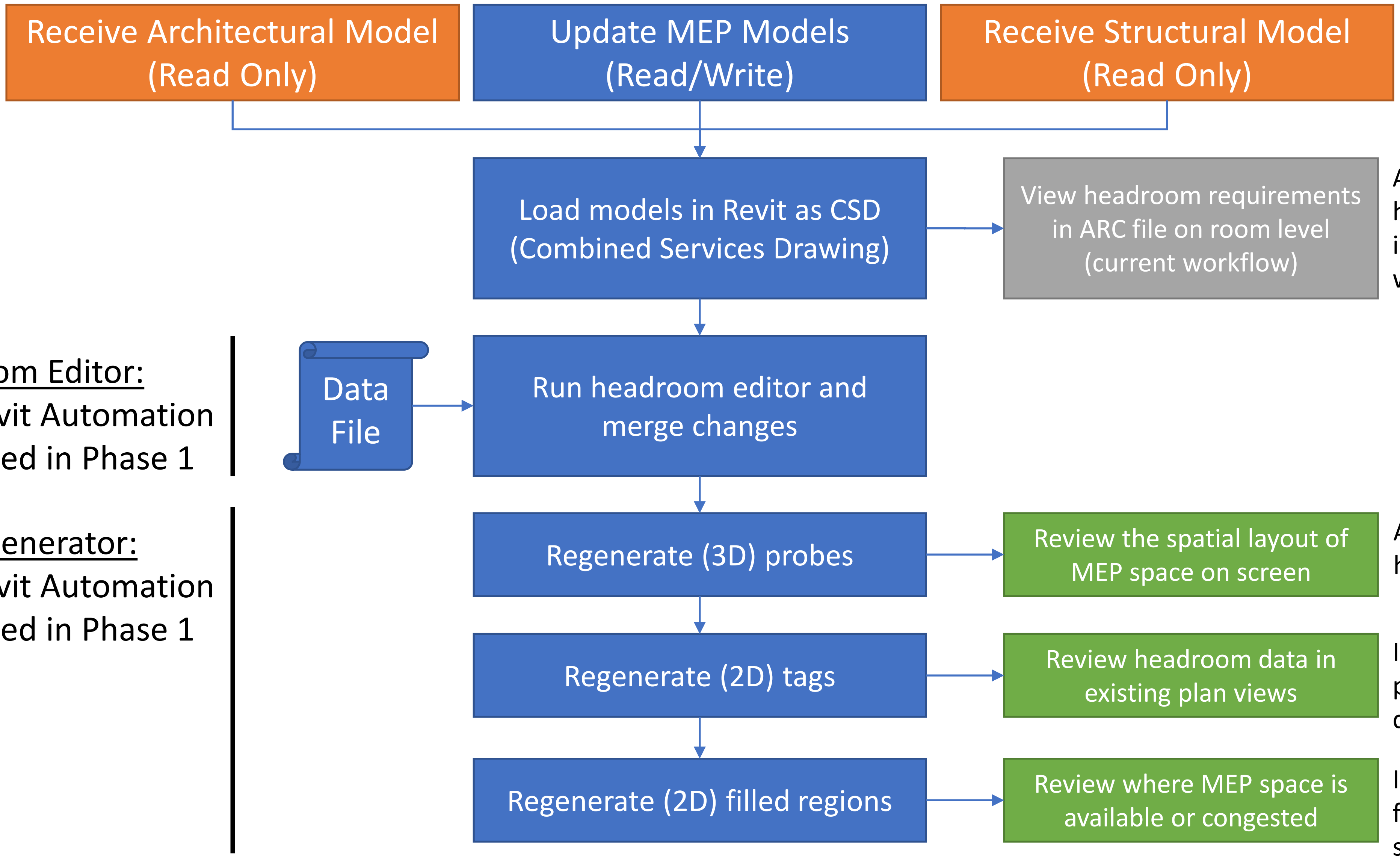
MEP Auto-Routing Automation Phase 1 Overall Space Probing Workflow



Receive Architectural Model (Read Only)

Update MEP Models (Read/Write)

Receive Structural Model (Read Only)

Load models in Revit as CSD (Combined Services Drawing)

View headroom requirements in ARC file on room level (current workflow)

Available MEP headroom is not visible in plan views with this workflow

<u>Headroom Editor:</u>
New Revit Automation developed in Phase 1

Data File

Run headroom editor and merge changes

<u>Probe Generator:</u>
New Revit Automation developed in Phase 1

Regenerate (3D) probes

Review the spatial layout of MEP space on screen

Available MEP headroom indicated

Regenerate (2D) tags

Review headroom data in existing plan views

Information can be presented in standard drawing format

Regenerate (2D) filled regions

Review where MEP space is available or congested

Information can be further condensed and simplified in standard drawing format

Revised 5 August 2017

Headroom Editor

Headroom Editor:
New Revit Automation
developed in Phase 1

Data File
Run headroom editor and merge changes

- New Revit Automation Developed in Phase 1
- Uses a data file that is stored side by side with the architectural model
  - Stores schedule with headroom information entered manually for all rooms in the architectural model that do not have a ceiling element
  - Used by space probing in the following workflow to generate probes
- Presents a user interface where users can:
  - Review architectural space data obtained from the architectural model
  - Review and modify headroom requirements and the probing mode for each room

Headroom Editor User Interface

- Core view is a grid view where each line item is an architectural room
- Table allows viewing and editing data for each line item

Columns retrieved from architectural model. Read Only.						Metadata. Read Only.		User editable columns.	
RVT File Name	Room Name	Room Element ID	Ceiling Detected (Yes/No)	Ceiling Type (Flat/Custom)	Ceiling Level (mm)	Mapped Room Name	Mapped Element ID	Custom Headroom (mm)	Probe Mode (Auto/Ceiling/ Headroom)

We would like to handle ceilings that are not flat. In this case, there is no single value that can represent the ceiling level

For flat ceilings, we can detect the base ceiling level

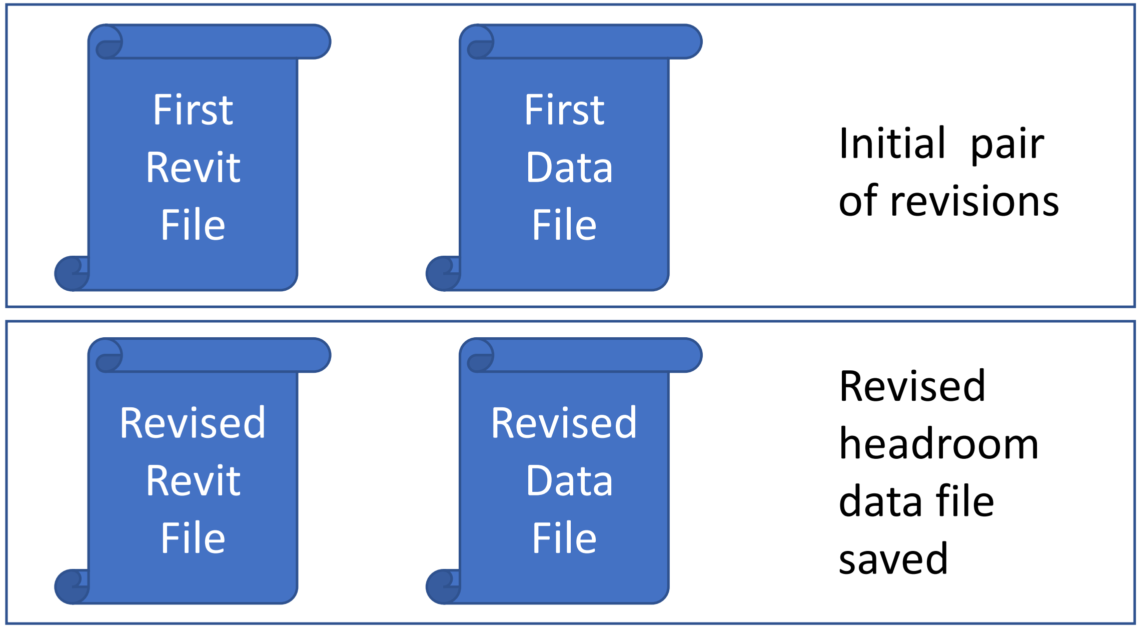
We need to maintain the mapped room element ID to map data to revised RVT files

Rooms without ceilings need manual headroom entry

Auto = favor ceiling mode, fall back to headroom if no ceiling found

Headroom Editor Data Storage

- Headroom data is planned to be stored side by side with the architectural model
- When the architectural model is replaced, the known headroom data can be re-associated again



Probing Modes

- Three modes proposed
  - Auto: Use ceiling level, if a ceiling element can be found. If no ceiling element found, use headroom that was manually entered. If headroom was not entered, or is zero, skip room
  - By Ceiling: Use ceiling if ceiling element found, otherwise, skip room.
  - By Headroom: Use headroom, if entered, otherwise, skip room even if ceiling element is found
- Users may use Auto for probing by default, and switch to Ceiling mode or Headroom mode if detailed control is needed
- This setting will be saved along with the headroom setting for the room in the custom data file

Headroom data mapping

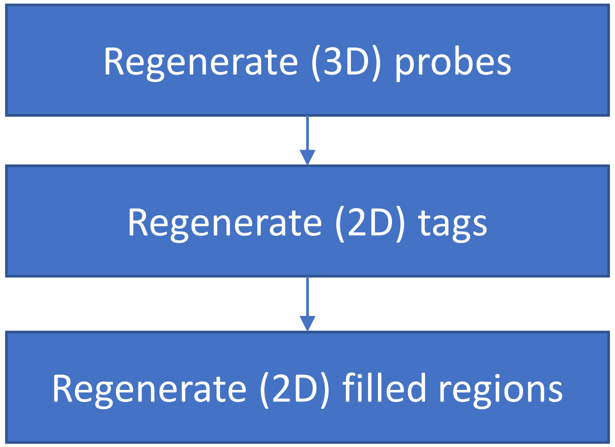
- We use the model name and element ID as compound key to map the room data
- When an updated model file is changed, we need to handle the following cases: room modified, room created, room deleted
- We first try to map to Element ID. If this fails, we can try to map by room name (in case the architect deleted and re-created the room with the same name). If this fails, the room data becomes un-mapped (orphaned) and may need to be re-entered
- Ideally, we could retrieve the headroom setting from the room element, but modifying the architectural model upstream is out of scope for this project

Headroom Data Schema (Technical)

- Revit File Name: String
- Room Name: string
- Element ID: int
- Ceiling Detected: bool
- Ceiling Type: enum
- Ceiling Level (mm): double
- Probe Mode: enum

Probe Generator

- New Revit Automation developed in Phase 1
- Creates/Re-creates 3D probes, 2D tags and 2D filled regions
- Input data from headroom editor is required to run the probe regeneration
- Probes are required to regenerate tags
- Probes and tags are required to regenerate the filled regions



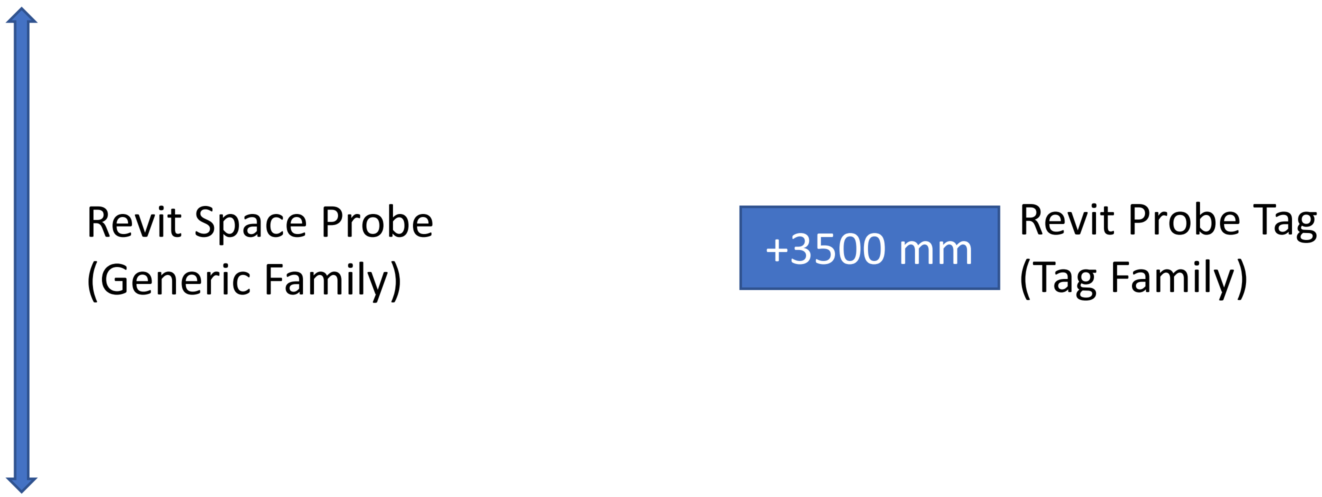
Regenerate (3D) probes

Regenerate (2D) tags

Regenerate (2D) filled regions

Probe and Tag Structure

- The probe is a 3D probe “arrow” that is inserted into the model at a 3D position
- We can tag this probe in 2D views and the tag will be updated according to changes to the probe, Revit keeps them in sync



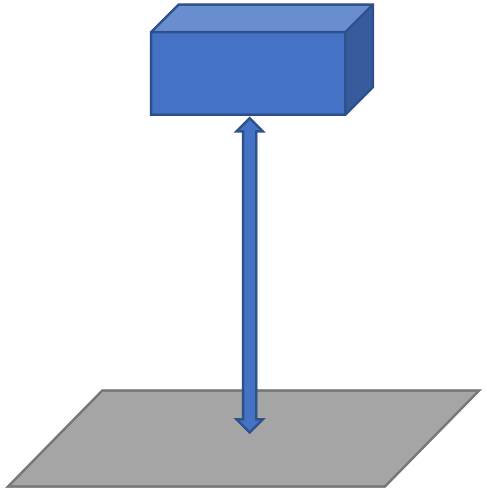
Revit Space Probe
(Generic Family)

+3500 mm

Revit Probe Tag
(Tag Family)

Probe Generation

- We locate the lowest point of MEP/structural elements in Z, providing an (x,y,z) coordinate
- We place/update the probe at this position and project the probe to the intersection of the ceiling or headroom level, depending on whether the ceiling exists and the probe setting

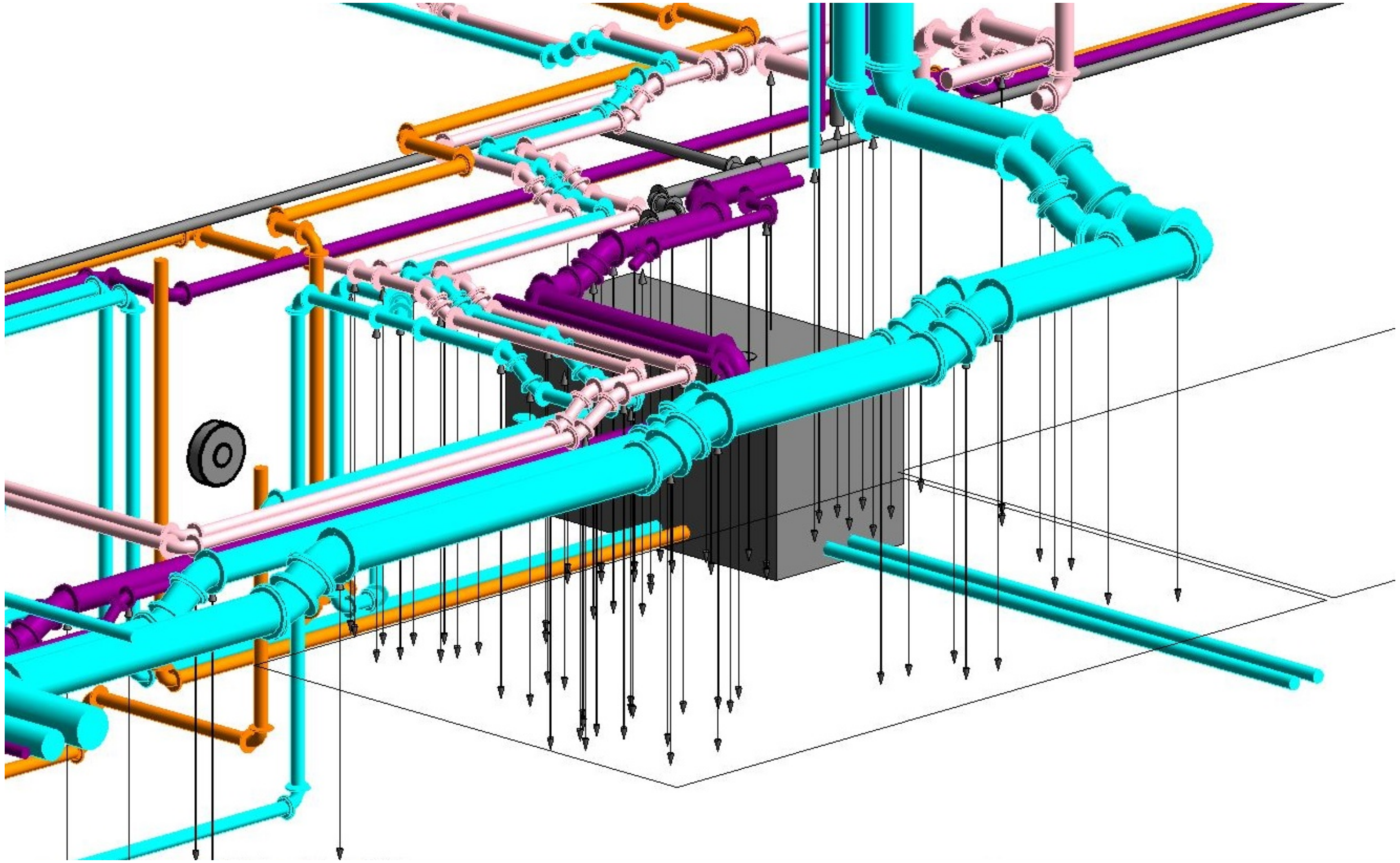


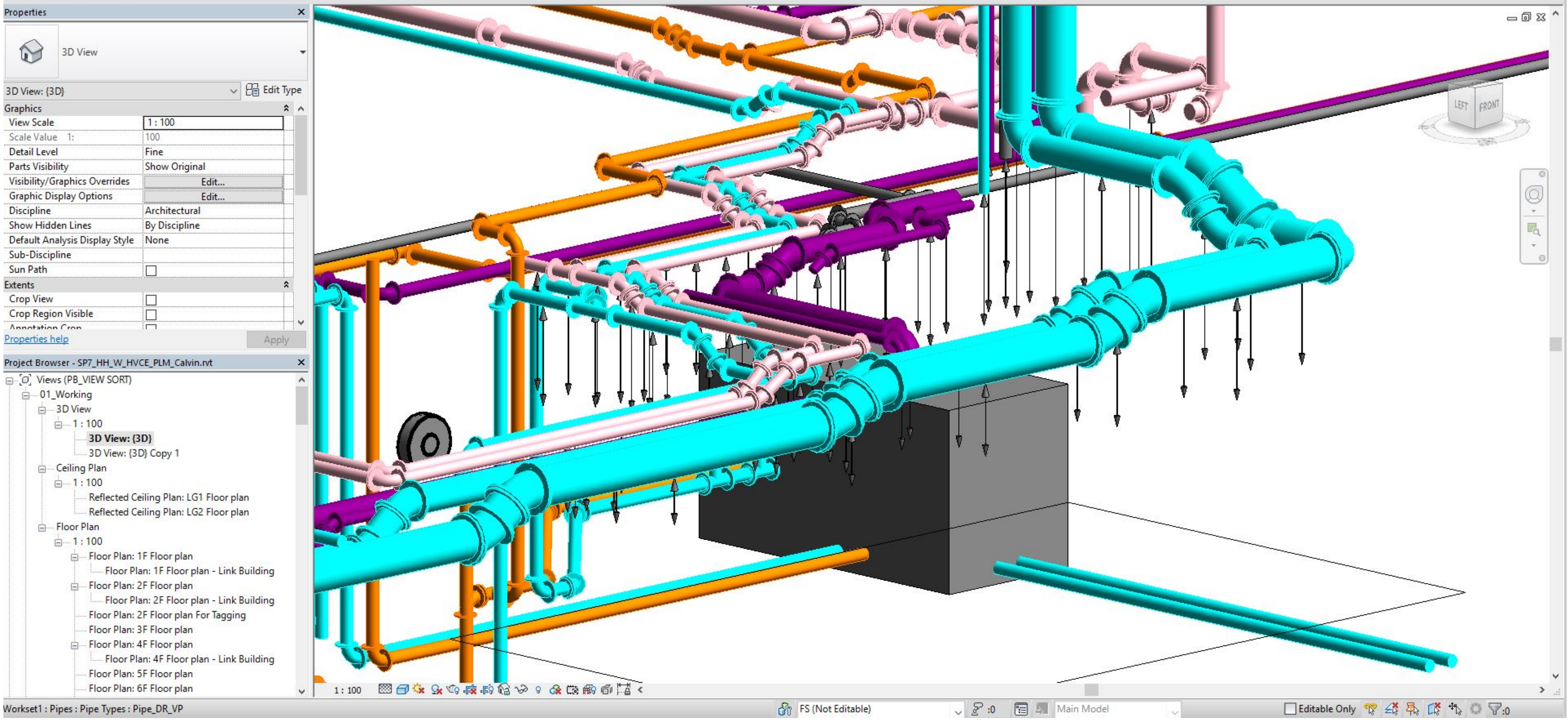
Existing MEP/structural element
(not modified by the probe)

Inserted space probe

Ceiling
level/headroom level

Probe Generation Proof of Concept





Properties

3D View

3D View: {3D}

Edit Type

Graphics

View Scale	1 : 100
Scale Value 1:	100
Detail Level	Fine
Parts Visibility	Show Original
Visibility/Graphics Overrides	Edit...
Graphic Display Options	Edit...
Discipline	Architectural
Show Hidden Lines	By Discipline
Default Analysis Display Style	None
Sub-Discipline	
Sun Path	□

Extents

Crop View	□
Crop Region Visible	□
Annotation Crop	□

Properties help

Apply

Project Browser - SP7_HH_W_HVCE_PLM_Calvin.rvt

```
Views (PB_VIEW SORT)
    01_Working
        3D View
            1 : 100
                3D View: {3D}
                3D View: {3D} Copy 1
        Ceiling Plan
            1 : 100
                Reflected Ceiling Plan: LG1 Floor plan
                Reflected Ceiling Plan: LG2 Floor plan
        Floor Plan
            1 : 100
                Floor Plan: 1F Floor plan
                    Floor Plan: 1F Floor plan - Link Building
                Floor Plan: 2F Floor plan
                    Floor Plan: 2F Floor plan - Link Building
                Floor Plan: 2F Floor plan For Tagging
                Floor Plan: 3F Floor plan
                Floor Plan: 4F Floor plan
                    Floor Plan: 4F Floor plan - Link Building
                Floor Plan: 5F Floor plan
                Floor Plan: 6F Floor plan
```

Workset1 : Pipes : Pipe Types : Pipe_DR_VP

FS (Not Editable)

:0

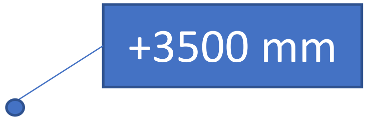
Main Model

□ Editable Only

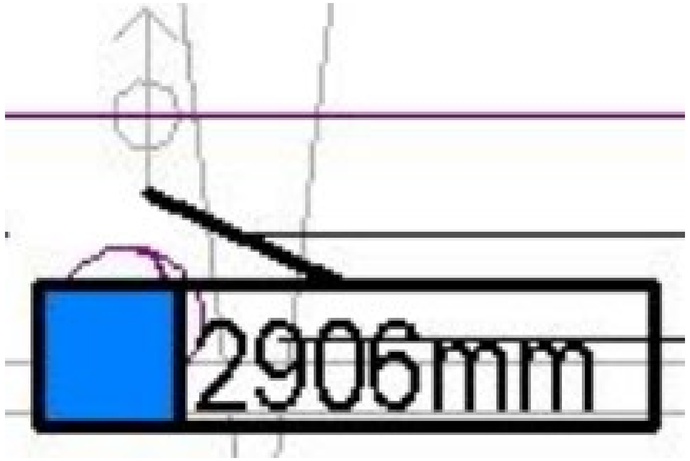
:0

Tag Generation

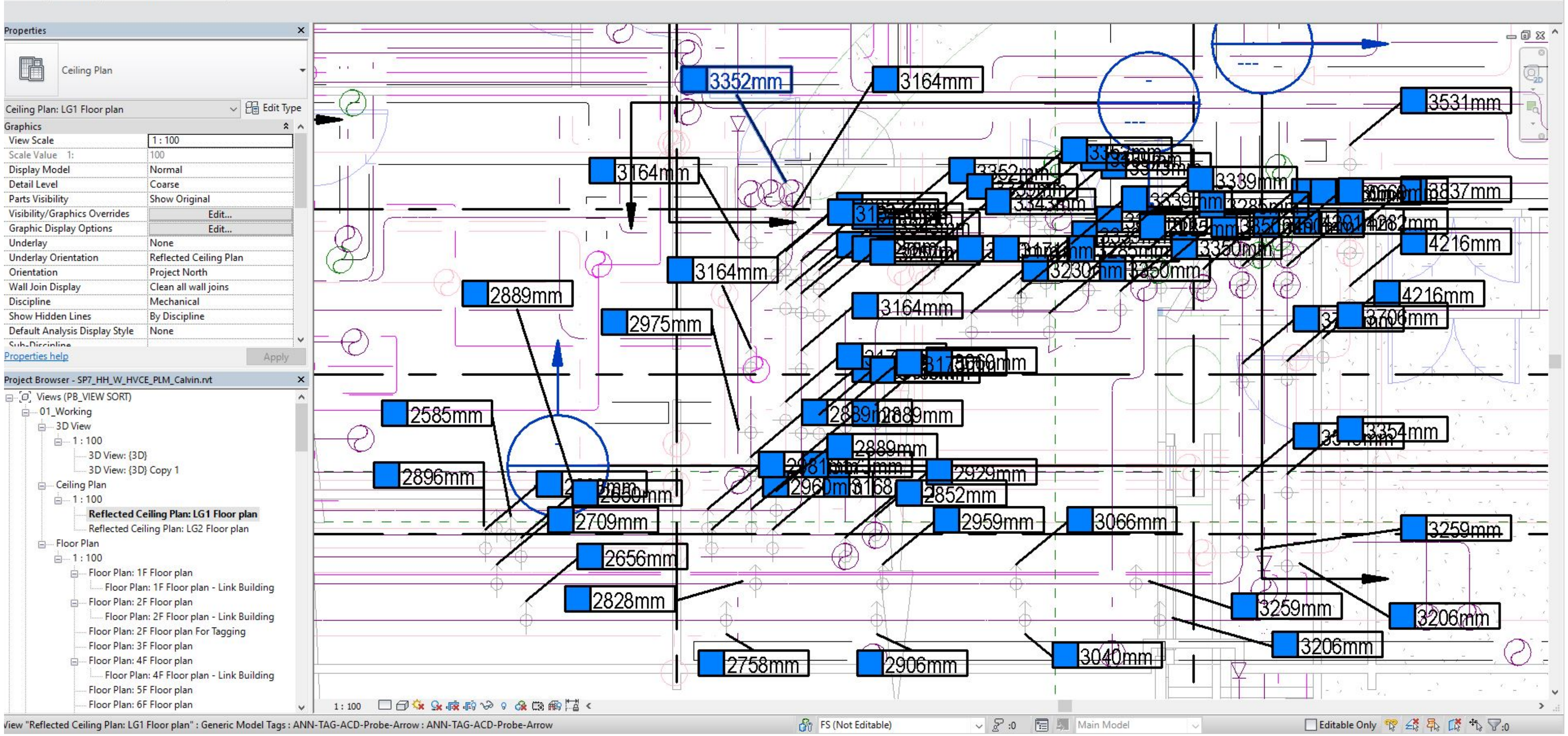
- The probe is used as the tagged element when placing out tags in the reflected ceiling plans
- These tags can map to probe properties, specifically, we use the probe height to show the available headroom in the tag



+3500 mm



Proof of Concept Tag Generation



Properties

Ceiling Plan

Ceiling Plan: LG1 Floor plan — Edit Type

Graphics	
View Scale	1 : 100
Scale Value 1:	100
Display Model	Normal
Detail Level	Coarse
Parts Visibility	Show Original
Visibility/Graphics Overrides	Edit...
Graphic Display Options	Edit...
Underlay	None
Underlay Orientation	Reflected Ceiling Plan
Orientation	Project North
Wall Join Display	Clean all wall joins
Discipline	Mechanical
Show Hidden Lines	By Discipline
Default Analysis Display Style	None
Sub-Discipline	

Properties help — Apply

Project Browser - SP7_HH_W_HVCE_PLM_Calvin.rvt

- Views (PB_VIEW SORT)
  - 01_Working
    - 3D View
      - 1 : 100
        - 3D View: {3D}
        - 3D View: {3D} Copy 1
    - Ceiling Plan
      - 1 : 100
        - **Reflected Ceiling Plan: LG1 Floor plan**
        - Reflected Ceiling Plan: LG2 Floor plan
    - Floor Plan
      - 1 : 100
        - Floor Plan: 1F Floor plan
          - Floor Plan: 1F Floor plan - Link Building
        - Floor Plan: 2F Floor plan
          - Floor Plan: 2F Floor plan - Link Building
        - Floor Plan: 2F Floor plan For Tagging
        - Floor Plan: 3F Floor plan
        - Floor Plan: 4F Floor plan
          - Floor Plan: 4F Floor plan - Link Building
        - Floor Plan: 5F Floor plan
        - Floor Plan: 6F Floor plan

View "Reflected Ceiling Plan: LG1 Floor plan" : Generic Model Tags : ANN-TAG-ACD-Probe-Arrow : ANN-TAG-ACD-Probe-Arrow

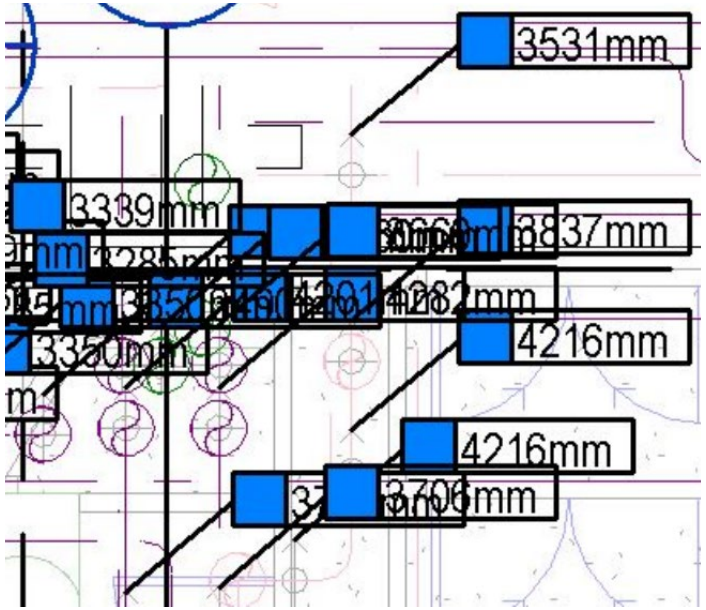
FS (Not Editable)

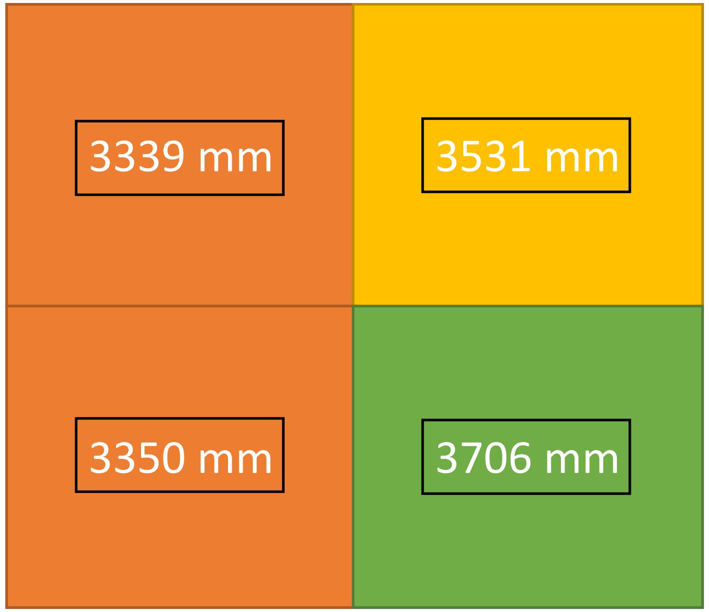
Main Model

□ Editable Only

Filled Region Generation

- Tagging every individual element creates clutter and overlapping tag information in the plan view
- By merging tags to zones, we can simplify the view





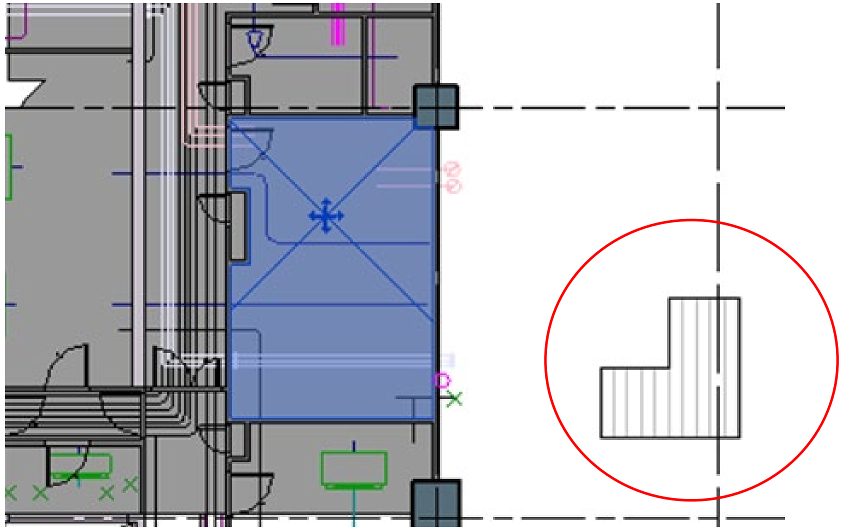
Conceptual grid region generation

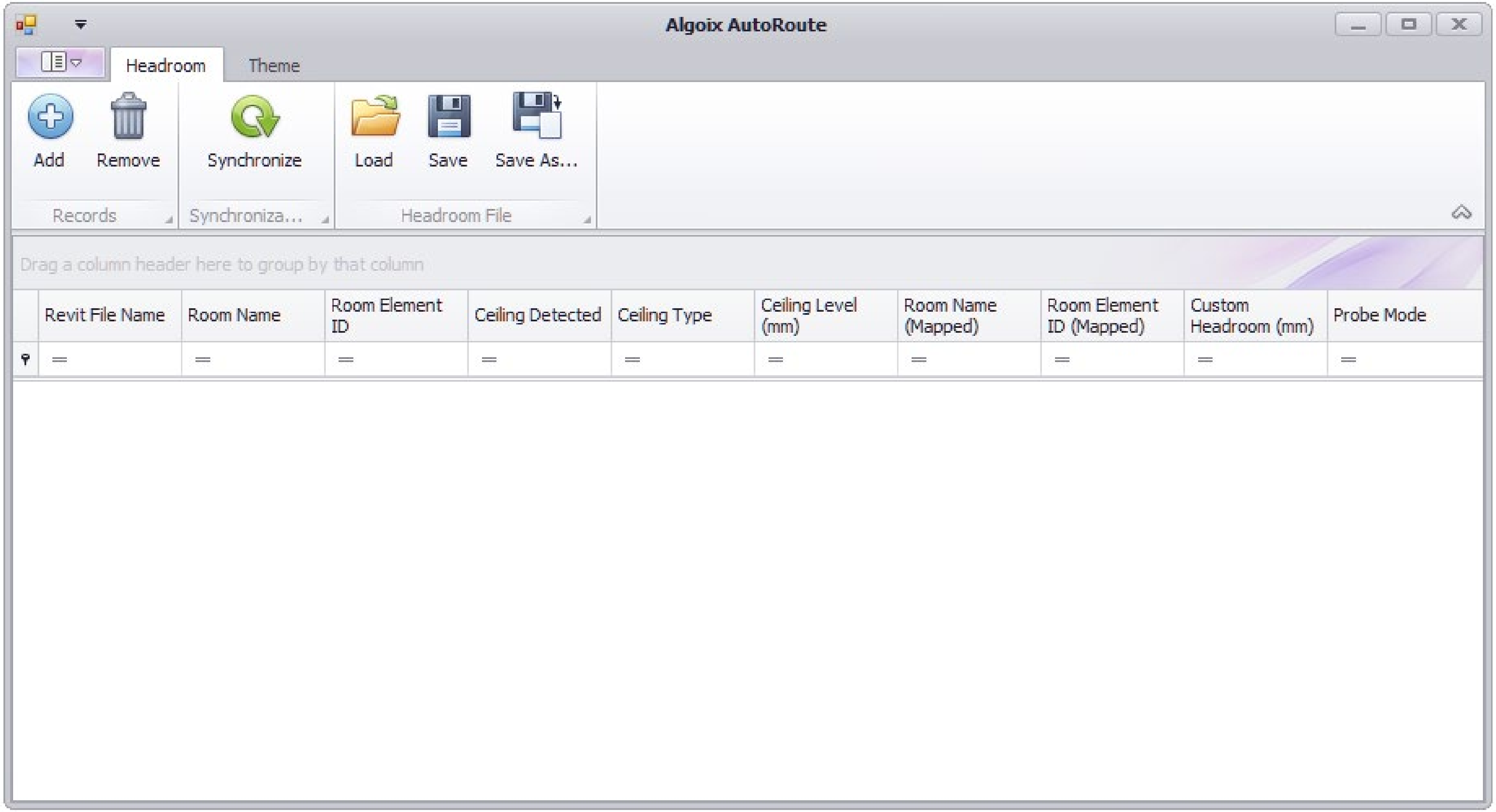
Filled Region Principles

- Overlay a 2D grid across the view coordinate system
- Within each grid cell, find the tagged probe with the lowest free headroom
- Remove all other tags except for the tag that has the lowest free headroom within each grid cell
- If adjacent grid cells have the same (or perhaps also similar) headroom, merge the cells, and use a single tag to denotes the lowest headroom for the adjoined region
- May be useful to allow users to customize the grid X and Y cell size, usually, equidistant axes would be the norm

Filled Region Generation Proof of Concept

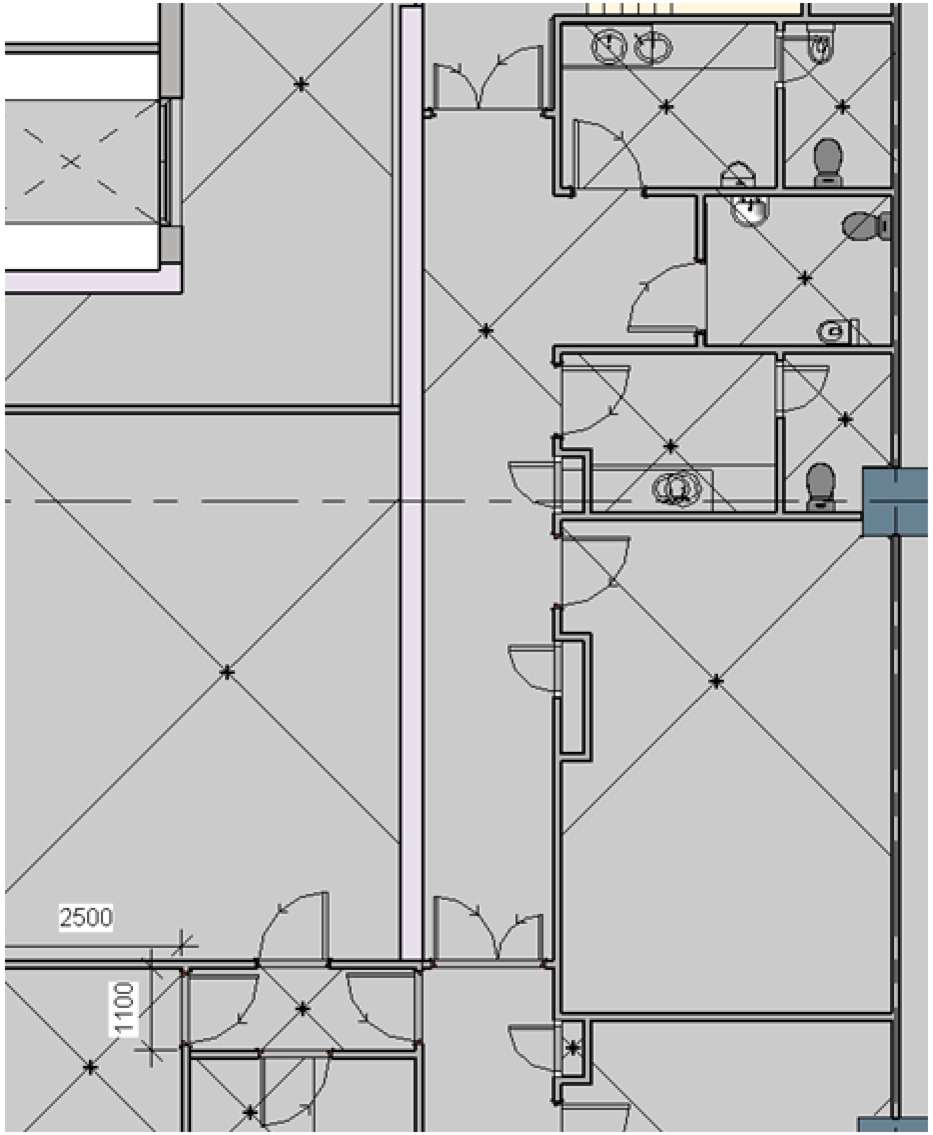
- Revit API supports generating filled regions in 2D views
- We plan to use this to generate regions within the room on the 2D plan to illustrate the headroom available across regions
- We are planning to look into using different colors for these regions depending on free headroom

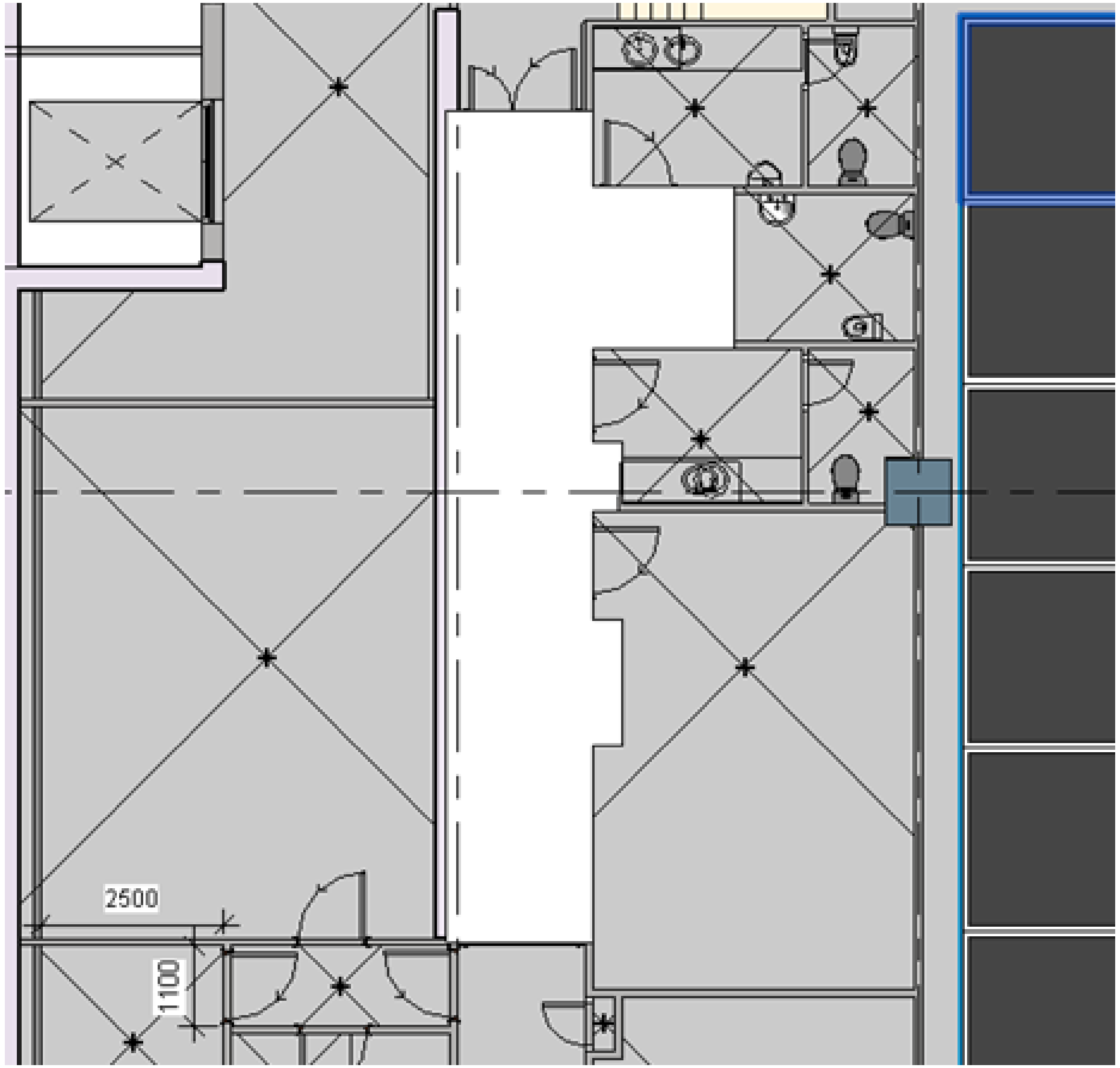




Drag a column header here to group by that column

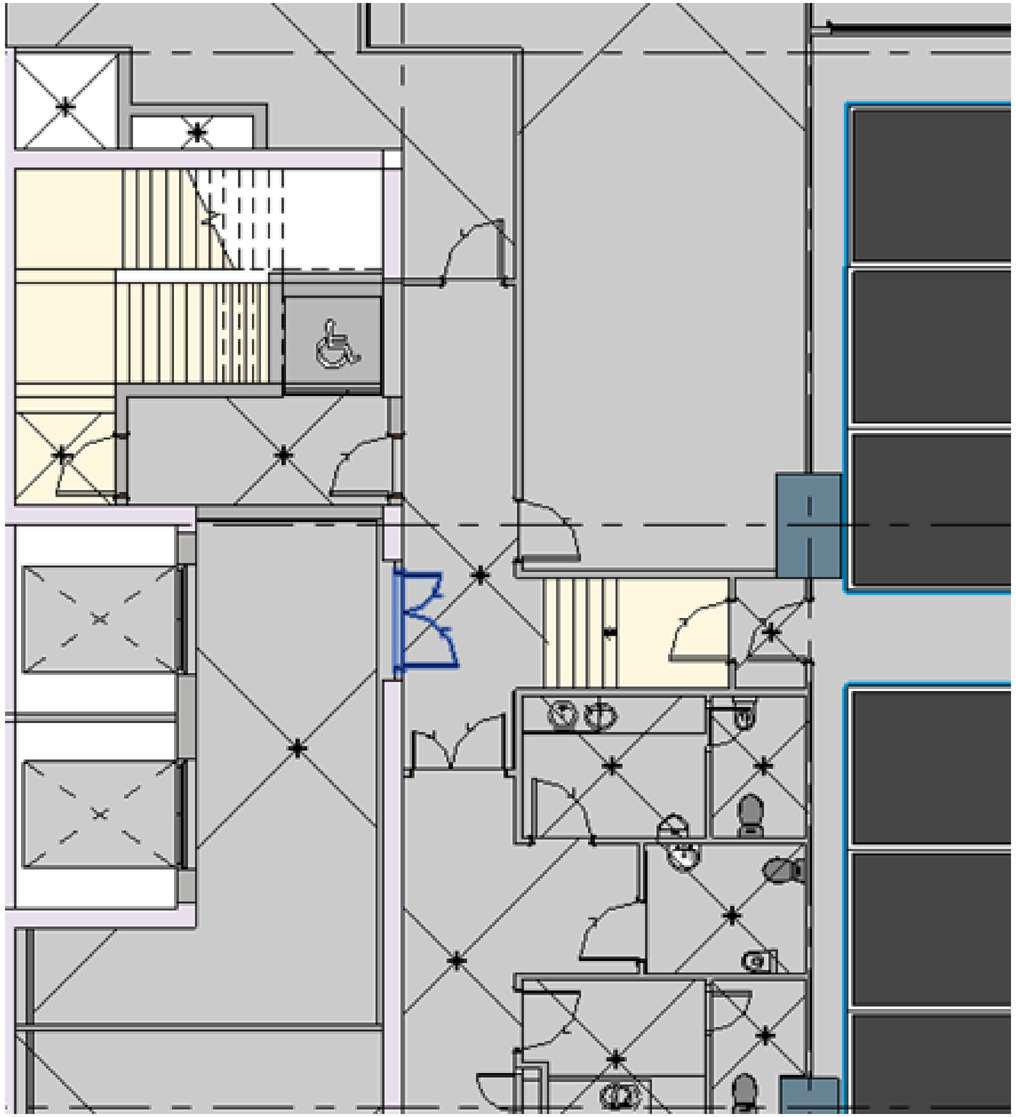
Revit File Name	Room Name	Room Element ID	Ceiling Detected	Ceiling Type	Ceiling Level (mm)	Room Name (Mapped)	Room Element ID (Mapped)	Custom Headroom (mm)	Probe Mode
=	=	=	=	=	=	=	=	=	=

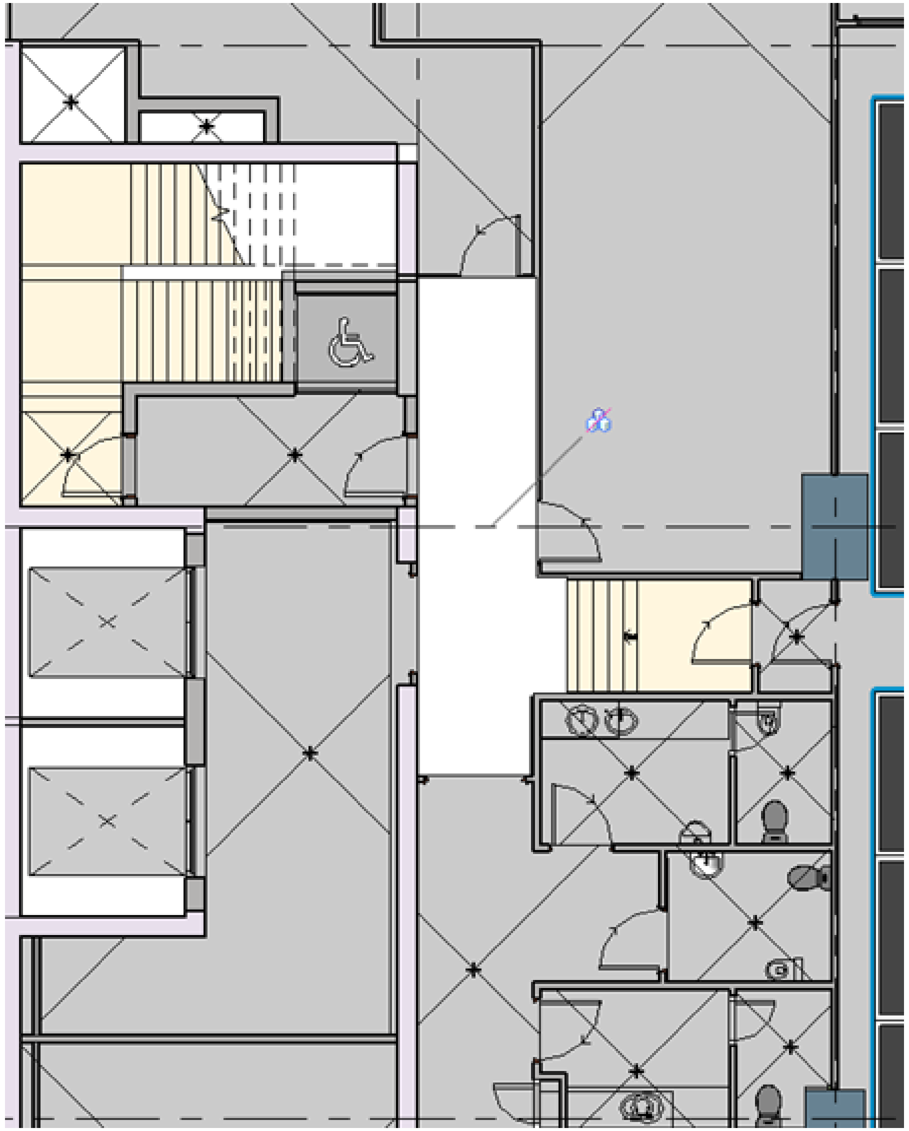




The original level plan.

- The picture after the region is filled when it is clicked.





Milestone **Start Date** **24-Jul-17**

MS1	Initiation Phase	HH provide ACID the requirements HH provide ACID the required drawing information	End of week 2	04-Aug-17
MS2	Planning Phase	ACID understand HH requirement and proceed on program	End of week 5	18-Aug-17
MS3	Trial Run Phase	ACID provide program to HH to trial run in HKJC clubhouse extensions	End of week 7	08-Sep-17
MS4	Execution Phase	Report issues and detail in UI and detail in functions	End of week 10	29-Sep-17
MS5	Controlling Phase	Program shall ready for use in project	End of week 13	20-Oct-17
MS6	Debug and Closing Phase	Debugging and release program	End of week 17	17-Nov-17

Milestone	Phase	Status	Key tasks remaining
MS1	Initiation Phase	Done	None
MS2	Planning Phase	Done	None
MS3	Trial Run Phase	In progress	Model data: • Isolated mock-up model of LG1 basement floor (ACID) Proof-of-concept (alpha) program versions: • Headroom editor prototype (Algoix) • Probe generator prototype (Algoix)
MS4	Execution Phase	Not started	Updated program versions for beta testing
MS5	Controlling Phase	Not started	Release candidate program for UAT Test report
MS6	Debug and Closing Phase	Not started	Final PROD program version Final documentation Final version of Revit family files

Progress Update: Schedule of BIM Program Development R01

Revised 2017-08-14 by Algoix/ACID JV Team