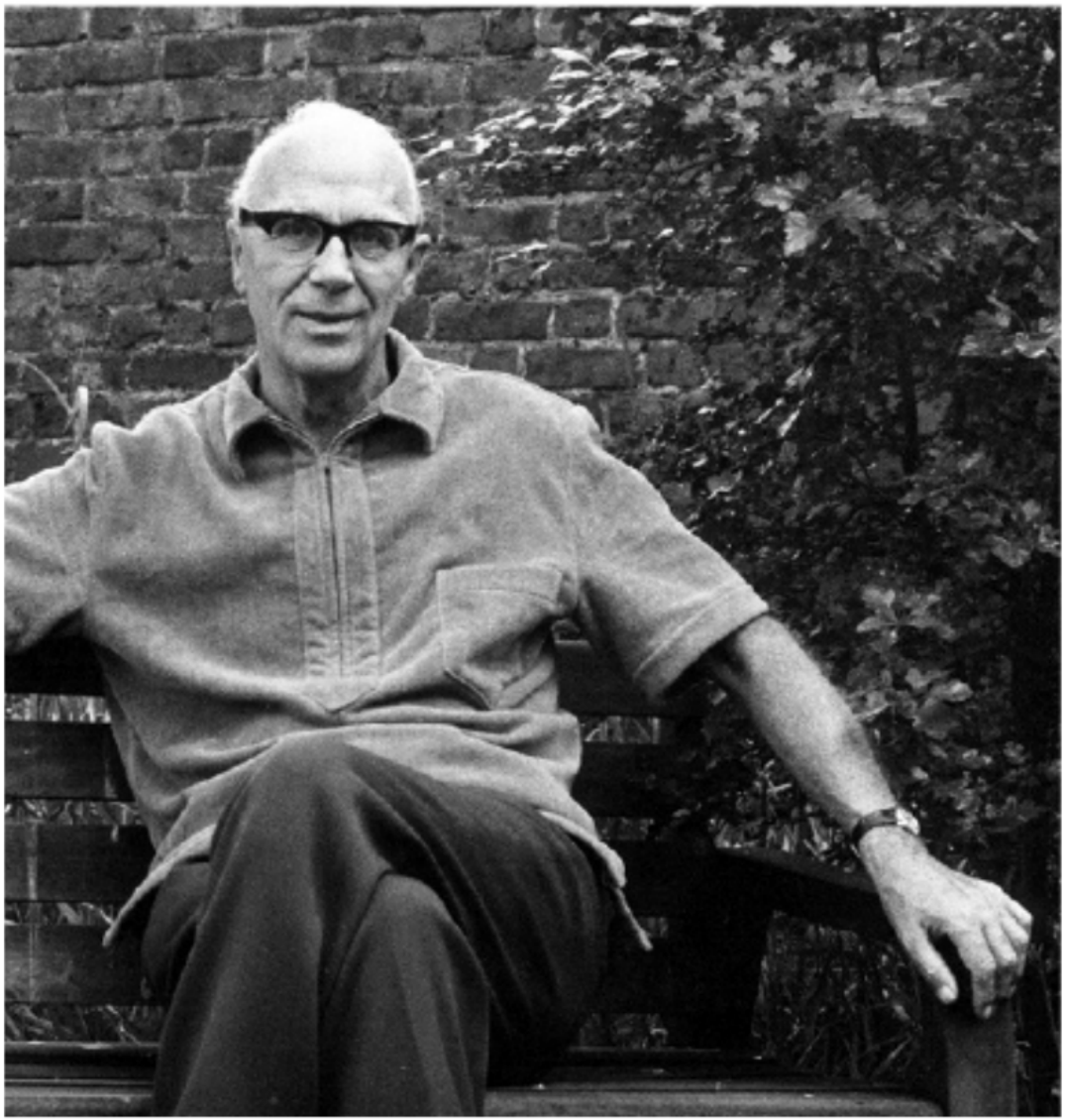
- Fully exploit the information modelling tools available in Revit to create large, intricate services systems.
- Collaborate effectively with other project team members when modeling Autodesk® Revit® MEP, Autodesk® Revit® Structure, or Autodesk® Revit® Architecture.
- Embed information into Revit families to make multidisciplinary calculations and analysis easier.
- Model a human in Revit-based software!

We are a truly global firm. From more than 90 offices worldwide, 11,000 planners, designers, engineers and consultants deliver innovative and inspiring projects.

ARUP



Arup's creative spark and intellectual independence has been there from the very beginning. These shared values, like the firm's name, are essentially derived from the beliefs and convictions of the firm's founder, the engineer and philosopher, Ove Arup.



BIM to us is: Total Architecture.

"…that all relevant design decisions have been considered together and have been integrated into a whole by a well organised team empowered to fix priorities. This is an ideal which can never - or only very rarely - be fully realised in practice, but which is well worth striving for, for artistic wholeness or excellence depends on it, and for our own sake we need the stimulation produced by excellence… "

Total Architecture

Collaboration (co-operation)!

"…that all relevant design decisions have been **considered together** and have been integrated into a whole by a well organised team empowered to fix priorities. This is an ideal which can never - or only very rarely - be fully realised in practice, but which is well worth striving for, for artistic wholeness or excellence depends on it, and for our own sake we need the stimulation produced by excellence… "

Total Architecture

Federated model!

"…that all relevant design decisions have been considered together and have been **integrated into a whole** by a well organised team empowered to fix priorities. This is an ideal which can never - or only very rarely - be fully realised in practice, but which is well worth striving for, for artistic wholeness or excellence depends on it, and for our own sake we need the stimulation produced by excellence… "

Total Architecture

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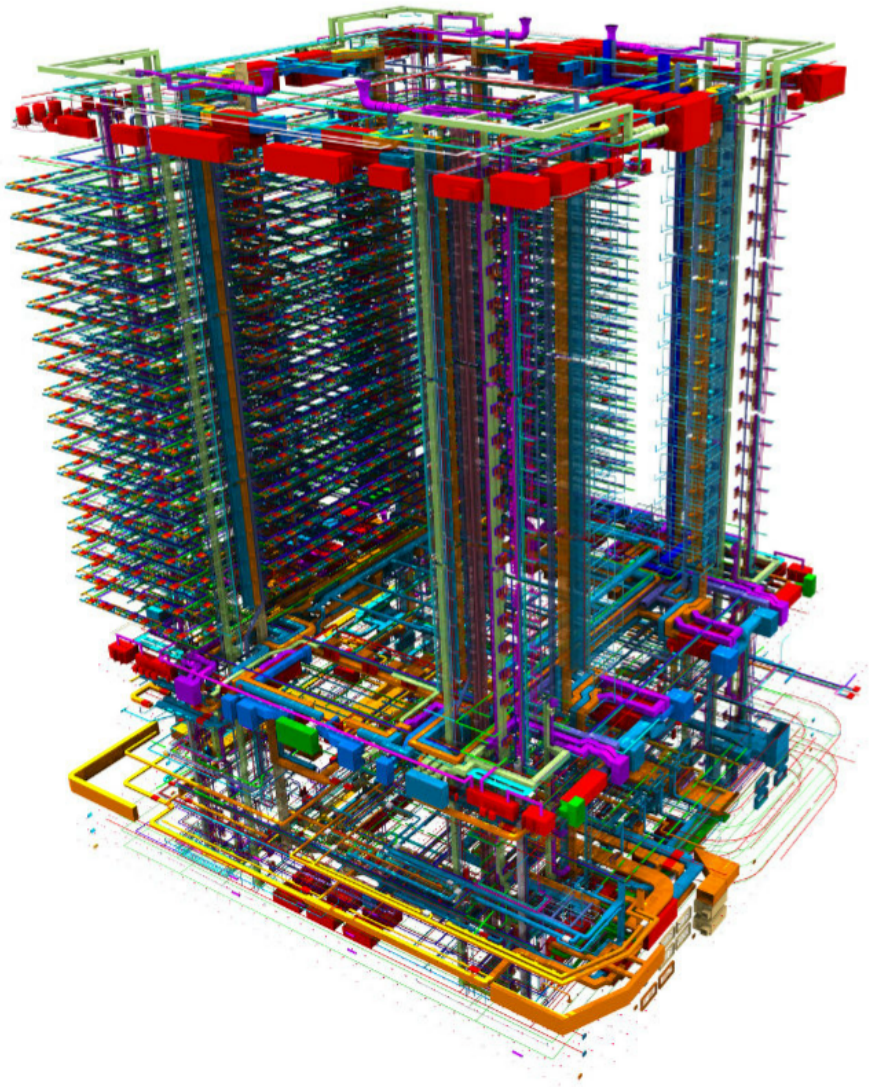
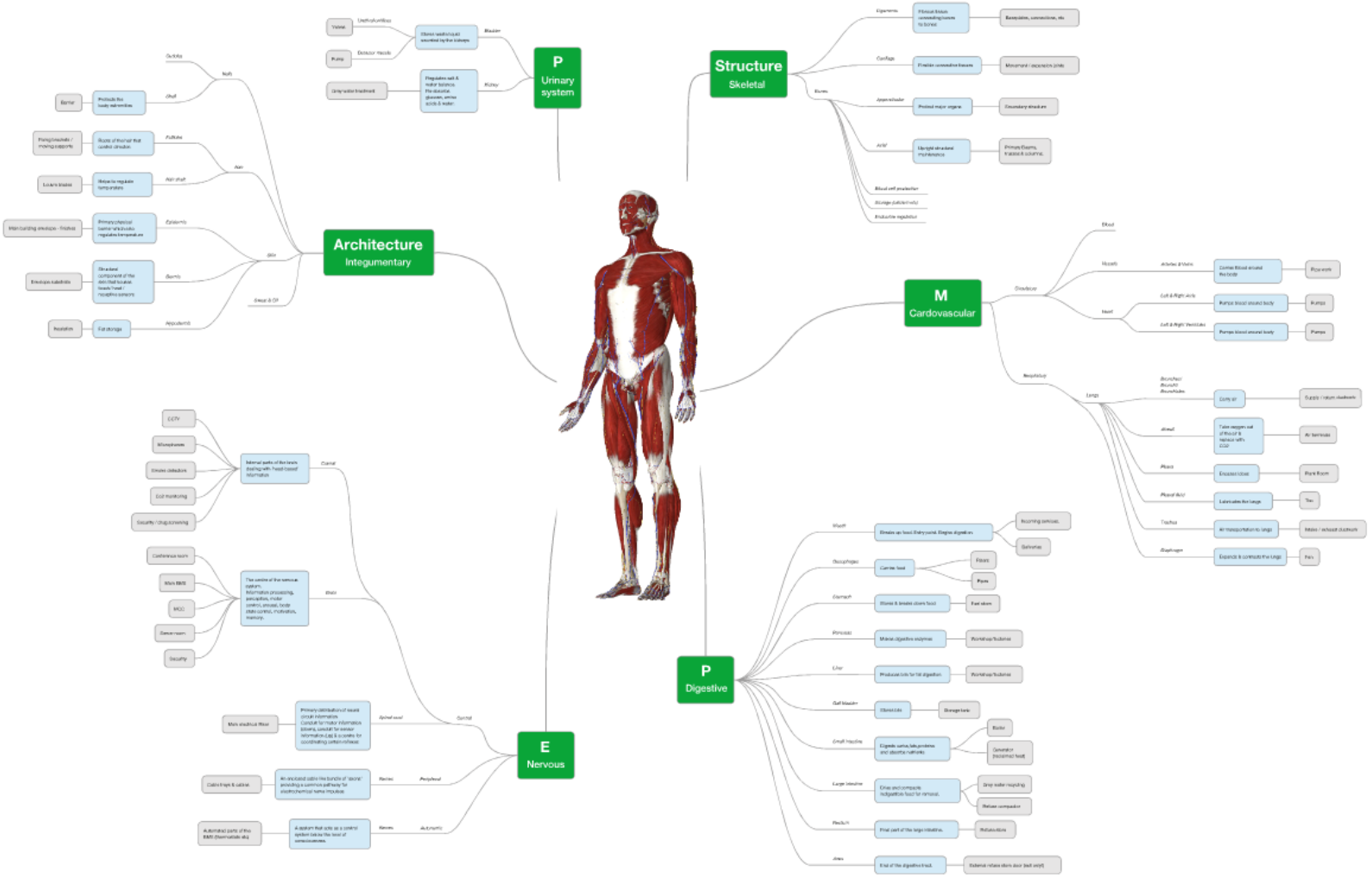
Ove Arup, Key Speech, 1970

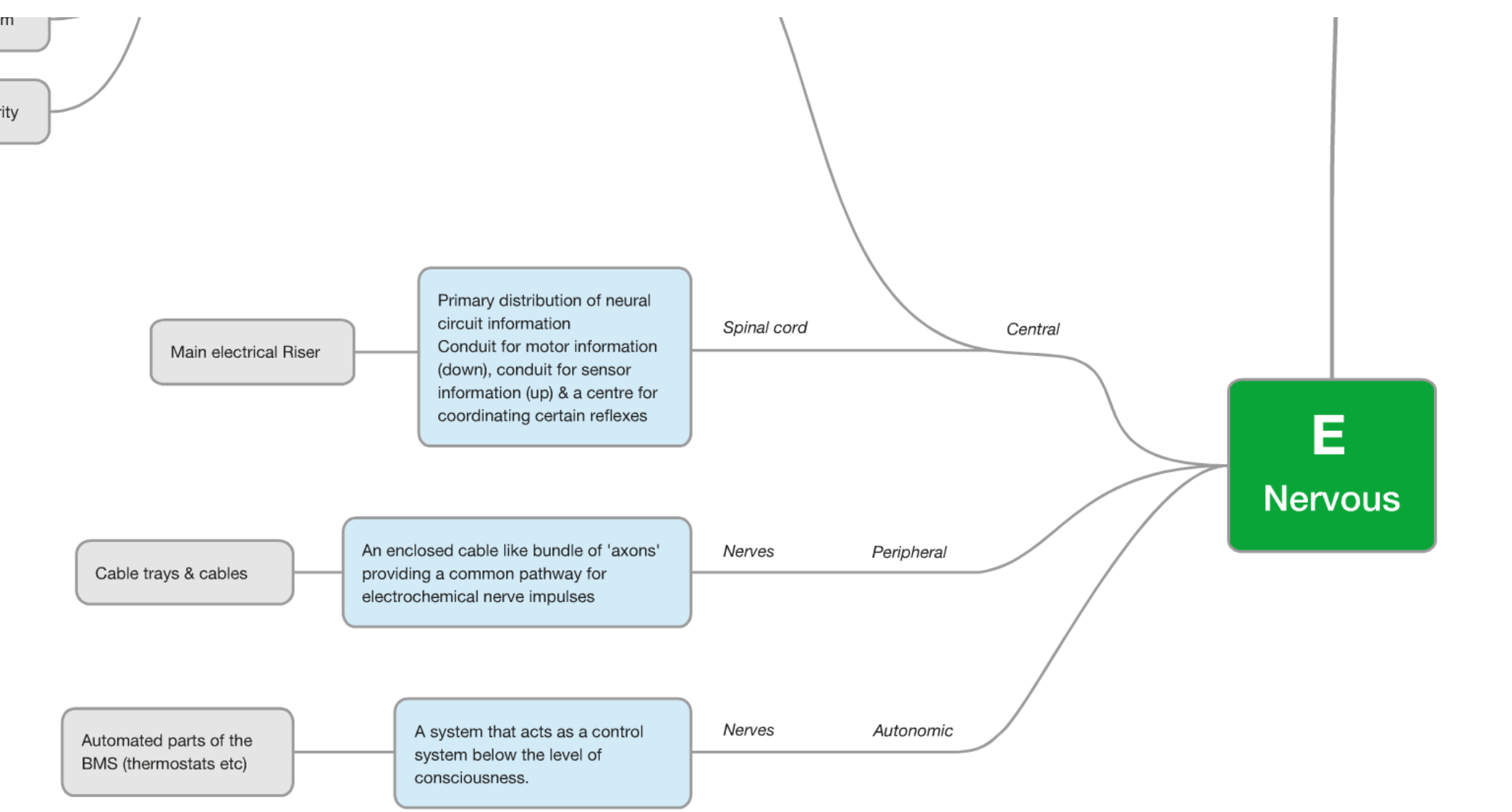
How it all started ...



Why a person?



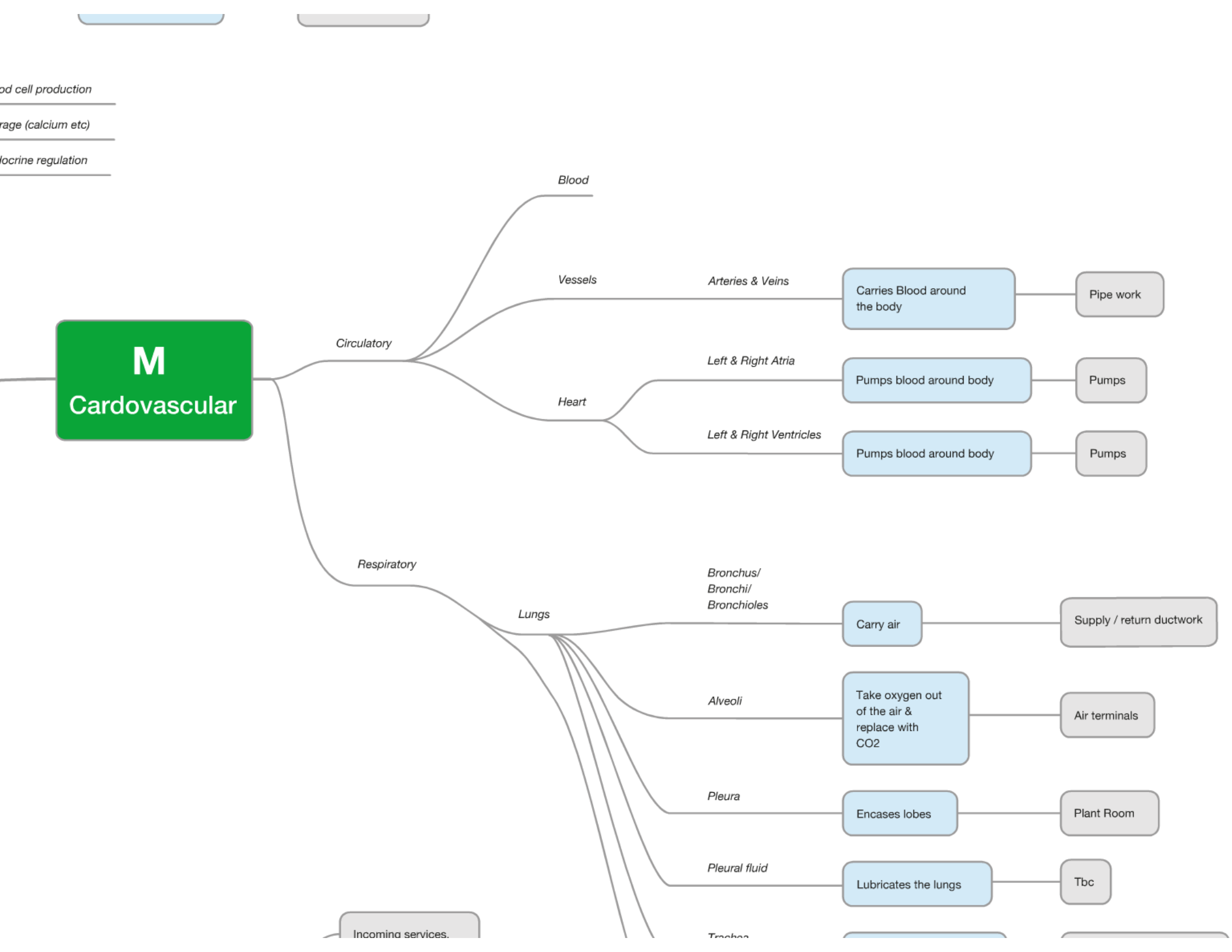
rchitecture Structure Building Servic


E
Nervous
Central
Spinal cord
Primary distribution of neural circuit information
Conduit for motor information (down), conduit for sensor information (up) & a centre for coordinating certain reflexes
Main electrical Riser
Peripheral
Nerves
An enclosed cable like bundle of 'axons' providing a common pathway for electrochemical nerve impulses
Cable trays & cables
Autonomic
Nerves
A system that acts as a control system below the level of consciousness.
Automated parts of the BMS (thermostats etc)

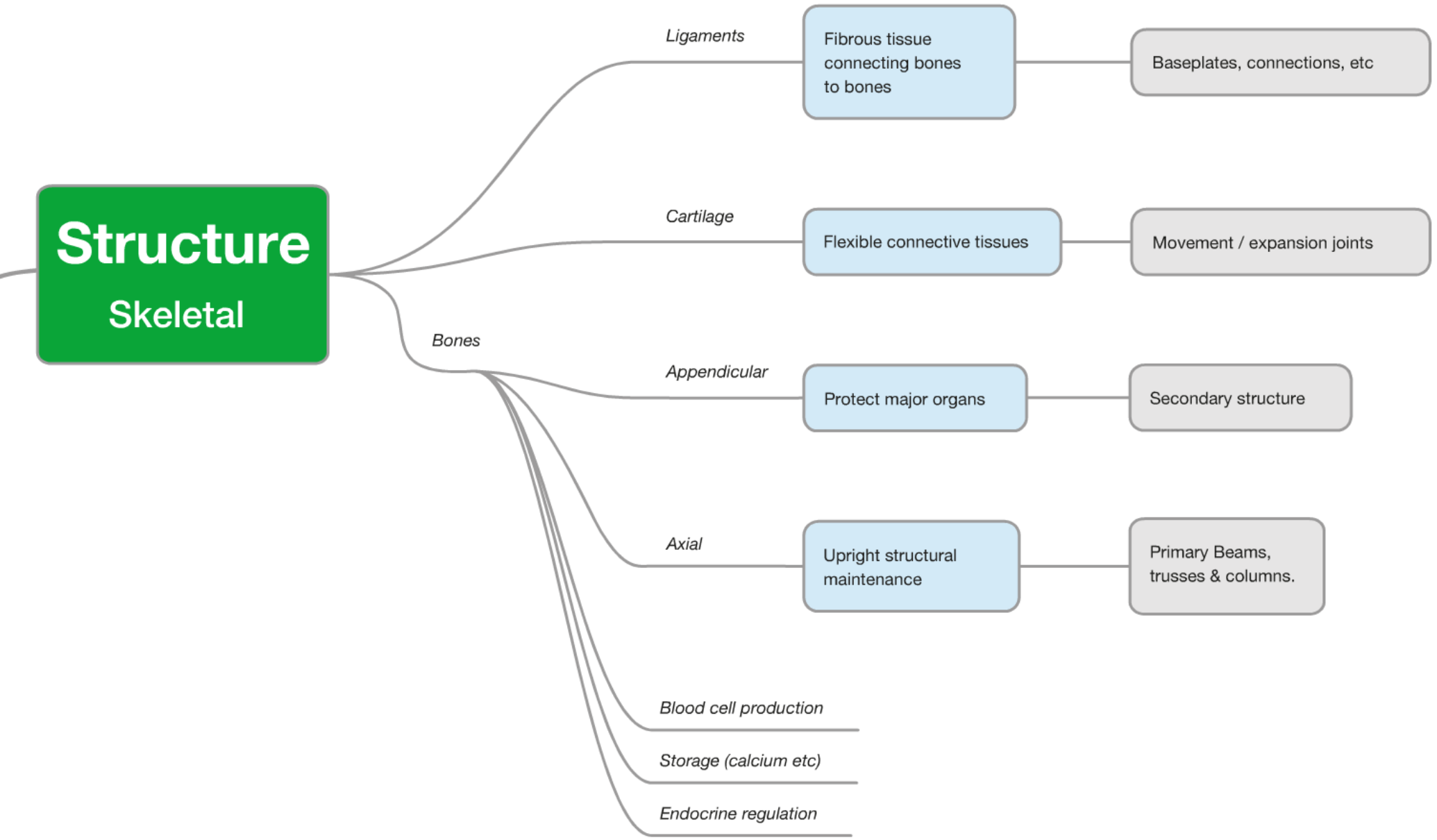
P
Digestive

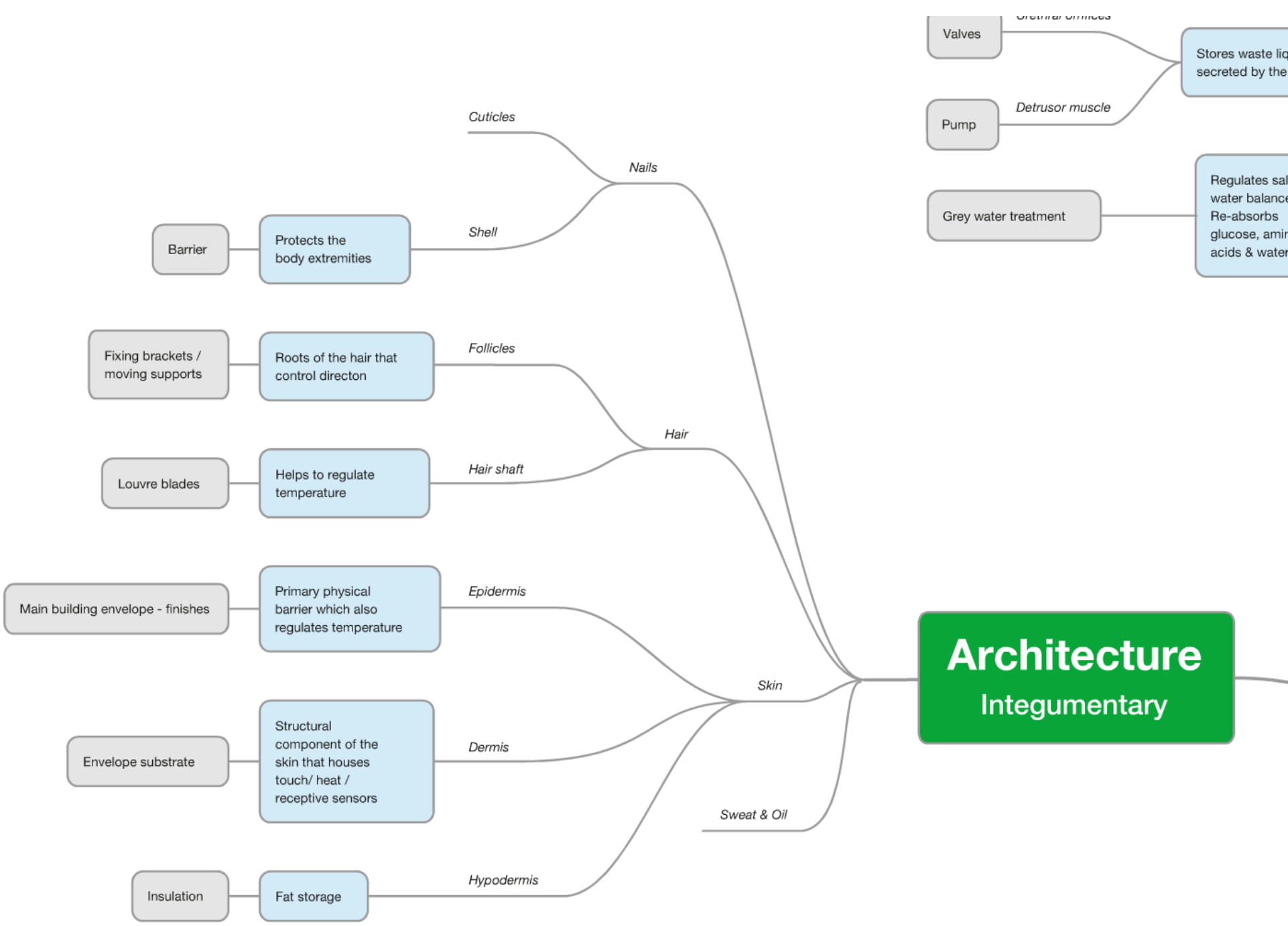
- *Mouth*
  - Breaks up food. Entry point. Begins digestion
    - Incoming services.
    - Deliveries
- *Oesophagus*
  - Carries food
    - Risers
    - Pipes
- *Stomach*
  - Stores & breaks down food
    - Fuel store
- *Pancreas*
  - Makes digestive enzymes
    - Workshop/factories
- *Liver*
  - Produces bile for fat digestion
    - Workshop/factories
- *Gall bladder*
  - Stores bile
    - Storage tank
- *Small intestine*
  - Digests carbs,fats,proteins and absorbs nutrients
    - Boiler
    - Generator (reclaimed heat)
- *Large intestine*
  - Dries and compacts indigestible food for removal.
    - Grey water recycling
    - Refuse compactor
- *Rectum*
  - Final part of the large intestine.
    - Refuse store
- *Anus*
  - End of the digestive tract.
    - External refuse store door (exit only!)

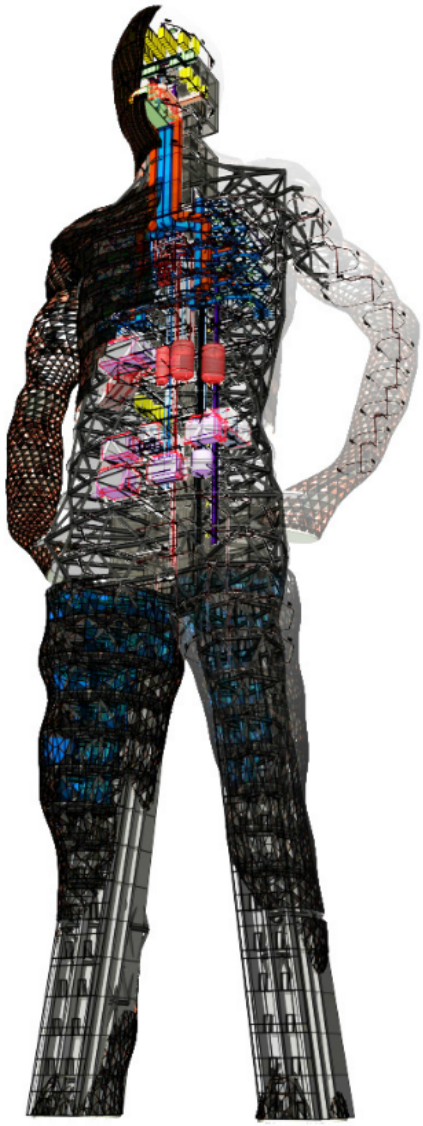
- *Pleura*
  - Encas
- *Pleural fluid*
  - Lubric
- *Trachea*
  - Air tra
- *Diaphragm*
  - Expan


od cell production
rage (calcium etc)
locrine regulation
M
Cardovascular
Circulatory
Blood
Vessels
Arteries & Veins
Carries Blood around the body
Pipe work
Heart
Left & Right Atria
Pumps blood around body
Pumps
Left & Right Ventricles
Pumps blood around body
Pumps
Respiratory
Lungs
Bronchus/ Bronchi/ Bronchioles
Carry air
Supply / return ductwork
Alveoli
Take oxygen out of the air & replace with CO2
Air terminals
Pleura
Encases lobes
Plant Room
Pleural fluid
Lubricates the lungs
Tbc
Incoming services,

erson?


Structure
Skeletal
Ligaments
Fibrous tissue connecting bones to bones
Baseplates, connections, etc
Cartilage
Flexible connective tissues
Movement / expansion joints
Bones
Appendicular
Protect major organs
Secondary structure
Axial
Upright structural maintenance
Primary Beams, trusses & columns.
Blood cell production
Storage (calcium etc)
Endocrine regulation


Architecture
Integumentary
Skin
Nails
Cuticles
Shell
Barrier
Protects the body extremities
Hair
Follicles
Fixing brackets / moving supports
Roots of the hair that control directon
Hair shaft
Louvre blades
Helps to regulate temperature
Epidermis
Main building envelope - finishes
Primary physical barrier which also regulates temperature
Dermis
Envelope substrate
Structural component of the skin that houses touch/ heat / receptive sensors
Hypodermis
Insulation
Fat storage
Sweat & Oil
Valves
Pump
Detrusor muscle
Stores waste liq
secreted by the
Grey water treatment
Regulates sal
water balance
Re-absorbs
glucose, amir
acids & water



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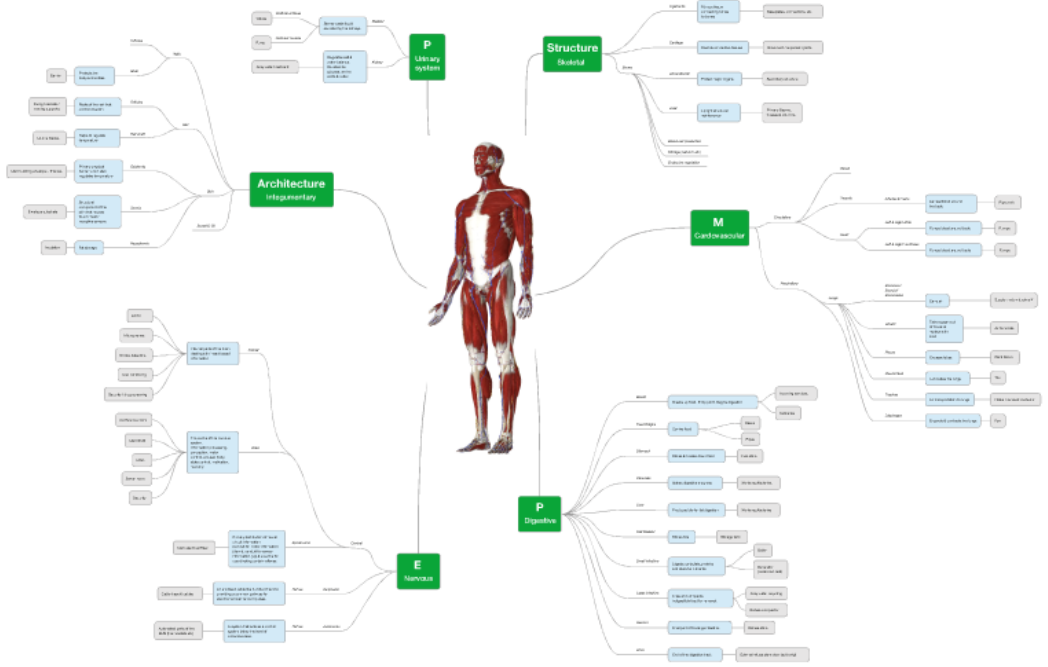


Architecture

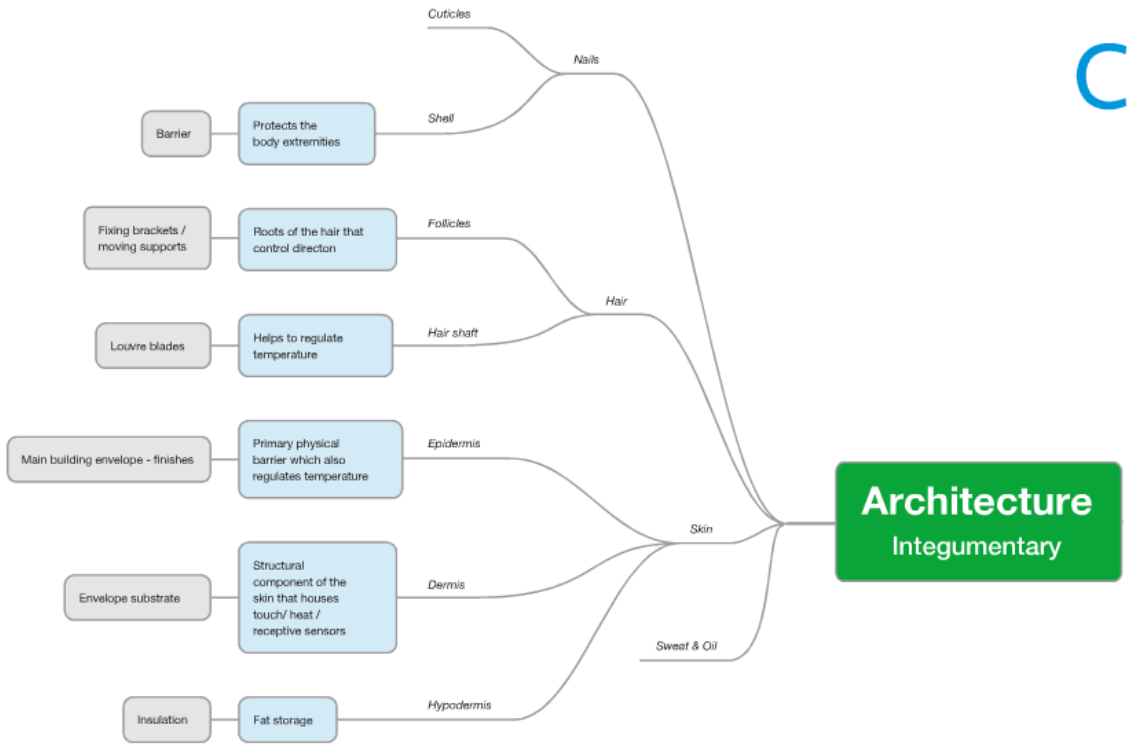
Process

Structure

Interoperability

Building Services

Data

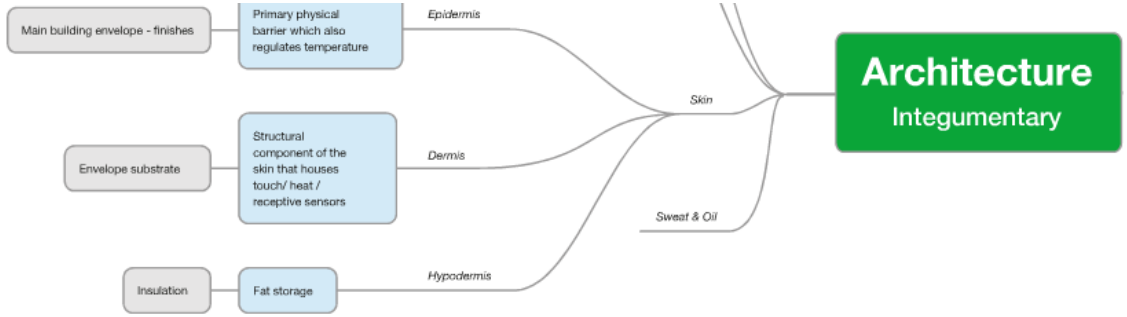


Casey Rutland

Associate Director

Architecture

=

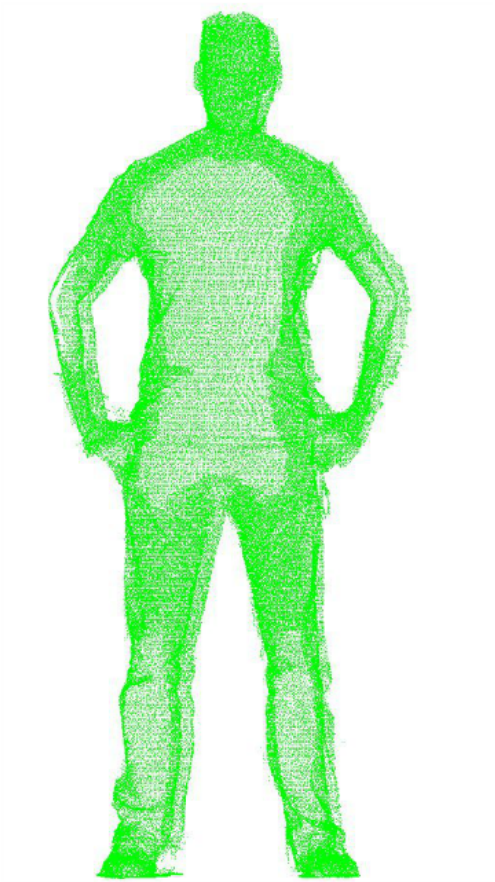


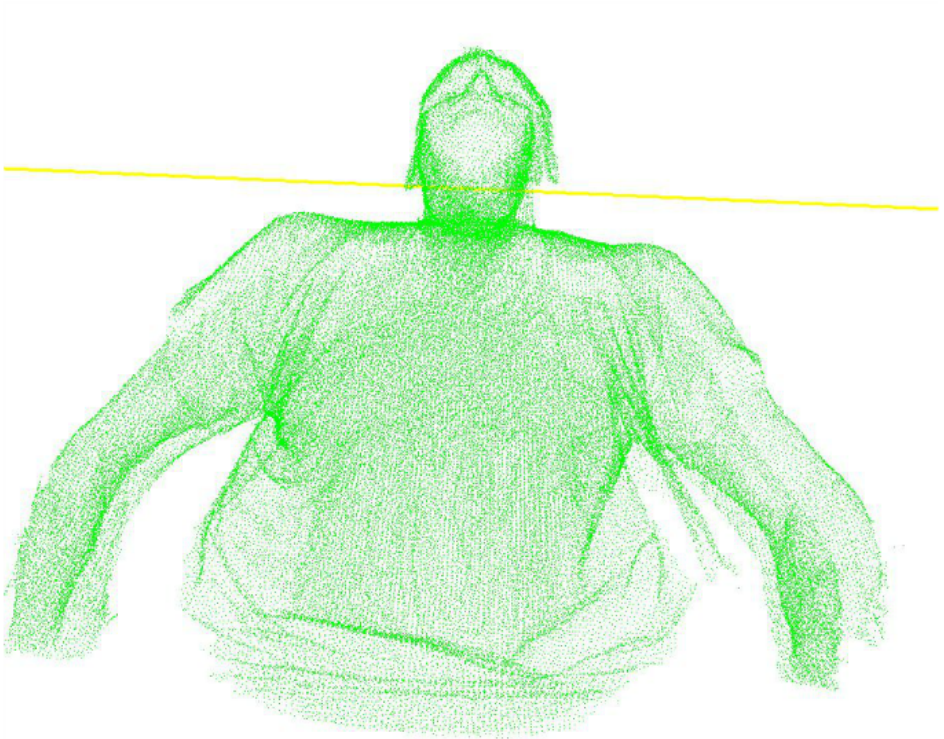
Architecture

=

Integumentary system

The Native Point Cloud





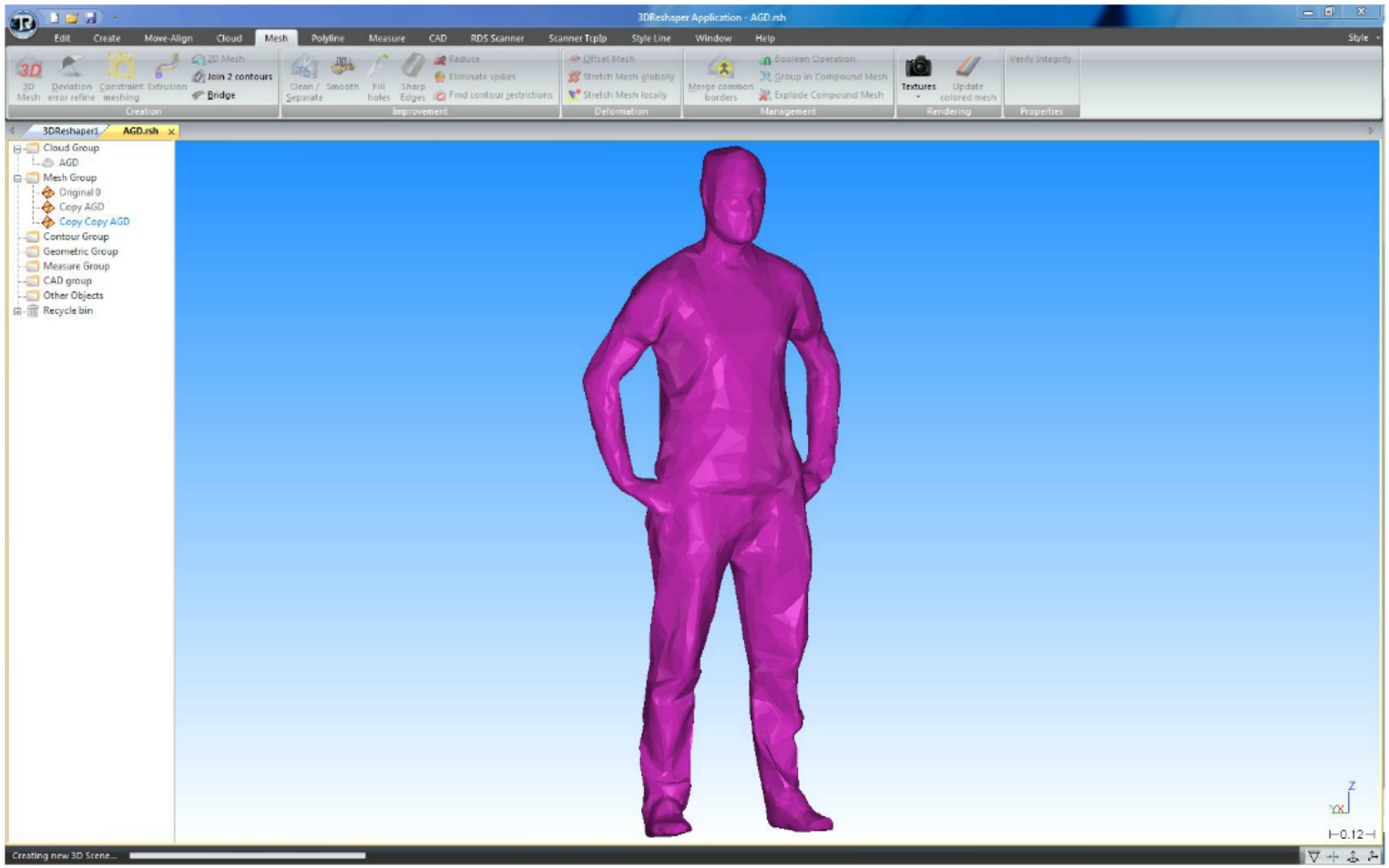
Scan-imation

Autodesk ReCap

Autodesk ReCap


YouTube

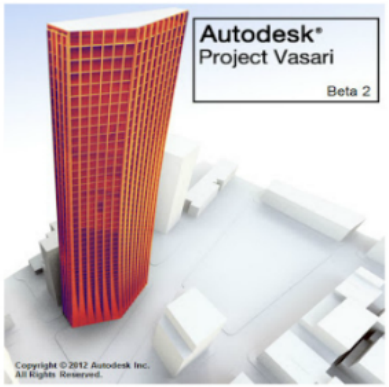
3DReshaper


3DReshaper Application - AGD.rsh
Edit
Create
Move-Align
Cloud
Mesh
Polyline
Measure
CAD
RDS Scanner
Scanner Toplp
Style Line
Window
Help
Style
3D Mesh
Deviation error refine
Constraint meshing
Extrusion
2D Mesh
Join 2 contours
Bridge
Creation
Clean / Separate
Smooth
Fill holes
Sharp Edges
Reduce
Eliminate spikes
Find contour restrictions
Improvement
Offset Mesh
Stretch Mesh globally
Stretch Mesh locally
Deformation
Merge common borders
Boolean Operation
Group in Compound Mesh
Explode Compound Mesh
Management
Textures
Update colored mesh
Rendering
Verify Integrity
Properties
3DReshaper1
AGD.rsh
Cloud Group
AGD
Mesh Group
Original 0
Copy AGD
Copy Copy AGD
Contour Group
Geometric Group
Measure Group
CAD group
Other Objects
Recycle bin
Creating new 3D Scene...
Z
YX
0.12

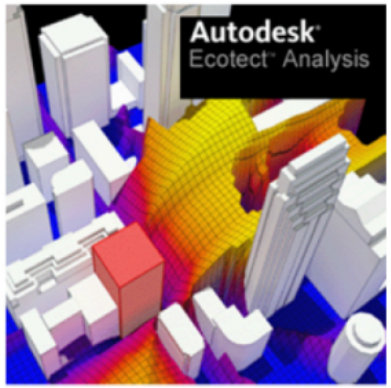
Virtually Human

AUTODESK REVIT

AUTODESK GREEN BUILDING STUDIO



AUTODESK VASARI



AUTODESK ECOTECT

+

RHINOCEROS 3D
GRASSHOPPER
GECO

RADIANCE
WINAIR

Site location

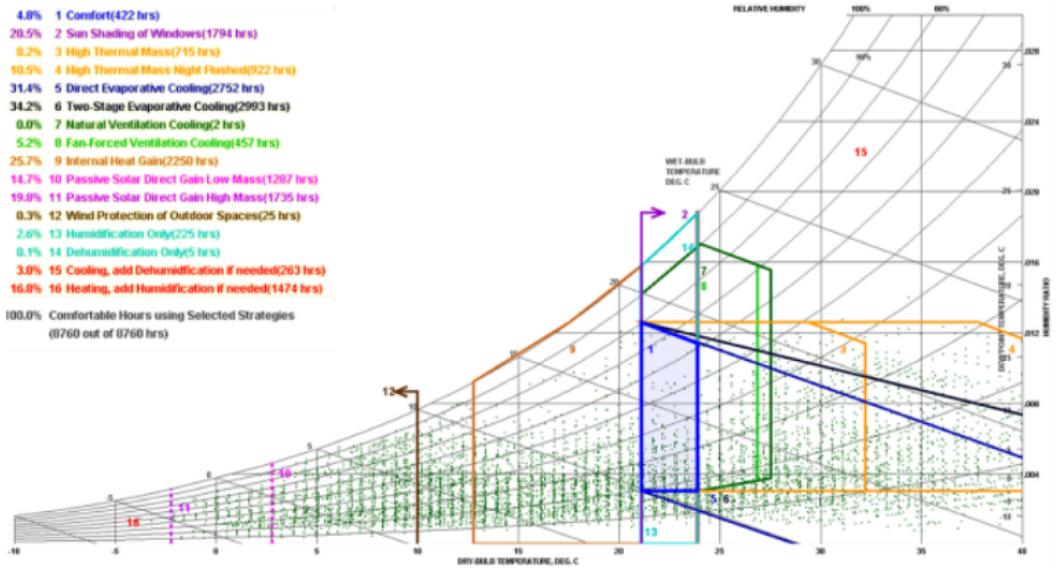
Ove @ Vegas!

Climate Information

PSYCHROMETRIC ANALYSIS

As the psychrometric chart from 'Climate consultant' shows, there are limited times of year in comfort zone, therefore significant cooling and heating periods are needed for this site.

Psychrometric chart overlay also shows that evaporative cooling strategy is most important one that should be considered for this site. In addition to this, passive heat gaining from solar and sun shading control can be a strategies.



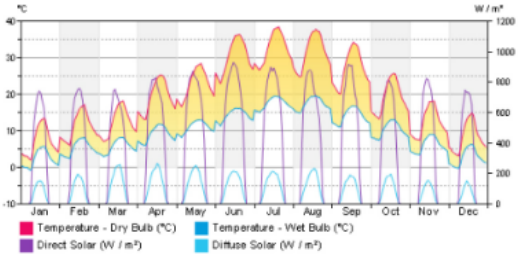
Psychrometric Chart and Design Strategy (Climate consultant)

WINTER

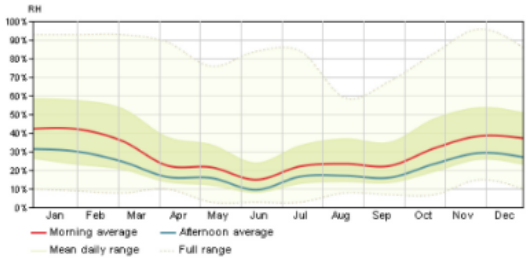
- Average max temperatures are lower than the comfort band (20-23.3℃)
  : Heating needs
  : Facing south to get passive heating
- Relative humidity level
  : Heating w/ humidification needed

SUMMER

- Peak temperatures in July at 38°C, much higher than comfort band
  : Focusing on overheating problem
  : Natural ventilation / Humidification in summer to provide passive cooling
- Large diurnal temperature / Humidity variation
  : Potential for thermal mass and night cooling
- Low humidity level for achieving comfort
  : Passive strategies for humidification needed



Diurnal Weather Averages (Autodesk Vasari)



Humidity (Autodesk Vasari)

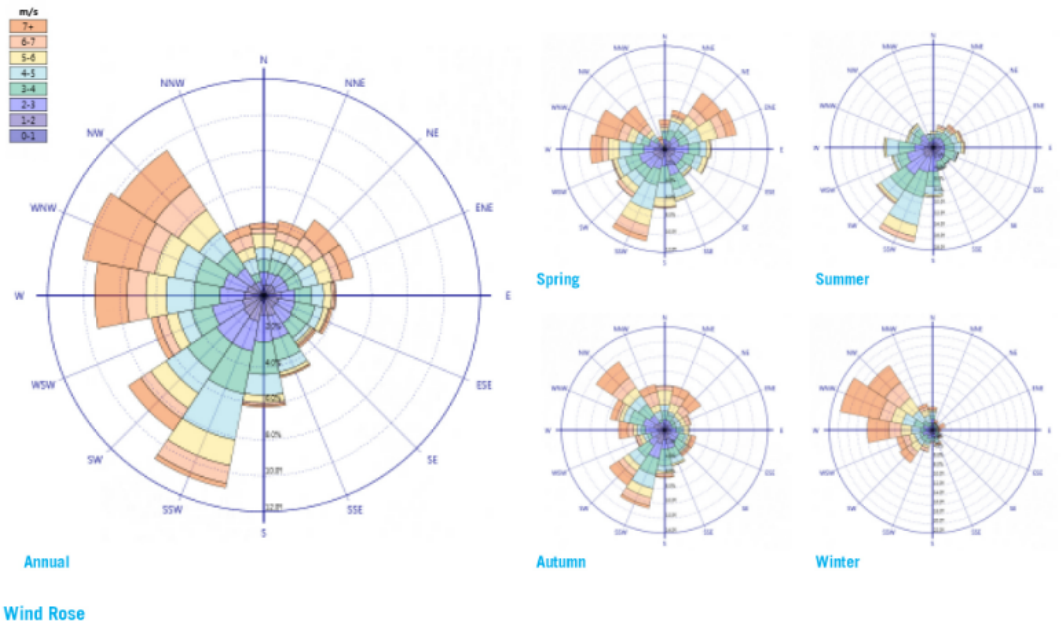
Wind Information

WIND

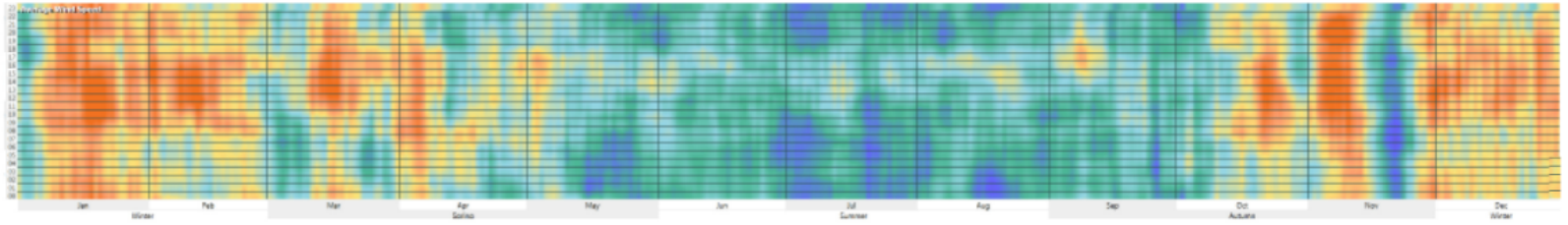
Looking at the data for the four seasons, there appears to be prevailing south-westerly wind flows with high wind speeds of 4 to 5 m/s. There appears to be infrequent but extreme events that originate from the north-west.

It may be worth considering orientating the long axis NE/SW to make use of cross ventilation – size windows appropriately taking into account other considerations – e.g. insects, security, etc.

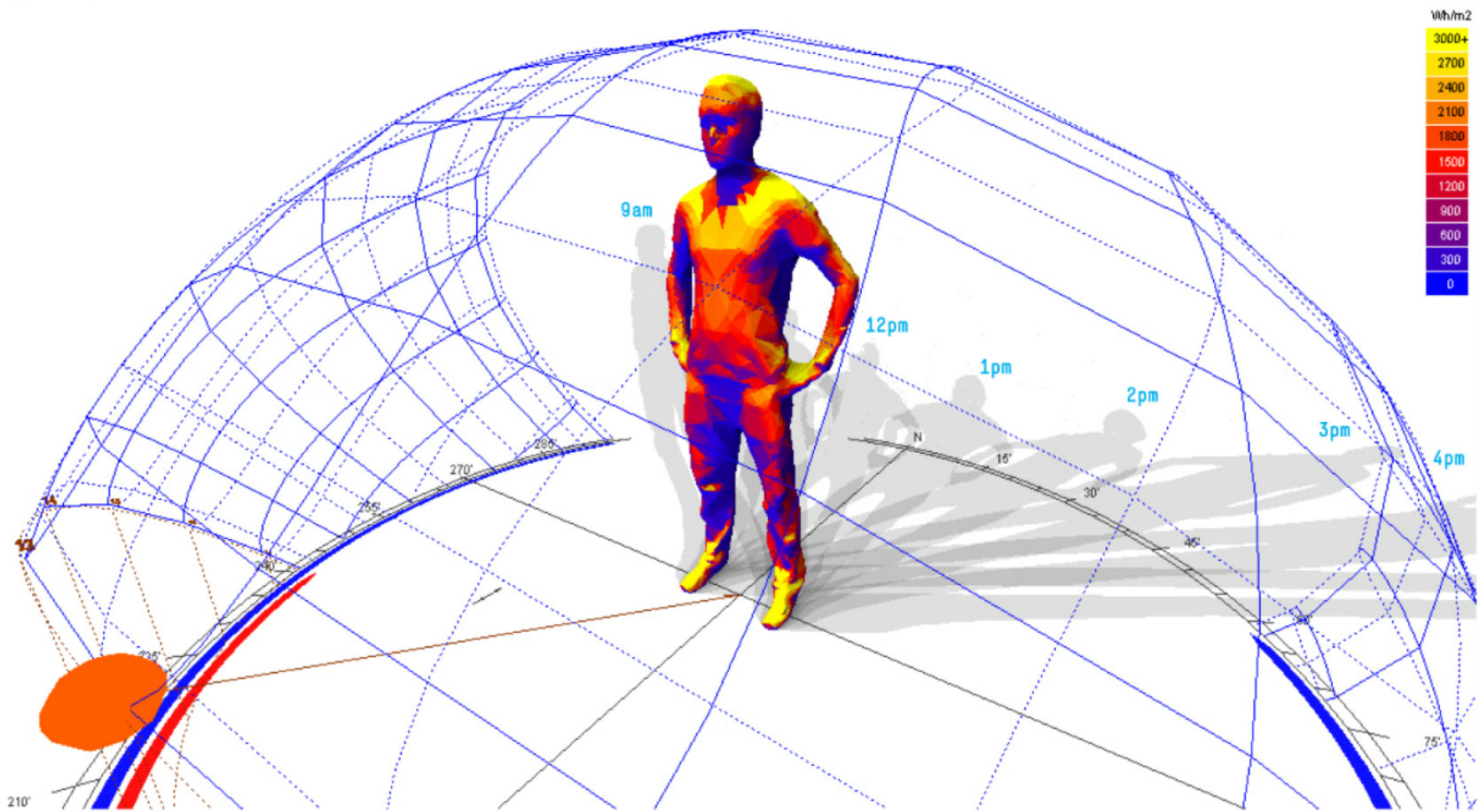
The wind speed is generally higher during the day (afternoon) than at night – the range of daytime velocities is such that thought would have to be given to how control of ventilation is achieved.



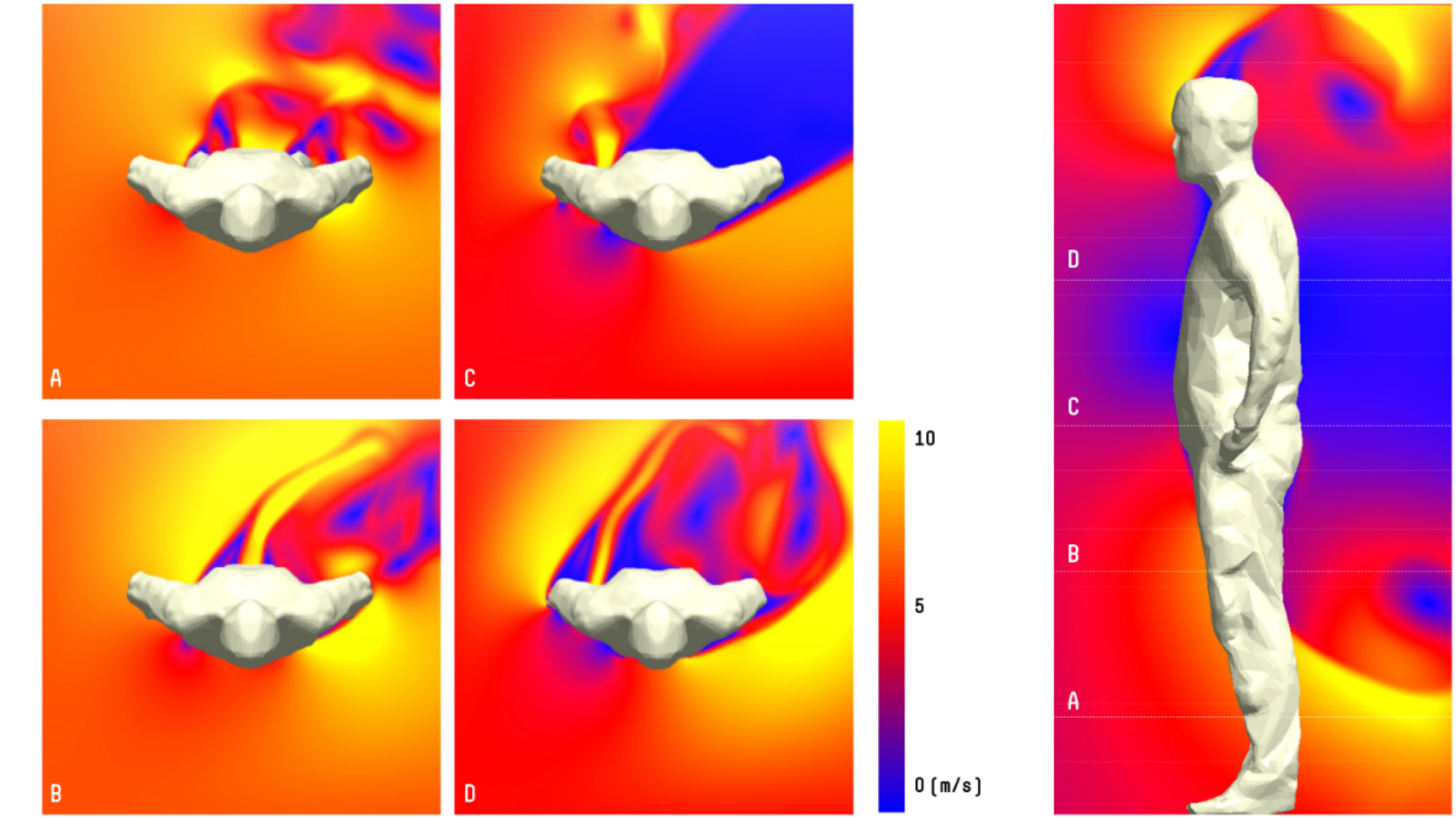
Wind Rose



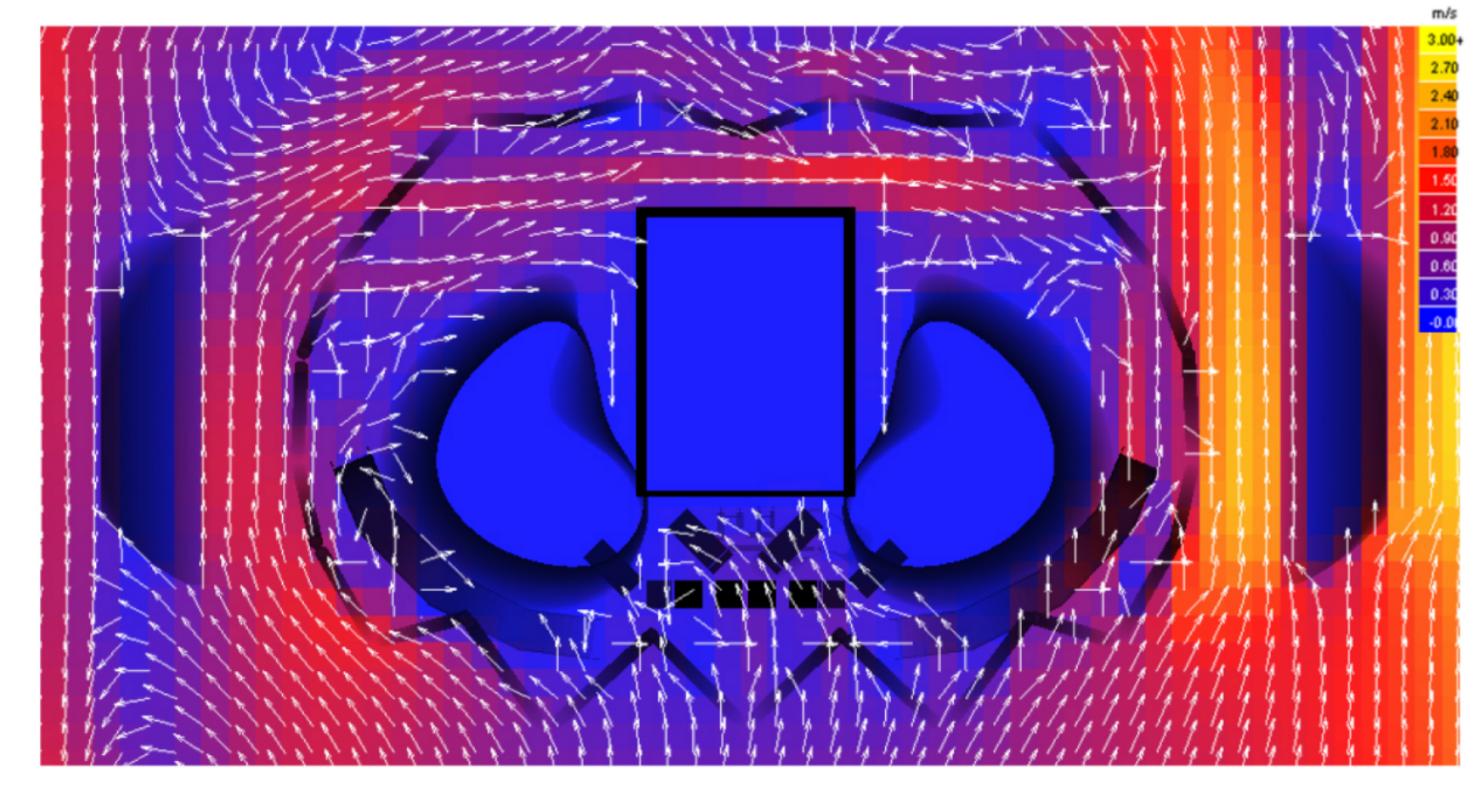
Solar Studies



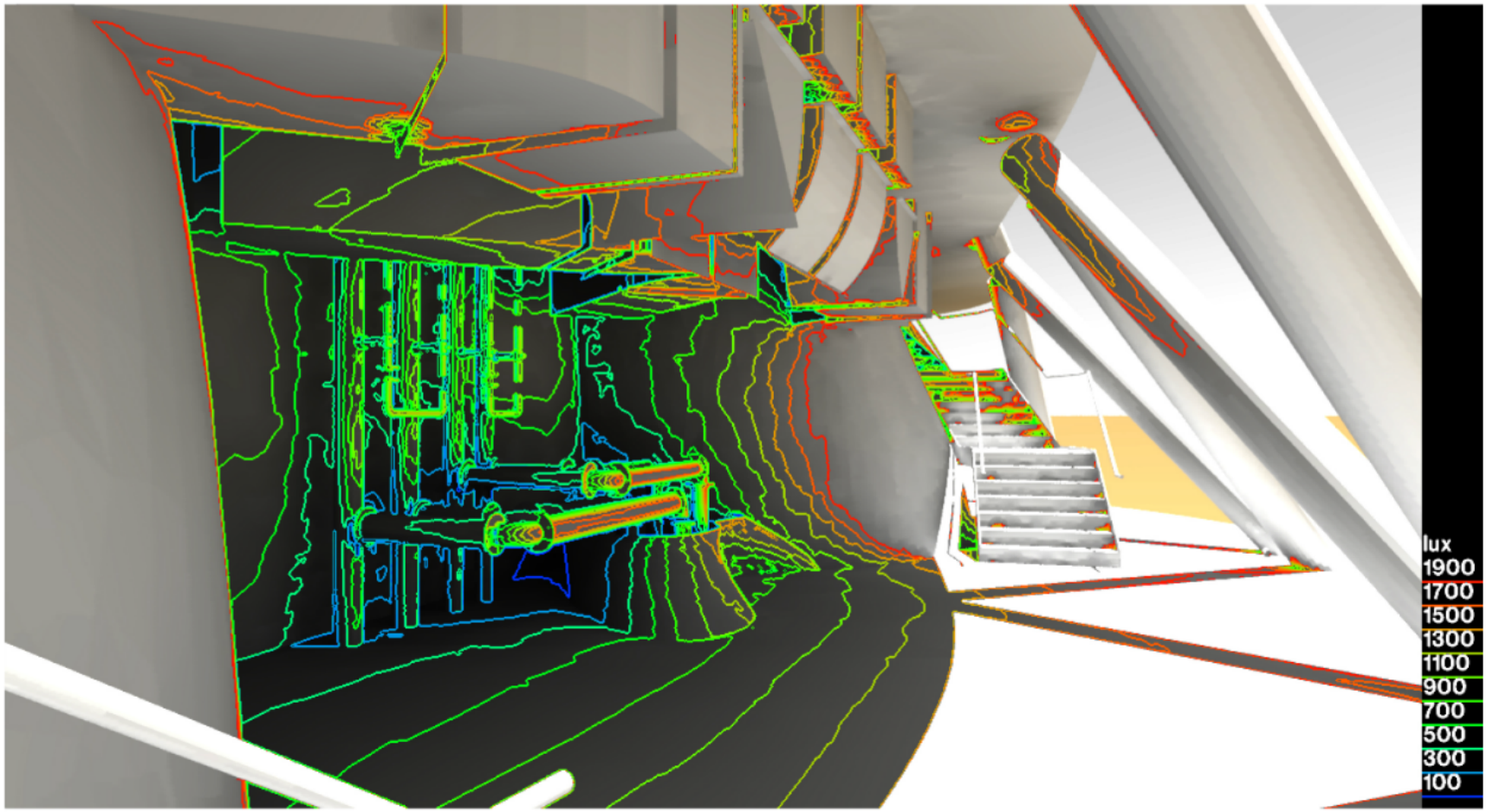
Air Flow Analysis



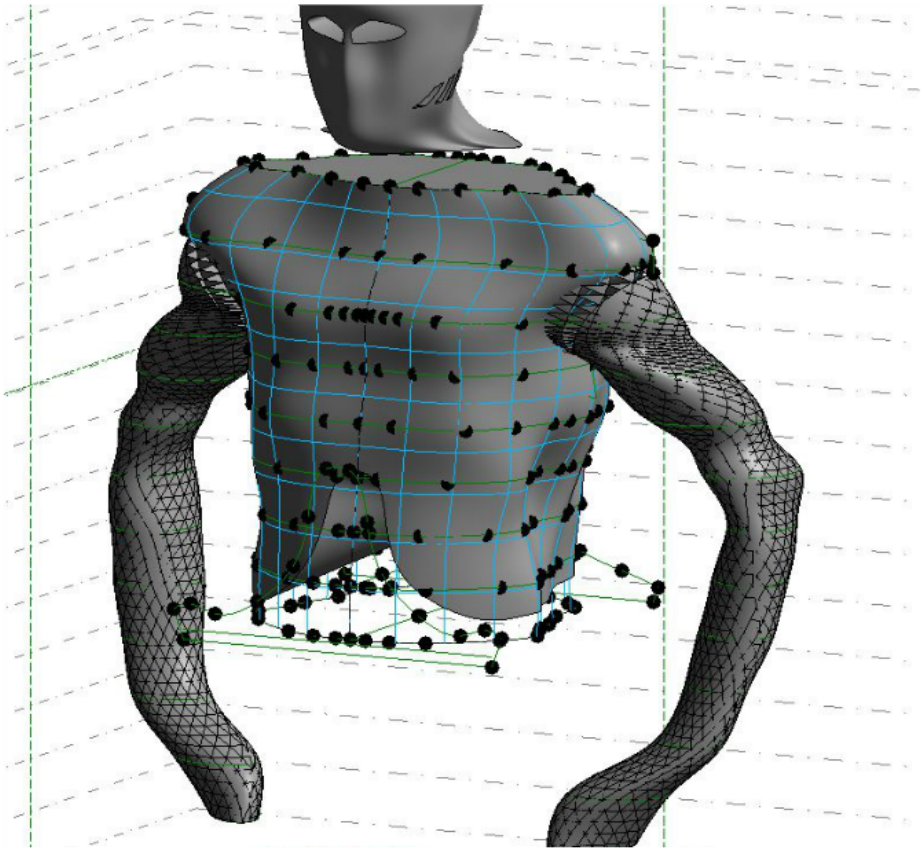
Macro Air Flow Analysis



Daylight Analysis



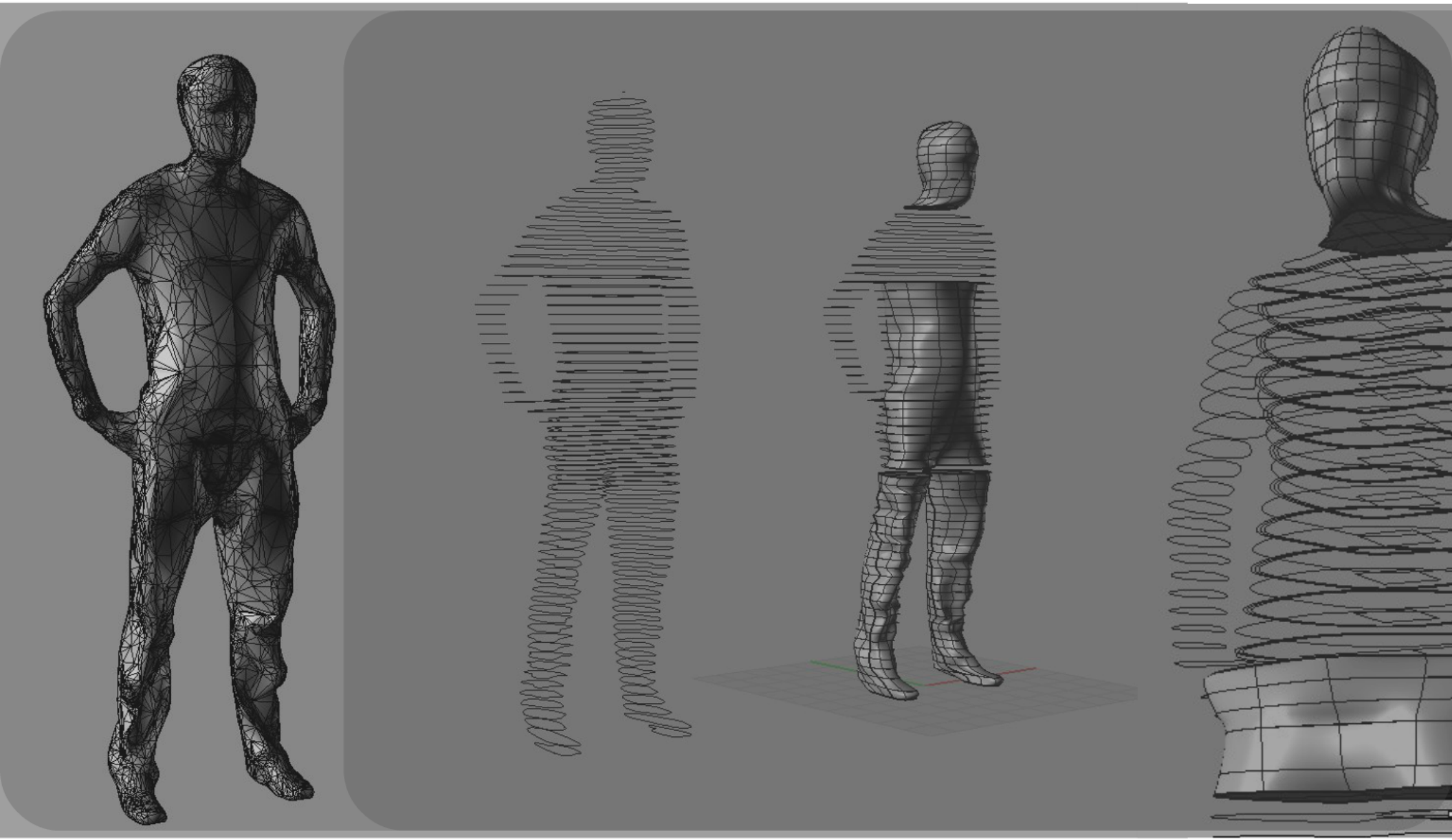
Mass model from Revit by tracing contours

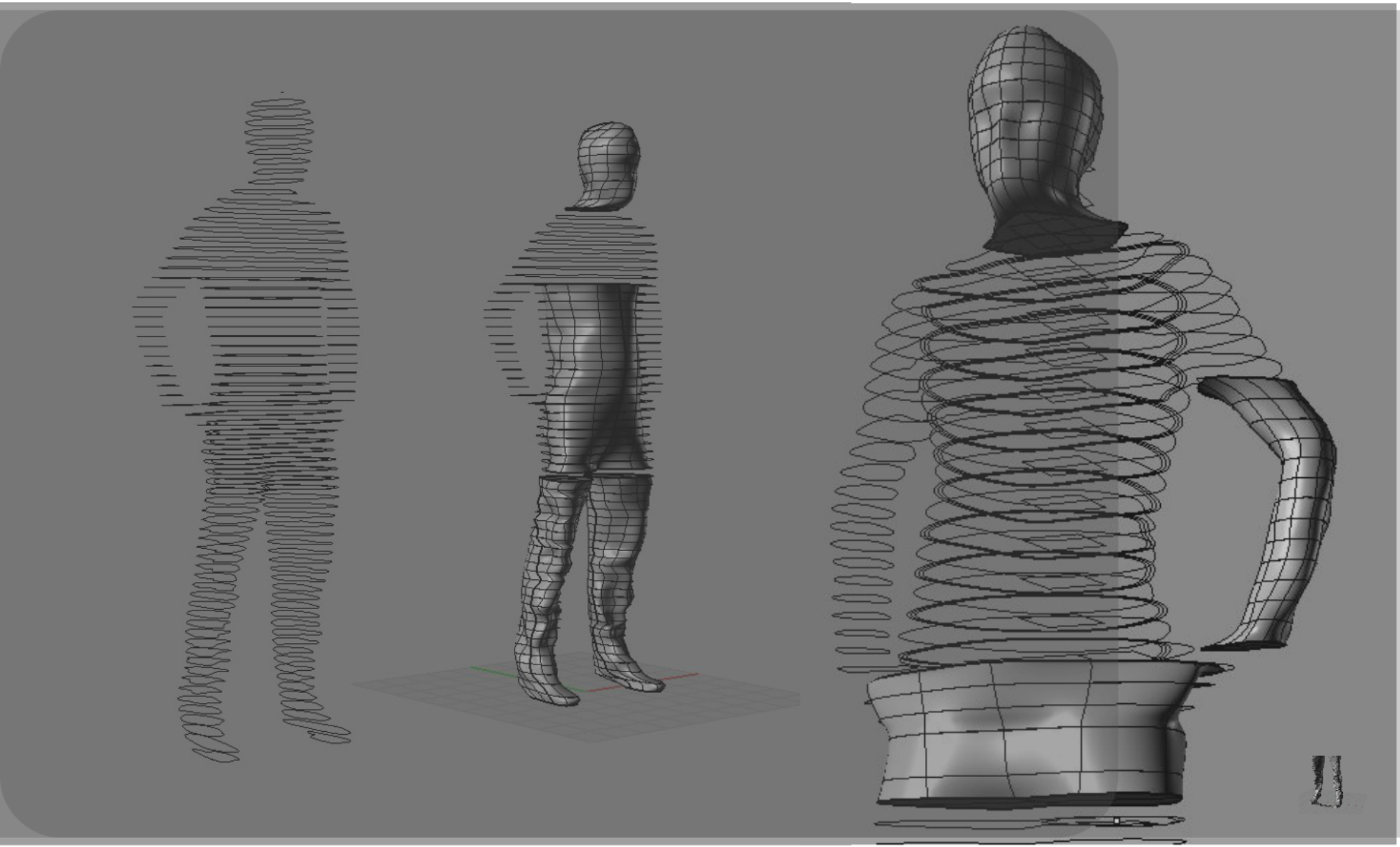


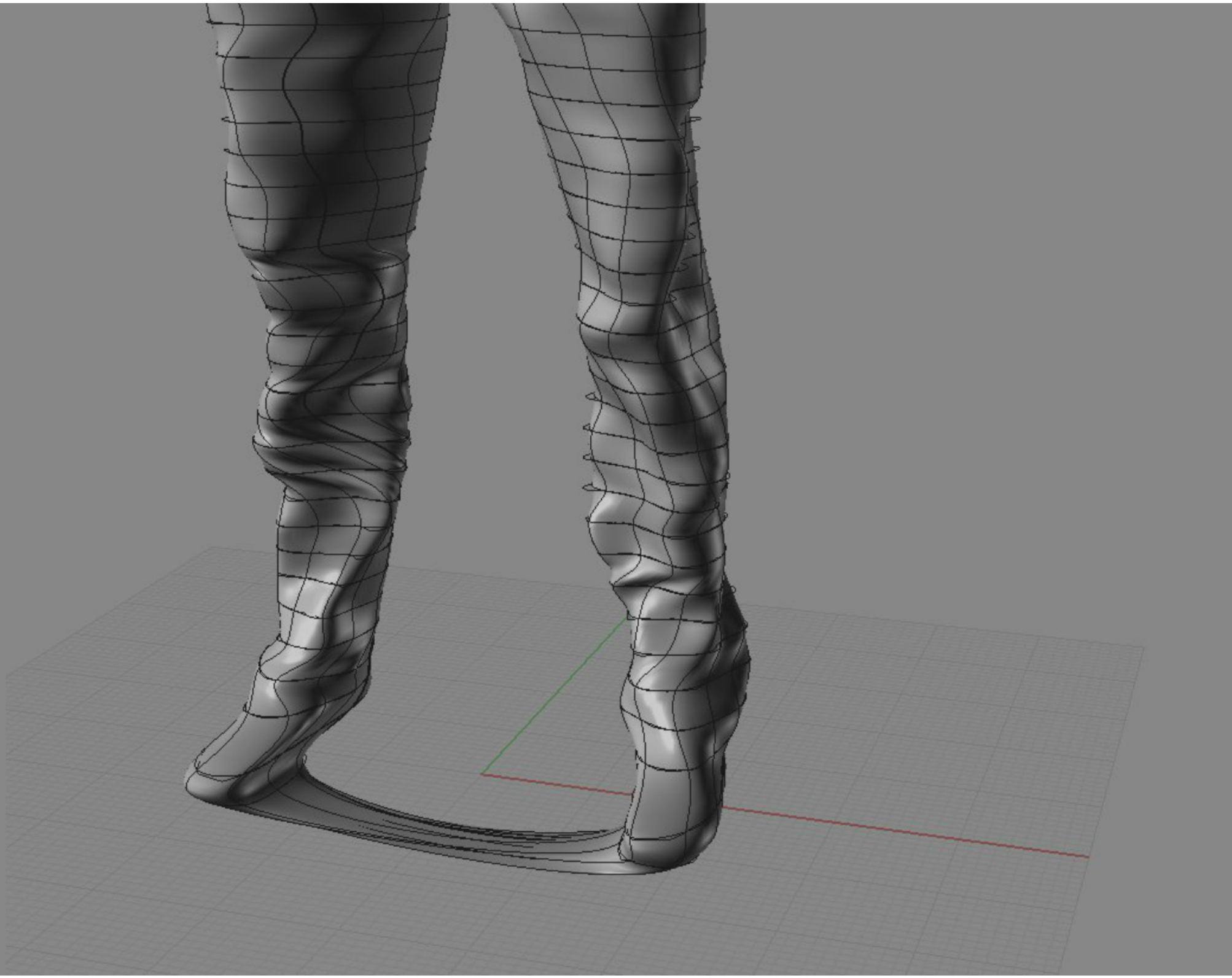
Not good enough...

too manual.

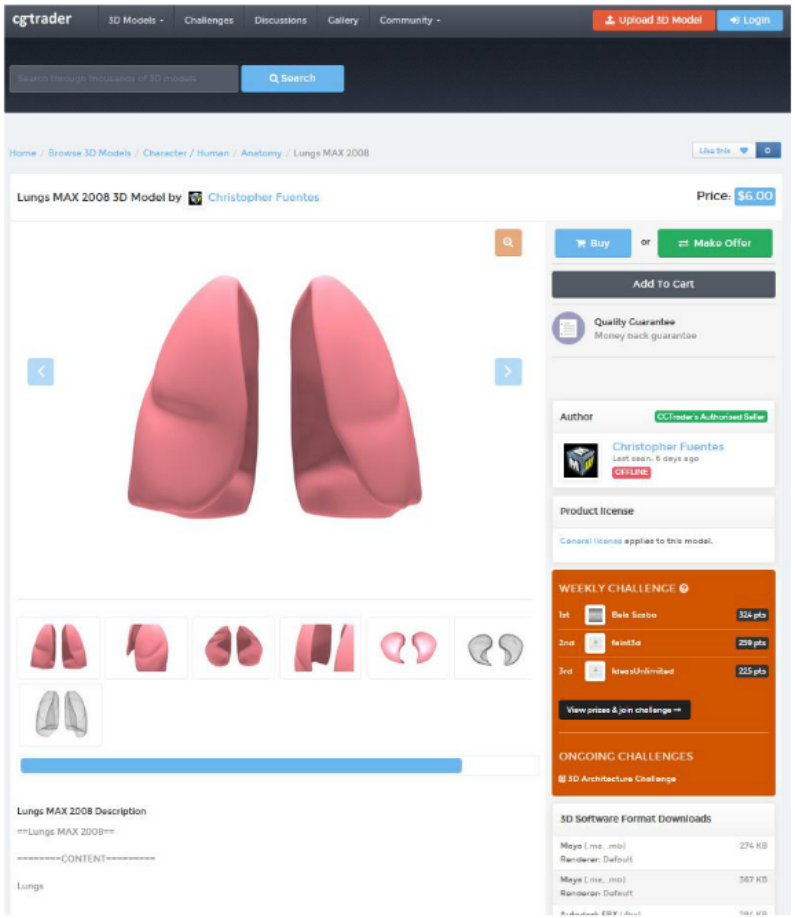
Inflexible.

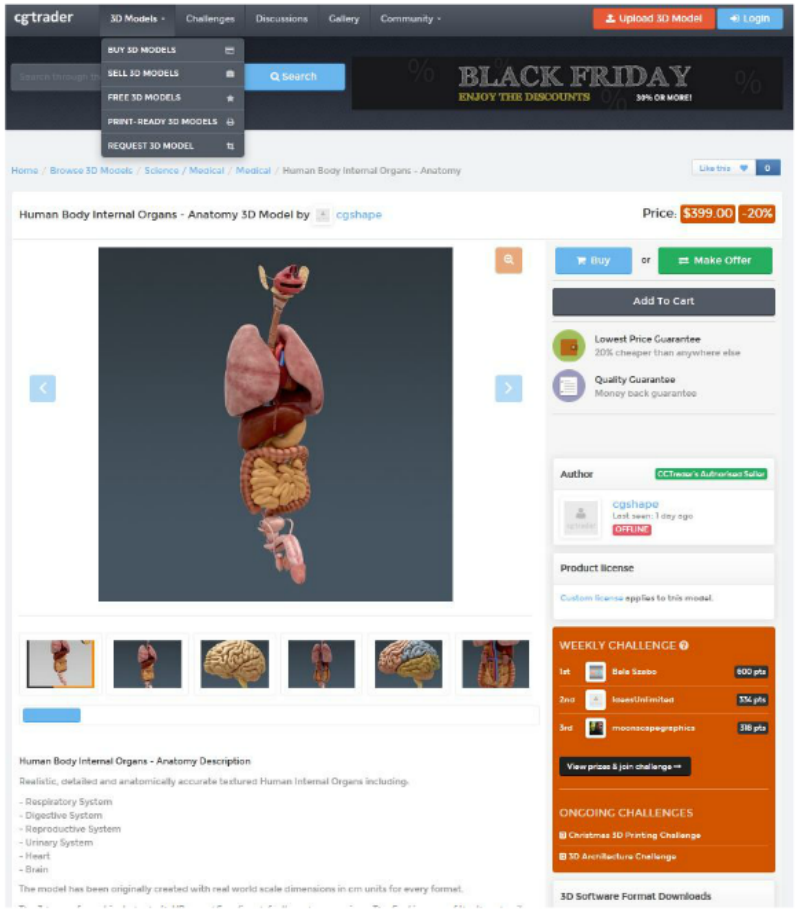




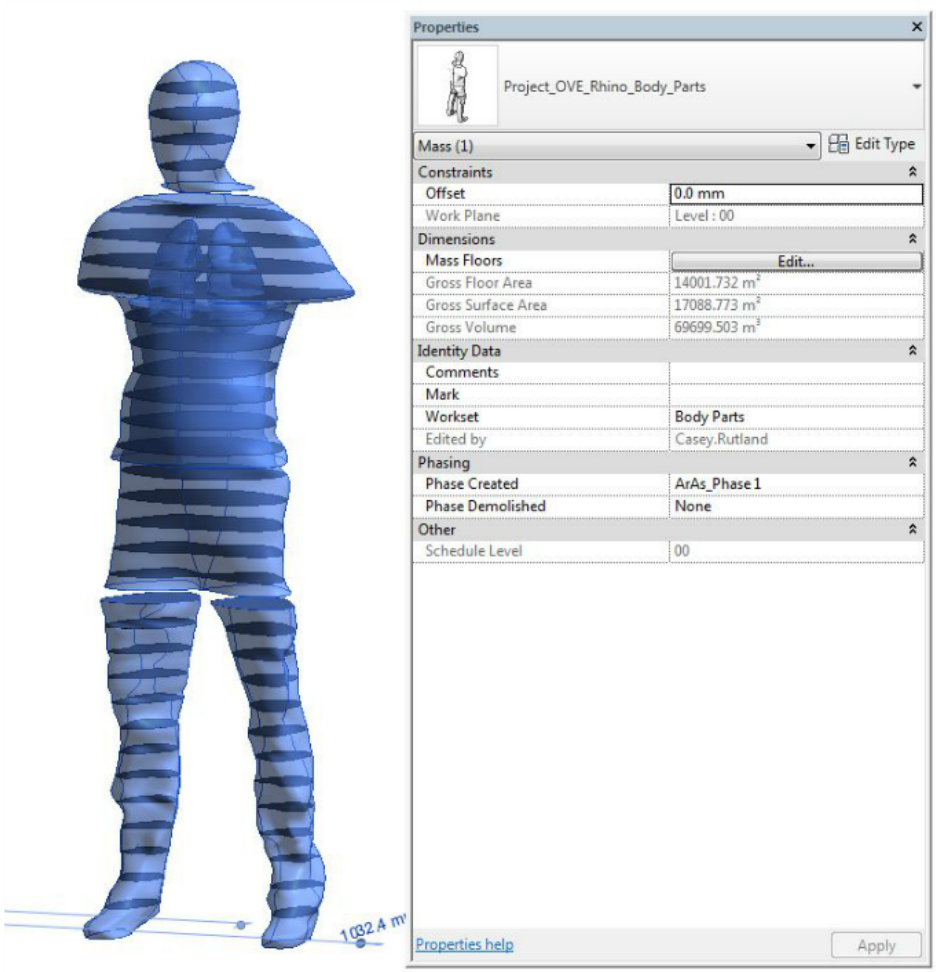


Mass model into Revit





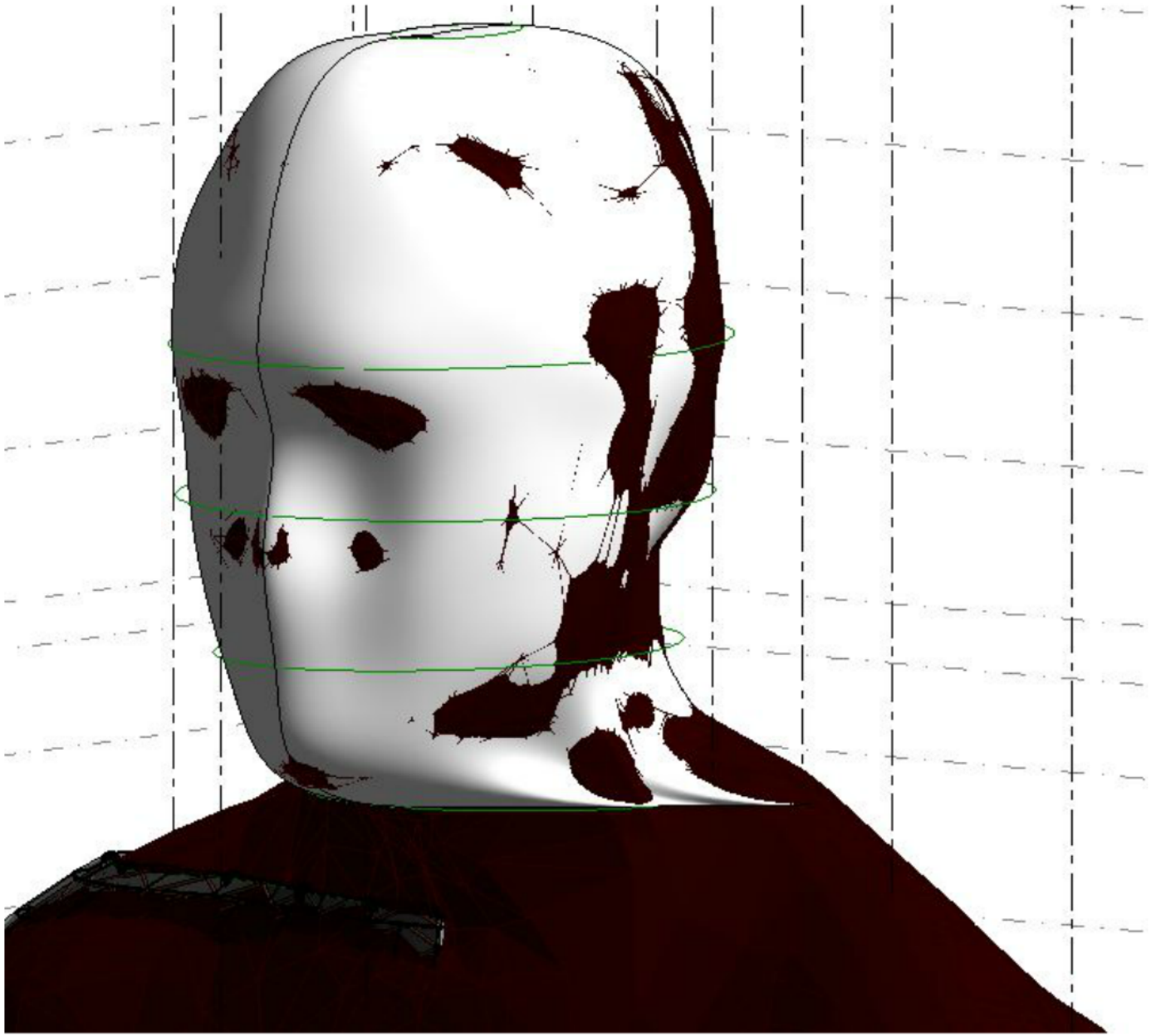
Mass model into Revit

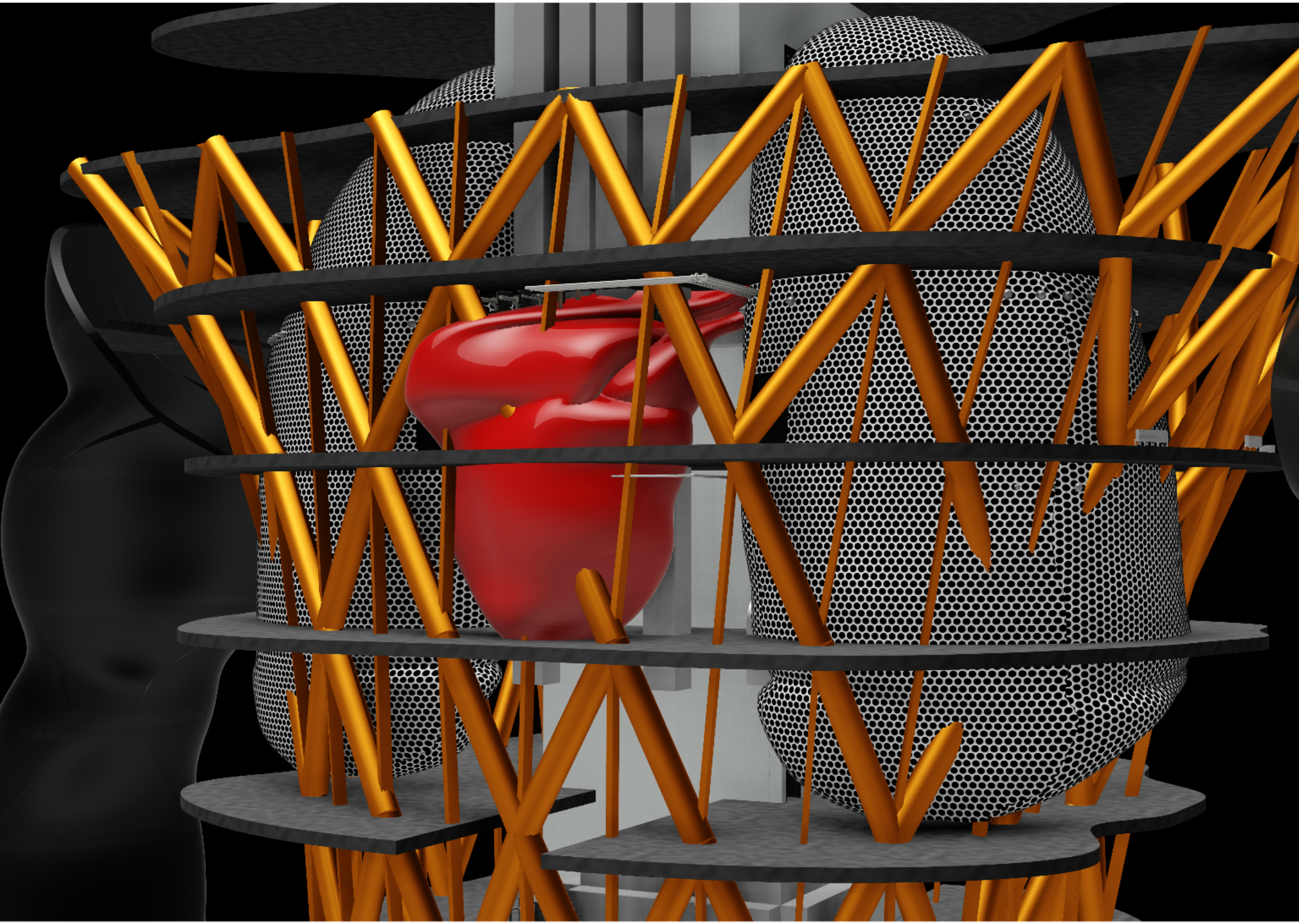


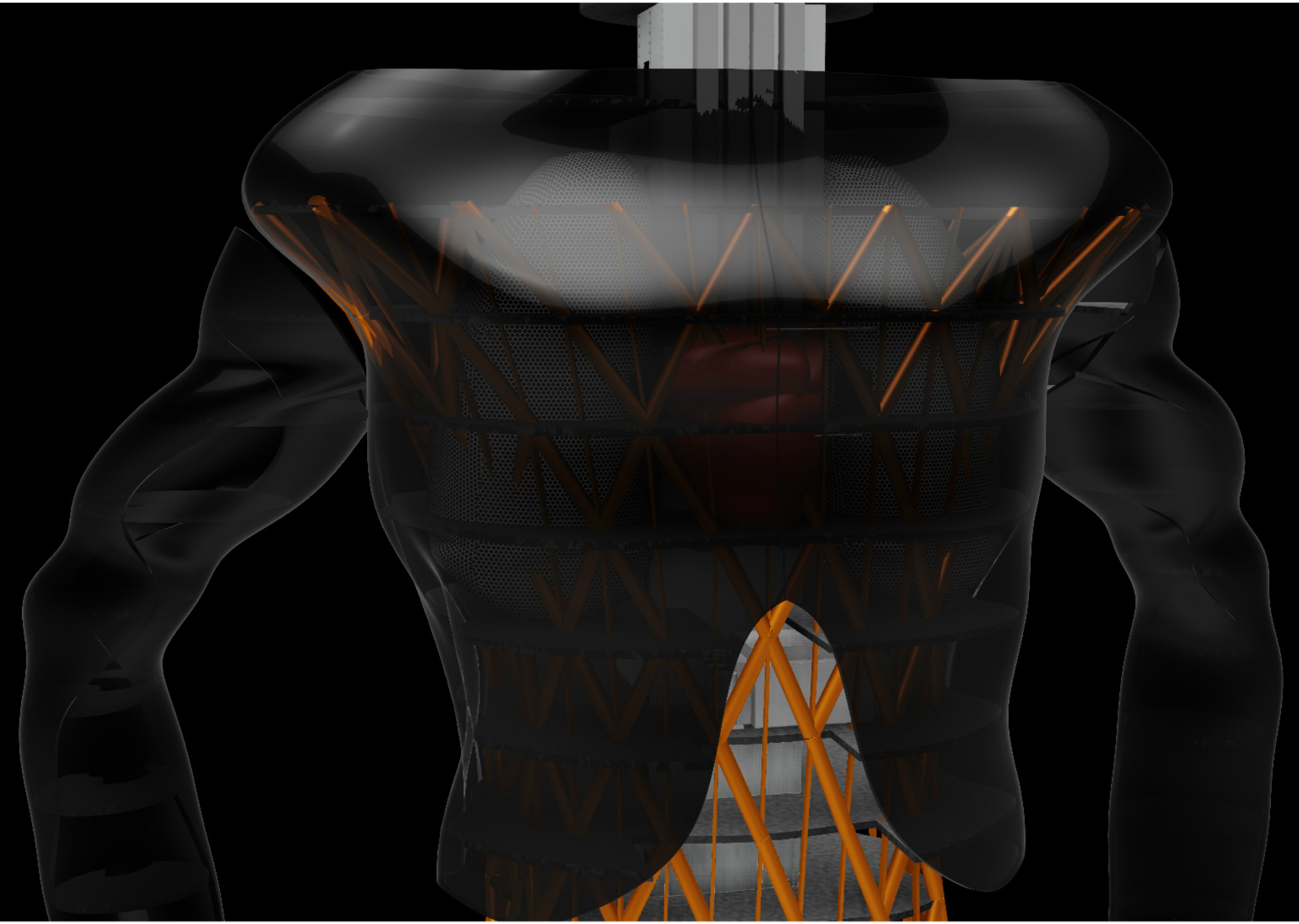
Mass floor areas used for initial rule-of-thumb plant sizing.

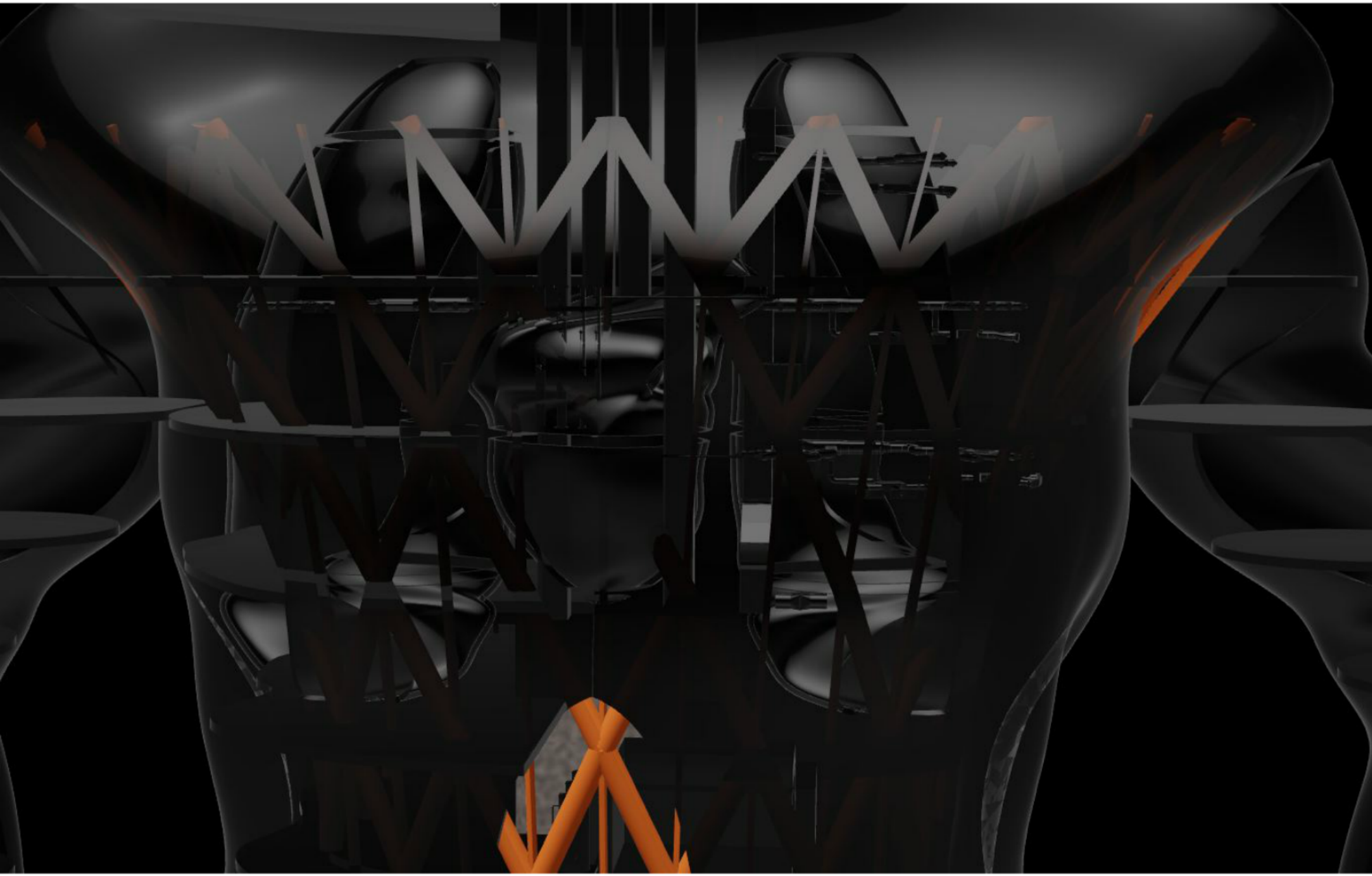
Wall by face!!

Jason?

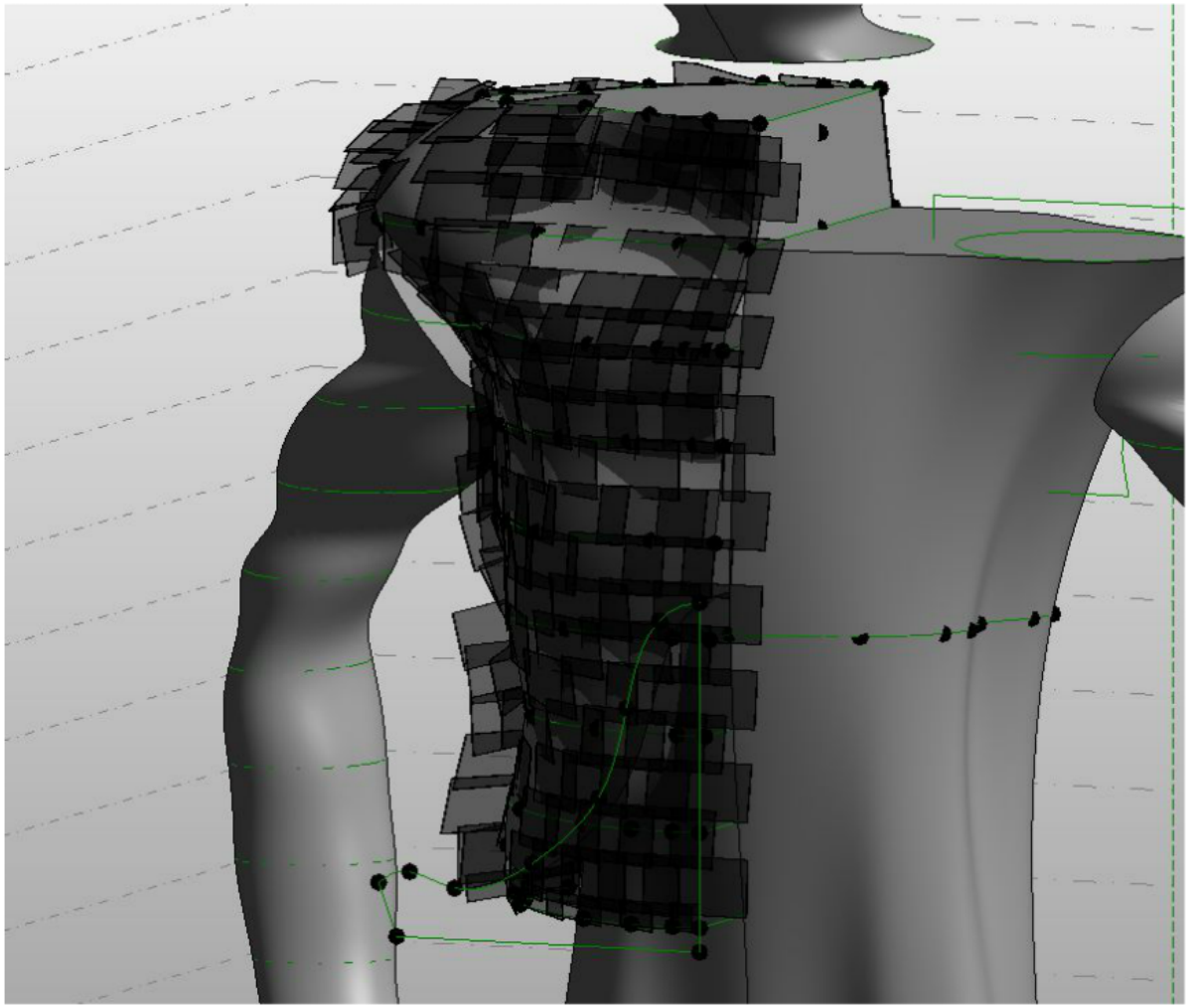


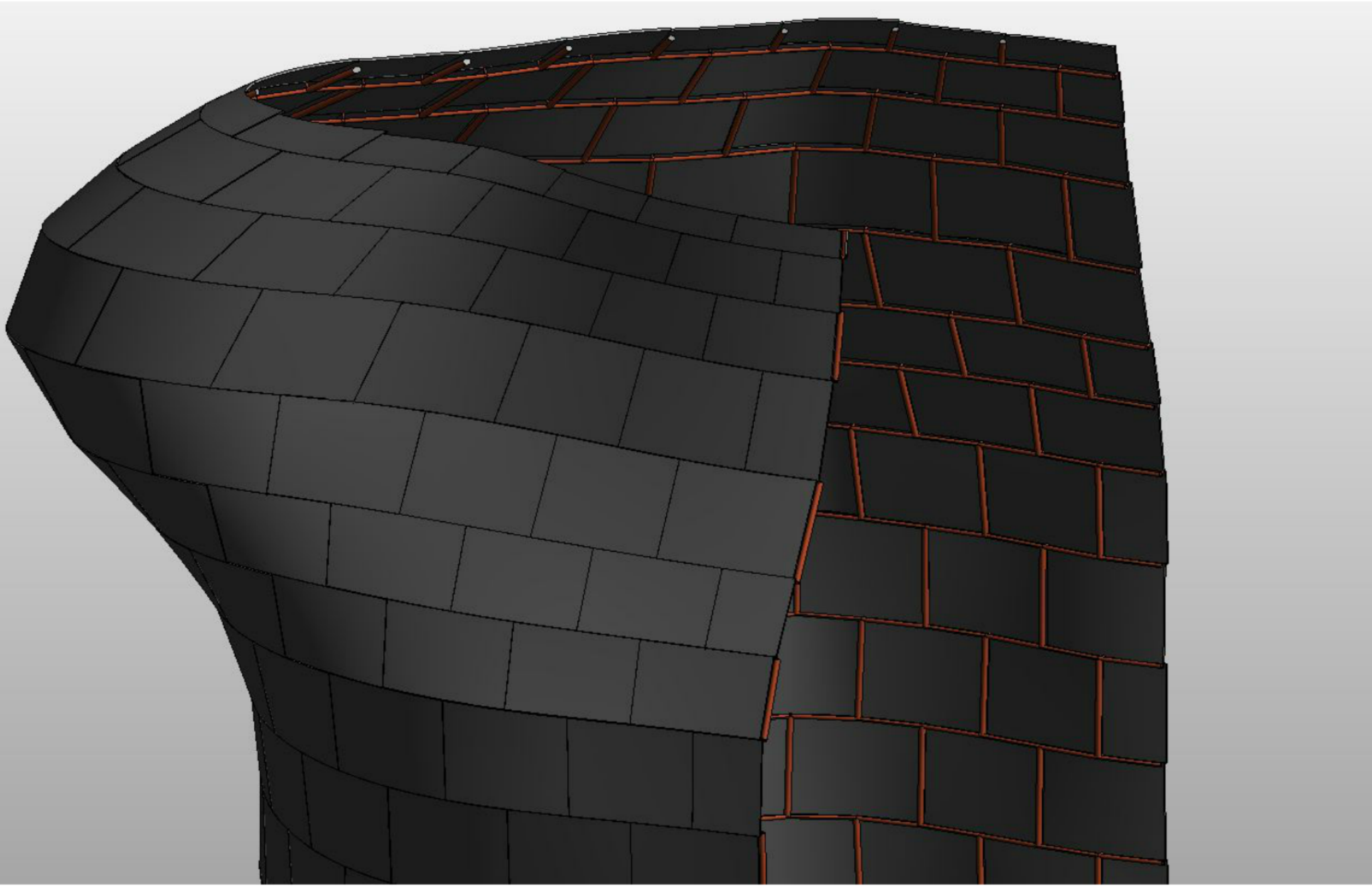


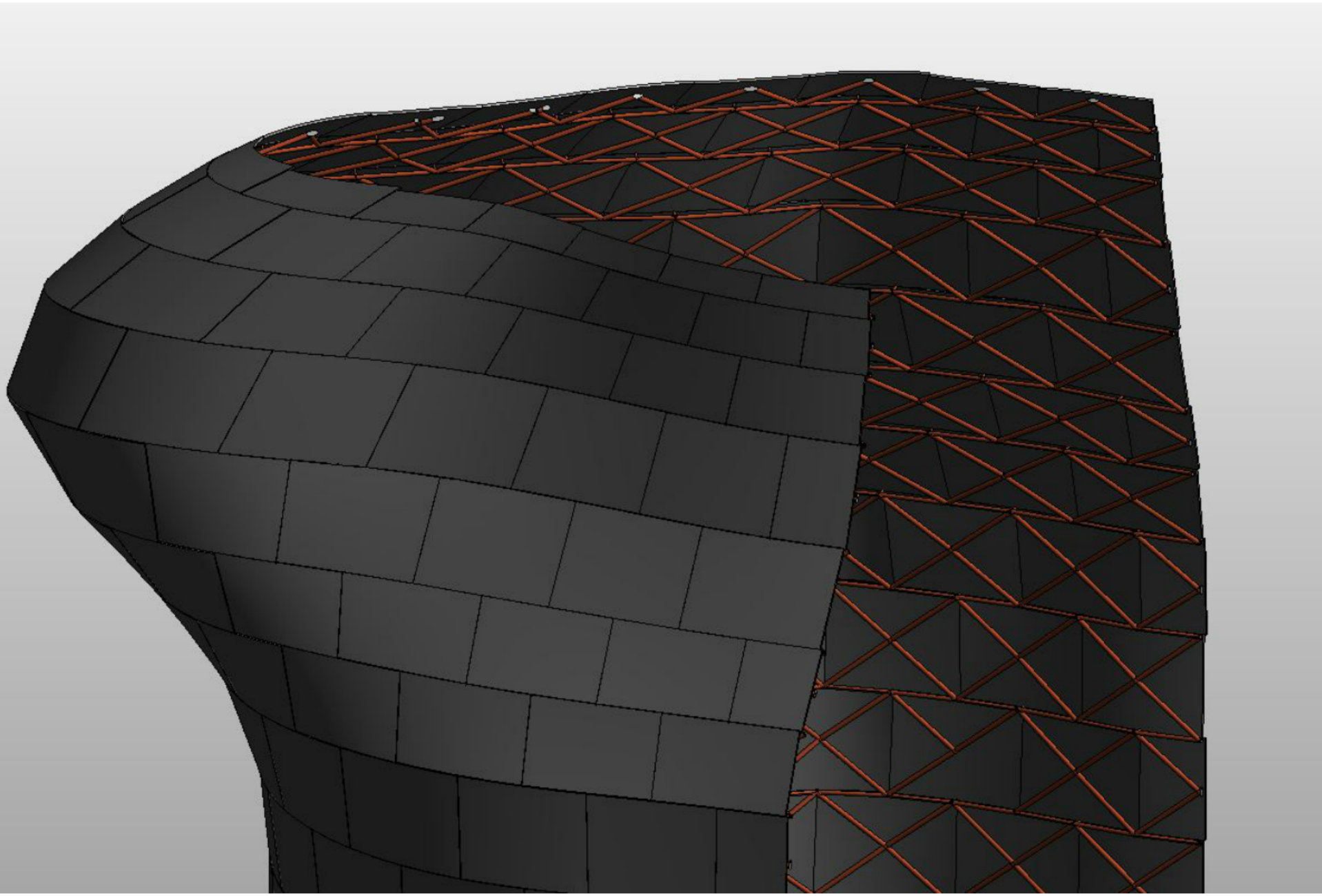




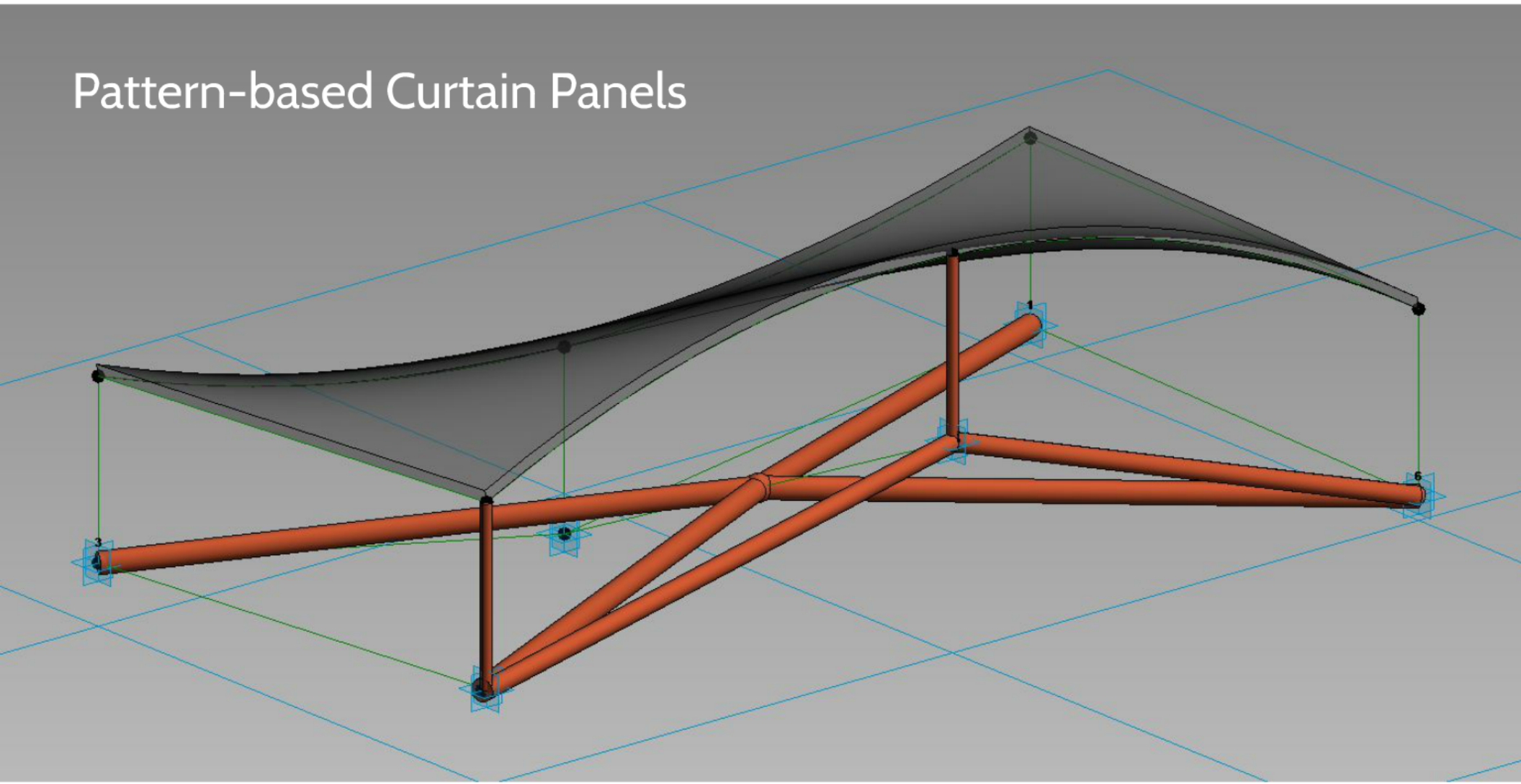
Cladding...



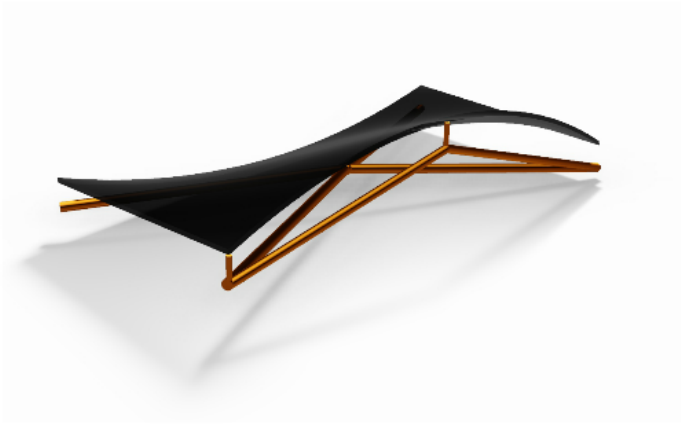




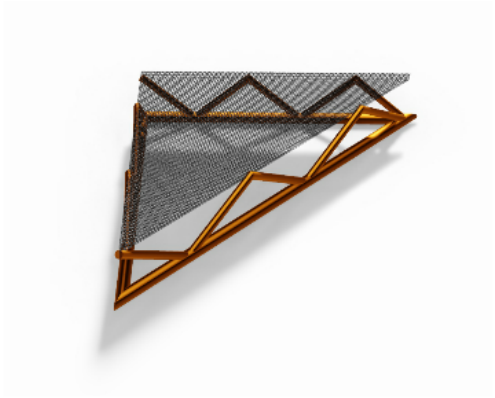
Pattern-based Curtain Panels



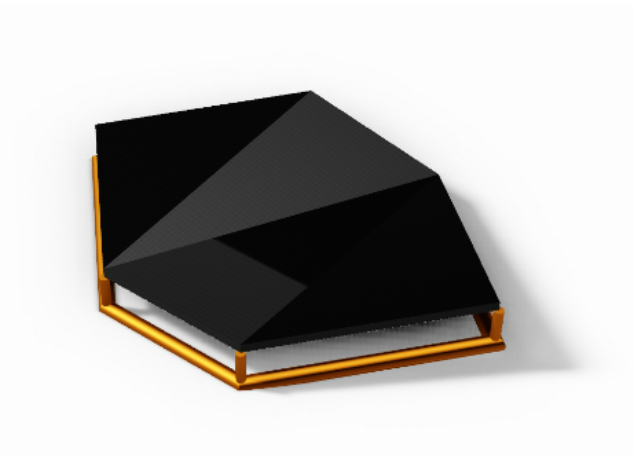
Pattern-based Curtain Panels



Chest

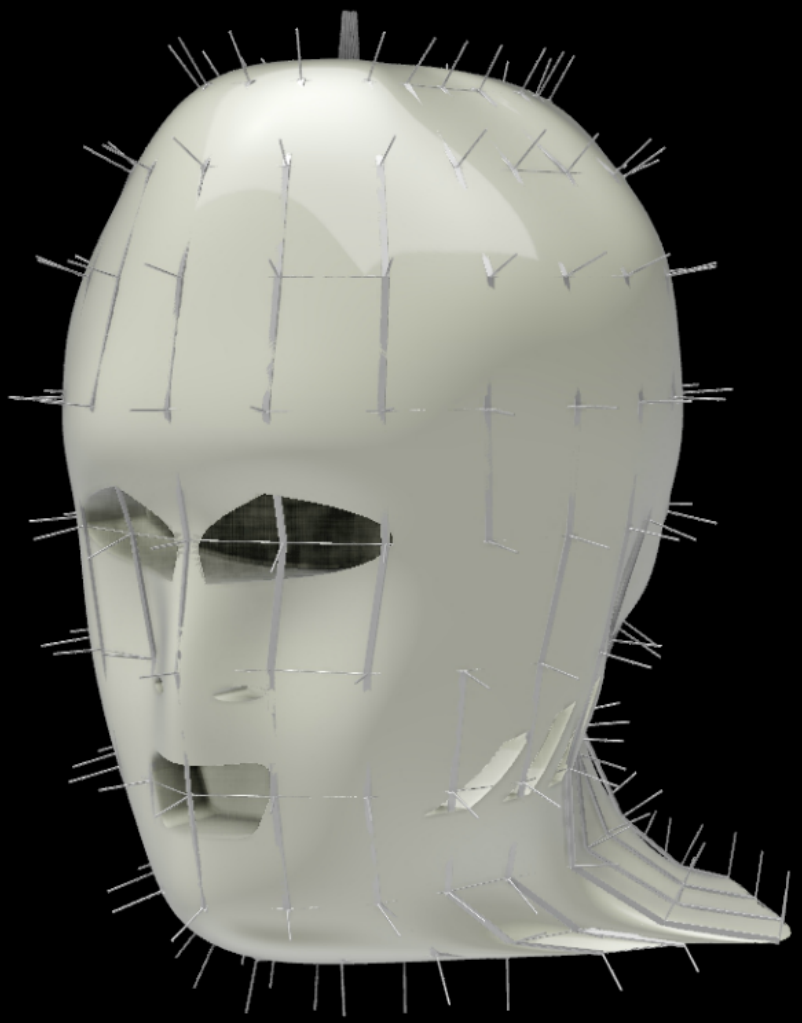


Arm

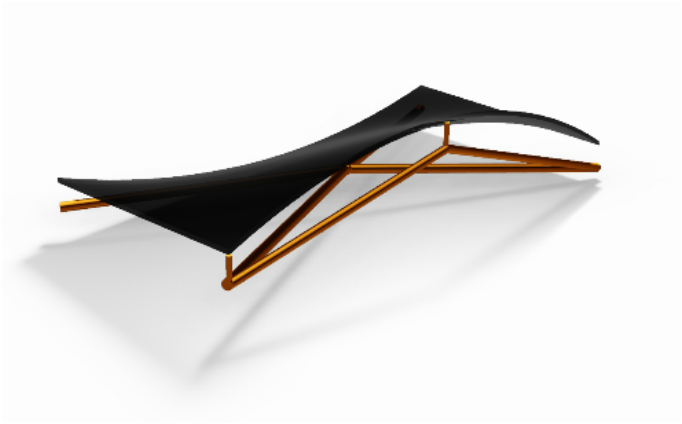


Leg

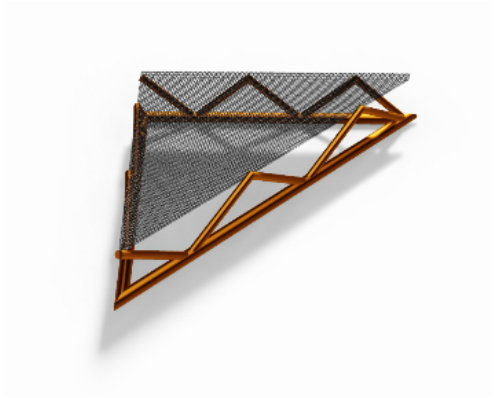
Pinhead?



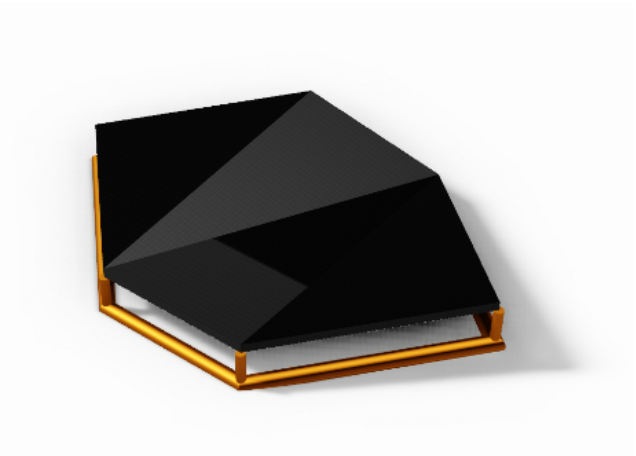
Pattern-based Curtain Panels



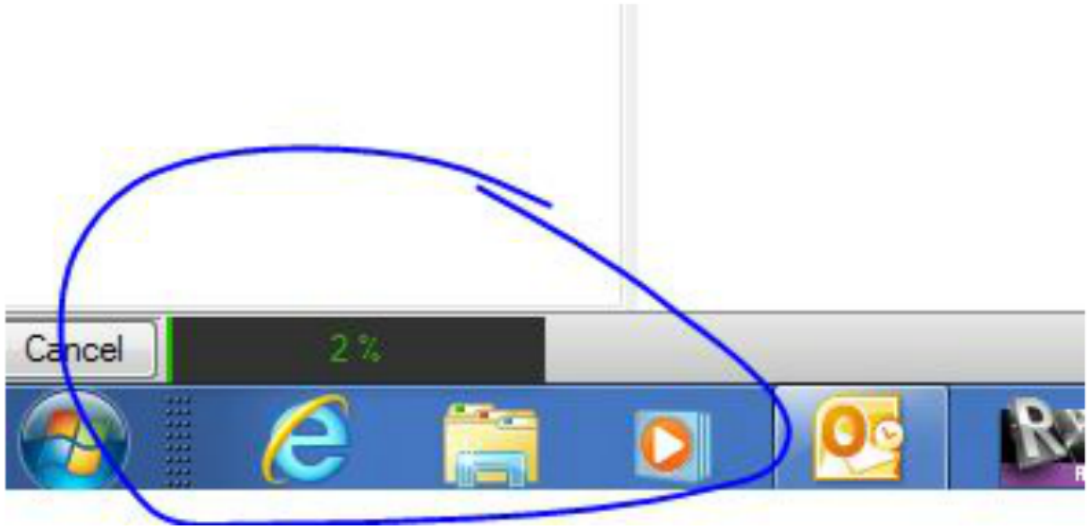
Chest



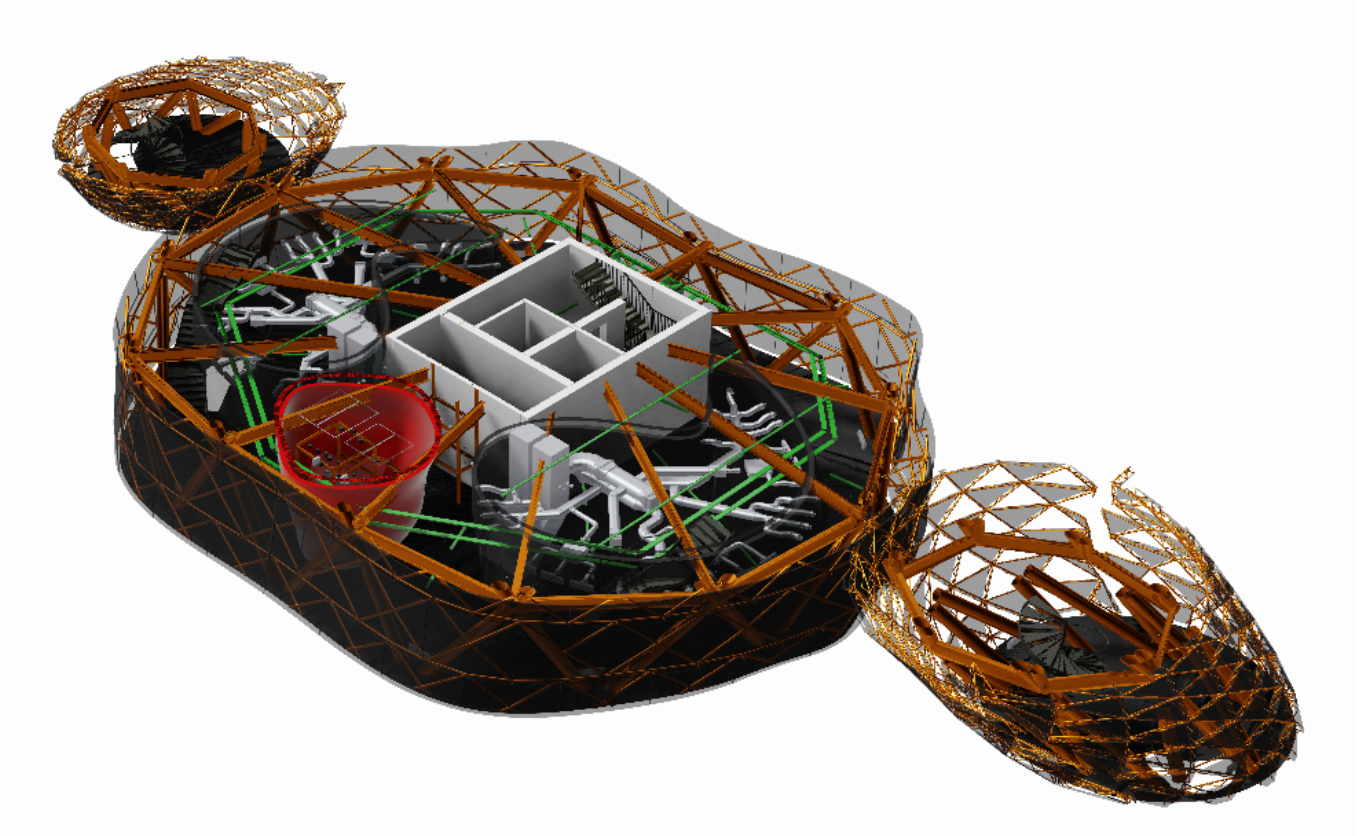
Arm

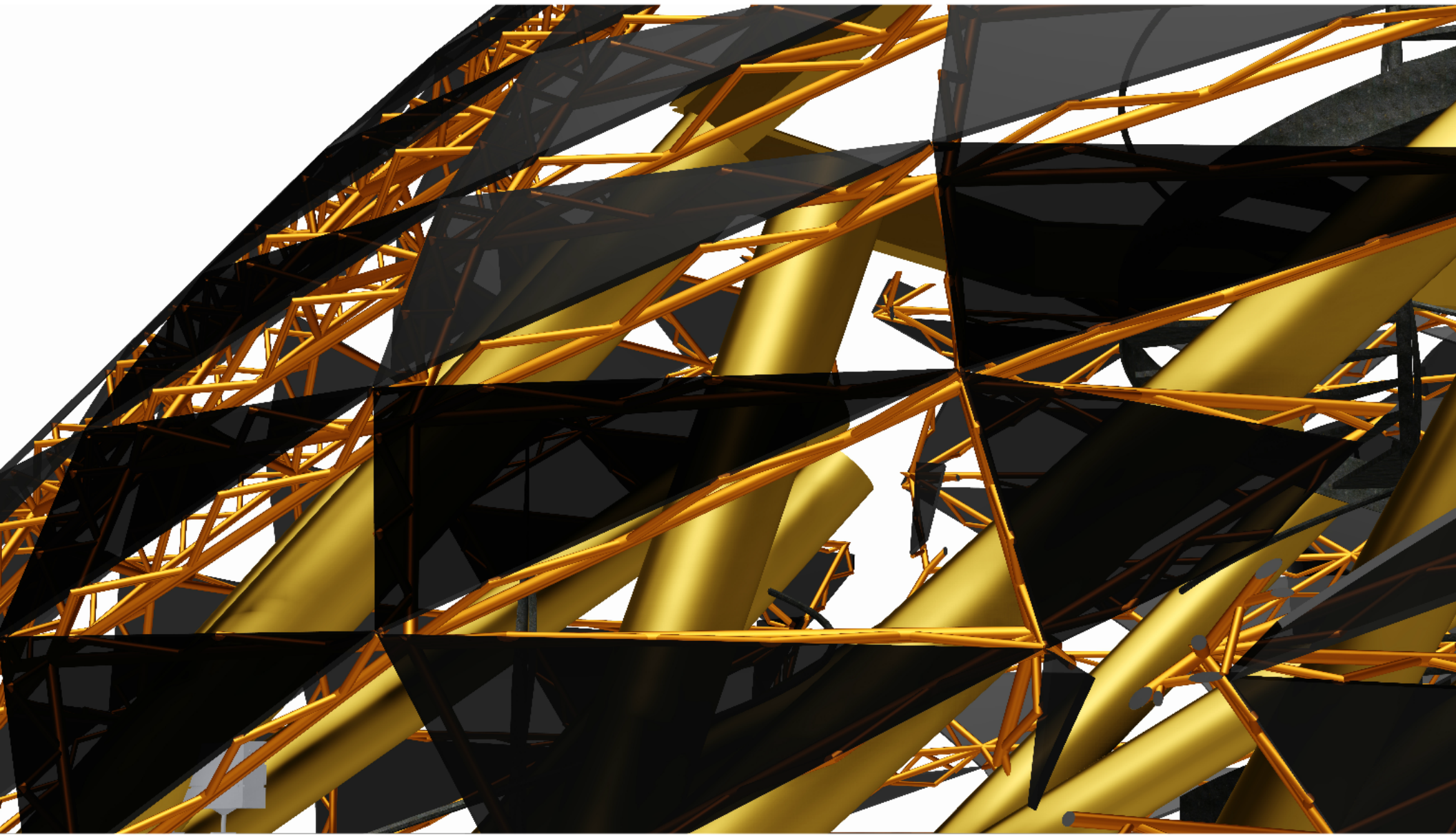


Leg

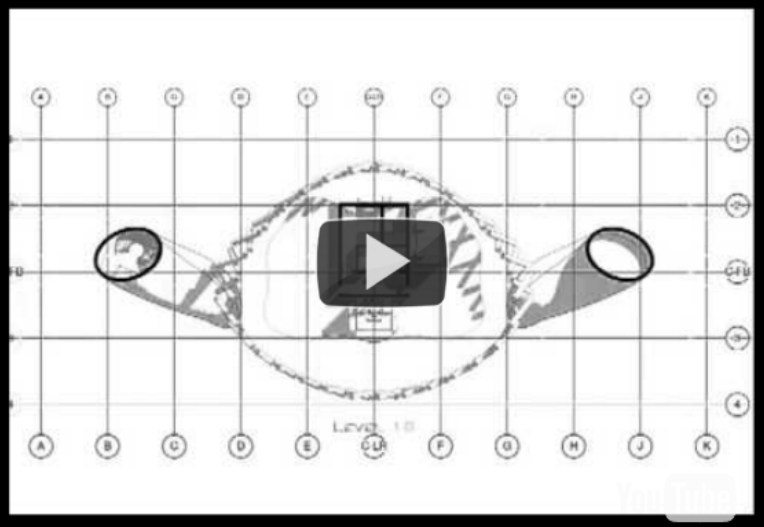

Cancel
2 %

Cladding...

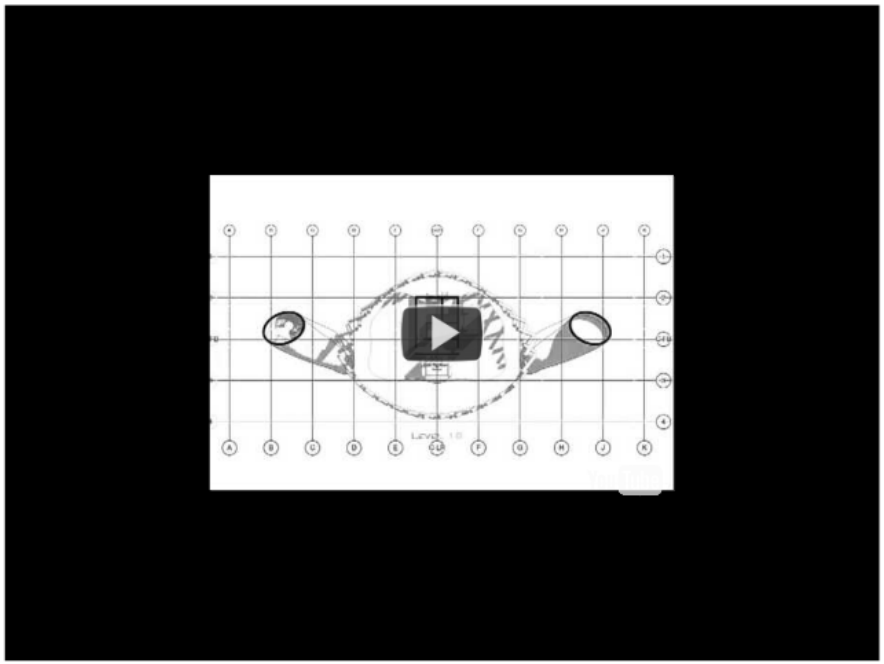


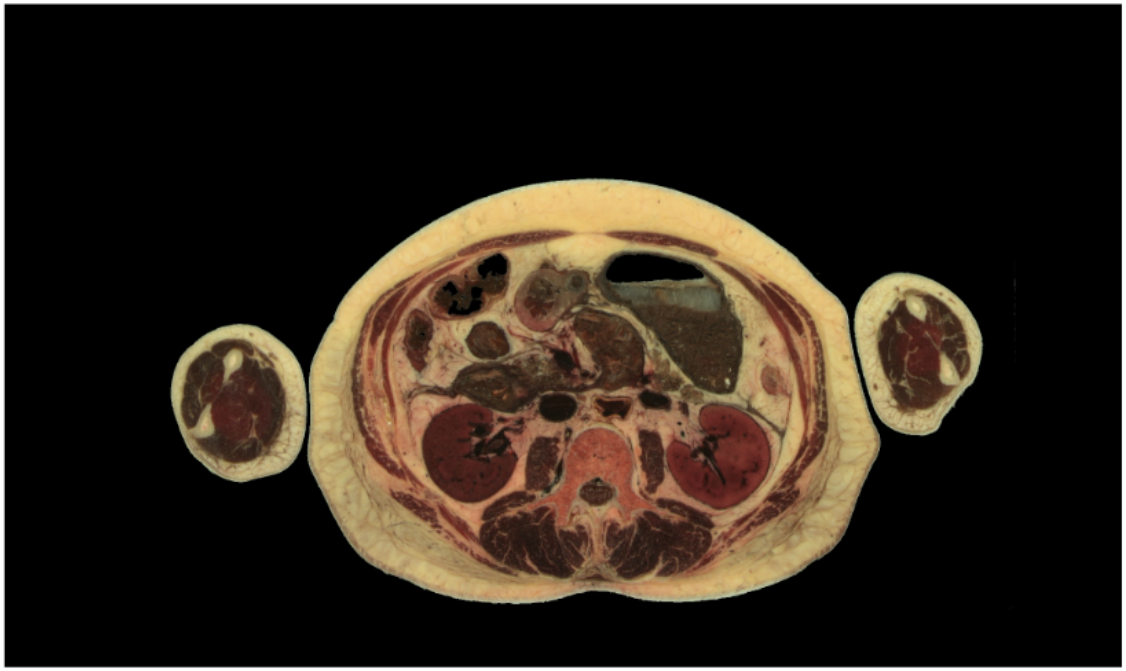


Plans...

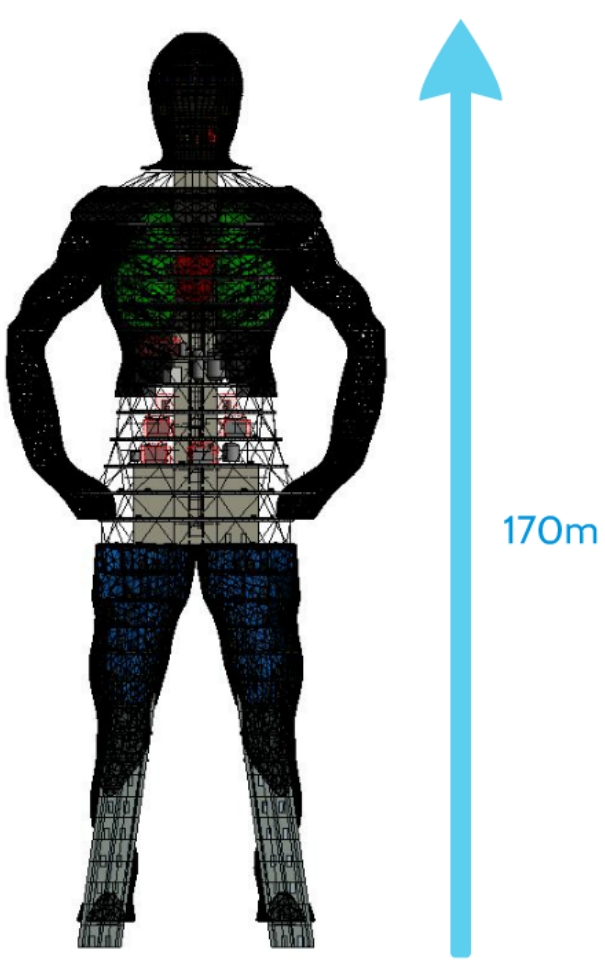


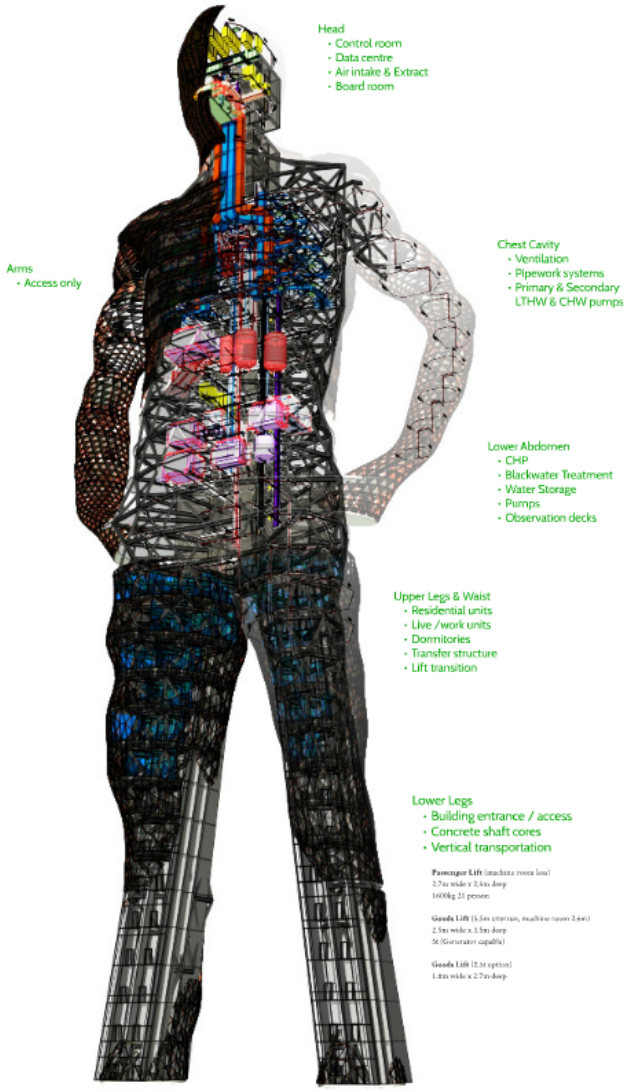
Plans...





Elevation


170m


Head
• Control room
• Data centre
• Air intake & Extract
• Board room
Arms
• Access only
Chest Cavity
• Ventilation
• Pipework systems
• Primary & Secondary LTHW & CHW pumps
Lower Abdomen
• CHP
• Blackwater Treatment
• Water Storage
• Pumps
• Observation decks
Upper Legs & Waist
• Residential units
• Live /work units
• Dormitories
• Transfer structure
• Lift transition
Lower Legs
• Building entrance / access
• Concrete shaft cores
• Vertical transportation
Passenger Lift (machine room less)
2.7m wide x 2.1m deep
1600kg 21 person
Goods Lift (1.5m external machine room 2.4m)
2.5m wide x 3.5m deep
5t (Generator capable)
Goods Lift (2.5t option)
1.8m wide x 2.7m deep

- Live / work units
- Dormitories
- Transfer structure
- Lift transition

Lower Legs

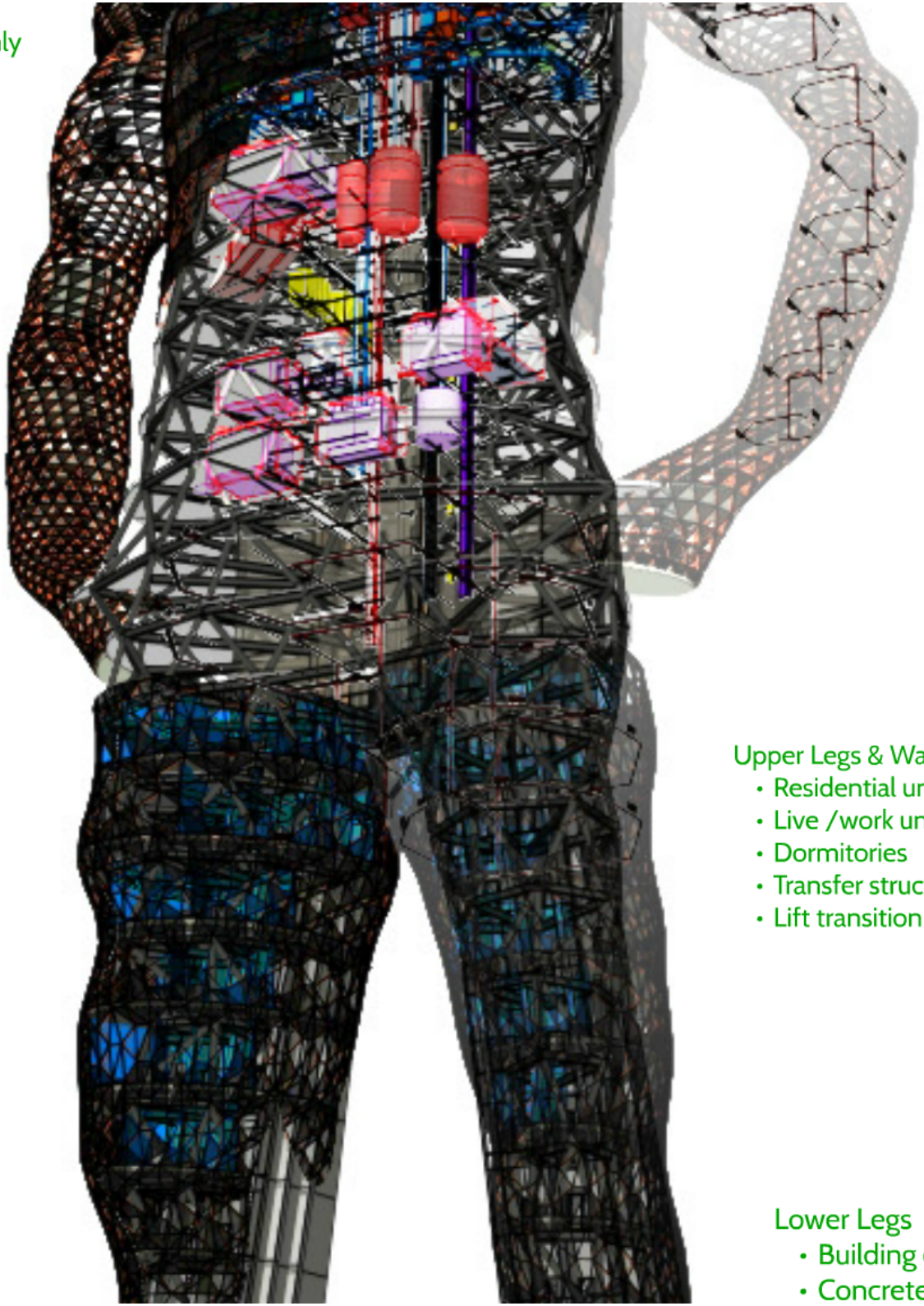
- Building entrance / access
- Concrete shaft cores
- Vertical transportation

Passenger Lift (machine room less)
2.7m wide x 2.5m deep
1600kg 21 person

Goods Lift (5.5m overrun, machine room 2.6m)
2.5m wide x 3.5m deep
5t (Generator capable)

Goods Lift (2.5t option)
1.8m wide x 2.7m deep

Arms
- Access only



- Pipework systems
- Primary & Secondary LTHW & CHW pumps

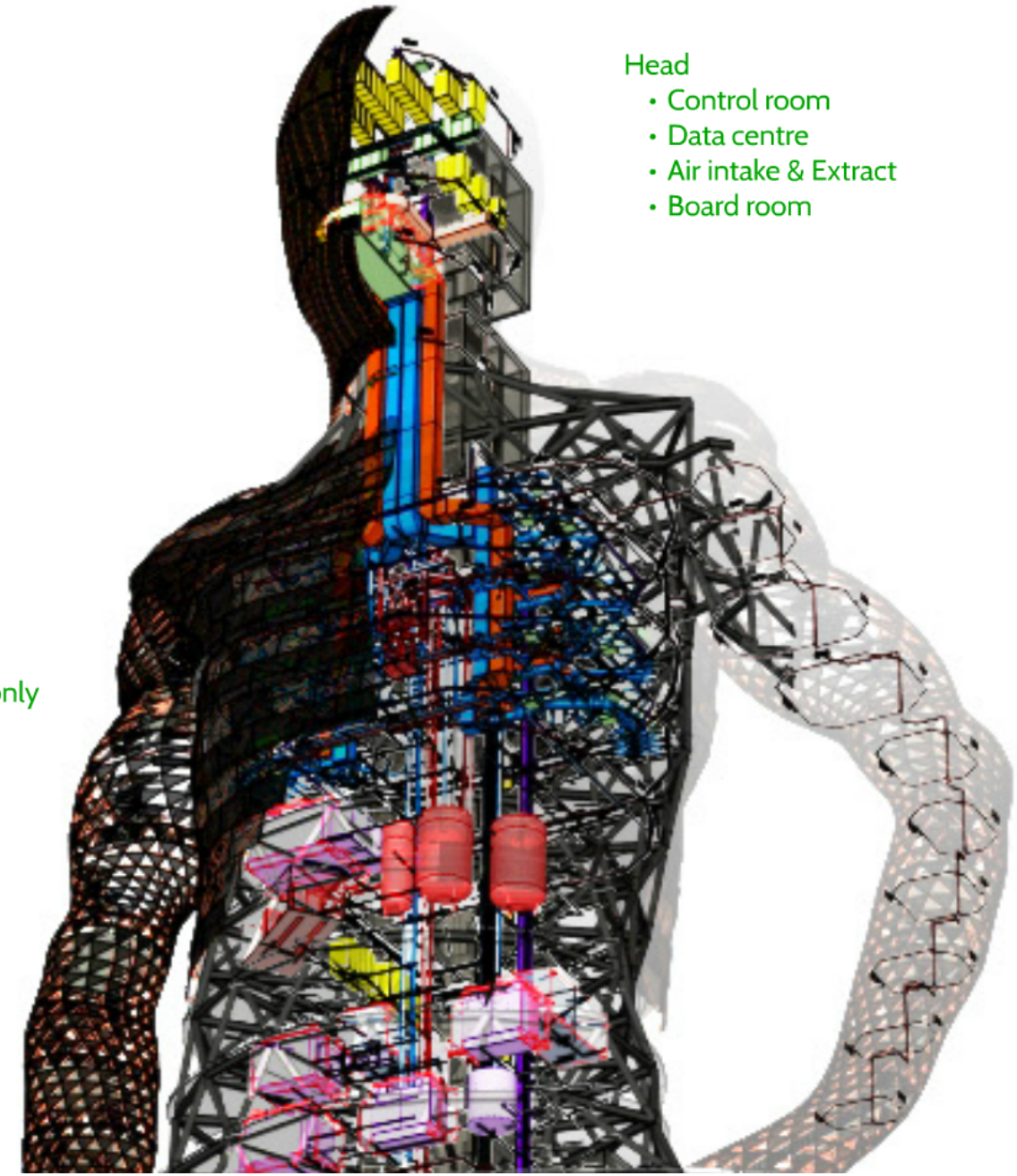
Lower Abdomen
- CHP
- Blackwater Treatment
- Water Storage
- Pumps
- Observation decks

Upper Legs & Waist
- Residential units
- Live /work units
- Dormitories
- Transfer structure
- Lift transition

Lower Legs
- Building entrance / access
- Concrete shaft cores

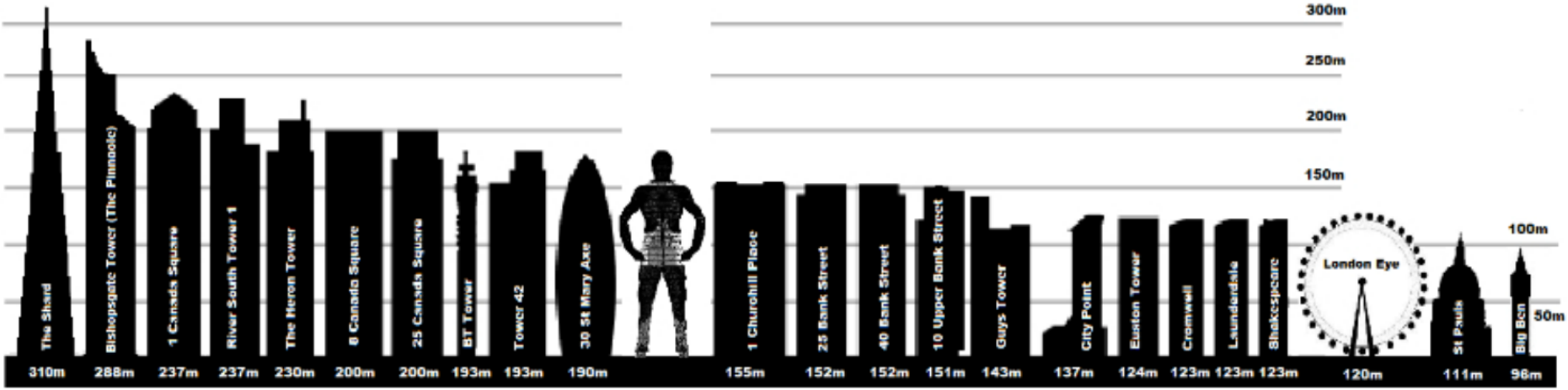
Head
- Control room
- Data centre
- Air intake & Extract
- Board room

Arms
- Access only

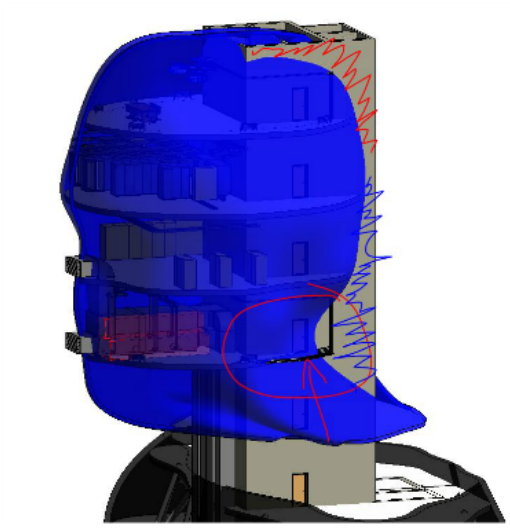


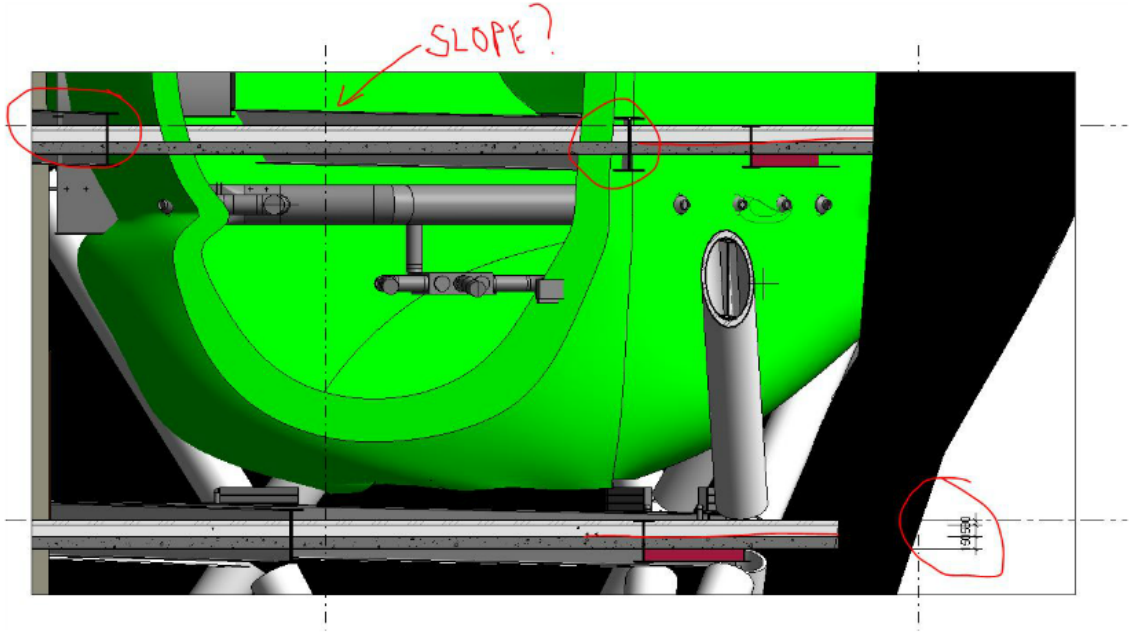
Chest Cavity
- Ventilation
- Pipework systems
- Primary & Secondary LTHW & CHW pumps

Lower Abdomen
- CHP
- Blackwater Treatment


300m
250m
200m
150m
100m
50m
The Shard
310m
Bishopsgate Tower (The Pinnacle)
288m
1 Canada Square
237m
River South Tower 1
237m
The Heron Tower
230m
8 Canada Square
200m
25 Canada Square
200m
BT Tower
193m
Tower 42
193m
30 St Mary Axe
190m
1 Churchill Place
155m
25 Bank Street
152m
40 Bank Street
152m
10 Upper Bank Street
151m
Guys Tower
143m
City Point
137m
Euston Tower
124m
Cromwell
123m
Lauderdale
123m
Shakespeare
123m
London Eye
120m
St Pauls
111m
Big Ben
98m

Collaboration / cooperation...





Old Skool

Architectural Summary

Improved workflow for creation of complex geometry (without rules!)

BIM fit for sharing between disciplines relative to design stage

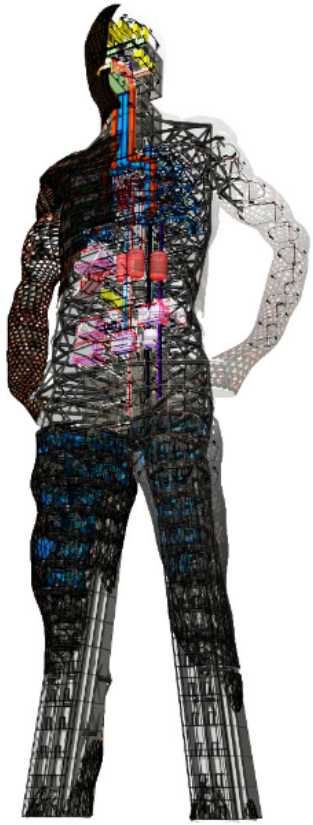
Design Collaboration and Interoperability

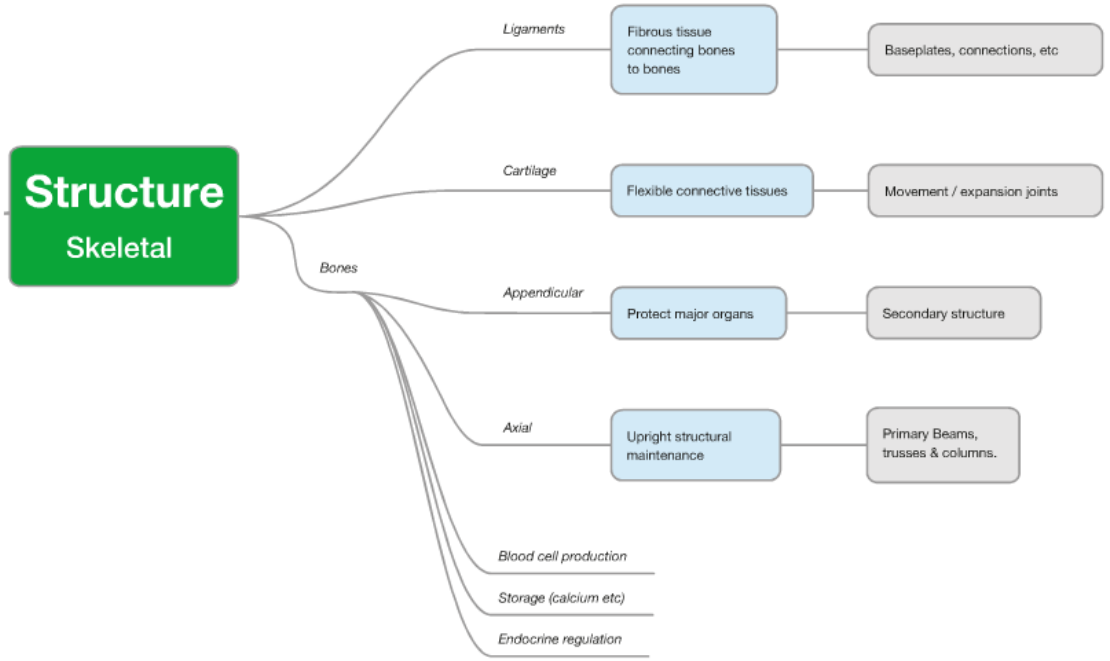
Reduced Drawing Output

Reduce Errors / Reduce Mark ups

Improve Efficiency between Design Team

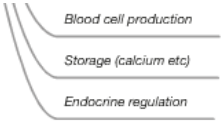
Design /Co-ordination confidence




Structure
Skeletal
Ligaments
Fibrous tissue connecting bones to bones
Baseplates, connections, etc
Cartilage
Flexible connective tissues
Movement / expansion joints
Bones
Appendicular
Protect major organs
Secondary structure
Axial
Upright structural maintenance
Primary Beams, trusses & columns.
Blood cell production
Storage (calcium etc)
Endocrine regulation

Structure

=



Structure

=

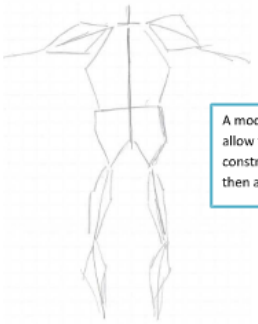
Skeletal/Muscular

Ken Enright
Senior Technician

&

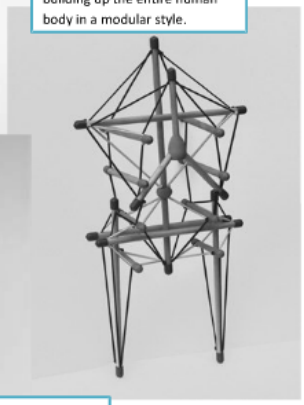
Jonathan Lock
Structural Associate

How does a person stand?

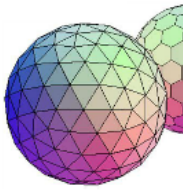


A modulated human body to allow the structure to be constructed separately and then assembled.

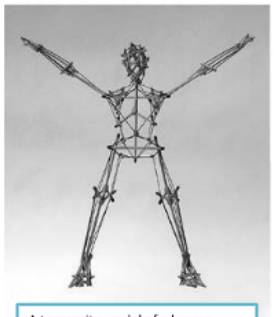
To the left is a dynamically realistic pelvis designed as a tensegrity structure. The complicated design can then be added to the torso (below) building up the entire human body in a modular style.



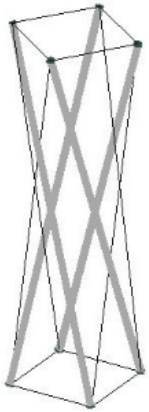
Internal Core formed of either steel or concrete (acting as bones). Outrigger truss forms arms. Internal floors are different shapes to mould façade to shape of a body. No gravity loads transferred between the floors.



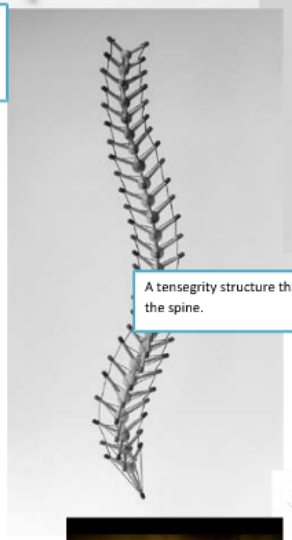
Geodesic Domes (Bucky B
lightweight structure. The
of compounds and protein



A tensegrity model of a human. Formed of multiple modules that are all independent tensegrity structures.

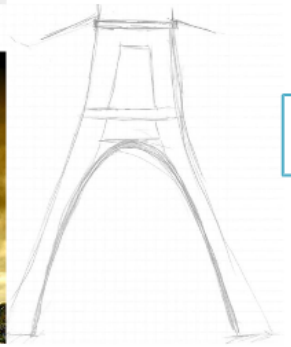


A simple example of a tensegrity structure that could be used as a simple torso.

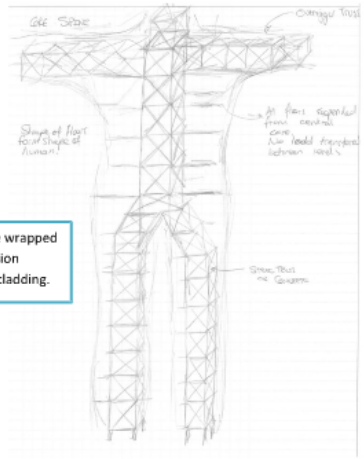


A tensegrity structure that models the spine.

An example of tensegrity structure in the Science park, Kolkata. Could be used as a leg of the structure.



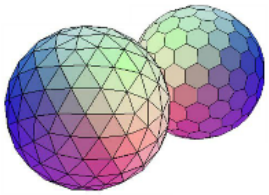
Steel Arched Legs – Inspiration from the Eiffel Tower.

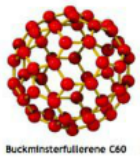


Façade can be wrapped in fabric (Tension Structure) or cladding.

Montreal Biodom
dome designed a
of the dome is sh

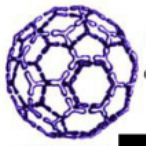
Internal Core formed of either steel or concrete (acting as bones). Outrigger truss forms arms. Internal floors are different shapes to mould façade to shape of a body. No gravity loads transferred between the floors.





Buckminsterfullerene C60

Emiliania huxleyi phytoplankton

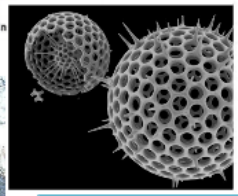


Triskelion

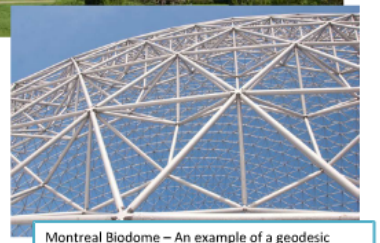
Clathrin

clathrin brain protein

Geodesic Domes (Bucky Balls) are an incredibly strong but lightweight structure. The geometry is natural, found in a variety of compounds and proteins.



A micro-organism, Radiolarian



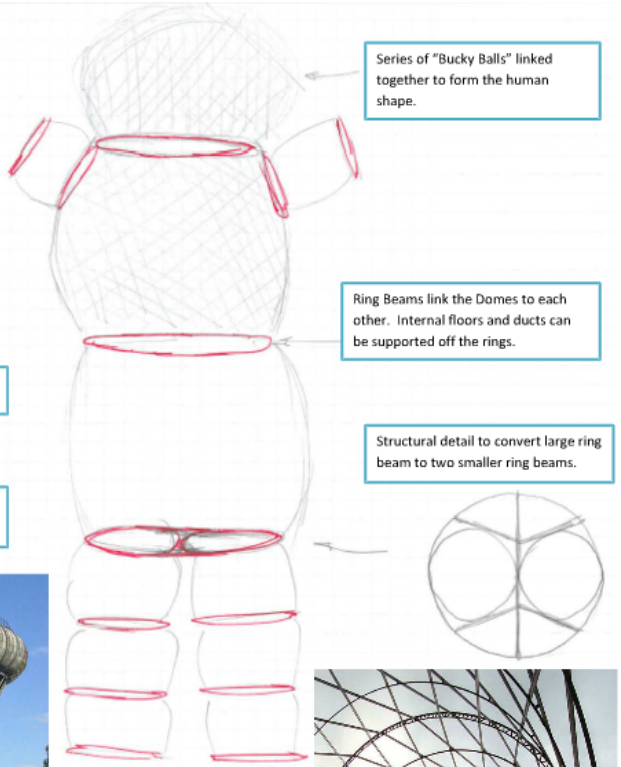
Montreal Biodome – An example of a geodesic dome designed and built as Expo 67. The detailing of the dome is shown.

Possible spiral floor arrangement within the domes.

Cladding Detailing on Space Dome in Florida.

The Dome is formed of a ring beam where two domes, one above and one below form the sphere. Same detailing as suggested in concept.

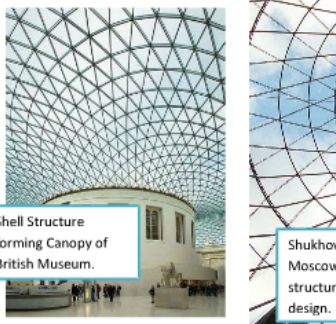
Ciechanow water tower - leg design?



Series of "Bucky Balls" linked together to form the human shape.

Ring Beams link the Domes to each other. Internal floors and ducts can be supported off the rings.

Structural detail to convert large ring beam to two smaller ring beams.

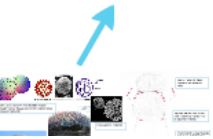


Shell Structure forming Canopy of British Museum.

Shukhov tower in Shabolovka Moscow. A tower using it's shell structure for its strength. Possible leg design.

How does a person stand?

Axial and appendicular skeletal structure

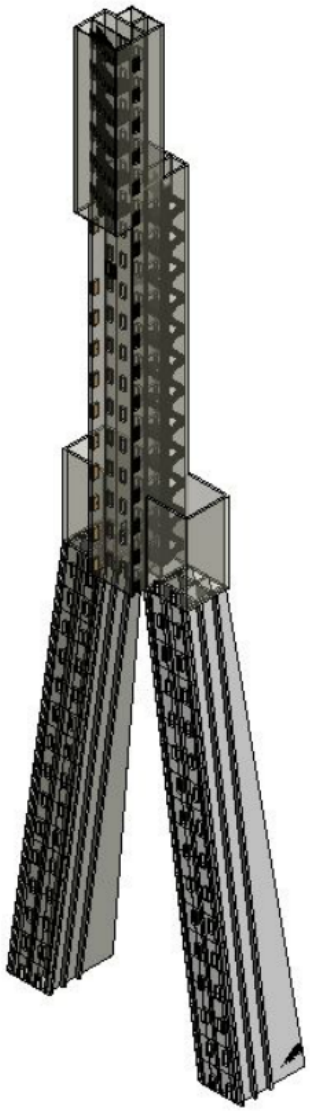


How does a person stand?

Lumbar support,

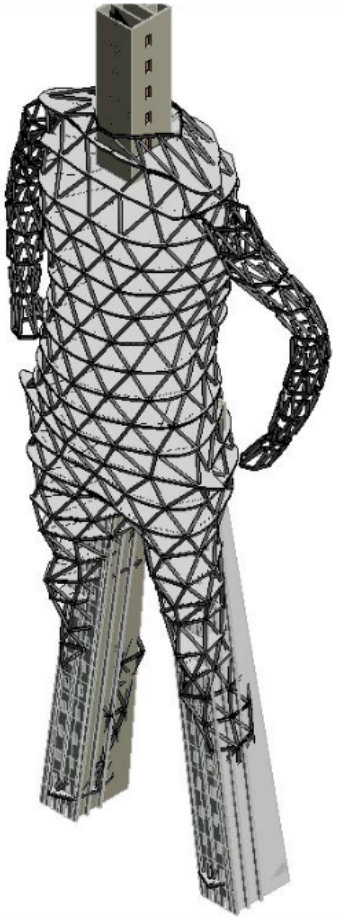
Cartilage

and Ligaments

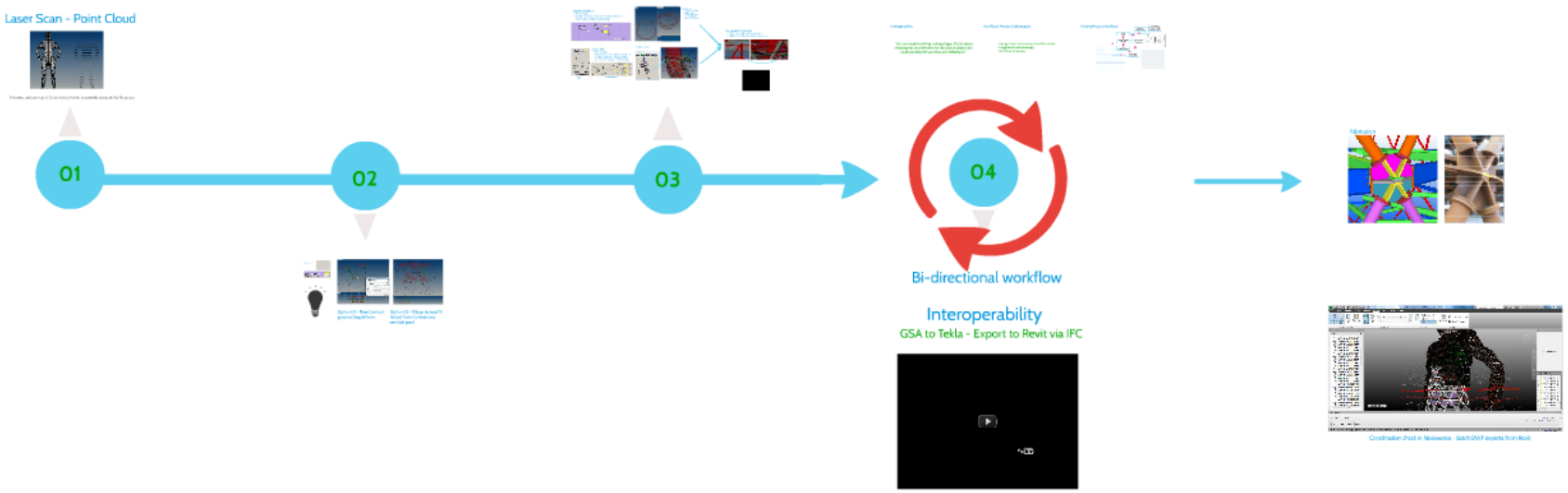


How does a person stand?

Skeleton and Muscular Systems working together - Tension and Compression

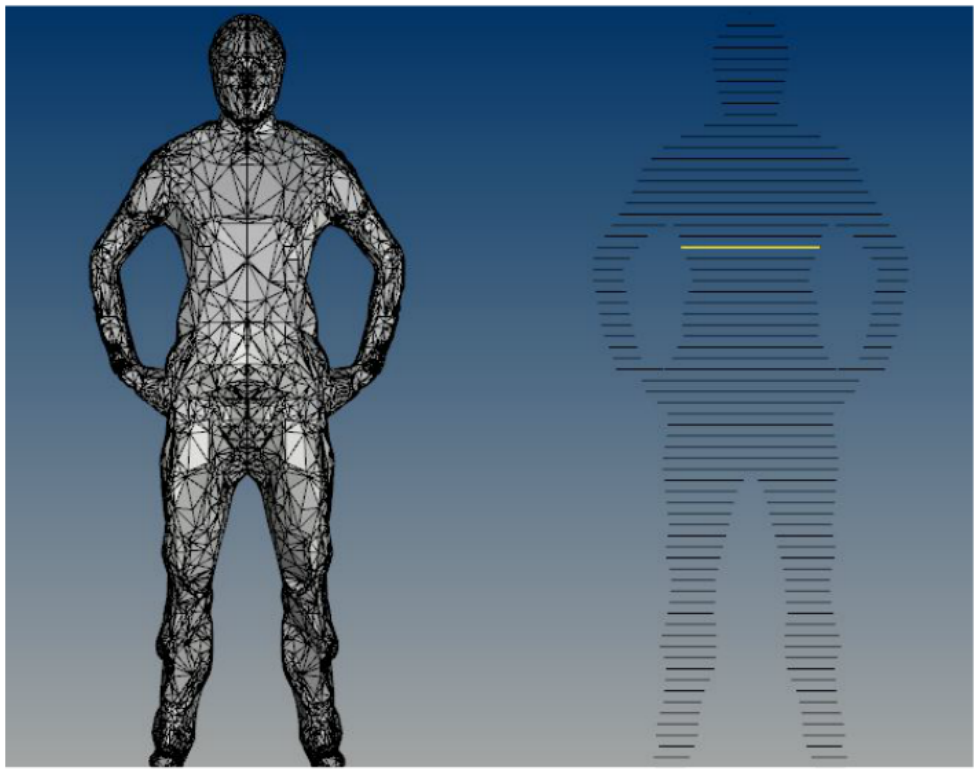


Structure design loop



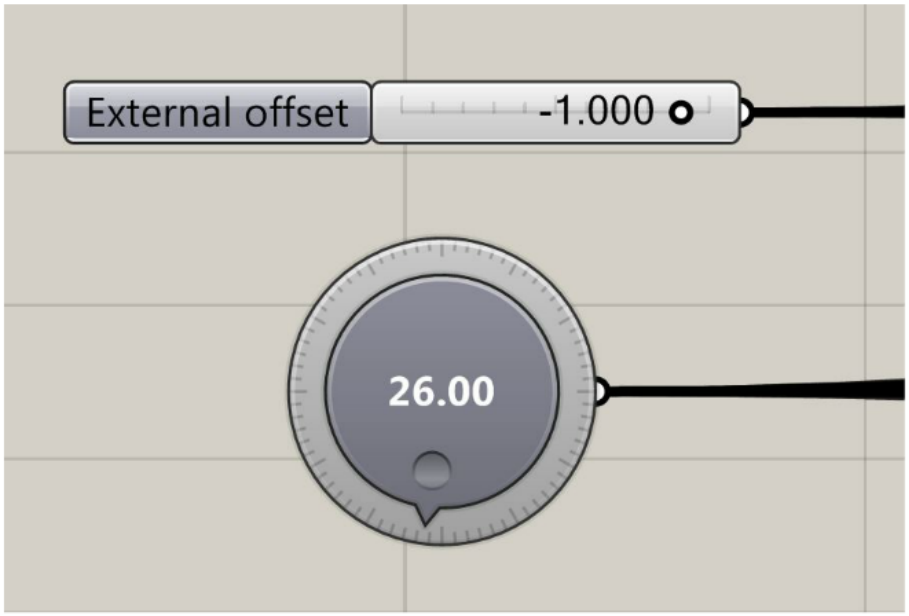
Rhino → Grasshopper → Salamander → GSA → Tekla → Revit

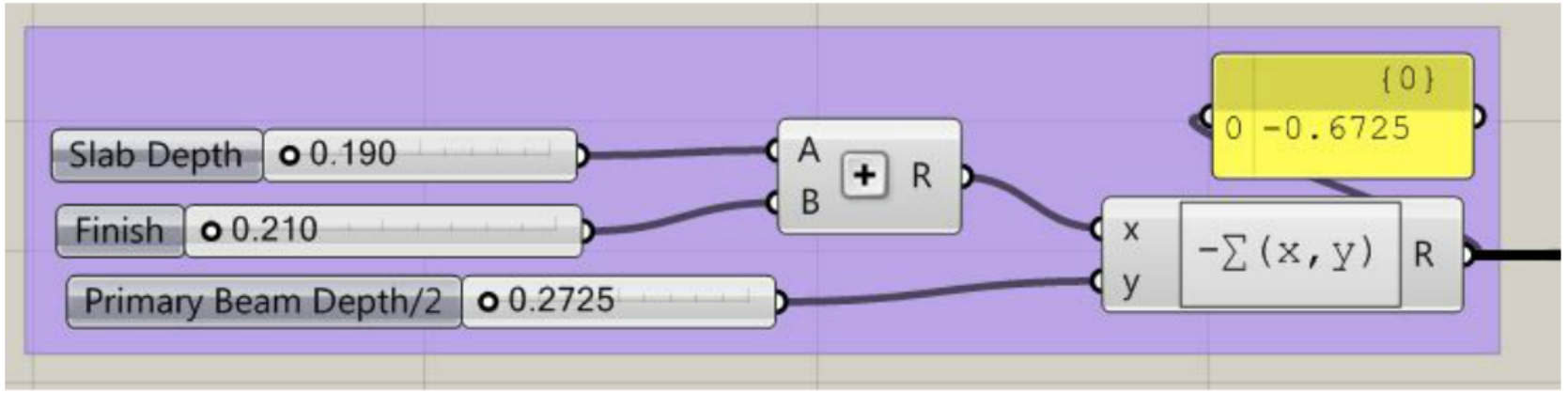
Laser Scan - Point Cloud



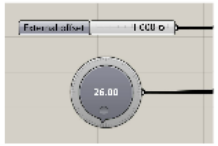
Promote contours cut at 2.5m vertical offset to provide setout of the Structure

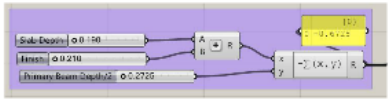
Primary inputs for the Diagrid scheme

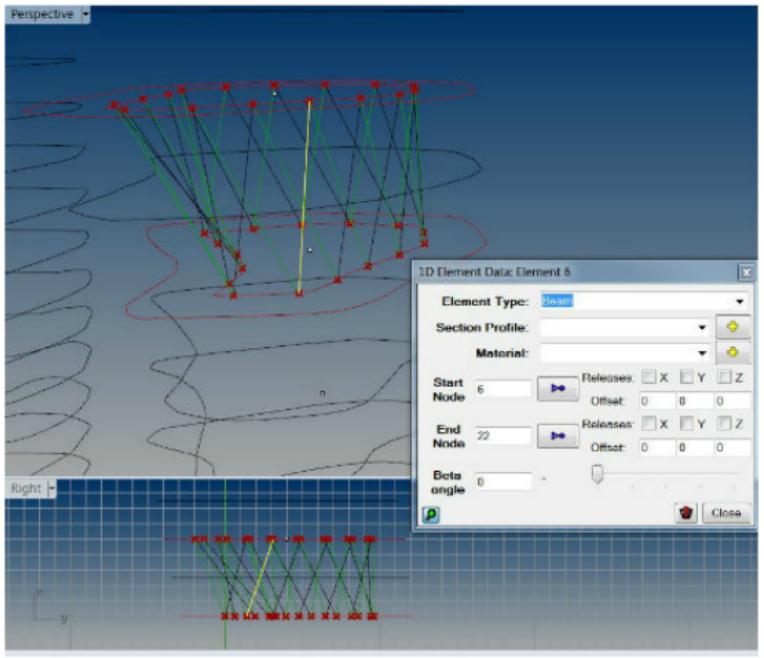


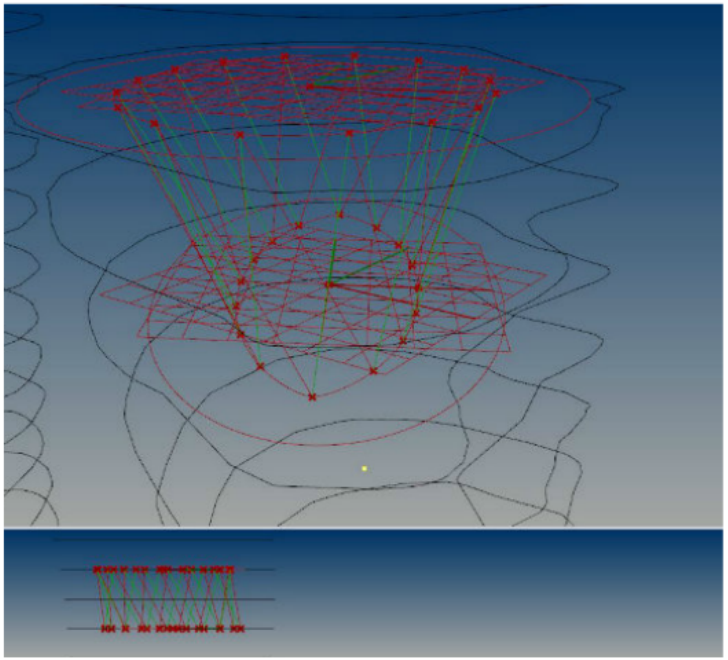


Primary inputs for the Diagrid scheme







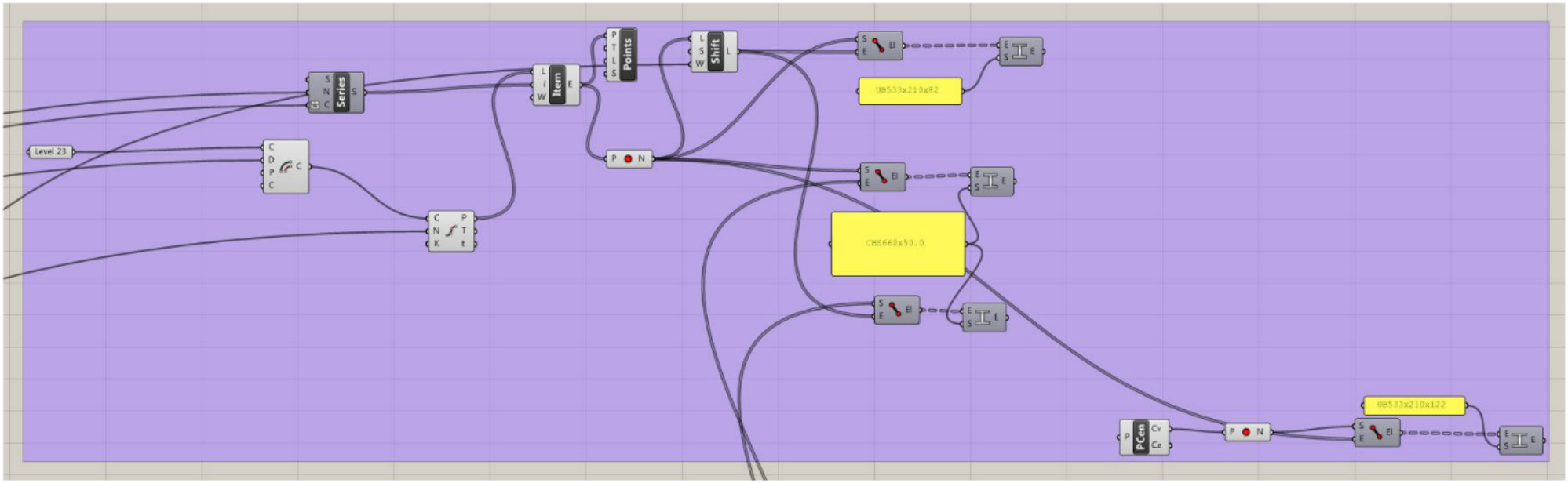


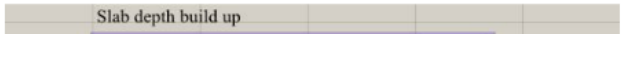
Option 01 - Floor Contour governs Diagrid form.

Option 02 - Ellipse by best fit Setout from Contour area centroid point

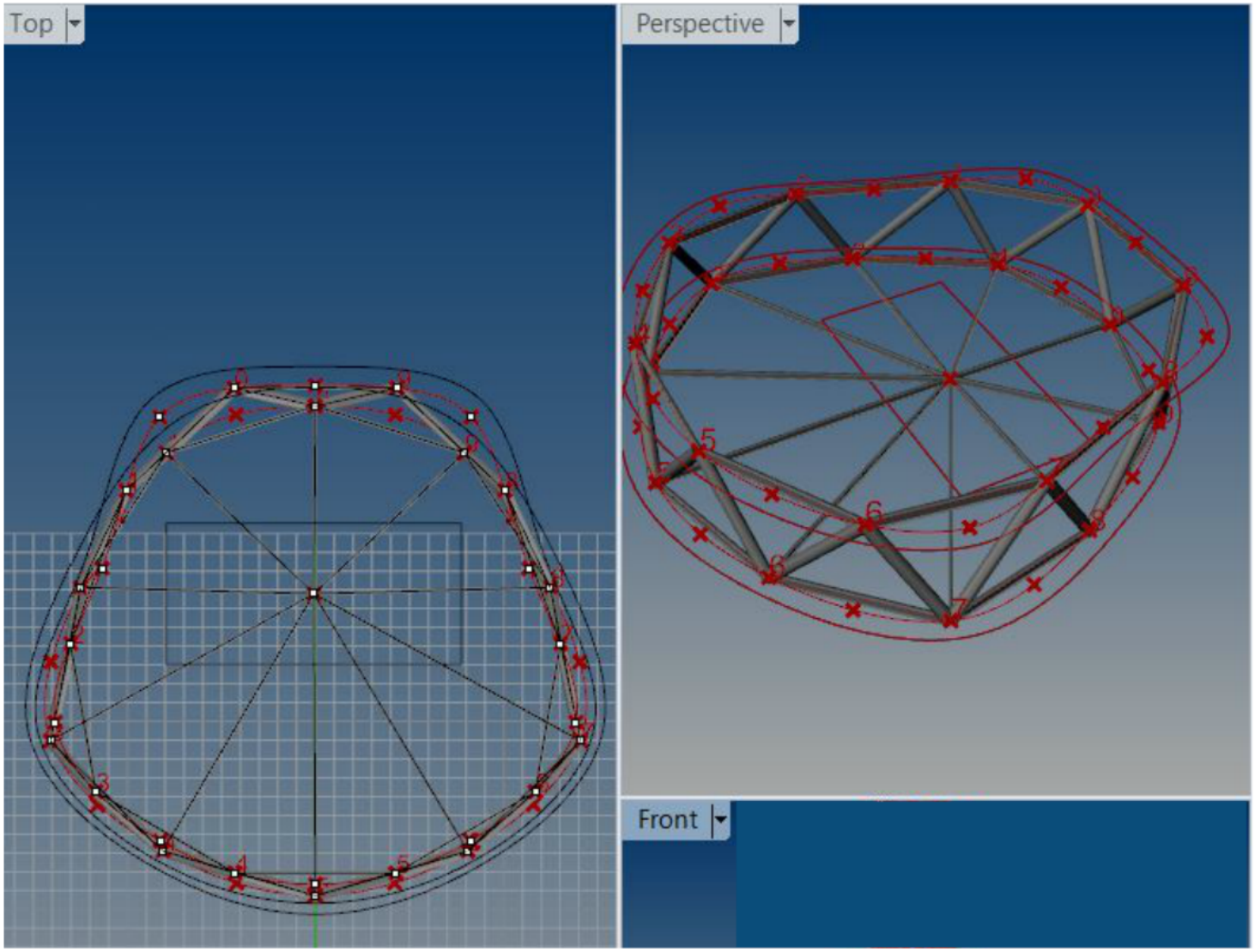
Torso floor logic diagram

- Primary inputs
- 10 types of components connected into a hierarchy
- Section sizes as inputs to Salamander





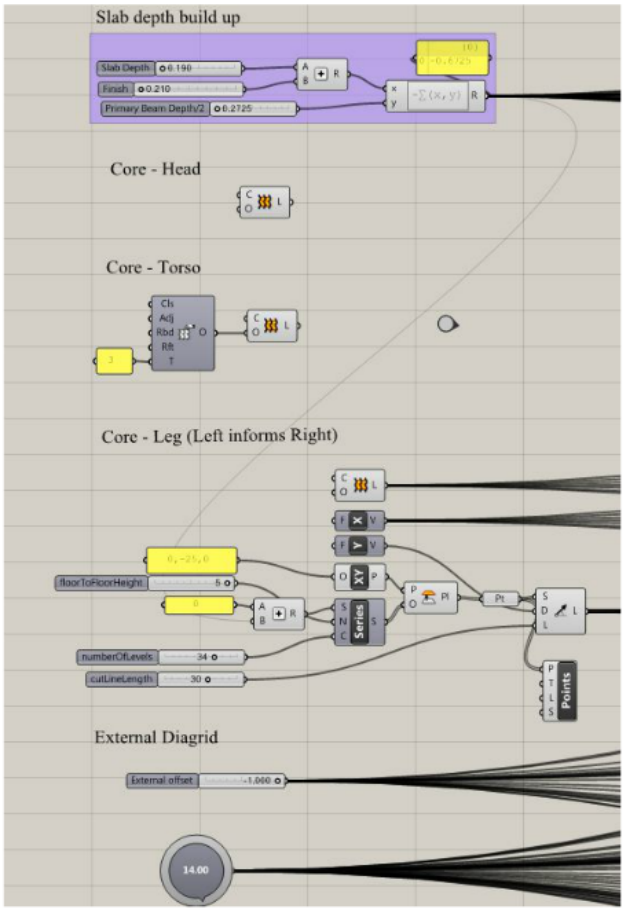
Leg floor logic



Floor Framing:

- Ring beam setout by Diagrid Nodes.
- Primary floor beams span from Diagrid nodes to Core centroid

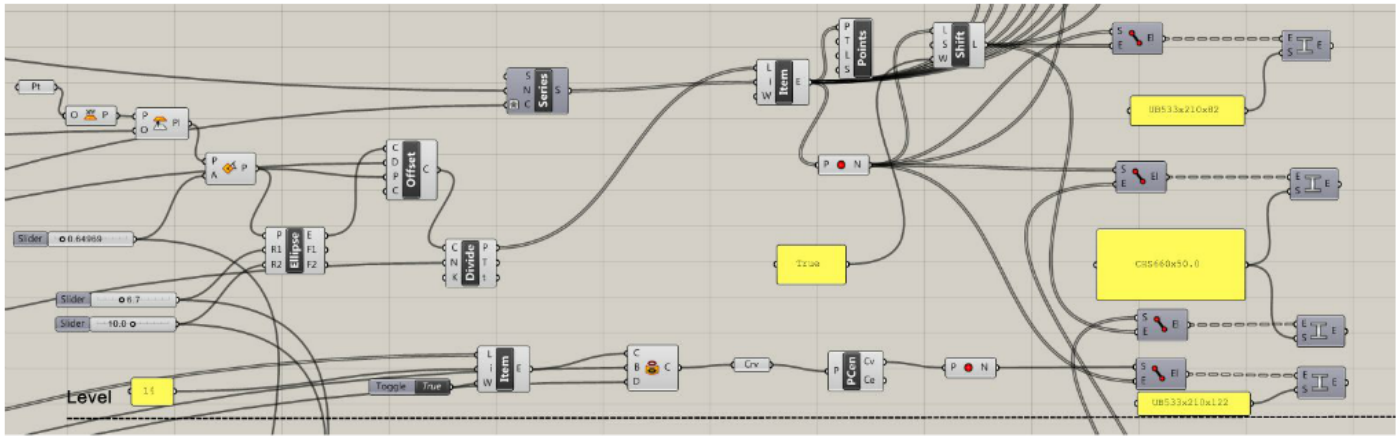
Floor Framing at leg



Inputs

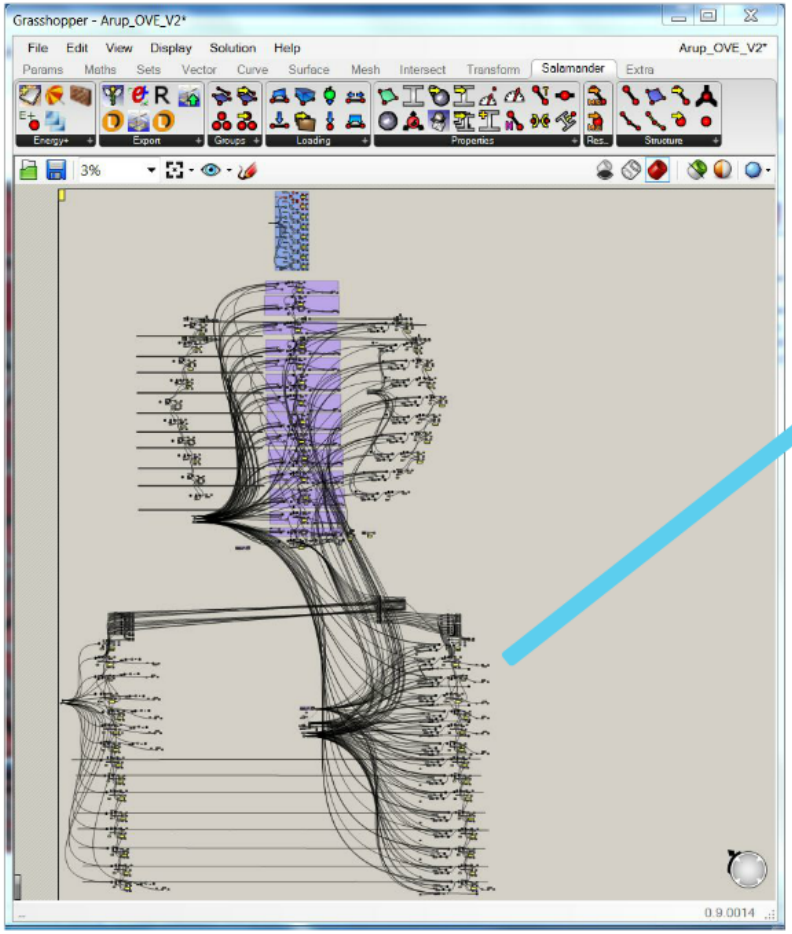
Leg floor logic

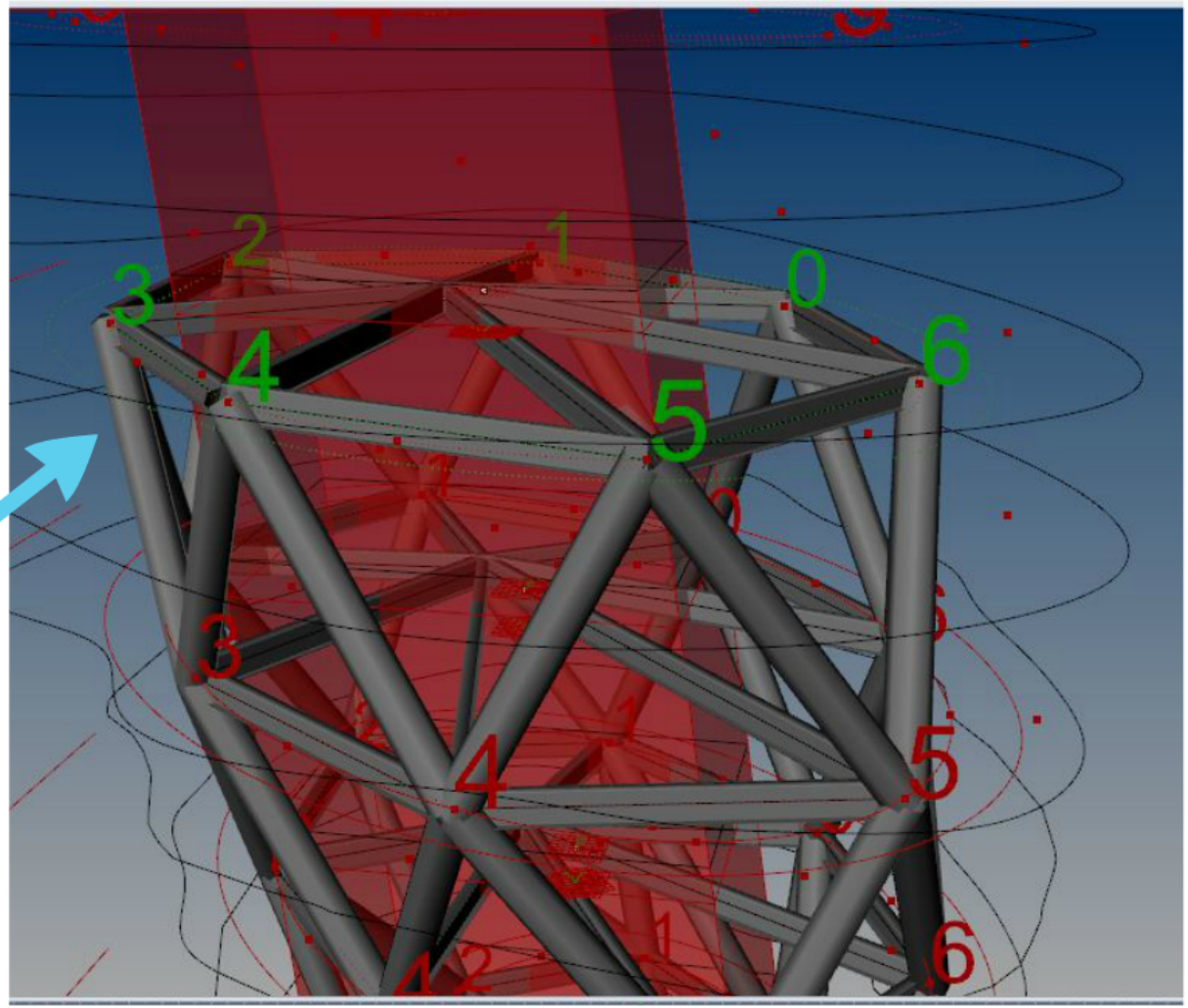
- Primary inputs
- Instance parameters to describe best fit
- 16 types of components connected
- Section sizes as inputs to Salamander



Floor logic diagram

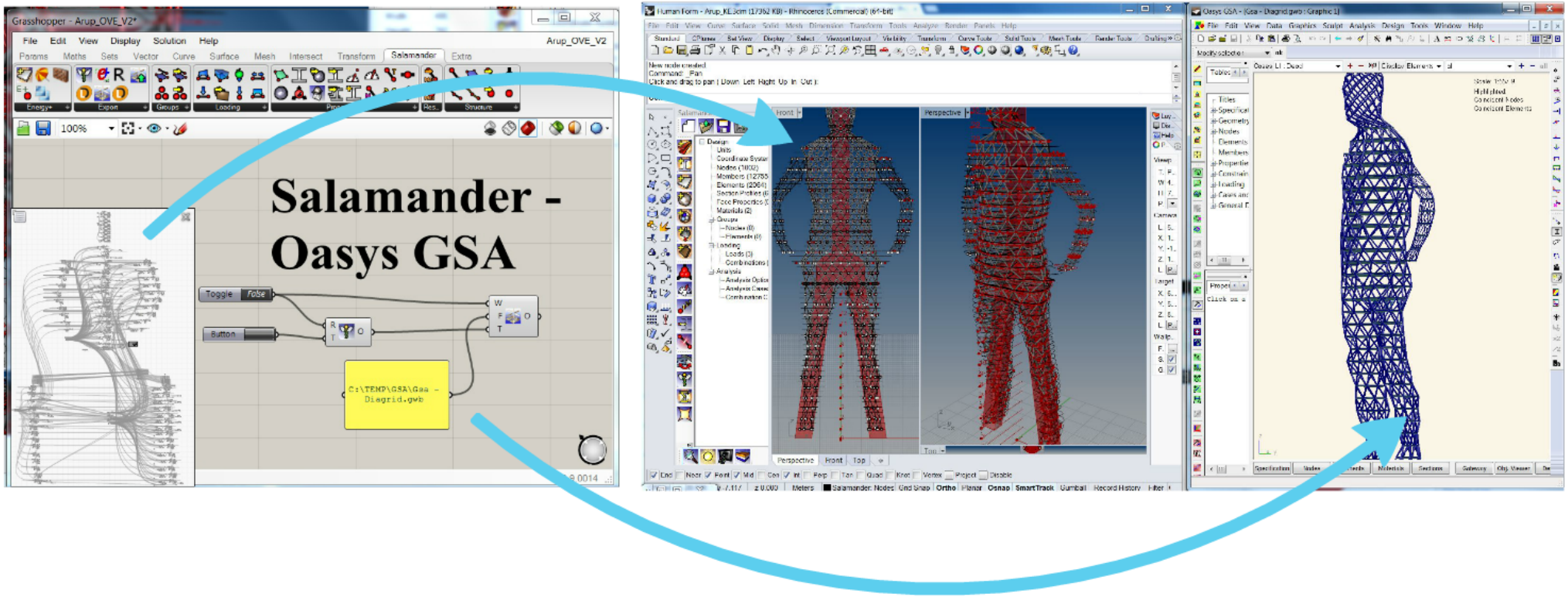
Floor Framing at leg





Interoperability with Analysis

- Trigger input push continuous updates
- Option to load, design check and optimize.




YouTube

04

Bi-directional workflow

Interoperability

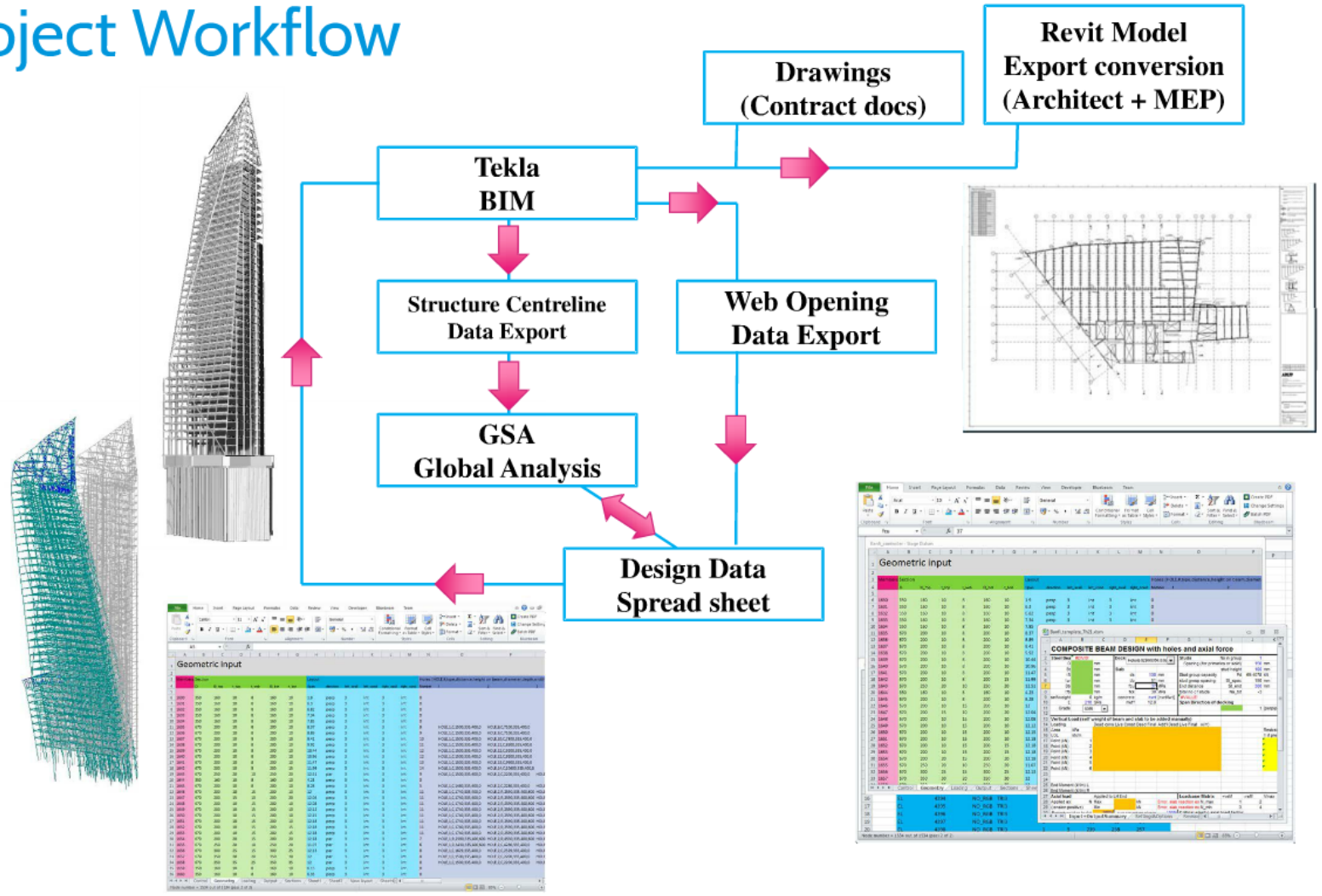
Interoperability

"You can model anything in all packages, it's just about choosing the most efficient for the type of project and understanding the workflow and deliverables"

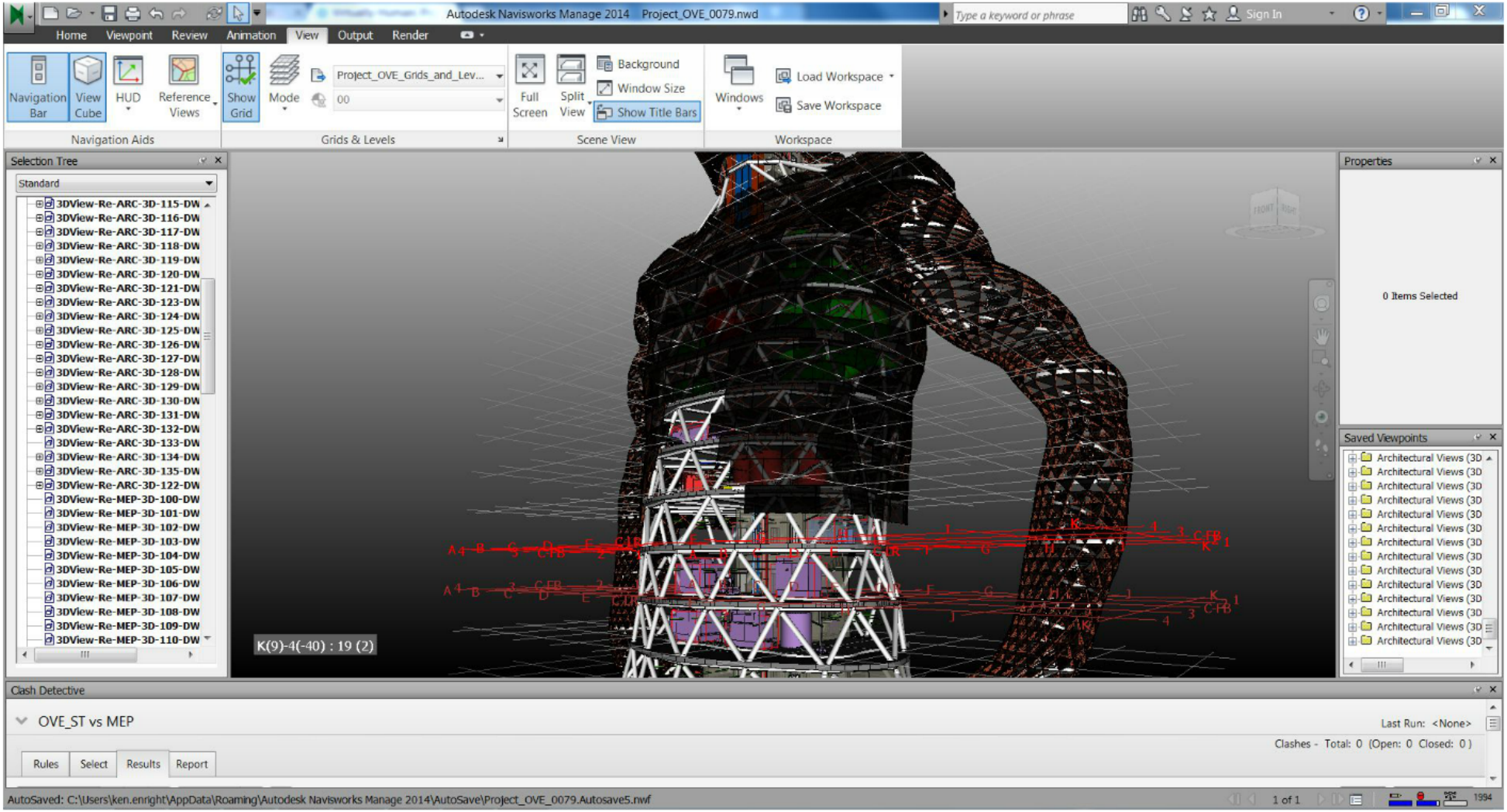
Workflow | Process | Deliverables

- Design coordination in Revit and Navisworks
- Integrated structural design
- BIM fit for fabrication.

Existing Project Workflow

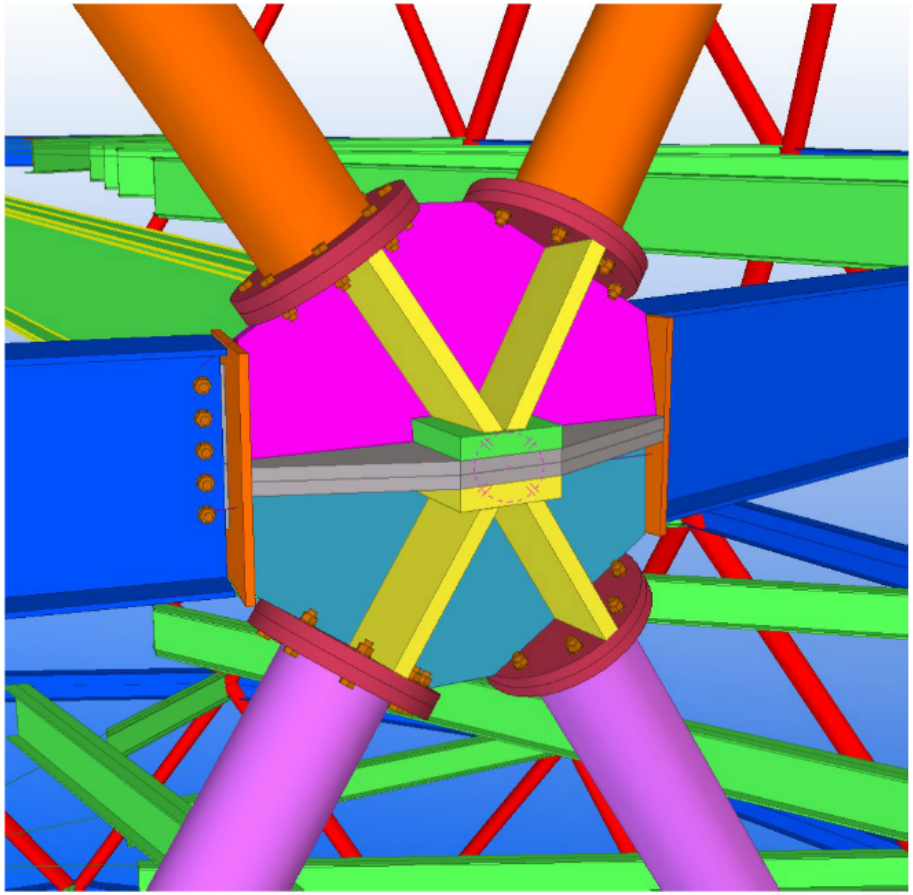


GSA to Tekla - Export to Revit via IFC



Coordination check in Navisworks - Batch DWF exports from Revit

Fabrication



Structural Summary

Streamlined Parametric design to Fabrication.

BIM fit for purpose and used by the Fabricator

Design Collaboration and Interoperability

Reduce Drawing Output

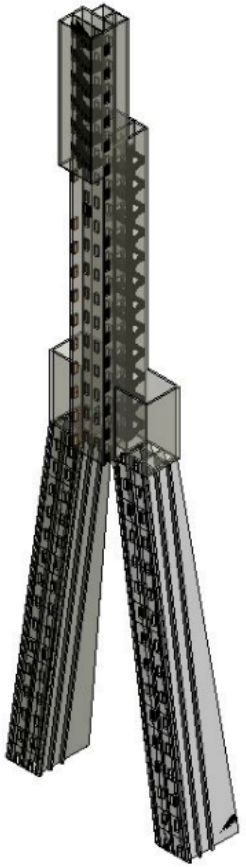
Reduce Errors / Reduce Mark ups

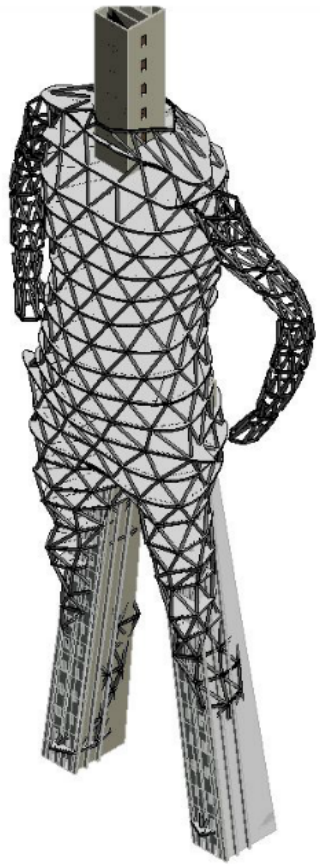
Design Data embedded within BIM

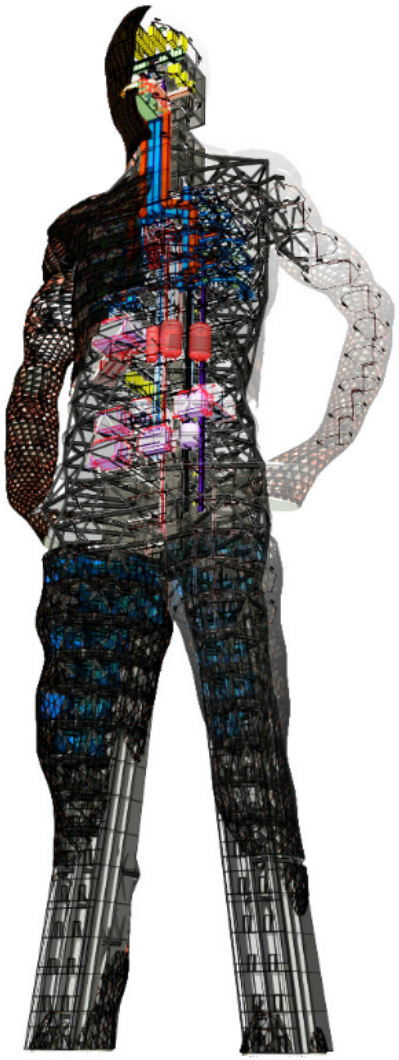
Schedules for connection design & specifications.

Improve Efficiency between Design Team

Engineer confidence





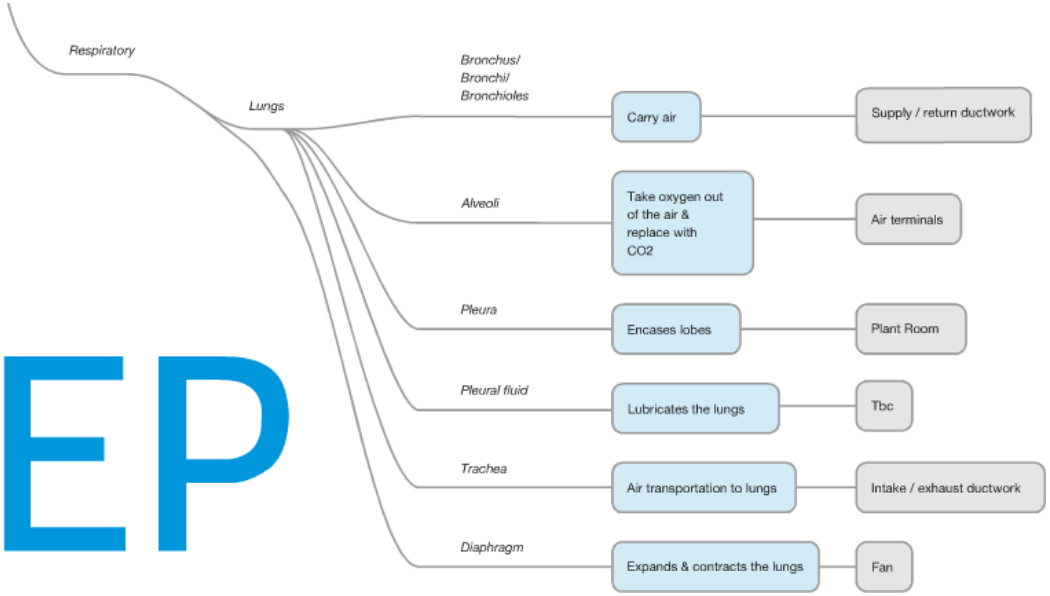


M
Cardovascular

- *Circulatory*
  - *Blood*
  - *Vessels*
    - *Arteries & Veins*
      - Carries Blood around the body
        - Pipe work
  - *Heart*
    - *Left & Right Atria*
      - Pumps blood around body
        - Pumps
    - *Left & Right Ventricles*
      - Pumps blood around body
        - Pumps
- *Respiratory*
  - *Lungs*
    - *Bronchus/ Bronchi/ Bronchioles*
      - Carry air
        - Supply / return ductwork
    - *Alveoli*
      - Take oxygen out of the air & replace with CO_2
        - Air terminals
    - *Pleura*
      - Encases lobes
        - Plant Room
    - *Pleural fluid*
      - Lubricates the lungs
        - Tbc
    - *Trachea*
      - Air transportation to lungs
        - Intake / exhaust ductwork
    - *Diaphragm*
      - Expands & contracts the lungs
        - Fan

MEP

=



MEP

=

Everything Else!

Key Services Themes

Intelligence

Automation

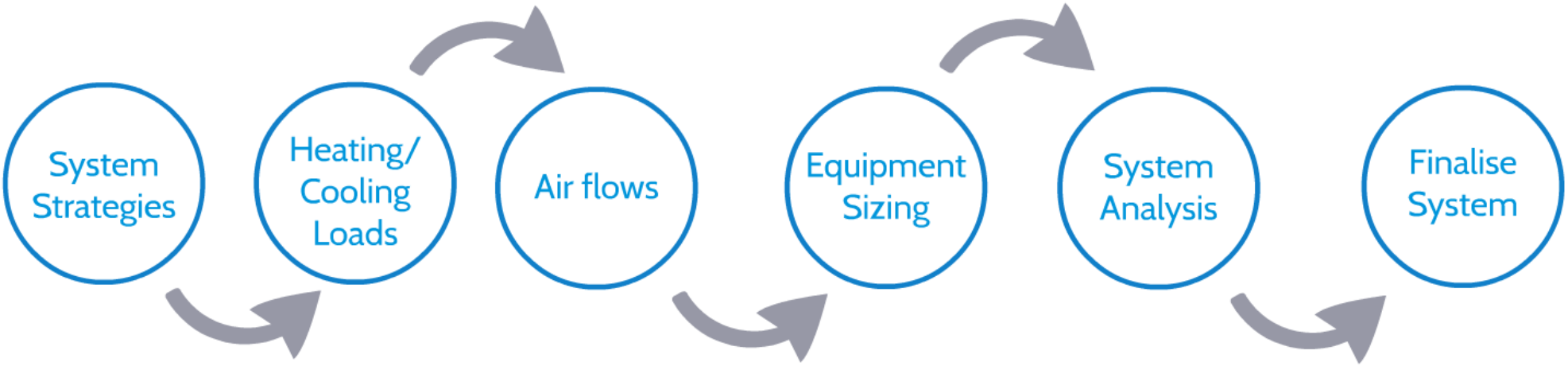
Efficiency

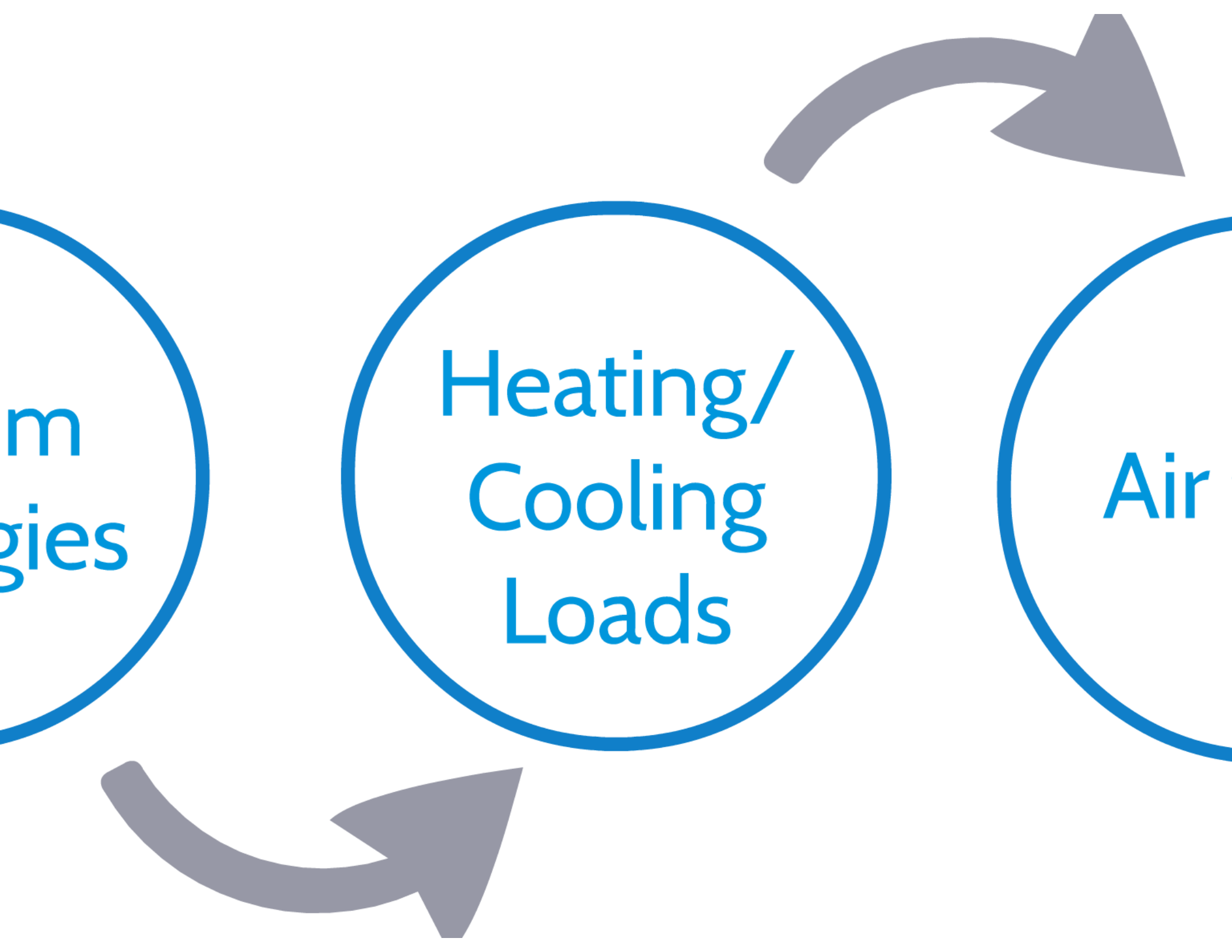
Current Process

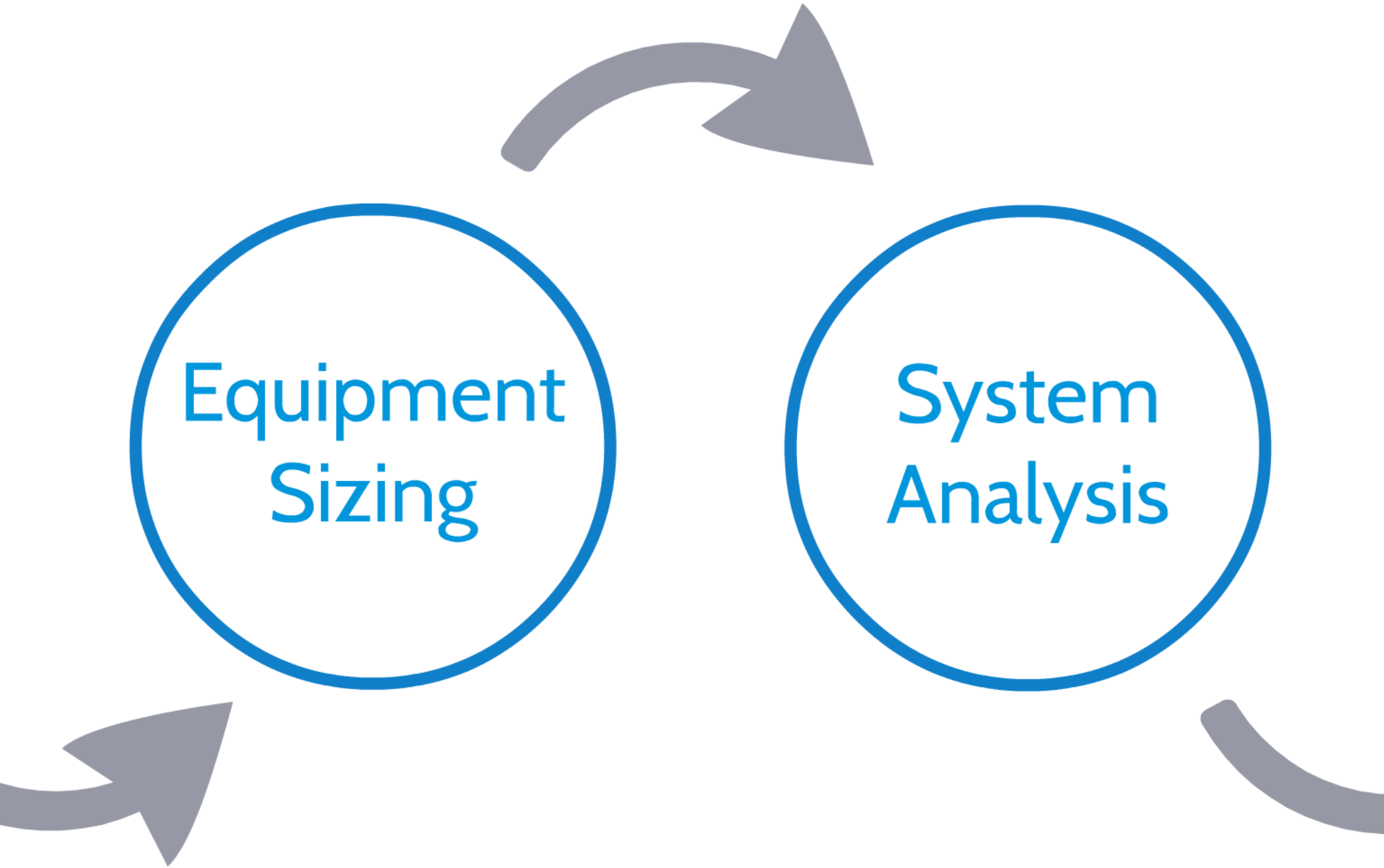
What are the opportunities to improve?

Current Process

What are the opportunities to improve?

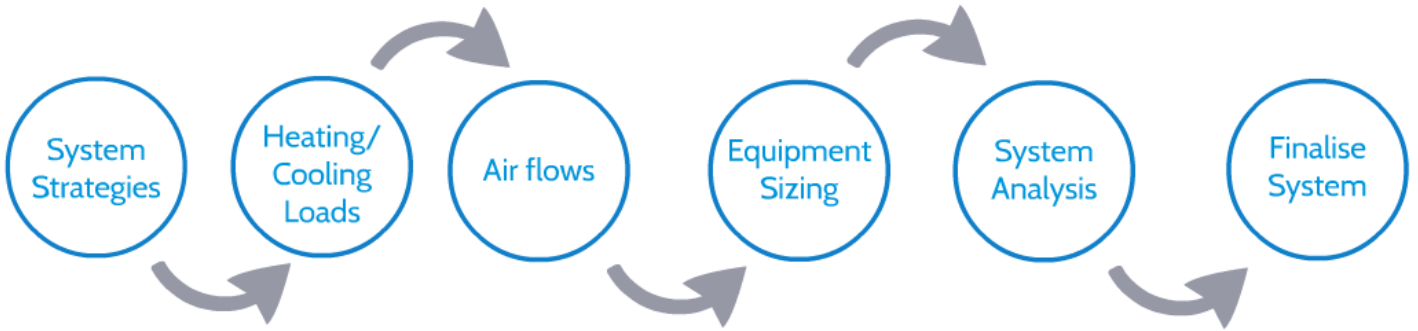



m
gies
Heating/
Cooling
Loads
Air


Equipment Sizing
System Analysis

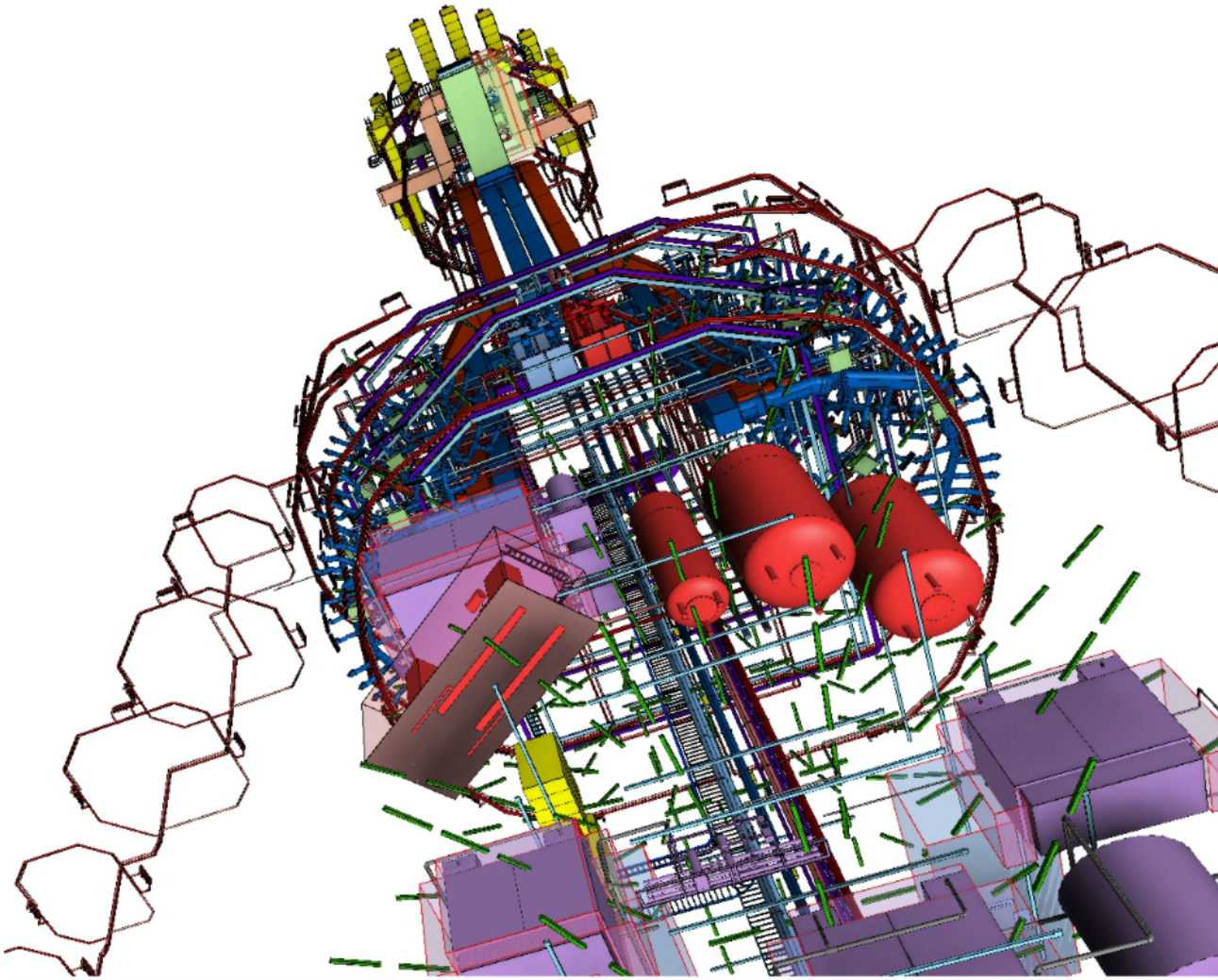
Current Process

What are the opportunities to improve?

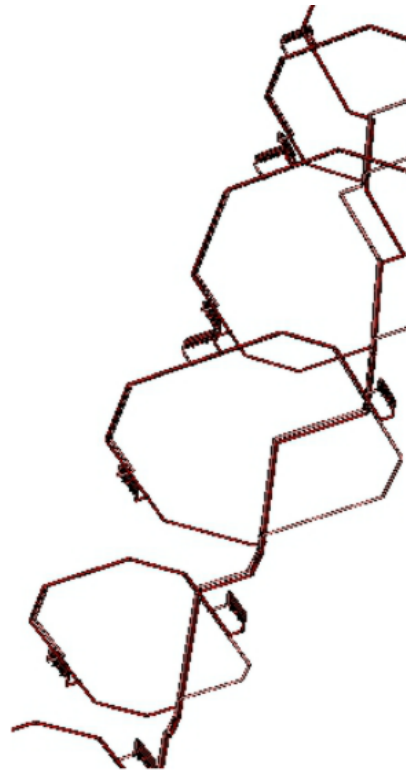


Ventilation

=



Ventilation



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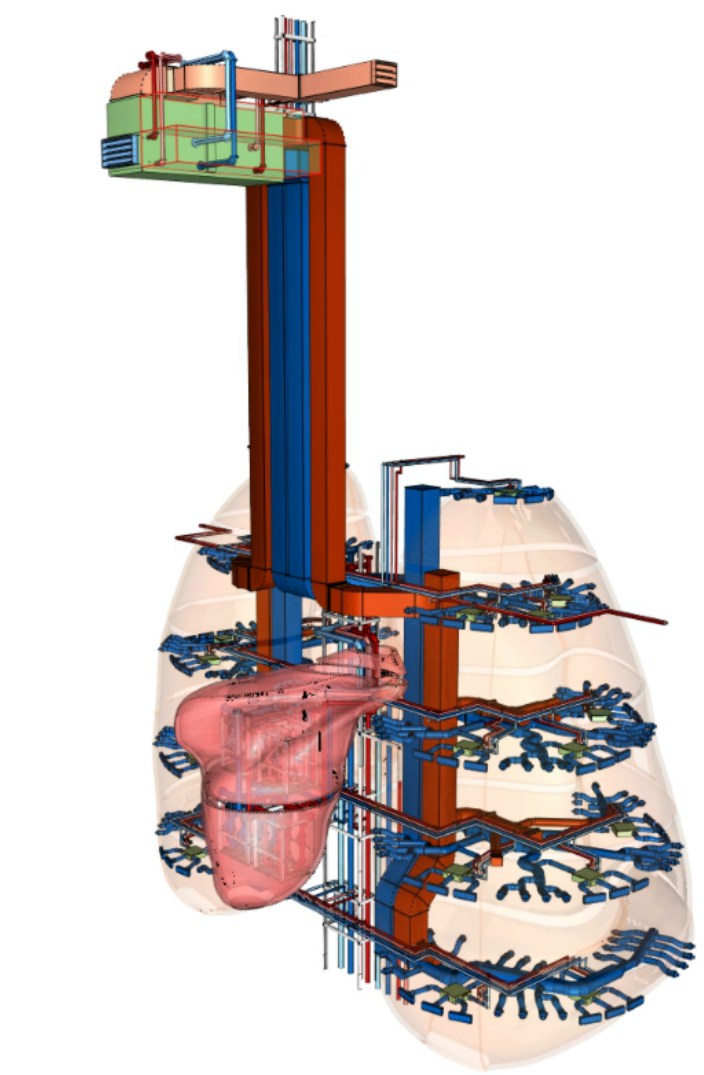
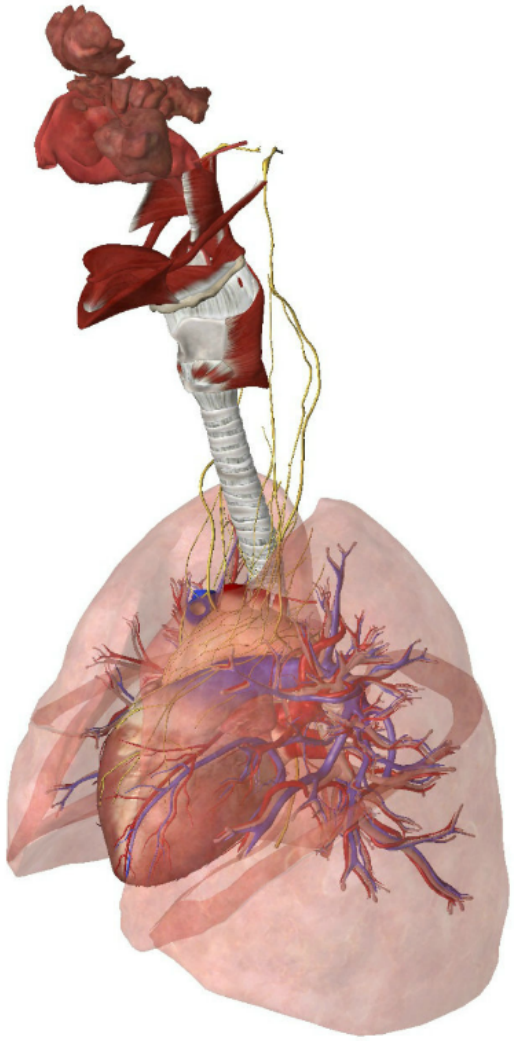
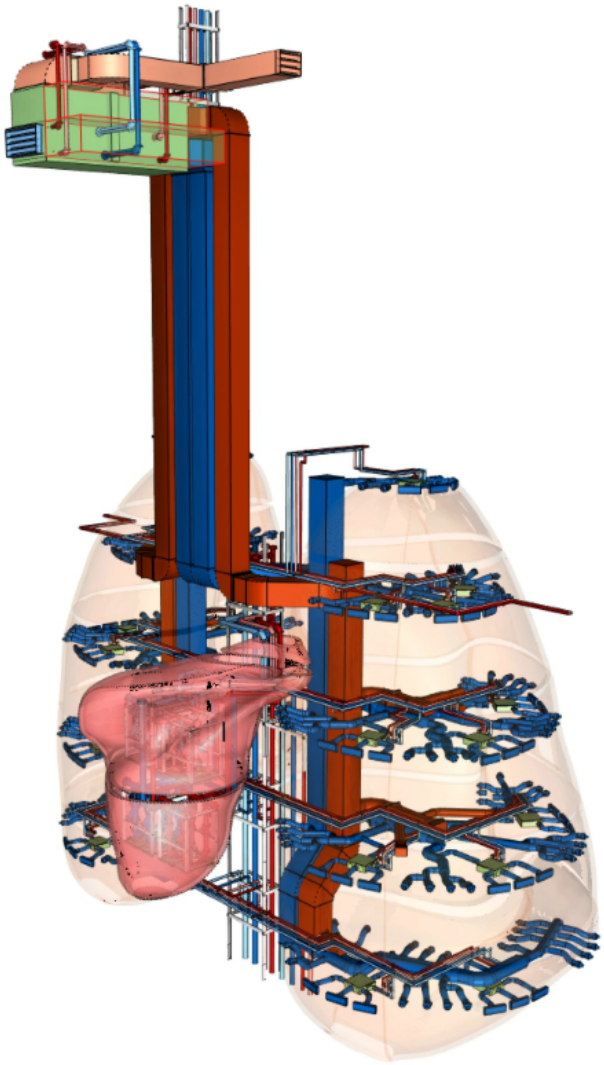
Respiratory

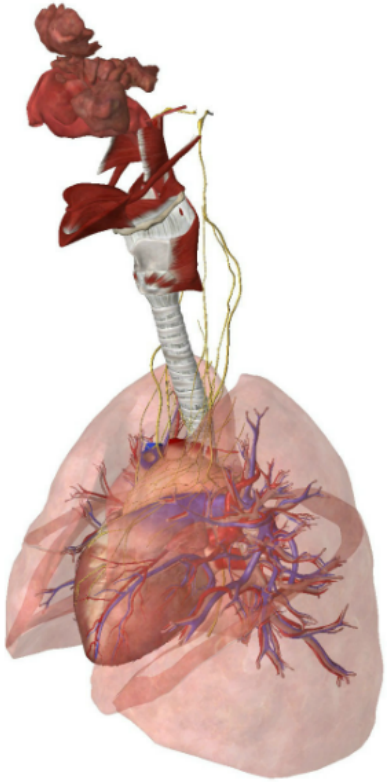


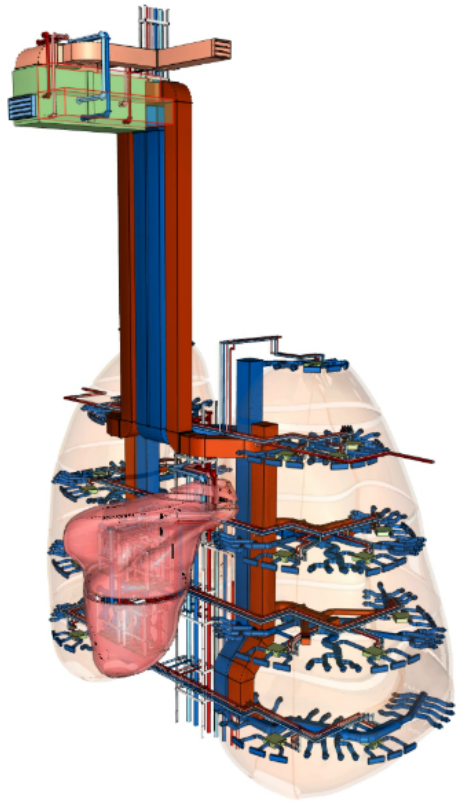
vel System → Lungs → AHU system





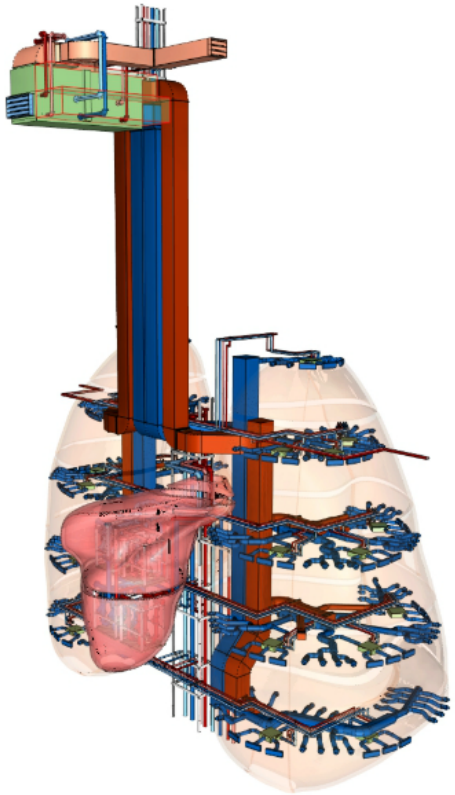
System → Level System → Lungs → AHU sy



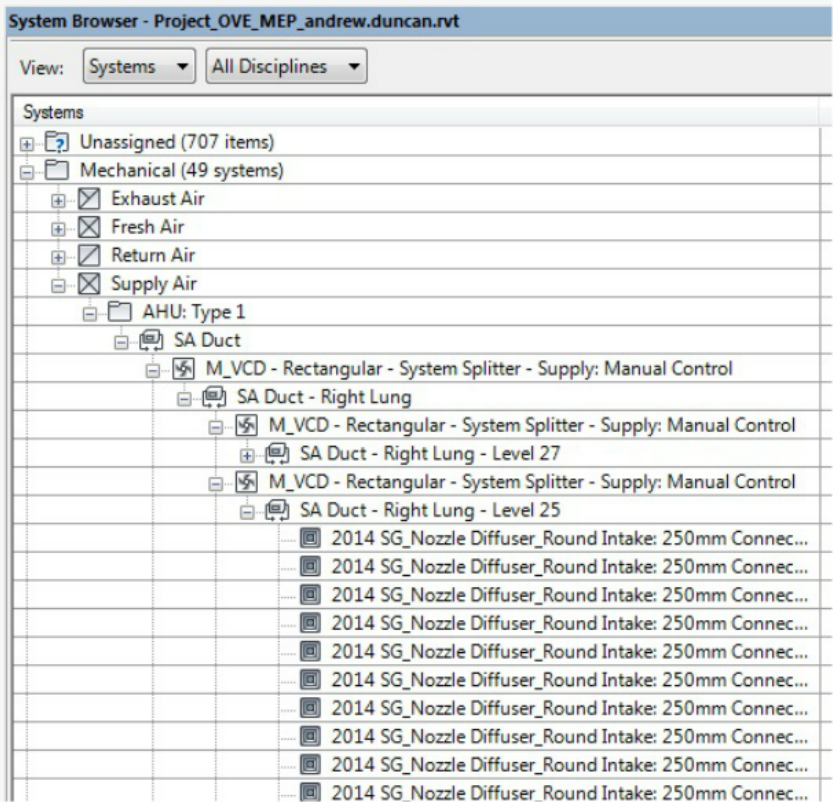


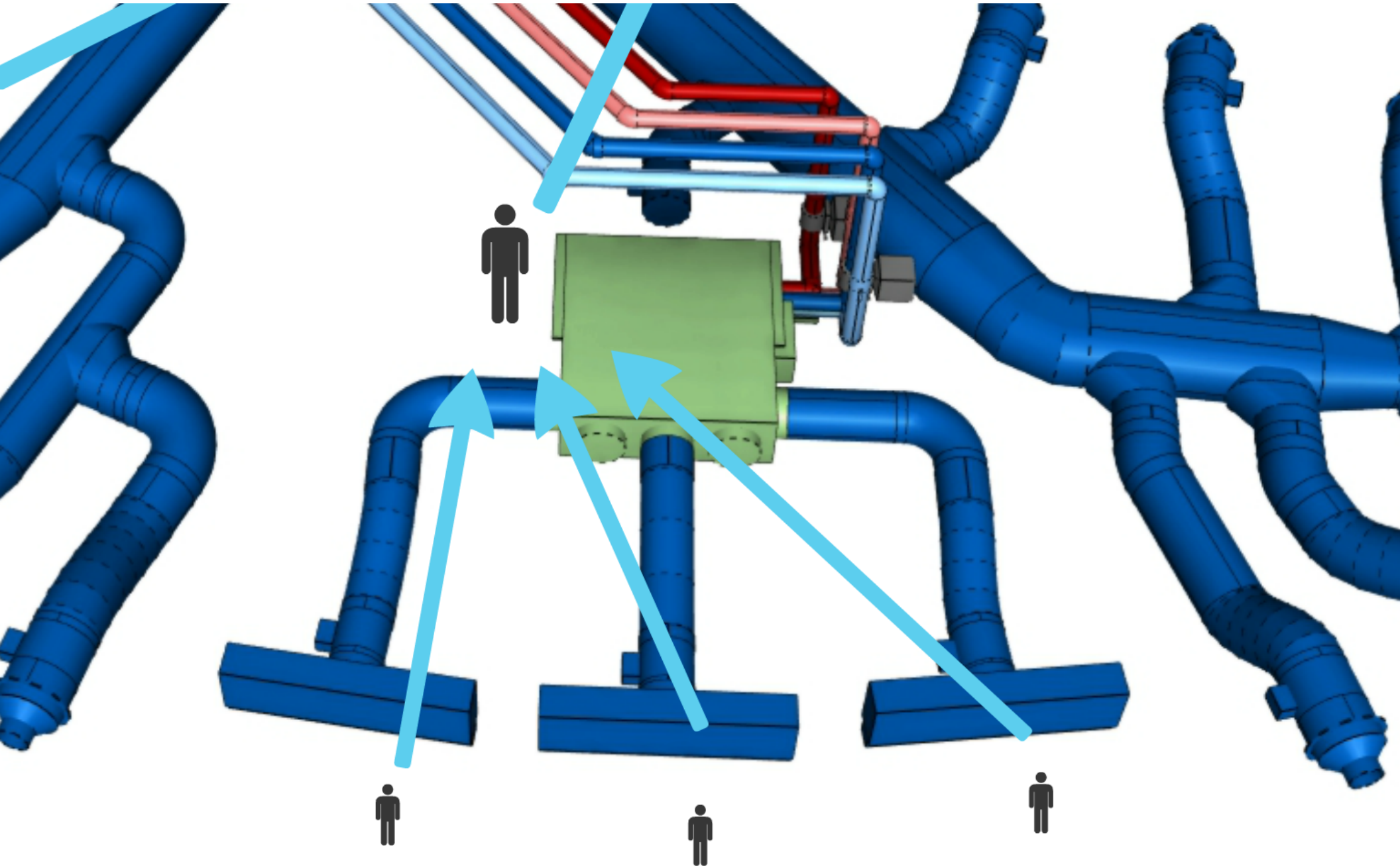
FCU System → Level System → Lungs → AHU system

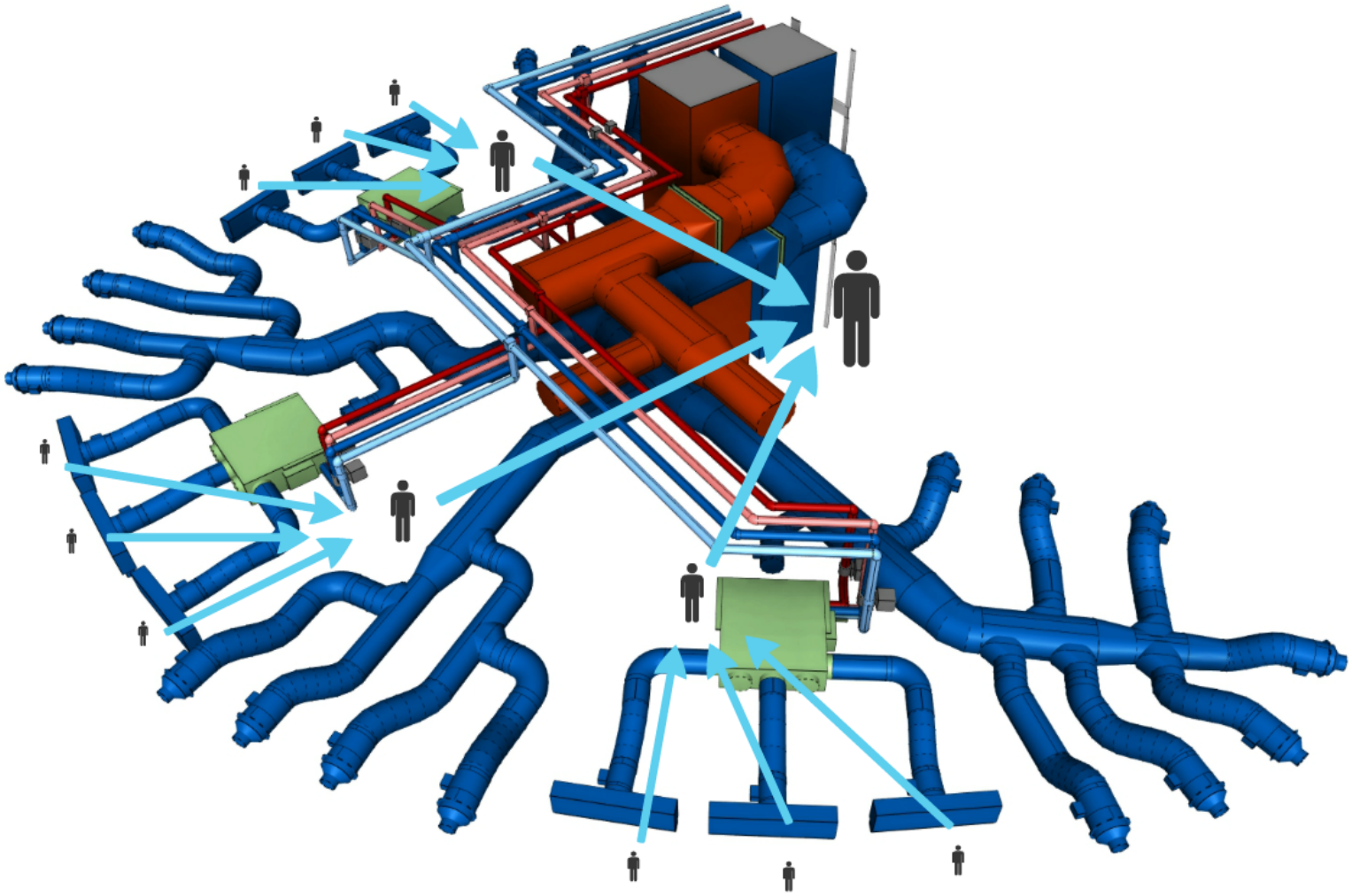
System Browser

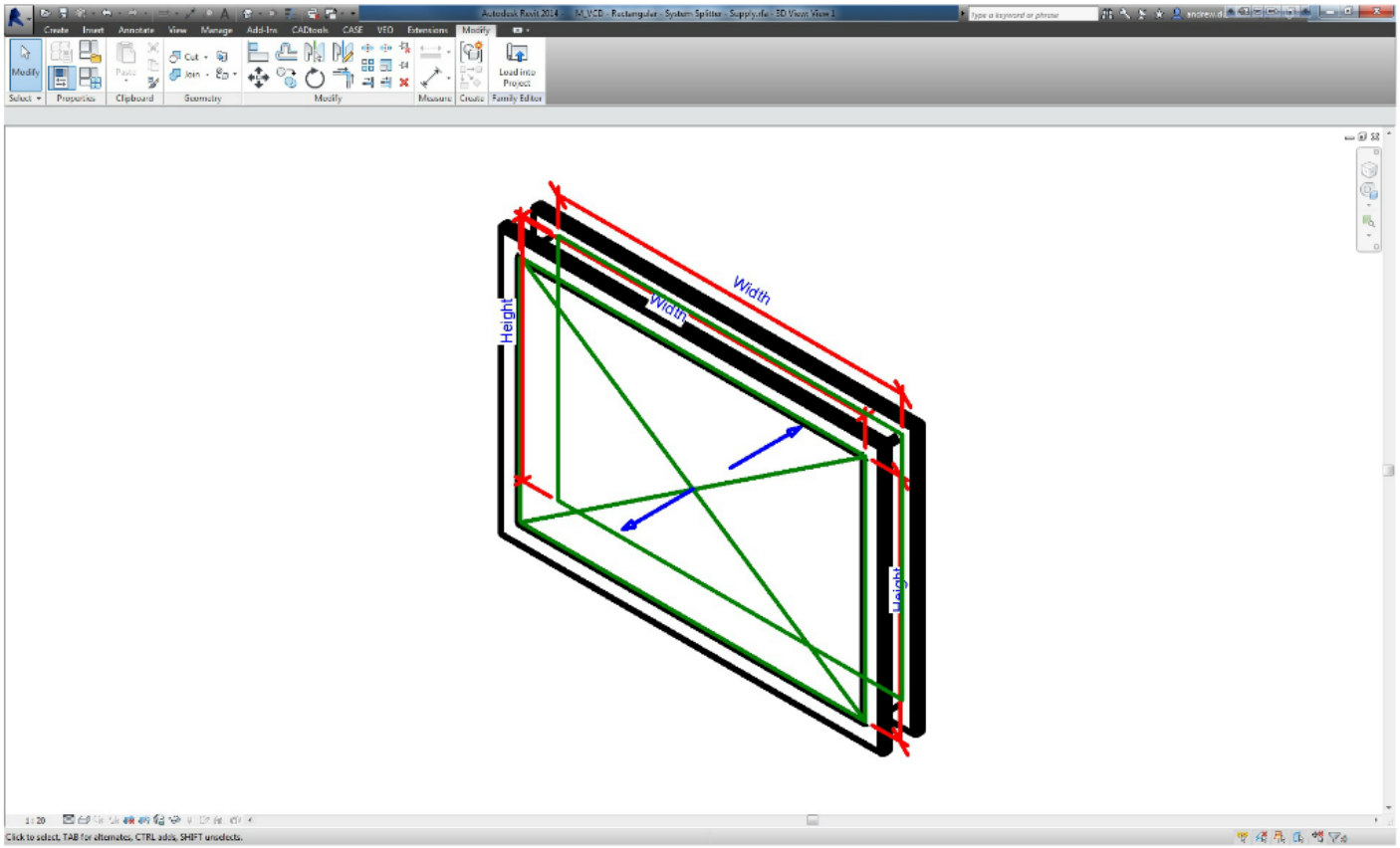


Lungs → AHU system



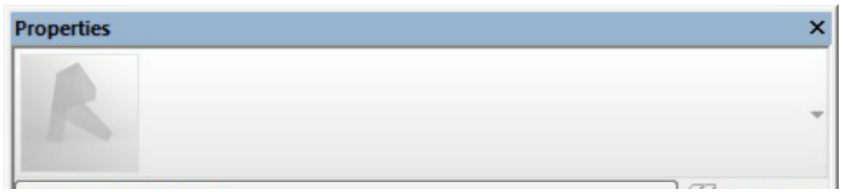






Preset = Child

System/Calculated = Parent



Preset = Child

System/Calculated = Parent

Properties

Connector Element (1) — Edit Type

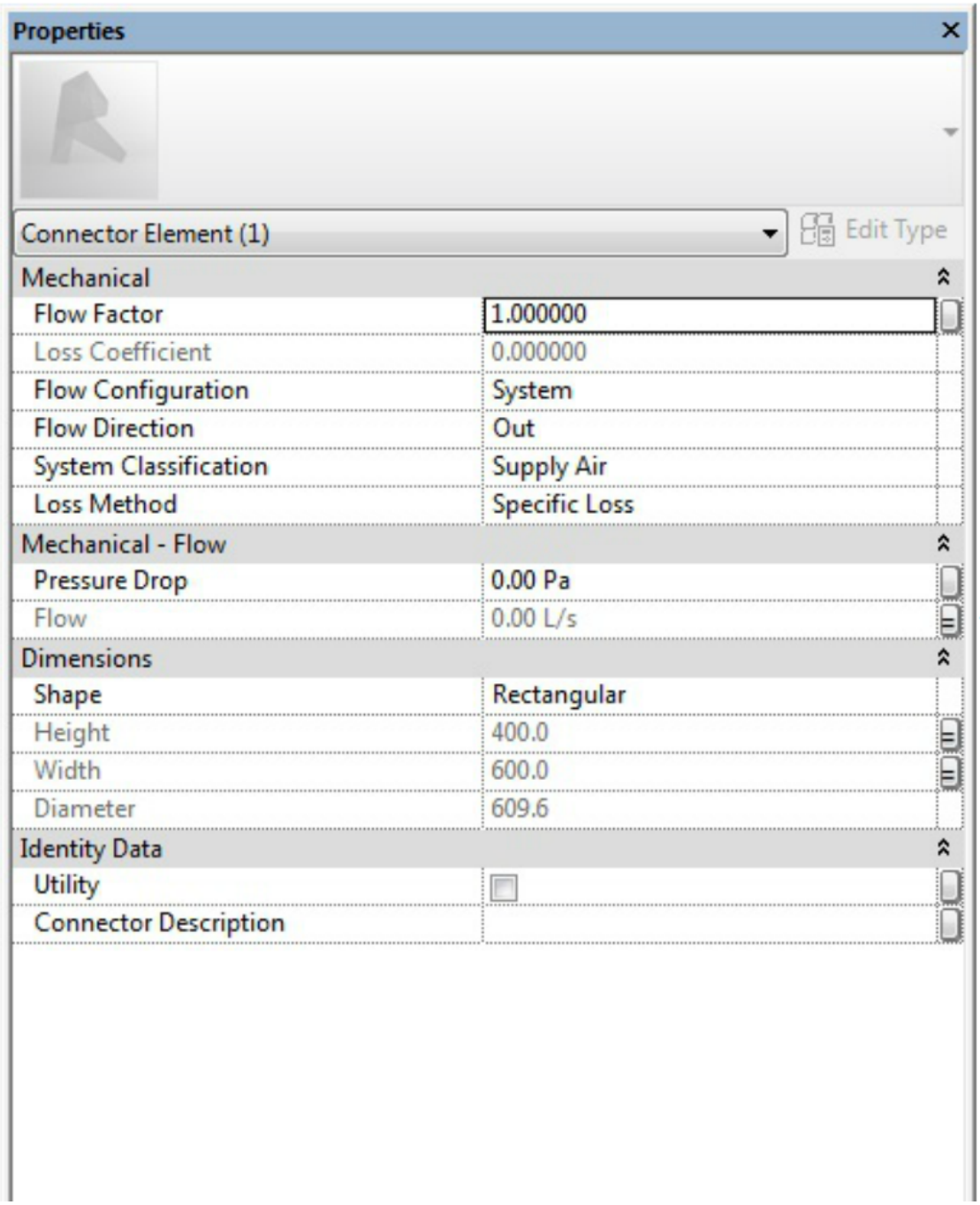
Mechanical	
Flow Factor	0.000000
Loss Coefficient	0.000000
Flow Configuration	Preset
Flow Direction	In
System Classification	Supply Air
Loss Method	Specific Loss
Mechanical - Flow	
Pressure Drop	0.00 Pa
Flow	0.00 L/s
Dimensions	
Shape	Rectangular
Height	400.0
Width	600.0
Diameter	609.6
Identity Data	
Utility	
Connector Description	

Properties

Connector Element (1) — Edit Type

Mechanical	
Flow Factor	1.000000
Loss Coefficient	0.000000
Flow Configuration	System
Flow Direction	Out
System Classification	Supply Air
Loss Method	Specific Loss
Mechanical - Flow	
Pressure Drop	0.00 Pa
Flow	0.00 L/s
Dimensions	
Shape	Rectangular
Height	400.0
Width	600.0
Diameter	609.6
Identity Data	
Utility	
Connector Description	

/Calculated = Parent



Parent

System will show a flow factor parameter. This should be set to 1 to pass over 100% of flow

Should be set to System or Calculated

- System doesn't require a physical connection to see flow from terminals.
- Calculated does.

Set flow parameter to reference another flow parameter in the family, but one that references the flow parameter on the child side. Also needs to be an Instance Parameter

Preset = Child

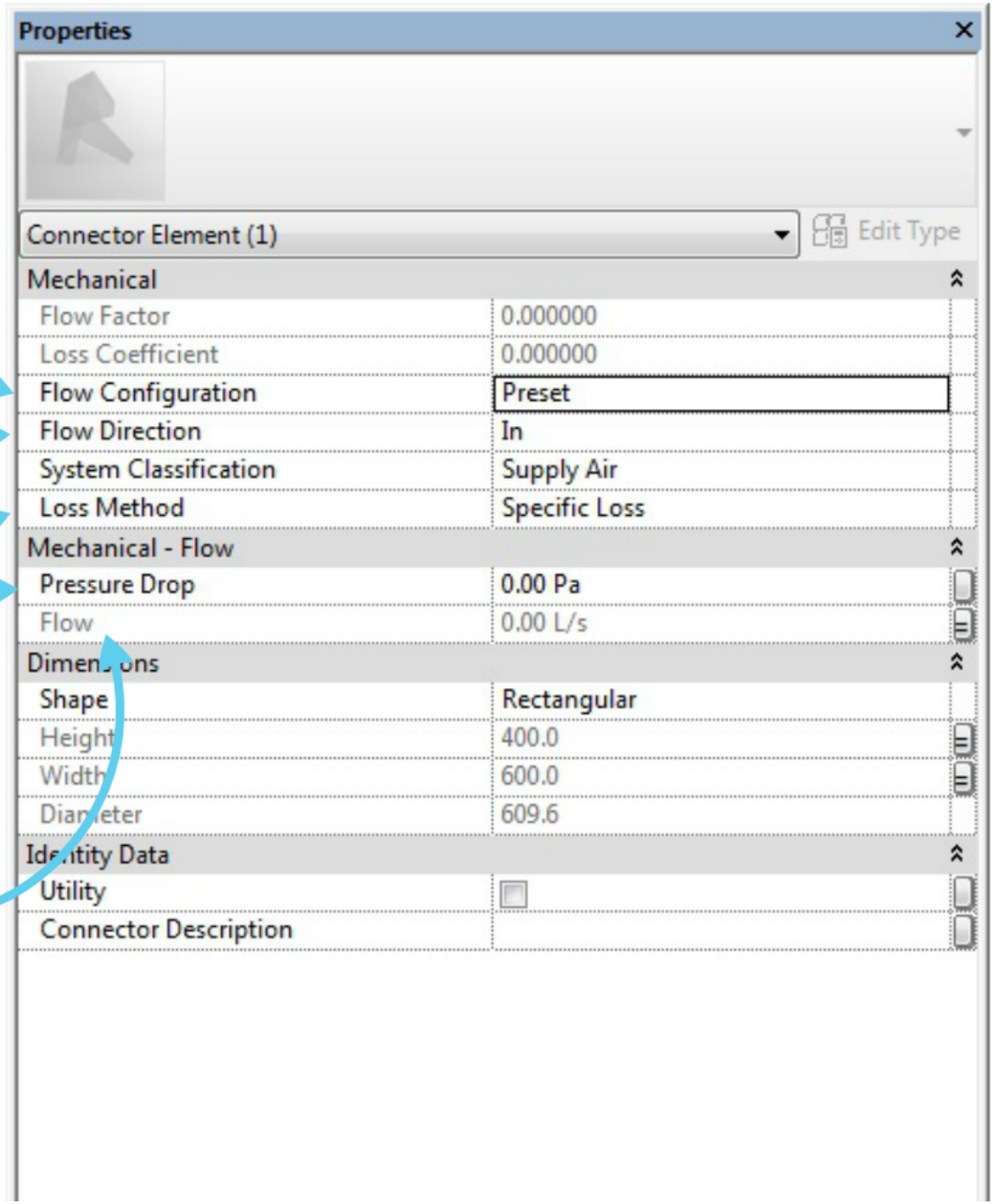
Child

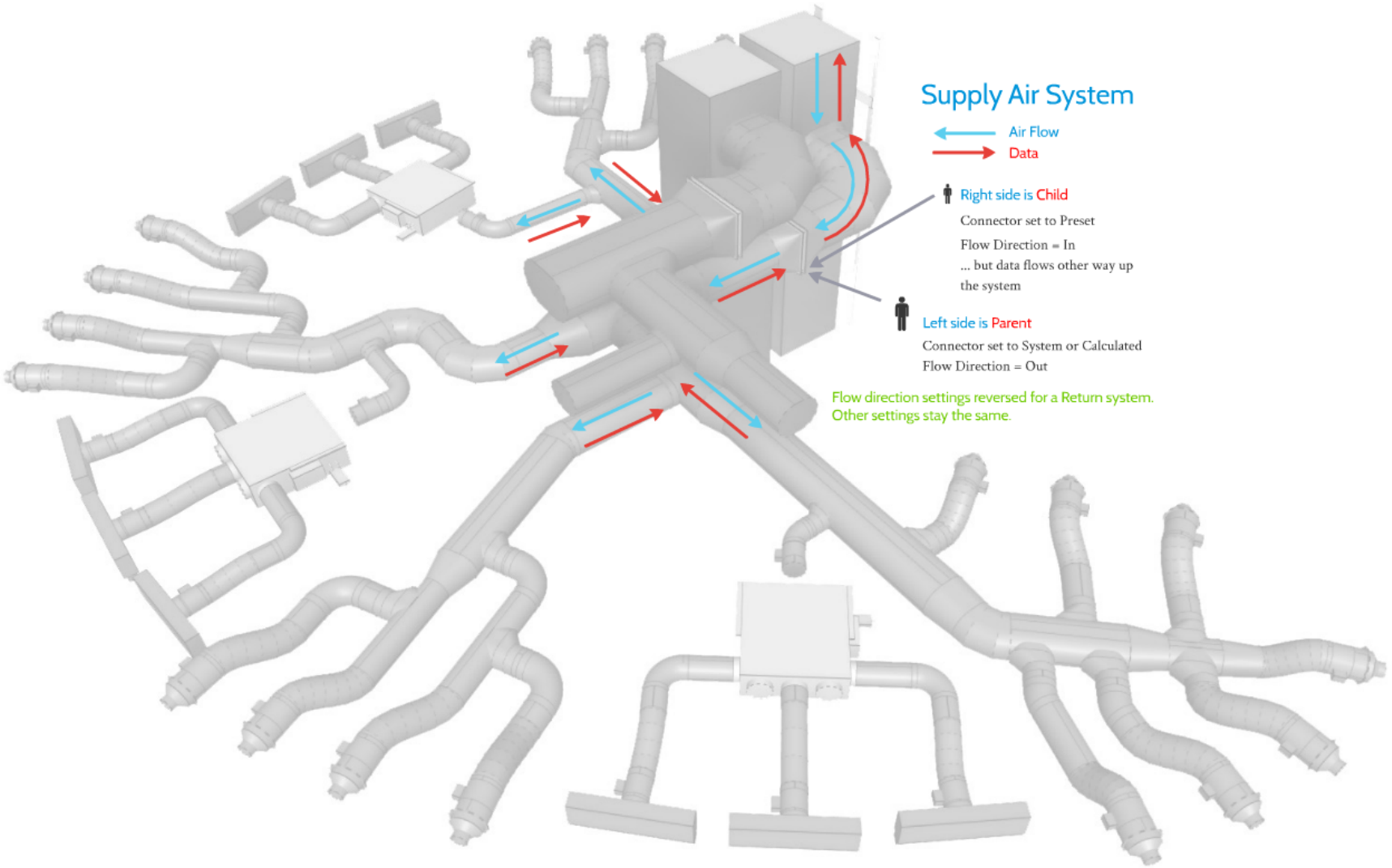
Pushing data from the terminal into the system ...

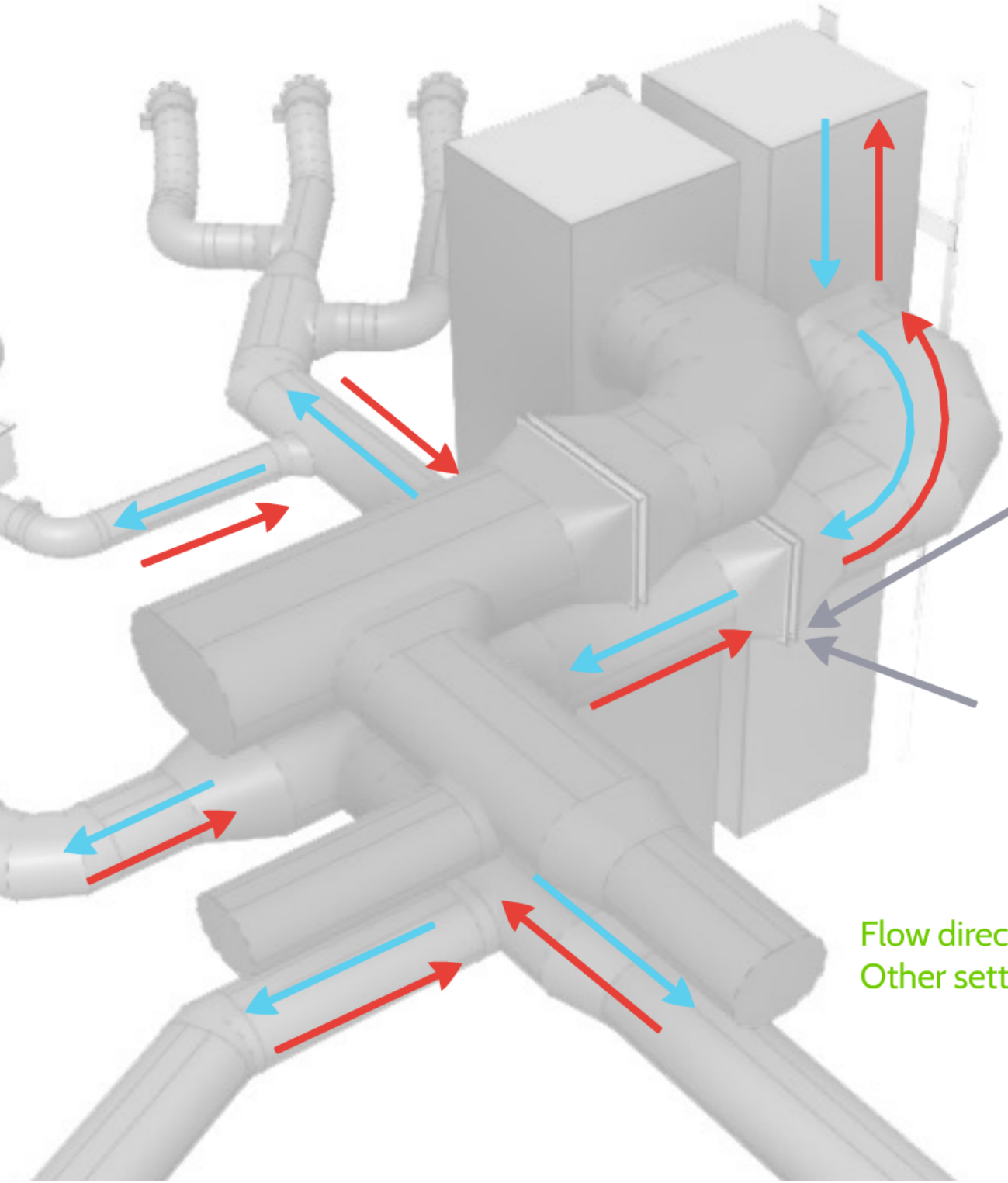
... but the air flow is going the other way so Flow Direction needs to be set to In

If you don't know the pressure drop, set to "Specific Loss" and 0 Pa to avoid warnings in model

Link flow to the air flow parameter, which must be an Instance parameter




Supply Air System
Air Flow
Data
Right side is Child
Connector set to Preset
Flow Direction = In
... but data flows other way up the system
Left side is Parent
Connector set to System or Calculated
Flow Direction = Out
Flow direction settings reversed for a Return system.
Other settings stay the same.



Supply Air System

Air Flow

Data

Right side is Child

Connector set to Preset

Flow Direction = In

... but data flows other way up the system

Left side is Parent

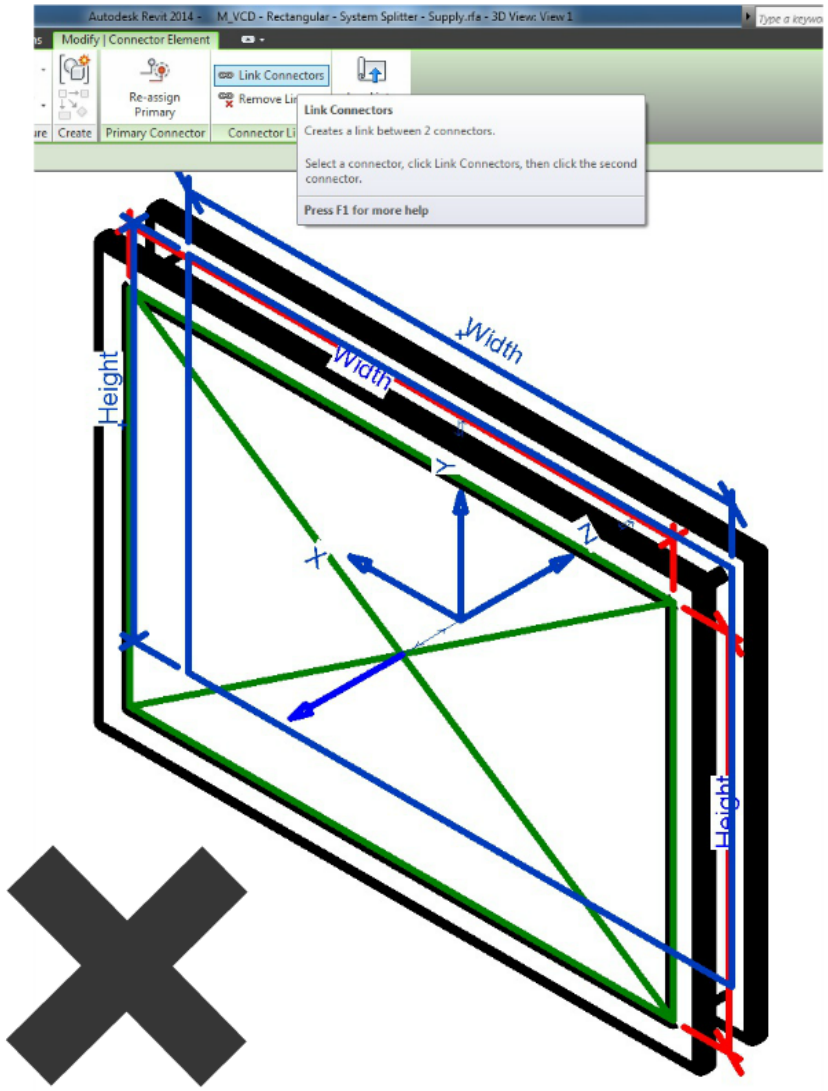
Connector set to System or Calculated

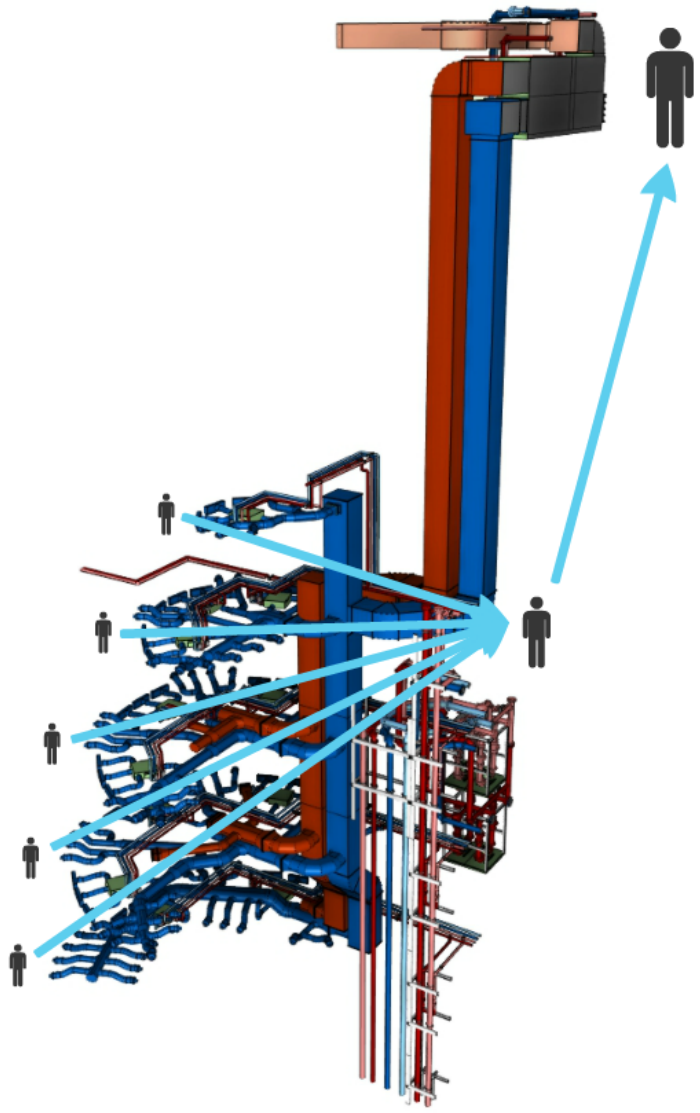
Flow Direction = Out

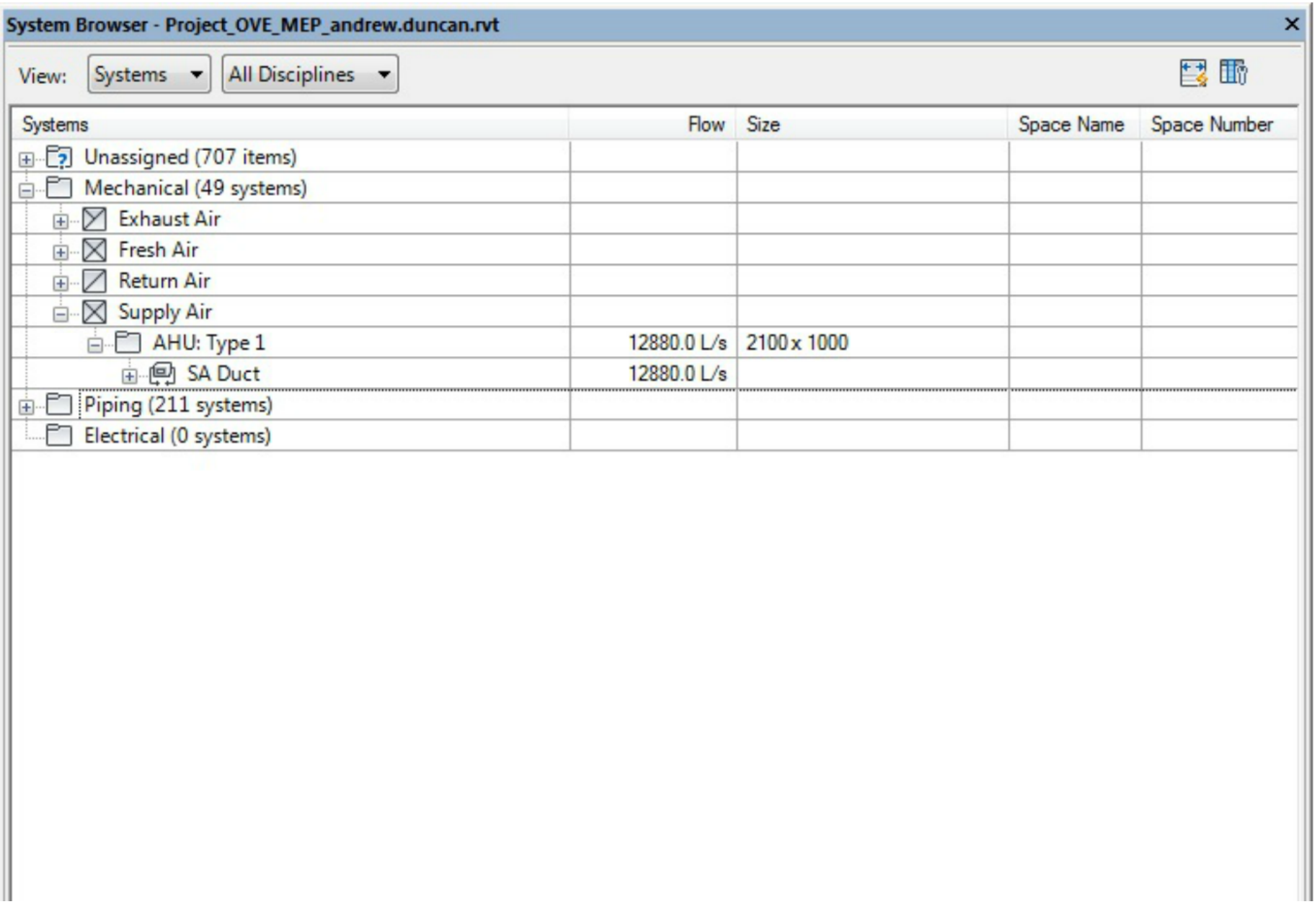
Flow direction settings reversed for a Return system.
Other settings stay the same.

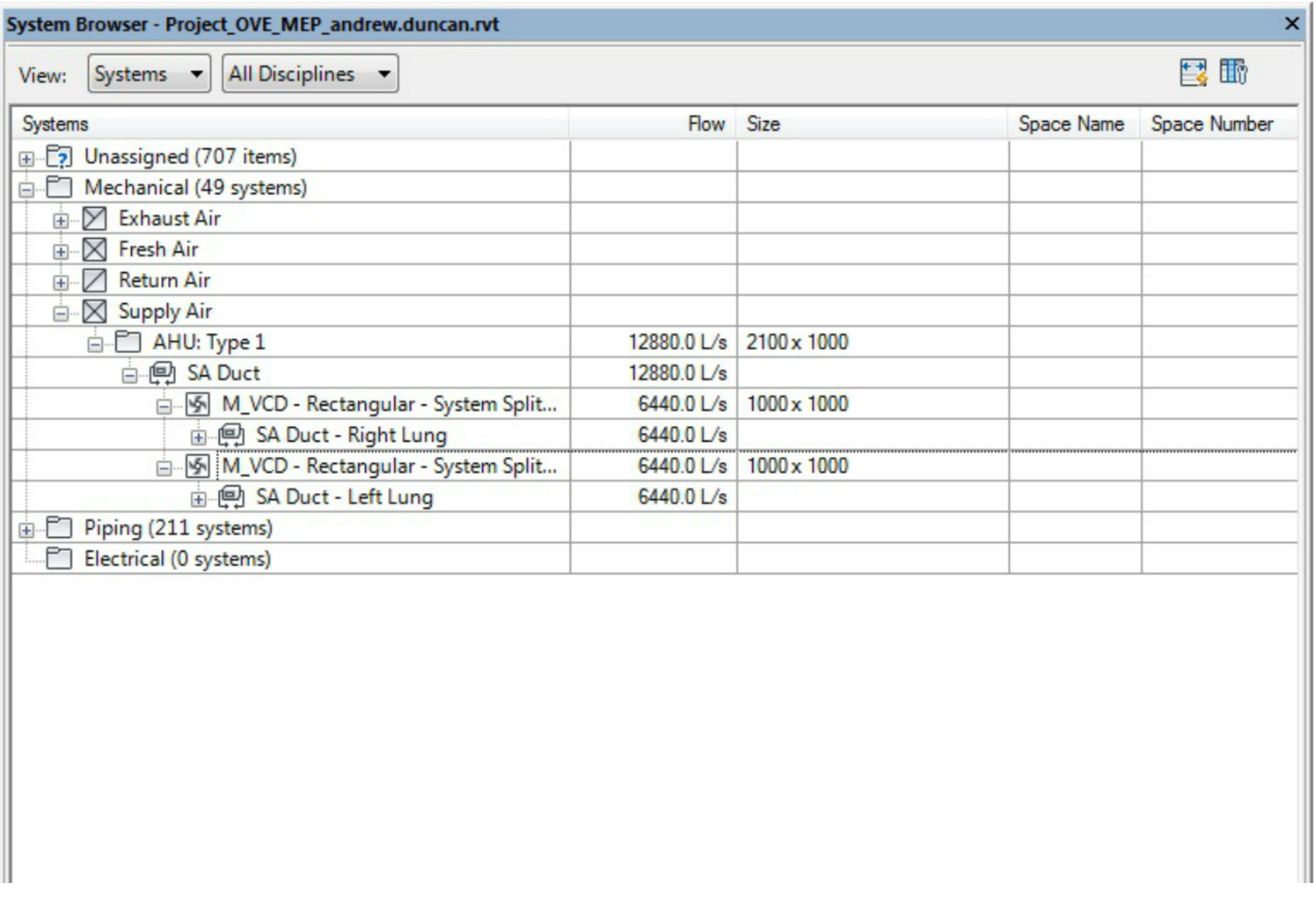
Do not linked Connectors

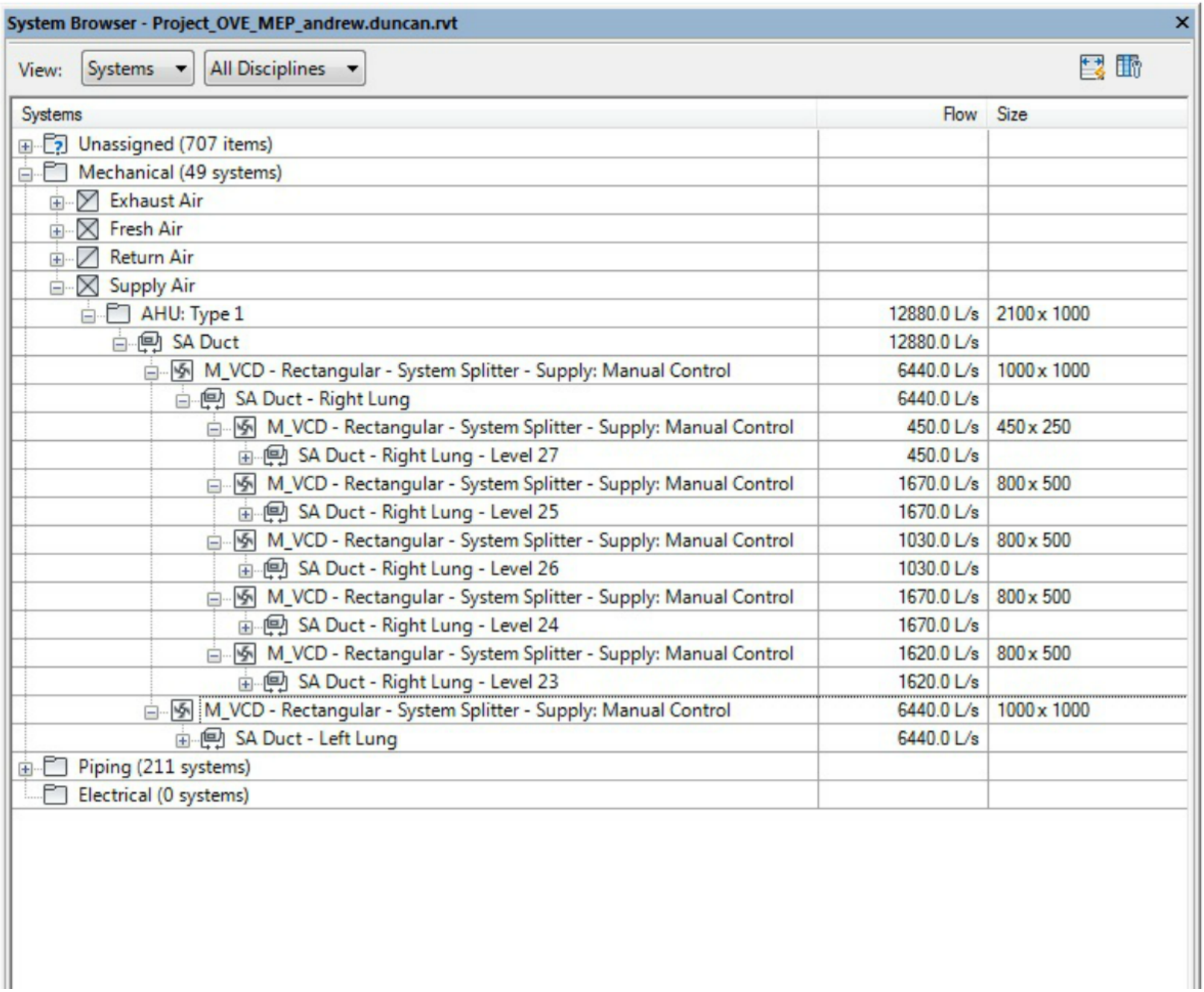
Not linking the connectors stops the system from being passed from one side of the system splitter to the other. This is how you create the system hierarchy that we will demonstrate






System Browser - Project_OVE_MEP_andrew.duncan.rvt
View:
Systems
All Disciplines
Systems
Flow
Size
Space Name
Space Number
Unassigned (707 items)
Mechanical (49 systems)
Exhaust Air
Fresh Air
Return Air
Supply Air
AHU: Type 1
12880.0 L/s
2100 x 1000
SA Duct
12880.0 L/s
Piping (211 systems)
Electrical (0 systems)


System Browser - Project_OVE_MEP_andrew.duncan.rvt
View:
Systems
All Disciplines
Systems
Flow
Size
Space Name
Space Number
Unassigned (707 items)
Mechanical (49 systems)
Exhaust Air
Fresh Air
Return Air
Supply Air
AHU: Type 1
12880.0 L/s
2100 x 1000
SA Duct
12880.0 L/s
M_VCD - Rectangular - System Split...
6440.0 L/s
1000 x 1000
SA Duct - Right Lung
6440.0 L/s
M_VCD - Rectangular - System Split...
6440.0 L/s
1000 x 1000
SA Duct - Left Lung
6440.0 L/s
Piping (211 systems)
Electrical (0 systems)


System Browser - Project_OVE_MEP_andrew.duncan.rvt
View:
Systems
All Disciplines
Systems
Flow
Size
Unassigned (707 items)
Mechanical (49 systems)
Exhaust Air
Fresh Air
Return Air
Supply Air
AHU: Type 1
12880.0 L/s
2100 x 1000
SA Duct
12880.0 L/s
M_VCD - Rectangular - System Splitter - Supply: Manual Control
6440.0 L/s
1000 x 1000
SA Duct - Right Lung
6440.0 L/s
M_VCD - Rectangular - System Splitter - Supply: Manual Control
450.0 L/s
450 x 250
SA Duct - Right Lung - Level 27
450.0 L/s
M_VCD - Rectangular - System Splitter - Supply: Manual Control
1670.0 L/s
800 x 500
SA Duct - Right Lung - Level 25
1670.0 L/s
M_VCD - Rectangular - System Splitter - Supply: Manual Control
1030.0 L/s
800 x 500
SA Duct - Right Lung - Level 26
1030.0 L/s
M_VCD - Rectangular - System Splitter - Supply: Manual Control
1670.0 L/s
800 x 500
SA Duct - Right Lung - Level 24
1670.0 L/s
M_VCD - Rectangular - System Splitter - Supply: Manual Control
1620.0 L/s
800 x 500
SA Duct - Right Lung - Level 23
1620.0 L/s
M_VCD - Rectangular - System Splitter - Supply: Manual Control
6440.0 L/s
1000 x 1000
SA Duct - Left Lung
6440.0 L/s
Piping (211 systems)
Electrical (0 systems)

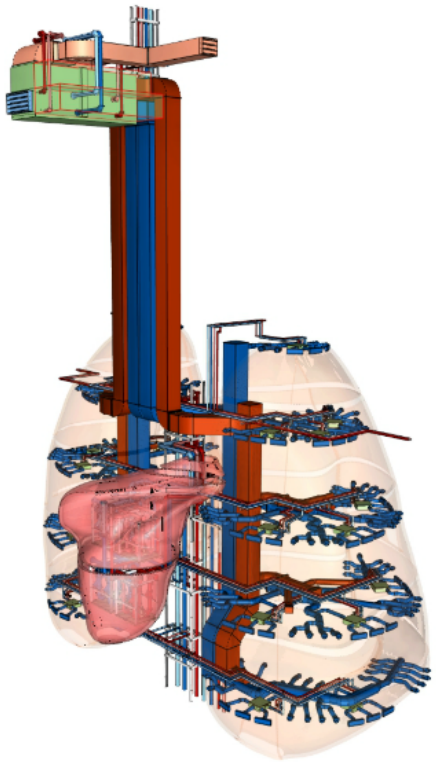
SA Duct - Right Lung - Level 25	1670.0 L/s	
2014 SG_Nozzle Diffuser_Round Intake: 250mm Connec...	80.0 L/s	250
2014 SG_Nozzle Diffuser_Round Intake: 250mm Connec...	80.0 L/s	250
2014 SG_Nozzle Diffuser_Round Intake: 250mm Connec...	80.0 L/s	250
2014 SG_Nozzle Diffuser_Round Intake: 250mm Connec...	80.0 L/s	250
2014 SG_Nozzle Diffuser_Round Intake: 250mm Connec...	80.0 L/s	250
2014 SG_Nozzle Diffuser_Round Intake: 250mm Connec...	80.0 L/s	250
2014 SG_Nozzle Diffuser_Round Intake: 250mm Connec...	80.0 L/s	250
2014 SG_Nozzle Diffuser_Round Intake: 250mm Connec...	80.0 L/s	250
2014 SG_Nozzle Diffuser_Round Intake: 250mm Connec...	80.0 L/s	250
2014 SG_Nozzle Diffuser_Round Intake: 250mm Connec...	80.0 L/s	250
2014 SG_Nozzle Diffuser_Round Intake: 250mm Connec...	80.0 L/s	250
2014 SG_Nozzle Diffuser_Round Intake: 250mm Connec...	80.0 L/s	250
2014 SG_Nozzle Diffuser_Round Intake: 250mm Connec...	80.0 L/s	250
2014 SG_Nozzle Diffuser_Round Intake: 250mm Connec...	80.0 L/s	250
2014 SG_Nozzle Diffuser_Round Intake: 250mm Connec...	80.0 L/s	250
2014 SG_Nozzle Diffuser_Round Intake: 250mm Connec...	80.0 L/s	250
2014 SG_Nozzle Diffuser_Round Intake: 250mm Connec...	80.0 L/s	250
2014 SG_Nozzle Diffuser_Round Intake: 250mm Connec...	80.0 L/s	250
2014 SG_Nozzle Diffuser_Round Intake: 250mm Connec...	80.0 L/s	250
2014_FCU_4-Pipe_Horizontal Ceiling Concealed_5 Spigo...	50.0 L/s	200
2014_FCU_4-Pipe_Horizontal Ceiling Concealed_5 Spigo...	50.0 L/s	200
2014_FCU_4-Pipe_Horizontal Ceiling Concealed_5 Spigo...	50.0 L/s	200
M_VCD - Rectangular - System Splitter - Supply: Manual Control	1030.0 L/s	800 x 500
SA Duct - Right Lung - Level 26	1030.0 L/s	
M_VCD - Rectangular - System Splitter - Supply: Manual Control	1670.0 L/s	800 x 500
SA Duct - Right Lung - Level 24	1670.0 L/s	
M_VCD - Rectangular - System Splitter - Supply: Manual Control	1620.0 L/s	800 x 500
SA Duct - Right Lung - Level 23	1620.0 L/s	
M_VCD - Rectangular - System Splitter - Supply: Manual Control	6440.0 L/s	1000 x 1000
SA Duct - Left Lung	6440.0 L/s	
Piping (211 systems)		

2014 SG_Nozzle Diffuser_Round Intake: 250mm Connec...	80.0 L/s	250
2014 SG_Nozzle Diffuser_Round Intake: 250mm Connec...	80.0 L/s	250
2014 SG_Nozzle Diffuser_Round Intake: 250mm Connec...	80.0 L/s	250
2014_FCU_4-Pipe_Horizontal Ceiling Concealed_5 Spigo...	50.0 L/s	200
SA Duct - Right Lung - Level 25 - FCU/25/04	210.0 L/s	
2014 SG_Ceiling Slot Diffuser_Horizontal Round ...	70.0 L/s	200
2014 SG_Ceiling Slot Diffuser_Horizontal Round ...	70.0 L/s	200
2014 SG_Ceiling Slot Diffuser_Horizontal Round ...	70.0 L/s	200
2014_FCU_4-Pipe_Horizontal Ceiling Concealed_5 Spigo...	50.0 L/s	200
SA Duct - Right Lung - Level 25 - FCU/25/05	210.0 L/s	
2014 SG_Ceiling Slot Diffuser_Horizontal Round ...	70.0 L/s	200
2014 SG_Ceiling Slot Diffuser_Horizontal Round ...	70.0 L/s	200
2014 SG_Ceiling Slot Diffuser_Horizontal Round ...	70.0 L/s	200
2014_FCU_4-Pipe_Horizontal Ceiling Concealed_5 Spigo...	50.0 L/s	200
SA Duct - Right Lung - Level 25 - FCU/25/06	210.0 L/s	
2014 SG_Ceiling Slot Diffuser_Horizontal Round ...	70.0 L/s	200
2014 SG_Ceiling Slot Diffuser_Horizontal Round ...	70.0 L/s	200
2014 SG_Ceiling Slot Diffuser_Horizontal Round ...	70.0 L/s	200
M_VCD - Rectangular - System Splitter - Supply: Manual Control	1030.0 L/s	800 x 500
SA Duct - Right Lung - Level 26	1030.0 L/s	

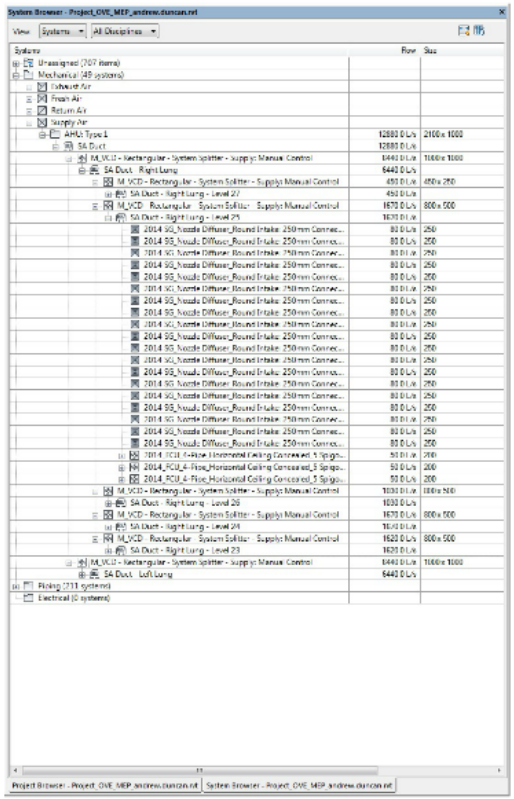
YouTube

Ventilation Summary

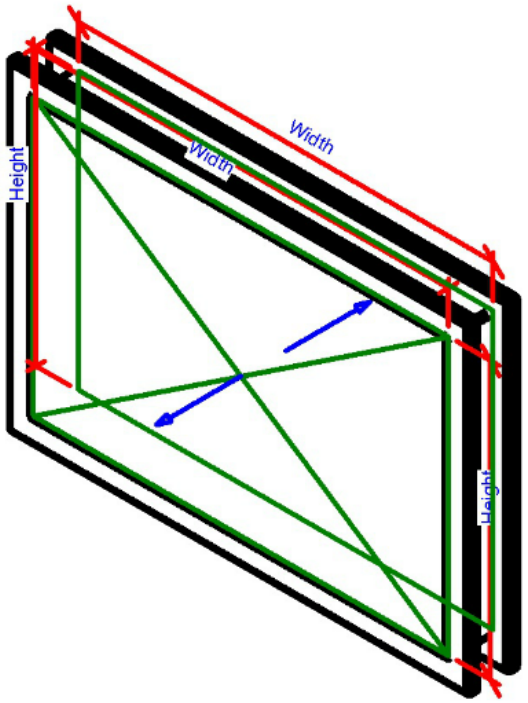
Model Drives Flow



Neat System Browser



All Because of ....

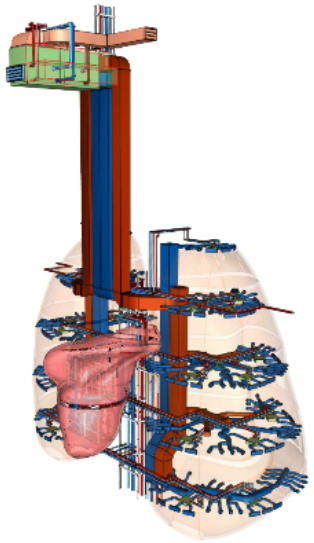


System Splitter

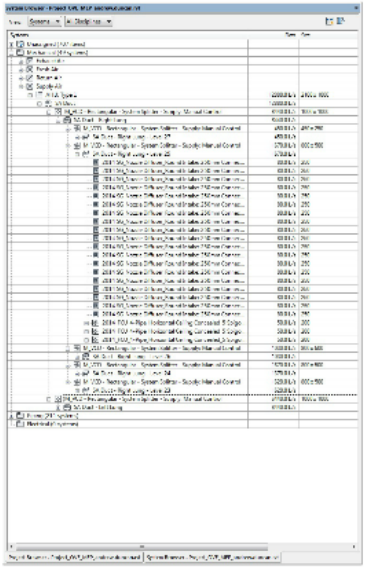
we're not finished with the airflow ye

Ventilation Summary

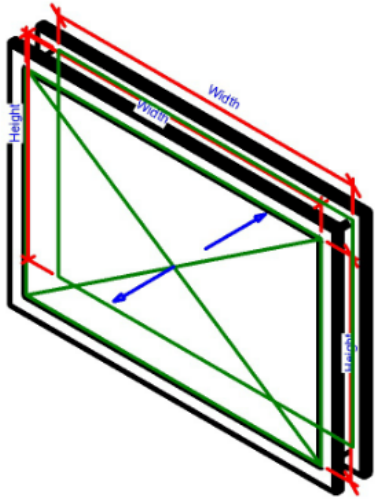
Model Drives Flow



Neat System Browser

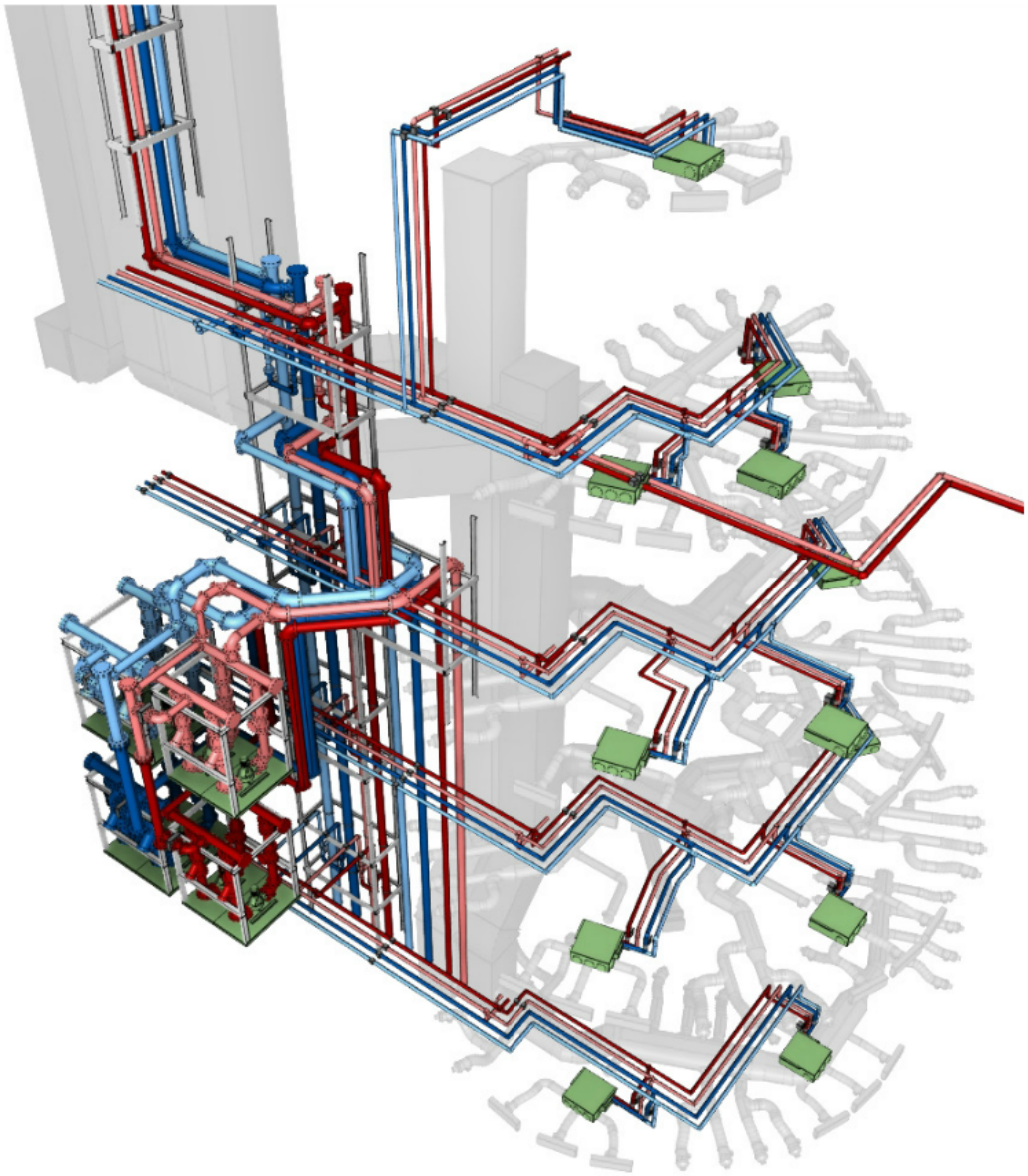


All Because of ....



System Splitter

... but we're not finished with the airflow yet ...

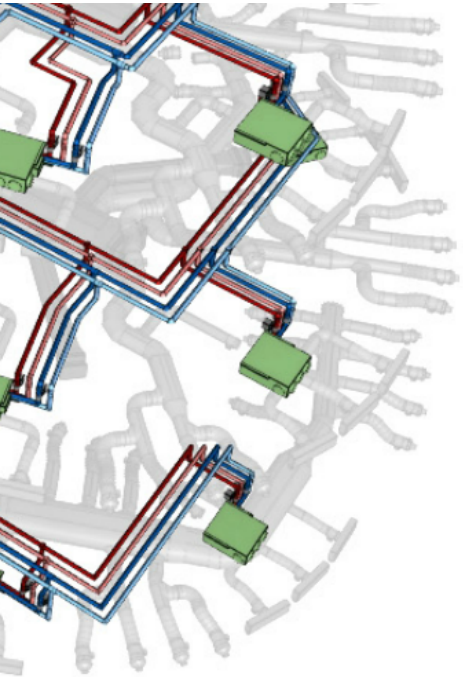


Mike Slessor

Mechanical Engineer

Pipework

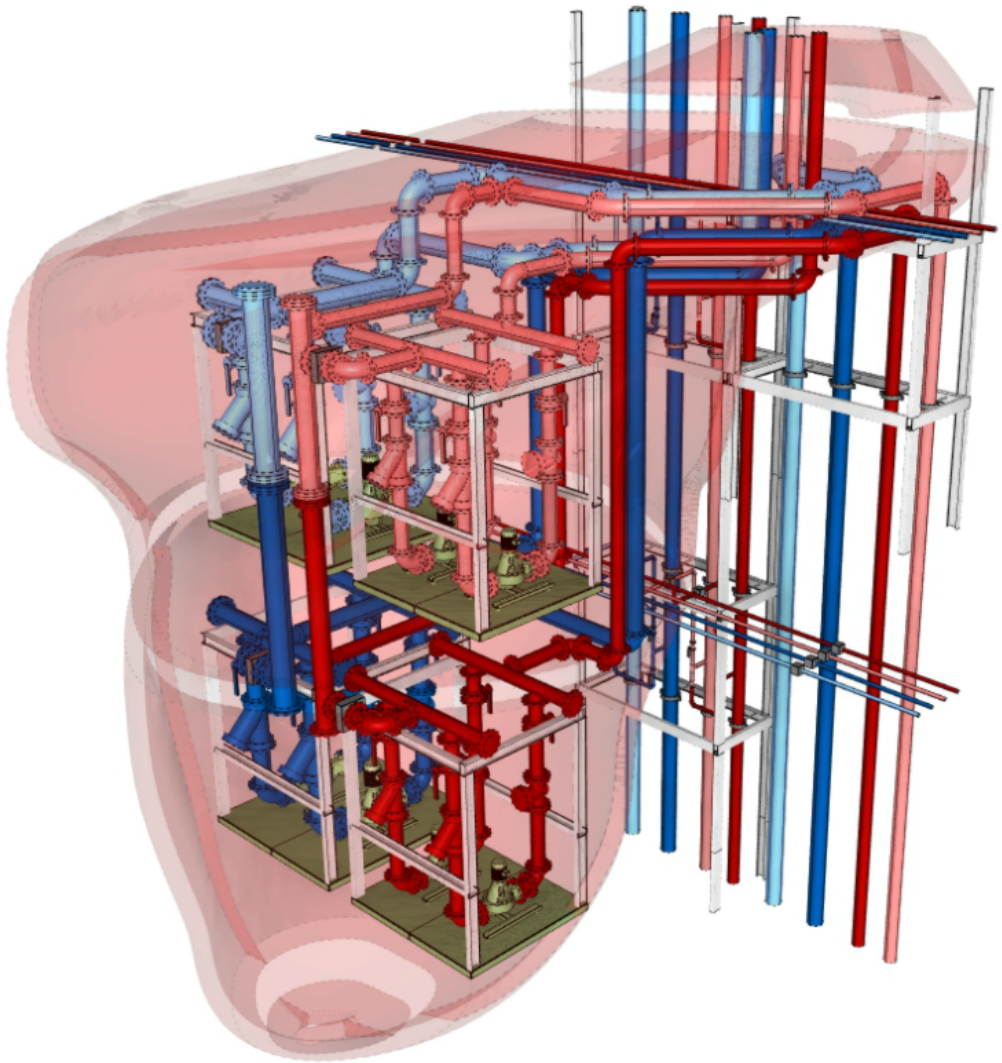
=



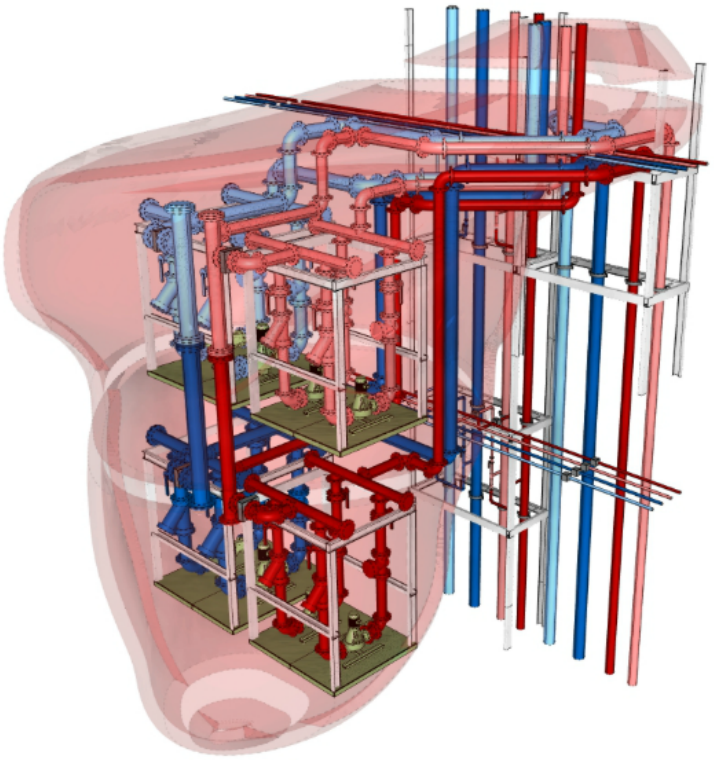
Pipework

=

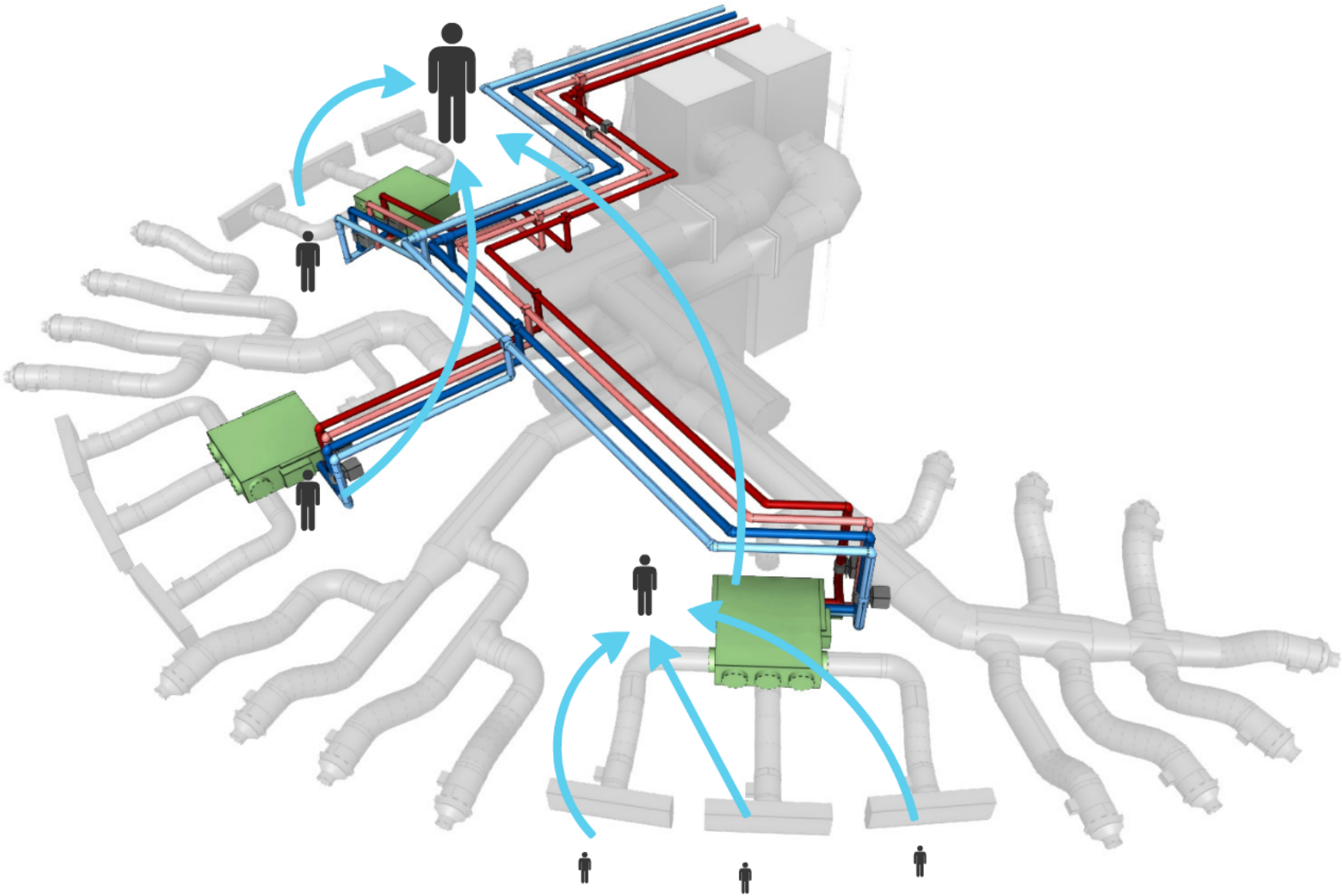
Circulatory



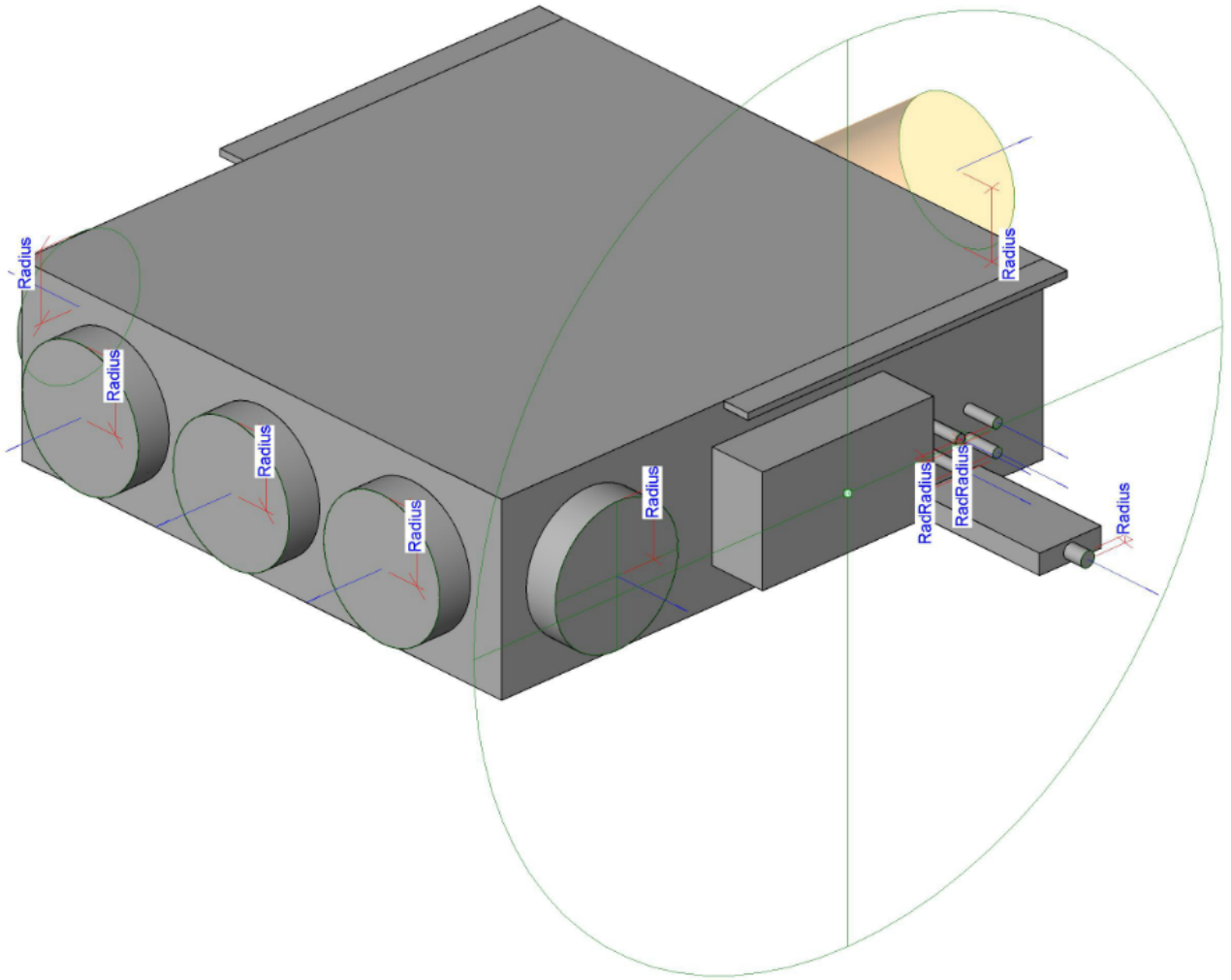
Circulatory

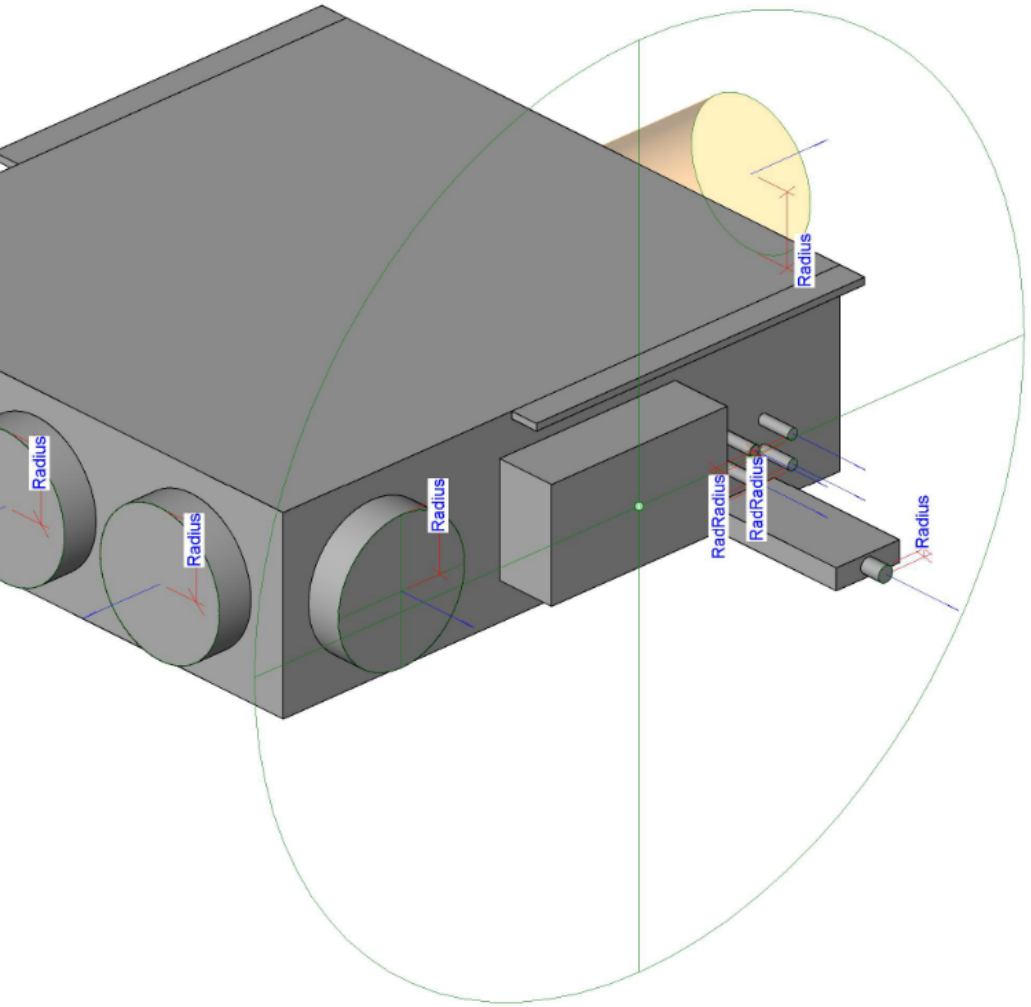


Terminal Unit System → Level System → Riser System → Primary Plant System



Maximise opportunity in families





Family Types

Name: Highline 270-09

Parameter	Value	Formula	Lock
Mechanical - Flow			
Supply Air Flow Selection	282.00 L/s	=	
Supply Air Flow E (default)	0.00 L/s	=	
Supply Air Flow D (default)	0.00 L/s	=	
Supply Air Flow C (default)	0.00 L/s	=	
Supply Air Flow (default)	150.00 L/s	= Supply Air Flow A + Supply Air Flow B + Supply Air Flow C + Supply Air Flow D +	
Supply Air Flow B (default)	0.00 L/s	=	
Supply Air Flow A (default)	150.00 L/s	=	
Room Sound Level	NR 35	=	
Return Air Flow (default)	120.00 L/s	= if(not(Supply Air Flow - Fresh Air Flow > 0 L/s), 0 L/s, Supply Air Flow - Fresh Air Fl	
Fresh Air Flow (default)	30.00 L/s	=	
Fan Speed	Medium	=	
External Static Pressure Drop	30.00 Pa	=	
Mechanical - Loads			
LTHW Flow (default)	0.05 L/s	= Heating Load / (Water Specific Heat Capacity * Fluid Density * (LTHWF Temperatu	
Heating Load Selection	4521.00 W	=	
Heating Load (default)	2000.00 W	=	
Cooling Load Total Selection	4512.00 W	=	
Cooling Load Total (default)	2790.00 W	= Supply Air Flow * Air Density * Air Enthalpy Unit Conversion * (OnCoil Cooling Ent	
Cooling Load Sensible Selection	3688.00 W	=	
Cooling Load Sensible (default)	2170.80 W	= Supply Air Flow * Air Density * Air Specific Heat Capacity * (OnCoil Cooling DBT -	
CHW Flow (default)	0.11 L/s	= Cooling Load Total / (Water Specific Heat Capacity * Fluid Density * (CHWR Temp	
Dimensions			
Energy Analysis			
Water Specific Heat Capacity	4.1800 J/(g·°C)	=	
Fluid Density	1000.000000 kg/m³	=	
Air Enthalpy Unit Conversion	1.0000 J/g	=	
Air Specific Heat Capacity	1.0050 J/(g·°C)	=	
Air Density	1.200000 kg/m³	=	
Model Properties			
Data			
Sound SA Lookup (default)	185.00 L/s	= size_lookup(Lookup Table Name 3, Lookup Unit Ref Text, 0 L/s, Supply Air Flow)	
Radiated 8_8 kHz (default)	21	= size_lookup(Lookup Table Name 2, "8000", 0, Lookup Unit Ref Number, Sound SA	
Radiated 7_4 kHz (default)	30	= size_lookup(Lookup Table Name 2, "4000", 0, Lookup Unit Ref Number, Sound SA	
Radiated 6_2 kHz (default)	37	= size_lookup(Lookup Table Name 2, "2000", 0, Lookup Unit Ref Number, Sound SA	
Radiated 5_1 kHz (default)	41	= size_lookup(Lookup Table Name 2, "1000", 0, Lookup Unit Ref Number, Sound SA	
Radiated 4_500 Hz (default)	46	= size_lookup(Lookup Table Name 2, "500", 0, Lookup Unit Ref Number, Sound SA L	
Radiated 3_250 Hz (default)	50	= size_lookup(Lookup Table Name 2, "250", 0, Lookup Unit Ref Number, Sound SA L	
Radiated 2_125 Hz (default)	47	= size_lookup(Lookup Table Name 2, "125", 0, Lookup Unit Ref Number, Sound SA L	
Radiated 1_63 Hz (default)	46	= size_lookup(Lookup Table Name 2, "63", 0, Lookup Unit Ref Number, Sound SA Lo	
Outlet 8_8 kHz (default)	23	= size_lookup(Lookup Table Name 1, "8000", 0, Lookup Unit Ref Number, Sound SA	
Outlet 7_4 kHz (default)	29	= size_lookup(Lookup Table Name 1, "4000", 0, Lookup Unit Ref Number, Sound SA	
Outlet 6_2 kHz (default)	32	= size_lookup(Lookup Table Name 1, "2000", 0, Lookup Unit Ref Number, Sound SA	

Family Types: New... Rename... Delete

Parameters: Add... Modify... Remove

Lookup Tables: Manage...

OK Cancel Apply Help

Air Specific Heat Capacity	1.0050 J/(g·°C)
Air Density	1.200000 kg/m³

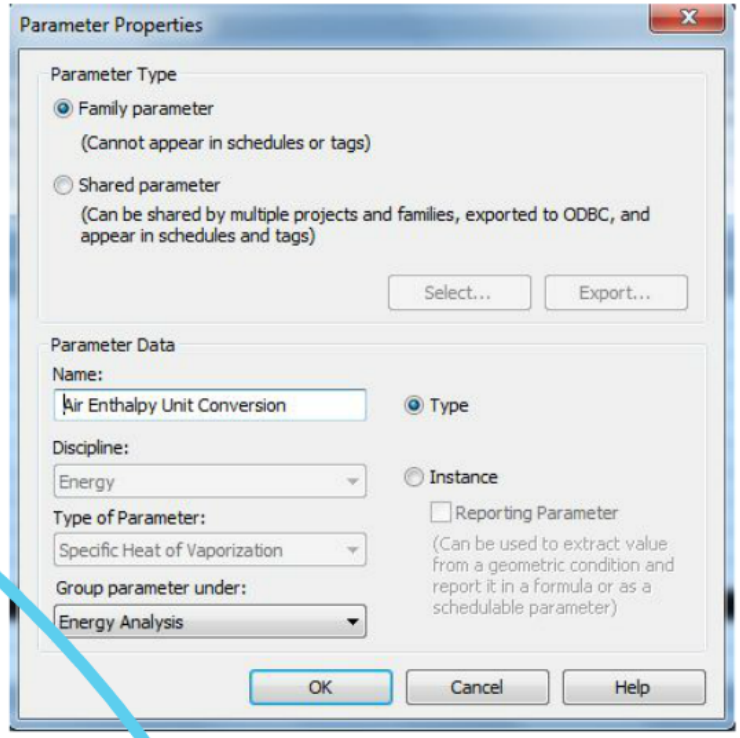
Mechanical - Loads		
Supply Air Flow (default)	150.00 L/s	= Supply Air Flow A + Supply Air Flow B + Supply Air Flow C + Supply Air Flow D + Supply Air Flow E
LTHW Flow (default)	0.05 L/s	= Heating Load / (Water Specific Heat Capacity * Fluid Density * (LTHWF Temperature - LTHWR Temperature))
Cooling Load Total (default)	2700.00 W	= Supply Air Flow * Air Density * Air Enthalpy Unit Conversion * (OnCoil Cooling Enthalpy - OffCoil Cooling Enthalpy)
Cooling Load Sensible (default)	2170.80 W	= Supply Air Flow * Air Density * Air Specific Heat Capacity * (OnCoil Cooling DBT - OffCoil Cooling DBT)
CHW Flow (default)	0.11 L/s	= Cooling Load Total / (Water Specific Heat Capacity * Fluid Density * (CHWR Temperature - CHWF Temperature))
Dimensions		
Energy Analysis		
Water Specific Heat Capacity	4.1800 J/(g·°C)	=
OnCoil Cooling Enthalpy	50.000000	=
OnCoil Cooling DBT	25.00 °C	=
OffCoil Cooling Enthalpy	34.500000	=
OffCoil Cooling DBT	13.00 °C	=
LTHWR Temperature	60.00 °C	=
LTHWF Temperature	70.00 °C	=
Fluid Density	1000.000000 kg/m³	=
CHWR Temperature	12.00 °C	=
CHWF Temperature	6.00 °C	=
Air Enthalpy Unit Conversion	1.0000 J/g	=
Air Specific Heat Capacity	1.0050 J/(g·°C)	=
Air Density	1.200000 kg/m³	=

Energy Analysis Properties (Equipment/Project Specific) → Cooling/ Heating Loads → CHW/LTHW flows

Supply Air Flow (Air Terminal) → Cooling/ Heating Loads

Data		
Sound SA Lookup (default)	185.00 L/s	= size_lookup(Lookup Table Name 3, Lookup Unit Ref Text, 0 L/s, Supply Air Flow)
Radiated 8_8 kHz (default)	21	= size_lookup(Lookup Table Name 2, "8000", 0, Lookup Unit Ref Number, Sound SA Lookup)

Energy Analysis	
Water Specific Heat Capacity	4.1800 J/(g·°C)
OnCoil Cooling Enthalpy	50.000000
OnCoil Cooling DBT	25.00 °C
OffCoil Cooling Enthalpy	34.500000
OffCoil Cooling DBT	13.00 °C
LTHWR Temperature	60.00 °C
LTHWF Temperature	70.00 °C
Fluid Density	1000.000000 kg/m³
CHWR Temperature	12.00 °C
CHWF Temperature	6.00 °C
Air Enthalpy Unit Conversion	1.0000 J/g
Air Specific Heat Capacity	1.0050 J/(g·°C)
Air Density	1.200000 kg/m³



Mechanical - Loads		
Supply Air Flow (default)	150.00 L/s	= Supply Air Flow A + Supply Air Flow B + Supply Air Flow C + Supply Air Flow D + Supply Air Flow E
LTHW Flow (default)	0.05 L/s	= Heating Load / (Water Specific Heat Capacity * Fluid Density * (LTHWF Temperature - LTHWR Temperature))
Cooling Load Total (default)	2700.00 W	= Supply Air Flow * Air Density * Air Enthalpy Unit Conversion * (OnCoil Cooling Enthalpy - OffCoil Cooling Enthalpy)
Cooling Load Sensible (default)	2170.80 W	= Supply Air Flow * Air Density * Air Specific Heat Capacity * (OnCoil Cooling DBT - OffCoil Cooling DBT)
CHW Flow (default)	0.11 L/s	= Cooling Load Total / (Water Specific Heat Capacity * Fluid Density * (CHWR Temperature - CHWF Temperature))
Dimensions		
Energy Analysis		
Water Specific Heat Capacity	4.1800 J/(g·°C)	=
OnCoil Cooling Enthalpy	50.000000	=
OnCoil Cooling DBT	25.00 °C	=
OffCoil Cooling Enthalpy	34.500000	=

Air Specific Heat Capacity	1.0050 J/(g·°C)
Air Density	1.200000 kg/m³

Mechanical - Loads		
Supply Air Flow (default)	150.00 L/s	= Supply Air Flow A + Supply Air Flow B + Supply Air Flow C + Supply Air Flow D + Supply Air Flow E
LTHW Flow (default)	0.05 L/s	= Heating Load / (Water Specific Heat Capacity * Fluid Density * (LTHWF Temperature - LTHWR Temperature))
Cooling Load Total (default)	2700.00 W	= Supply Air Flow * Air Density * Air Enthalpy Unit Conversion * (OnCoil Cooling Enthalpy - OffCoil Cooling Enthalpy)
Cooling Load Sensible (default)	2170.80 W	= Supply Air Flow * Air Density * Air Specific Heat Capacity * (OnCoil Cooling DBT - OffCoil Cooling DBT)
CHW Flow (default)	0.11 L/s	= Cooling Load Total / (Water Specific Heat Capacity * Fluid Density * (CHWR Temperature - CHWF Temperature))
Dimensions		
Energy Analysis		
Water Specific Heat Capacity	4.1800 J/(g·°C)	=
OnCoil Cooling Enthalpy	50.000000	=
OnCoil Cooling DBT	25.00 °C	=
OffCoil Cooling Enthalpy	34.500000	=
OffCoil Cooling DBT	13.00 °C	=
LTHWR Temperature	60.00 °C	=
LTHWF Temperature	70.00 °C	=
Fluid Density	1000.000000 kg/m³	=
CHWR Temperature	12.00 °C	=
CHWF Temperature	6.00 °C	=
Air Enthalpy Unit Conversion	1.0000 J/g	=
Air Specific Heat Capacity	1.0050 J/(g·°C)	=
Air Density	1.200000 kg/m³	=

Energy Analysis Properties (Equipment/Project Specific) → Cooling/ Heating Loads → CHW/LTHW flows

Supply Air Flow (Air Terminal) → Cooling/ Heating Loads

Data		
Sound SA Lookup (default)	185.00 L/s	= size_lookup(Lookup Table Name 3, Lookup Unit Ref Text, 0 L/s, Supply Air Flow)
Radiated 8_8 kHz (default)	21	= size_lookup(Lookup Table Name 2, "8000", 0, Lookup Unit Ref Number, Sound SA Lookup)

Energy Analysis Properties (Equipment/Project Specific) → Cooling/ Heating Loads → CHW/LTHW flows

Supply Air Flow (Air Terminal) → Cooling/ Heating Loads

Supply Air Flow (Air Terminal) → Noise Data

Data		
Sound SA Lookup (default)	185.00 L/s	= size_lookup(Lookup Table Name 3, Lookup Unit Ref Text, 0 L/s, Supply Air Flow)
Radiated 8_8 kHz (default)	21	= size_lookup(Lookup Table Name 2, "8000", 0, Lookup Unit Ref Number, Sound SA Lookup)
Radiated 7_4 kHz (default)	30	= size_lookup(Lookup Table Name 2, "4000", 0, Lookup Unit Ref Number, Sound SA Lookup)
Radiated 6_2 kHz (default)	37	= size_lookup(Lookup Table Name 2, "2000", 0, Lookup Unit Ref Number, Sound SA Lookup)
Radiated 5_1 kHz (default)	41	= size_lookup(Lookup Table Name 2, "1000", 0, Lookup Unit Ref Number, Sound SA Lookup)
Radiated 4_500 Hz (default	46	= size_lookup(Lookup Table Name 2, "500", 0, Lookup Unit Ref Number, Sound SA Lookup)
Radiated 3_250 Hz (default	50	= size_lookup(Lookup Table Name 2, "250", 0, Lookup Unit Ref Number, Sound SA Lookup)
Radiated 2_125 Hz (default	47	= size_lookup(Lookup Table Name 2, "125", 0, Lookup Unit Ref Number, Sound SA Lookup)
Radiated 1_63 Hz (default)	46	= size_lookup(Lookup Table Name 2, "63", 0, Lookup Unit Ref Number, Sound SA Lookup)
Outlet 8_8 kHz (default)	23	= size_lookup(Lookup Table Name 1, "8000", 0, Lookup Unit Ref Number, Sound SA Lookup)
Outlet 7_4 kHz (default)	29	= size_lookup(Lookup Table Name 1, "4000", 0, Lookup Unit Ref Number, Sound SA Lookup)
Outlet 6_2 kHz (default)	32	= size_lookup(Lookup Table Name 1, "2000", 0, Lookup Unit Ref Number, Sound SA Lookup)
Outlet 5_1 kHz (default)	40	= size_lookup(Lookup Table Name 1, "1000", 0, Lookup Unit Ref Number, Sound SA Lookup)
Outlet 4_500 Hz (default)	43	= size_lookup(Lookup Table Name 1, "500", 0, Lookup Unit Ref Number, Sound SA Lookup)
Outlet 3_250 Hz (default)	47	= size_lookup(Lookup Table Name 1, "250", 0, Lookup Unit Ref Number, Sound SA Lookup)
Outlet 2_125 Hz (default)	45	= size_lookup(Lookup Table Name 1, "125", 0, Lookup Unit Ref Number, Sound SA Lookup)
Outlet 1_63 Hz (default)	48	= size_lookup(Lookup Table Name 1, "63", 0, Lookup Unit Ref Number, Sound SA Lookup)
Inlet 8_8 kHz (default)	21	= size_lookup(Lookup Table Name 2, "8000", 0, Lookup Unit Ref Number, Sound SA Lookup)
Inlet 7_4 kHz (default)	30	= size_lookup(Lookup Table Name 2, "4000", 0, Lookup Unit Ref Number, Sound SA Lookup)
Inlet 6_2 kHz (default)	37	= size_lookup(Lookup Table Name 2, "2000", 0, Lookup Unit Ref Number, Sound SA Lookup)
Inlet 5_1 kHz (default)	41	= size_lookup(Lookup Table Name 2, "1000", 0, Lookup Unit Ref Number, Sound SA Lookup)
Inlet 4_500 Hz (default)	46	= size_lookup(Lookup Table Name 2, "500", 0, Lookup Unit Ref Number, Sound SA Lookup)
Inlet 3_250 Hz (default)	50	= size_lookup(Lookup Table Name 2, "250", 0, Lookup Unit Ref Number, Sound SA Lookup)
Inlet 2_125 Hz (default)	47	= size_lookup(Lookup Table Name 2, "125", 0, Lookup Unit Ref Number, Sound SA Lookup)
Inlet 1_63 Hz (default)	46	= size_lookup(Lookup Table Name 2, "63", 0, Lookup Unit Ref Number, Sound SA Lookup)

Data		
Sound SA Lookup (default)	185.00 L/s	= size_lookup(Lookup Table Name 3, Lookup Unit Ref Text, 0 L/s, Supply Air Flow)
Radiated 8_8 kHz (default)	21	= size_lookup(Lookup Table Name 2, "8000", 0, Lookup Unit Ref Number, Sound SA Lookup)
Radiated 7_4 kHz (default)	30	= size_lookup(Lookup Table Name 2, "4000", 0, Lookup Unit Ref Number, Sound SA Lookup)
Radiated 6_2 kHz (default)	37	= size_lookup(Lookup Table Name 2, "2000", 0, Lookup Unit Ref Number, Sound SA Lookup)
Radiated 5_1 kHz (default)	41	= size_lookup(Lookup Table Name 2, "1000", 0, Lookup Unit Ref Number, Sound SA Lookup)
Radiated 4_500 Hz (default	46	= size_lookup(Lookup Table Name 2, "500", 0, Lookup Unit Ref Number, Sound SA Lookup)
Radiated 3_250 Hz (default	50	= size_lookup(Lookup Table Name 2, "250", 0, Lookup Unit Ref Number, Sound SA Lookup)
Radiated 2_125 Hz (default	47	= size_lookup(Lookup Table Name 2, "125", 0, Lookup Unit Ref Number, Sound SA Lookup)
Radiated 1_63 Hz (default)	46	= size_lookup(Lookup Table Name 2, "63", 0, Lookup Unit Ref Number, Sound SA Lookup)
Outlet 8_8 kHz (default)	23	= size_lookup(Lookup Table Name 1, "8000", 0, Lookup Unit Ref Number, Sound SA Lookup)
Outlet 7_4 kHz (default)	29	= size_lookup(Lookup Table Name 1, "4000", 0, Lookup Unit Ref Number, Sound SA Lookup)
Outlet 6_2 kHz (default)	32	= size_lookup(Lookup Table Name 1, "2000", 0, Lookup Unit Ref Number, Sound SA Lookup)
Outlet 5_1 kHz (default)	40	= size_lookup(Lookup Table Name 1, "1000", 0, Lookup Unit Ref Number, Sound SA Lookup)
Outlet 4_500 Hz (default)	43	= size_lookup(Lookup Table Name 1, "500", 0, Lookup Unit Ref Number, Sound SA Lookup)
Outlet 3_250 Hz (default)	47	= size_lookup(Lookup Table Name 1, "250", 0, Lookup Unit Ref Number, Sound SA Lookup)
Outlet 2_125 Hz (default)	45	= size_lookup(Lookup Table Name 1, "125", 0, Lookup Unit Ref Number, Sound SA Lookup)
Outlet 1_63 Hz (default)	48	= size_lookup(Lookup Table Name 1, "63", 0, Lookup Unit Ref Number, Sound SA Lookup)
Inlet 8_8 kHz (default)	21	= size_lookup(Lookup Table Name 2, "8000", 0, Lookup Unit Ref Number, Sound SA Lookup)
Inlet 7_4 kHz (default)	30	= size_lookup(Lookup Table Name 2, "4000", 0, Lookup Unit Ref Number, Sound SA Lookup)
Inlet 6_2 kHz (default)	37	= size_lookup(Lookup Table Name 2, "2000", 0, Lookup Unit Ref Number, Sound SA Lookup)
Inlet 5_1 kHz (default)	41	= size_lookup(Lookup Table Name 2, "1000", 0, Lookup Unit Ref Number, Sound SA Lookup)
Inlet 4_500 Hz (default)	46	= size_lookup(Lookup Table Name 2, "500", 0, Lookup Unit Ref Number, Sound SA Lookup)
Inlet 3_250 Hz (default)	50	= size_lookup(Lookup Table Name 2, "250", 0, Lookup Unit Ref Number, Sound SA Lookup)
Inlet 2_125 Hz (default)	47	= size_lookup(Lookup Table Name 2, "125", 0, Lookup Unit Ref Number, Sound SA Lookup)
Inlet 1_63 Hz (default)	46	= size_lookup(Lookup Table Name 2, "63", 0, Lookup Unit Ref Number, Sound SA Lookup)

1 2 3 4 5

Outlet 5_1 kHz (default)	40	= size_lookup(Lookup Table Name 1, "1000", 0, Lookup Unit Ref Number, Sound SA Lookup)
Outlet 4_500 Hz (default)	43	= size_lookup(Lookup Table Name 1, "500", 0, Lookup Unit Ref Number, Sound SA Lookup)
Outlet 3_250 Hz (default)	47	= size_lookup(Lookup Table Name 1, "250", 0, Lookup Unit Ref Number, Sound SA Lookup)
Outlet 2_125 Hz (default)	45	= size_lookup(Lookup Table Name 1, "125", 0, Lookup Unit Ref Number, Sound SA Lookup)
Outlet 1_63 Hz (default)	48	= size_lookup(Lookup Table Name 1, "63", 0, Lookup Unit Ref Number, Sound SA Lookup)

	A	B	C	D	E	F	G	H	I	J	K	L	M
1		Ref##OTHI	SA##HVA	PD##HVA	63##OTHE	125##OTH	250##OTH	500##OTH	1000##OTI	2000##OTI	4000##OTI	8000##OTHER##	
2	Unit9-97	9	97	30	45	41	42	38	34	24	17	23	
3	Unit9-142	9	142	30	48	44	45	42	38	29	24	23	
4	Unit9-185	9	185	30	48	45	47	43	40	32	29	23	
5	Unit9-226	9	226	30	51	47	48	45	43	36	34	26	
6	Unit9-263	9	263	30	53	49	50	47	45	39	37	30	
7	Unit9-299	9	299	30	55	52	52	48	48	41	41	35	

1 Lookup Table Name

FCU Discharge Sound Data

Inlet 3_250 Hz (default)	50	= size_lookup(Lookup Table Name 2, "250", 0, Lookup Unit Ref Number, Sound SA Lookup)
Inlet 2_125 Hz (default)	47	= size_lookup(Lookup Table Name 2, "125", 0, Lookup Unit Ref Number, Sound SA Lookup)
Inlet 1_63 Hz (default)	46	= size_lookup(Lookup Table Name 2, "63", 0, Lookup Unit Ref Number, Sound SA Lookup)

1 2 3 4 5

Outlet 5_1 kHz (default)	40	= size_lookup(Lookup Table Name 1, "1000", 0, Lookup Unit Ref Number, Sound SA Lookup)
Outlet 4_500 Hz (default)	43	= size_lookup(Lookup Table Name 1, "500", 0, Lookup Unit Ref Number, Sound SA Lookup)
Outlet 3_250 Hz (default)	47	= size_lookup(Lookup Table Name 1, "250", 0, Lookup Unit Ref Number, Sound SA Lookup)
Outlet 2_125 Hz (default)	45	= size_lookup(Lookup Table Name 1, "125", 0, Lookup Unit Ref Number, Sound SA Lookup)
Outlet 1_63 Hz (default)	48	= size_lookup(Lookup Table Name 1, "63", 0, Lookup Unit Ref Number, Sound SA Lookup)

	A	B	C	D	E	F	G	H	I	J	K	L	M
1		Ref##OTHI	SA##HVAI	PD##HVAI	63##OTHE	125##OTH	250##OTH	500##OTH	1000##OTI	2000##OTI	4000##OTI	8000##OTHER##	
2	Unit9-97	9	97	30	45	41	42	38	34	24	17	23	
3	Unit9-142	9	142	30	48	44	45	42	38	29	24	23	
4	Unit9-185	9	185	30	48	45	47	43	40	32	29	23	
5	Unit9-226	9	226	30	51	47	48	45	43	36	34	26	
6	Unit9-263	9	263	30	53	49	50	47	45	39	37	30	
7	Unit9-299	9	299	30	55	52	52	48	48	41	41	35	
8	Unit9-336	9	336	30	56	54	54	50	50	44	44	38	
9	Unit9-370	9	370	30	58	56	56	51	52	46	46	41	
10	Unit9-404	9	404	30	64	58	57	53	54	48	48	43	
11	Unit12-120	12	120	30	44	41	40	39	35	25	18	23	
12	Unit12-163	12	163	30	45	45	43	42	38	29	23	23	
13	Unit12-206	12	206	30	47	46	44	43	41	33	29	23	
14	Unit12-250	12	250	30	50	48	46	45	44	36	34	27	
15	Unit12-289	12	289	30	53	51	49	47	47	40	38	32	
16	Unit12-326	12	326	30	55	53	51	49	49	42	41	36	
17	Unit12-366	12	366	30	56	55	53	51	52	45	44	40	
18	Unit12-402	12	402	30	58	57	55	53	54	47	46	43	
19	Unit12-445	12	445	30	61	59	56	55	56	49	48	45	
20	Unit13-124	13	124	30	44	43	41	40	35	25	17	23	
21	Unit13-177	13	177	30	47	46	44	44	39	31	25	23	
22	Unit13-227	13	227	30	49	48	46	45	42	35	31	24	
23	Unit13-272	13	272	30	52	51	49	48	45	39	36	30	
24	Unit13-316	13	316	30	54	53	52	50	49	42	41	36	
25	Unit13-355	13	355	30	55	56	54	53	52	45	44	40	
26	Unit13-397	13	397	30	57	58	55	54	54	47	46	43	
27	Unit13-440	13	440	30	58	60	57	56	57	50	49	46	
28	Unit13-478	13	478	30	60	62	60	58	58	52	51	49	

1 Lookup Table Name

FCU Discharge Sound Data

2 Output Column

e.g. 63 Hz Sound Data

3 Default Value

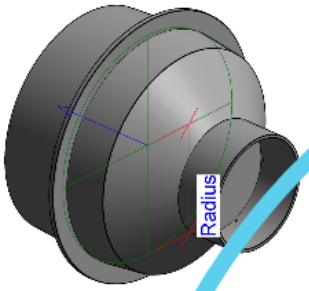
In this case zero

4 Lookup Row 1

FCU Unit Size

5 Lookup Row 2

FCU Unit Airflow



	A	B	C	D	E	F	G	H	I
1		ND##length	SA##HVAC	PD##HVAC	NC##OTHE	T1##length##millimeters	T2##length	T3##length##millimeters	
2	250-57	250	57	10	0	2800	5800	11300	
3	250-81	250	81	20	0	4000	8000	13500	
4	250-100	250	100	30	0	4900	10100	15000	
5	250-118	250	118	43	0	5800	11600	16500	
6	250-137	250	13	58	0	6800	12500	17700	
7	250-156	250	56	75	21	8000	13500	18900	
8	250-194	250	194	115	27	9800	15000	21100	
9	250-236	250	236	172	32	11600	16500	23200	
10	250-274	250	274	232	36	12500	17700	25000	
11	250-312	250	312	299	39	13500	18900	26600	

Family Types

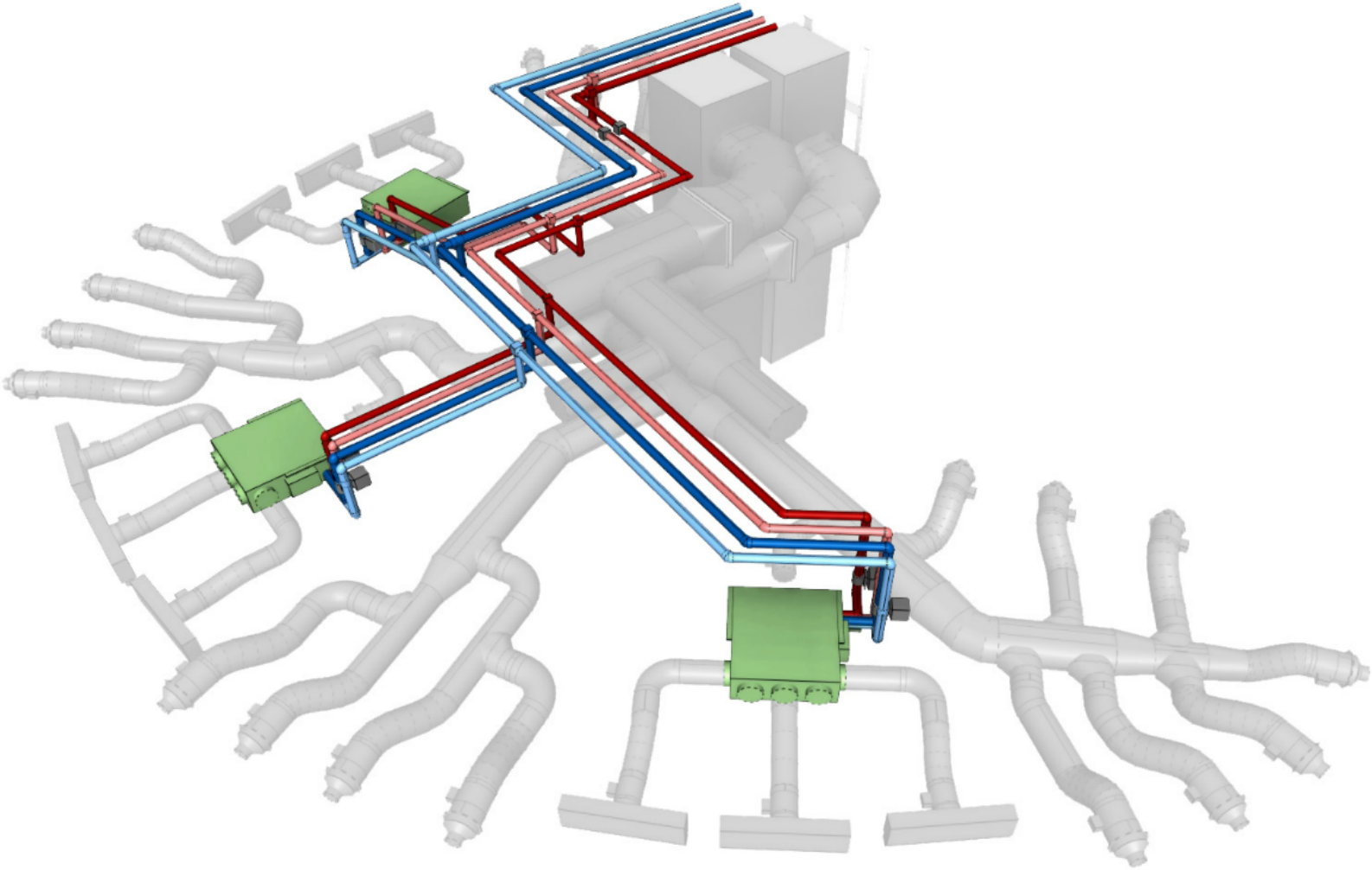
Name: 250mm Connection

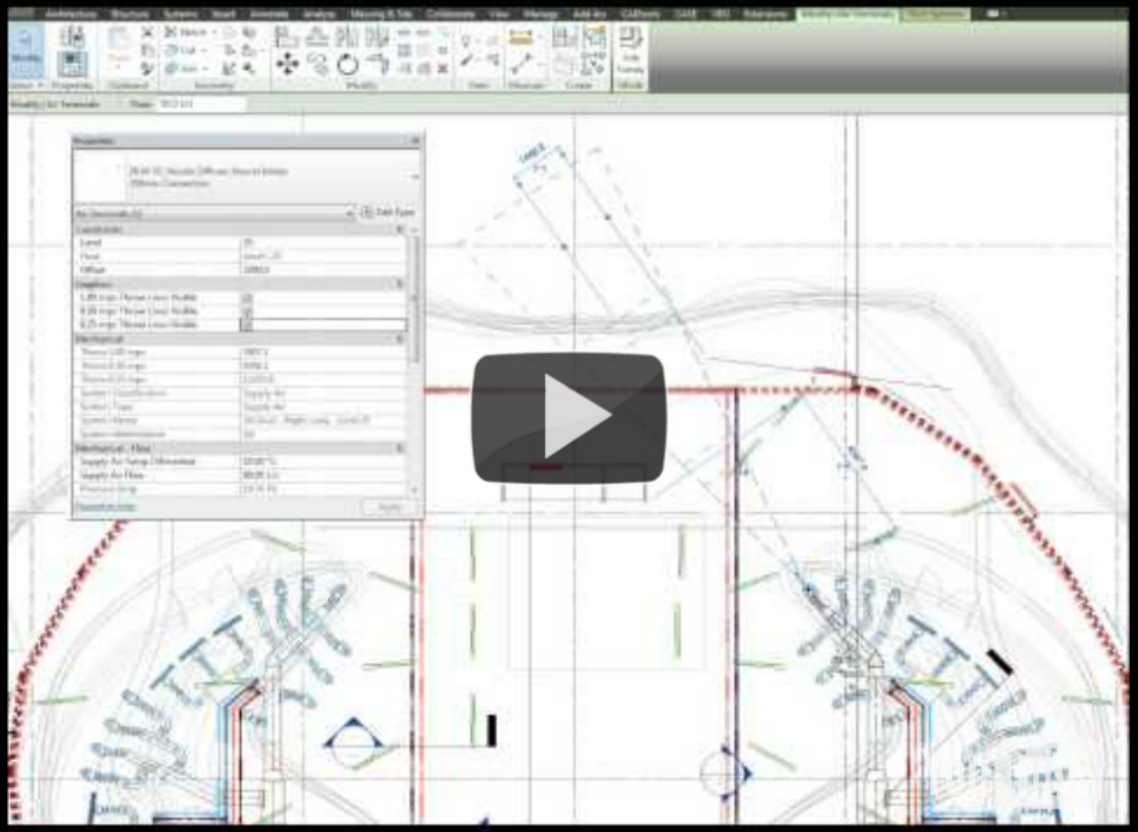
Parameter	Value	Formula
Graphics		
1.00 mps Throw Lines Visible	☑	=
0.50 mps Throw Lines Visible	☑	=
0.25 mps Throw Lines Visible	☑	=
Text		
Lookup Table Name	SG_Nozzle Diffuser_Ti	=
Mechanical		
Throw 1.00 mps (default)	4000.0	= if(not(size_lookup(Lookup Table Name, "T1", (T1 Factor 1 * (log(Supply Air Flow / 1 L/s) / log(2.71828)) + T1 Factor 2) * 1 mm, Duct Diameter, Supply
Throw 0.50 mps (default)	8000.0	(not(size_lookup(Lookup Table Name, "T2", (T2 Factor 1 * (log(Supply Air Flow / 1 L/s) / log(2.71828)) + T2 Factor 2) * 1 mm, Duct Diameter, Supply
Throw 0.25 mps (default)	13000.0	= if(not(size_lookup(Lookup Table Name, "T3", (T3 Factor 1 * (log(Supply Air Flow / 1 L/s) / log(2.71828)) + T3 Factor 2) * 2 mm, Duct Diameter, Supply
Supply Air Flow (default)	81.00 L/s	=
Pressure Drop (default)	20.00 Pa	= size_lookup(Lookup Table Name, "PD", ((PD Factor 1 * Supply Air Flow ^ 2) / (1 L/s) + PD Factor 2 * Supply Air Flow) / (1 L/s) * (1 Pa), Duct Diameter, S
Nominal NR Noise Level (default)	0	= if(size_lookup(Lookup Table Name, "NC", (NC Factor 1 * (log(Supply Air Flow / 1 L/s) / log(2.71828)) + NC Factor 2), Duct Diameter, Supply Air Flow) <

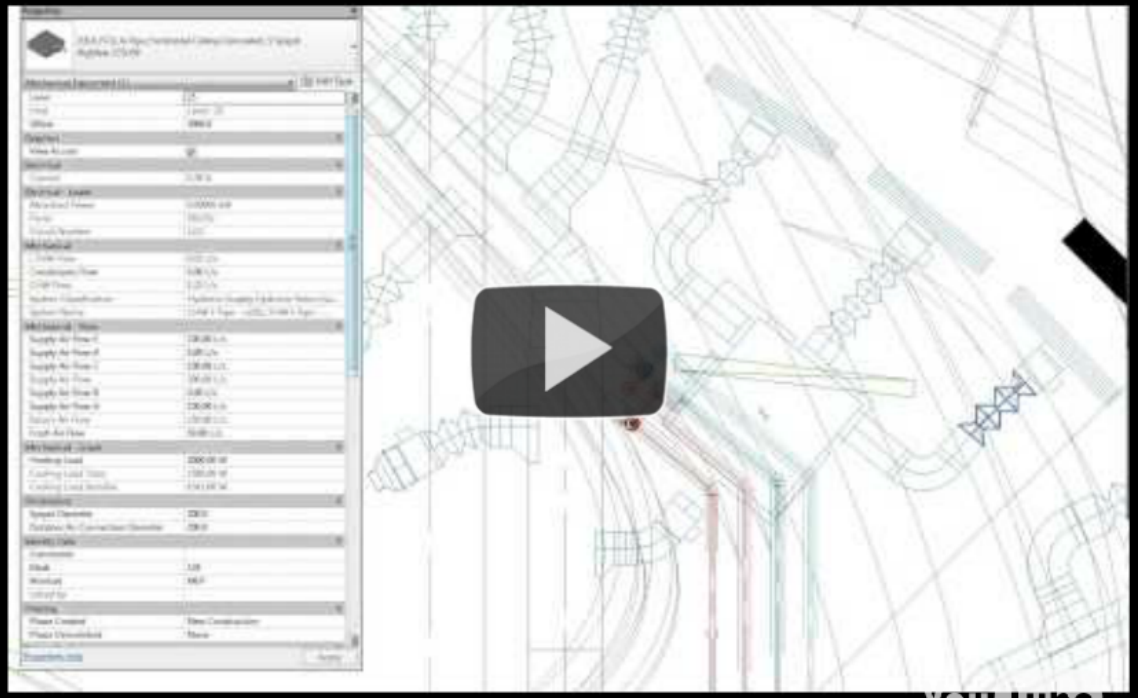
F	G	H	I
T1##length##millimeters	T2##length	T3##length##millimeters	
2800	5800	11300	
4000	8000	13500	
4900	10100	15000	
5800	11600	16500	
6800	12500	17700	
8000	13500	18900	
9800	15000	21100	
11600	16500	23200	
12500	17700	25000	
13500	18900	26600	

/ 1 L/s) / log(2.71828)) + T1 Factor 2) * 1 mm, Duct Diameter, Supply
/ 1 L/s) / log(2.71828)) + T2 Factor 2) * 1 mm, Duct Diameter, Supply
/ 1 L/s) / log(2.71828)) + T3 Factor 2) * 2 mm, Duct Diameter, Supply
L/s) + PD Factor 2 * Supply Air Flow) / (1 L/s) * (1 Pa), Duct Diameter, S
1 L/s) / log(2.71828)) + NC Factor 2), Duct Diameter, Supply Air Flow) <

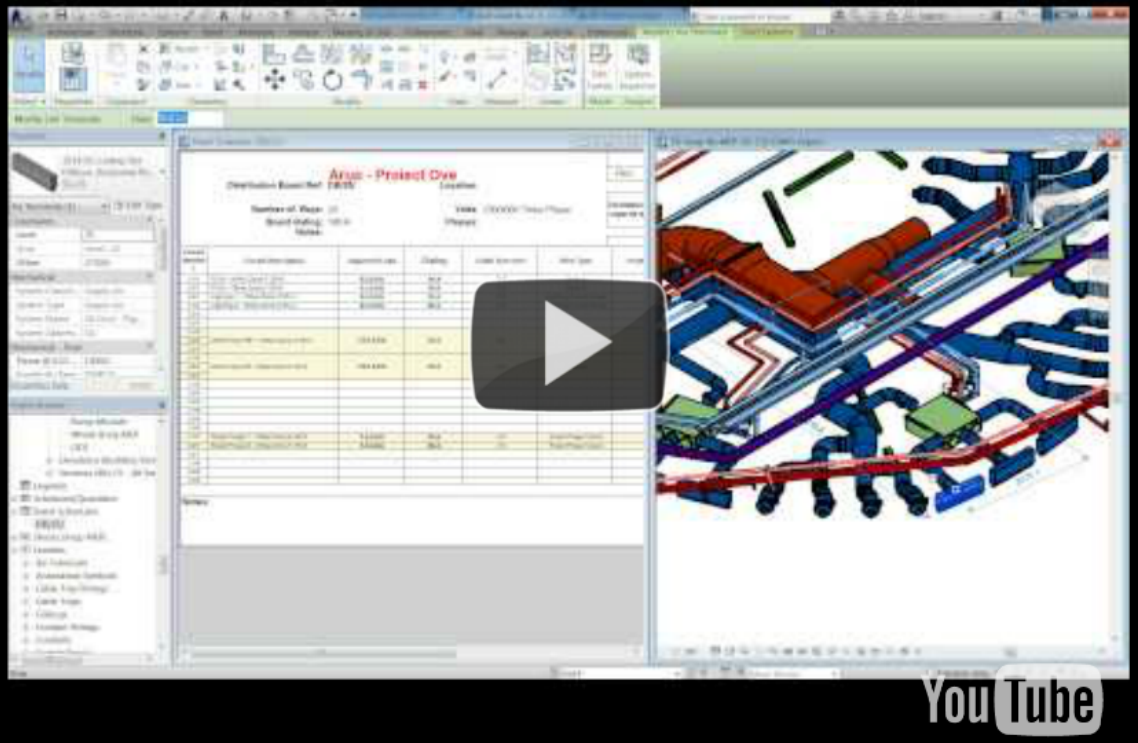
Note: Lookups are unit aware








YouTube


Argo - Project Dve
YouTube

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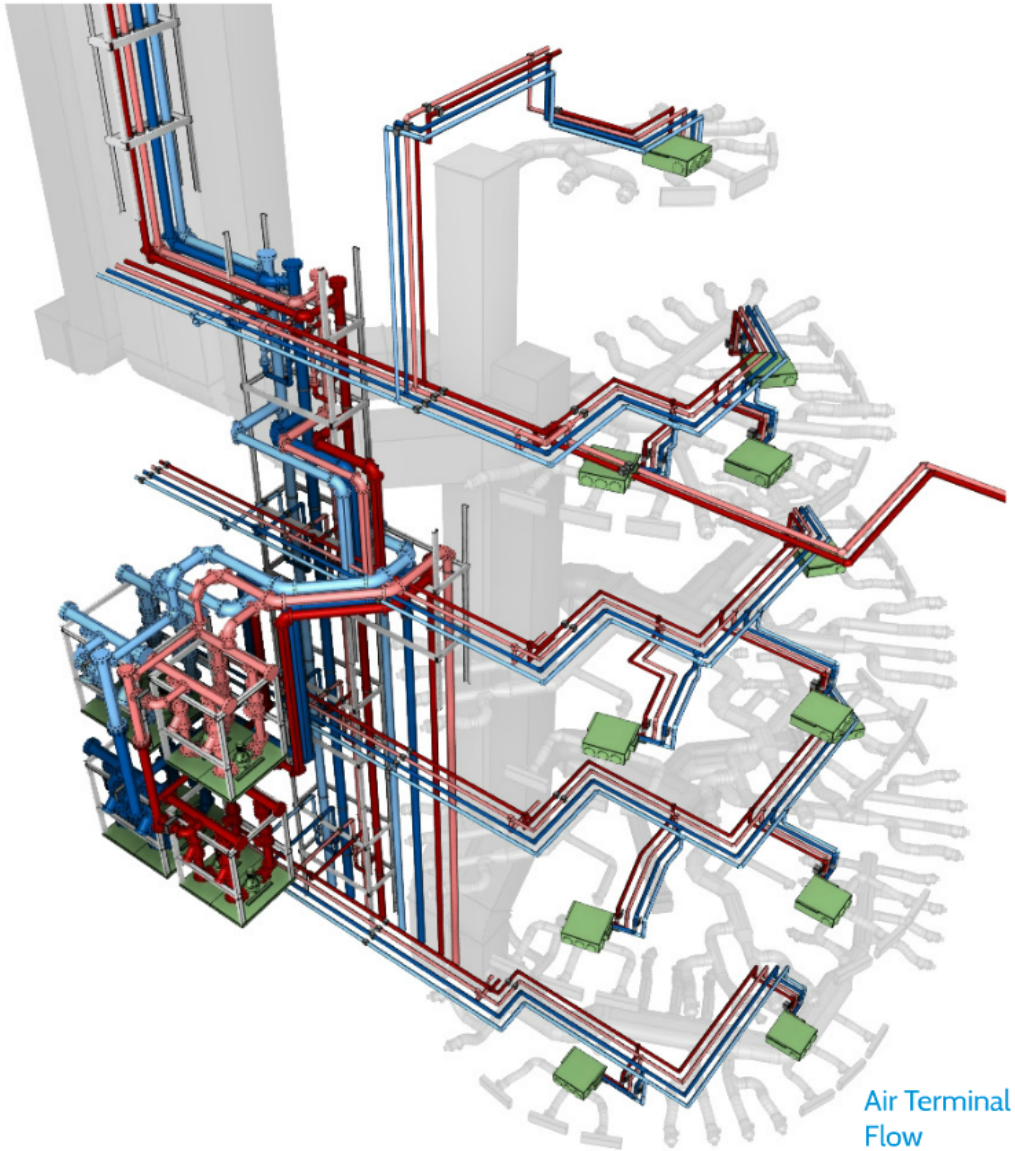
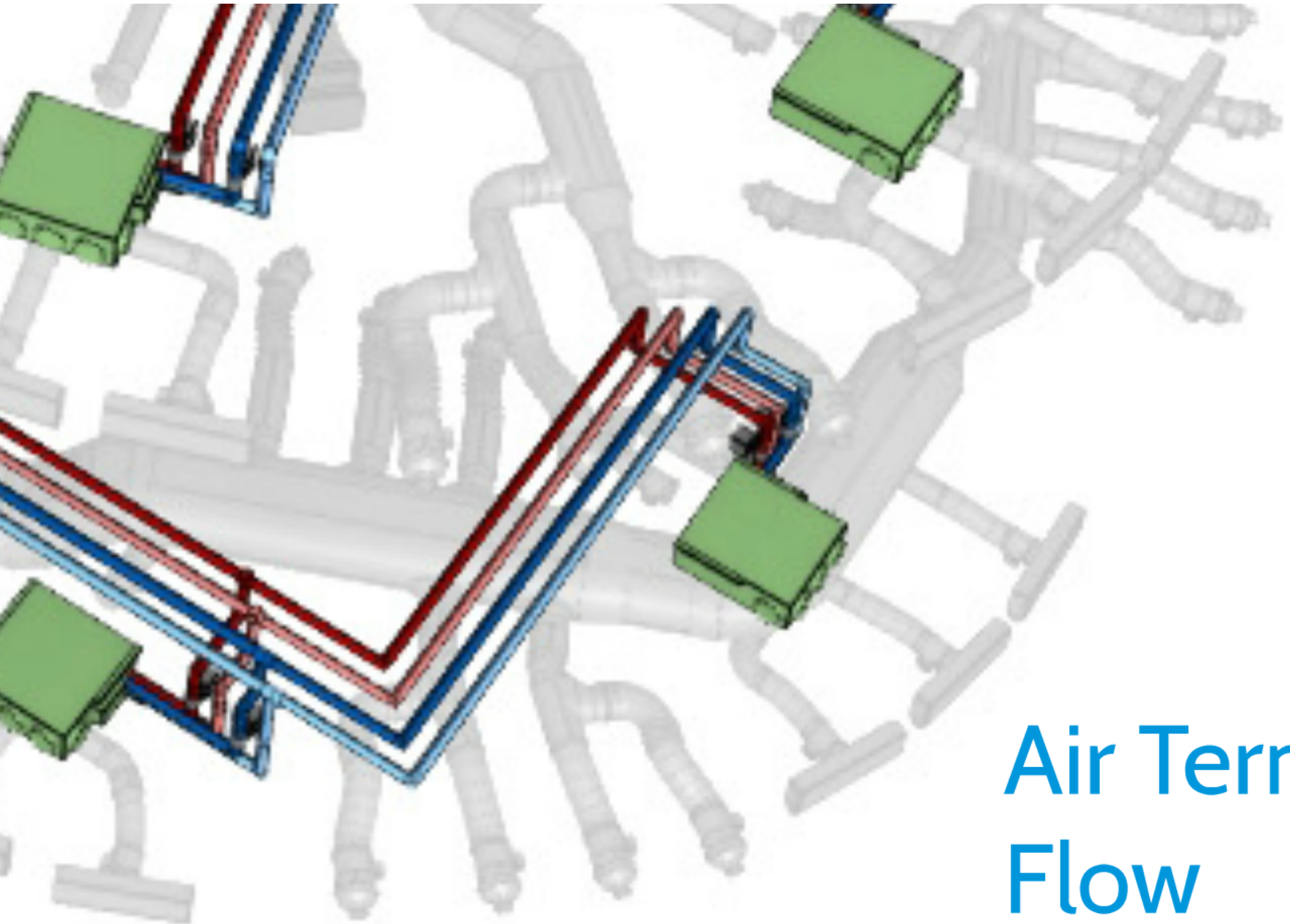

Air Terminal
Flow
Fan Coil
Unit
Duct



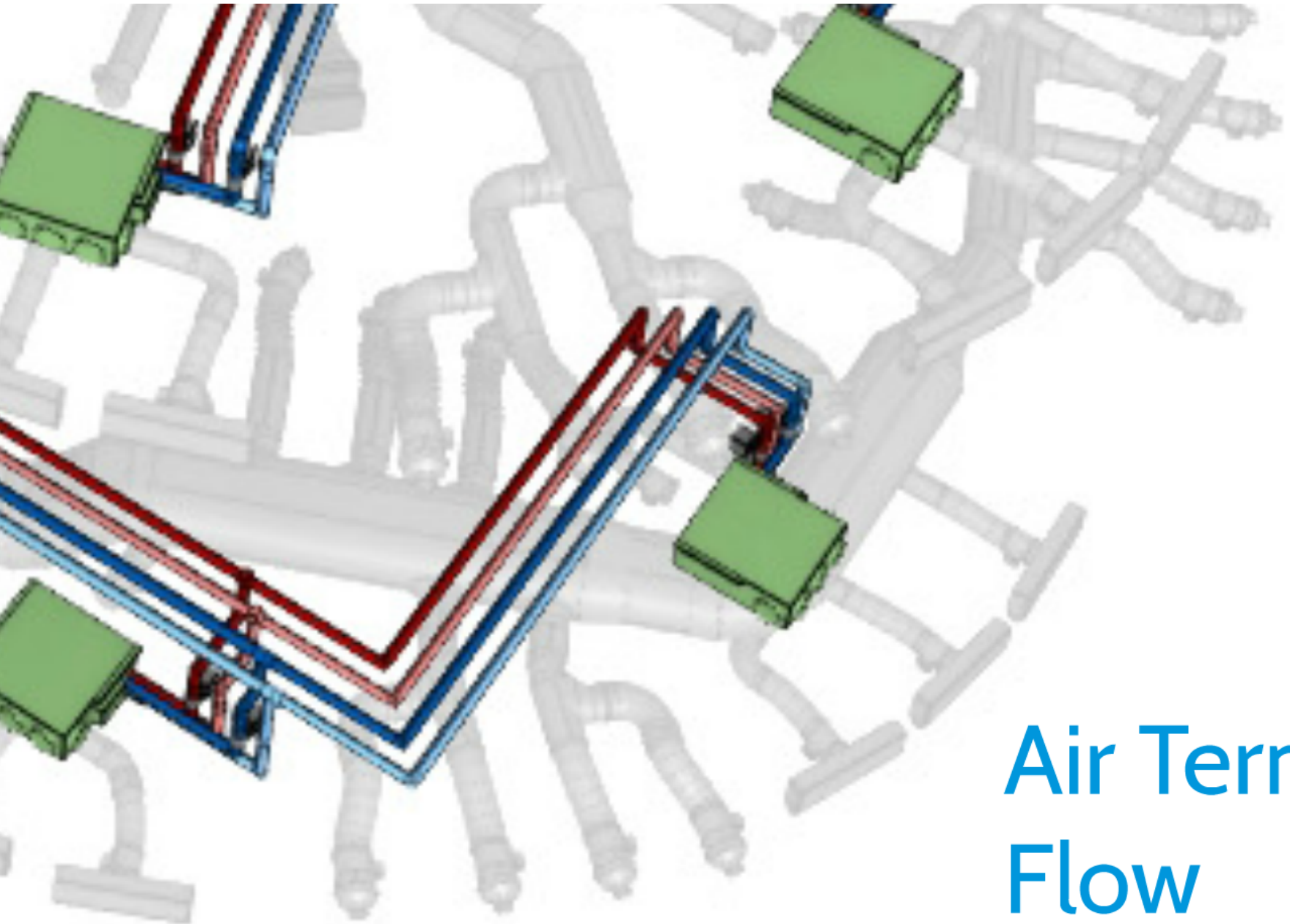
Air Terminal Flow

Air Terminal Flow

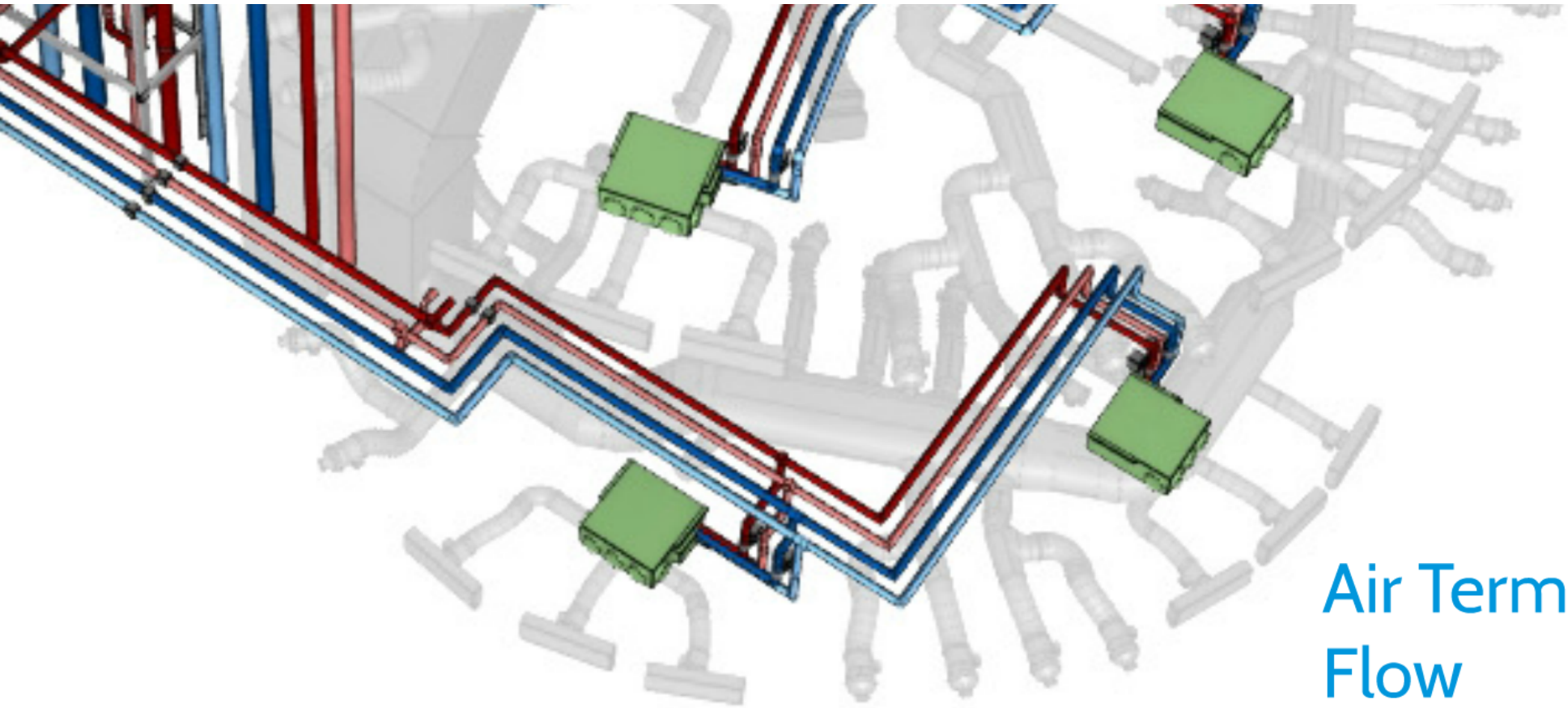
Throw

Pressure Drop

Noise



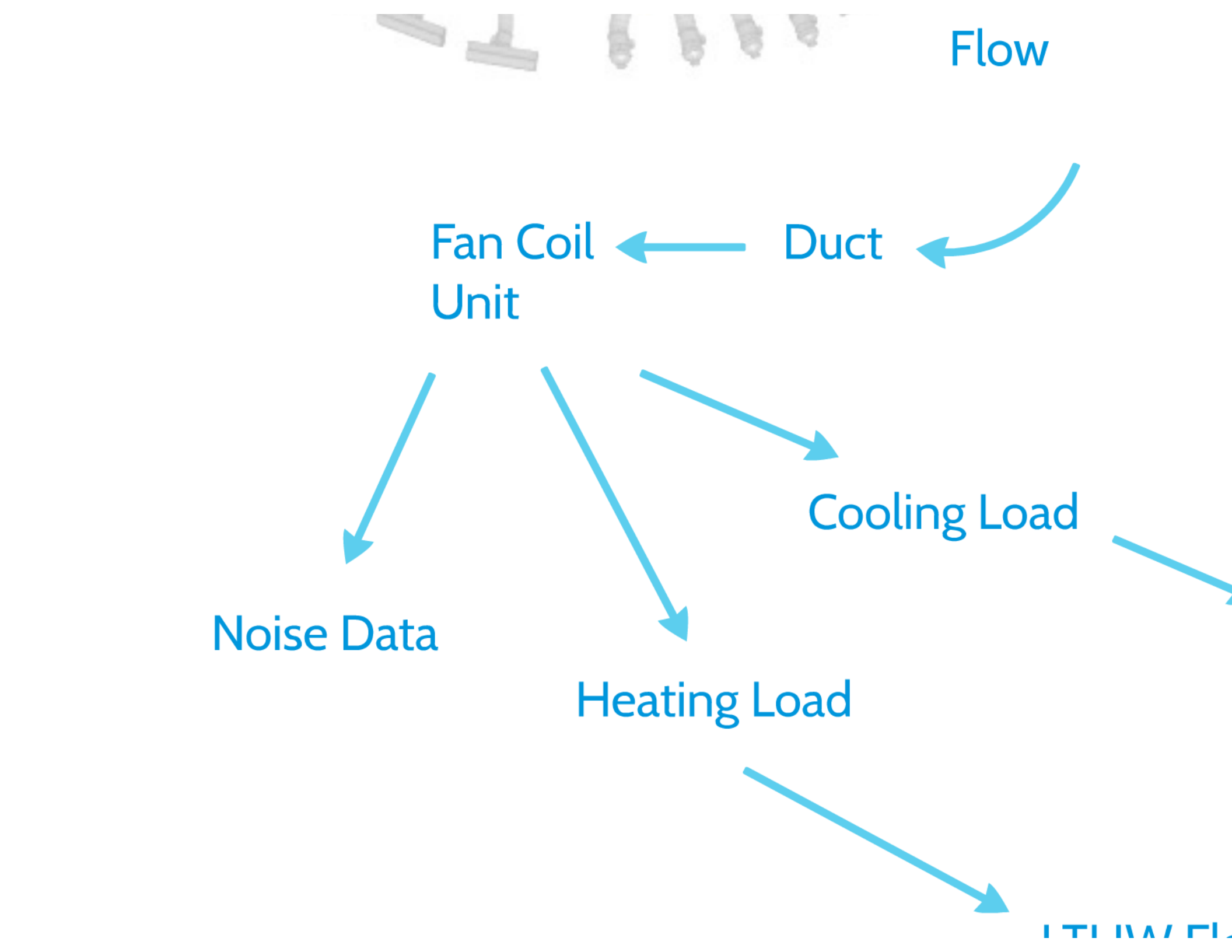
Air Terminal Flow

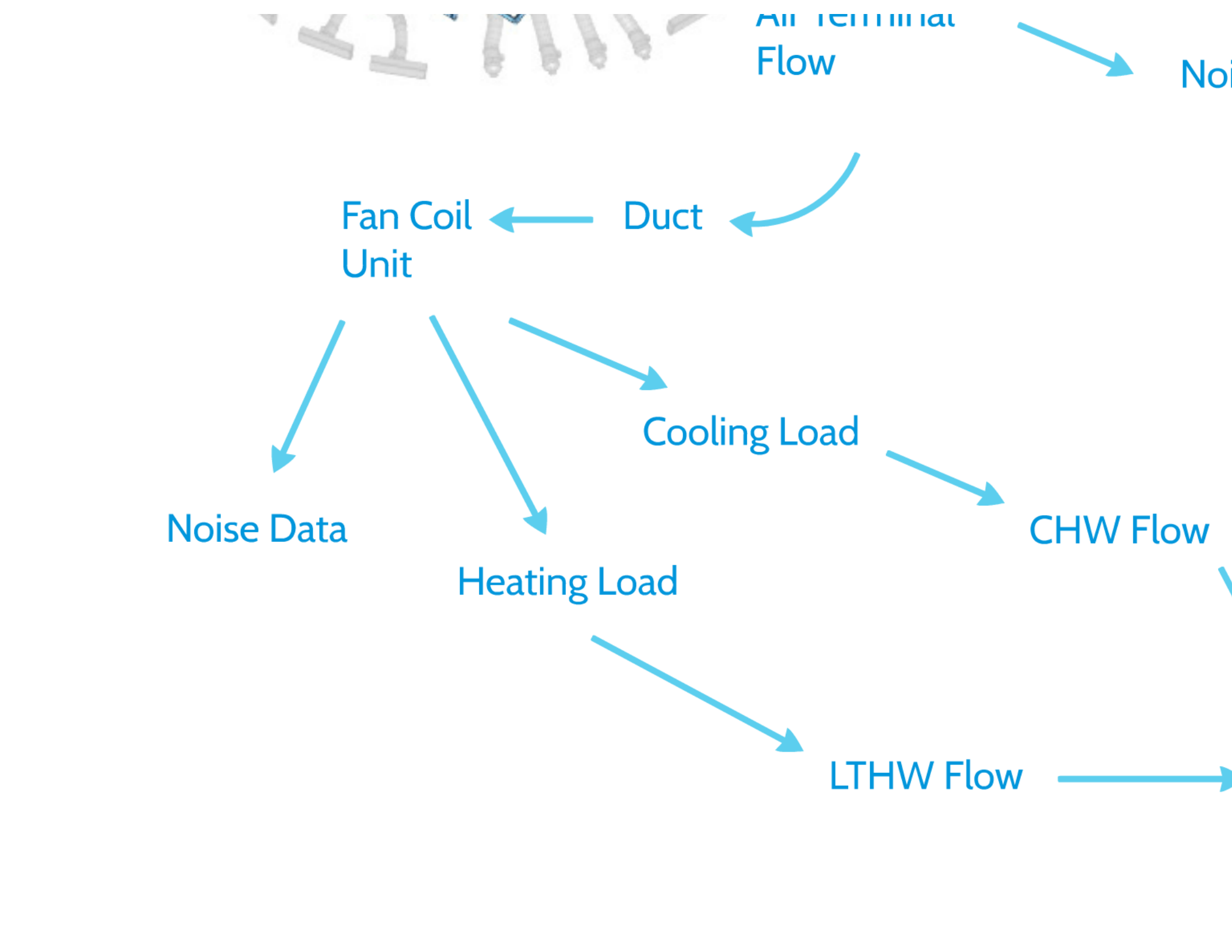


Air Terminal
Flow

Duct

Fan Coil
Unit


Flow
Duct
Fan Coil Unit
Noise Data
Cooling Load
Heating Load


Flow
Fan Coil Unit
Duct
Cooling Load
Noise Data
Heating Load
CHW Flow
LTHW Flow

Air Terminal Flow

Drop

Noise

Duct

Fan Coil Unit

Noise Data

Heating Load

Cooling Load

CHW Flow

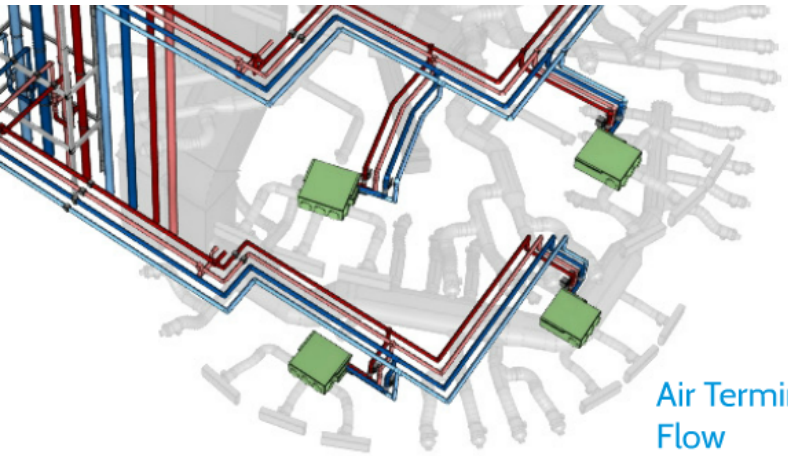
LTHW Flow

Pipes

Chillers

Boilers

Pumps



Air Terminal Flow

Throw

Pressure Drop

Noise

Duct

Fan Coil Unit

Noise Data

Heating Load

Cooling Load

CHW Flow

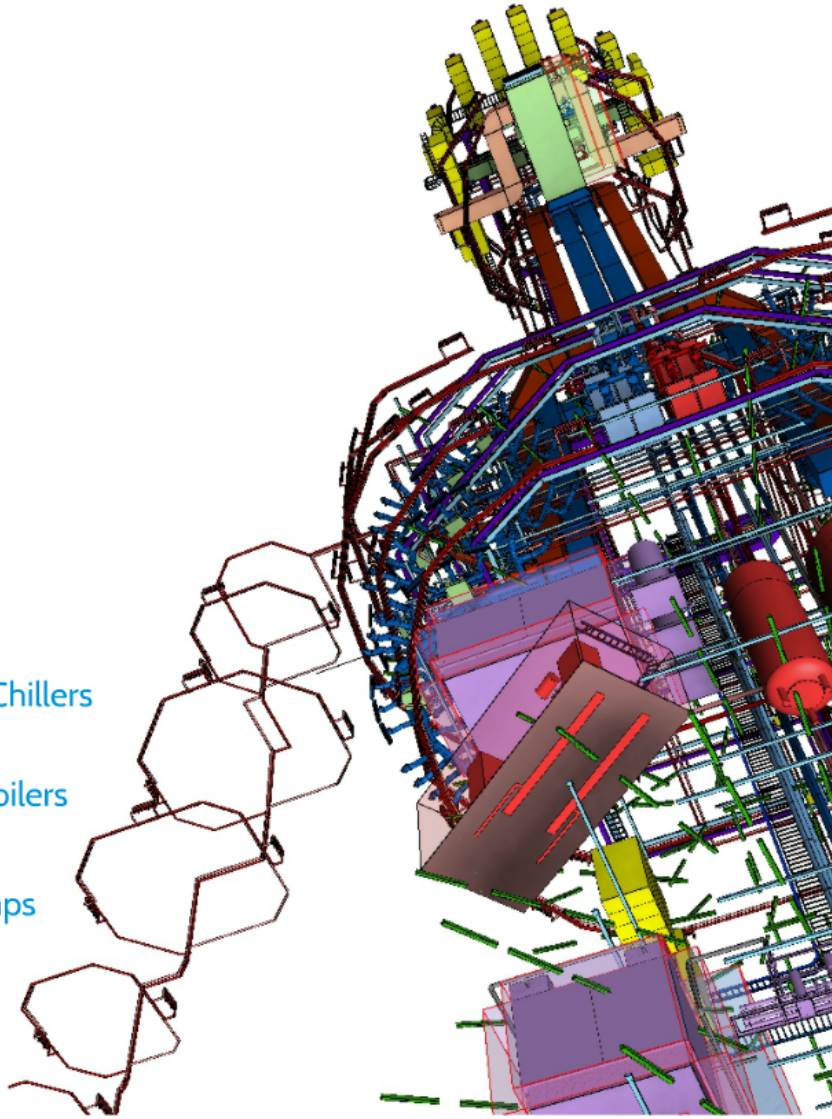
LTHW Flow

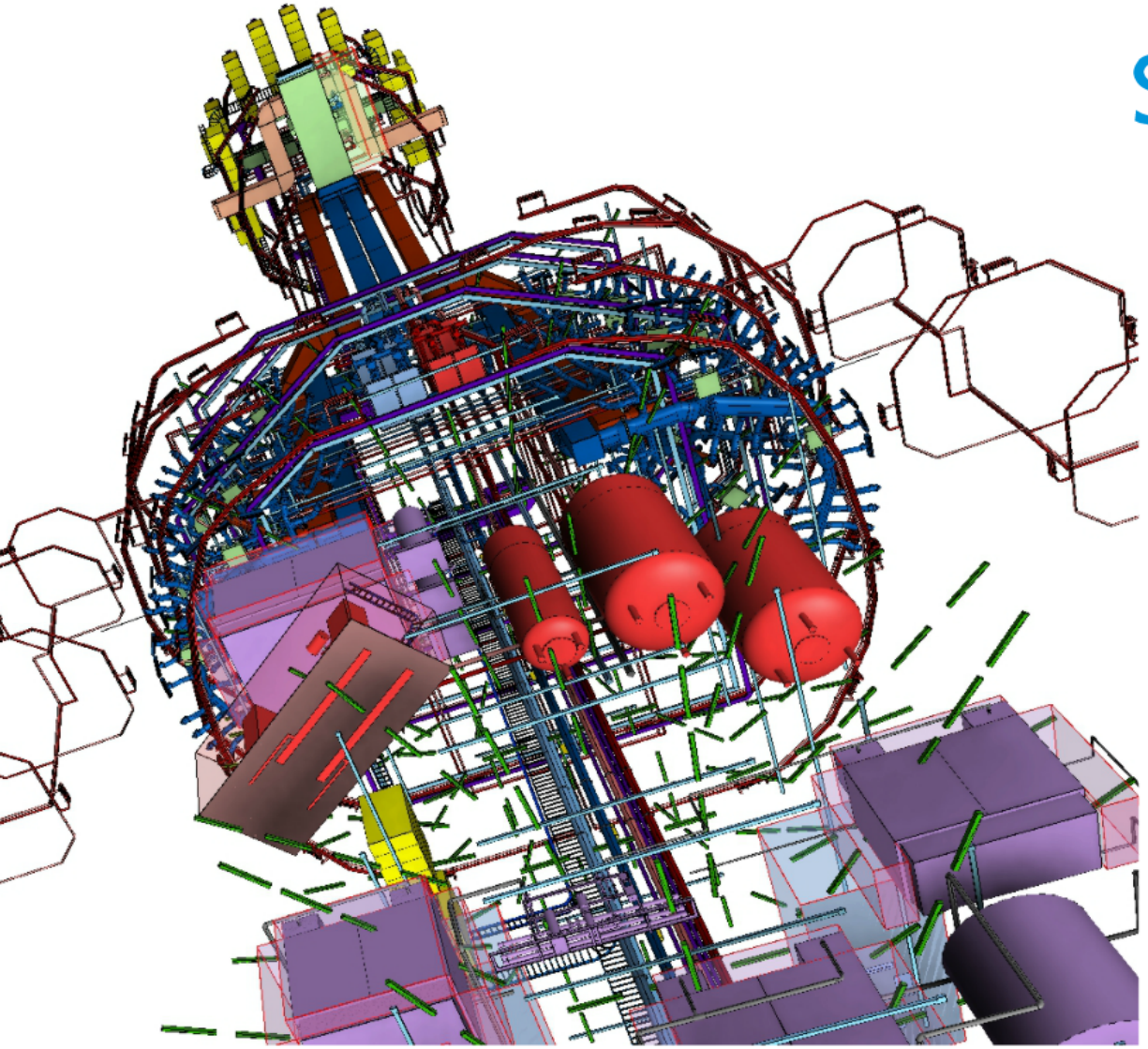
Pipes

Chillers

Boilers

Pumps



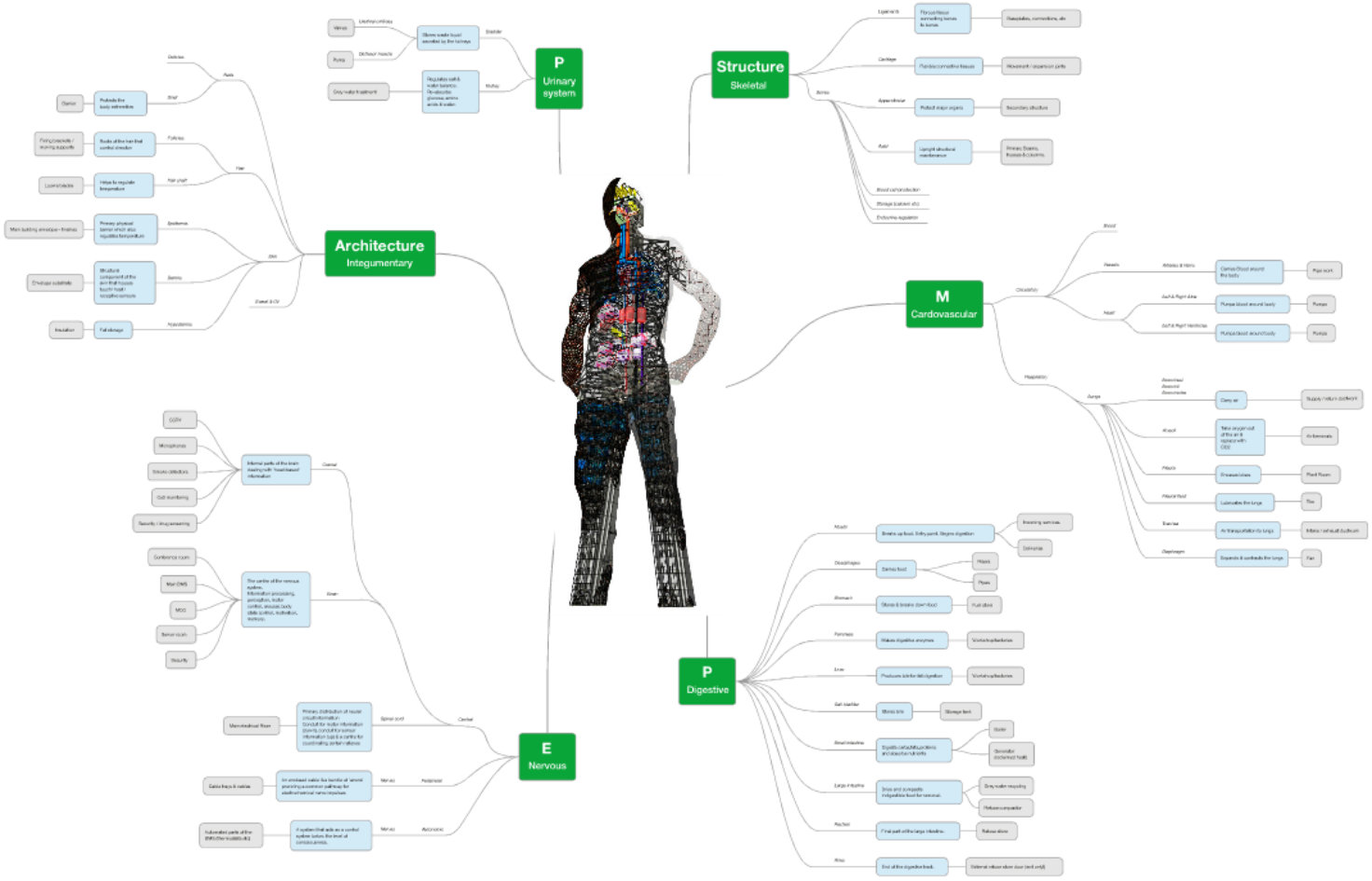


Services Summary

Single Input (Air Terminal)
Drives all other parameters in system

- Increase Automation
- Maximize Efficiency

So Where Next?



Credits

ARUP

Andrew Duncan
Casey Rutland
Dominic Coyle
George Scott
Jonathan Lock
Judith Schulz
Ken Enright
Leonora Lang
Mike Slessor
Nina Tabink
Peter Brickell
Simon Davies
So Hyun
Thomas Taggart
Tom Mossop
Tony Pullen
Thomas Clewlow

External Collaborators

soluis — Derek Rae

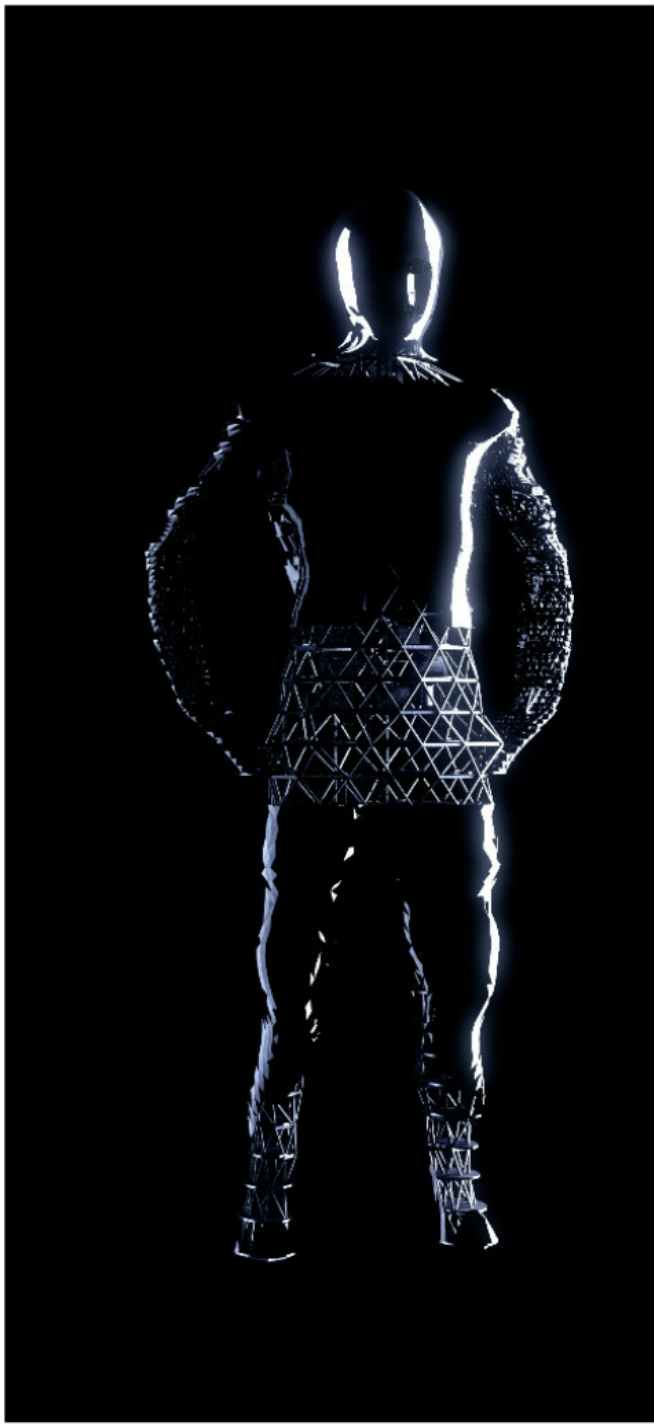
UNDERGROUND — Matt McCarter

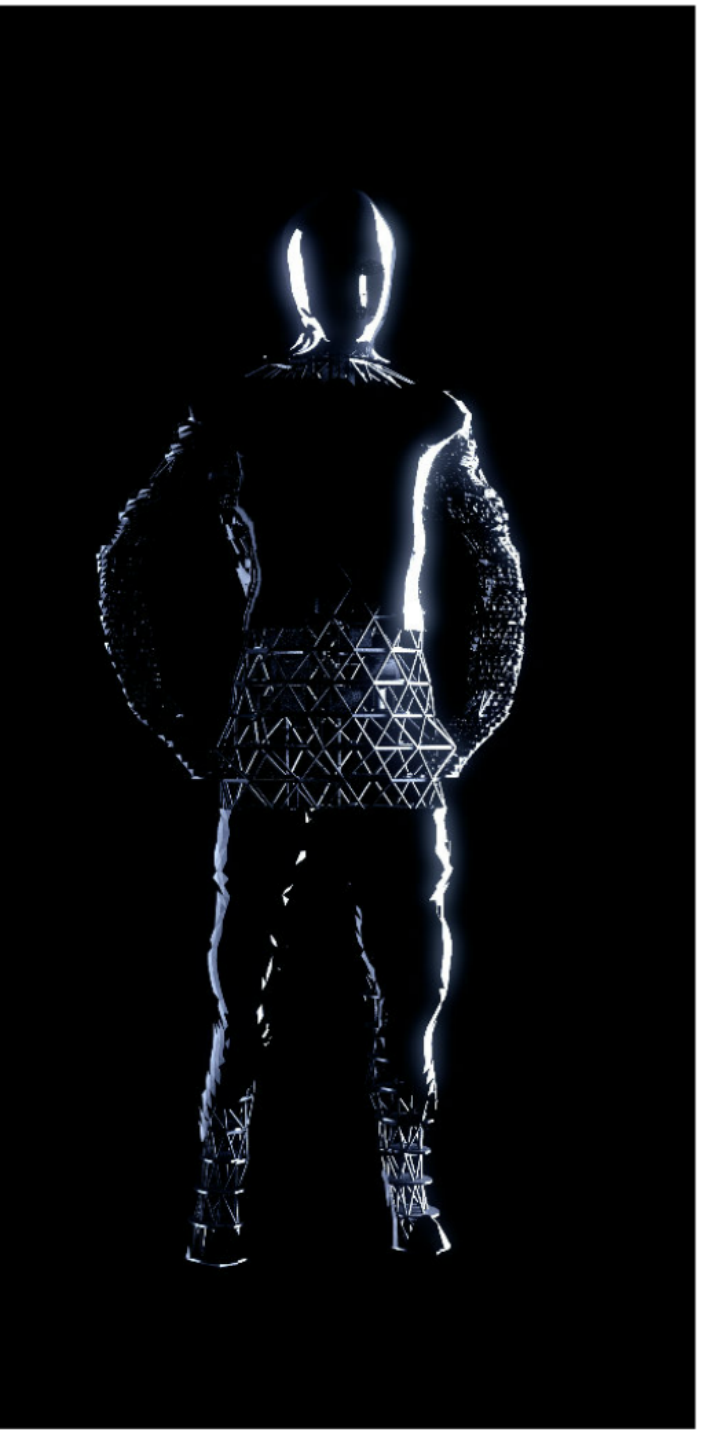
FARO — David Southam

TEKLA — Andrew Bellerby

Thank You

AUTODESK.





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ARUP