
Streamlining BIM/CAD/CAM Conversions for Panel Manufacturing

Signetron Inc.

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Team

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The Problem

Problem Definition:

- Develop a fast, accurate workflow for panelization of building facades with minimal occupant disruption
 - Less than 7 days of onsite installation
- We target low rise multifamily buildings, initially in colder climates and eventually in all climates
- Potential market size: 89% of US residential buildings, 200 billion sqft
- Can result in 2000 Tbtu in envelope energy savings annually.

Research Question:

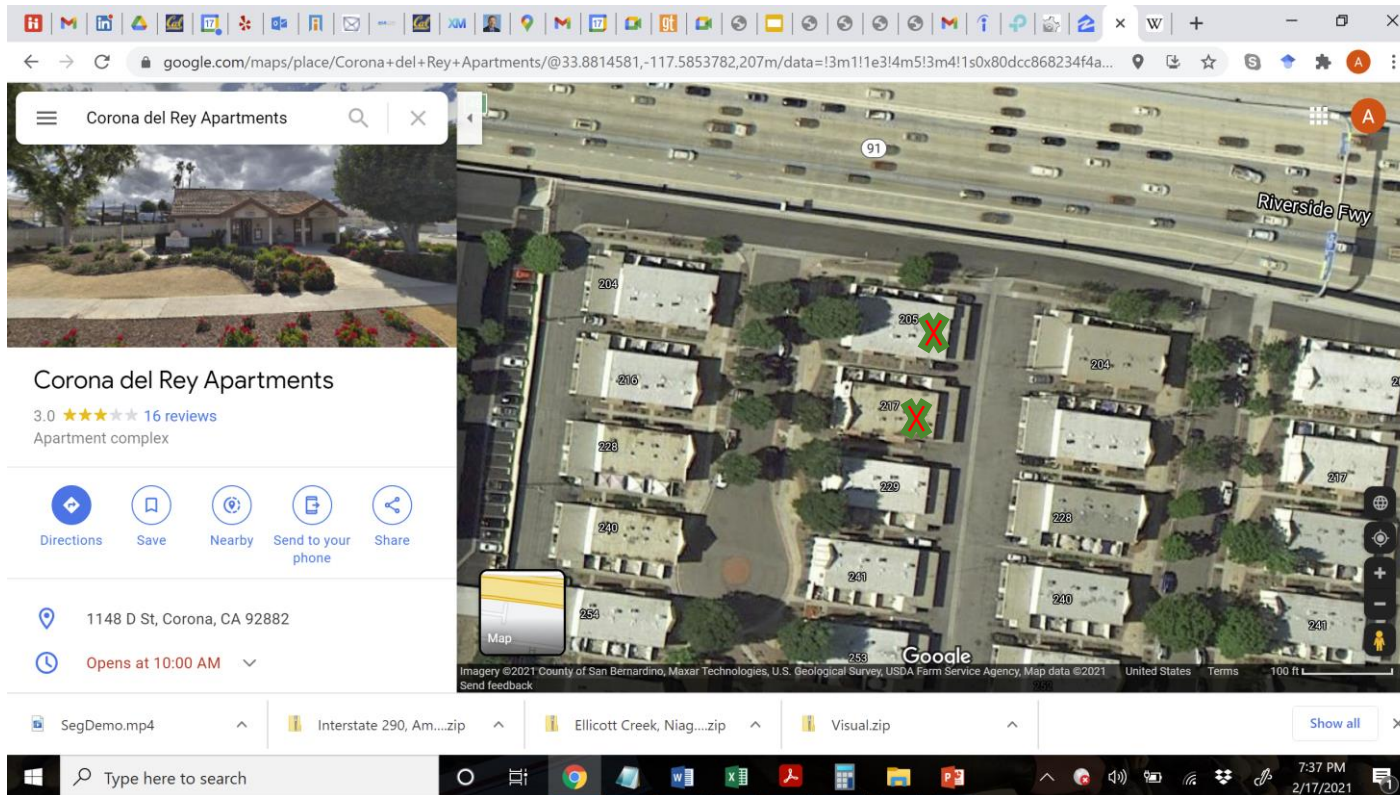
- Develop an integrated design to manufacturing workflow for recladding building facades in energy retrofits.
- Develop panelization algorithms informed by material and manufacturing constraints.



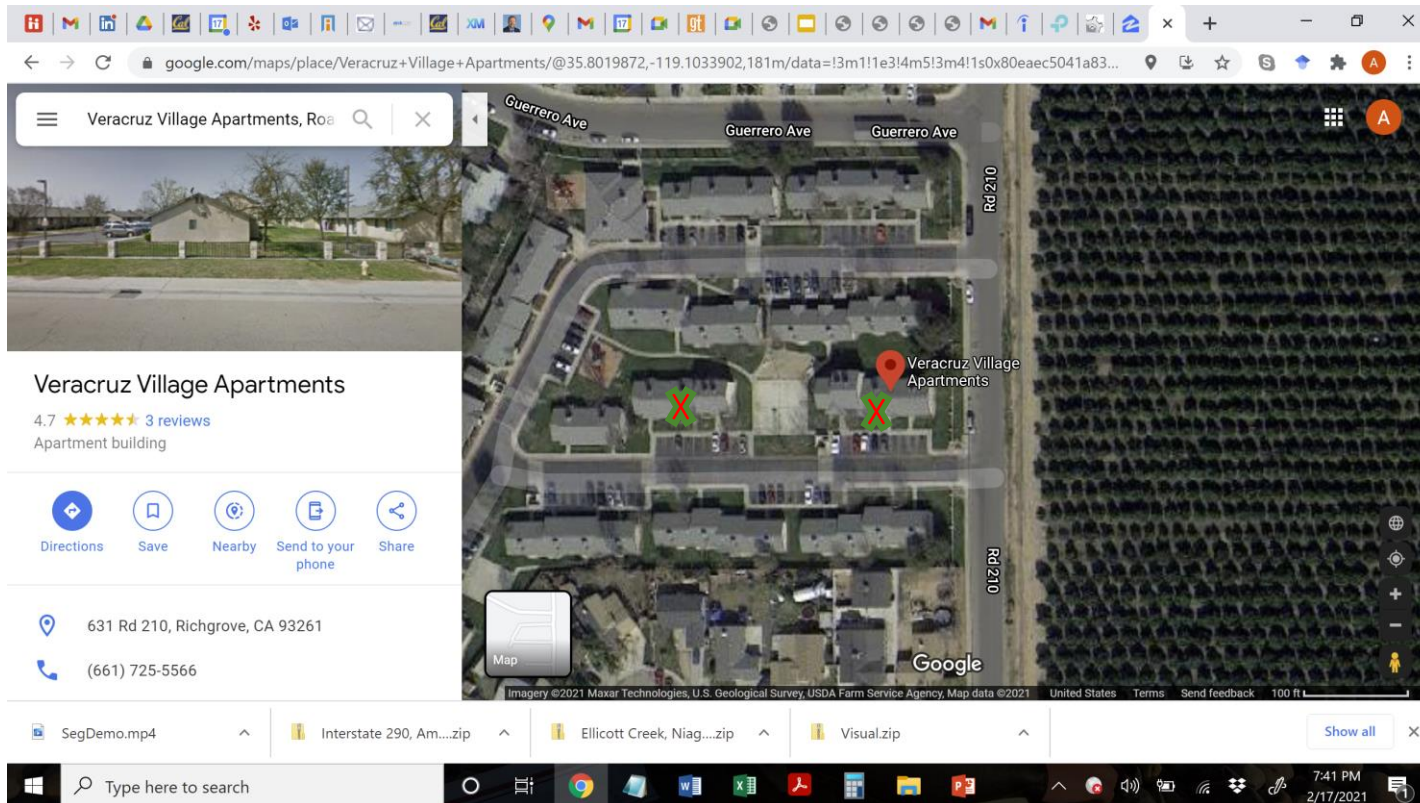
Signetron Software PaTER at a Glance

- Takes point cloud as input
- Allows for intended demolitions in software as indicated by architects
 - Distinguishes between “permanent” demolishing (e.g. AC unit) vs temporary one (e.g. pipes)
- **Creates a dimensionally accurate wireframe model of the building.**
 - Automated or Interactive or Hybrid
 - .dwg or .dxf format
- **Allows for interactive precise delineation of windows, doors and other fenestrations.**
 - Takes both color and geometry into account for increased accuracy
- **Panelizes the wireframe model automatically**
 - Takes panel manufacturer constraints into account:
 - Min/max panel height/width; distance between window and panel edge
 - Three modes of paneling: window aligned, window enclosed, window crossing
 - Paneling can be done inside Qpater or in Rhino/Grasshopper, after exporting wireframe models
 - Paneling output is in .dwg format and can be sent to fabricators directly without human intervention
- **Deviation maps:**
 - Allows for metrically accurate visualization of the unevenness of façades.
 - Can be edited by the user interactively
 - Used by panel installers during installation to plan order of installation, high points, etc.
- **Tested on multiple datasets in Central and Southern CA.**

Corona Del Rey Apartments, Corona CA

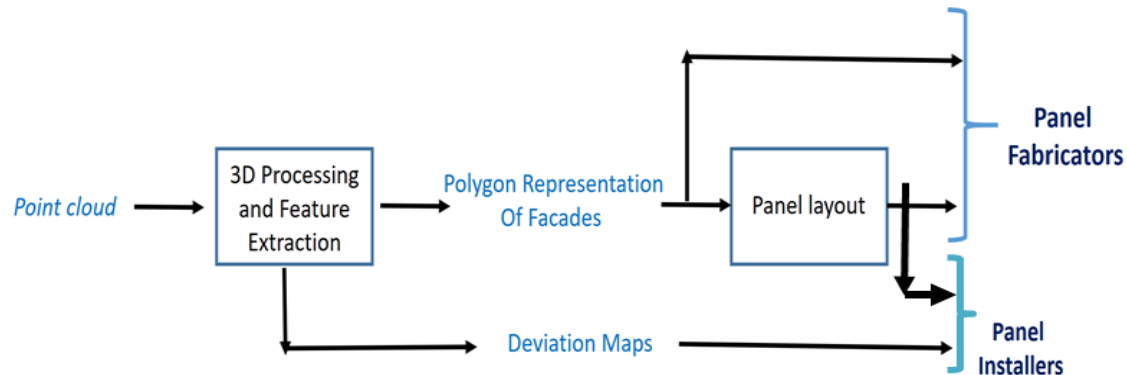


Vera Cruz Apartments

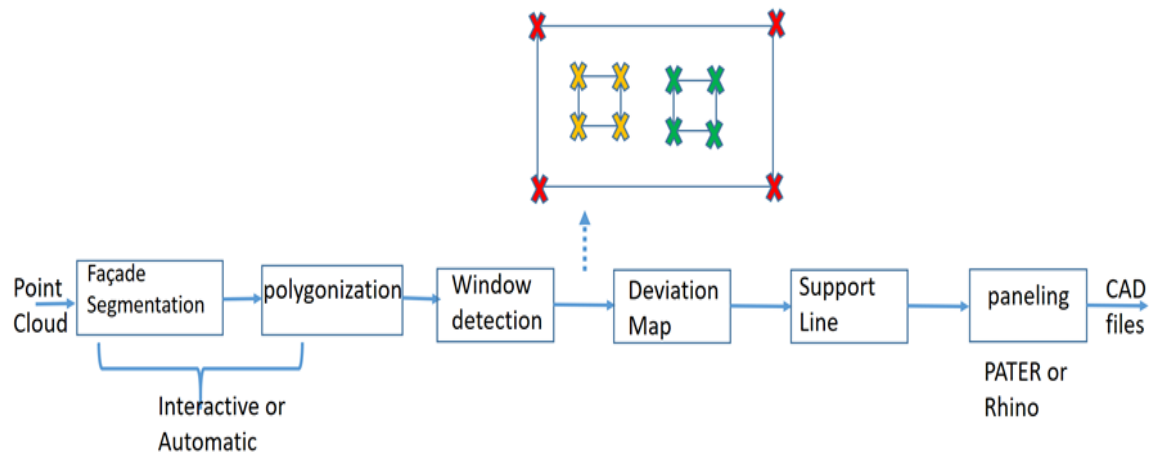


Point clouds for both buildings



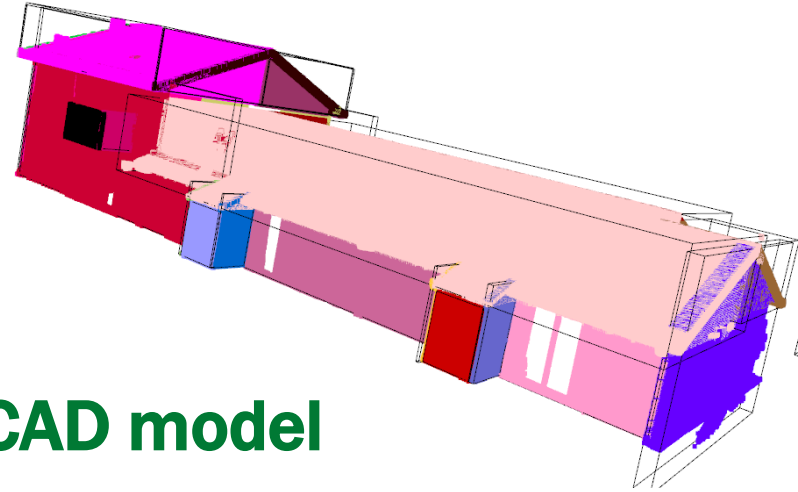


High level block diagram of the Signetron software workflow

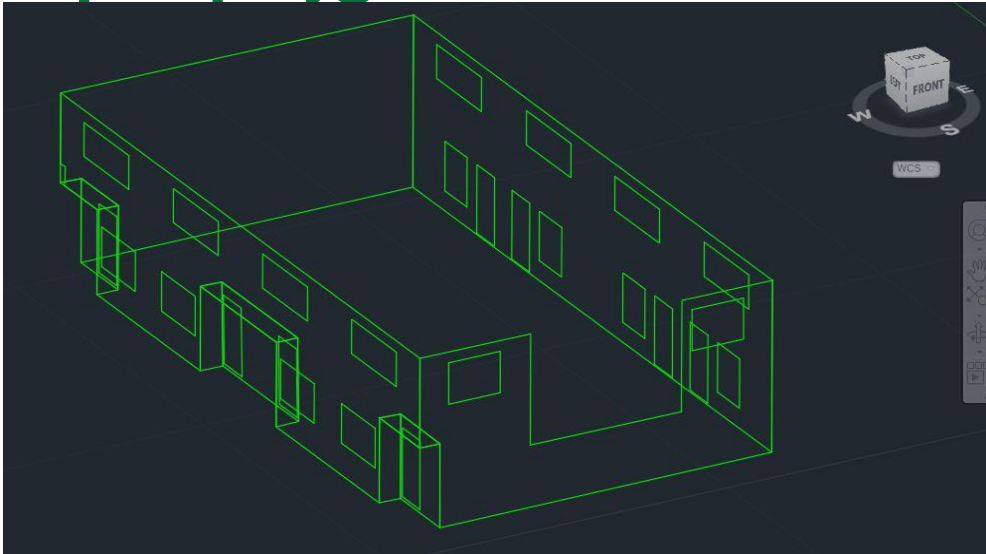


Detailed block diagram of Signetron Qpater software.

Step 1: Façade Segmentation:

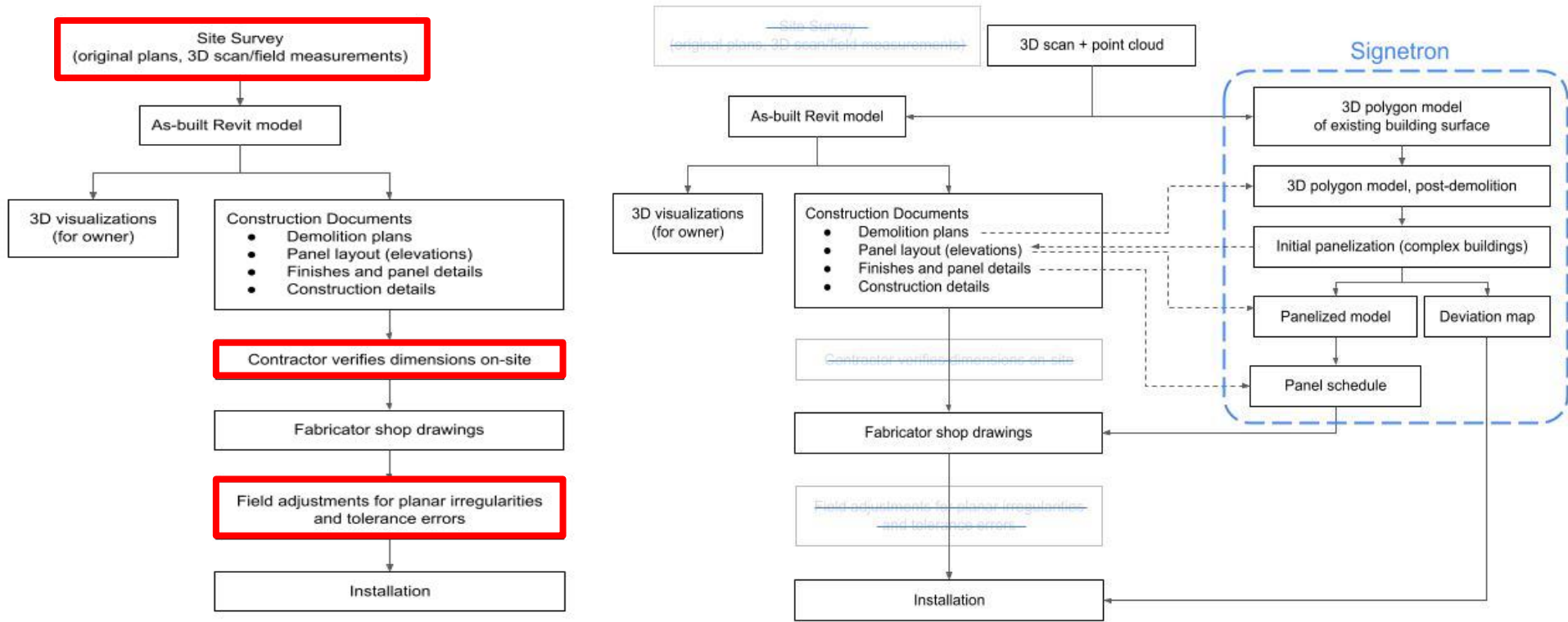


Step 2: polygonization: wireframe CAD model



- Wireframe model deals with all non-idealities of old buildings:
- Facades not vertical, warped, non-planar, non-Manhattan, non-plumb

Comparison of “business as-usual” workflow vs PaTER

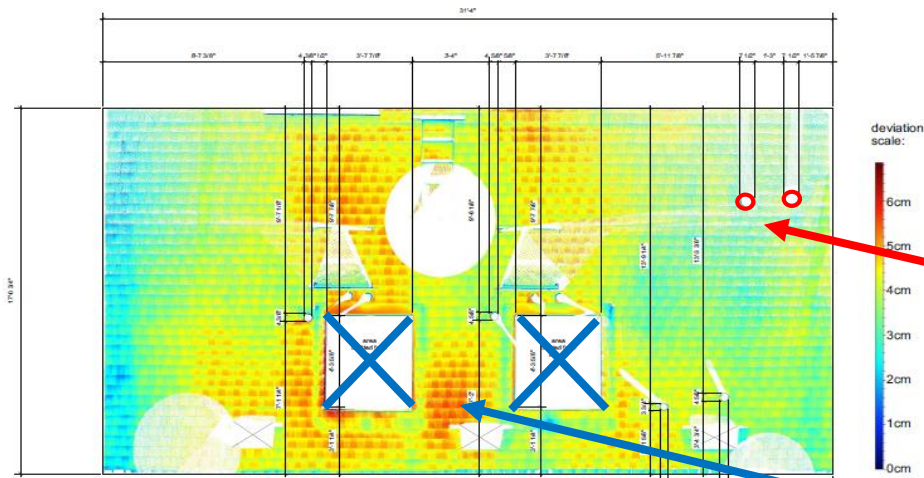


Today's business-as-usual-workflow for panelized retrofits

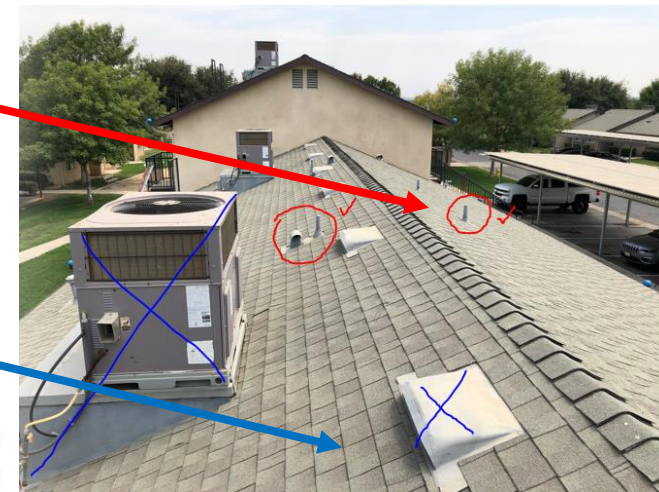
Proposed workflow integration and optimization

Courtesy of Katie Ackerly from DB Architects

Qpater generated dimensioned deviation maps indicating penetrations such as pipes & air conditioning.



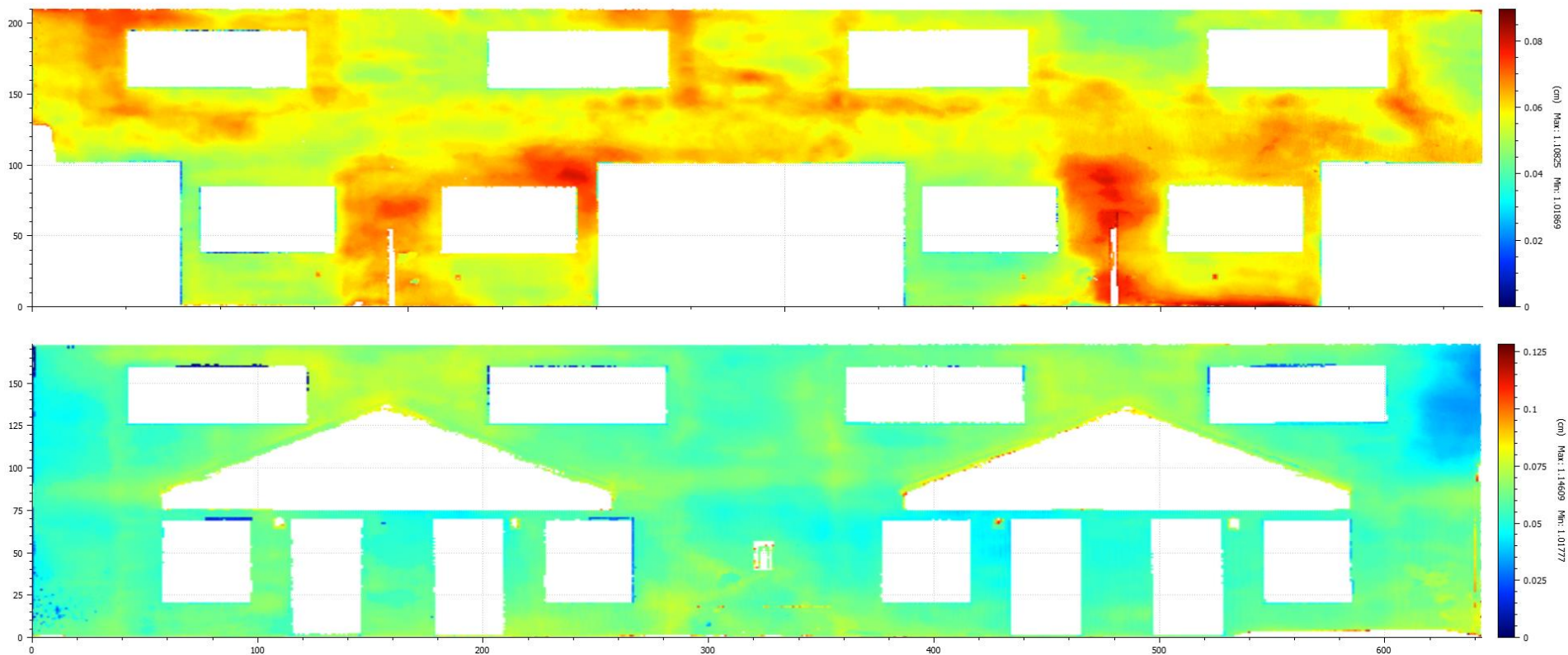
Architect demolition plan



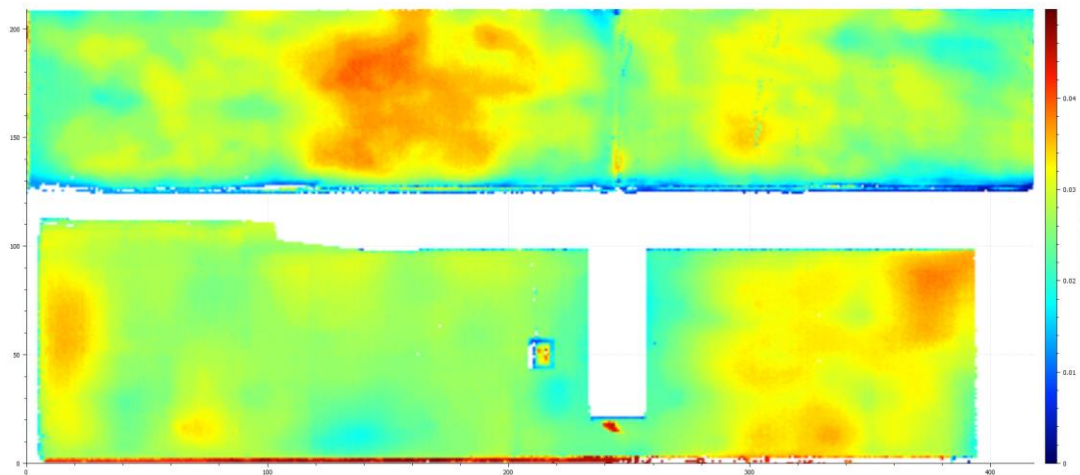
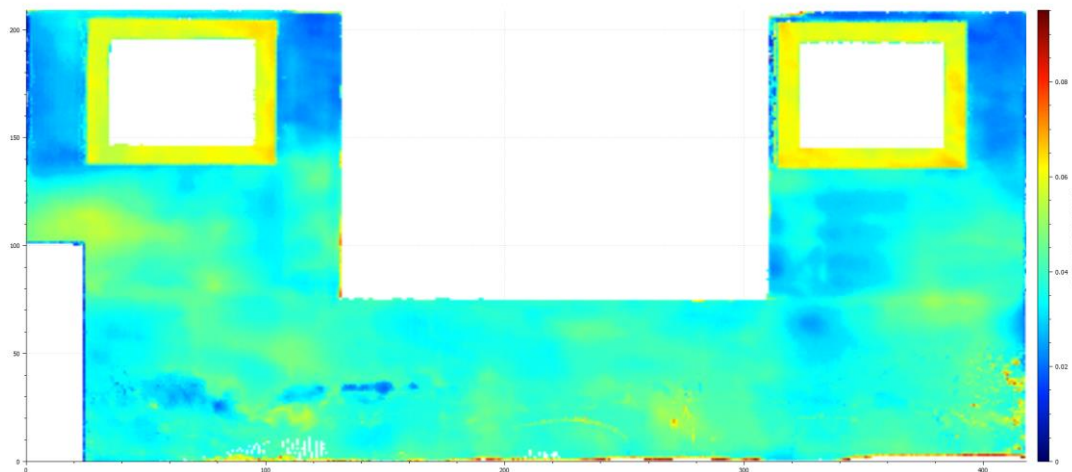
Two kinds of demolition:

- Permanently demolished objects like AC
- Temporarily demolished, but eventually kept objects such as pipes

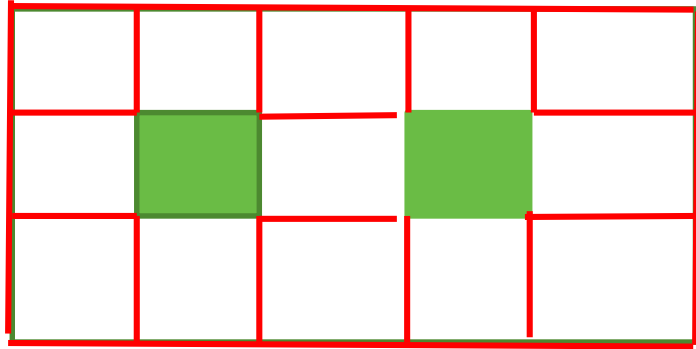
Deviation Files for Corona 205: from PATER



Deviation Files for Corona 205 from PaTER

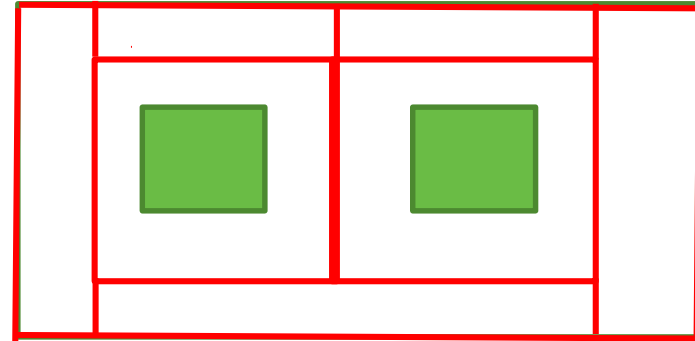


Three Panel Window Cases for Different Panel Manufacturers

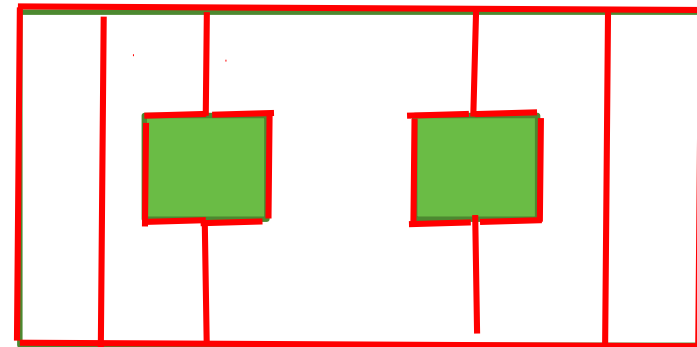


Case 1: Window seams aligned with panel seams

minWidth	0.3m (1 ')
maxWidth	0.3m (1 ')
minHeight	2.44m (8 ')
maxHeight	2.44m (8 ')
Window to panel distance	25.4 cm (10")



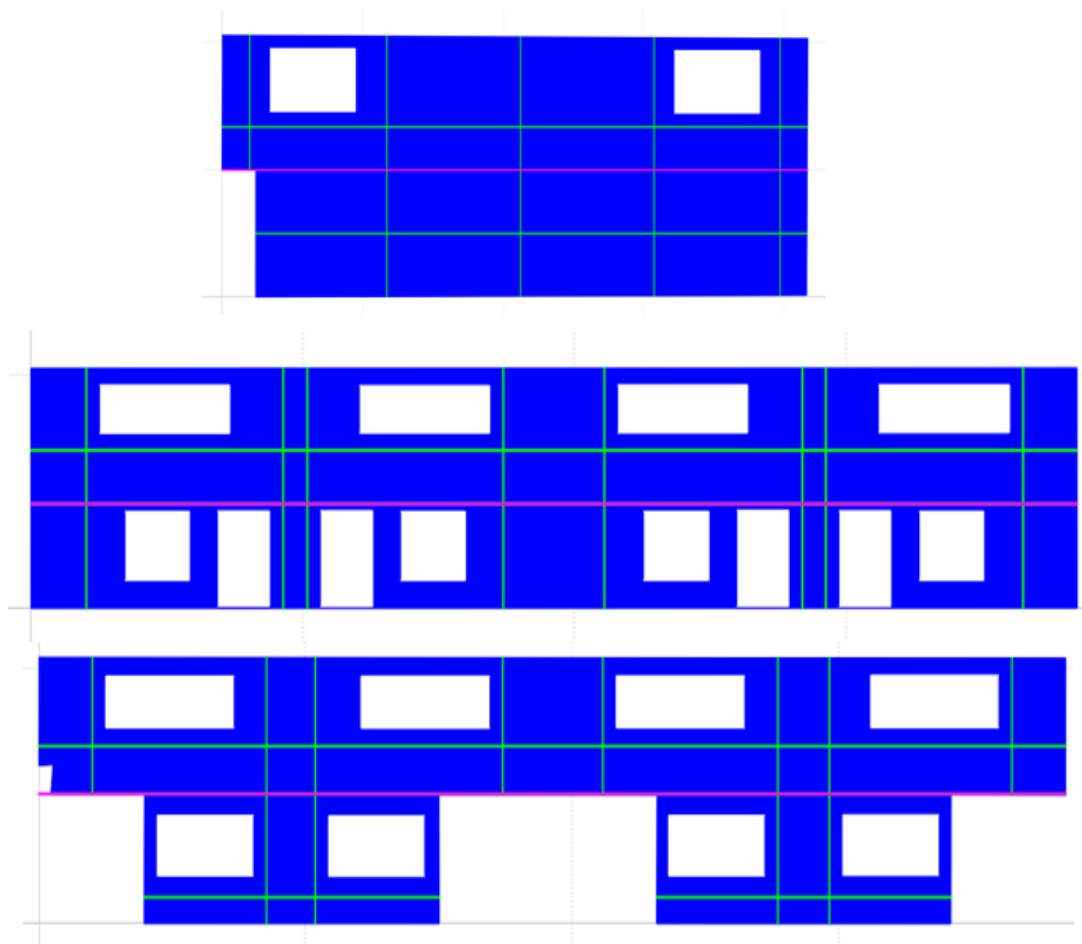
Case 2: Panels enclosing windows



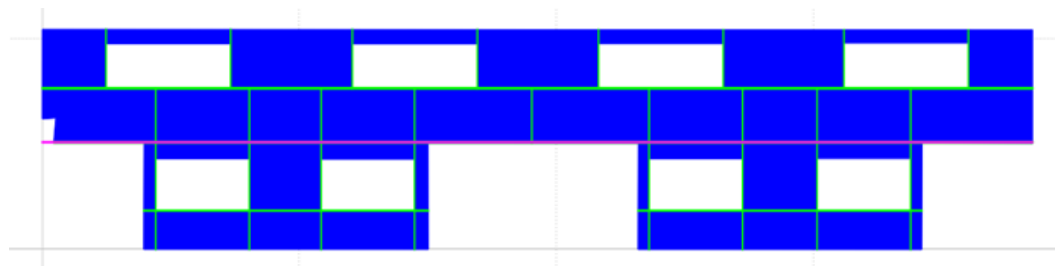
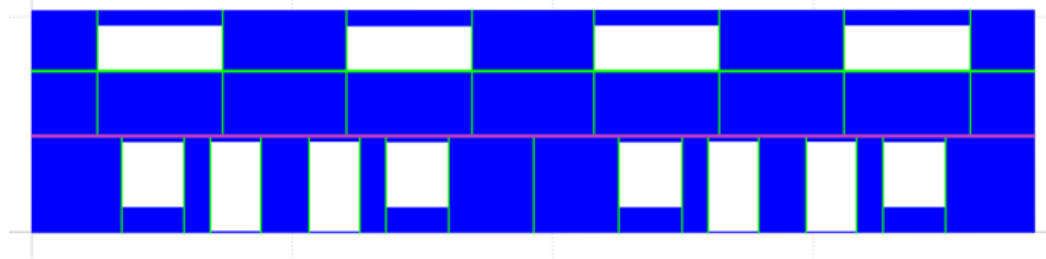
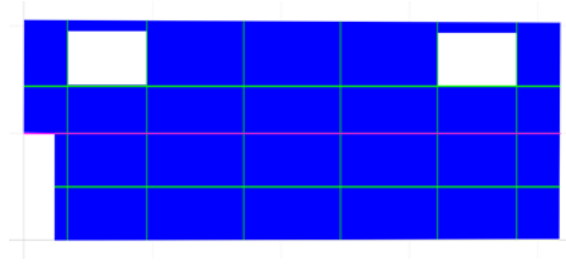
Case 3: Panel seams intersecting with windows

Panelization Parameters Used in Signetron PaTER Tool.

Case 1: Window enclosed paneling for Corona 205 with support lines



Case 2: Window Aligned paneling for Corona 205



Adjusting max panel height and width affects # of panels

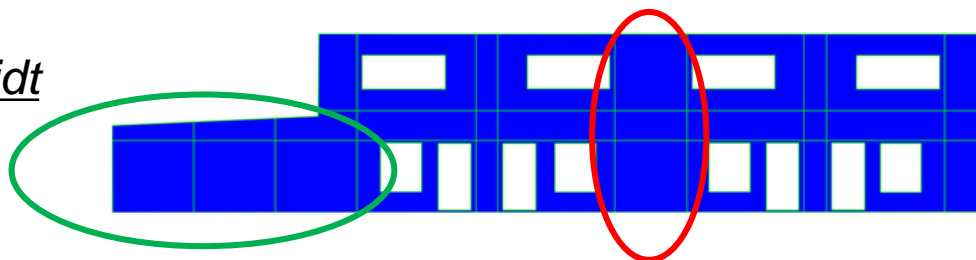
Façade/Case	Number of Panels (8 feet)	Number of Panels (11 ½ feet 6)	Number of Panels (16 feet)
217 Façade 2 / Case 1	31	20	13
217 Façade 2 / Case 2	53	40	39
217 Façade 2 / Case 3a	36	20	16
217 Façade 2 / Case 3b	36	25	22

Example Case 1

$\frac{\text{maxHeight}}{\text{maxWidth}}$

h

8 feet



Panels

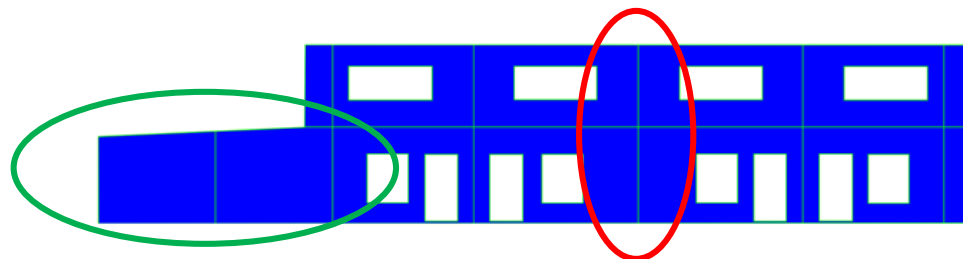
31

11 ½ feet



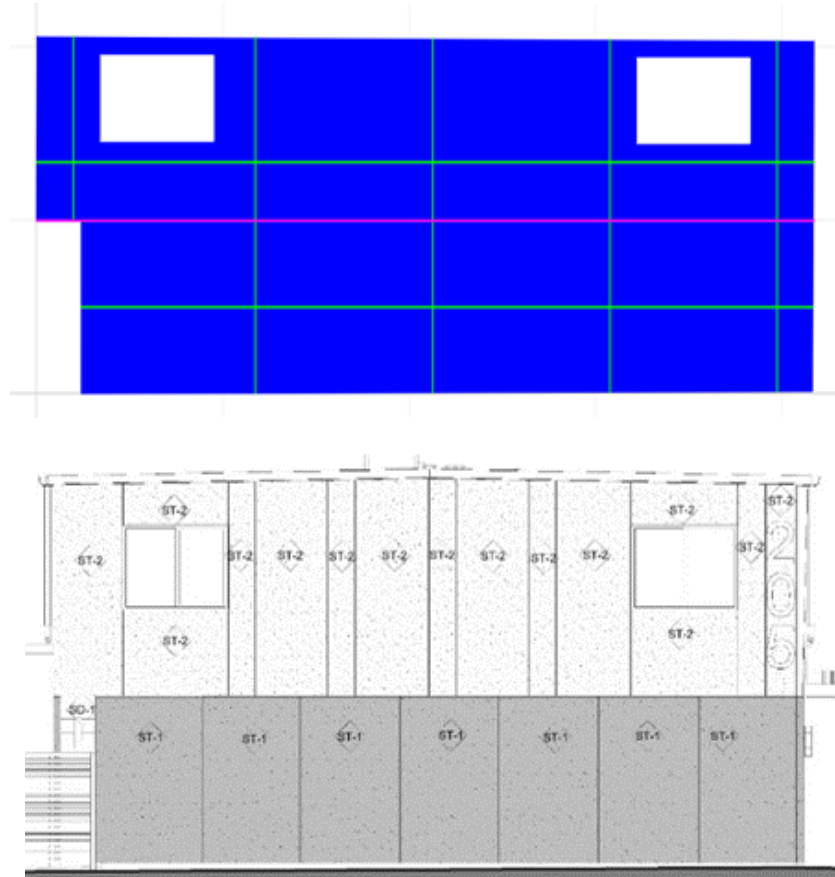
20

16 feet

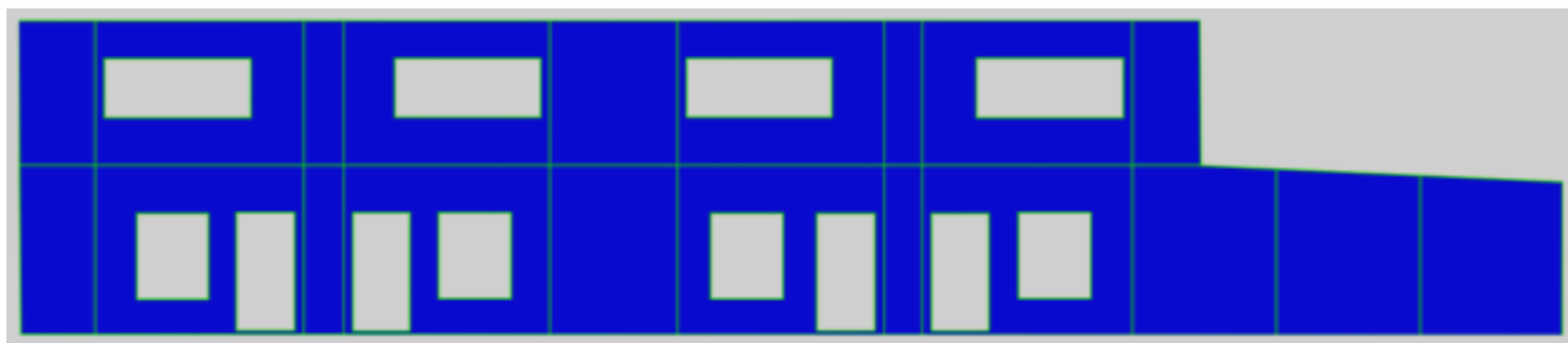


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Qualitative comparison of PaTER vs architect panel configuration



Qualitative comparison of PaTER vs architect panel configuration



Panel layout with Rhino Grasshopper, Galapagos → Scripting



Rhinoceros
NURBS modeling for Windows

CAD



grasshopper

Scripting

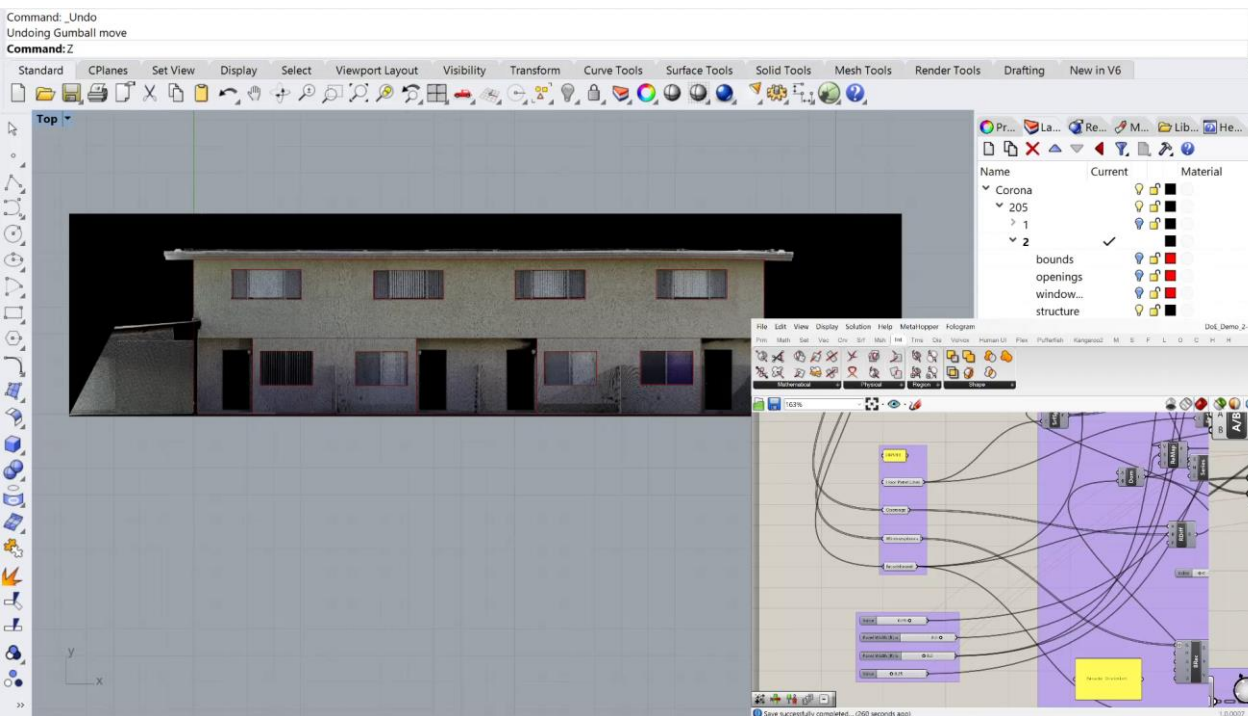


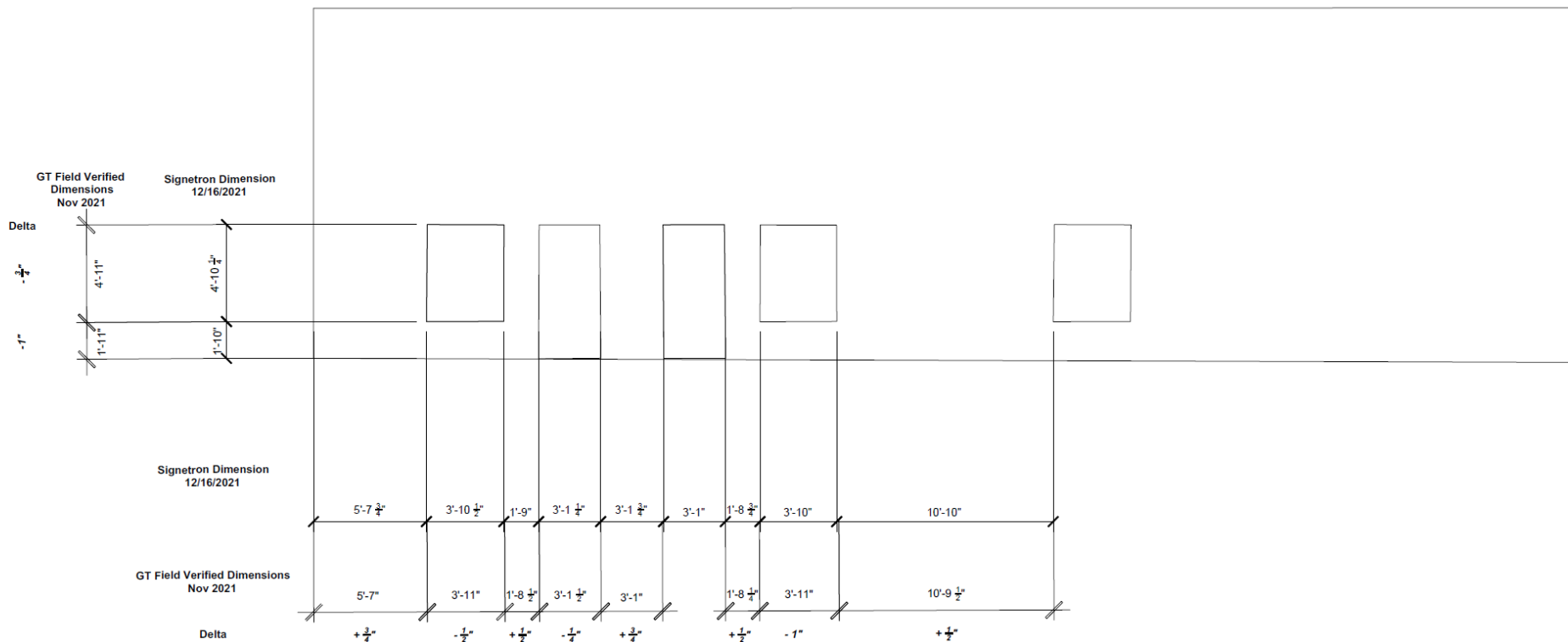
Galapagos

Evolutionary Solver

Design Criteria

- Maximum and minimum panel size
→ set by user
- Distance between panel and opening
→ set by user
- Intersection with openings
→ minimize
- Panel Similarity
→ maximize





- Comparison against hand measurements with tape
- Hand measurements not consistent from one day to the next: +/- 1 inch discrepancy

Current status of the software

- Patent on algorithms filed in Dec. 2021
- Software available for beta trials for interested parties now
- Internally tested by architects.
- User manual, and installation instructions
- Timing:
 - 45 minutes of human interaction for façade generation
 - 2 minutes per window
 - For Cornoa 205
 - 2.5 hours of human interaction to create the shop drawings from point cloud