The Future of Change

Laser Scanning and Building Information Modeling for the Renovation of Labs (From a Mechanical Perspective)

Hemisphere Engineering Inc.

Trevor M. Uitvlugt P.Eng

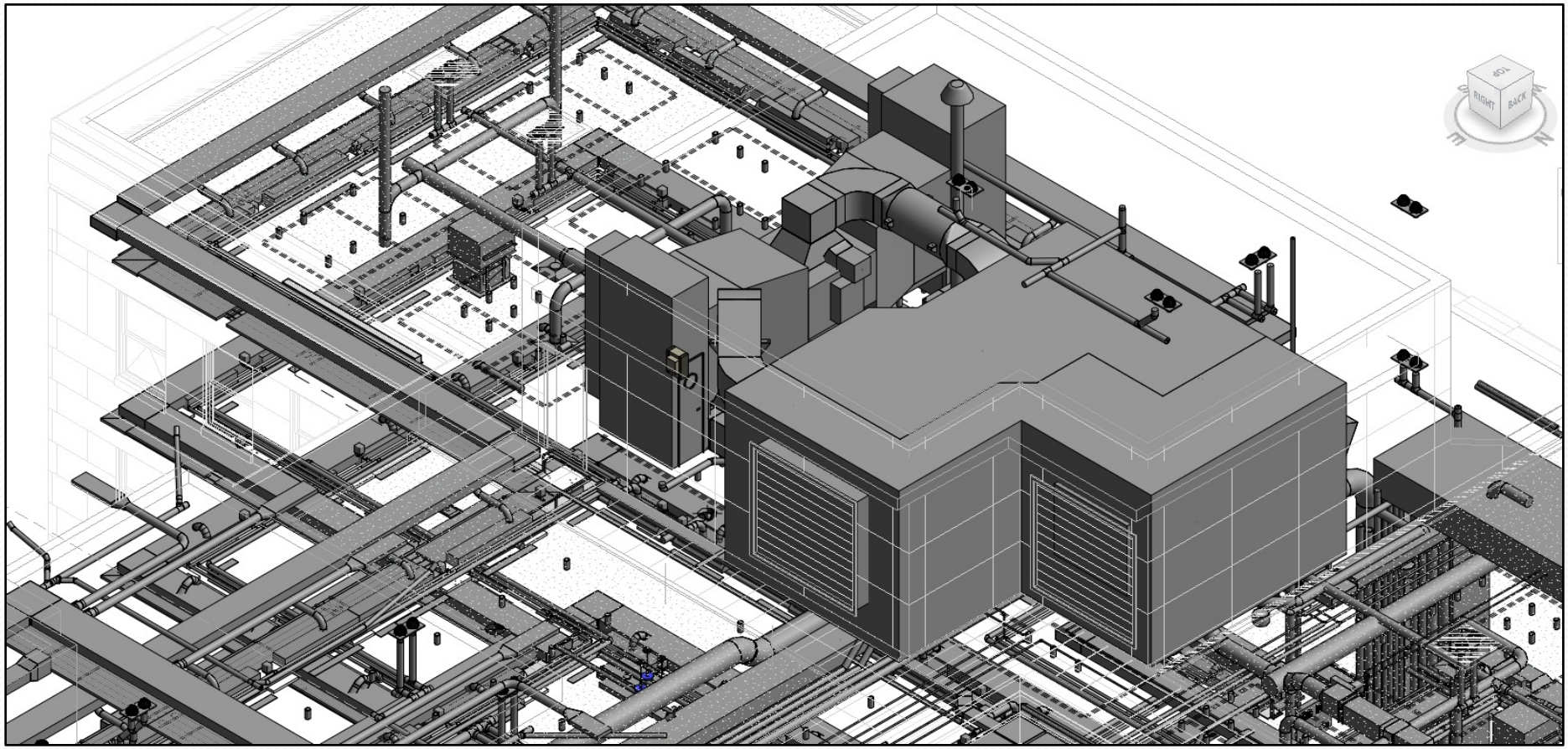
Who Am I?

- Mechanical Engineer
- Designed Several Labs
  - Edmonton
  - Winnipeg
- CAD / BIM Manager
  - Introduce and Champion new technology
  - Passionate about Building Information Modeling.

Outline:

- What is BIM?
  - Uses
  - Strengths/Weaknesses
  - Pros / Cons
- 3d Laser Scanning
- Example Project

Building Information Modeling



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What is BIM?

BIM is:

- “the creation and use of coordinated, internally consistent, computable information about a project in design and construction”

What is BIM?

BIM is:

- “a digital representation of physical and functional characteristics of a facility.”

An Industry in Transition…

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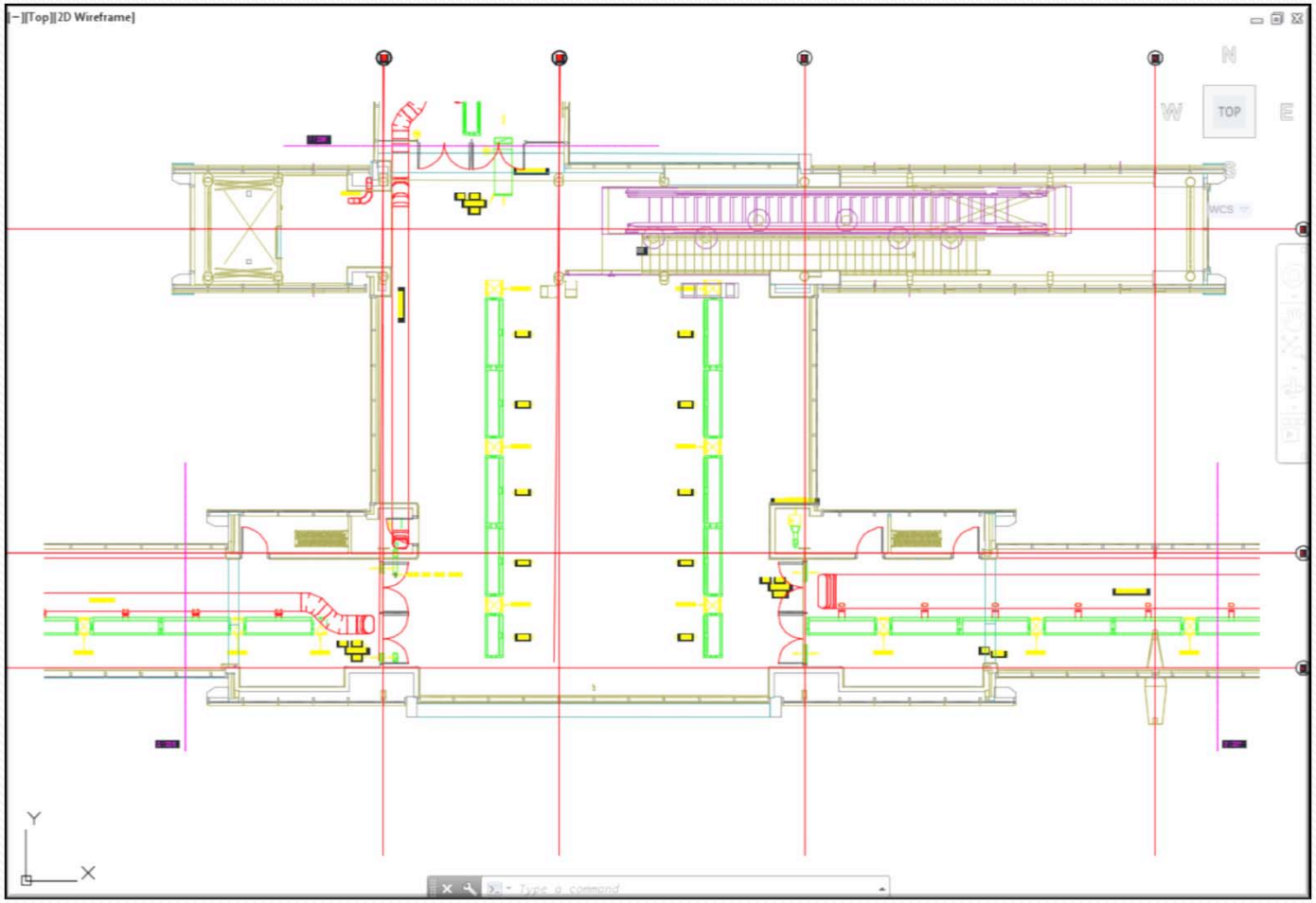
“New” Traditional Documents…



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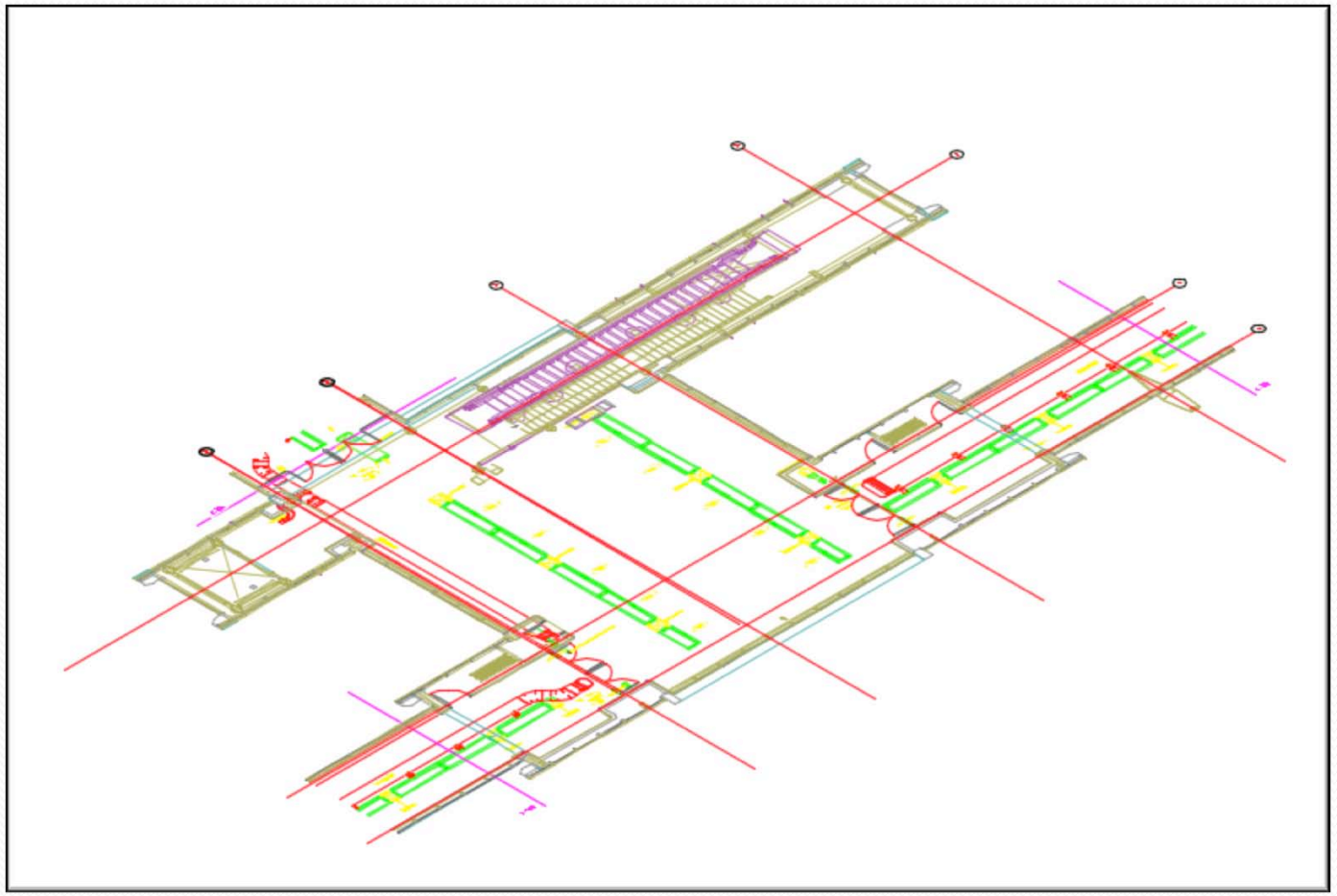
“New” Traditional Documents



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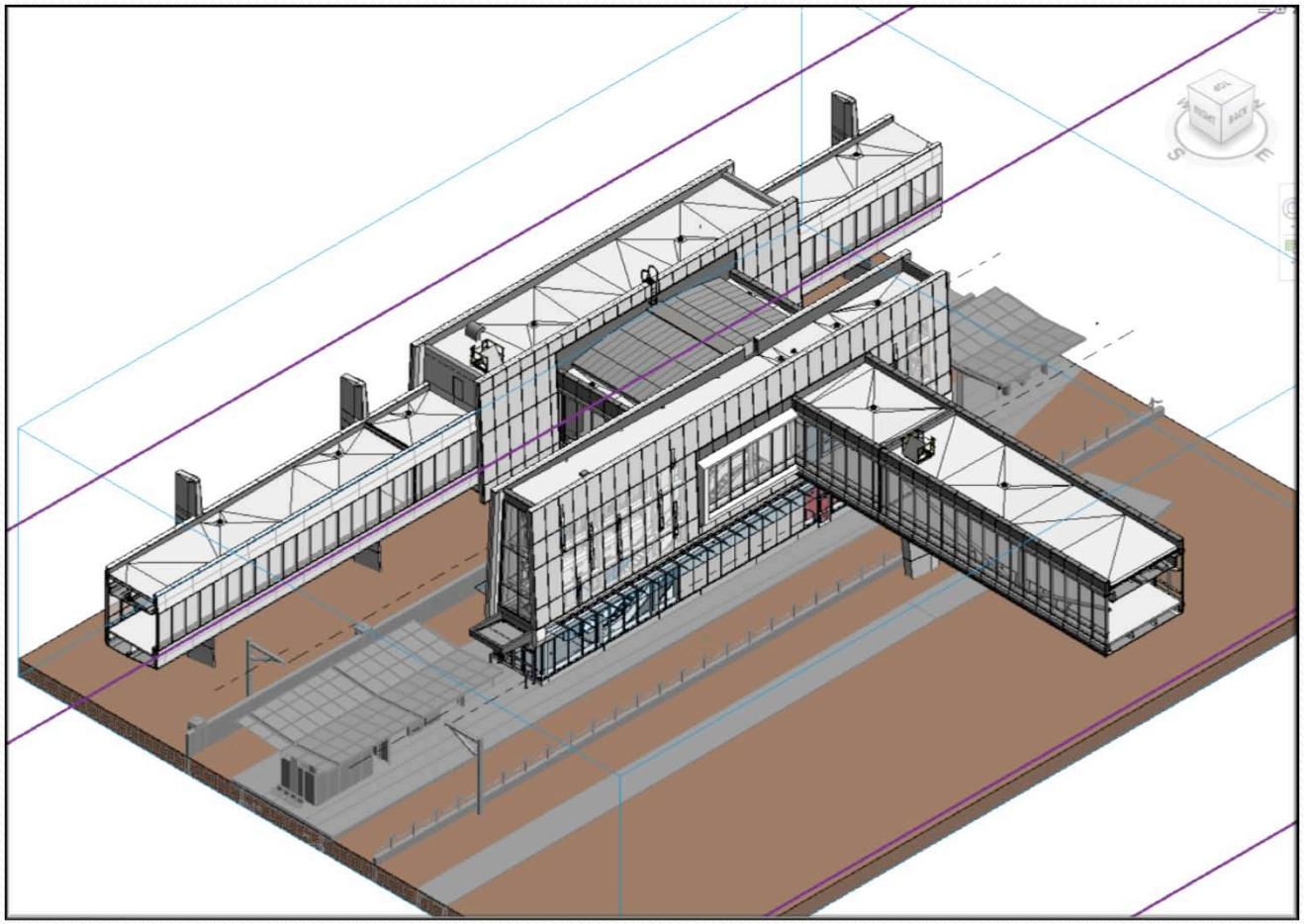
3d Modeling and BIM



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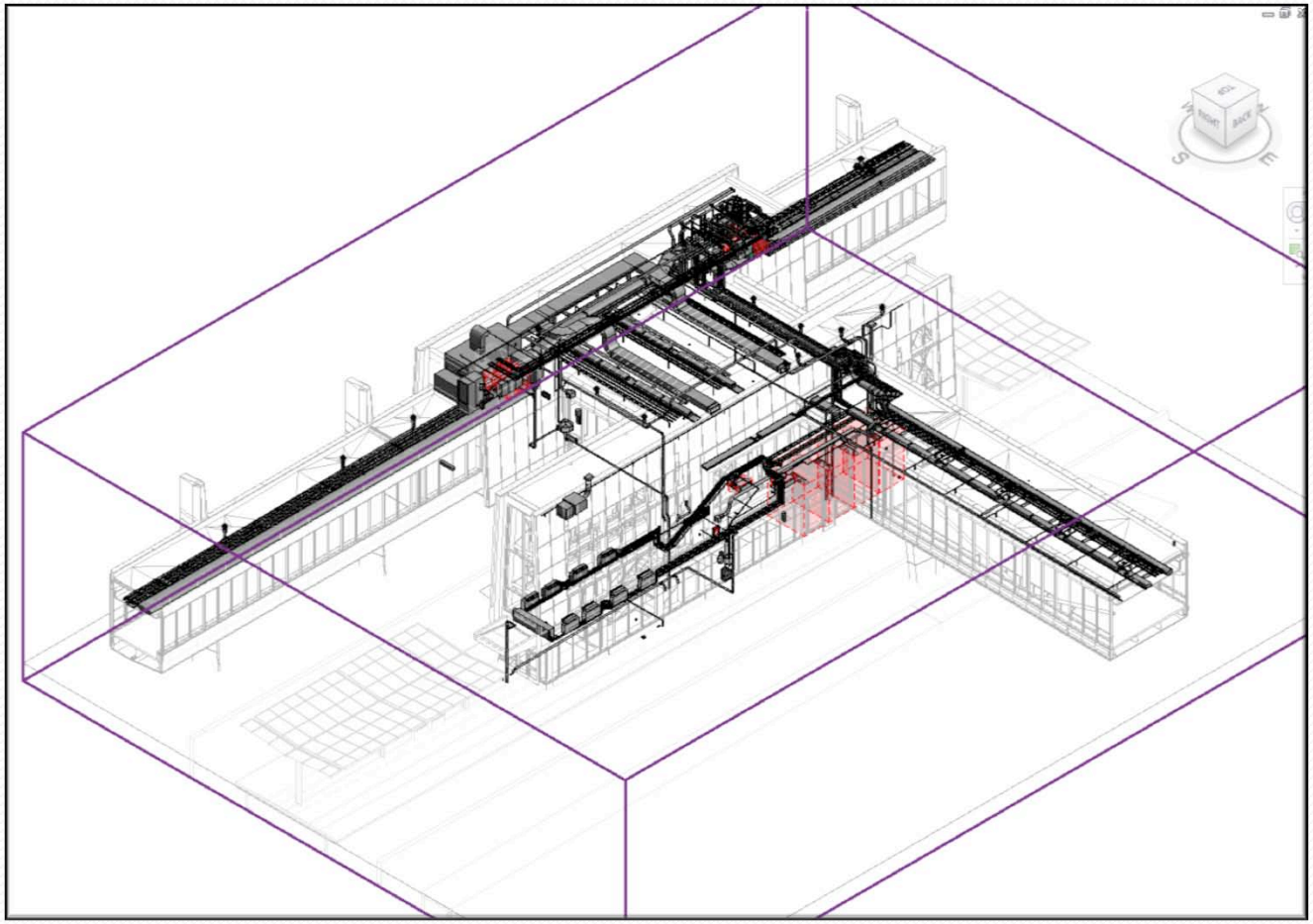
New Possibilities….



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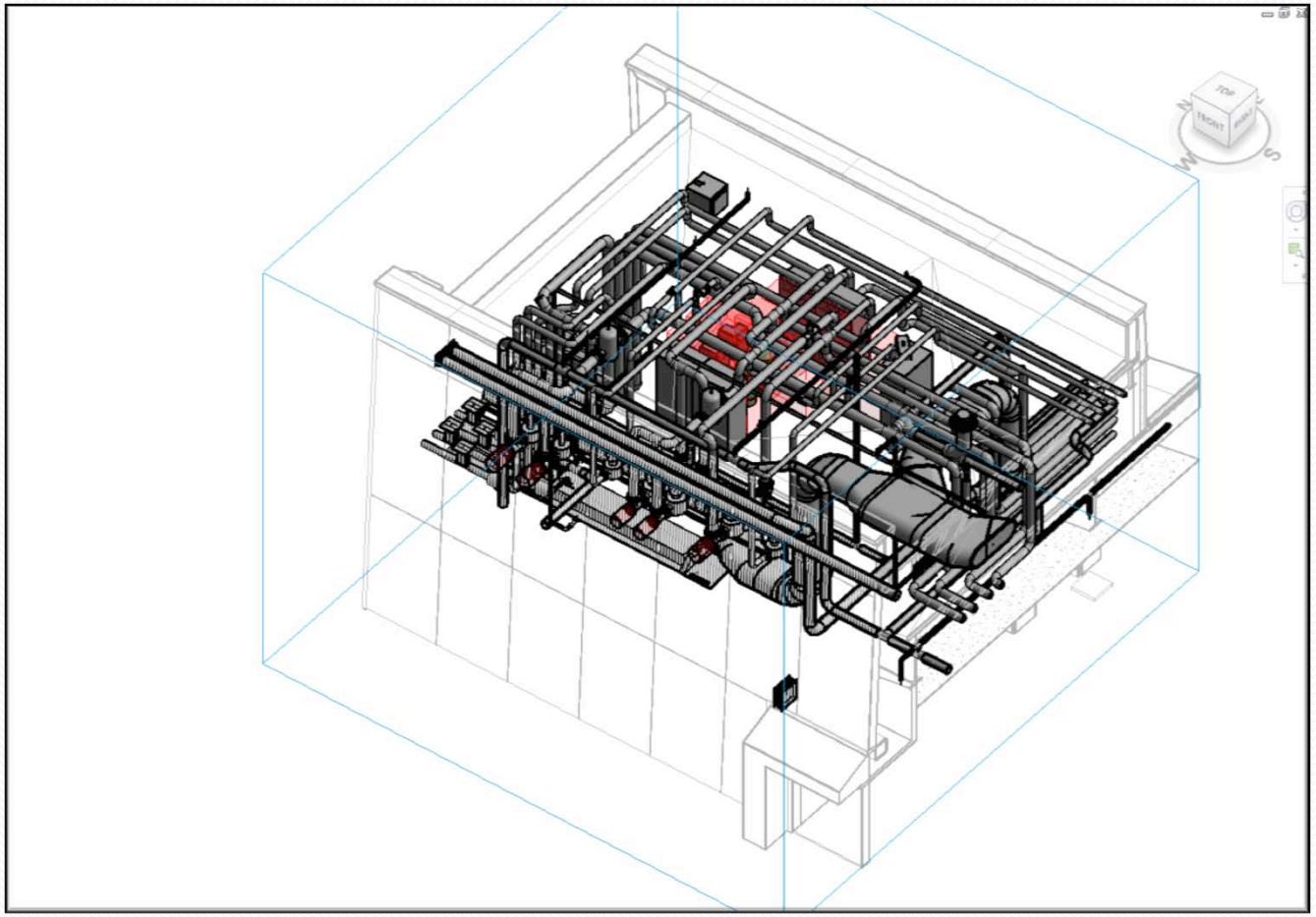
3d Coordination and Visualization



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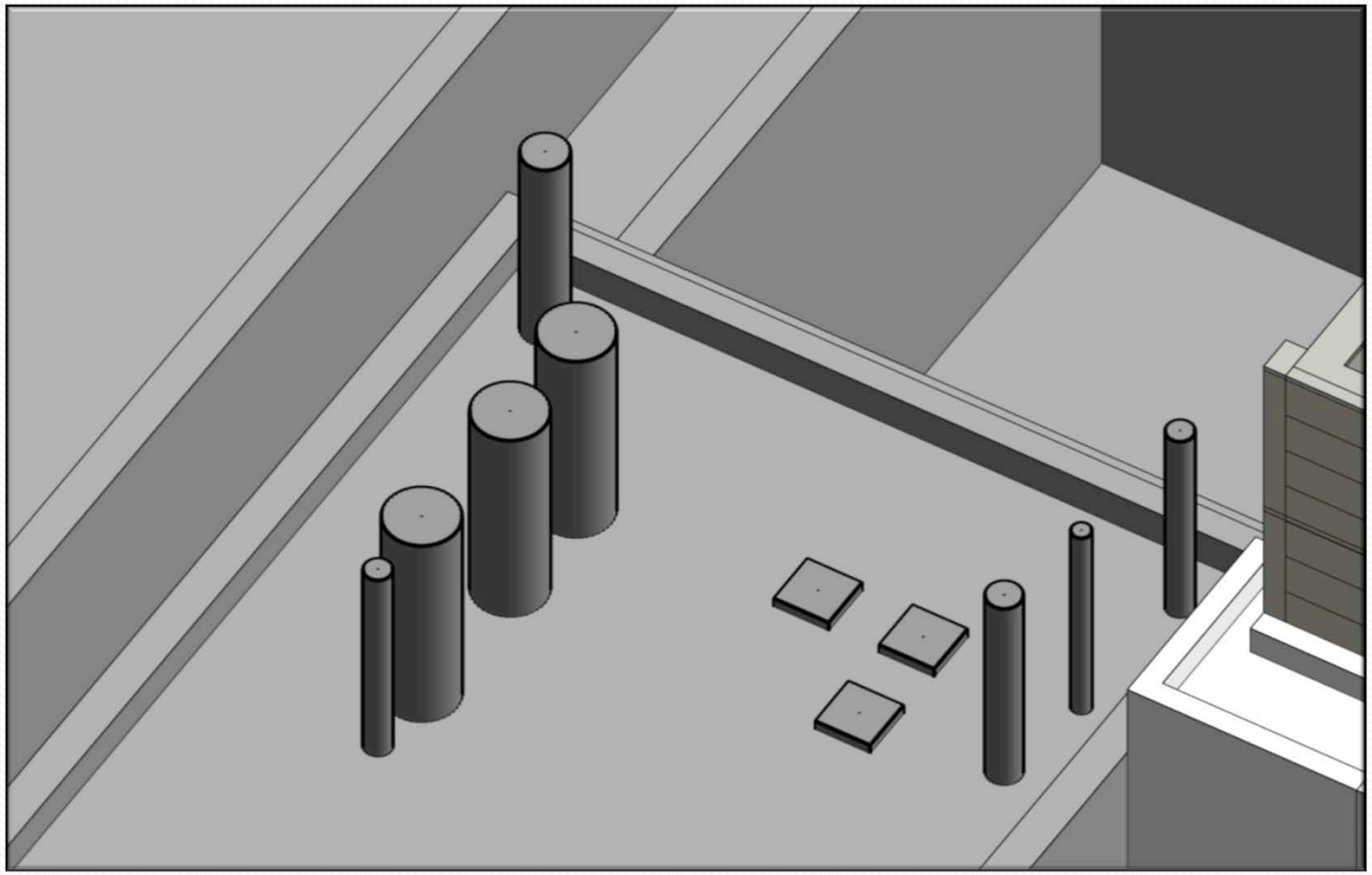
Strength: Visualization



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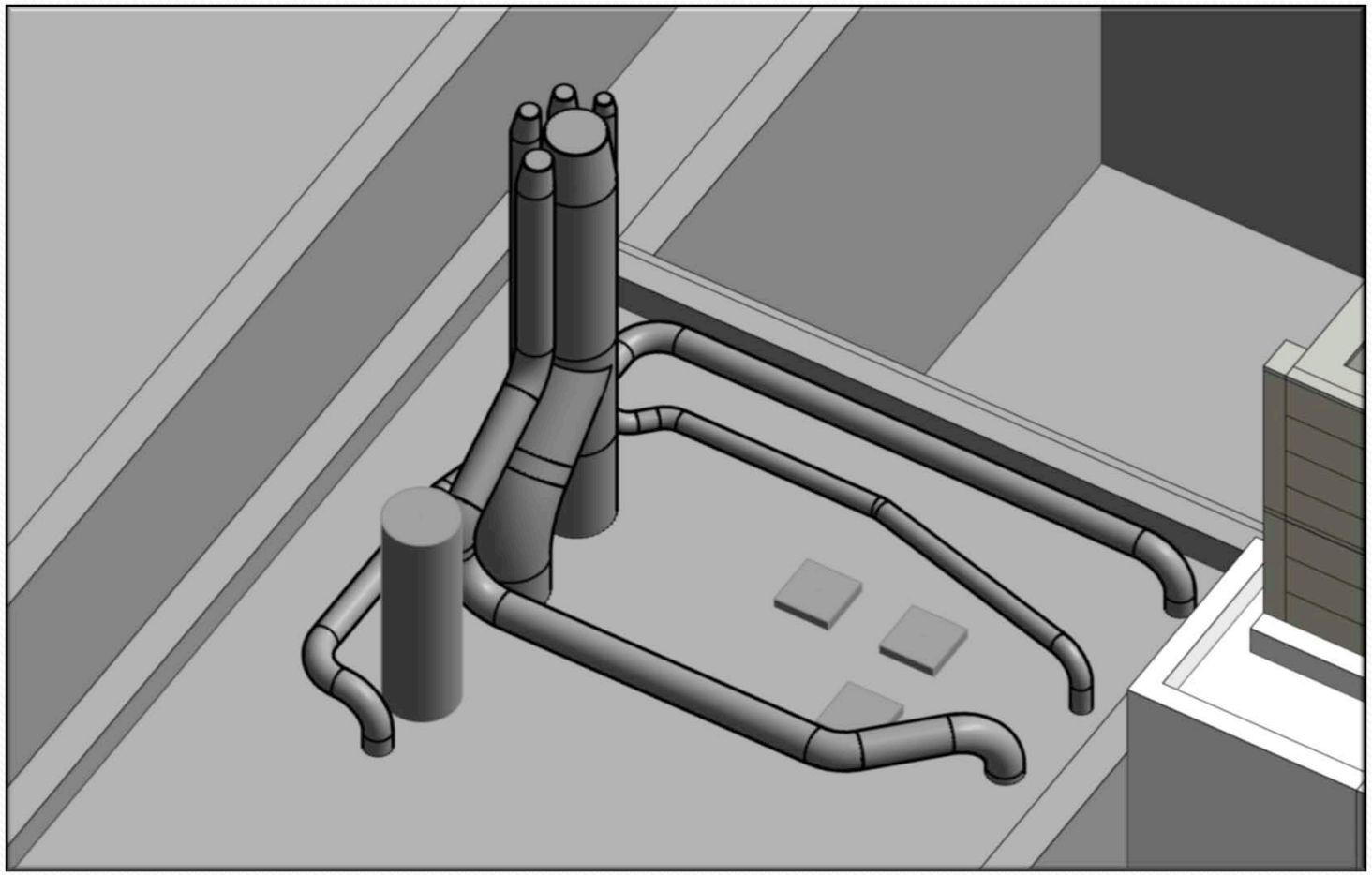
Strength: Visualization



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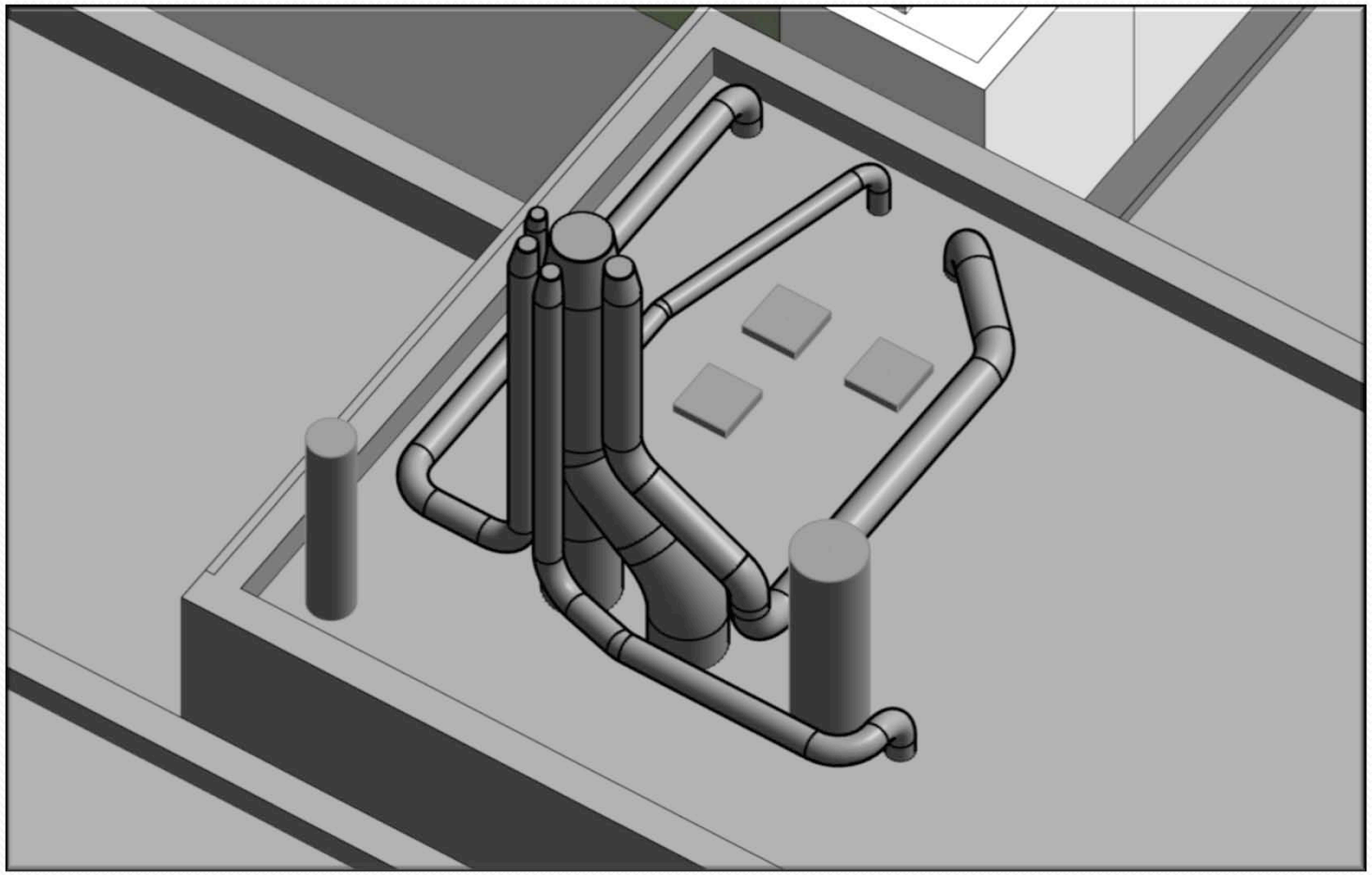
Strength: Visualization



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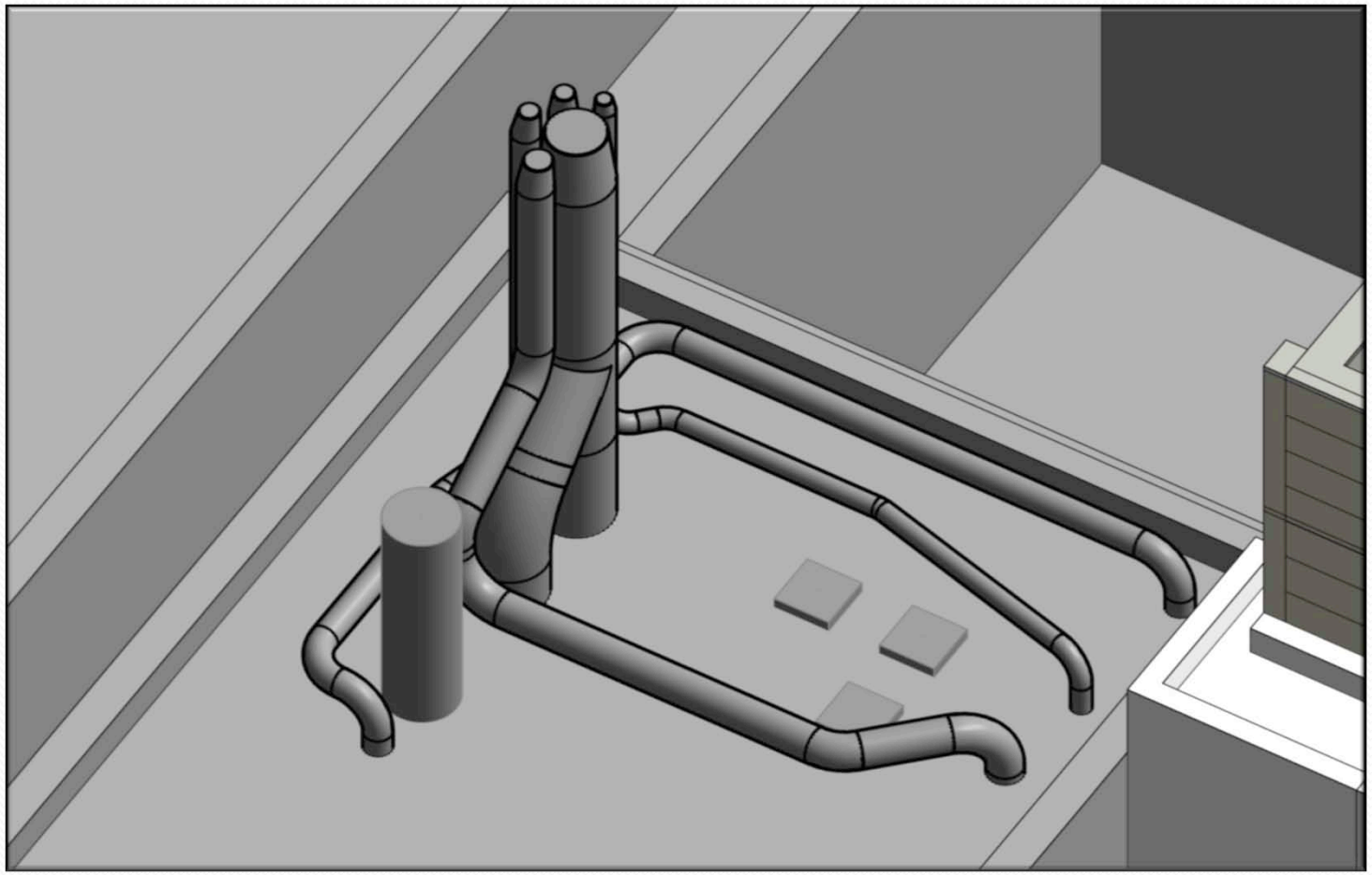
Strength: Visualization



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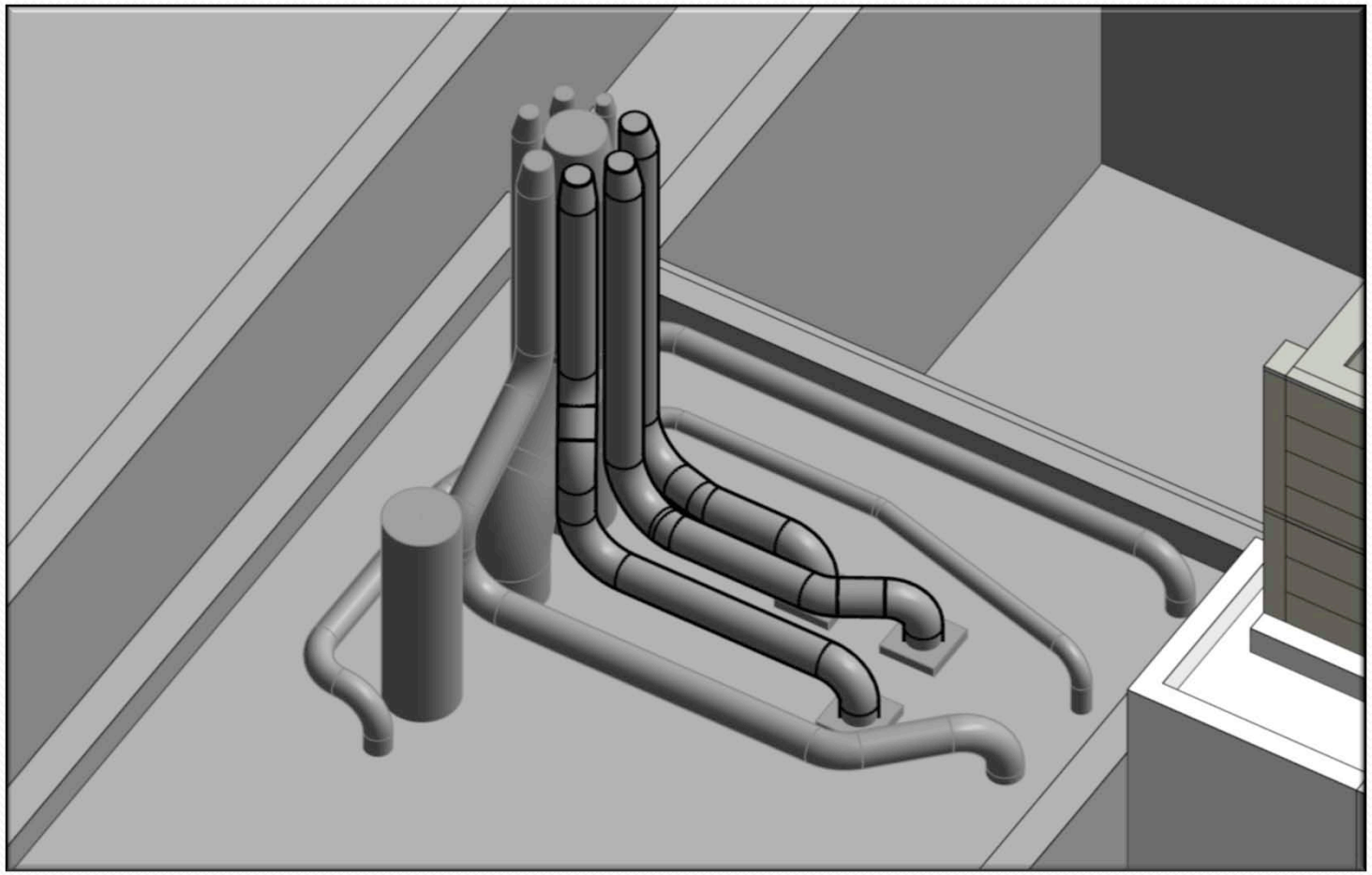
Strength: Phasing



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Applications for BIM:

- New Construction.
- Complex geometry.
- Desire / Need for coordination.

Levels of Detail

From portions of AIA Document G202 - Project Building Information Modeling Protocol Form:

- *The degree to which an element's geometry and attached information has been thought through - the degree to which project team members may rely on the information when using the model.*

LOD 100:

- Model Elements Graphically represented with a **symbol or other generic representation**.
- Information related to the Model Element can be derived from other Model Elements
  - cost per square foot, tonnage of HVAC, etc.
- Examples:
  - Schematic/Conceptual Design.
  - Class D estimates.

LOD 200:

- Model Element is graphically represented within the Model as a **generic** system, object, or assembly
  - approximate quantities
  - Size
  - Shape
  - Location
  - orientation.
  - Non-graphic information may also be attached to the Model Element (Meta Data).
- Examples: Design Development Reports. Class C Estimates.

LOD 300:

- Model Element is graphically represented within the Model as a **specific** system, object or assembly.
  - Quantity, Size, shape, location, and orientation.
- Non-graphic information may also be attached to the Model Element.
- Examples: Traditional Contract Documents. Class A or B Estimates.
- May be used for Simple Interference drawings and Clash detection.

LOD 350:

- Similar to LOD 300
- Digital communication between linked elements
  - Diffuser air flow, to fan air flow, to motor horsepower, to MCC load
- Examples: Traditional Contract Documents with Model Generated Schedules.

LOD 400:

- The Model Element is graphically represented within the Model as a specific system, object or assembly in terms of size, shape, location, quantity, and orientation with detailing, fabrication, assembly, and installation information.
- Non-graphic information may also be attached to the Model Element.
- Examples: Fabrication drawings, Shop Drawings, Detailed interference drawings and clash detection.

LOD 500:

- The Model Element is a **field verified representation** in terms of size, shape, location, quantity, and orientation.
- Non-graphic information may also be attached to the Model Elements.
- Examples: Detailed “As-Built” record documents. Facility Maintenance and control.

What Level do you want?

- Start Small.
- What is the experience level of your Consultant team?
- What is the experience level of your contractor team?
- What is the experience of the Owner and Maintenance team?

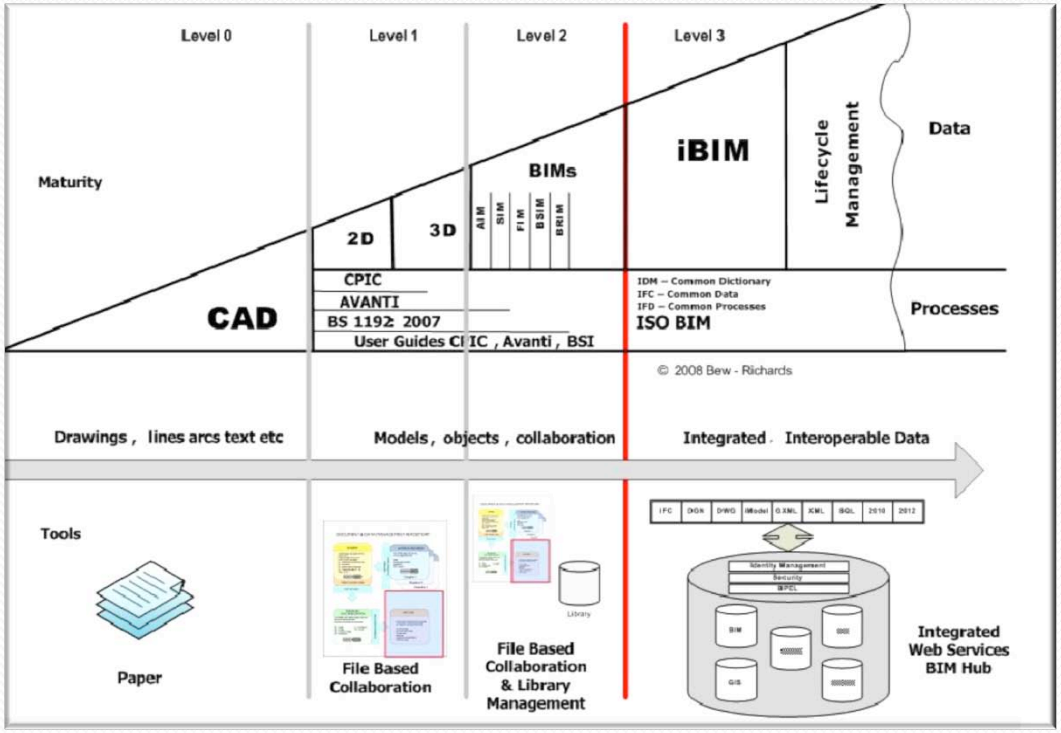
What Level do you want?

- Every LOD is more expensive then the previous.
- LOD 1 to 3.5 are handled by the Consultant Team.
- LOD 4 is Handled by the Contractor.
- LOD 5 is Handled by a Specialist.

“BIM Levels”

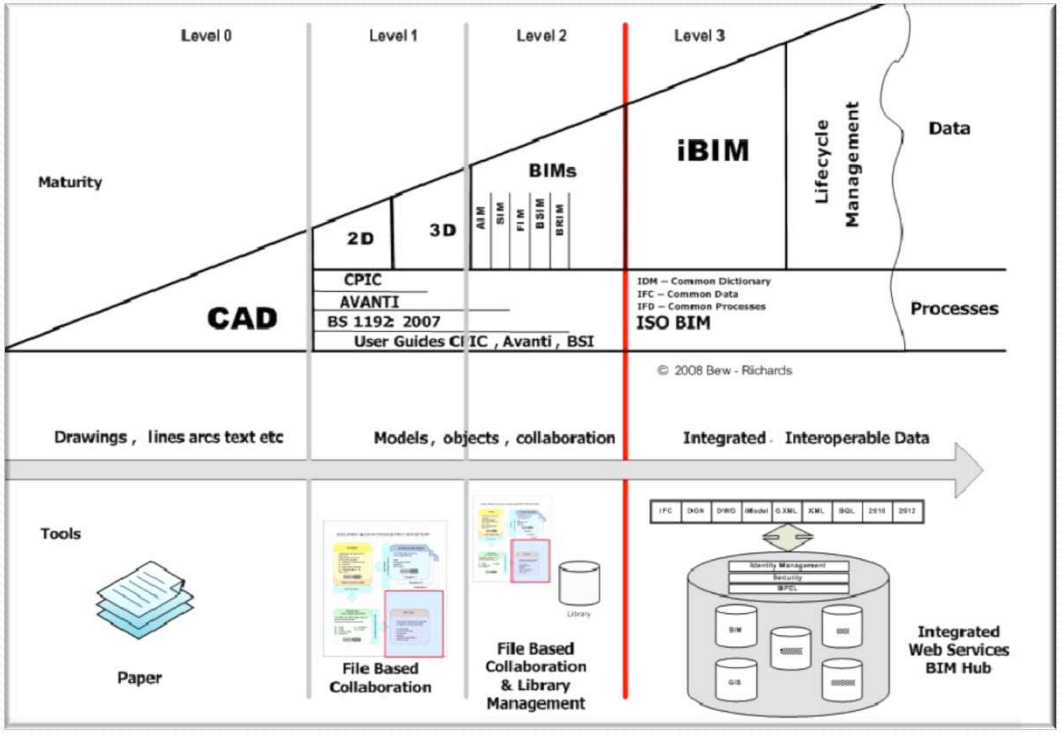
- (Typically a UK Standard)
- Not to be confused with Levels of Detail or Levels of Development
- Level of Data organization, Centralization, and intelligence in a building model:

“BIM Levels”



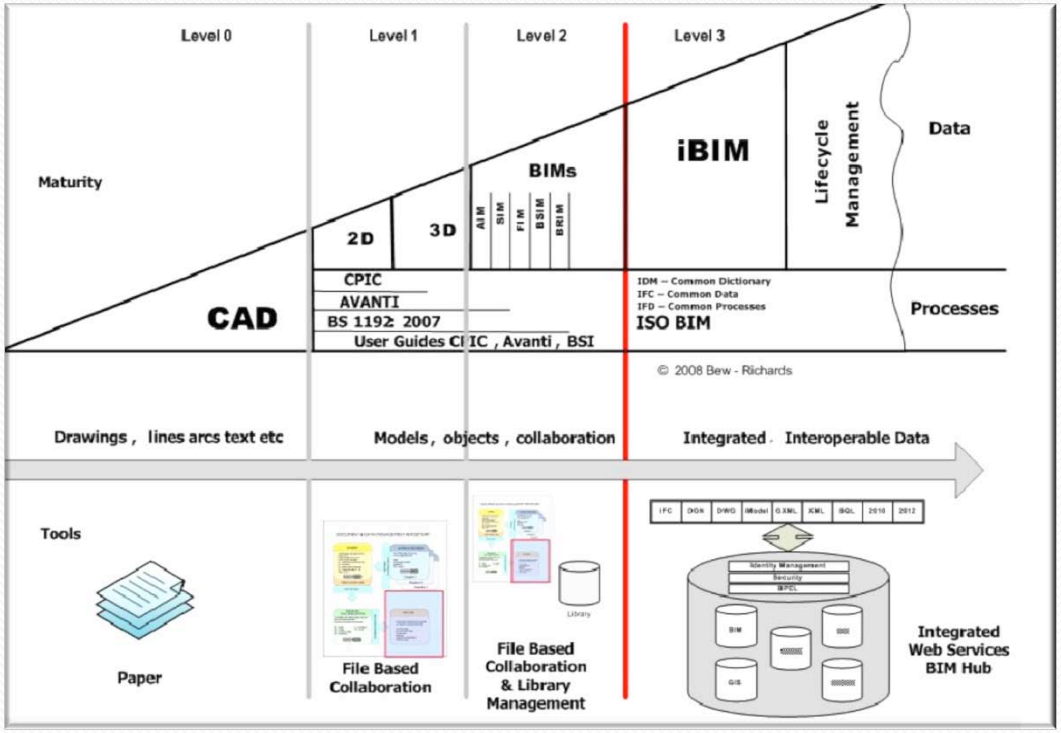
- Level 0 BIM: 2D CAD data (Dumb lines arcs and circles)

“BIM Levels”



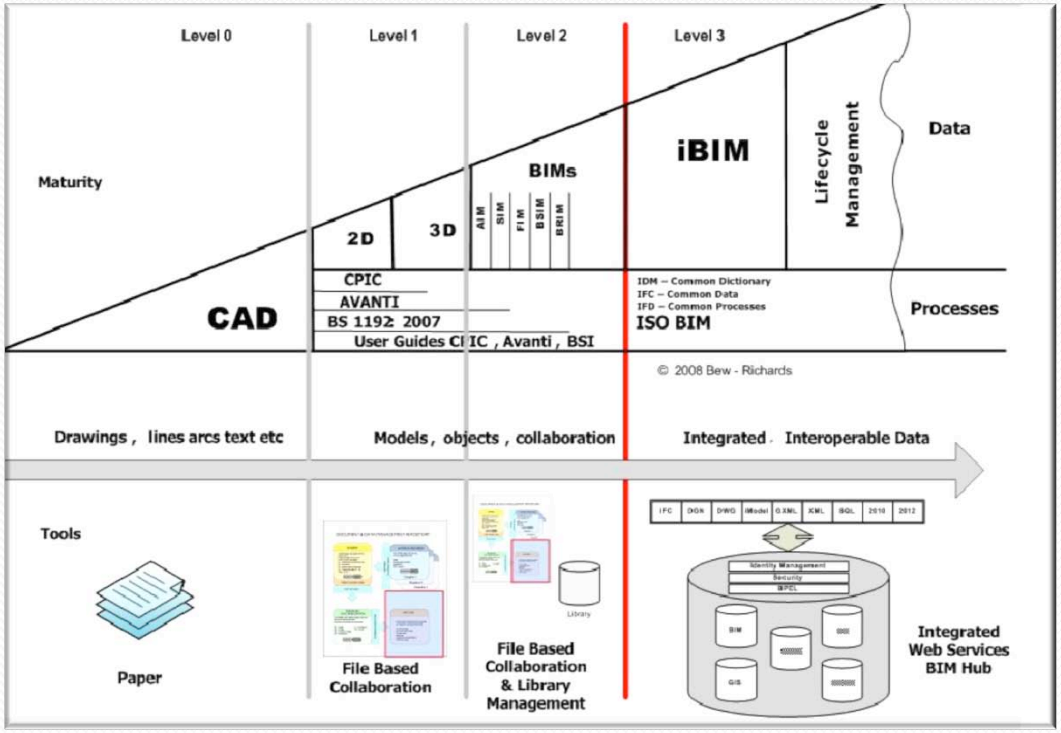
- Level 1 BIM: 2D CAD data with standards and consistent structure. Information is spatially coordinated and is broken down into logical groups, either by layer standards, references, folders or a combination of methods.

“BIM Levels”



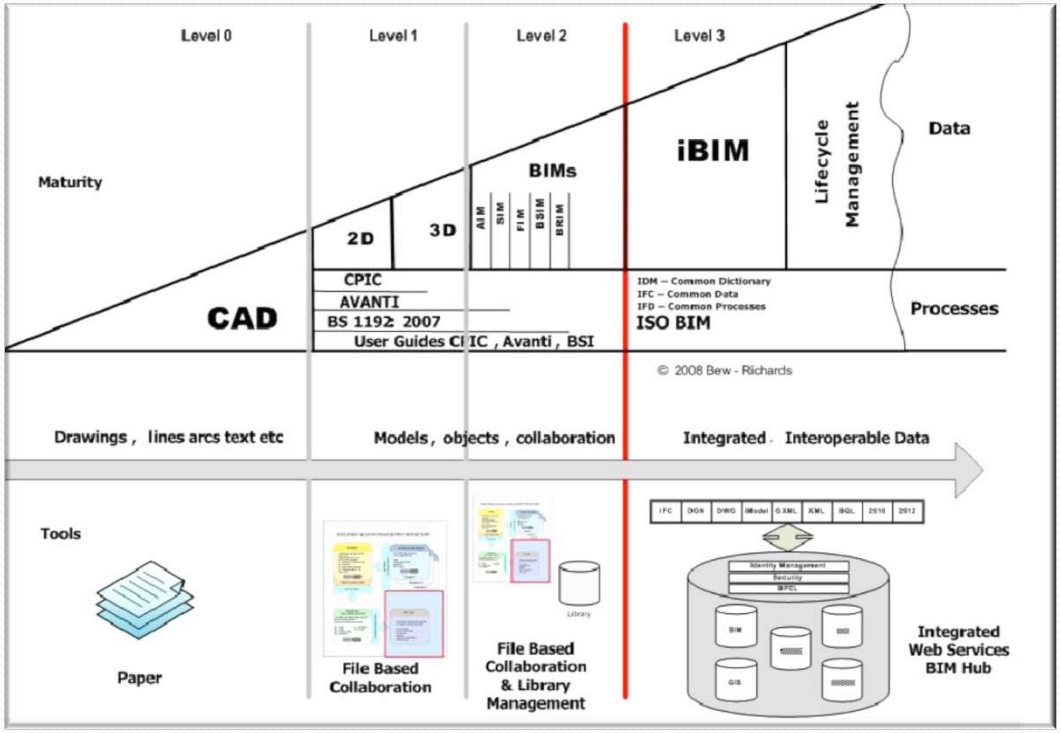
- Level 1.5 BIM: 3D CAD or model data with standards per Level 1.

“BIM Levels”



- Level 2 BIM: Adoption of Building Information Modeling. Collaborative and process-led authoring, exchange and publication of data.
- Added intelligence and metadata is included in the model.
- The metadata is used for schedules, specifications, and in a raw format in COBie spreadsheets.
- A BIM execution plan is required.

“BIM Levels”



- Level 3 BIM: Utopian definition of BIM. A fully interoperable, immersive BIM environment where all individual BIMs are part of a complete project model, regardless of software, regardless of location. This level may not possible or practical with today’s technology.

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3d, 4d, 5d, 6d BIM

- 3D BIM: Building Object are physically represented in the x, y, and z axis.
- 4D BIM: 3D BIM plus project schedule (time)
- 5D BIM: 4D BIM plus element costs / Budget.
- 6D BIM: 5D BIM plus full life cycle management information.

Where are we today?

- BIM is maturing.
- BIM Level 1 is Standard (AutoCAD)
- BIM Level 1.5 is common (Revit)
- BIM Level 2 is Rare
- LOD 3 is common.
- LOD 4 is achievable.
- LOD 5 is Very Rare.
- 3d BIM is Common
- 4d BIM is Rare
- 5d, 6d BIM is Very Rare

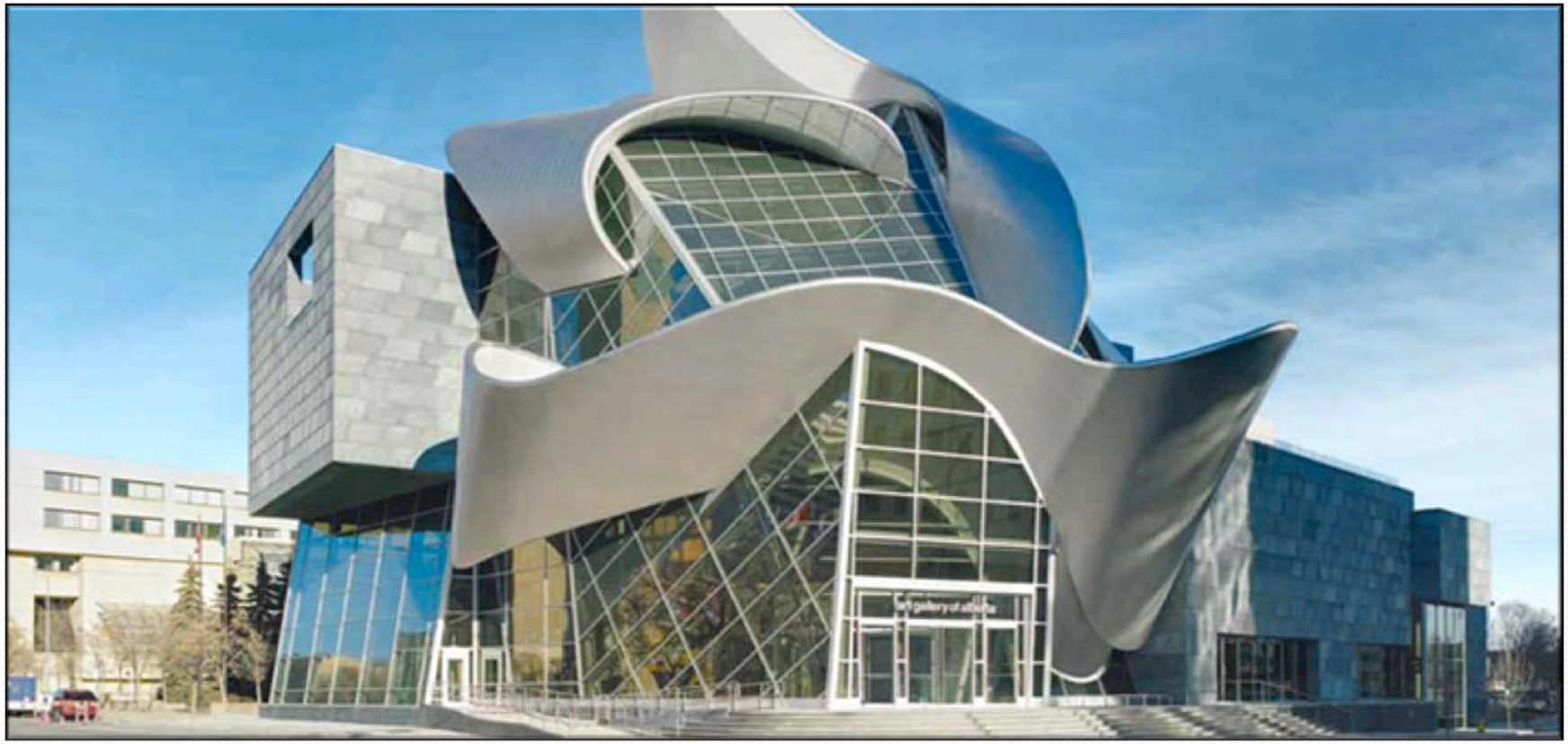
What are the Cons?

- Pushback from some consulting teams.
- “Not Enough Fees”
- Drawing is easy, Modeling is Hard.
- Not yet reached the “Tipping Point”
- Some consultants are not used to thinking in 3d.
- Change in workflows.
  - Equipment schedules / Meta Data.
  - Additional Coordination.

What are the Cons?

- Modeling is like Virtual Construction:
  - Changes are more difficult.
- Things can be modeled that cannot be built.
- The best Modelers may not have construction experience.
- A Low LOD model does not show all details.
- The software tools allow for more “Creativity” from the Architectural team.

Creativity – Two Edged Sword



- Art Gallery of Alberta

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More Cons:

- 3d object (Familiy) libraries are incomplete
- Models may be “Fudged” to make the 2d plans look better.
- Different levels of expertise among all consultant groups.
- The consultant “Deliverable” is still the 2d drawings.

What about Renovations?

- If design is hard, renovations are harder.
- Many more limitations:
  - Existing Conditions
  - Limited information
  - Obsolete documentation
  - Project Phasing
  - “The Unexpected”

Garbage in – Garbage Out

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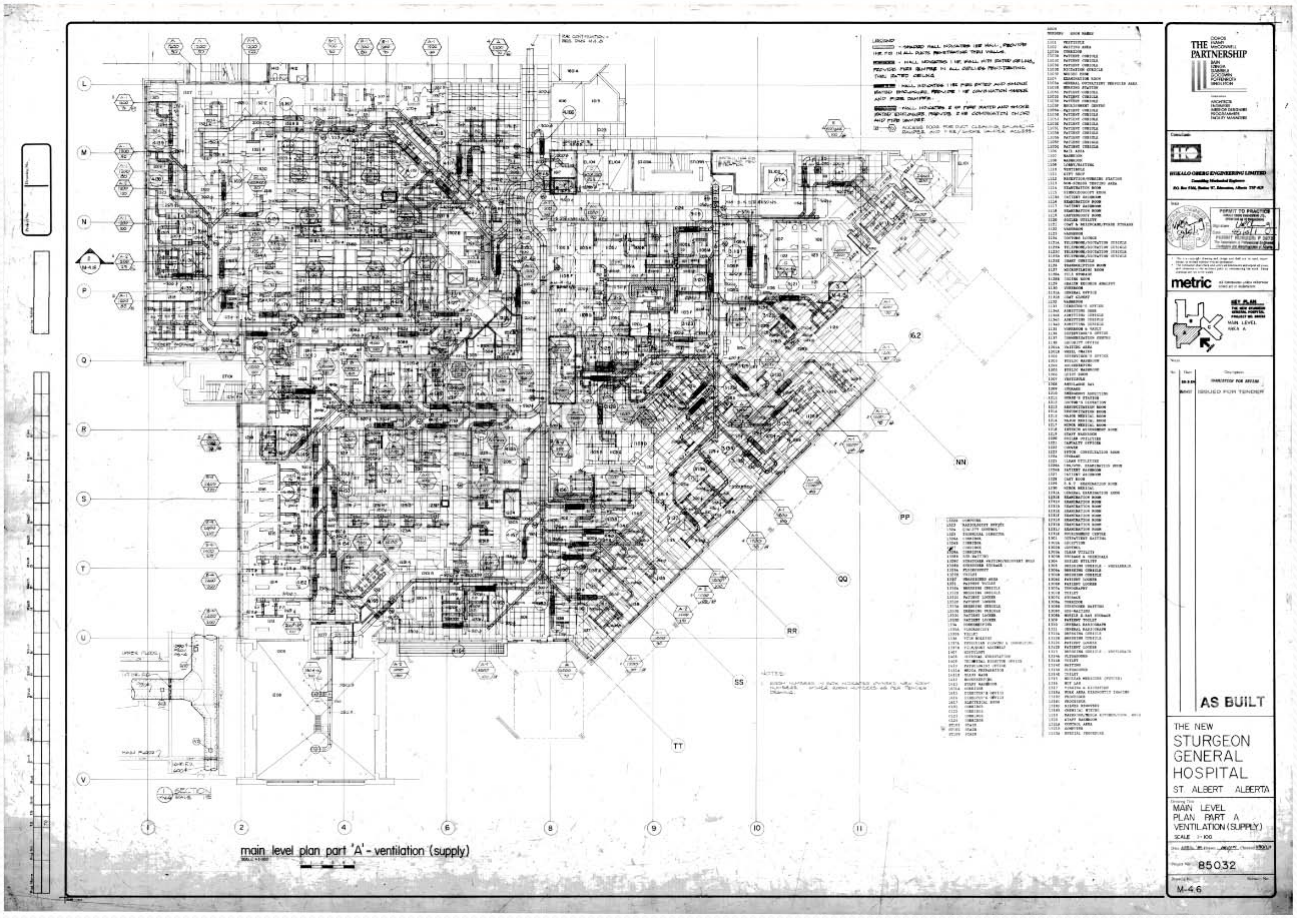
Existing Conditions

- "Record Drawings"
  - May not be available.
  - May not be accurate.
  - May not be complete.
  - May be Obsolete.
  - Are not usually 3d.
  - May only be available in a Raster Format.
  - May be hand drawn.
  - May be in Rough Condition.

Record Drawings…



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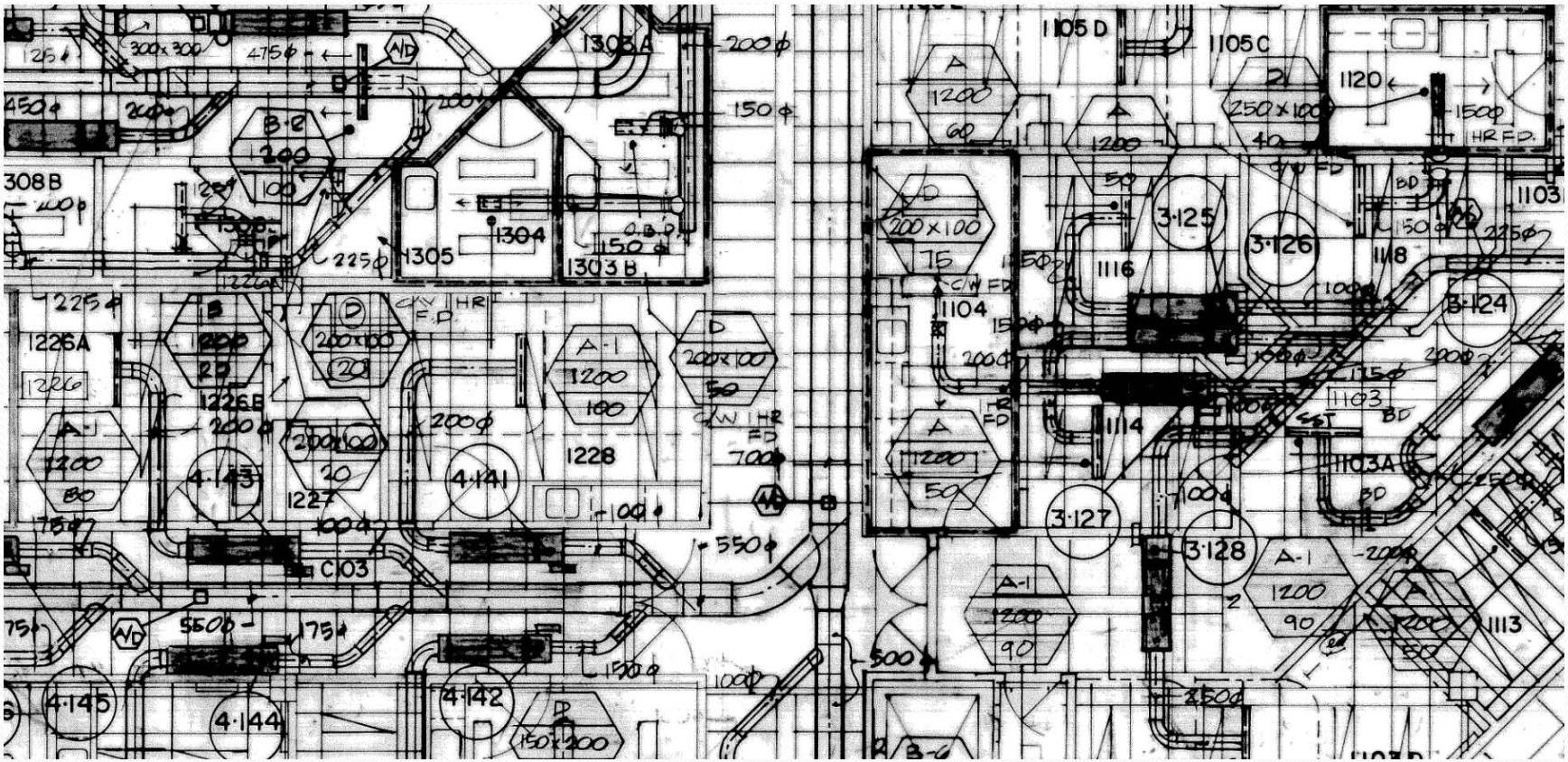
Raster Image (Hand Drawn)



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Site Verification

- Use photographs and tape measures to identify / document “as built” conditions.
- Time consuming
- Measurements are only as accurate as the measurer.
- Accurate measurements may not be physically possible.
- How do you measure Conduit Racks?

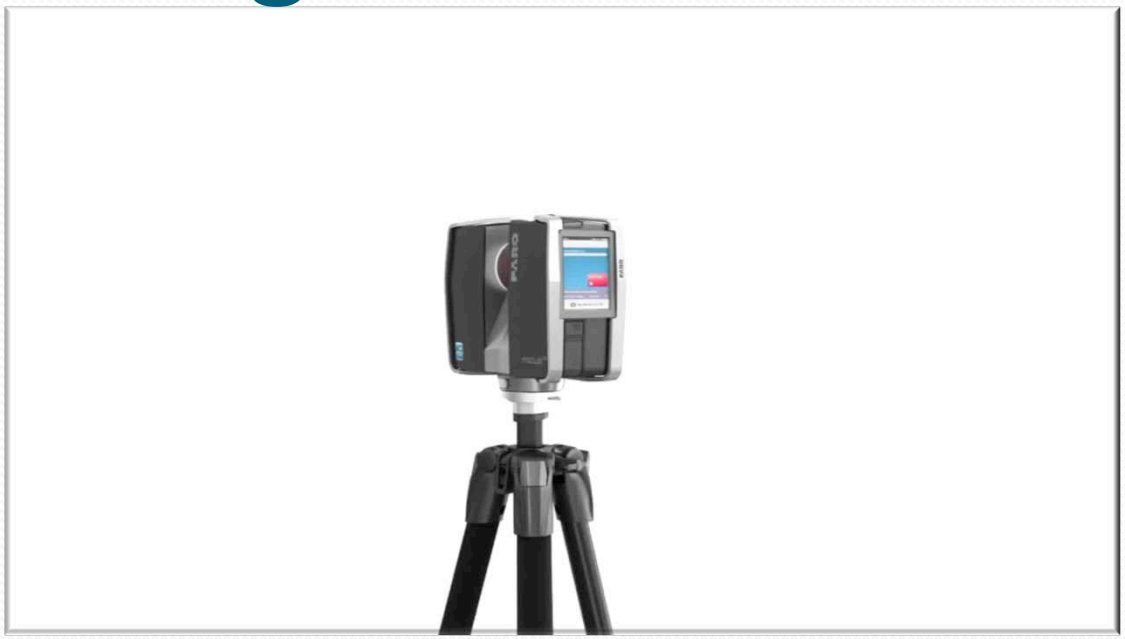
Site Verification

- Site areas may be restricted, secure, or remote.
- You always leave with at least one missing dimension.
- The item you need a photograph of is just outside of the photo taken.
- Storage and retrieval of all the photos is cumbersome.

Measuring the Immeasurable

- New Technology is emerging:
  - 3d Laser Scanning

Laser Scanning: How it works



•A pulsed laser signal is sent out and bounces back off any hard surface.

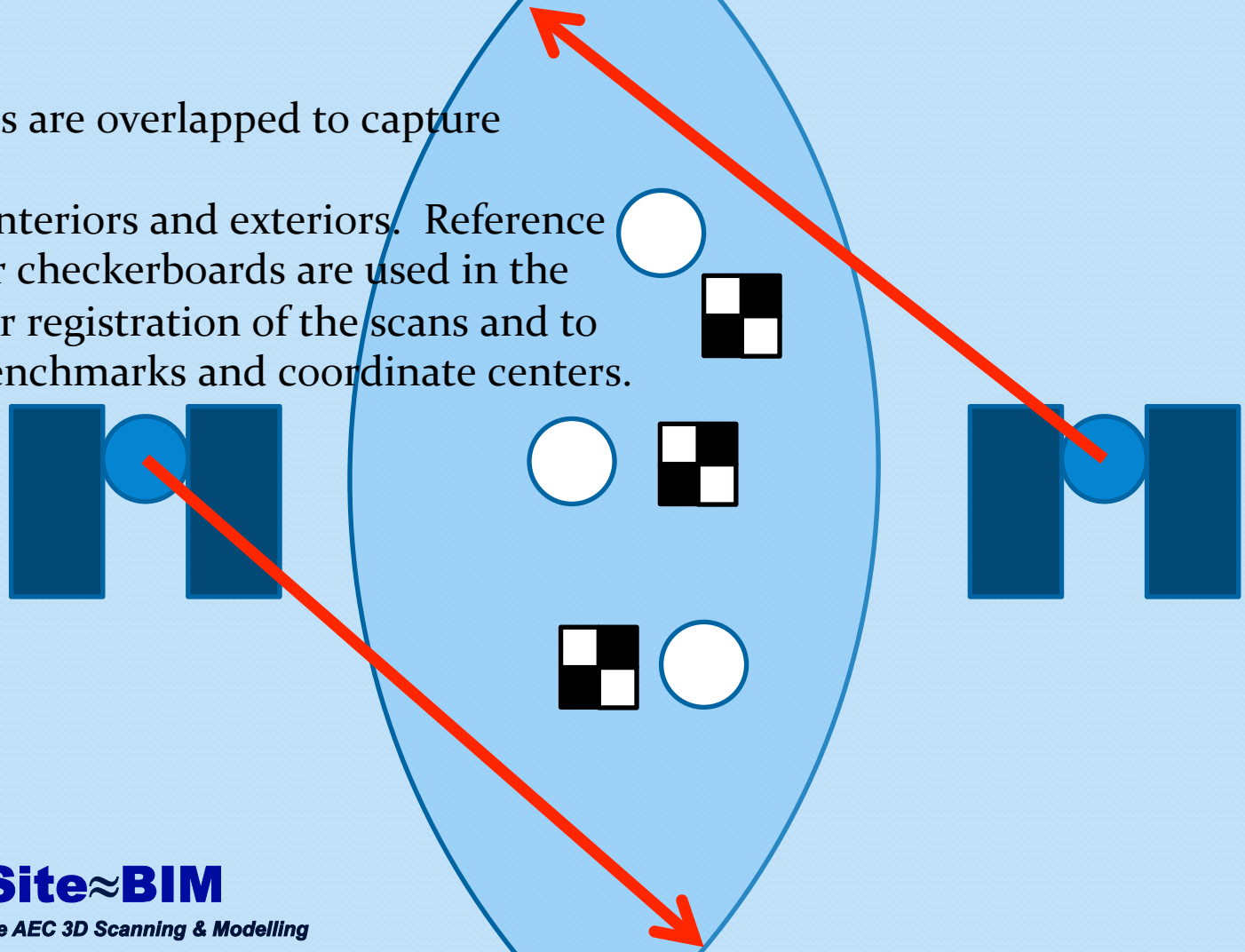
•The returned signal is recorded as an XYZ coordinate, with colour intensity and RGB values.

Site≈BIM

For Precise AEC 3D Scanning & Modelling

Laser Scanning: How it Works

Field scans are overlapped to capture complete
building interiors and exteriors. Reference spheres or checkerboards are used in the overlap for registration of the scans and to tie into benchmarks and coordinate centers.



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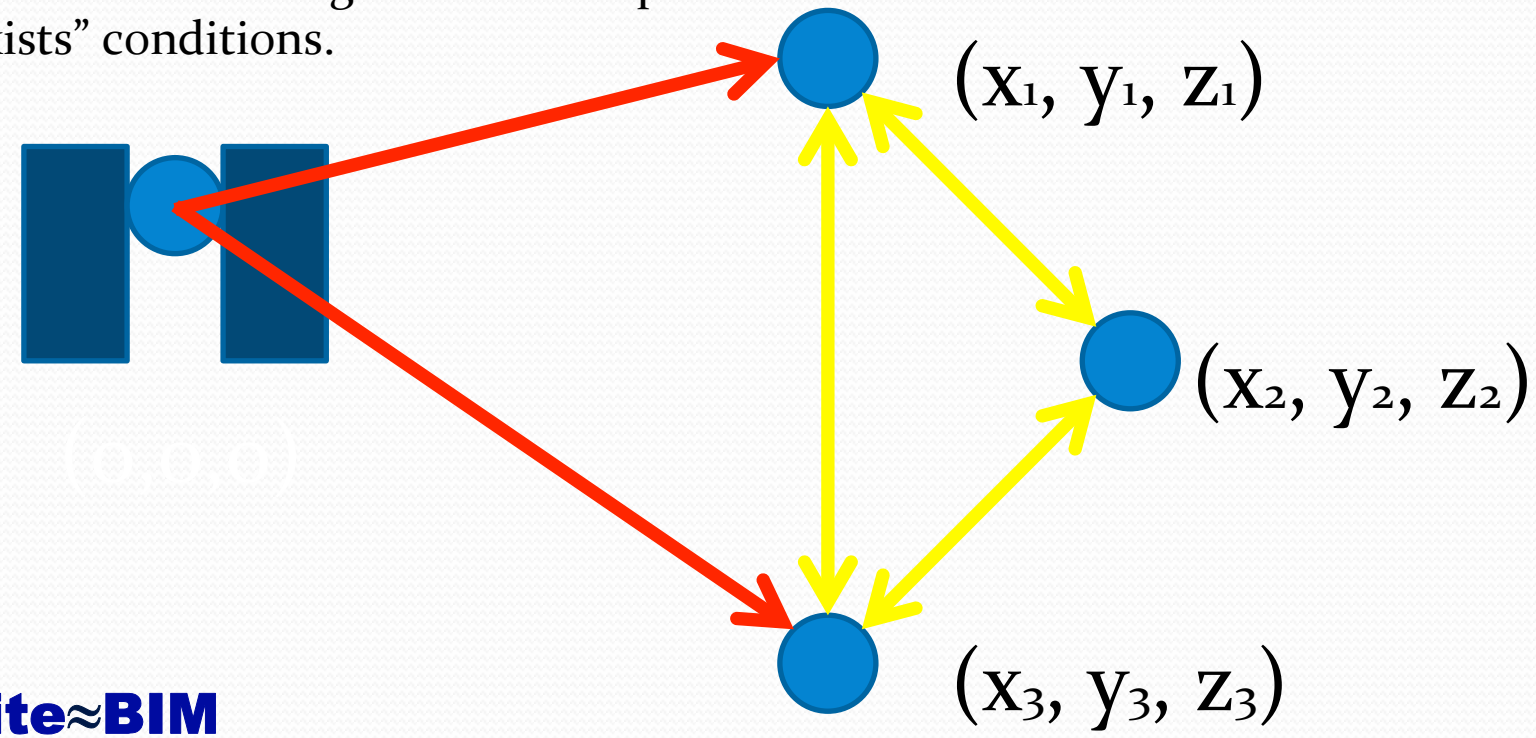
Laser Scanning: How it Works

The specialized software uses coordinate algorithms to place the millions of points into an accurate arrangement that represents "As Exists" conditions.



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Fultonvale Elementary / Jr. High School

Roof Plans

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Fultonvale Elementary / Jr. High School

Existing Conditions

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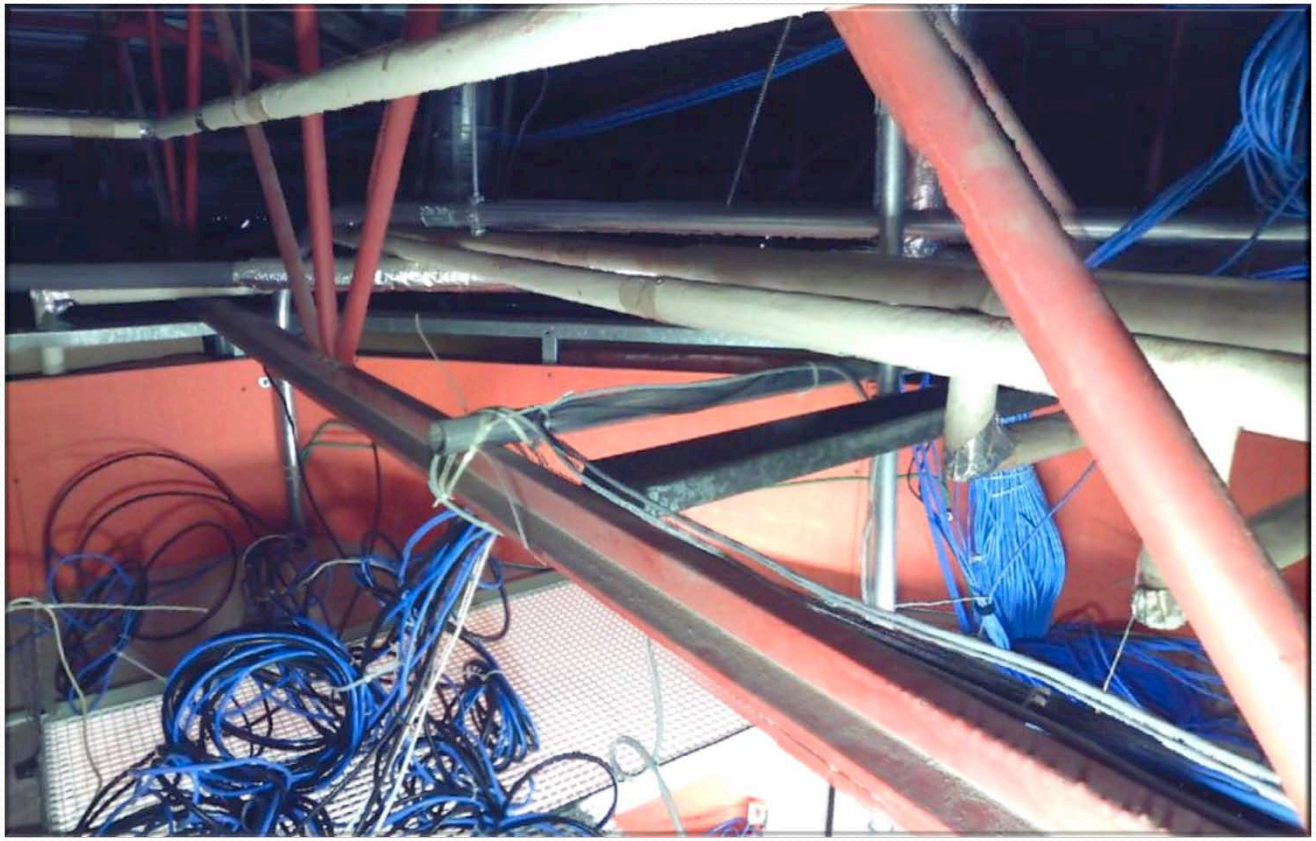
Edmonton Area Hospital

Ceiling Spaces



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Fultonvale Elementary / Jr. High School

Existing Conditions

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Ukrainian Canadian Alberta Museum and Archives

3d Point Clouds

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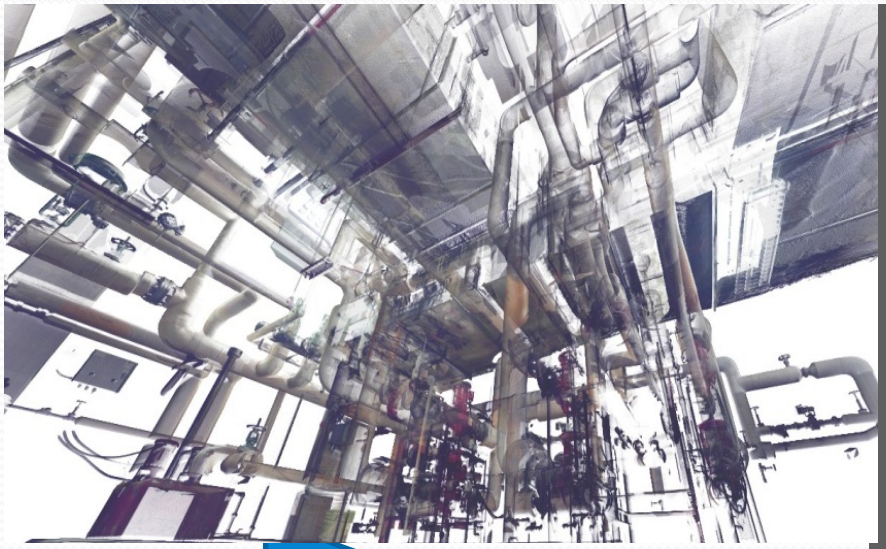
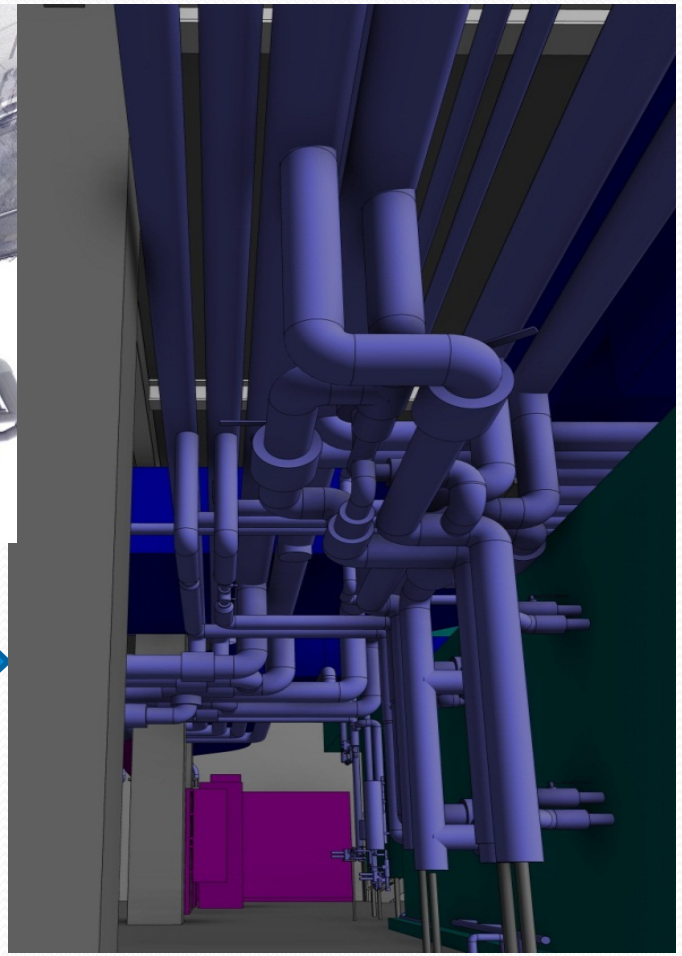
Point Cloud Conversion



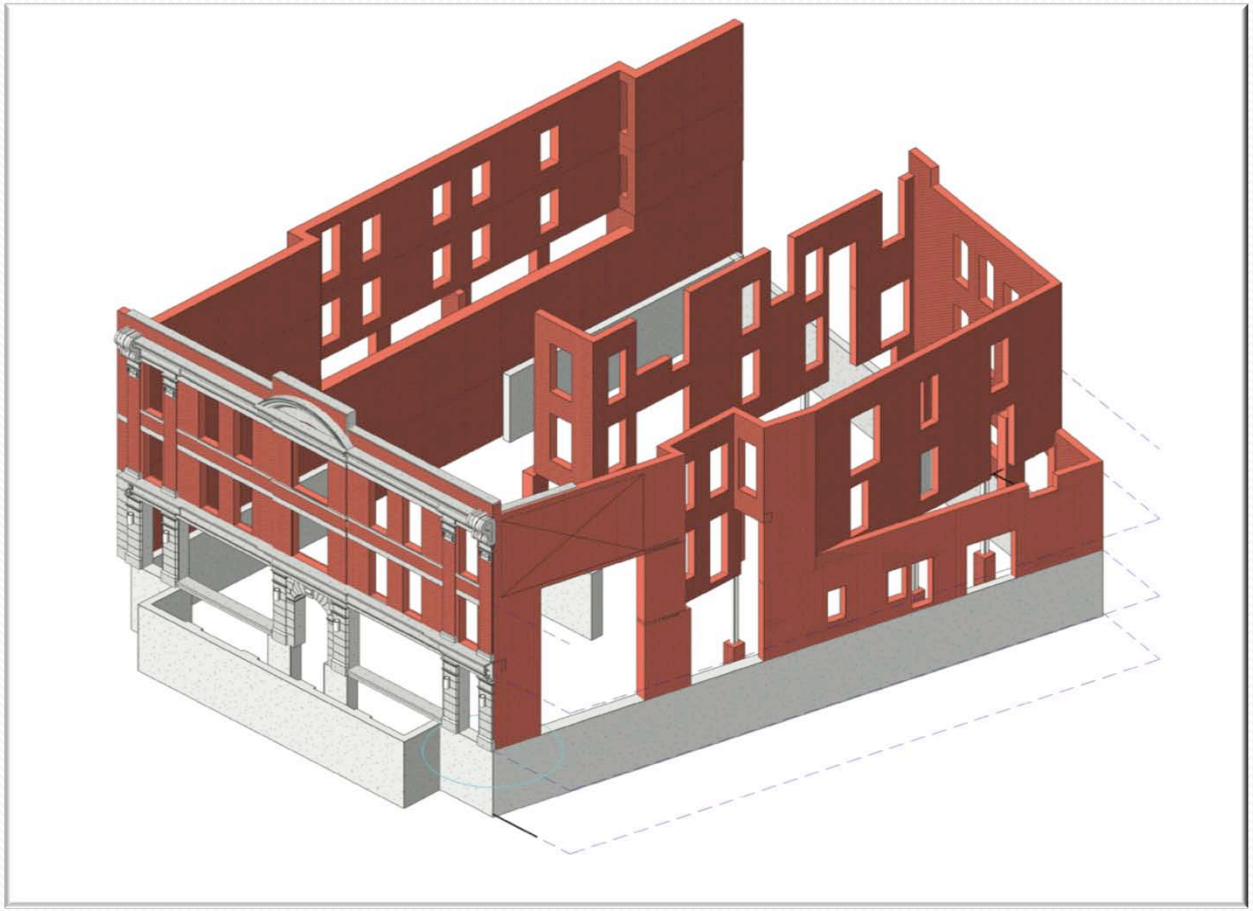


Feature recognition software takes the point cloud and identifies pipes, ductwork, walls, floors, doors and windows into parametric models.

Site≈BIM

For Precise AEC 3D Scanning & Modelling

Point Cloud Conversion



Site≈BIM
For Precise AEC 3D Scanning & Modelling

Model elements can be generated from massing or more intelligently, from use of standard families.

Case Study:

- Boiler Replacement Project
- Maximum Security Institution
- Remote Location
- No “As-built” Drawings
- Limited Fees

First Site Visit:

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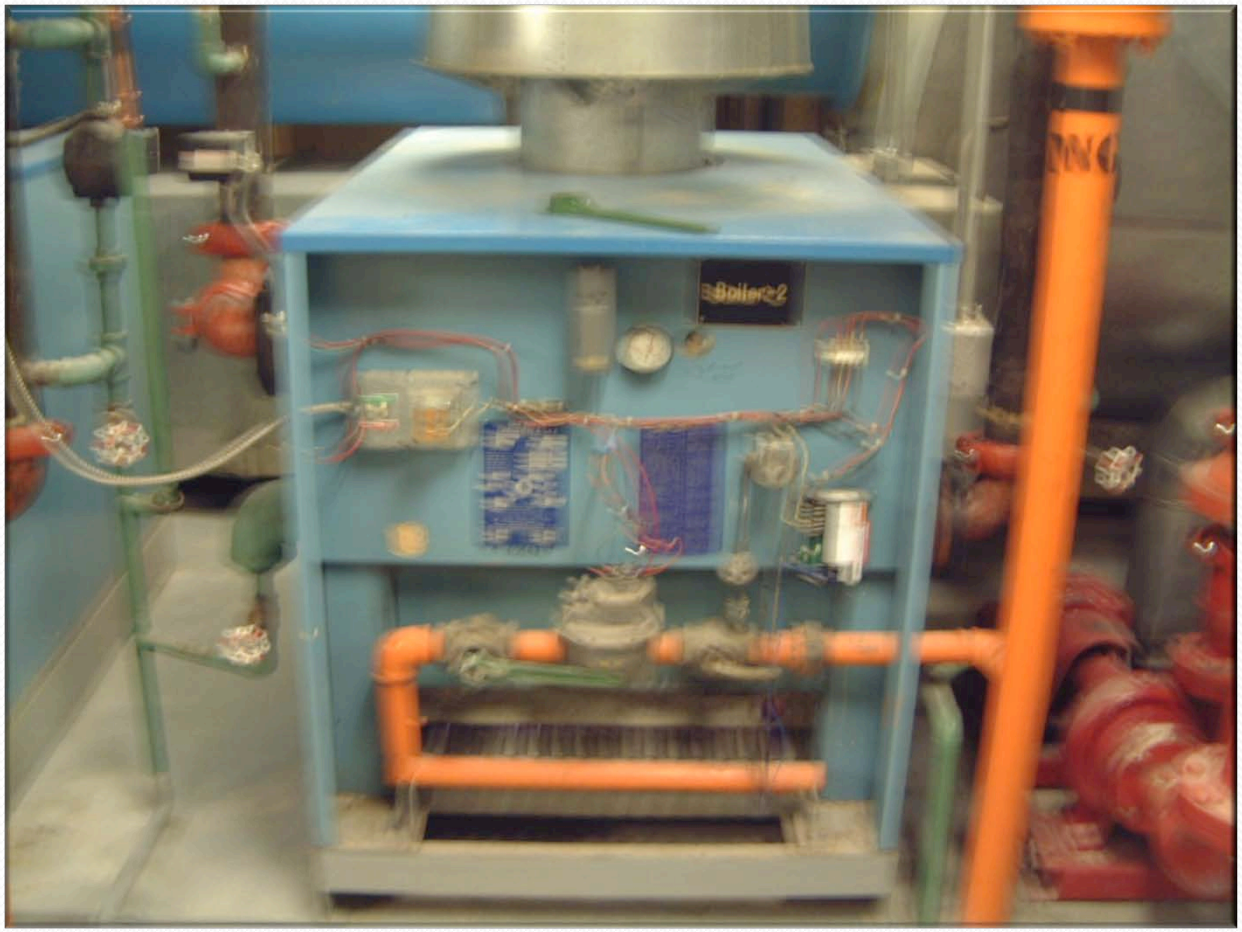
First Site Visit:



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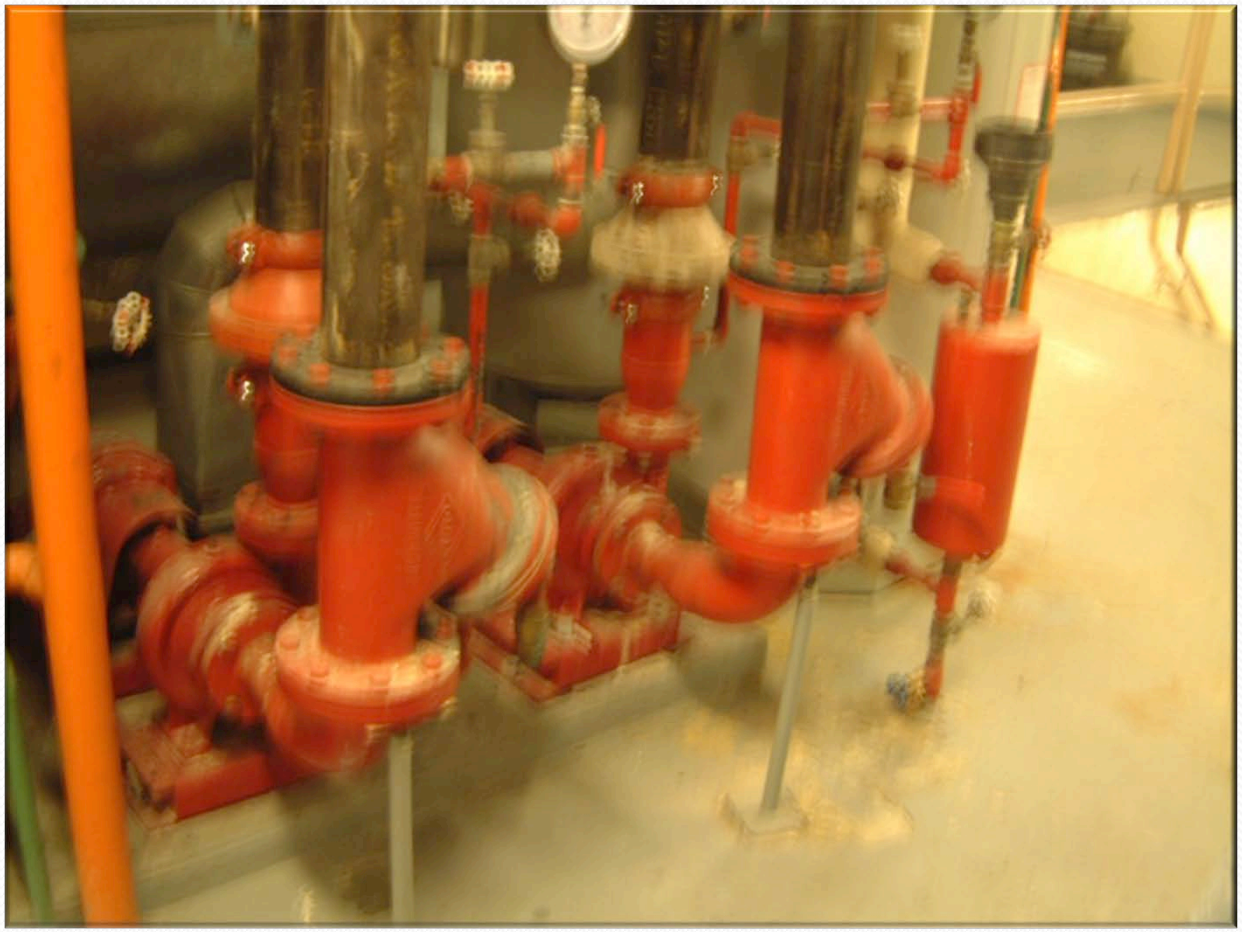
First Site Visit:



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First Site Visit:

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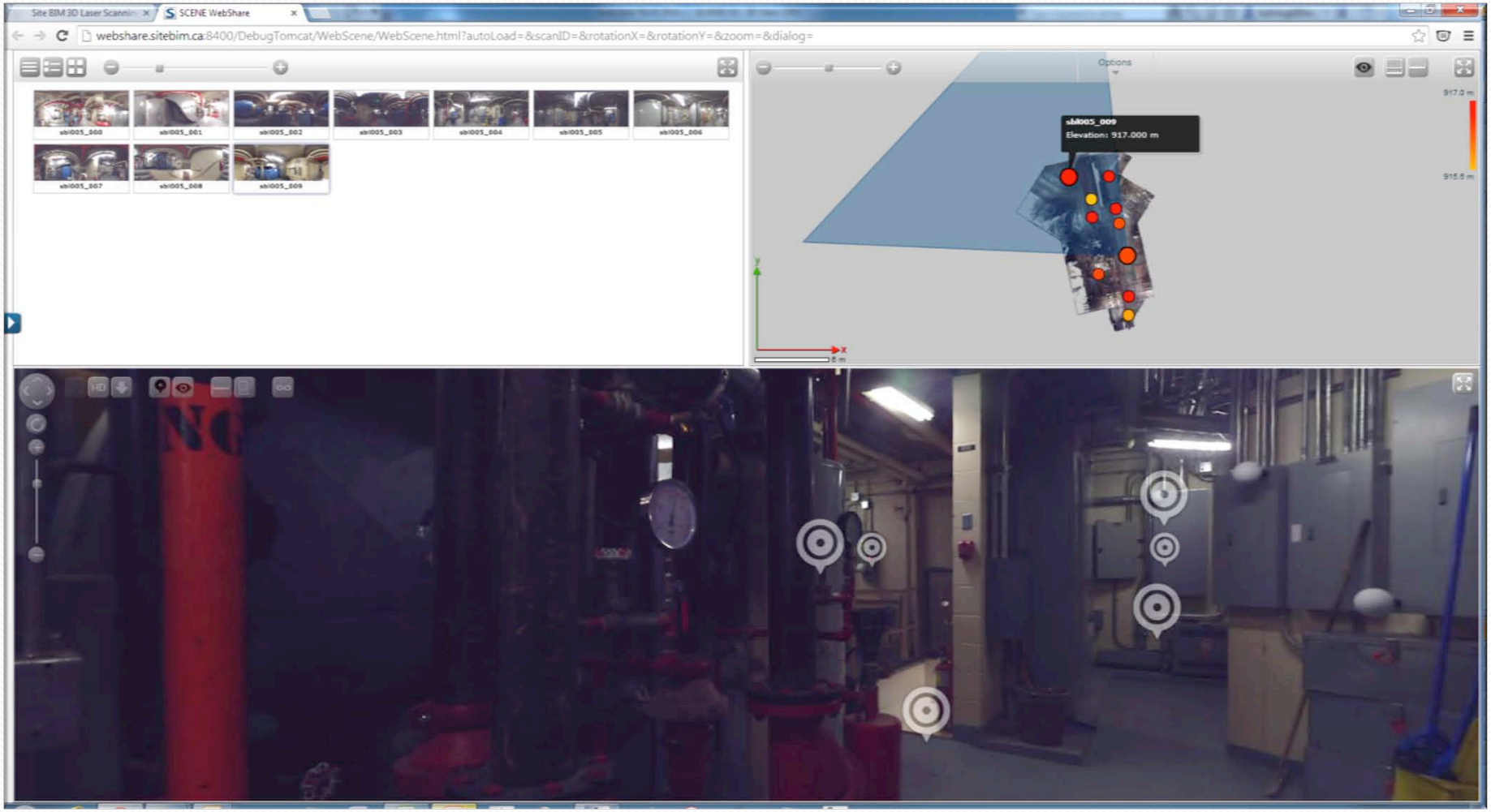
We Need a Better Solution…

- Is our Design is going to be Garbage in / Garbage out?
- Just include many notes of “Coordinate on site”?
- Do we do this “quick and dirty” or do we do this right?
- Let’s try Laser scanning, convert to Revit, then convert to AutoCAD!

Scene Website:



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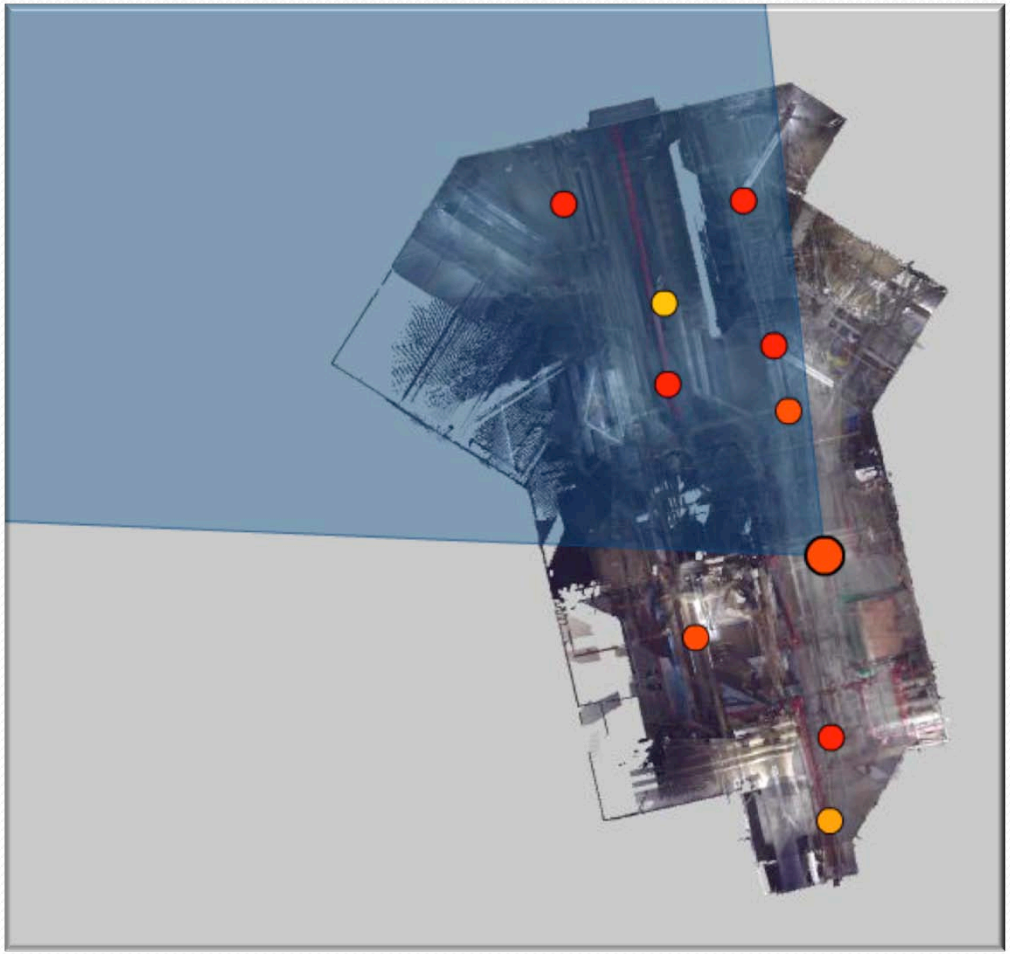
Scene Site Plan:



- Dots indicate scan locations
- Shade indicates Field of View

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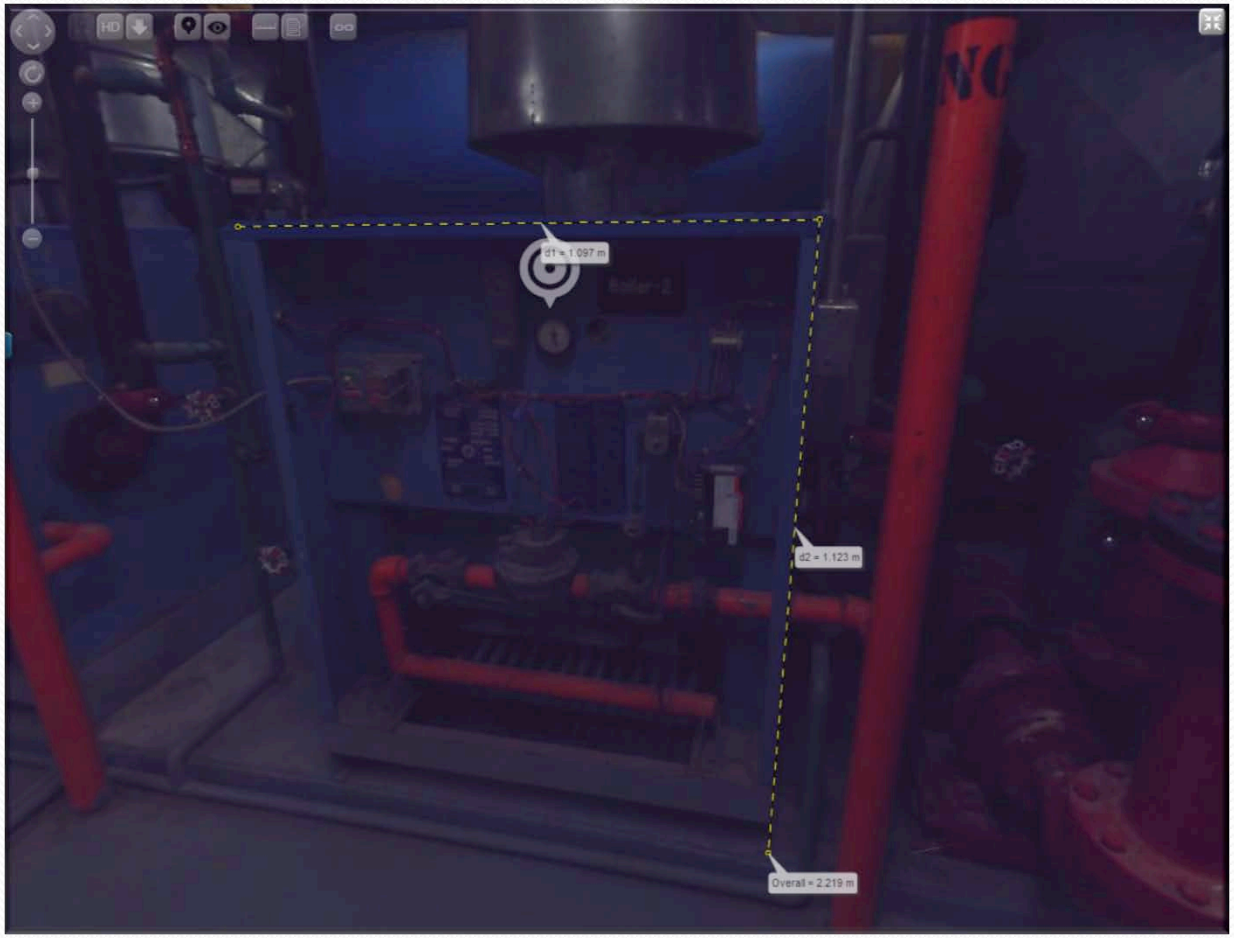
Scene Website:

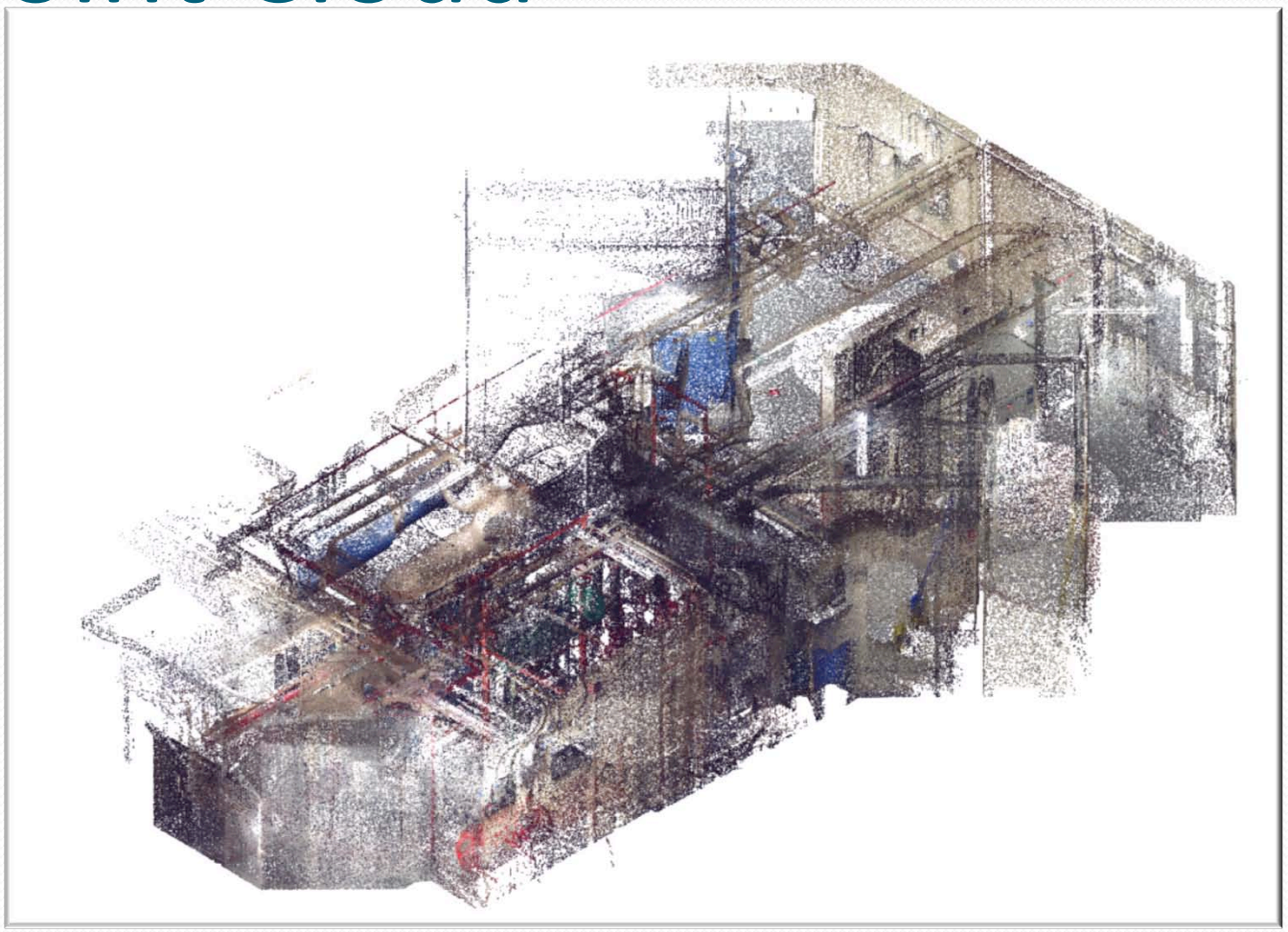
- 360 x 180 photographic image sphere
- Targets indicate other scan locations

Scaleable Images



- Point cloud is underlayed with the visual images.
- Images can be measured

3d Point Cloud



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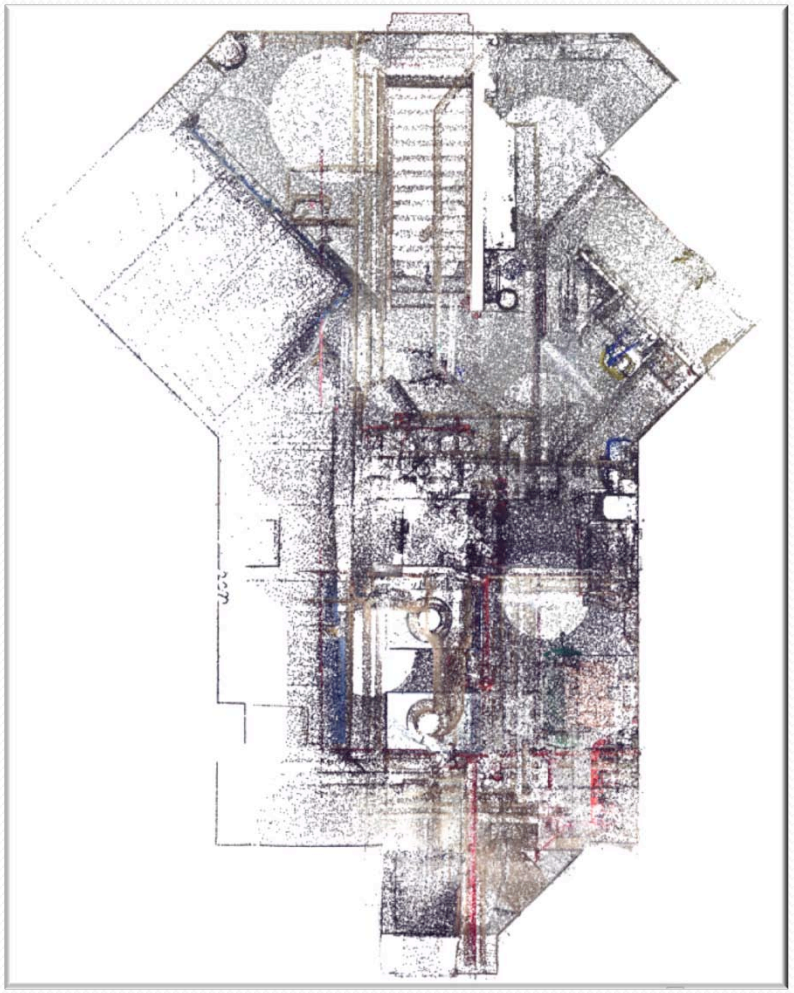
Point Cloud – Top View



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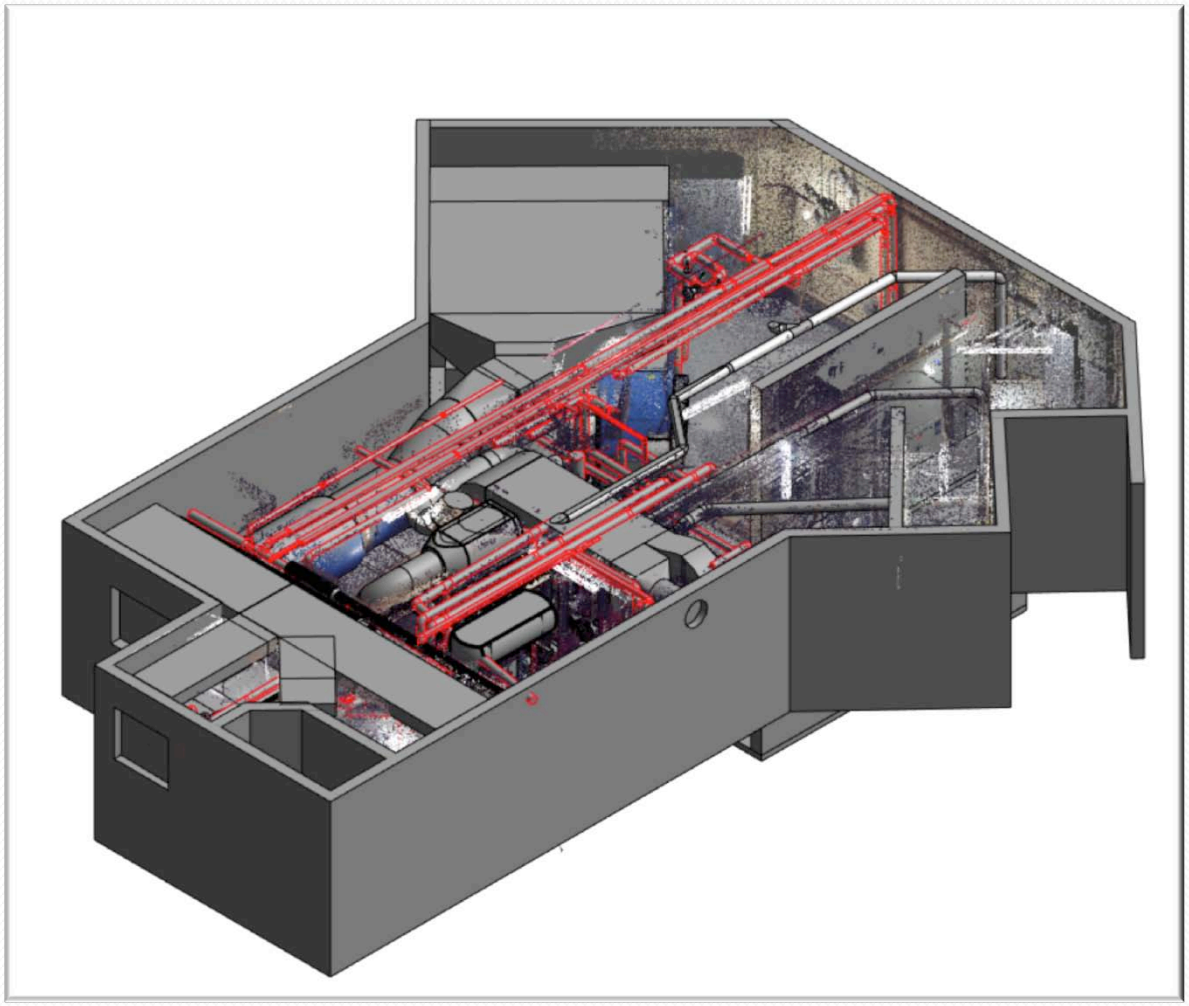
Convert point cloud to Revit



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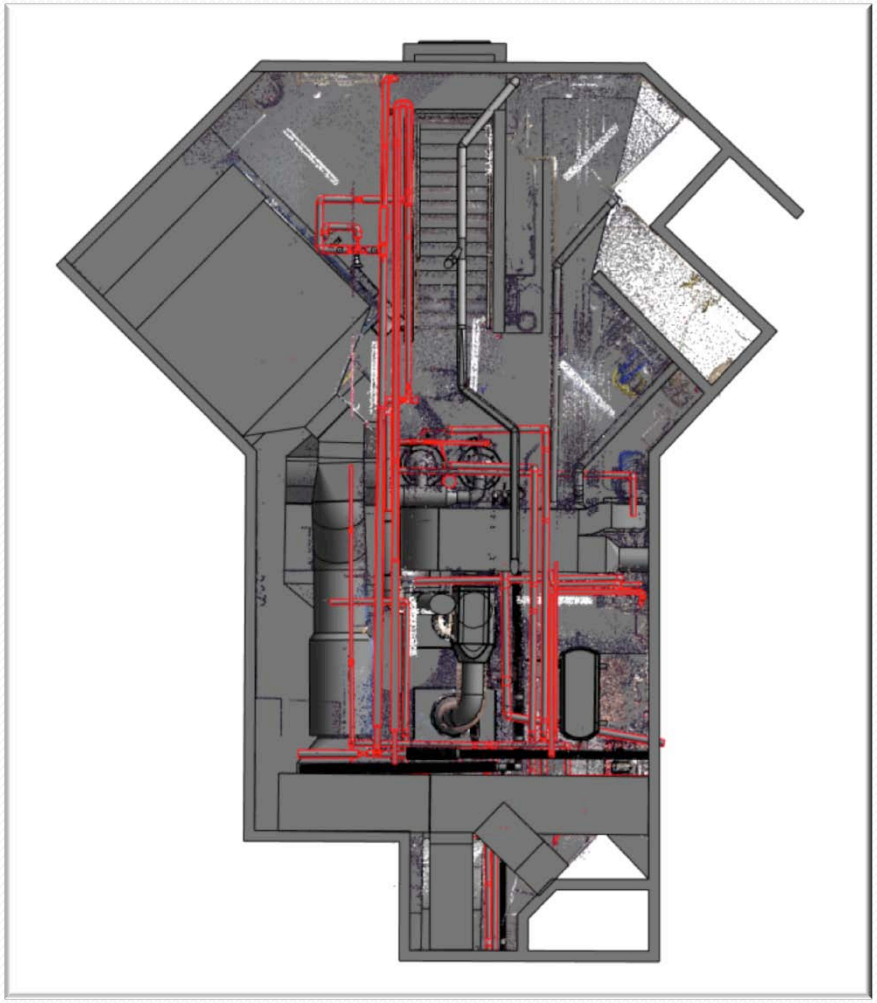
Revit - Top View



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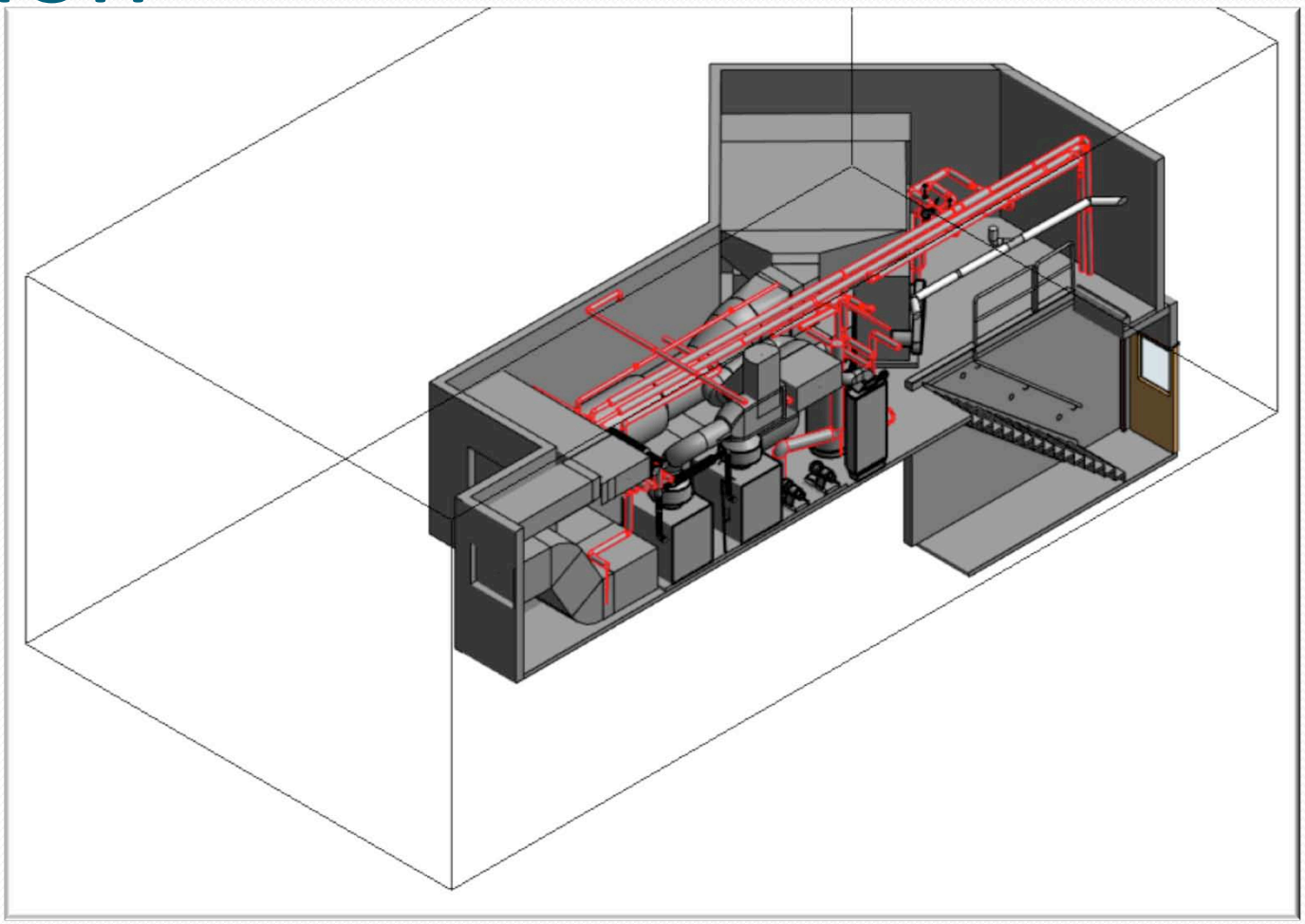
3d Section



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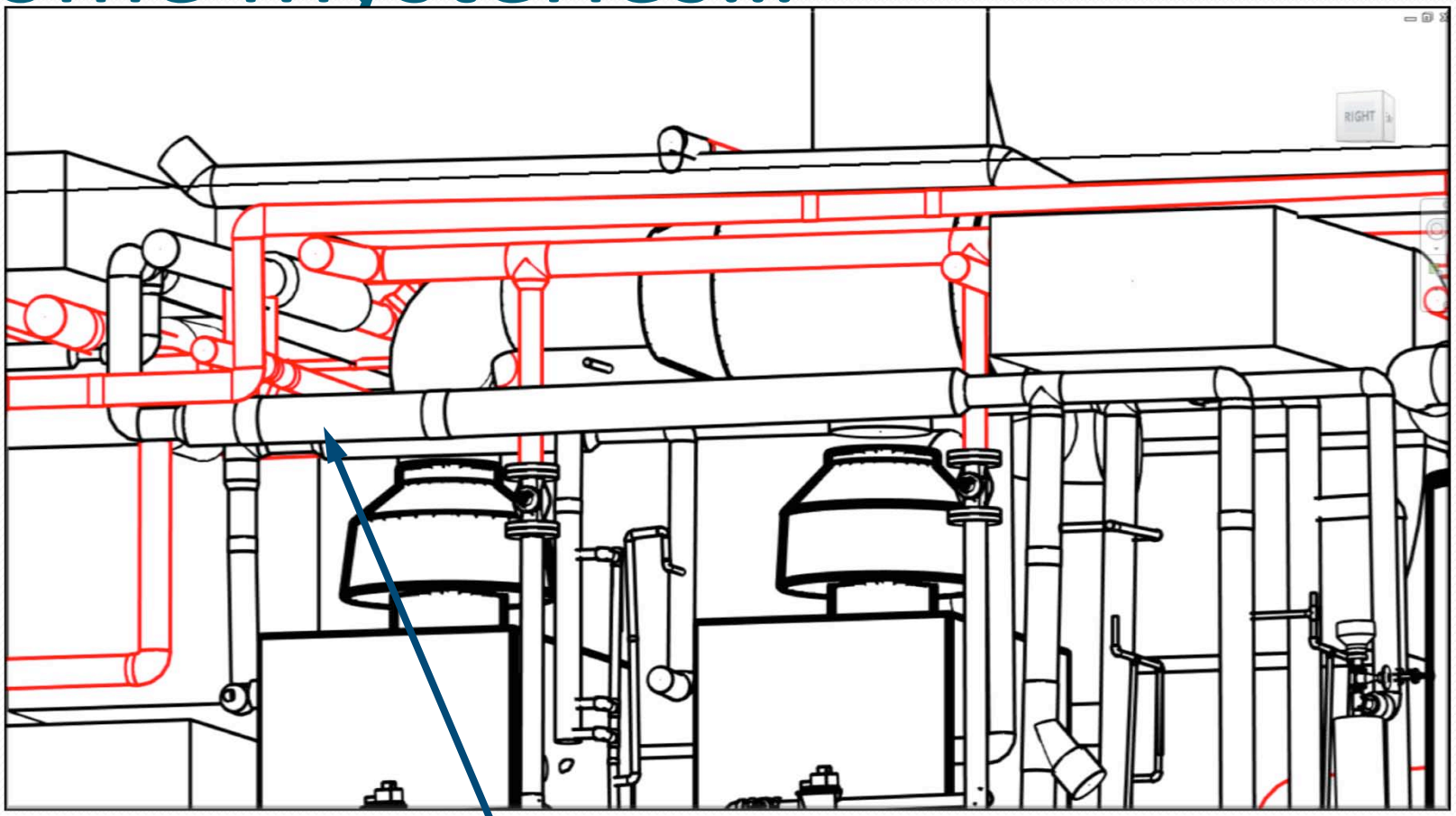
Some Mysteries…



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Pipe increases in size, then reduces?

Some Mysteries…

Pipe insulation removed.

Strange Geometry

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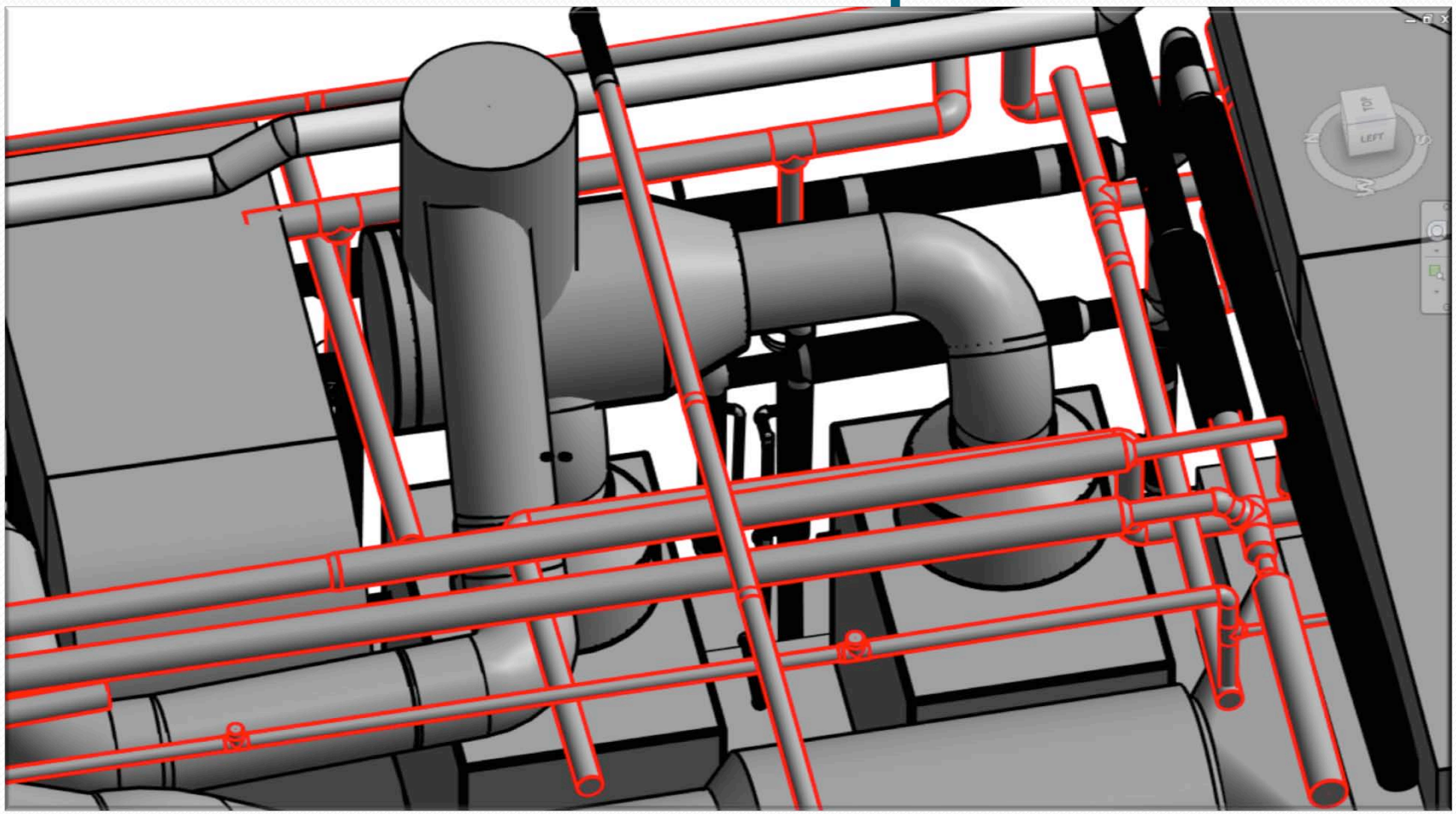
Some Revisions Required



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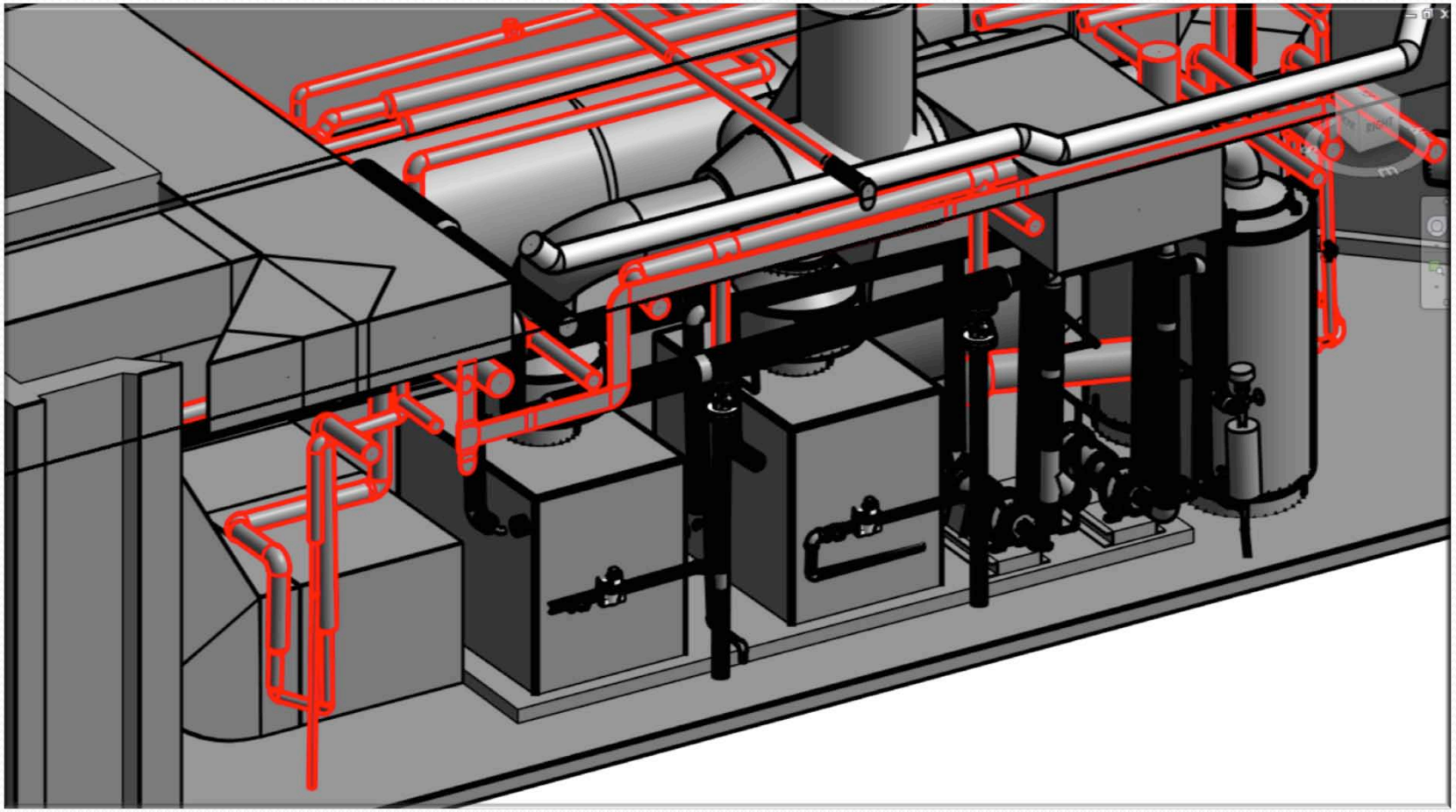
Existing Conditions



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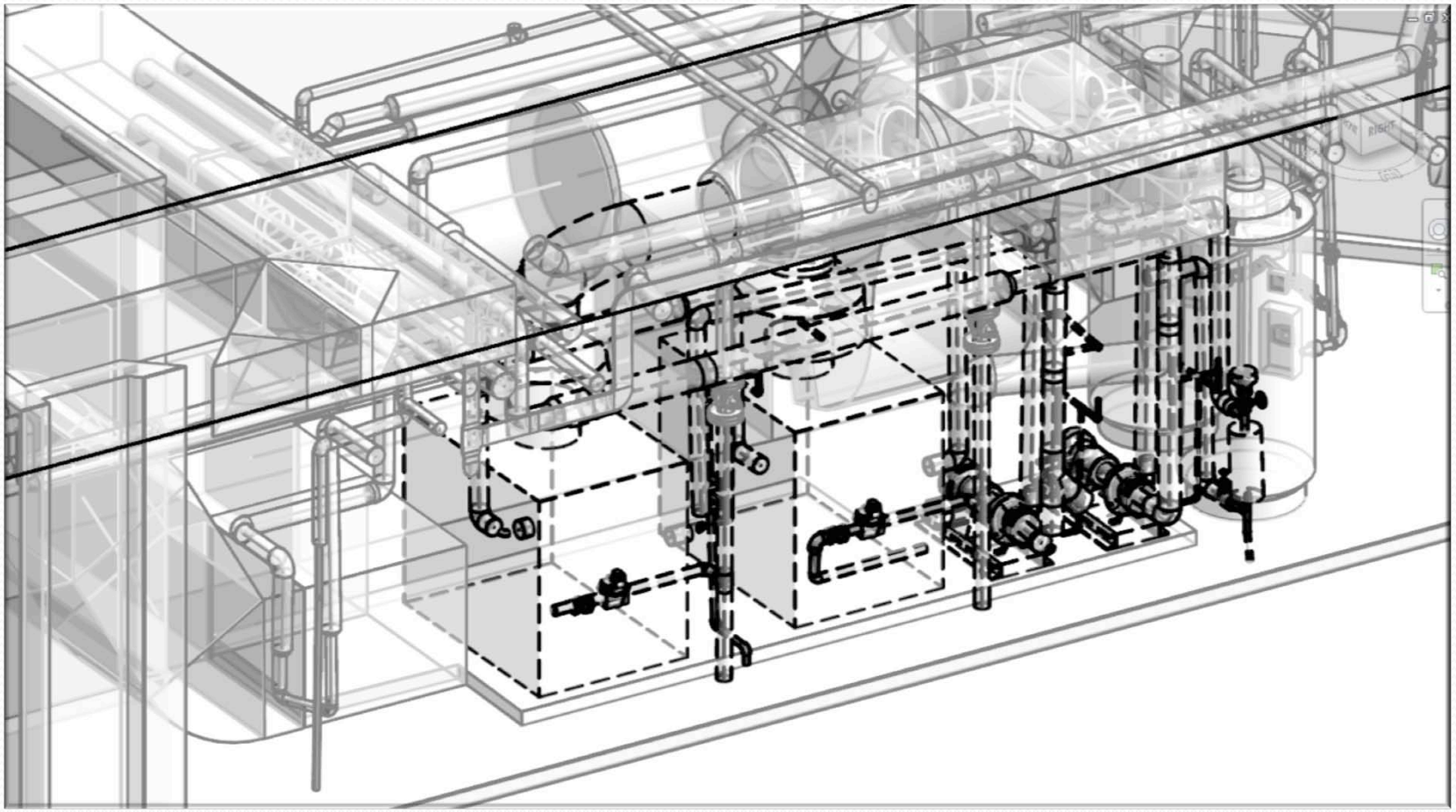
Demolition Plans



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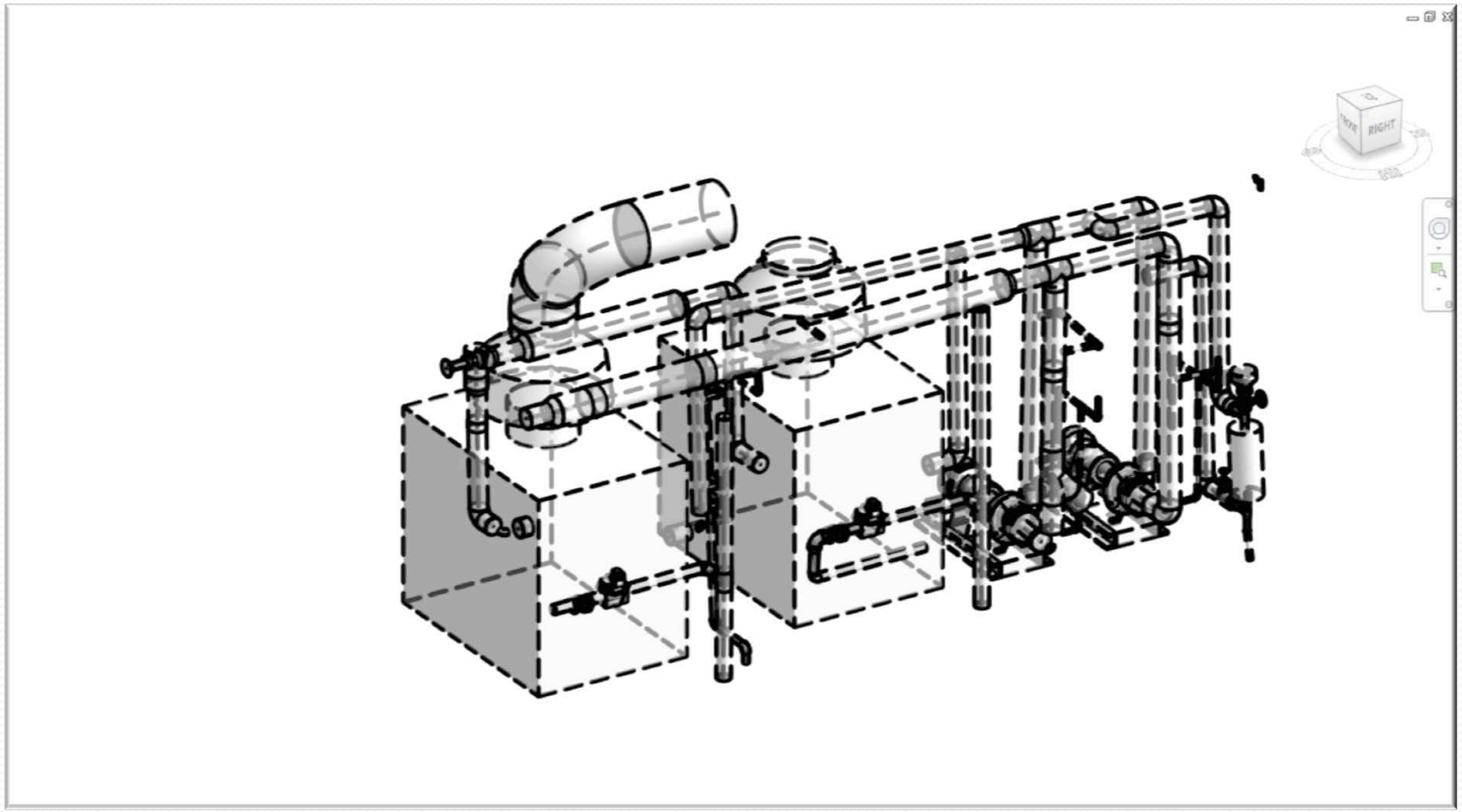
Demolition Items



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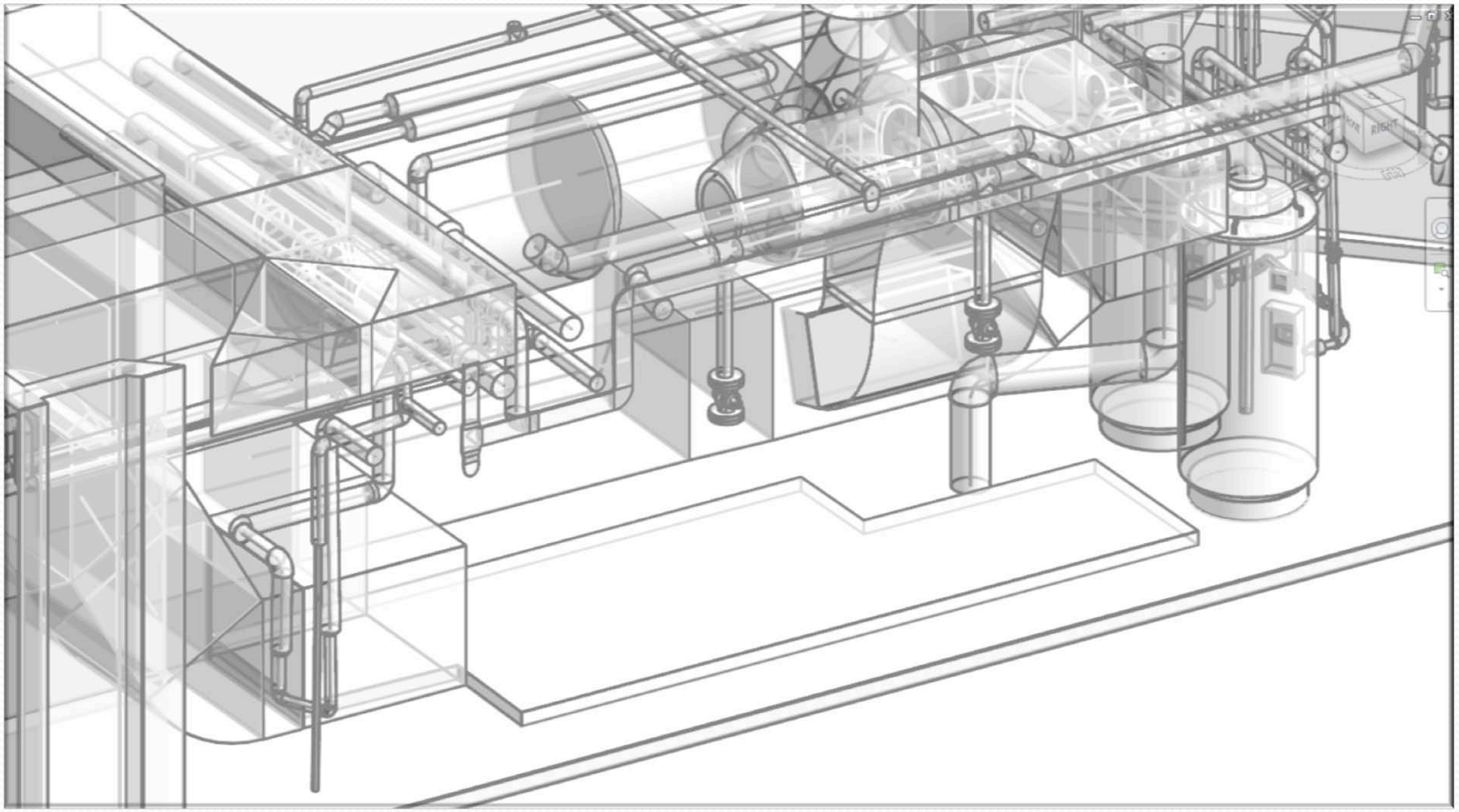
Demolished items removed



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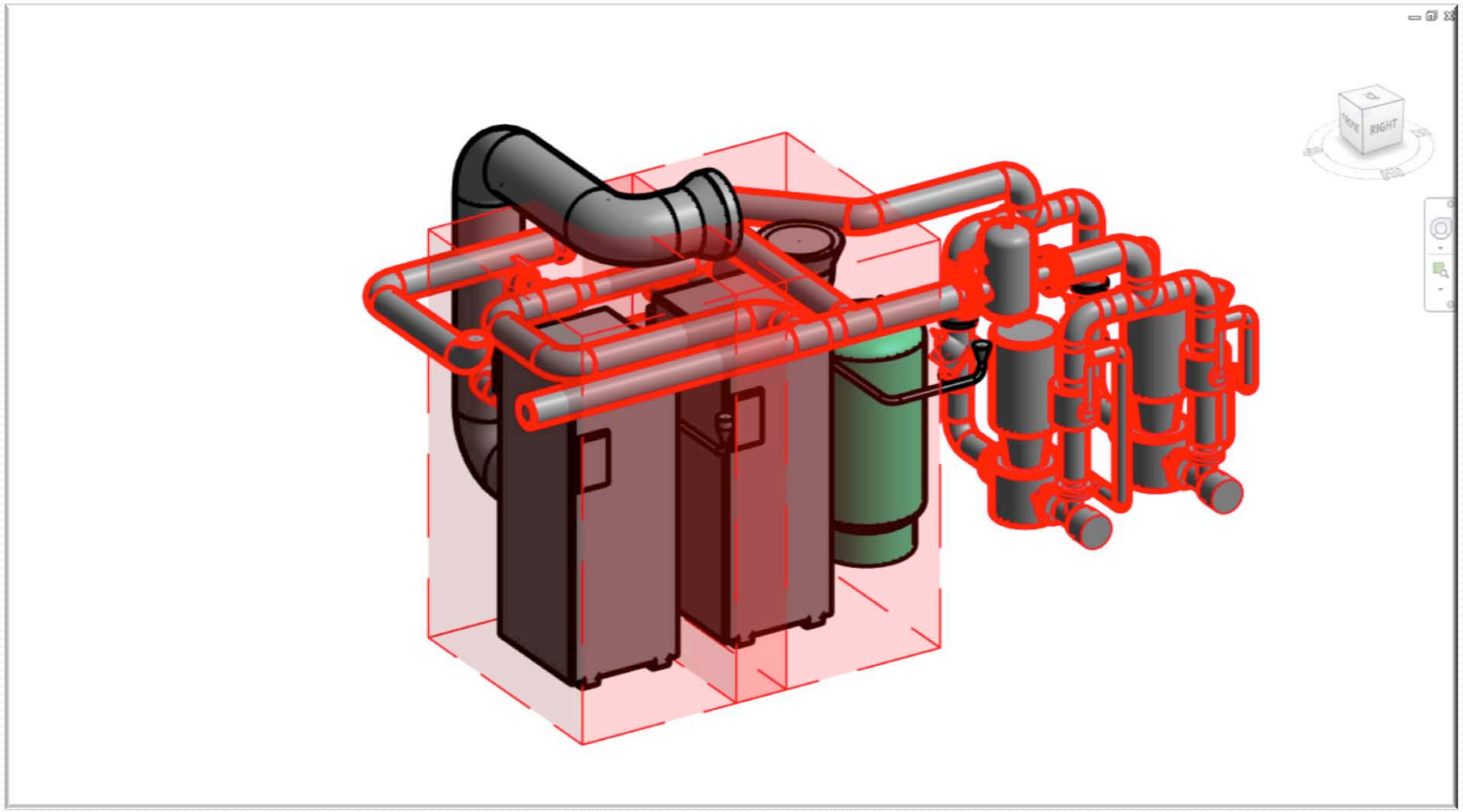
New Items Only



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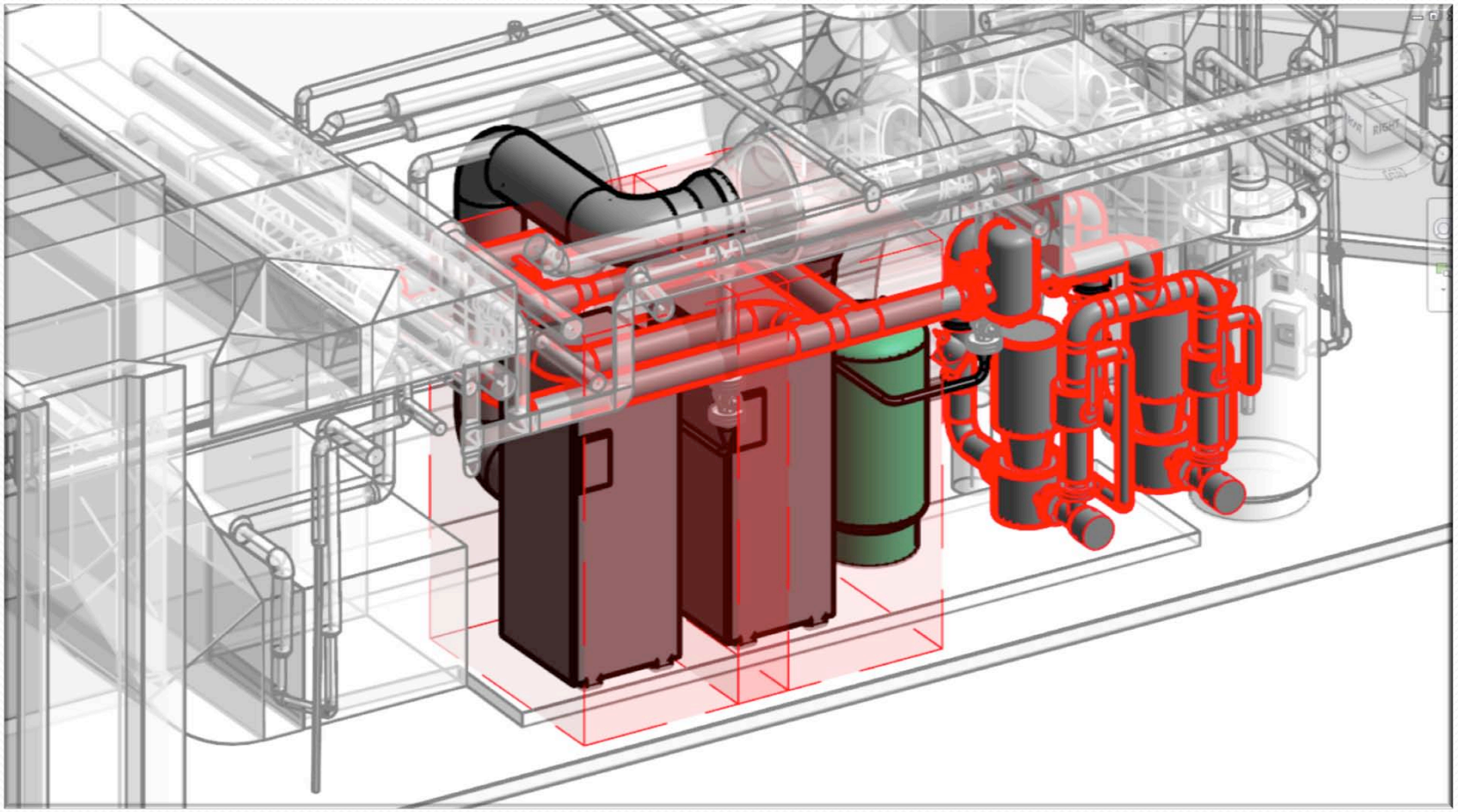
New Items Only



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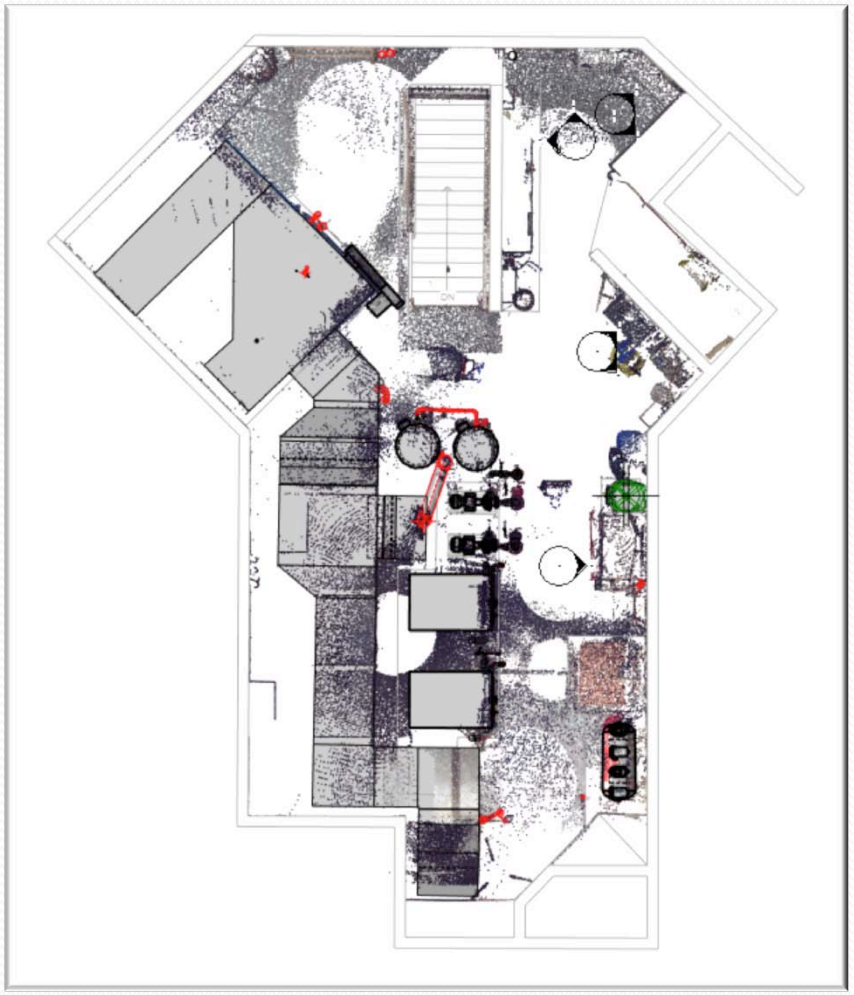
Added Benefits: Elevations



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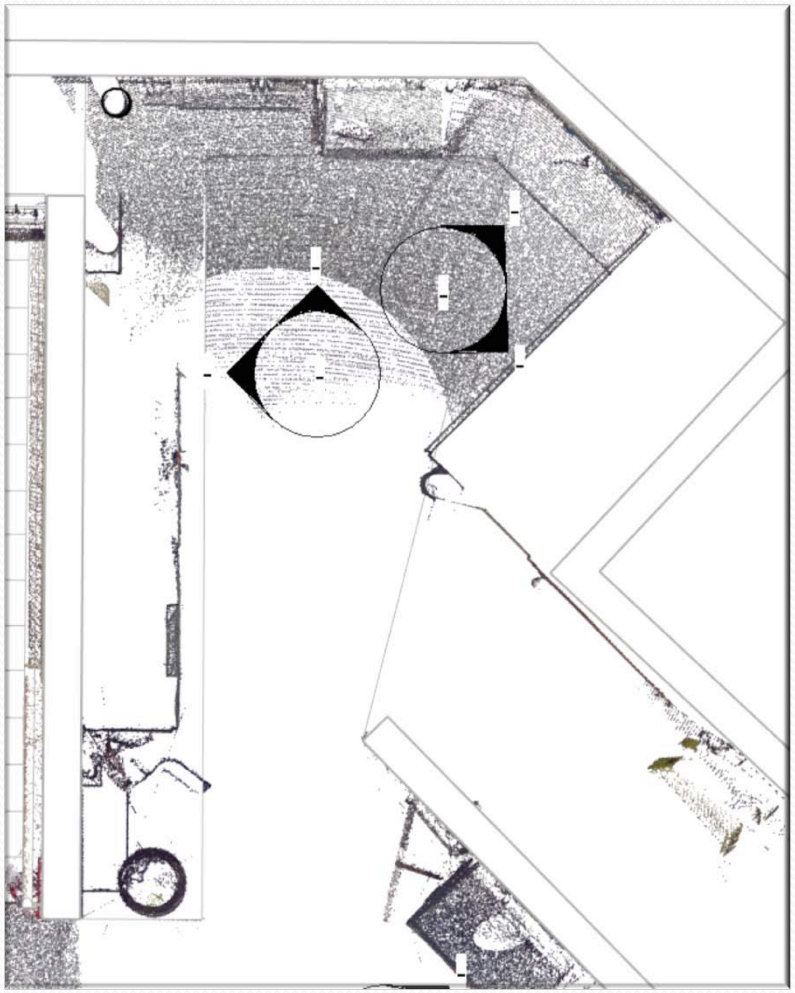
Electrical Area



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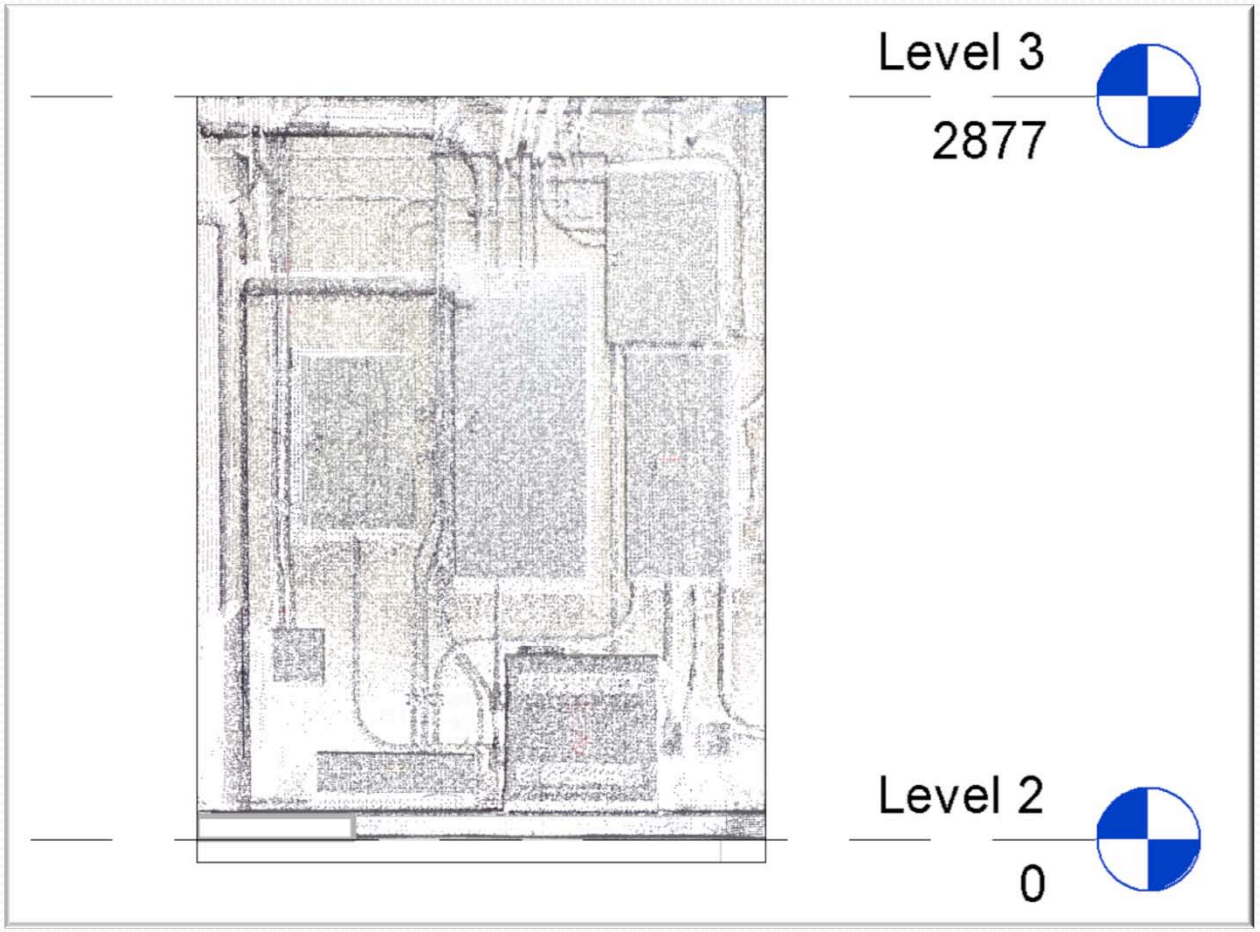
Electrical Elevation



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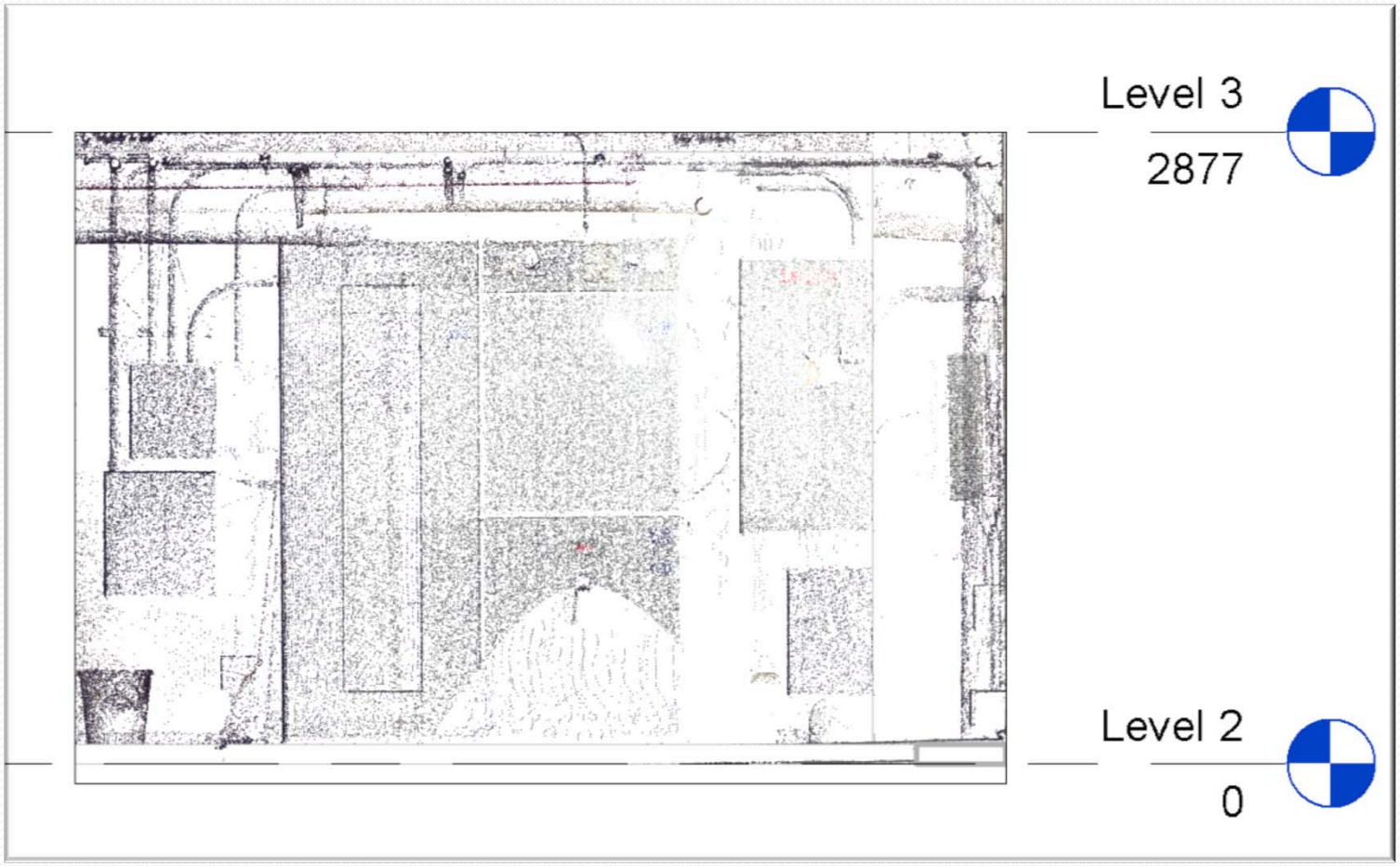
Electrical Elevation



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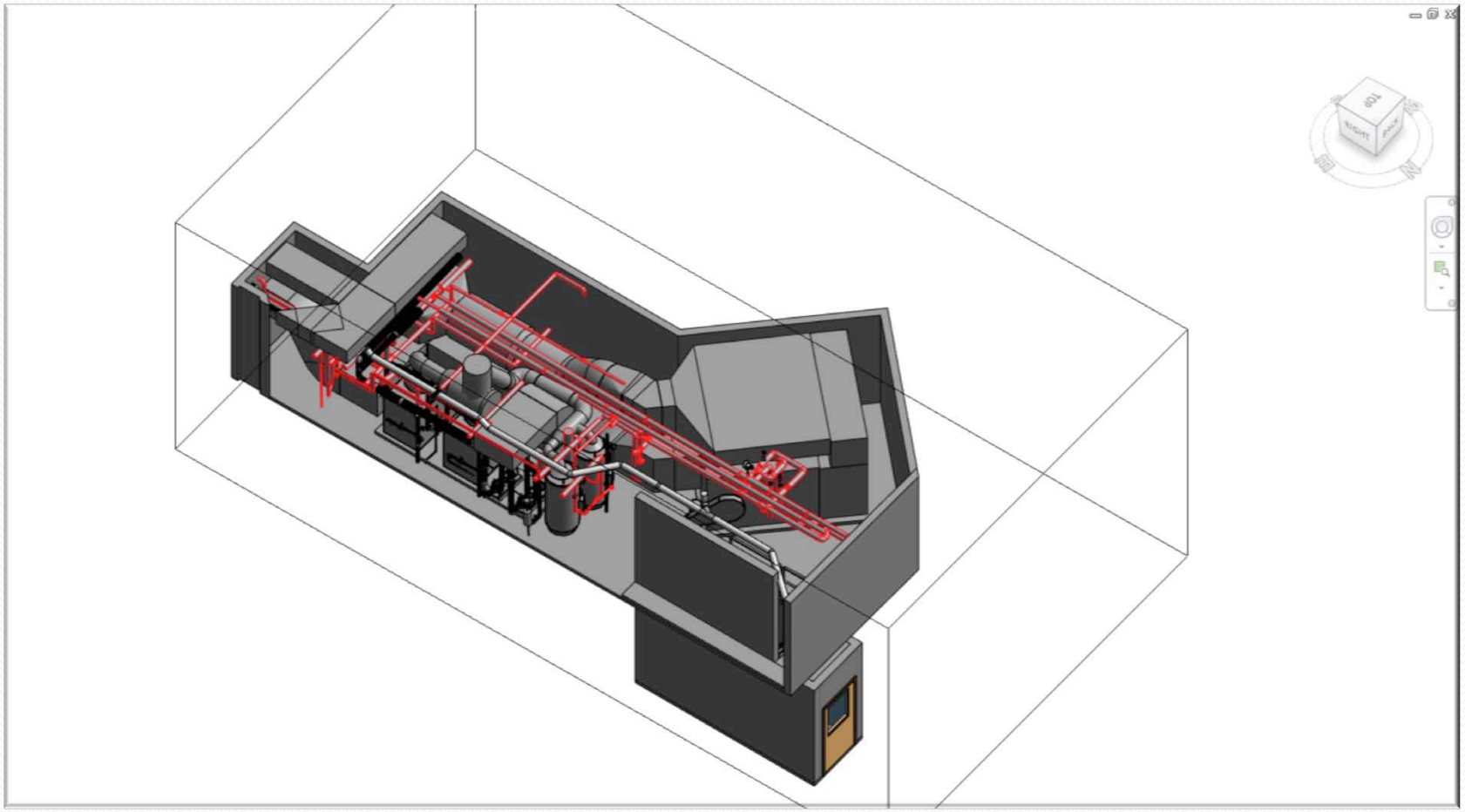
Where is the Combustion Air?

- Need to confirm combustion air sizing for new boilers.
- Cannot find combustion air in any view or photo.
- Does not appear in the model

Some Photos from site.

Where is the Combustion Air?



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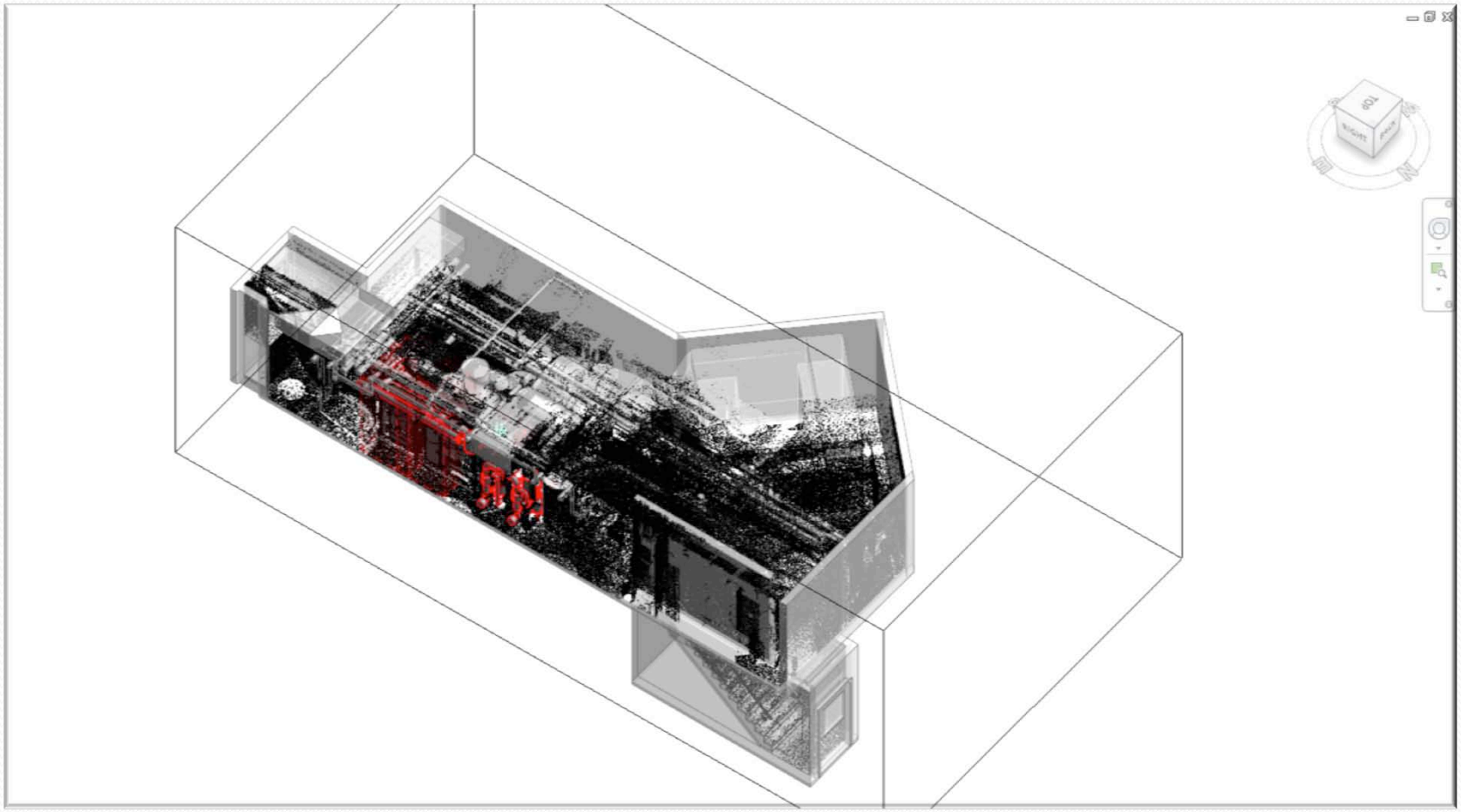
Turn on the point cloud



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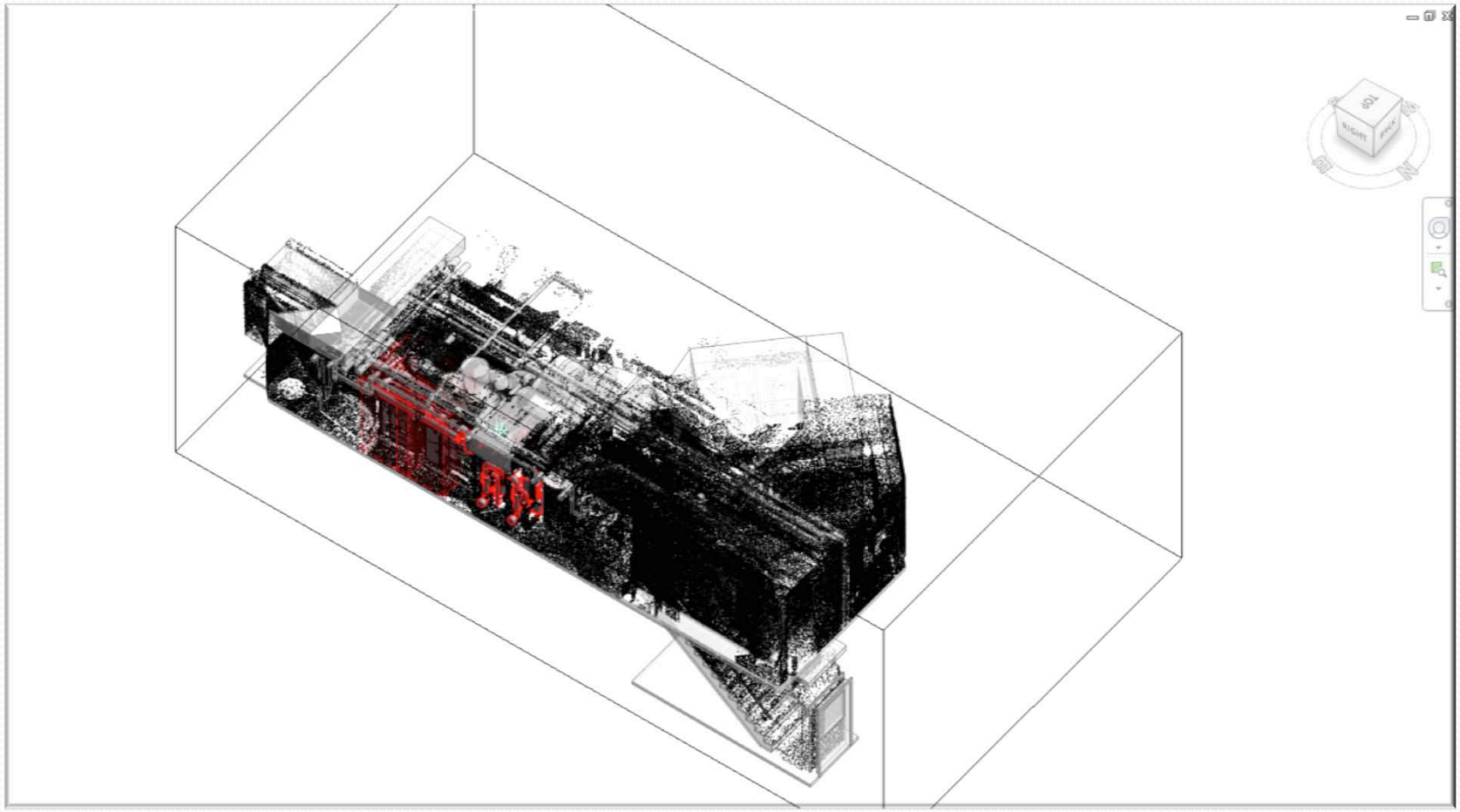
Turn off the walls.



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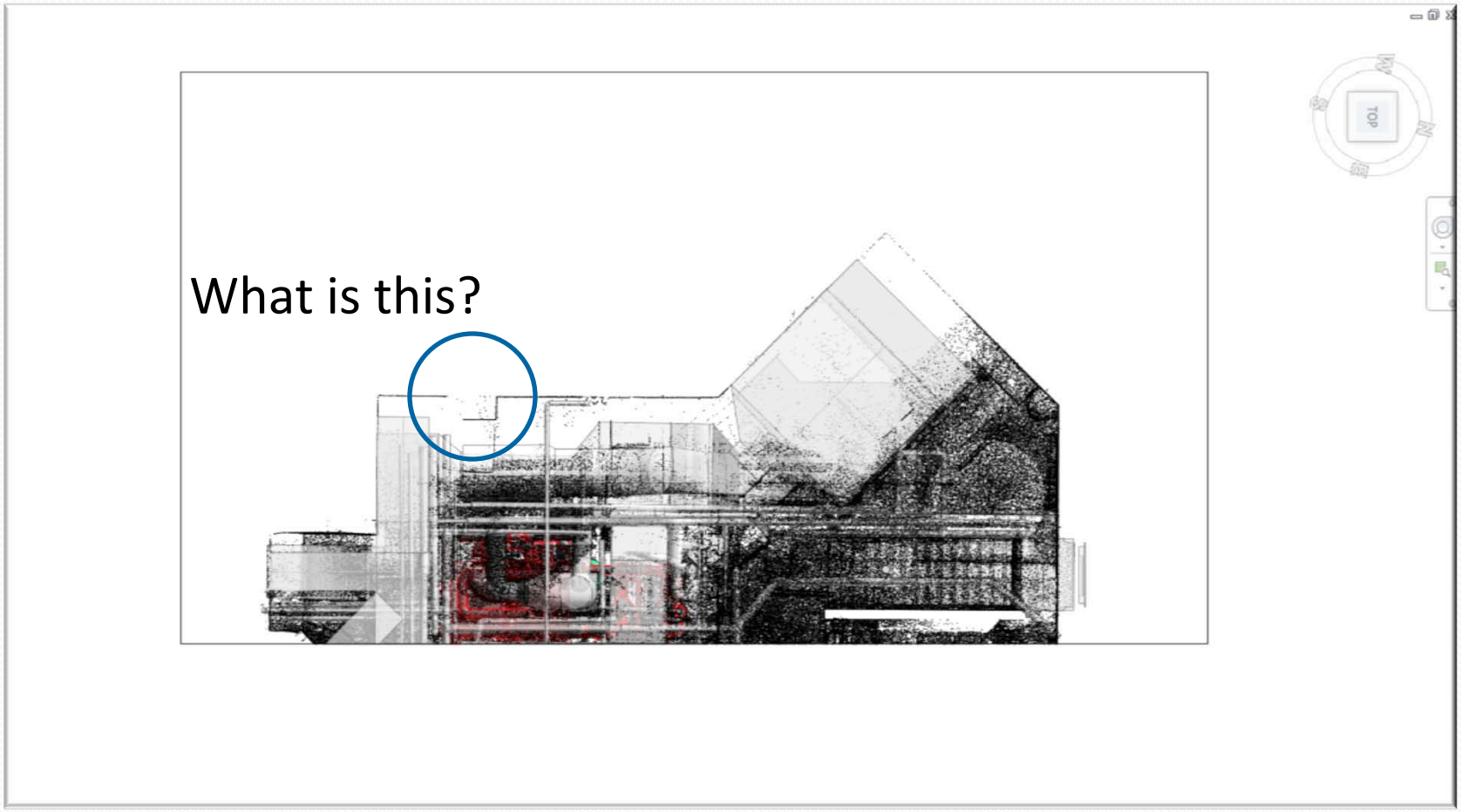
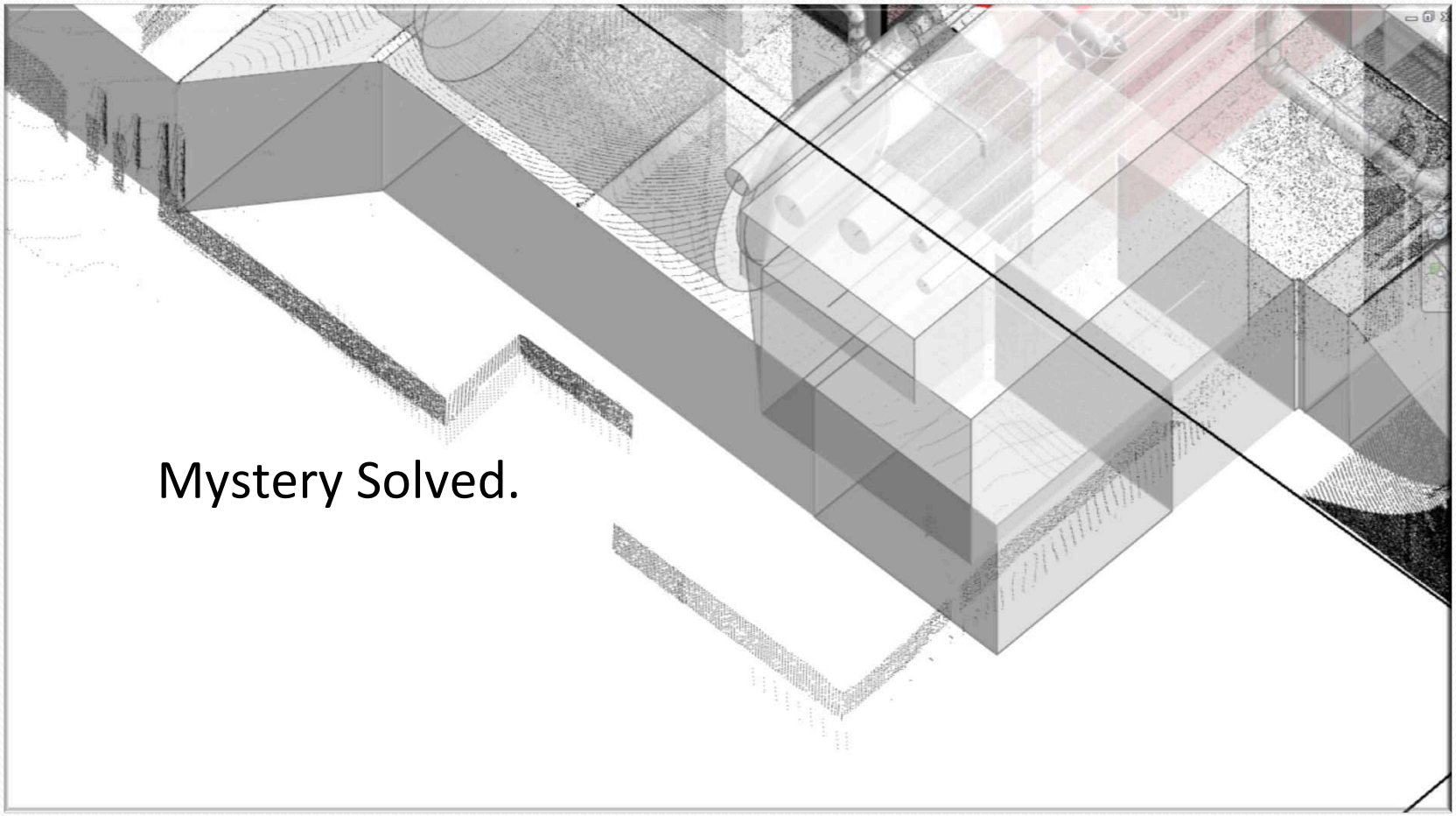
Top View



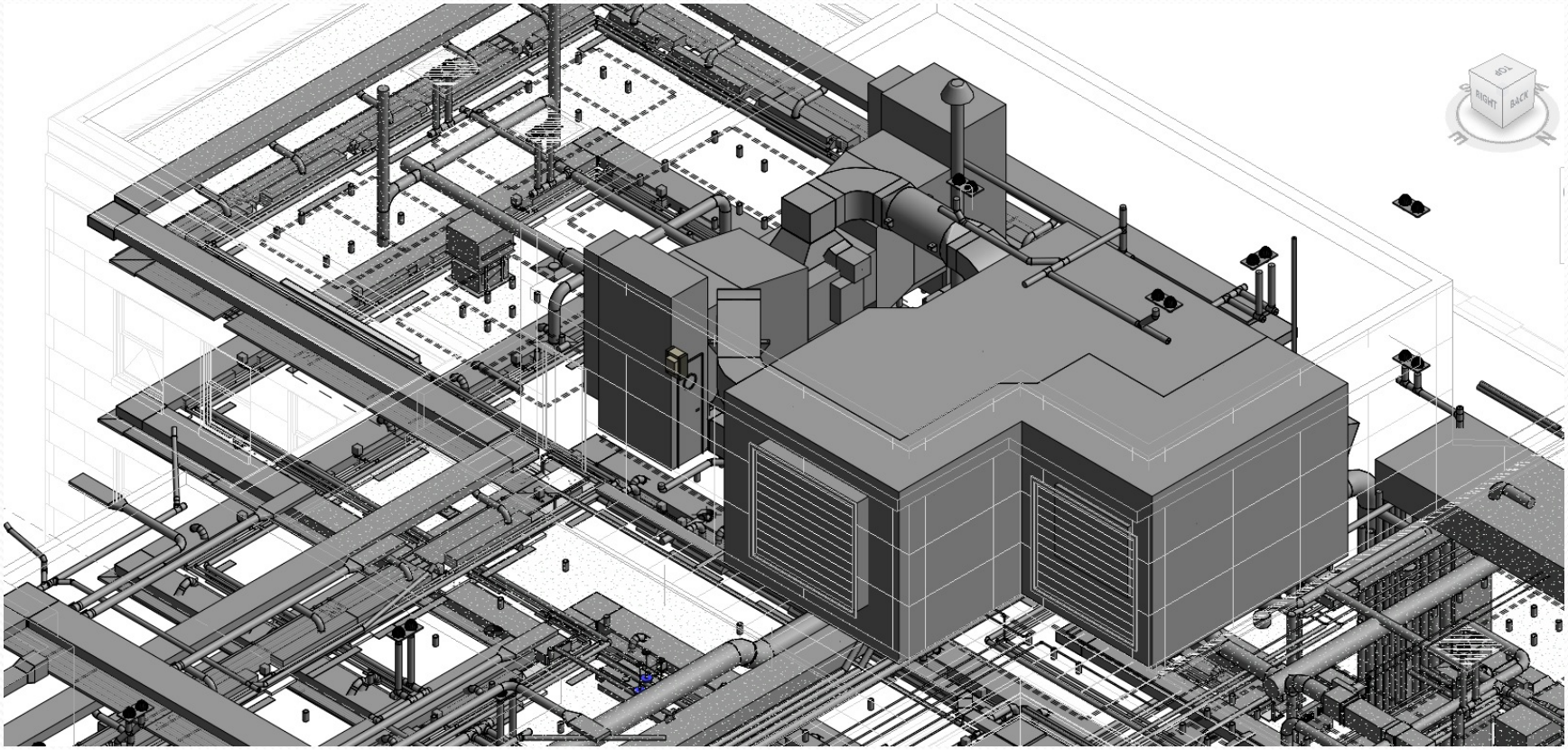
Rotate the view.



Applications for Labs

- Is BIM and Laser Scanning the right choice?
- Investment in Design leads to Payback in construction.
- May increase design time.
- Increase design accuracy.
- Decrease site confusion.
- Decrease coordination related changes
- Clearer documents lead to lower tenders

Thank You!



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