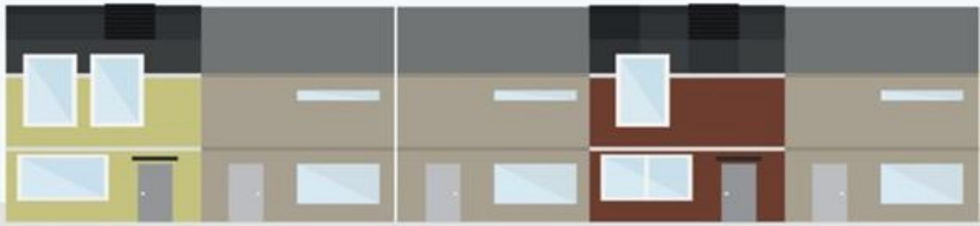

MORE—CONNECT

MORE-CONNECT PROJECT HAS RECEIVED FUNDING FROM THE EUROPEAN UNION'S H2020 FRAMEWORK PROGRAMME FOR RESEARCH AND INNOVATION UNDER GRANT AGREEMENT NO 633477.nTHE INFORMATION IN THIS PUBLICATION DOES NOT NECESSARILY REPRESENT THE VIEW OF THE EUROPEAN COMMISSION.

Technical Guidance “3D scanning and BIM process”

Training materials

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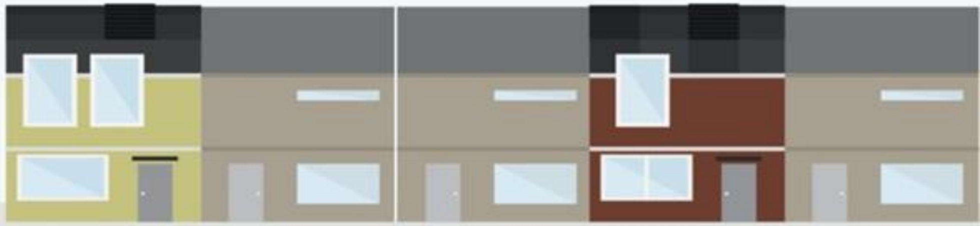
contributors: Anatolijs Borodiņecs, Modris Dobelis,
Riga Technical University

- One of the MORE – CONNECT project objectives is to develop a one-stop-shop concept for the end-users. In this ‘one-stop-shop’ proposition the end-user will deal with only one party, responsible for the total renovation, starting from an inventory of the existing situation, inventory of specific end-user demands, translation into modular renovation kits, mounting and installing, financing and aftercare. This can be done only by use of modern technologies and BIM process.
- This module is focused on description of 3D practical application for building retrofitting process. In scope of this module tips and tricks for quality 3D scanning of existing multi apartment buildings will be presented and discussed. Two 3D technology: “classic” and “3D from drone” will be *presented* and compared.
- The “point cloud to BIM” process will be explained and analyzed through the different software. In addition the energy simulation and prefabricated modules design on the created BIM model will be explained.
- After completing this module individuals will be able to choose proper scanning technology and software for data processing. Which allows them to organize and manage retrofitting process based on 3D scanning and automated production process.



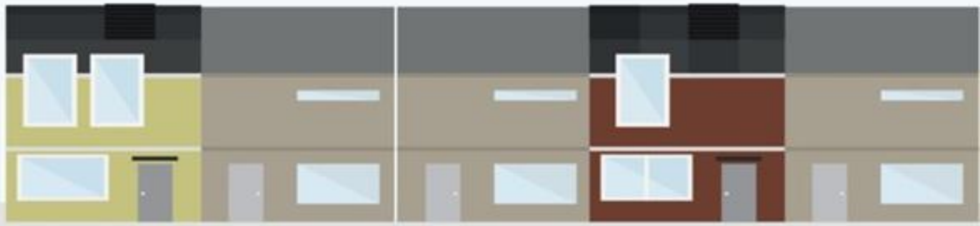
Content

- **PART I -3D DATA CAPTURING USING PHOTOGRAMMETRY DATA**

- **PART II – 3D DATA CAPTURING USING 3D LASERSCANNING DATA**

- **PART III – 3D MODEL CREATION AND BIM MODELING FROM POINT CLOUDS**

Reality Capturing – what is this?



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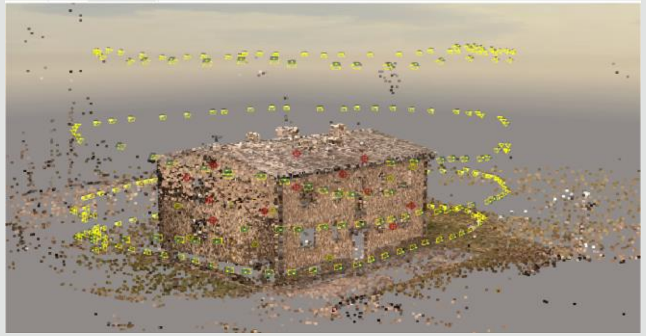
"Reality is merely an illusion, albeit a very persistent one." – Albert Einstein

- Probably first appearance of term: High-definition surveying (HDS): a new era in reality capture (2004) by Erwin Frei , Jonathan Kung , Richard Bukowski in: Proceedings of ISPRS Workshop Laser-Scanners for Forest and Landscape Assessment
- "The correct term is data capture. None of us are capturing reality. "Reality capture", "capture reality" - both just marketing terms. They are good marketing phrases and I just hope no one really believes them..." – Matt Young
- Reality Capturing: laserscanned or photogrammetrically 3D documented assets/environments – 3D documentation of existing reality (not virtual reality)

General steps:

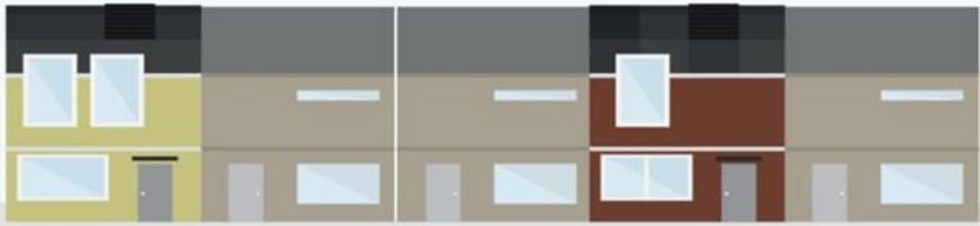

equipment


analyzed object


on-site scanning


final results

PART –I



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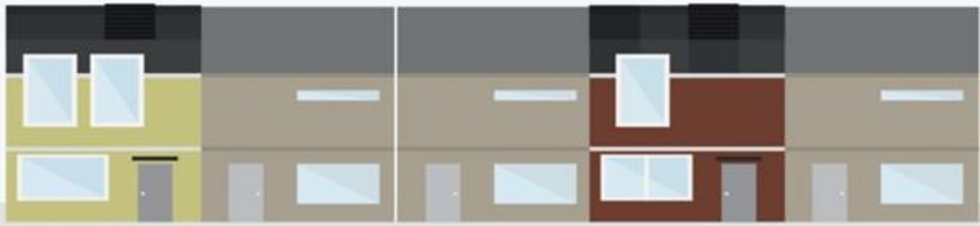
3D data capturing using photogrammetry - DRONES

1. General information – Reality Capturing by Photogrammetry
2. Drone flight planning
3. Flight and capturing image data
4. Processing photos in ContextCapture Master
5. Setting of control points
6. BIM Modelling
7. Laser scanning point cloud data processing
8. Data comparison

PART - I



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General Information – Reality Capturing by Photogramm

To use the photogrammetry method and its technologies we need the optical sensor to take the photos, software to postprocessing data - possible to use commercial and semi commercial software, and CAD software for see and processing data.

Devices and software

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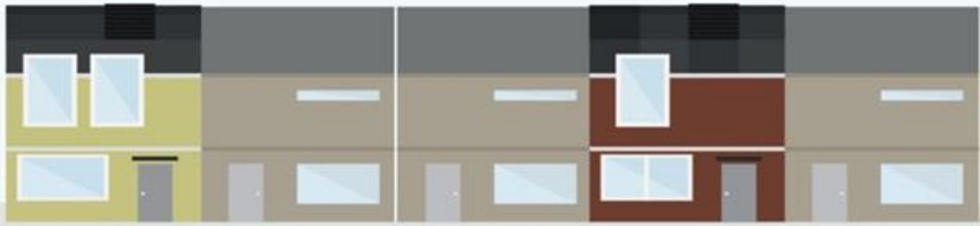

1) Drone Phantom 4
2) Camera DJI FC330
3) Used software:
   - ContextCapture Master
   - Acute 3D Viewer
   - Cloud Compare
   - Leica Cyclone
   - Bentley Descartes
   - AutoDesk 360 Viewer Online

non-commercial Cloud Compare

acute3D a Bentley Systems Company

compare the cloud.net

Bentley CONTEXT CAPTURE

commercial Leica Cyclone

BENTLEY DESCARTES Bentley Sustaining Infrastructure

AUTODESK® 360

Modern photogrammetry

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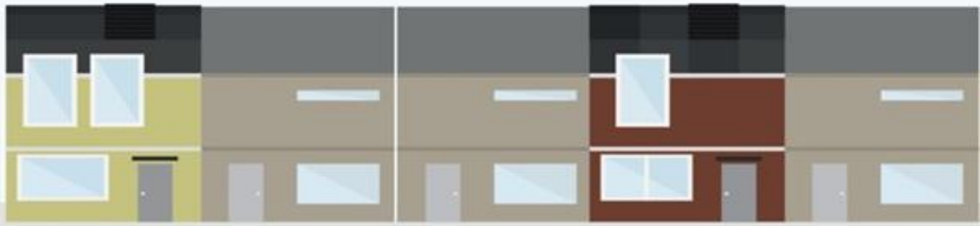

Photogrammetry technology development during last decade:

– Compact high resolution digital photo and video cameras

– New algorithms for determination of correlations between pictures

– Powerful standard computers and graphic processors

– Lighter and more compact sensors for spatial location and orientation: GPS, micro electromechanical sensors

- MEMS (gyroscopes, accelerometers, compasses, barometers etc.)

– Unmanned aerial vehicles (UAV, drones) with automated flight control

Advantages:

– Extended digital photogrammetry application possibilities in various sectors

– Low cost photogrammetry, which is available for non-professionals

– Usage of drones and other mechanical vehicles in the data collection process

– Extended real-world spatial modeling capabilities

Modern Photogrammetry Features

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Data capturing

- Usage of various digital cameras: compact, mirrorless, SLR, video, built-in
- A variety of image capture methods: from the ground, land vehicles, from overflights, from flights around; different combinations of these methods
- Smaller and faster preparations for field works
- Automated mission planning and execution

Data processing

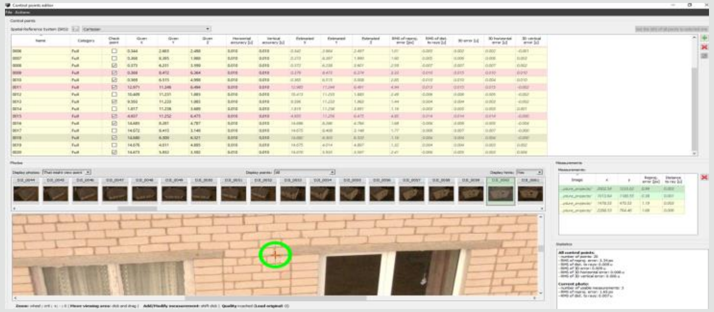
- Fully automated data processing with specialized desktop software (Bentley Context Capture, Pix4Dmapper, Agisoft PhotoScan) or cloud computing services
- It is not necessary prior camera calibration •

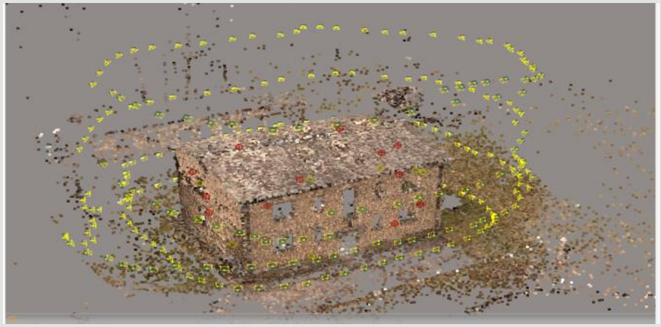
Data products

- True orthophoto, 3D point cloud, digital surface model (DSM), 3D mesh model

TIP

Easy to scan, difficult to analyze.





PART –I Workflow

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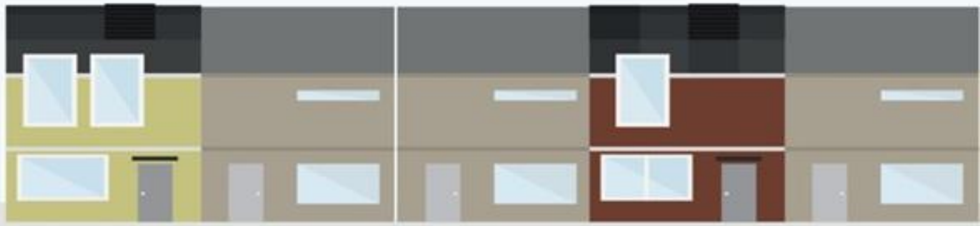

1. **Images acquisition planning**

   - It based on images processing techniques requirements.
   - Flight planning can be performed with software (eg. Pix4Dcapture, DroneDeploy), which can be used to manage automatic flight.

2. **Ground control points marking and surveying**

   - It is optional, but is required to ensure absolute precision.

3. **Data capture.**

4. **Automatic processing of images**

   - Bentley ContextCapture: performing aerotriangulation (tie points detection, image positioning and orientation, georeferencing), 3D model generation, generation of necessary data products (3D point cloud, orthophoto, DSM).

5. Further geoprocessing, using, and publishing of results

Images Acquisition Planning

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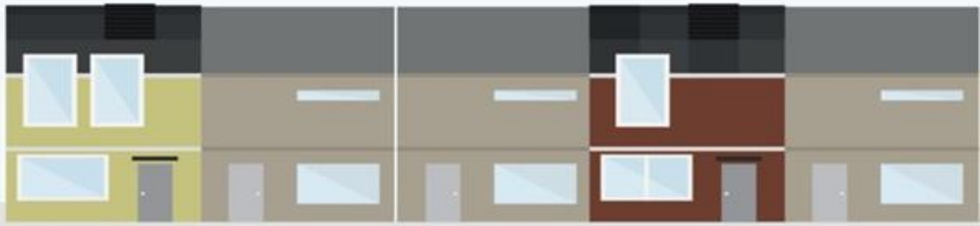
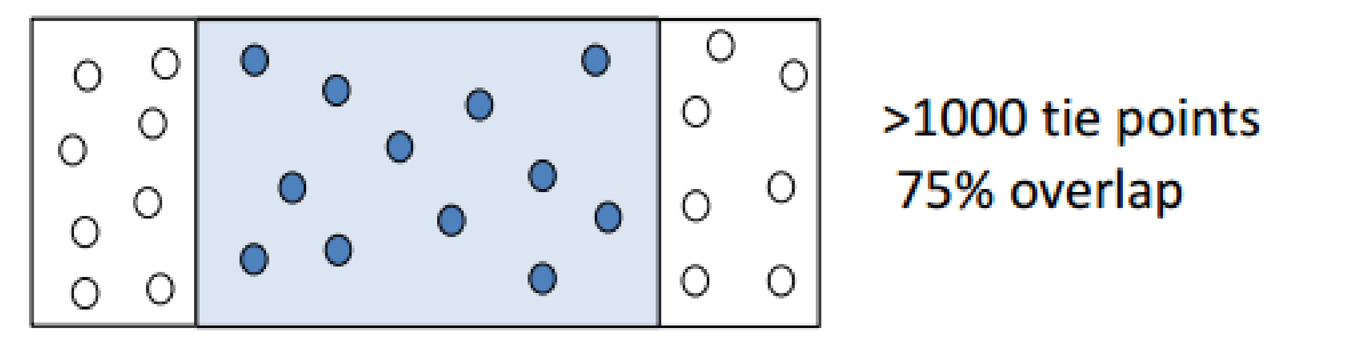


- Drastically affect image processing performance, the quality and completeness
- Goal: To ensure the greatest possible total number of tie points in images on which camera calibration, position and orientation of images can be estimated
- Unlike traditional photogrammetry it is used much larger number of tie points (> 1000) for each image pair (compared to a few tens to a few points in the traditional photogrammetry)
- The large number of tie points provides opportunities during processing to evaluate much more unknown p … g automatic calibration for your cam…



Flight plans

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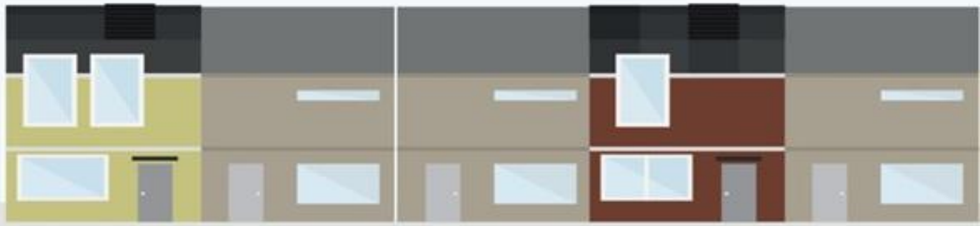
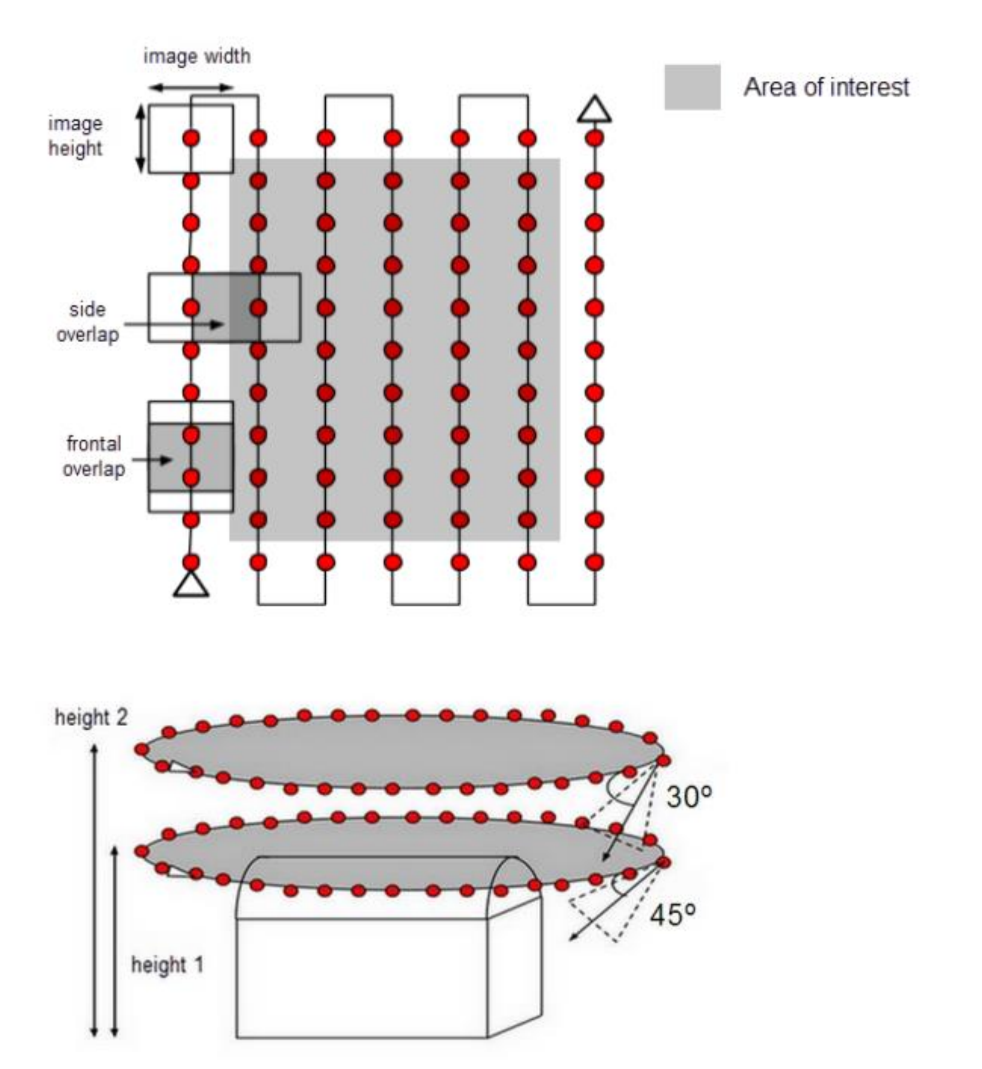


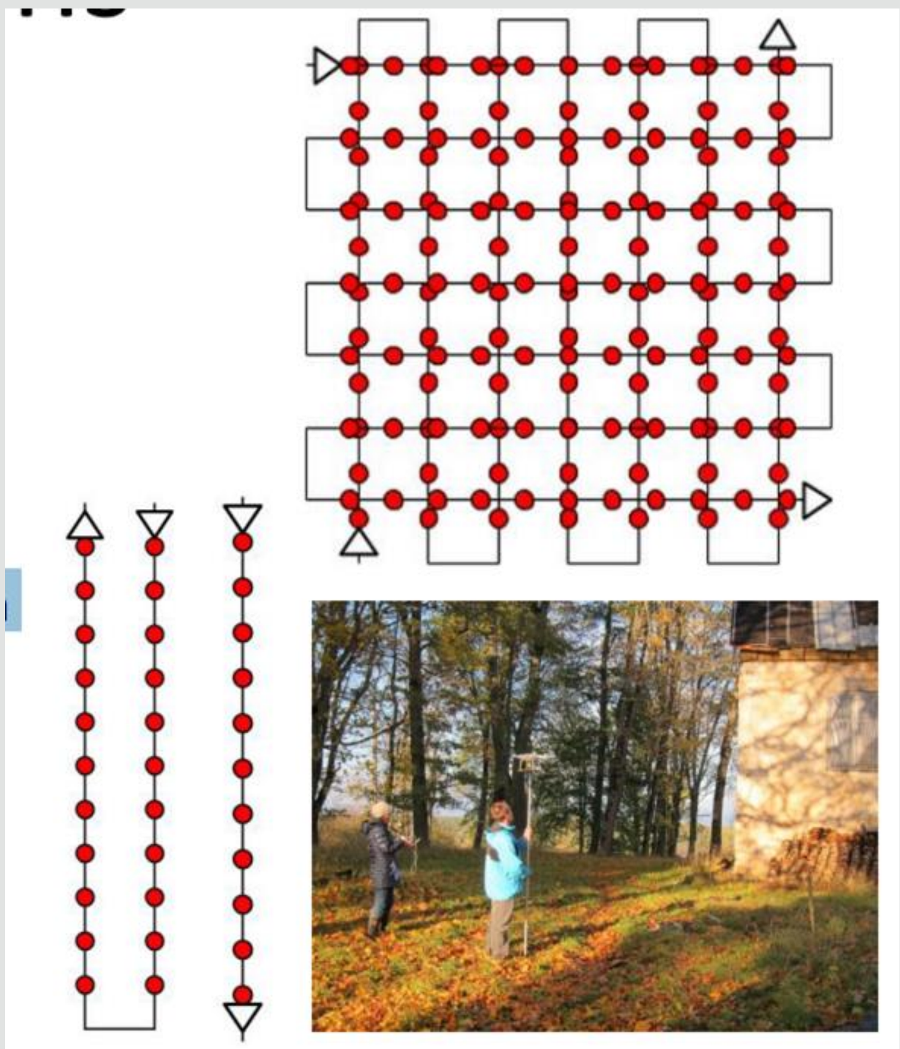
- Grid flight plan (Nadir or Oblique)
  - Optimal for areas and surfaces – Result: orthophotos, digital terrain model
  - Recommendations:
    - 75% frontal overlap
    - 60% side overlap
    - Wherever possible, a regular grid and a constant height
- Fly around plan
  - Optimal for buildings, individual objects
  - Result: point cloud, 3D model
  - Recommendations:
    - One image at every 5-10°
    - More images at the corners of the building



Flight plans

- **Double grid flight plan**
  - Optimal for urban and built-up areas
  - For reconstruction of façades reconstruction direction of camera 10-35 ° from the vertical

- **Other plans**
  - Corridor flight plan (roads, railways) recommends round-trip route (dual pass) with a vertical or oblique views or one-way route (single pass), but then with a 90% overlap
  - Circular or spiral routes for vertical objects (towers, chimneys, masts)
  - From ground
  - Various combination of mentioned plans



Other conditions and limitations

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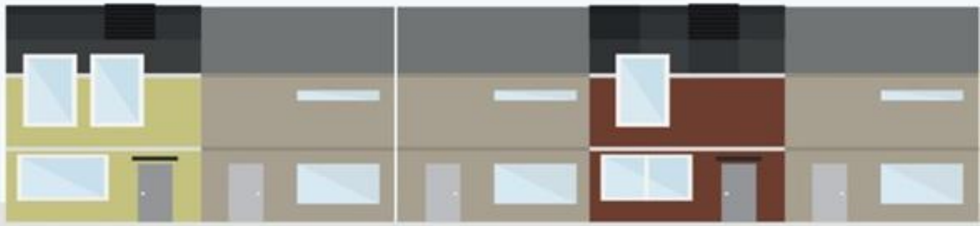
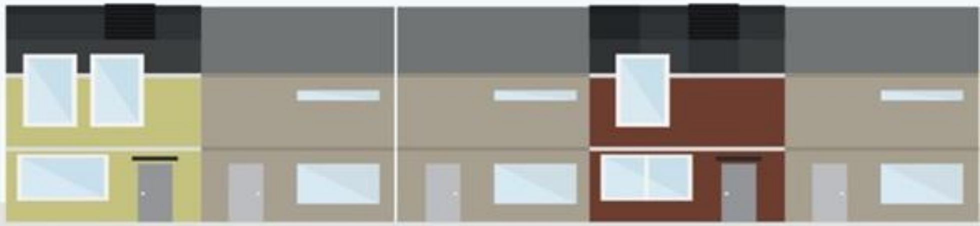


- Day time and weather:
  - Required good lighting conditions.
  - Bright sunlight gives too high contrast for images.
  - Low Sun's height above the horizon gives troublesome shadows.
  - Optimal conditions - a little cloudy day without precipitation.

- Limitations:
  - Difficulties in reconstruction of reflective and transparent surfaces, including glass.
  - Difficulties in reconstruction surfaces with a little visual content including sand, snow, waterbodies and flat walls without texture
  - A special treatment required for dense vegetation, trees and forests.
  - Specific acquisition plan is required for narrow and structured vertical objects like power and communication towers, masts, wind turbines etc.
  - Not suitable for interior modelling in bad lighting conditions.



Flight and capturing image data

Fieldwork

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1,5 hours

Flight plan

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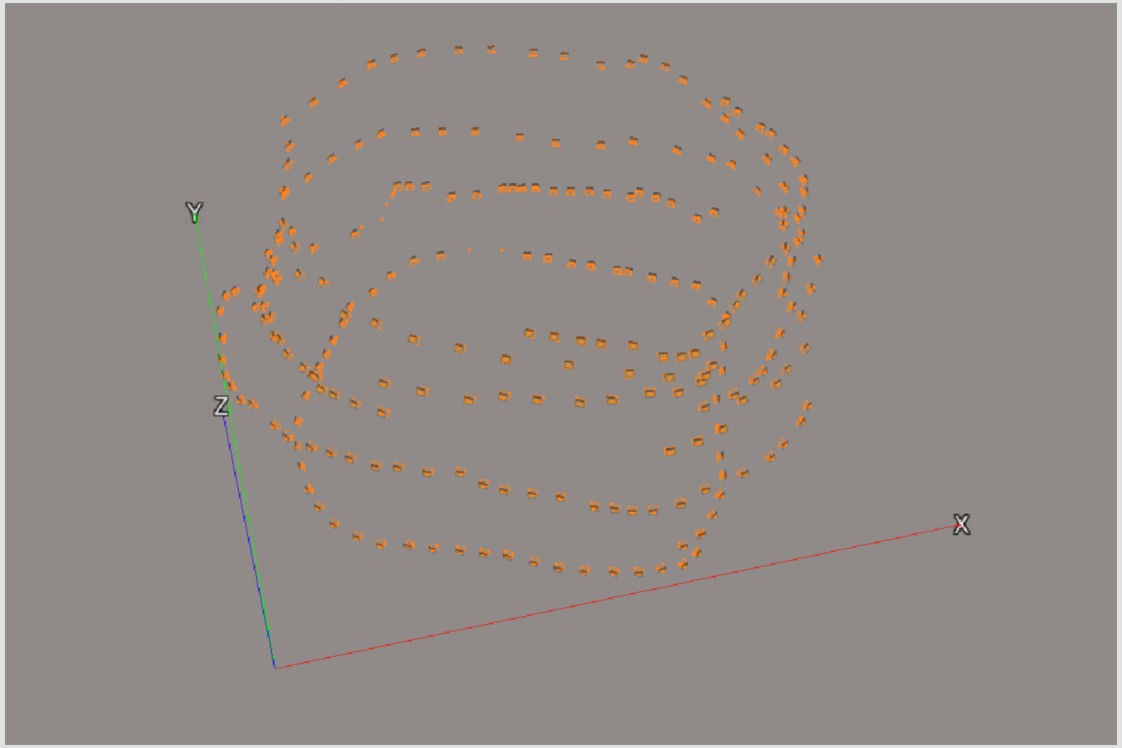
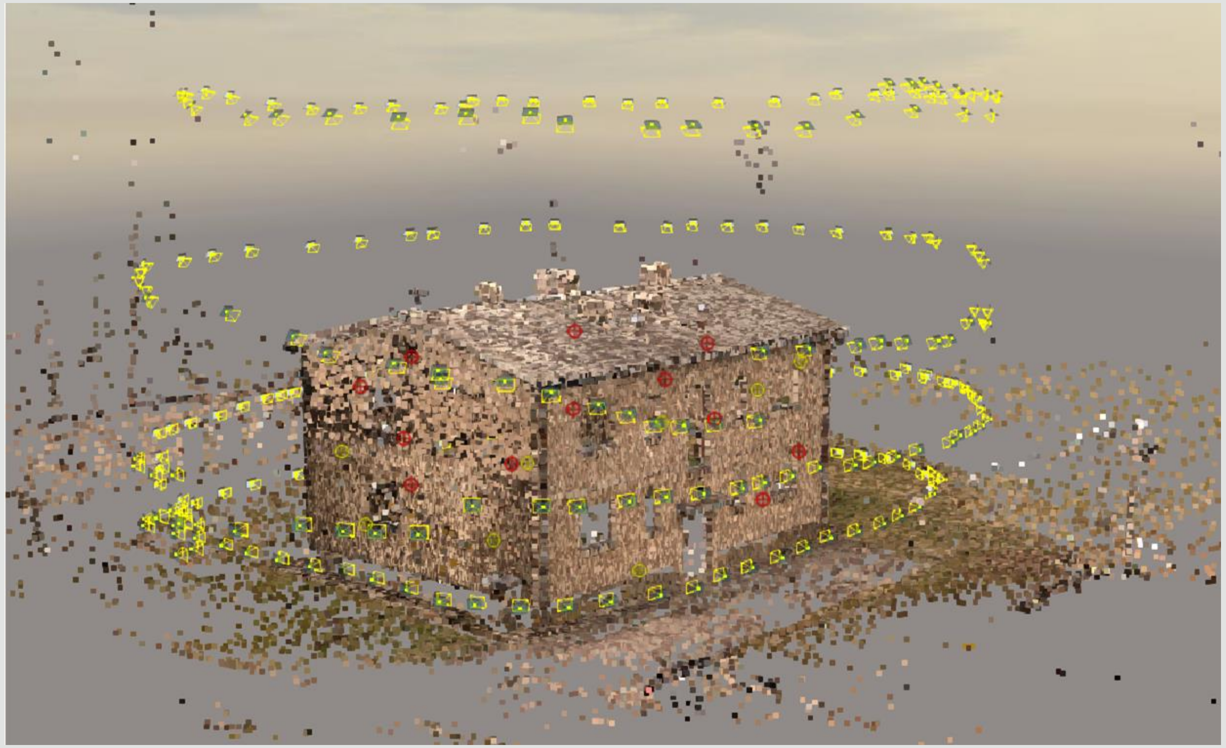
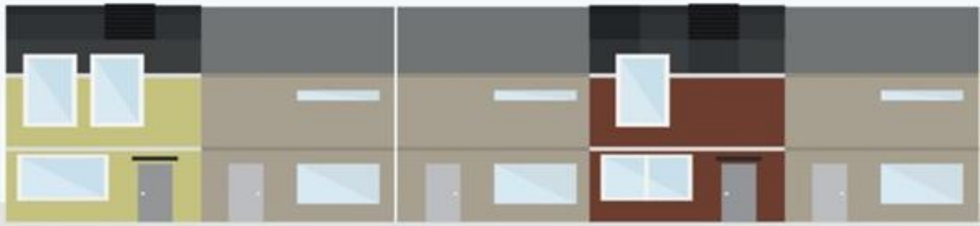
- Photos taken in 4 layers - three from flight, one from ground





Flight information



1) Photos taken in 19th April, 2017
2) Drone Phantom 4 DJI FC330
3) Weather – partly cloudy
4) Flight time - 1 hour 30 minutes
5) Number of photos - 250
6) Camera's resolution - 12.4 megapixels
7) Image format - DNG (RAW)

Image	
Image ID	
Dimensions	4000 x 3000
Width	4000 pixels
Height	3000 pixels
Horizontal resolution	72 dpi
Vertical resolution	72 dpi
Bit depth	24
Compression	
Resolution unit	2
Colour representation	sRGB
Compressed bits/pixel	3.80041466666666667

Camera	
Camera maker	DJI
Camera model	FC330
F-stop	f/2.8
Exposure time	1/866 sec.
ISO speed	ISO-100
Exposure bias	-1.7 step
Focal length	4 mm
Max aperture	2.97
Metering mode	Centre Weighted Average
Subject distance	0 mm
Flash mode	No flash function
Flash energy	
35mm focal length	20

Processing photos in ContextCapture Master

Creating reality model in ContextCapture Master

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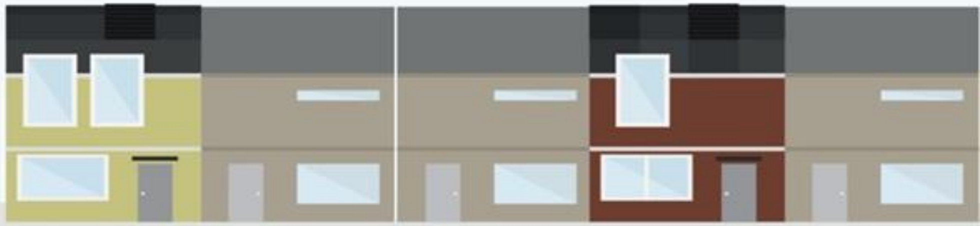
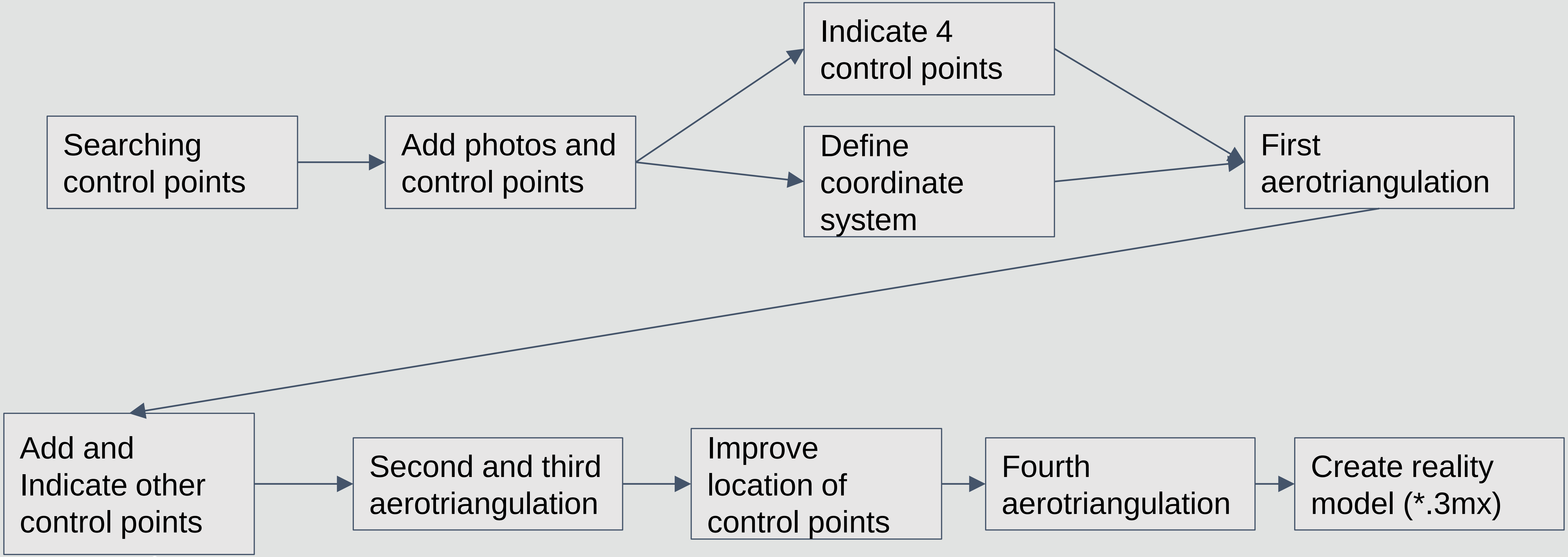
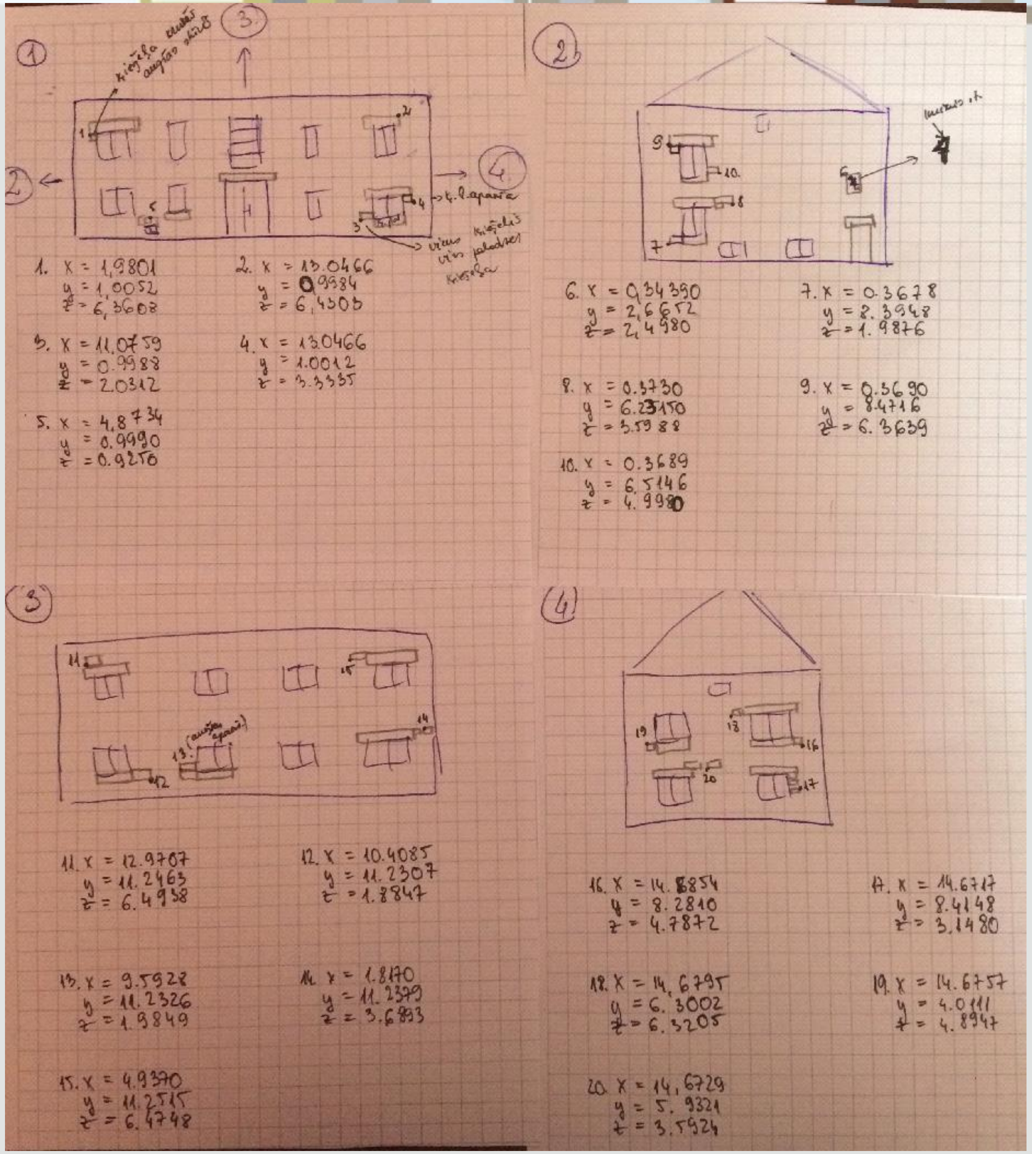




PART –I

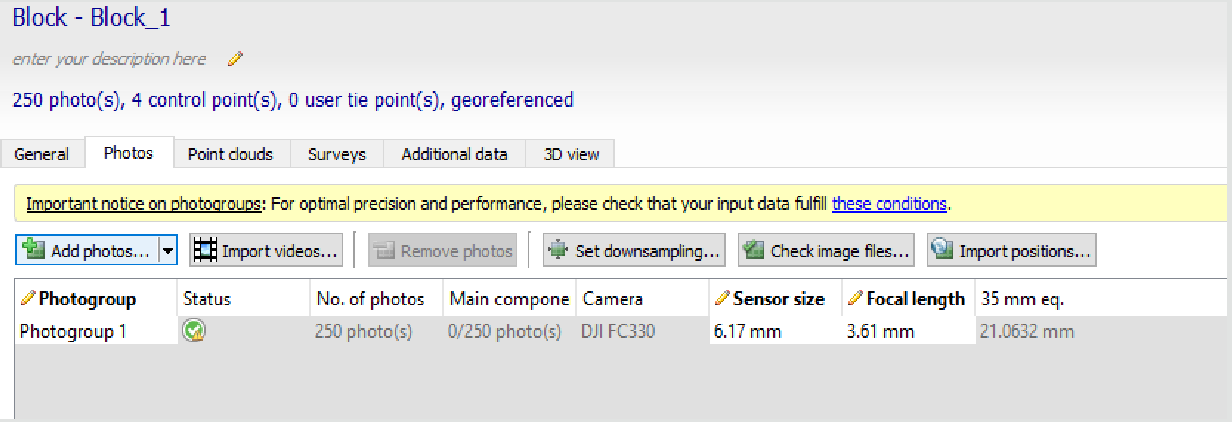
Control points

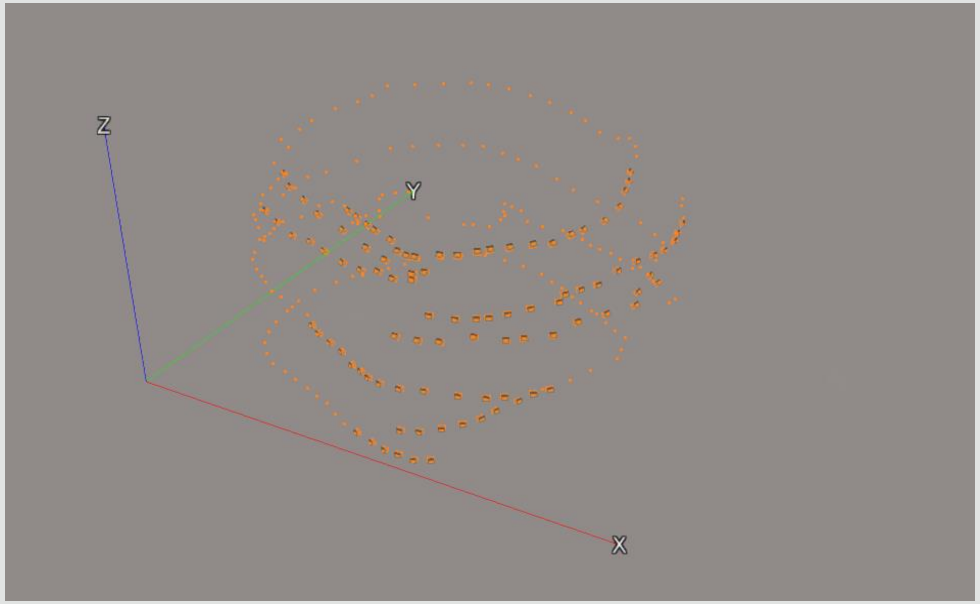
- It must be able to see one control point at least in 3 photos.
- 20 control points. 4 control points on each building wall.
- It is important that control points are positioned on both floors and in both corners of walls.
- Control points in different places better tie reality model.

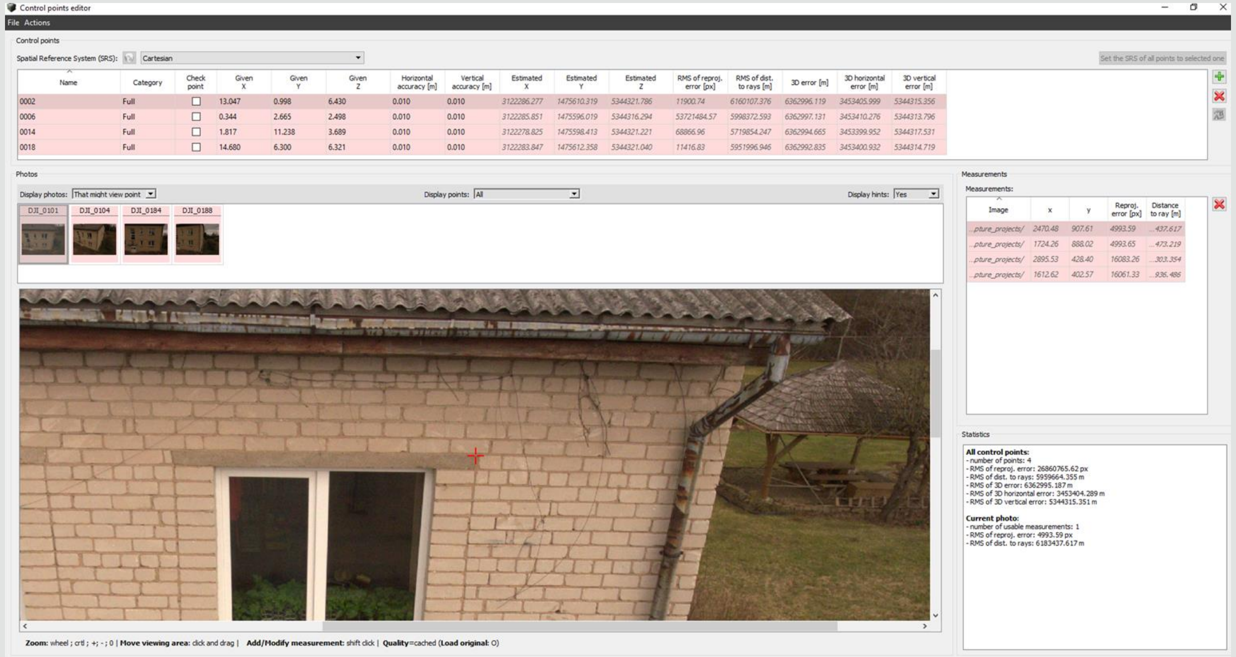


Data processing in ContextCapture Master

- Adding photos and control points.
- Indicate 4 control points and define coordinate syst
- Do first aerotriangulation.







Indicating control points

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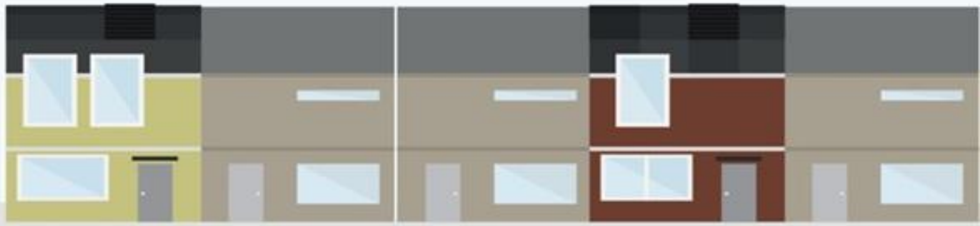

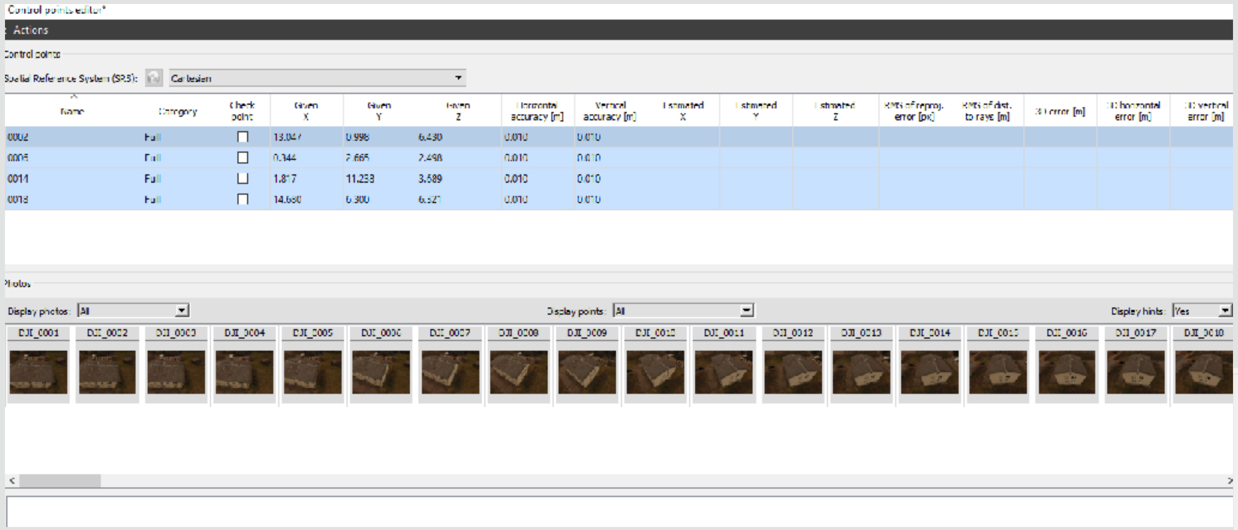

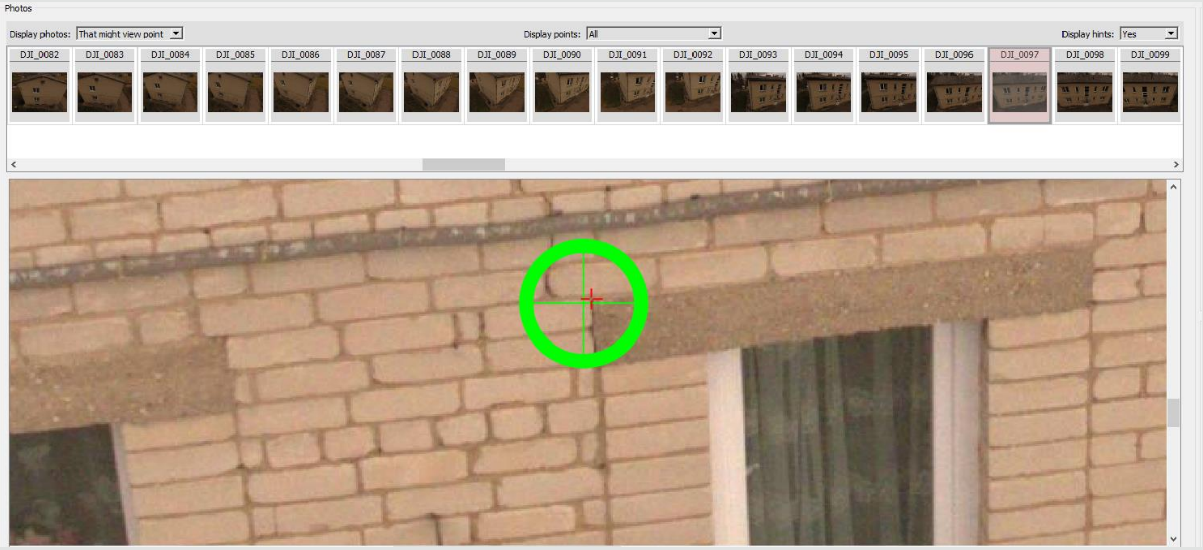

First aerotriangulation

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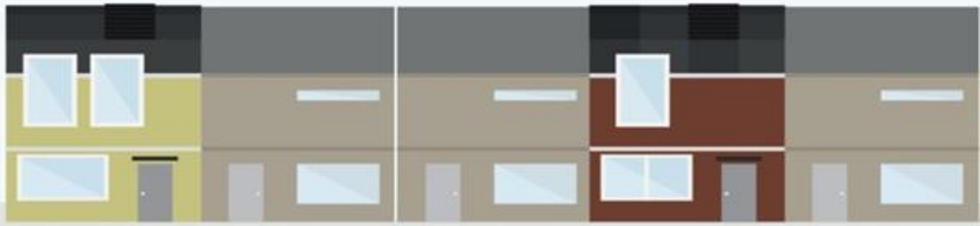
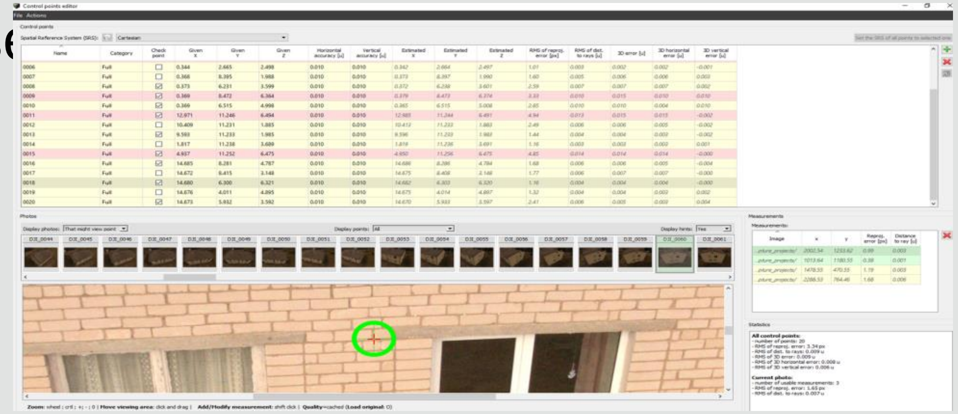
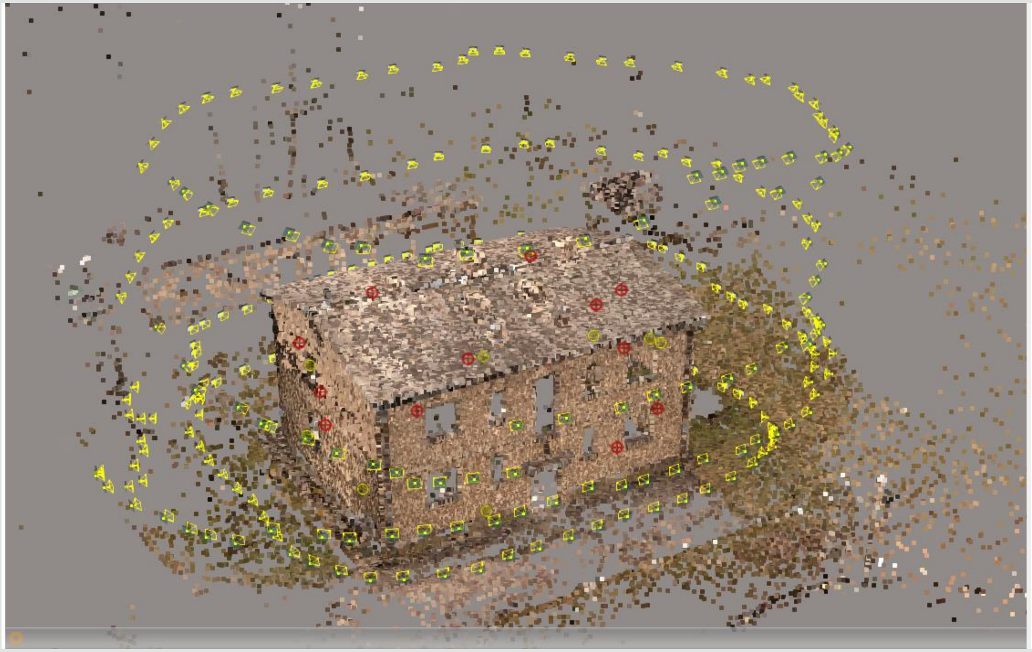


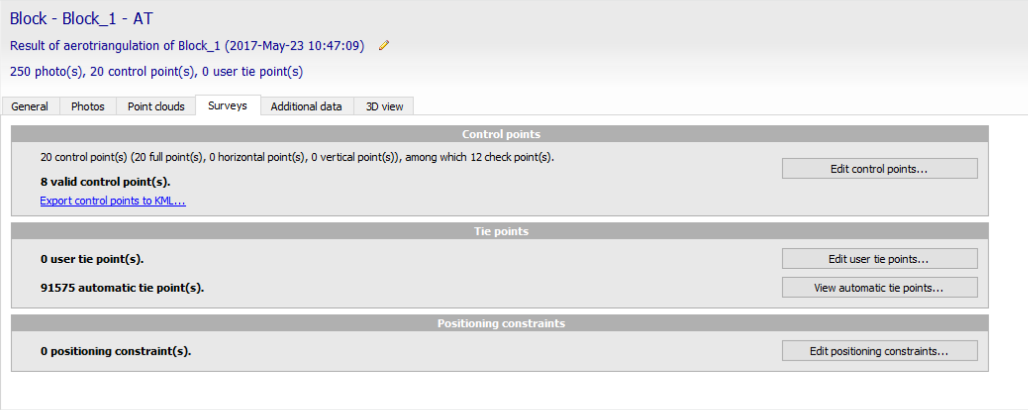
- After first aerotriangulation model is located in th e correct place -
  it has a defined coordinate system.

- Improve location of first 4 control points.
- Add and indicate other 16 control points.
- Define photos precision - 1 cm.
- 8 of all 20 control points are pick as accurate, other 12 points are checkpoints. Checkpoints helps to evaluate reality models accuracy.

- Do se







Second and third aerotriangulation

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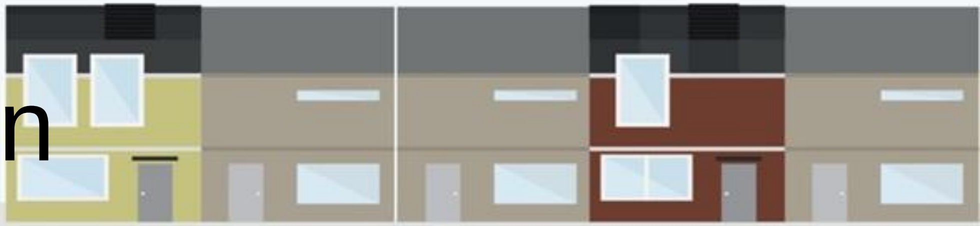
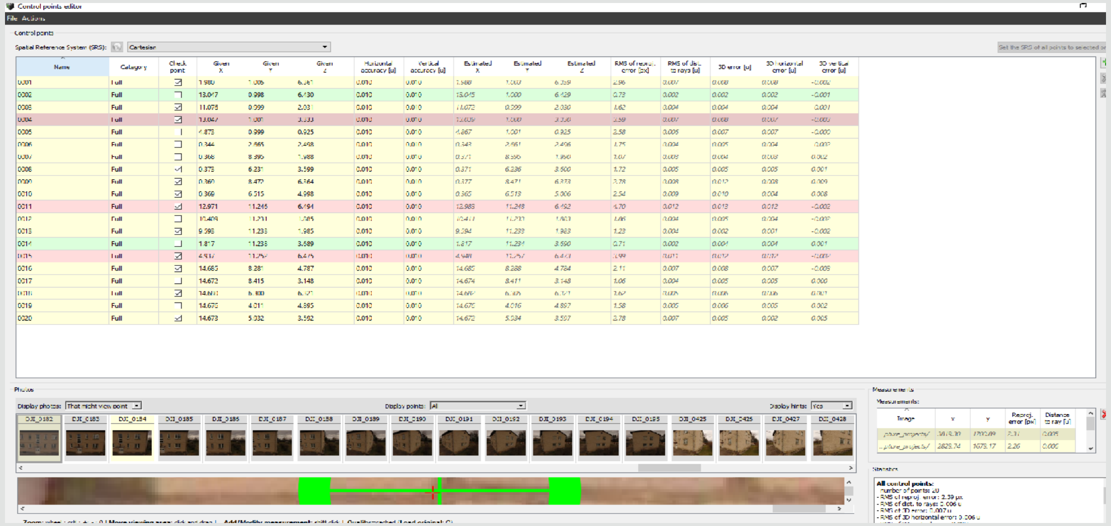
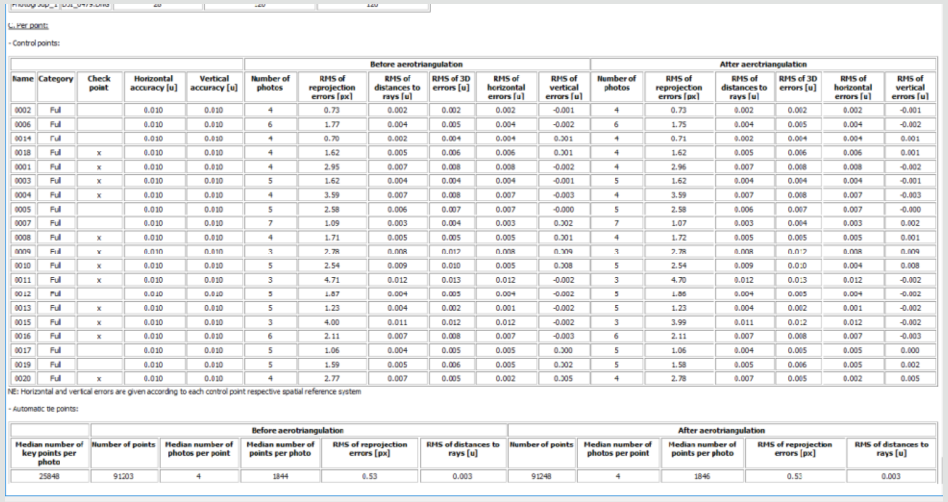


- Improve location of control points.

- Do fourth aerotriangulation.





C. Per point:

- Control points:

					Before aerotriangulation						After aerotriangulation					
Name	Category	Check point	Horizontal accuracy [u]	Vertical accuracy [u]	Number of photos	RMS of reprojection errors [px]	RMS of distances to rays [u]	RMS of 3D errors [u]	RMS of horizontal errors [u]	RMS of vertical errors [u]	Number of photos	RMS of reprojection errors [px]	RMS of distances to rays [u]	RMS of 3D errors [u]	RMS of horizontal errors [u]	RMS of vertical errors [u]
0002	Full		0.010	0.010	4	0.73	0.002	0.002	0.002	-0.001	4	0.73	0.002	0.002	0.002	-0.001
0006	Full		0.010	0.010	6	1.77	0.004	0.005	0.004	-0.002	6	1.75	0.004	0.005	0.004	-0.002
0014	Full		0.010	0.010	4	0.70	0.002	0.004	0.004	0.001	4	0.71	0.002	0.004	0.004	0.001
0018	Full	x	0.010	0.010	4	1.62	0.005	0.006	0.006	0.001	4	1.62	0.005	0.006	0.006	0.001
0001	Full	x	0.010	0.010	4	2.95	0.007	0.008	0.008	-0.002	4	2.96	0.007	0.008	0.008	-0.002
0003	Full	x	0.010	0.010	5	1.62	0.004	0.004	0.004	-0.001	5	1.62	0.004	0.004	0.004	-0.001
0004	Full	x	0.010	0.010	4	3.59	0.007	0.008	0.007	-0.003	4	3.59	0.007	0.008	0.007	-0.003
0005	Full		0.010	0.010	5	2.58	0.006	0.007	0.007	-0.000	5	2.58	0.006	0.007	0.007	-0.000
0007	Full		0.010	0.010	7	1.09	0.003	0.004	0.003	0.002	7	1.07	0.003	0.004	0.003	0.002
0008	Full	x	0.010	0.010	4	1.71	0.005	0.005	0.005	0.001	4	1.72	0.005	0.005	0.005	0.001
0009	Full	x	0.010	0.010	3	2.78	0.008	0.012	0.008	0.009	3	2.78	0.008	0.012	0.008	0.009
0010	Full	x	0.010	0.010	5	2.54	0.009	0.010	0.005	0.008	5	2.54	0.009	0.010	0.004	0.008
0011	Full	x	0.010	0.010	3	4.71	0.012	0.013	0.012	-0.002	3	4.70	0.012	0.013	0.012	-0.002
0012	Full		0.010	0.010	5	1.87	0.004	0.005	0.004	-0.002	5	1.86	0.004	0.005	0.004	-0.002
0013	Full	x	0.010	0.010	5	1.23	0.004	0.002	0.001	-0.002	5	1.23	0.004	0.002	0.001	-0.002
0015	Full	x	0.010	0.010	3	4.00	0.011	0.012	0.012	-0.002	3	3.99	0.011	0.012	0.012	-0.002
0016	Full	x	0.010	0.010	6	2.11	0.007	0.008	0.007	-0.003	6	2.11	0.007	0.008	0.007	-0.003
0017	Full		0.010	0.010	5	1.06	0.004	0.005	0.005	0.000	5	1.06	0.004	0.005	0.005	0.000
0019	Full		0.010	0.010	5	1.59	0.005	0.006	0.005	0.002	5	1.58	0.005	0.006	0.005	0.002
0020	Full	x	0.010	0.010	4	2.77	0.007	0.005	0.002	0.005	4	2.78	0.007	0.005	0.002	0.005

NE: Horizontal and vertical errors are given according to each control point respective spatial reference system

- Automatic tie points:

	Before aerotriangulation					After aerotriangulation				
Median number of key points per photo	Number of points	Median number of photos per point	Median number of points per photo	RMS of reprojection errors [px]	RMS of distances to rays [u]	Number of points	Median number of photos per point	Median number of points per photo	RMS of reprojection errors [px]	RMS of distances to rays [u]
25848	91203	4	1844	0.53	0.003	91248	4	1846	0.53	0.003

Fourth aerotriangulation

- Average error after fourth aerotriangulation - 0.003m.
- Creating reality model (*.3mx).

Name	Category	Check point	Given X	Given Y	Given Z	Horizontal accuracy [u]	Vertical accuracy [u]
0001	Full	☑	1.980	1.005	6.361	0.010	0.010
0002	Full	☐	13.047	0.998	6.430	0.010	0.010
0003	Full	☑	11.076	0.999	2.031	0.010	0.010
0004	Full	☑	13.047	1.001	3.333	0.010	0.010
0005	Full	☐	4.873	0.999	0.925	0.010	0.010

	Before aerotriangulation					After aerotriangulation				
Median number of key points per photo	Number of points	Median number of photos per point	Median number of points per photo	RMS of reprojection errors [px]	RMS of distances to rays [u]	Number of points	Median number of photos per point	Median number of points per photo	RMS of reprojection errors [px]	RMS of distances to rays [u]
25848	91203	4	1844	0.53	0.003	91248	4	1846	0.53	0.003

Output - reality mesh model (*.3mx)

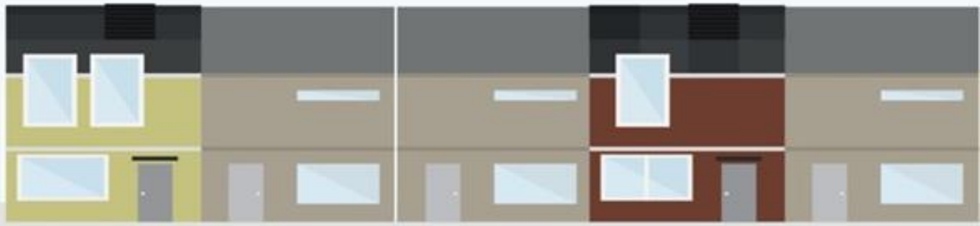
MORE—CONNECT

http://demo.mikrokods.lv/Saules_iela_4a_3mx/App/index.html#%2F

PART –I

ContextCapture Master products

MORE—CONNECT



1. Point cloud (a)
2. 3D mesh model (b)
3. Orthophoto (c)

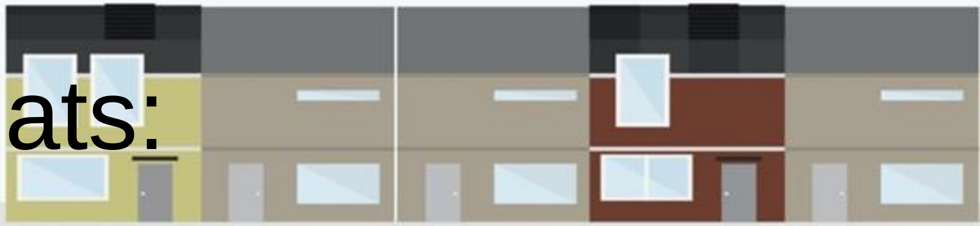
B)

C)

a)

100340369
9.486404 0.508713 -0.006912 -1294 46 38 62
-0.406815 6.905594 -0.005814 -1486 55 52 56
-2.699387 -1.115097 -0.052414 -46 54 48 48
-2.201187 -4.016312 -0.007797 -814 56 45 43
-2.199387 -4.016312 -0.008591 -990 60 48 47
-2.200089 -4.016403 -0.010513 -119 73 64 71
-2.197800 -4.016403 -0.010605 -1598 53 41 41
-2.257095 -4.015915 -0.008713 -590 73 60 60
-2.252090 -4.016006 -0.008102 -174 73 57 59
-2.267197 -4.015701 -0.007187 -318 74 63 58
-2.282608 -4.004196 -0.007187 -238 75 61 63
-2.284714 -4.004501 -0.007492 -318 79 64 67
-2.285812 -4.015305 -0.008987 345 70 59 65
-2.286392 -4.011887 -0.009109 393 75 61 70
-2.282303 -4.014206 -0.008011 -238 70 61 54
-2.282303 -4.015305 -0.010208 105 79 68 75
-2.284012 -4.012589 -0.010086 184 75 64 71
-2.282913 -4.012192 -0.010208 137 79 68 75
-2.284714 -4.014511 -0.009293 281 75 64 71
-2.285110 -4.012589 -0.008713 265 75 61 69
-2.281296 -4.012985 -0.009689 248 78 67 74
-2.283096 -4.011307 -0.009109 168 77 64 72
-2.284500 -4.009903 -0.009903 200 75 63 71
-2.281998 -4.009293 -0.009995 232 77 67 74
-2.285995 -4.007614 -0.009506 168 77 63 71
-2.281601 -4.005905 -0.008408 -478 73 59 61
-2.284012 -4.006699 -0.009811 152 76 64 72
-2.282608 -4.006088 -0.009995 216 78 71 78
-2.284805 -4.007004 -0.008011 -350 73 59 61
-2.283005 -4.004593 -0.008194 -334 79 64 67
-2.285904 -4.002487 -0.010391 137 71 66 71
-2.286301 -4.000290 -0.009903 200 71 66 71
-2.283310 -4.002609 -0.008713 265 75 70 75
-2.284805 -4.002090 -0.010513 200 75 69 75
-2.283096 -4.003494 -0.009811 200 75 70 75
-2.284897 -4.001389 -0.009293 281 72 67 72
-2.282303 -4.000900 -0.009415 200 77 70 76
-2.281296 -4.012100 -0.007797 -158 71 60 58
-2.284714 -4.012192 -0.007614 -334 70 59 57
-2.286514 -4.010910 -0.007309 -318 65 54 52
-2.285385 -4.008713 -0.007095 -350 68 54 54
-2.282608 -4.010605 -0.007706 -366 67 56 54

ContextCapture Master output formats:



3D mesh model:

- 3MX
- Smart3DCapture S3C
- OpenSceneGraph binary (OSGB)
- Autodesk F8X
- Collada(DAE)
- StereoLithography (STL)
- ESRI i3s scene database
- LOD tree export
- Google Earth KML
- SpacEyes3D Builder layer

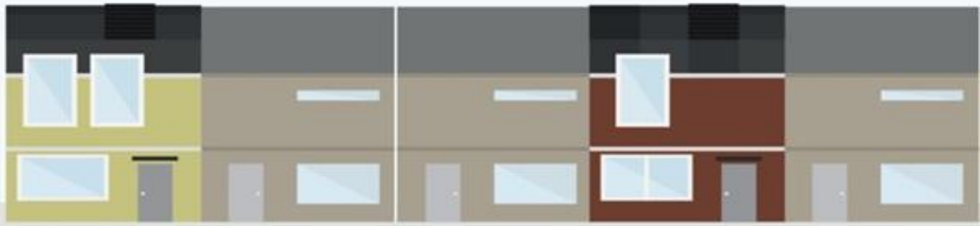
Point Cloud:

- LAS/LAZ
- POD

Ortophoto and digital terrain model:

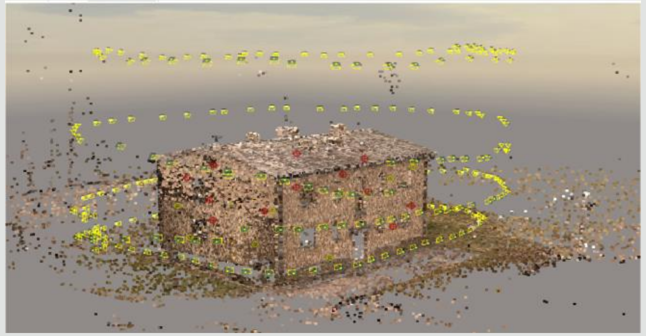
- geoTIFF
- JPEG

Time consumed



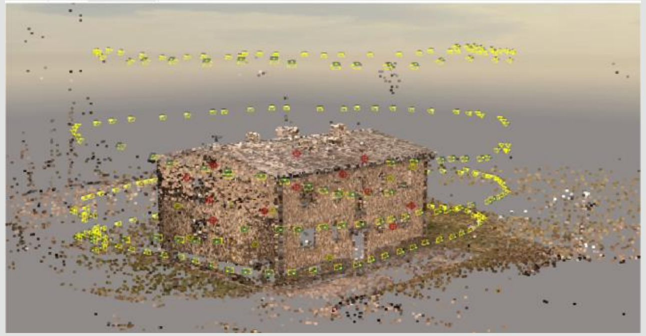
MORE—CONNECT

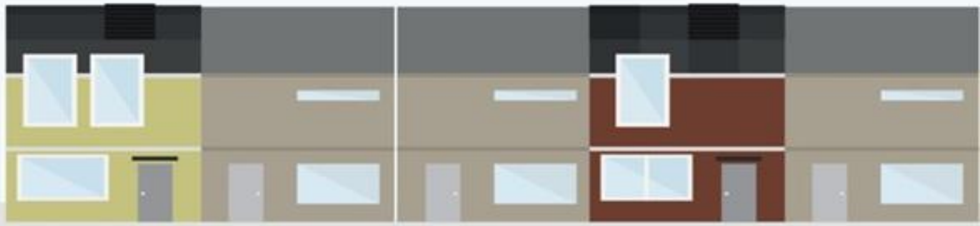
1. Flight planning and preparing
    - 1 hour
2. Flight and capturing images (arrival time to an object is not included):
    - 1 hour and 30 minutes
3. Processing photos in ContextCapture Master and searching for control points in Cloud Compare:
    - Searching for control points and indication (including control points area editing)
        - 3 hours
    - Creating production (reality model) -
        - 2 hours 12 minutes



PART -1 END

http://demo.mikrokods.lv/Saules_iela_4a_3mx/App/index.html#%2F

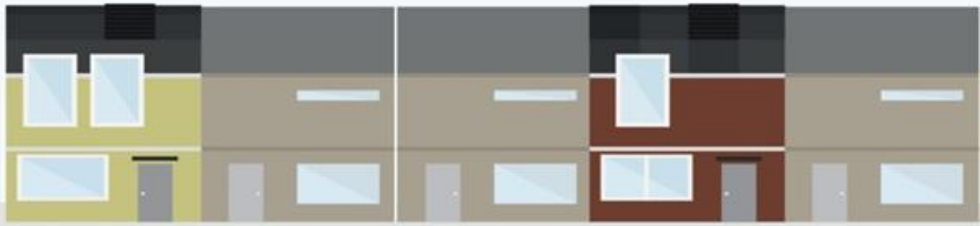




3D data capturing using 3D laserscanning

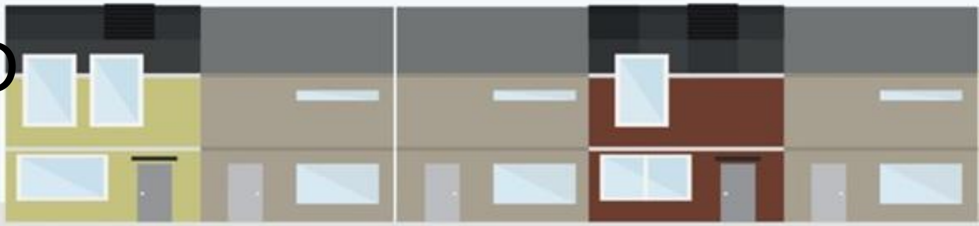
1. General information – 3D data capturing with 3D laserscanner
2. Field work on pilot object
3. Laser scanning point cloud data processing

General information – 3D data capturing with 3D laserscanner



- Lasercanning:

  - Object and place analyze;
  - Laserscanning
  - Registration of the scan positions;
  - Preprocessing scan results;
  - Export to anatother software



General information – 3D data capturing with 3D laserscanner

MORE — CONNECT

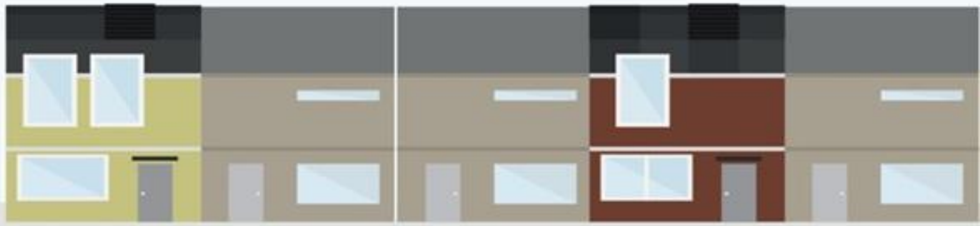
- Object analyze:
- Type of the object;
- Details of the object;
- Place where is object;
- Work planning;

or

General information – 3D data capturing with 3D laserscanner

MORE—CONNECT

- Laserscanning process
  - Find the best laserscanner;
  - Select the accuracy;
  - Scanning;
  - Control;

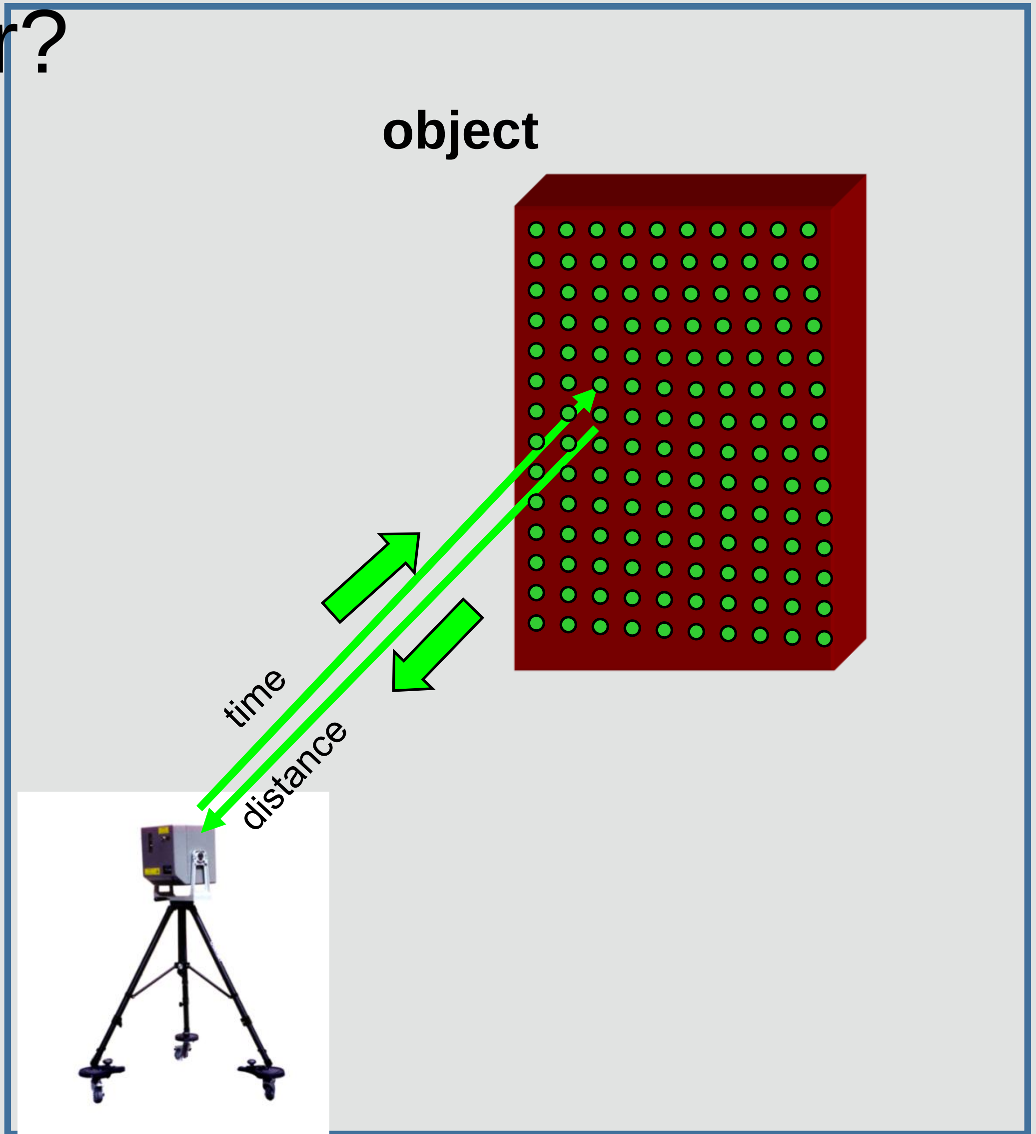


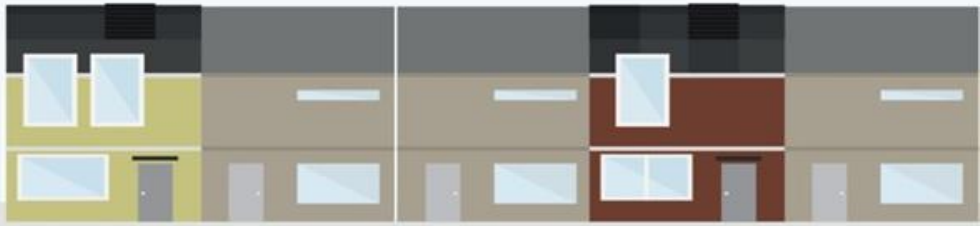
How to work 3D laserscanner?

1.

2.

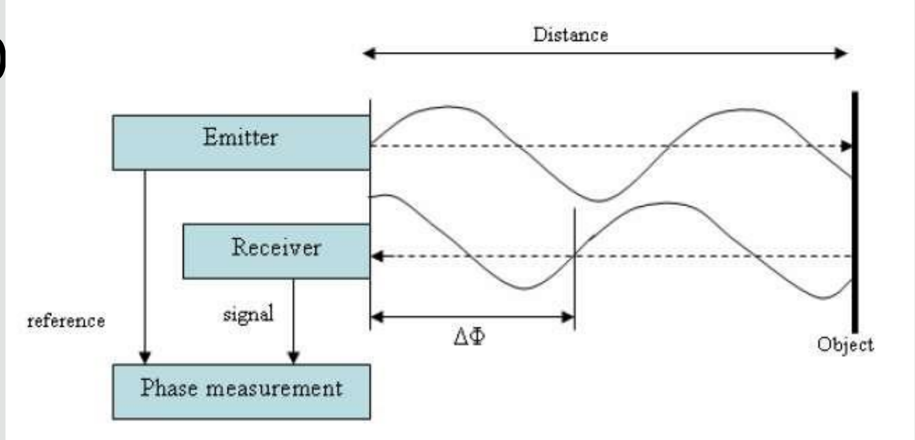
3.



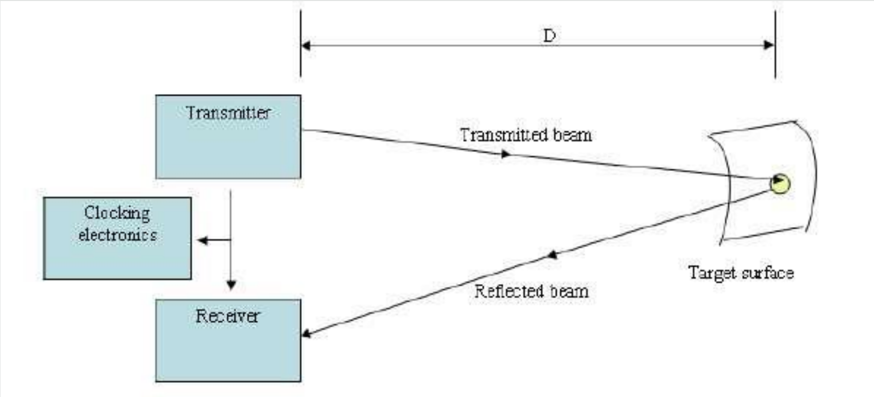


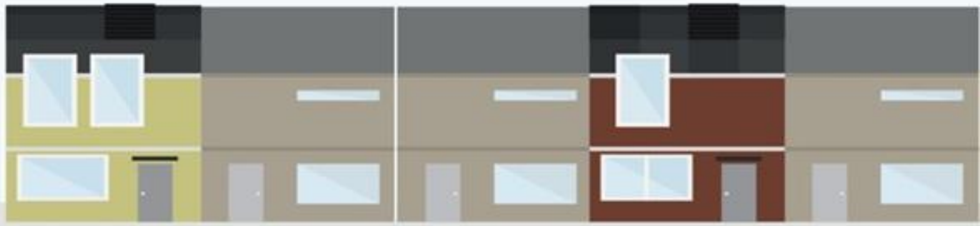
Laserscanner types

- From distances possible two types:
  - *phase* laserscanner(~150



  - *time of flight)* laserscanners (~500m)



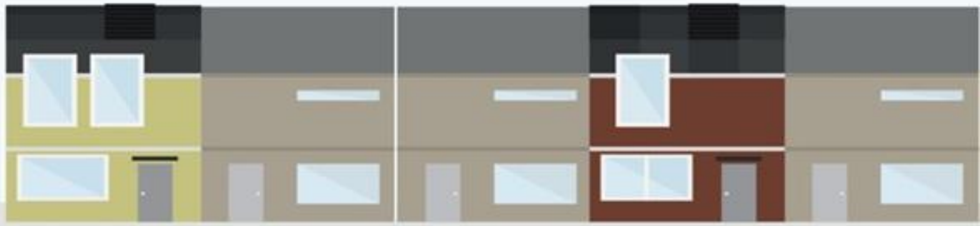


Types of the laserscanner

- Show the laser (normal use the green) (532 nm);

- Near infrared(700÷1300 nm);
- Infrared (1330÷1550 nm);

Scanning pilot example



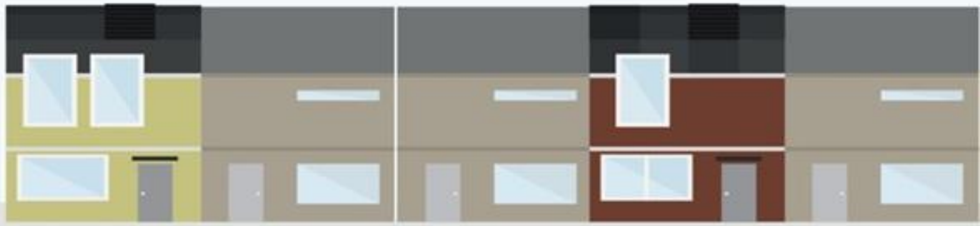
MORE — CONNECT

Instrument specification

- Faro scanner –accuracy 5 mm to 100 m
- Point spacing 3-5 mm
- RGB and intensity colors
- ~240 000 000 points in project
- 8 stations
- Field time 4 hours
- Registration, cleaning and export point cloud 3 hours
- Create the webshare project 2 hours
- Software
  - Faro Scene
  - Leica Cyclone
  - Bentley Descartes
  - Autodesk

Softwares

MORE — CONNECT



- Processing softwares
  - Farro scene 5.4 – for point clouds
  - Leica Cyclone 9.0 – for point clouds
  - Bentley Cloudworx 4x – for create 3D model
  - Bentley Connect 10.0 - for create 3D model
  - Bentley AicoSim – for create object for Energy Simulations
  - Autodesk revit
  - ArchiCad

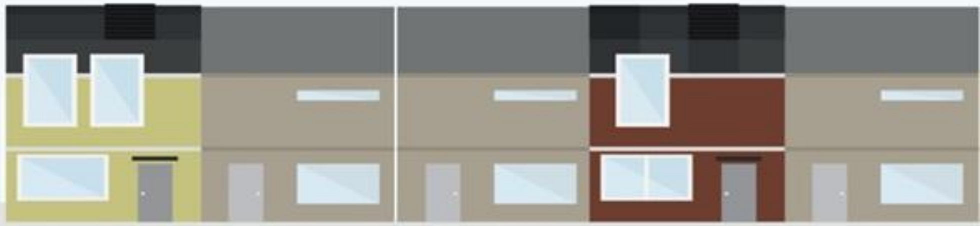
AUTODESK REVIT

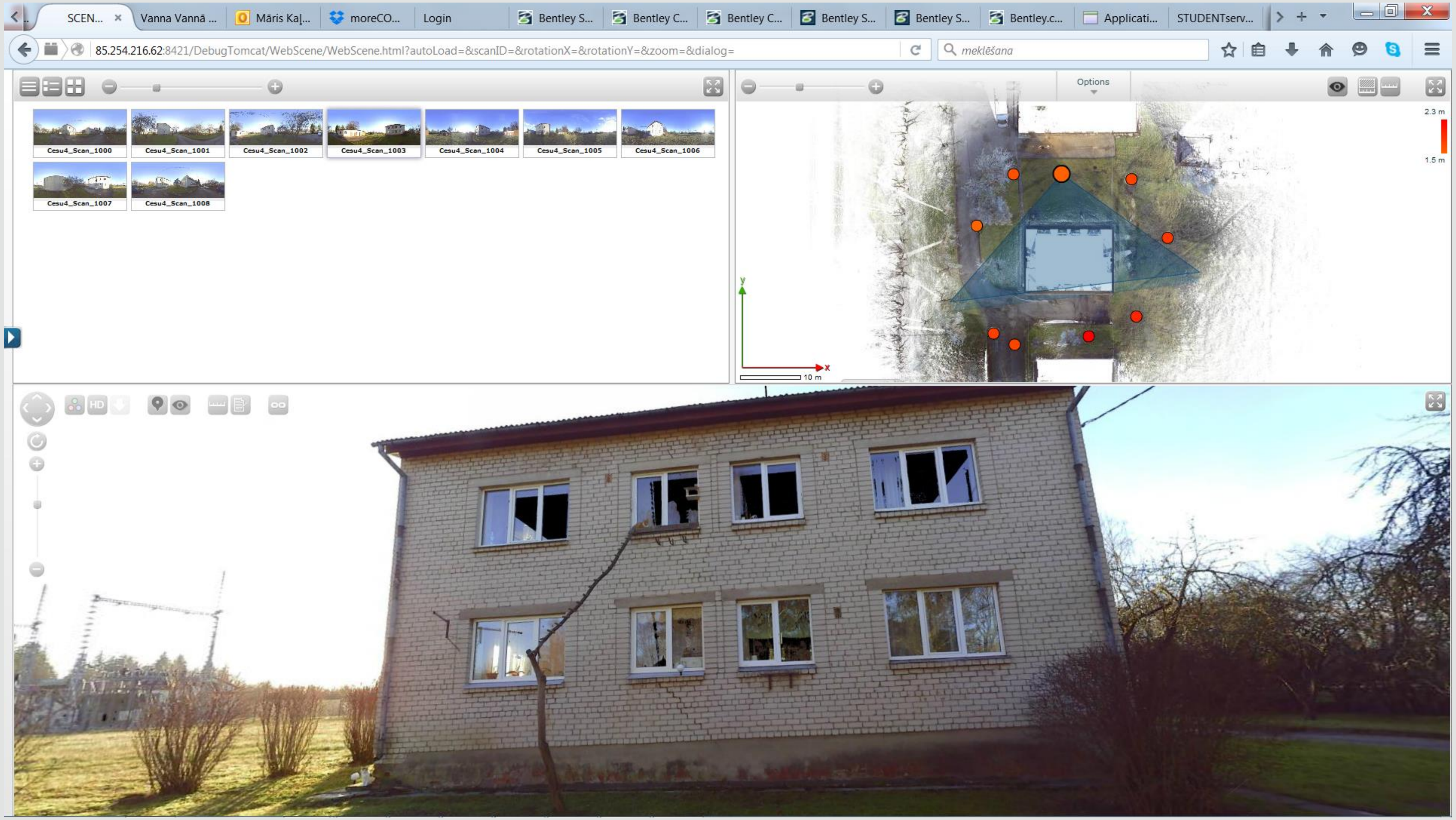
BENTLEY
Engineering the future together

GRAPHISOFT.
ARCHICAD

Plannig works

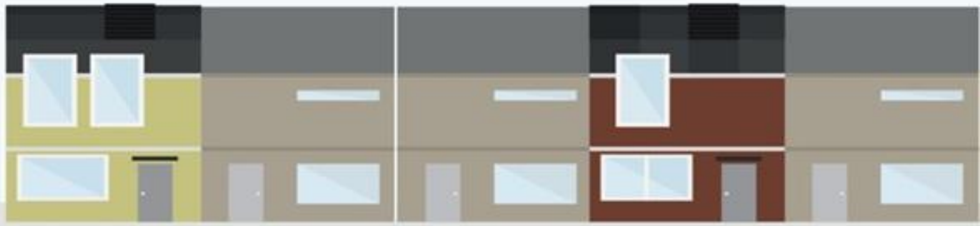
MORE——CONNECT

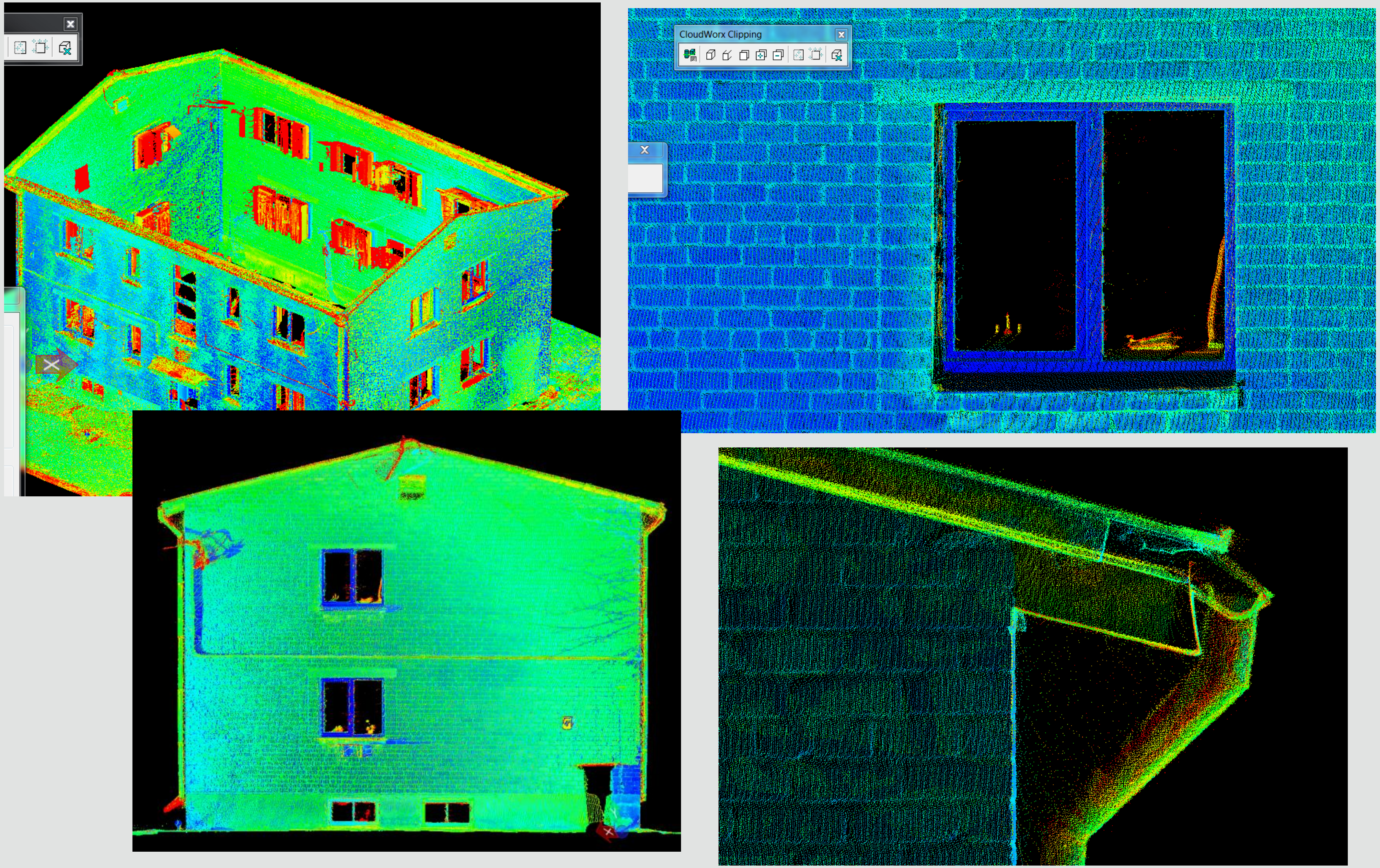




Results from scanning process

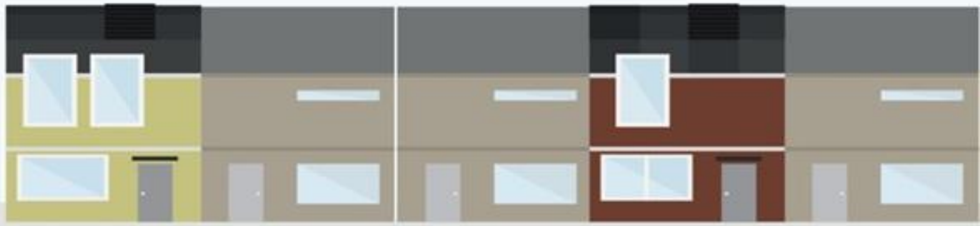
MORE — CONNECT





Advantages and disadvantages

MORE — CONNECT



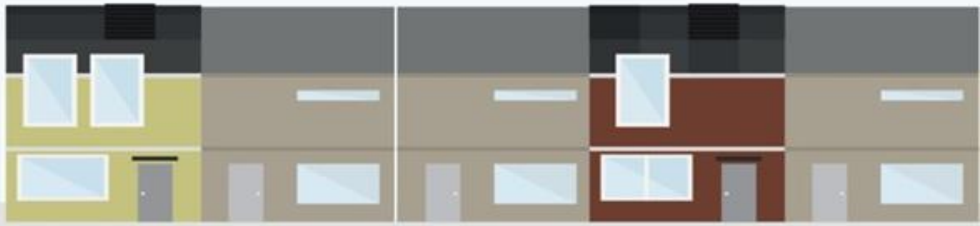
- Advantages
  - Fast
  - Hight accuracy

- Disadvantage
  - Without stafages not possible very nice to scan hight buildings
  - Depended from weather

PART III - 3D model and BIM

Renovation Problem

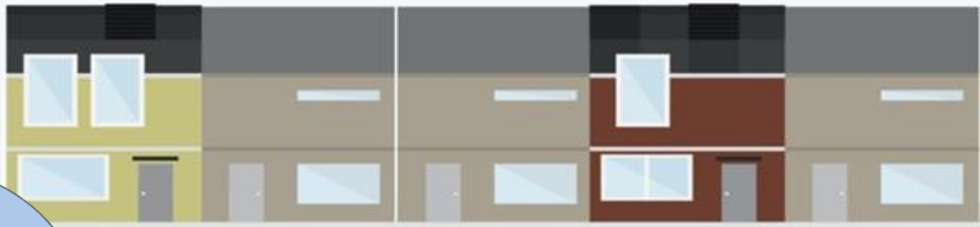
MORE—CONNECT

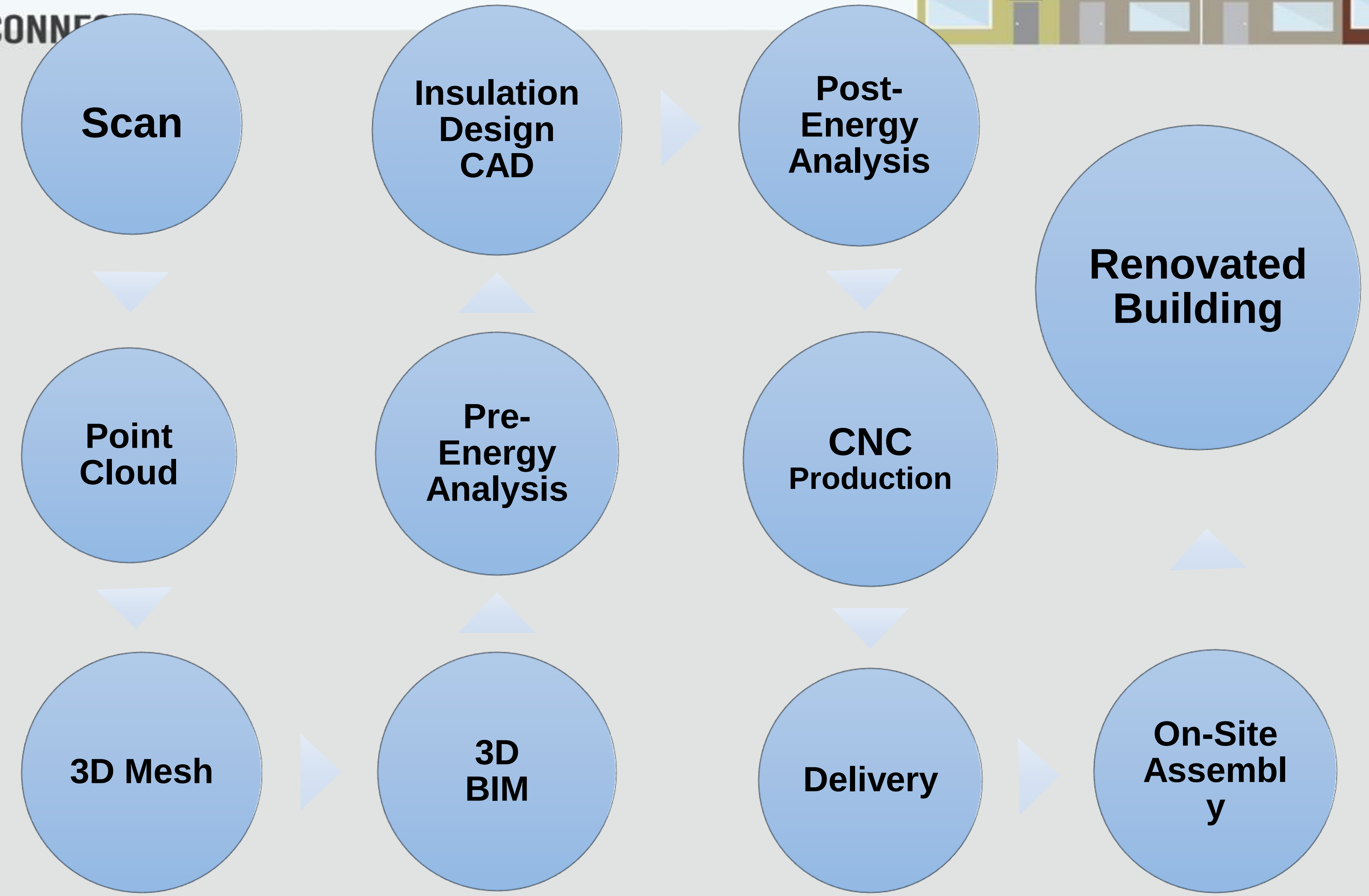


Existing Building → **Procedures** → **Renovated Building**

- **Energy**: As energy saving as possible
- **Model**: As precise as possible
- **Money**: As cheap as possible
- **Time**: As fast as possible

BIM Compatible Process Workflow

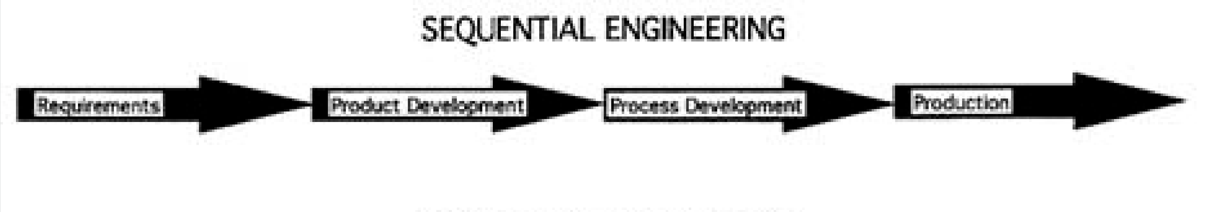


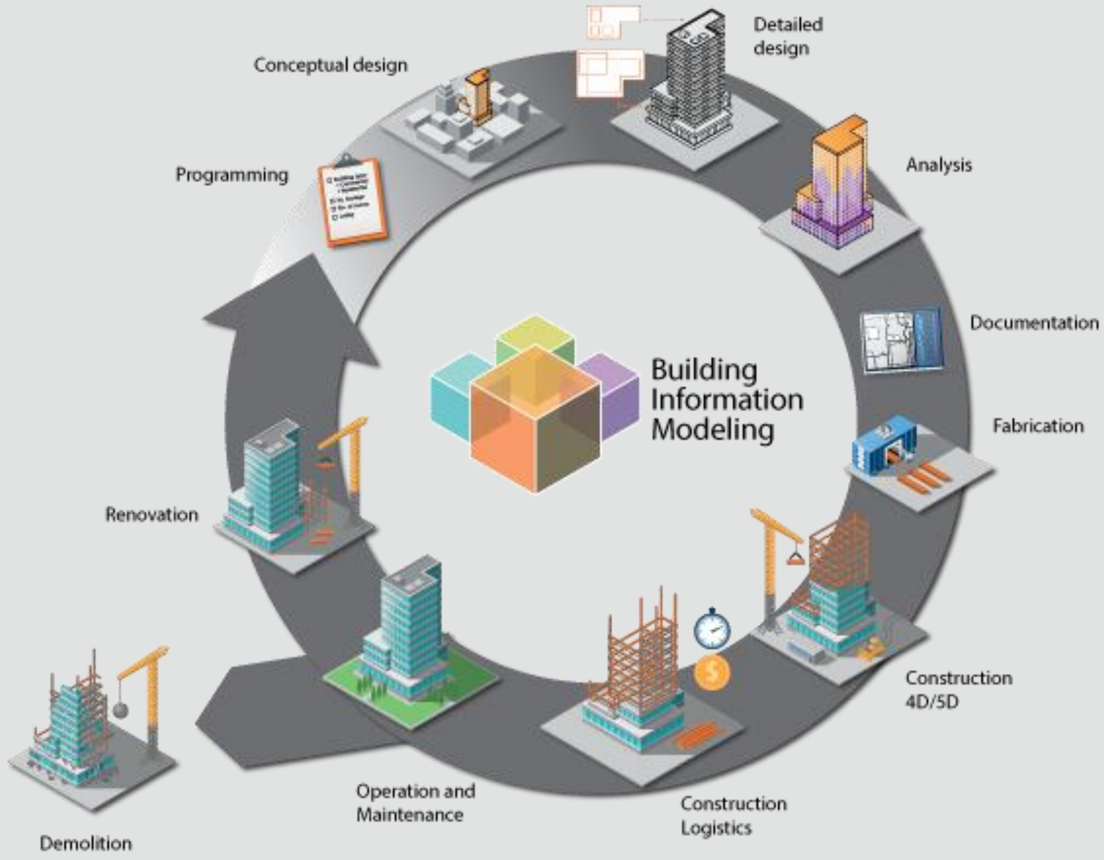


Sequential vs Concurrent Engineering

MORE—CONNECT

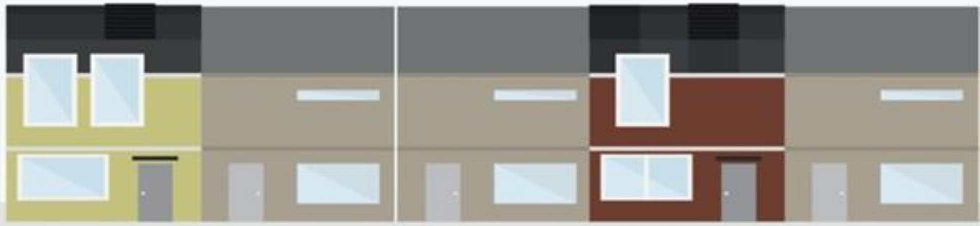
slow and tedious





Optimal Workflow

MORE—CONNECT



Point Cloud → CAD Software for Insulation Design → CNC Manufacturing

3D Point Cloud from Tallinn building was too huge:
- Surge hardware resources a lot
- Large amount of 3D capturing work
- Smaler building was selected – Cesis, Saules 4A

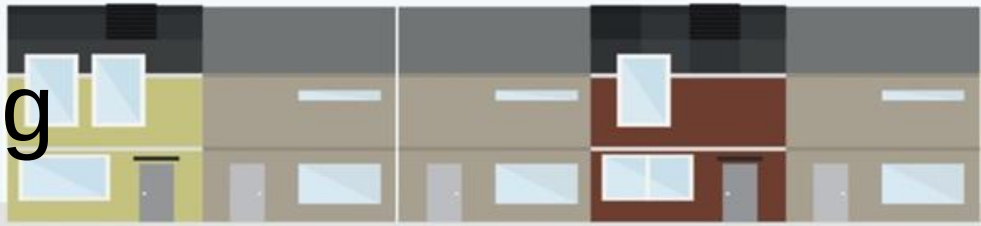
Example

Point Cloud → SEMA → Hundegger

Does not Exist at Present

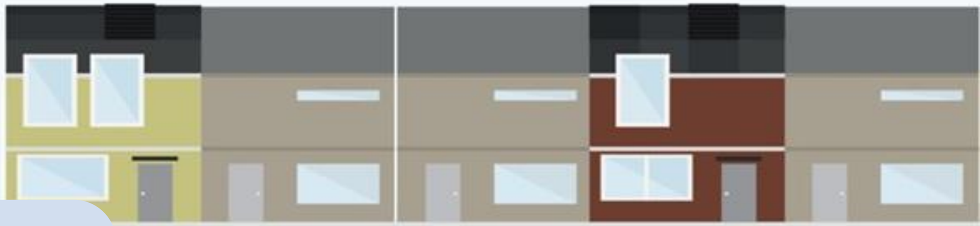
Workaround - Data Post-Processing

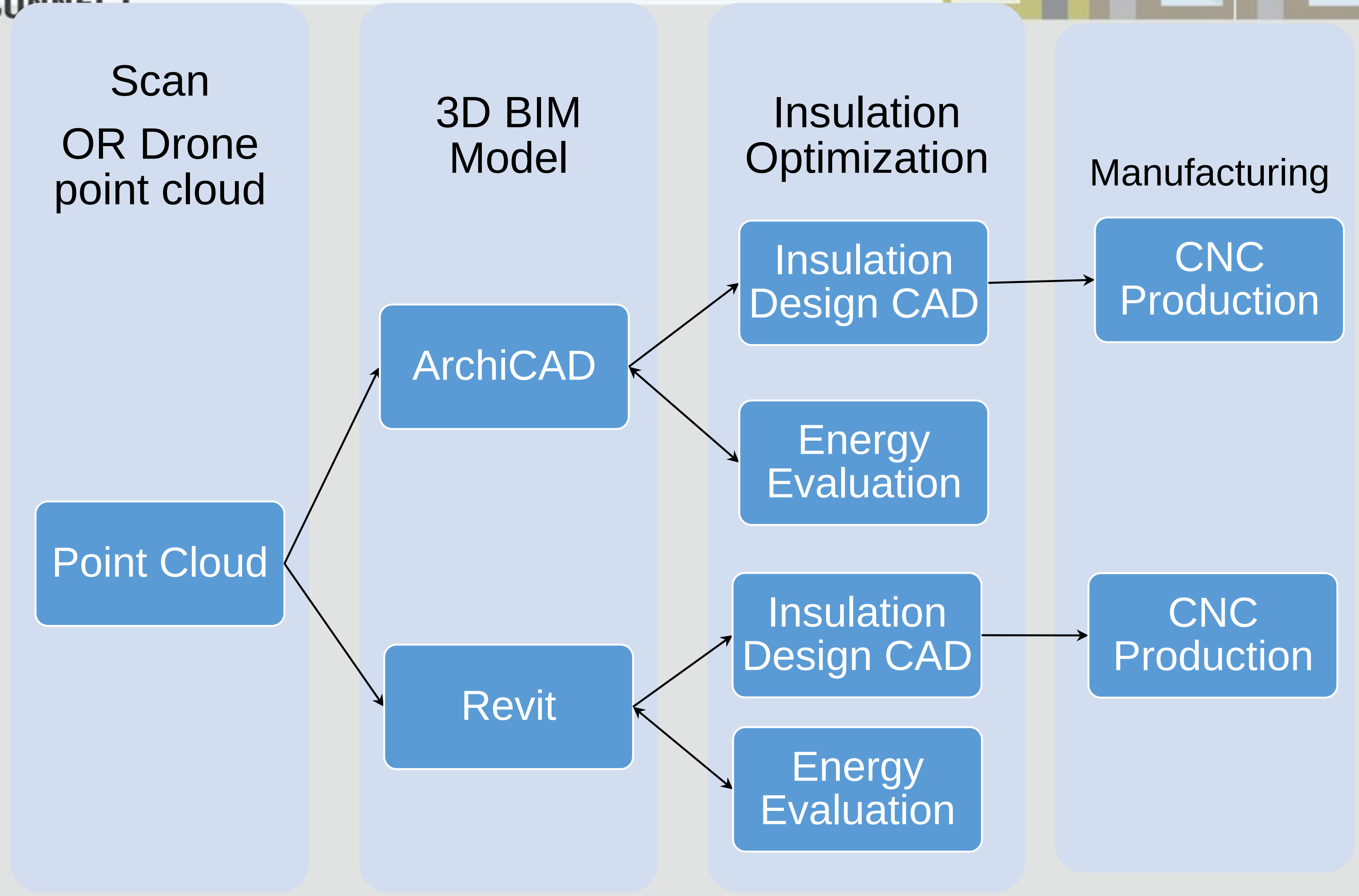
MORE—CONNECT



Pilot Study performed with ArchiCAD 19

Optimization of BIM Workflow



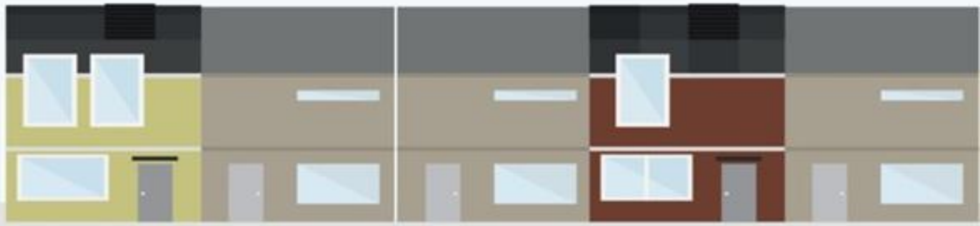


3D model and BIM

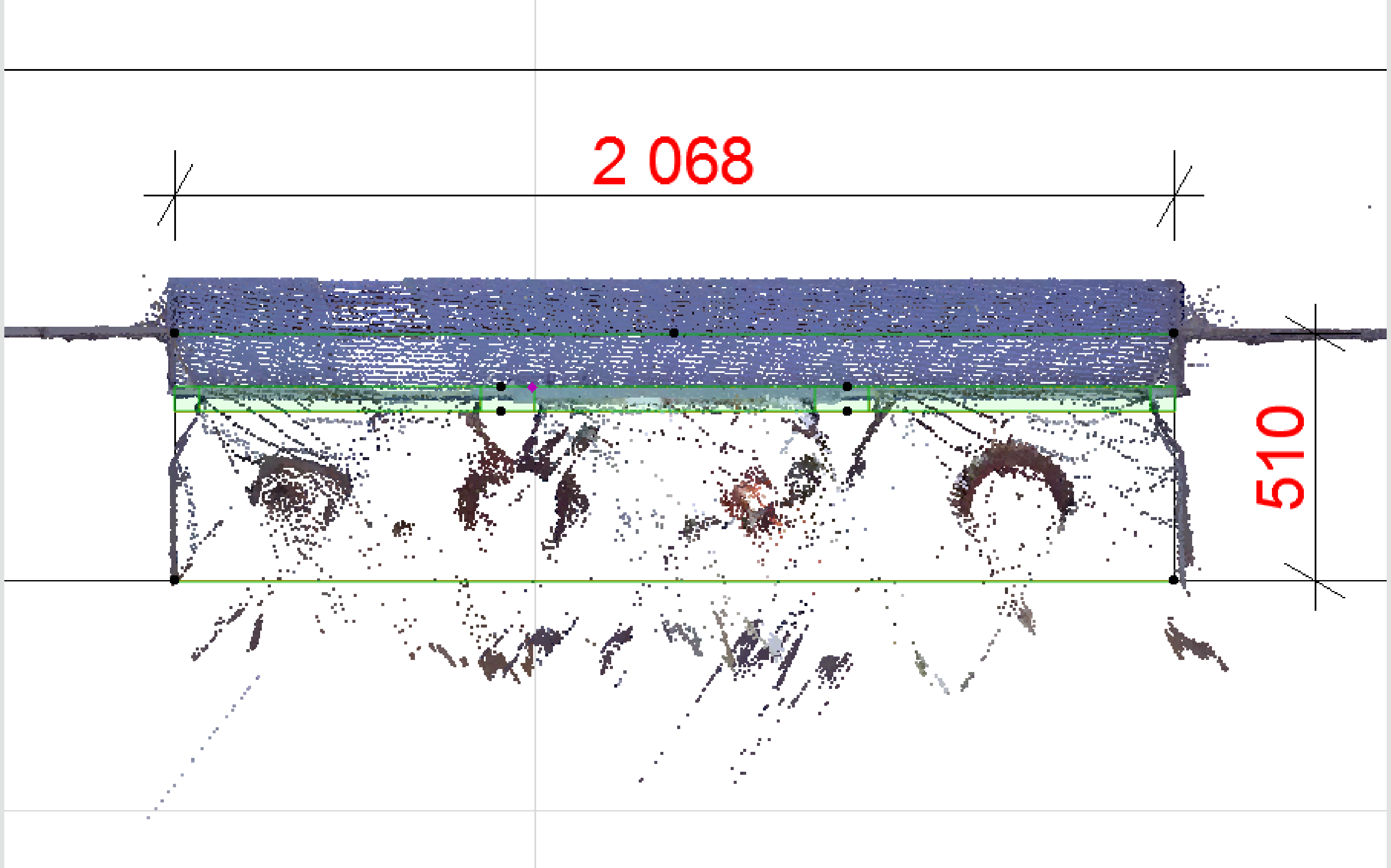
MORE—CONNECT

Manual Tracing Plans

East Elevation

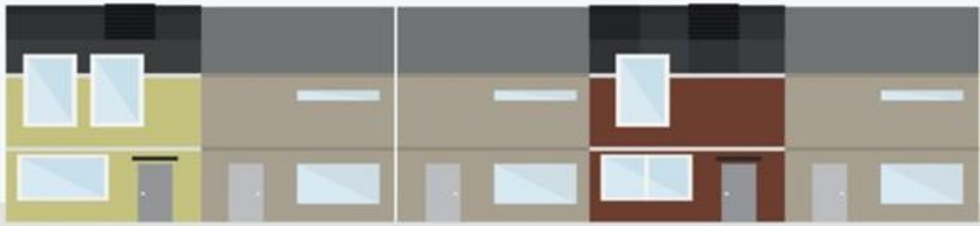


Manual Adjustment of Window



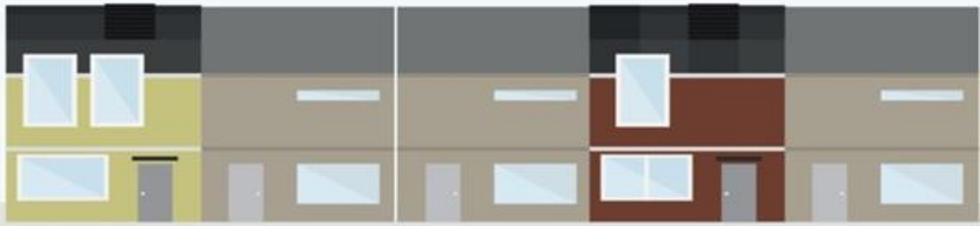
3D model and BIM

MORE—CONNECT



Windows Placement & Adjustment

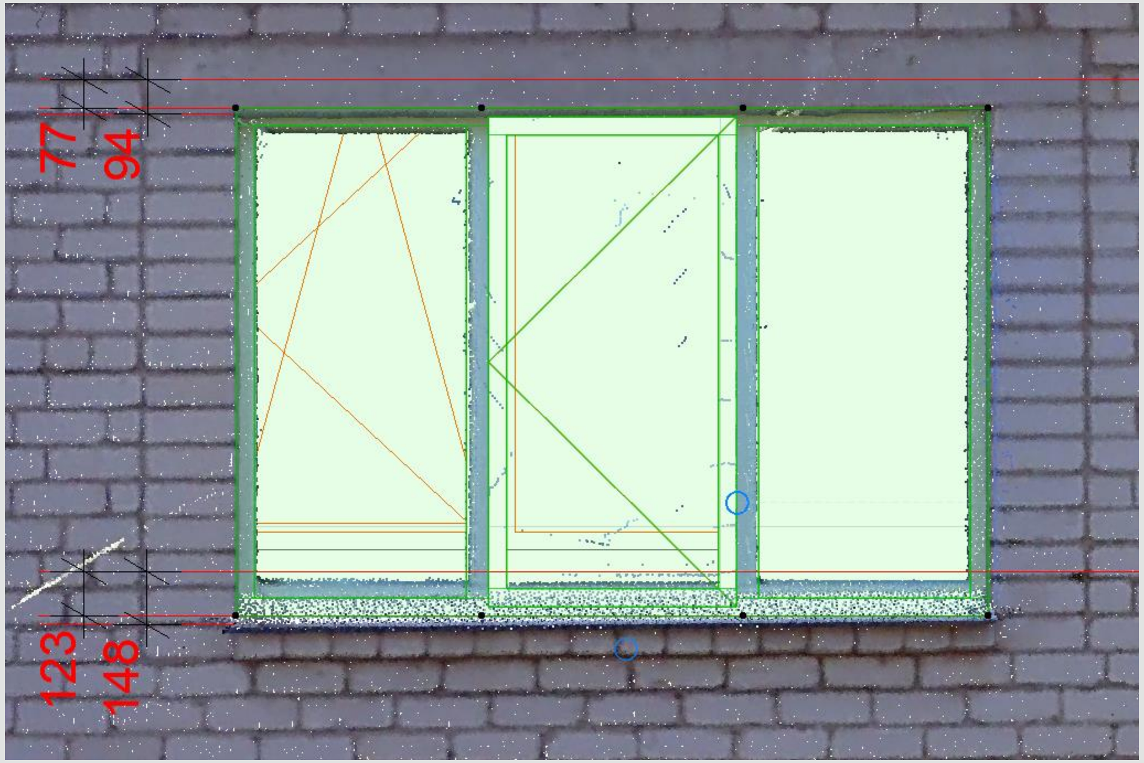
North Elevation



Key Factors Capturing 3D Model

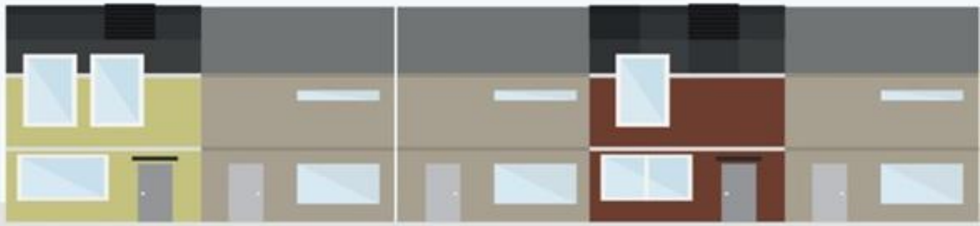
- Weather @ the Site when Scanning
- Vegetation and Neighbourhood Factors
- Foundation Settlement
- BIM Software Selection
- Software Price – ROI Issues
- Skills & Training to Optimize Workflow
- High Requirements Regarding PC Performance
- Human Factor Regarding Manual Tracing
- The Duration of Workflow and Number of Steps

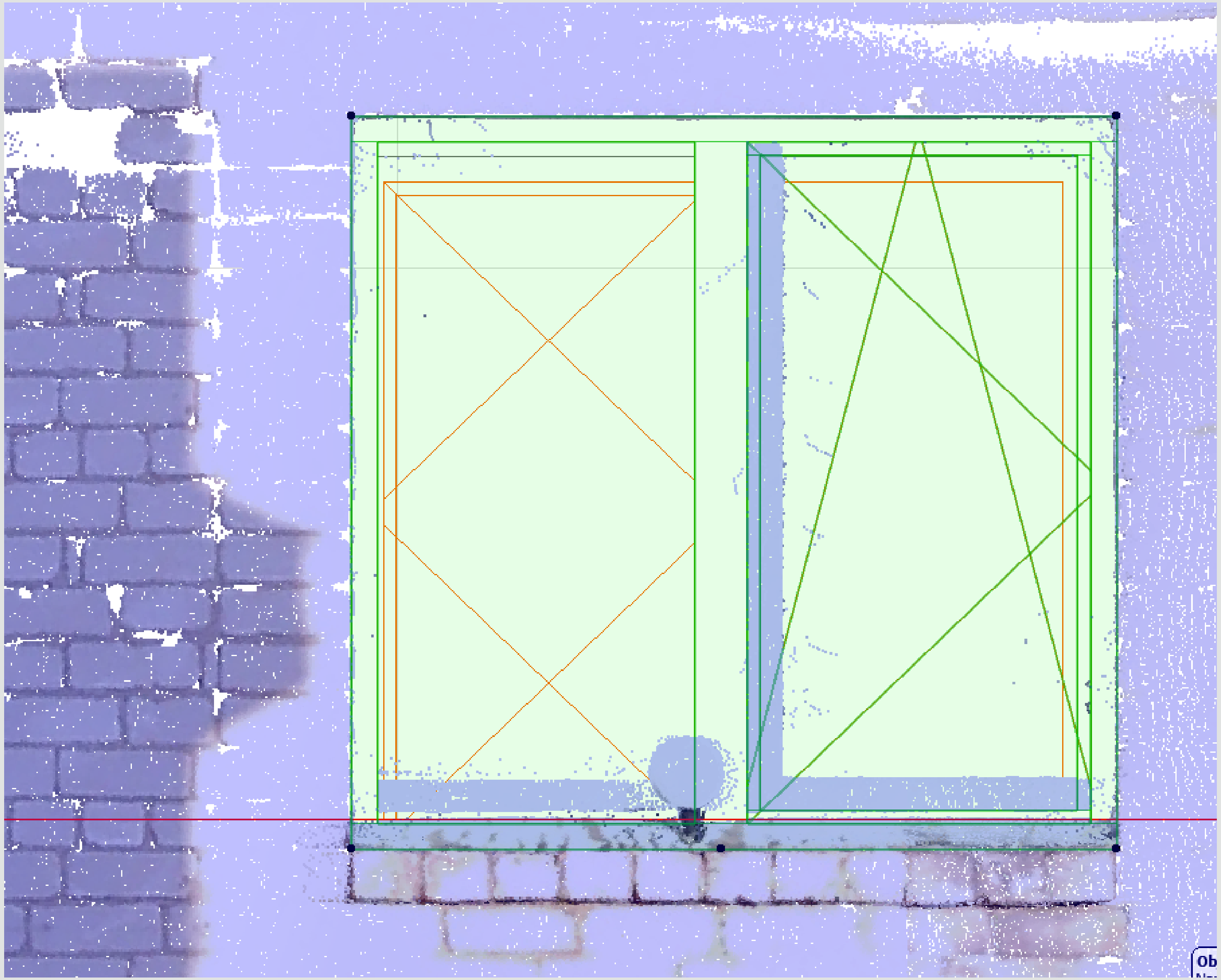
Problems – Foundation Settlement



Problems – Over-Exposed Areas

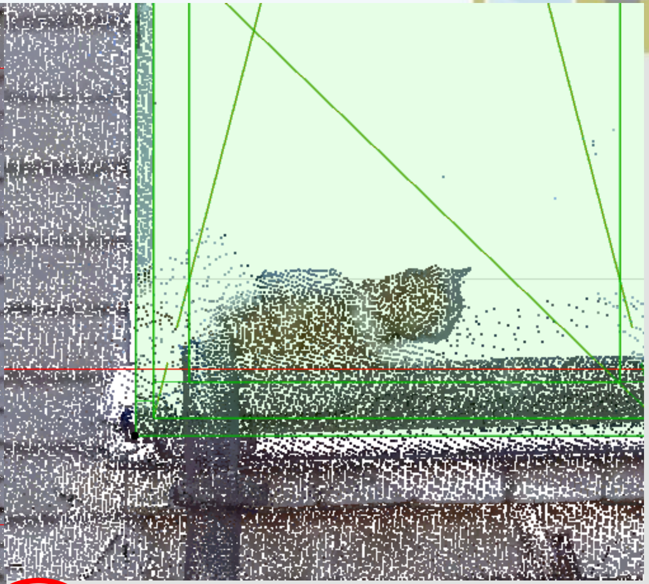
MORE — CONNECT



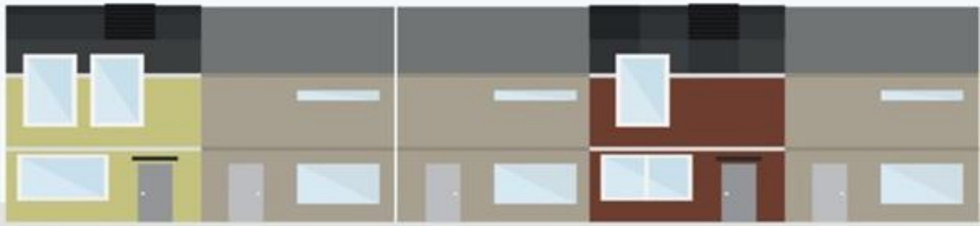


Problems – Vegetation, Animals, Neiborhoud

MORE



3D model and BIM

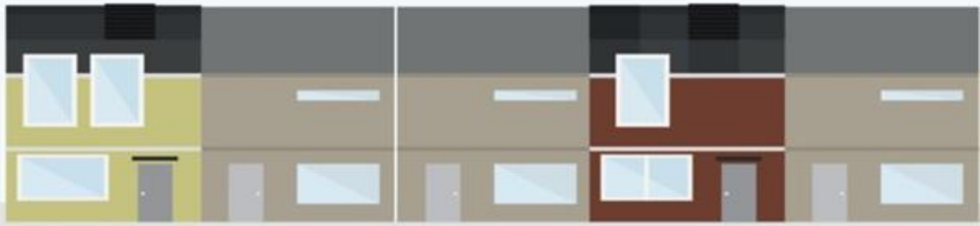


MORE—CONNECT

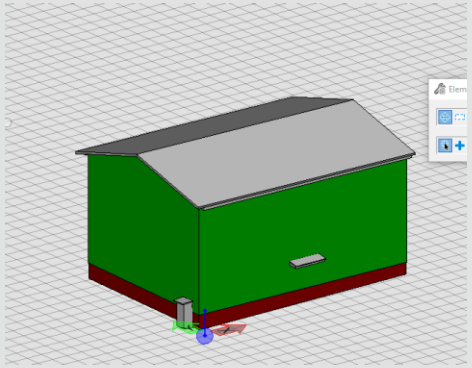
Manually Traced Building Envelope

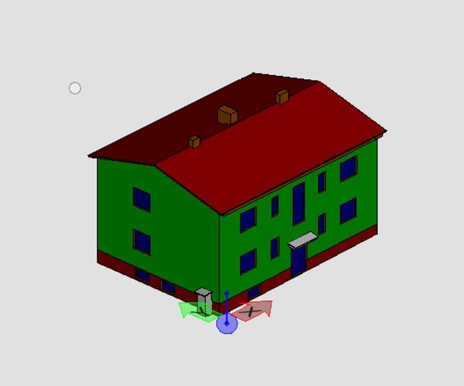
BIM Modeling from Drone

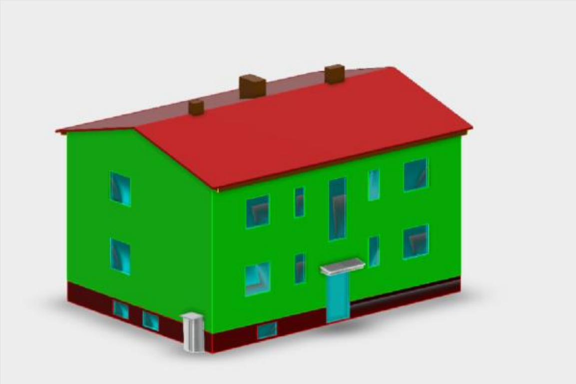
MORE—CONNECT



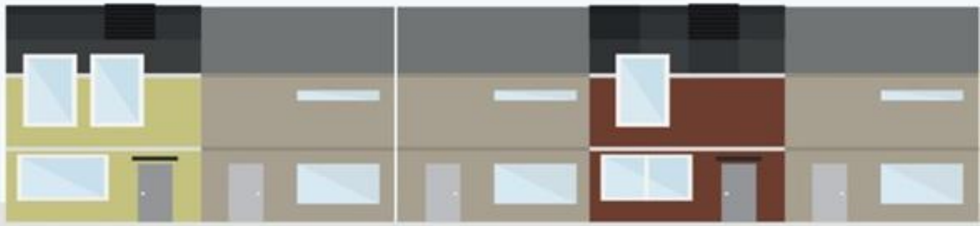
*.3mx model → LOD2 modeling → LOD3 modeling → BIM model







Used tools for BIM modelling

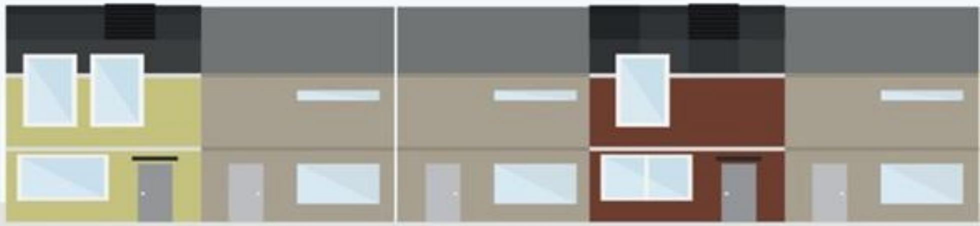


MORE — CONNECT

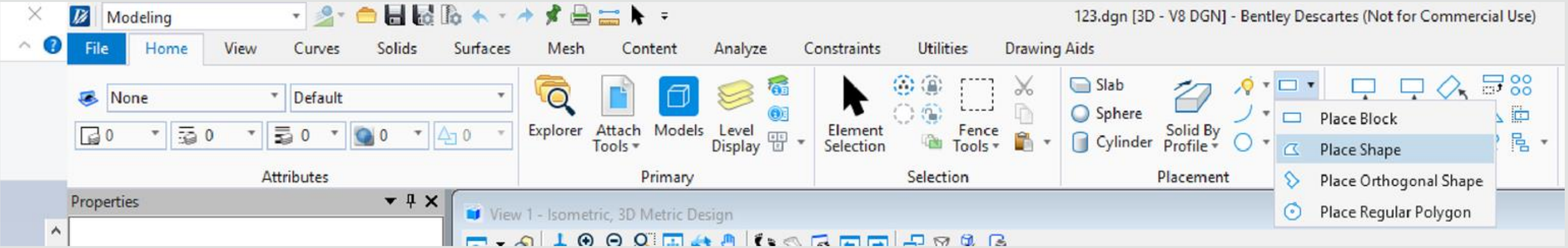
1. Software – Bentley Descartes
2. LOD2 modeling - walls, roof, basics
    - Place Shape function
    - Surfaces functions - Extend Surface; Trim Surface
3. LOD3 modeling - windows, doors
4. All processes in modeling are semi-automatic.

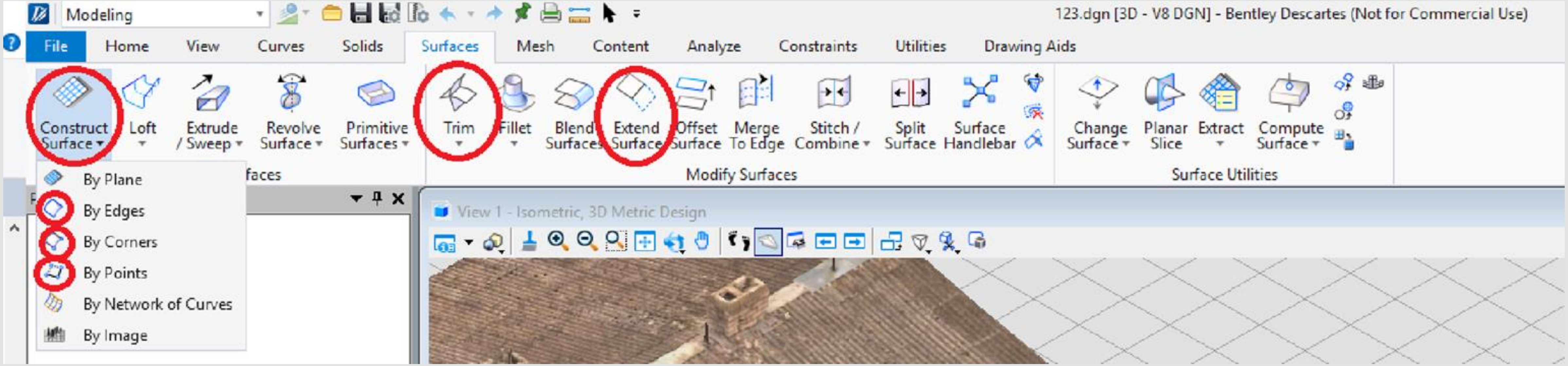
LOD 2 modeling

MORE——CONNECT



- Surfaces functions for creating walls, roof and basics

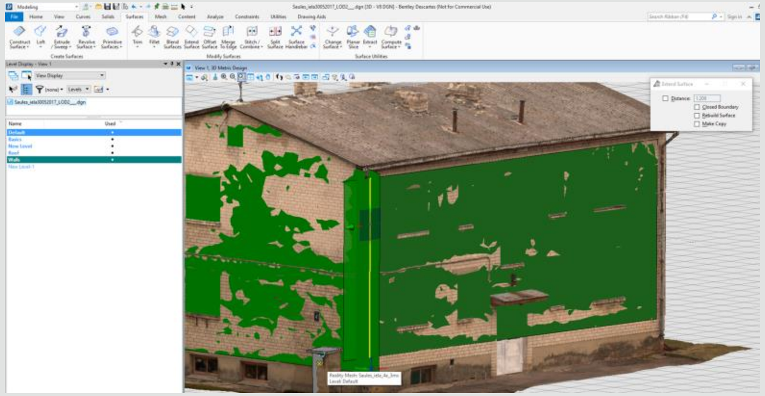




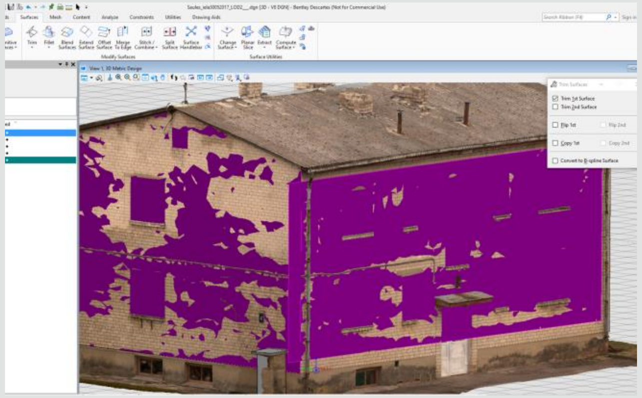
LOD 2 modeling

MORE—CONNECT

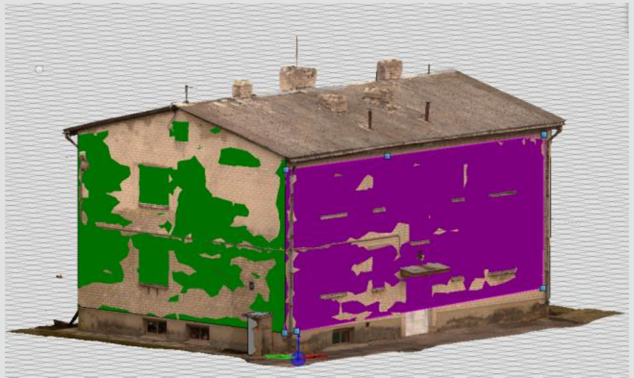
1. Place shape on the wall. (But not in the wall corners)



2. Extend 2 surfaces.



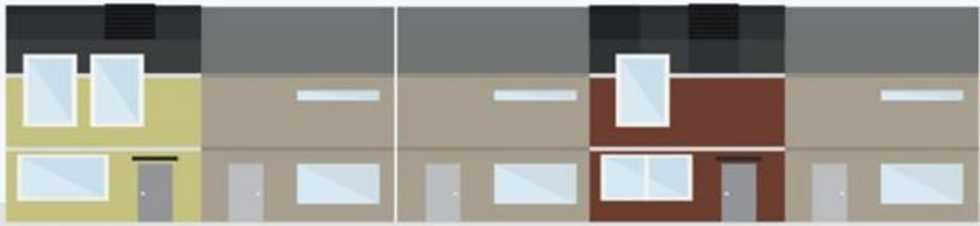
3. Show which 2 surfaces must be trimmed.

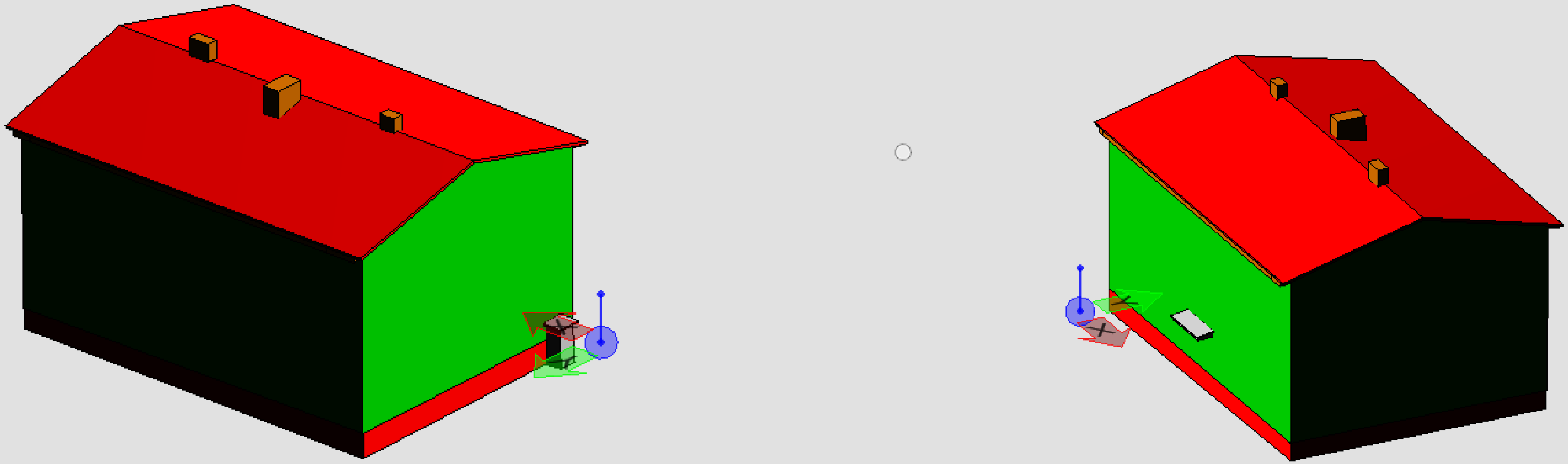


4. Both walls are crossed.

LOD 2 modeling=result

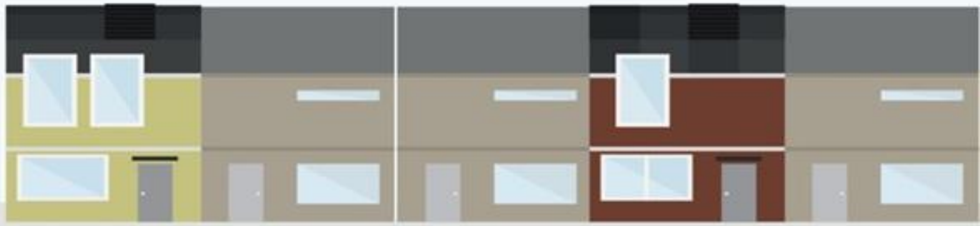
MORE——CONNECT

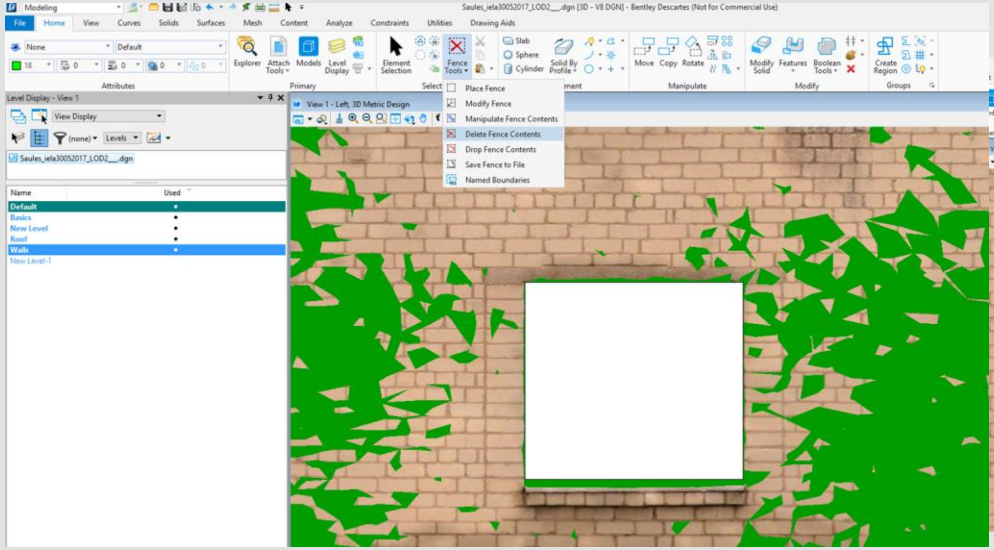


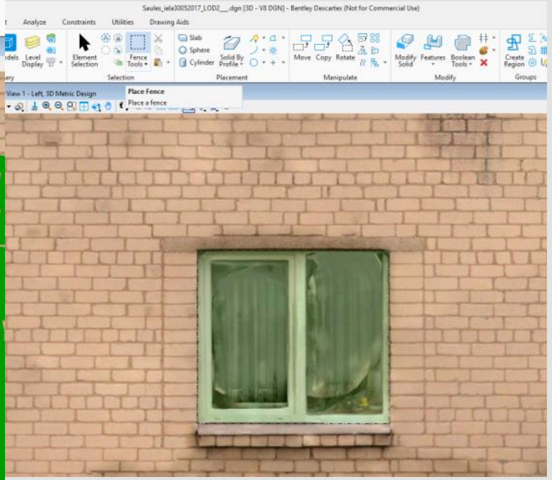


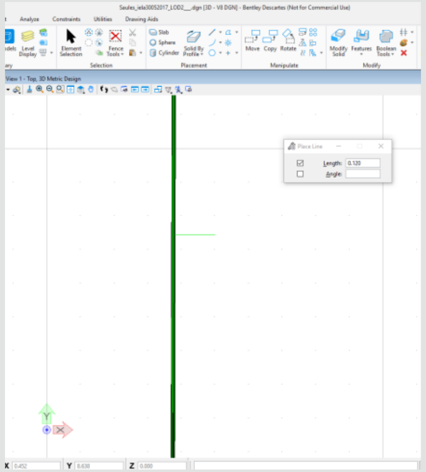
LOD3 modeling

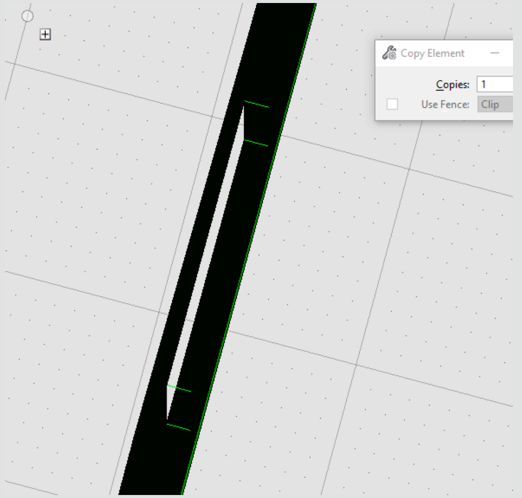
MORE —— CONNECT

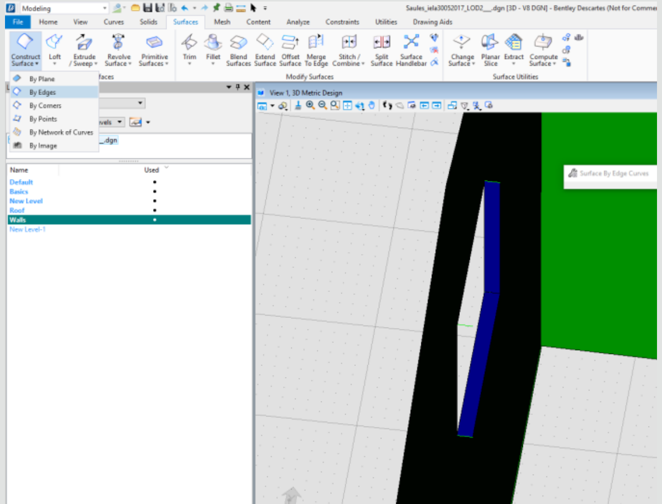


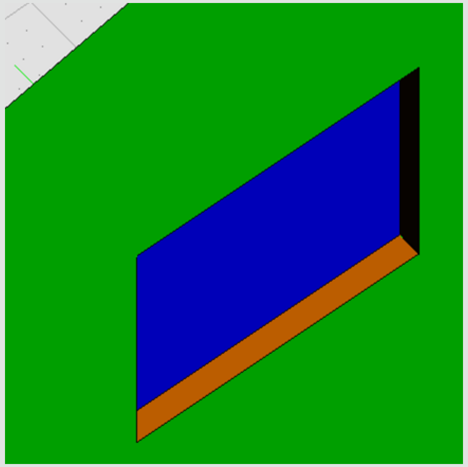




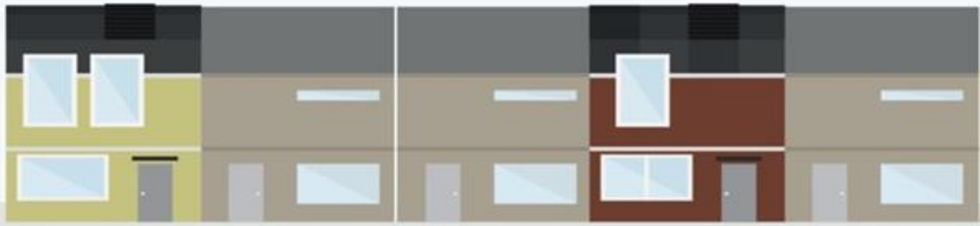


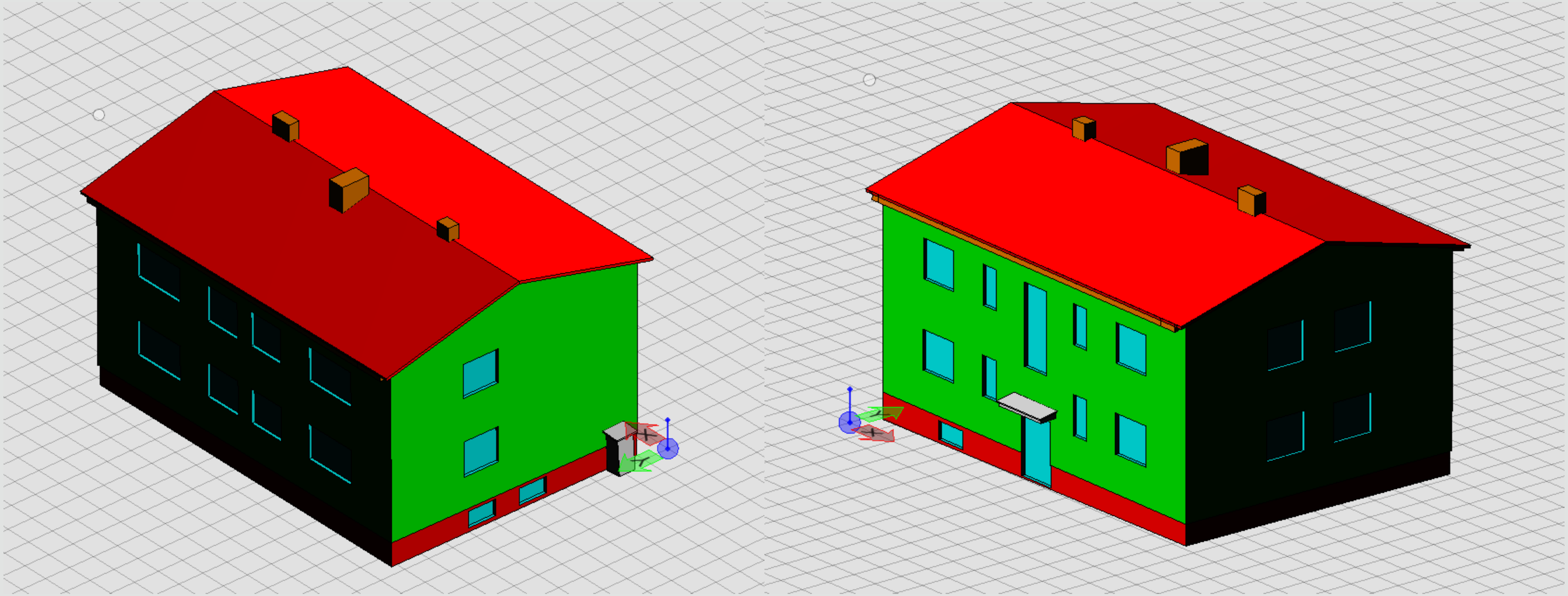




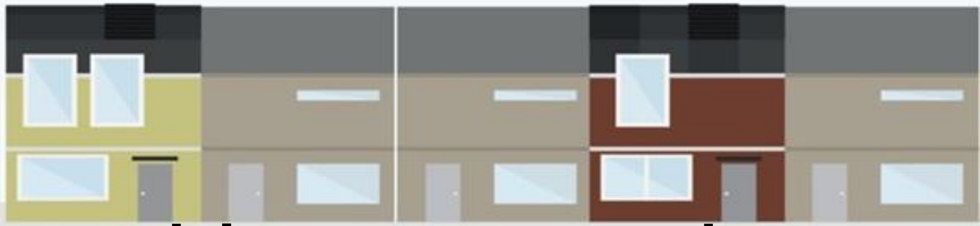


LOD3 model





3D model and BIM



MORE—CONNECT

Photogrammetry data, BIM model and laserscanning data comparison

1. Model by Section function
   - Backward and forward view for point cloud
   - Cut view for mesh model

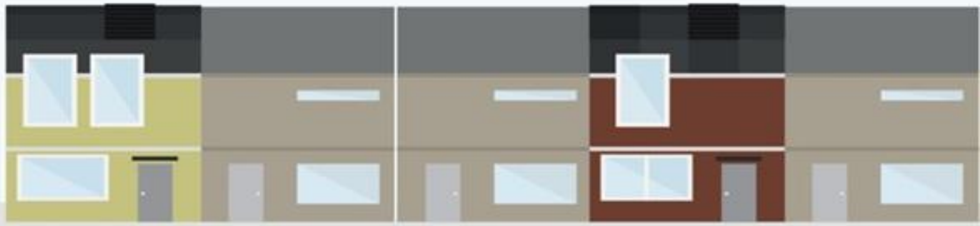
2. Hight Difference between reality model and laserscanning point cloud
   - Walls - fit in 1 cm *range*
   - Roof, windows *and other bottom (elements which was hard to capture)* - bigger than 1 cm.
3. Hight Difference between model andlaserscanning point cloud
   - LOD2 fits in 3cm range ;
   - LOD3 fits in 3.5cm range.

4. Hight Difference between model and reality model

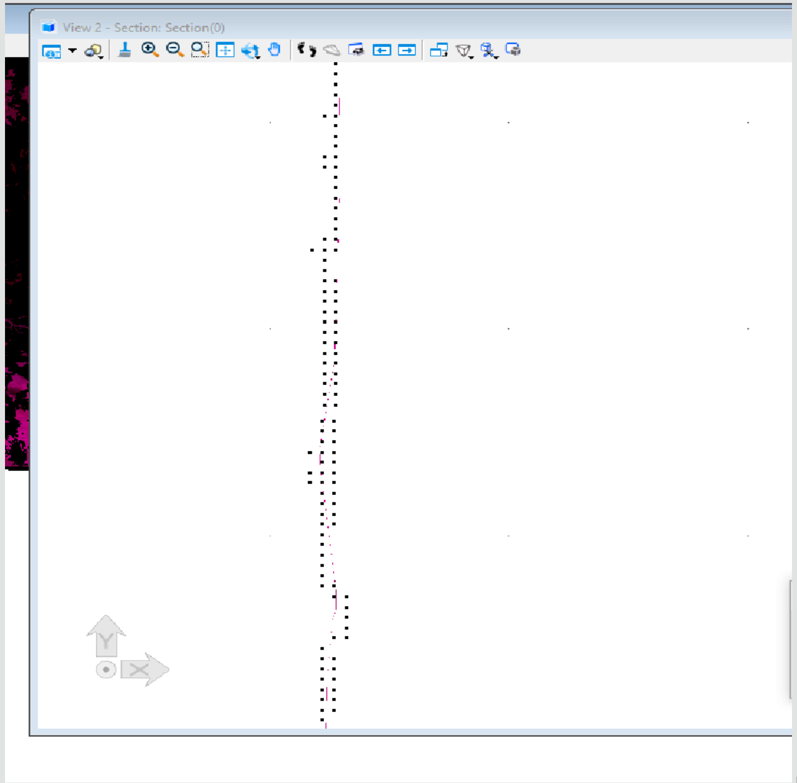
   - LOD2 fits in 3cm range;

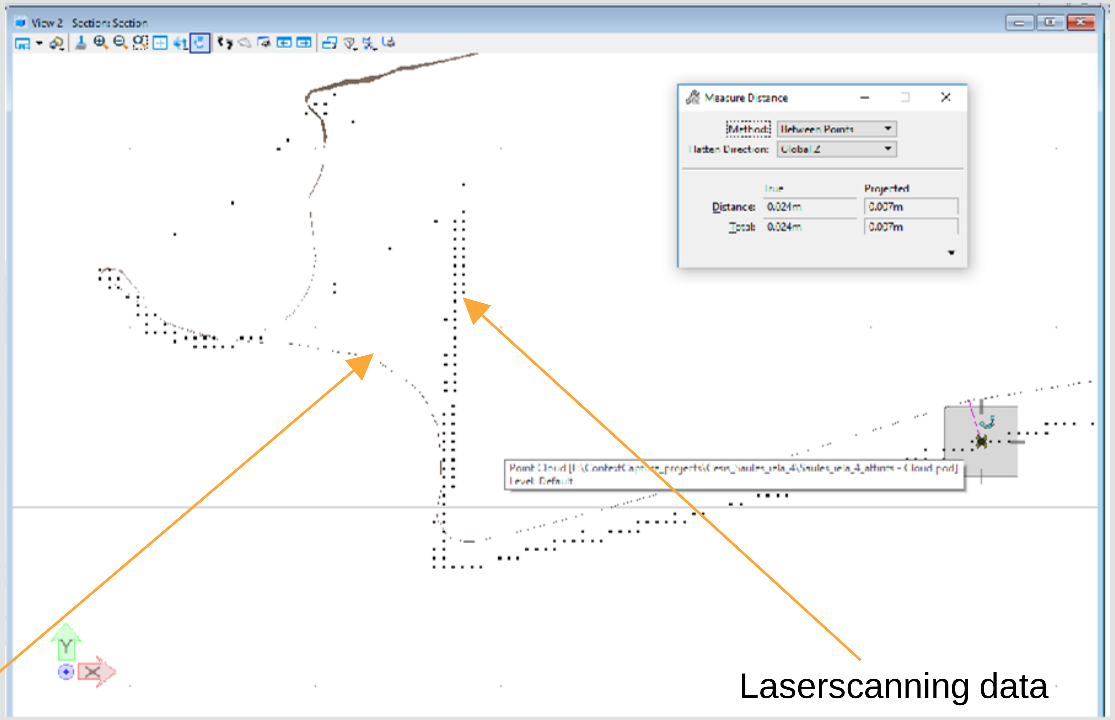
   - LOD3 - comparison is not performed because it would not be precise.

MORE—CONNECT



Comparison between reality model and point cloud

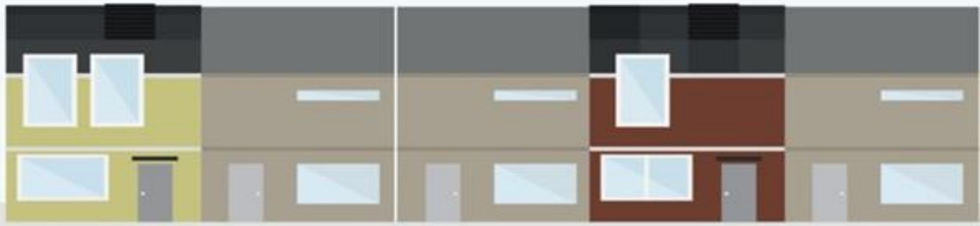




Reality model section

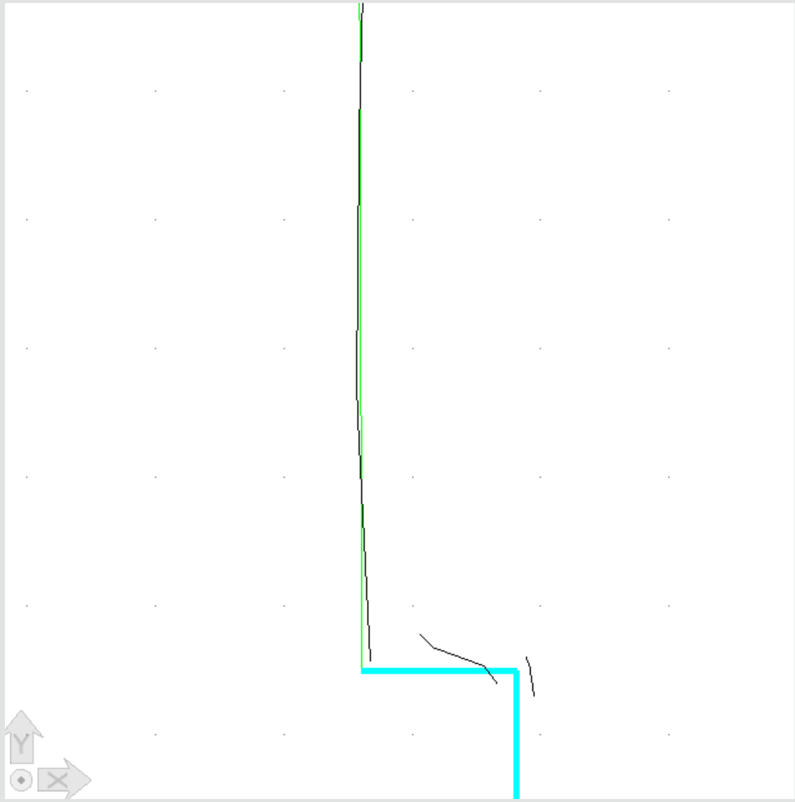
GOOD

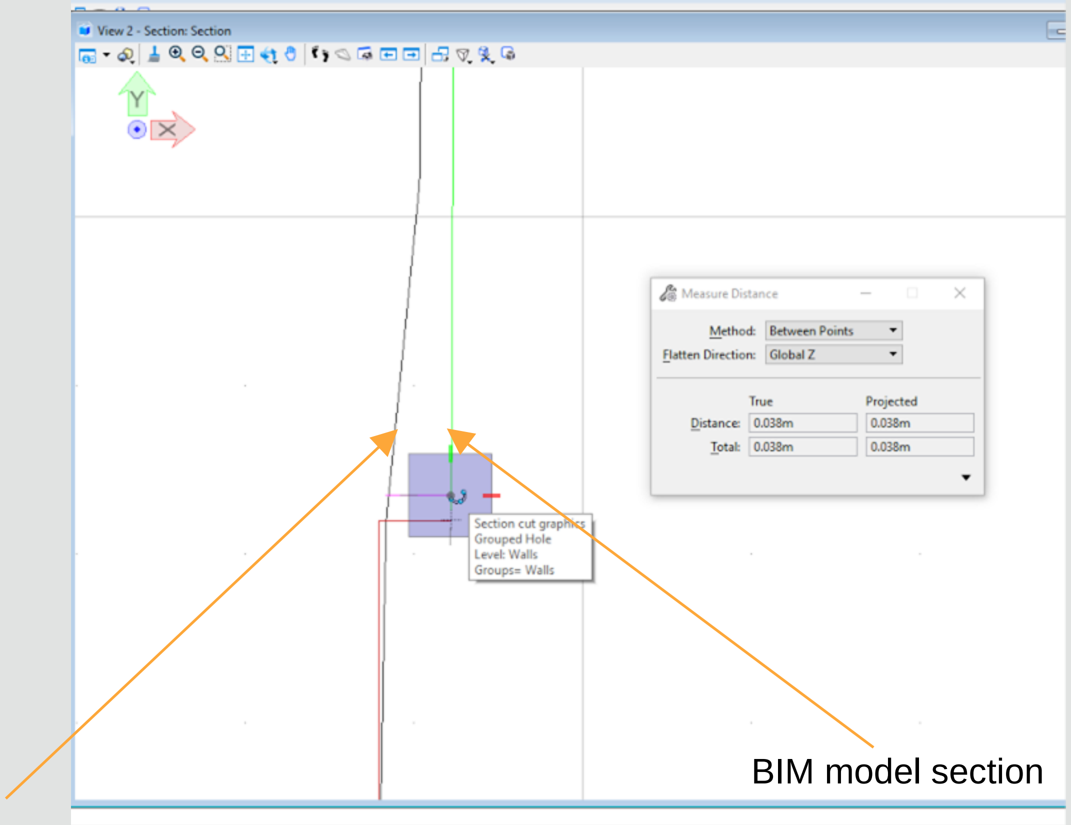
BAD



MORE — CONNECT

Comparison betweeen reality model and BIM model

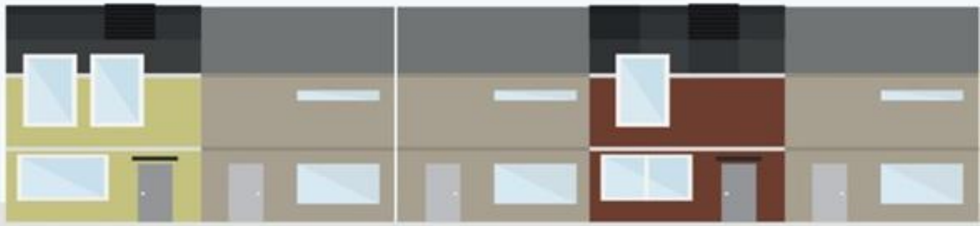




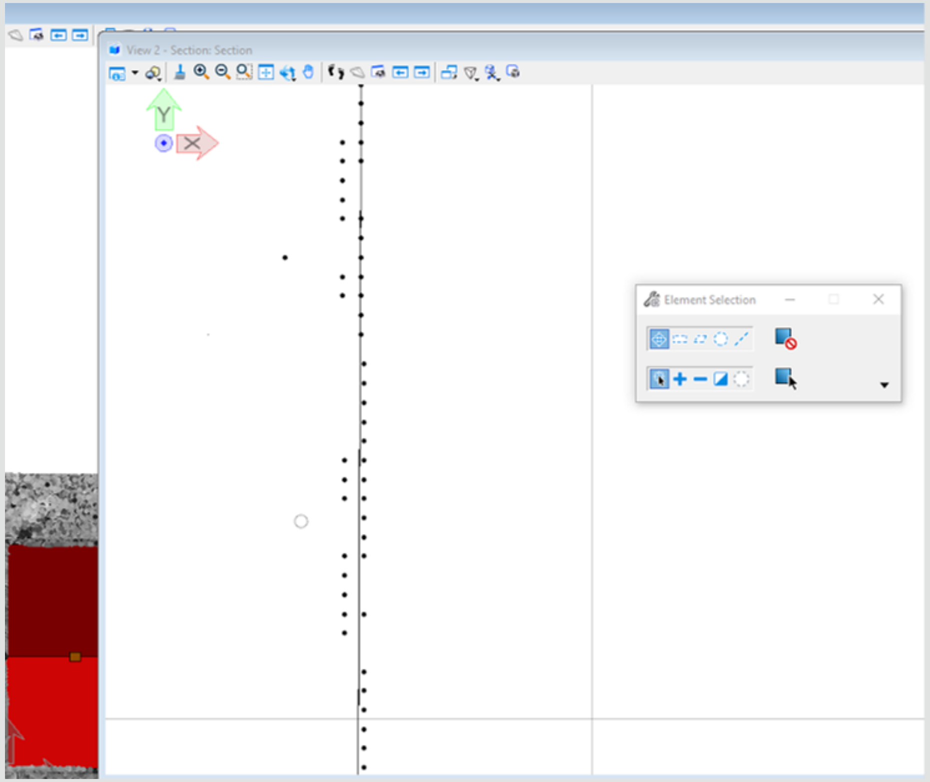
GOOD

BAD

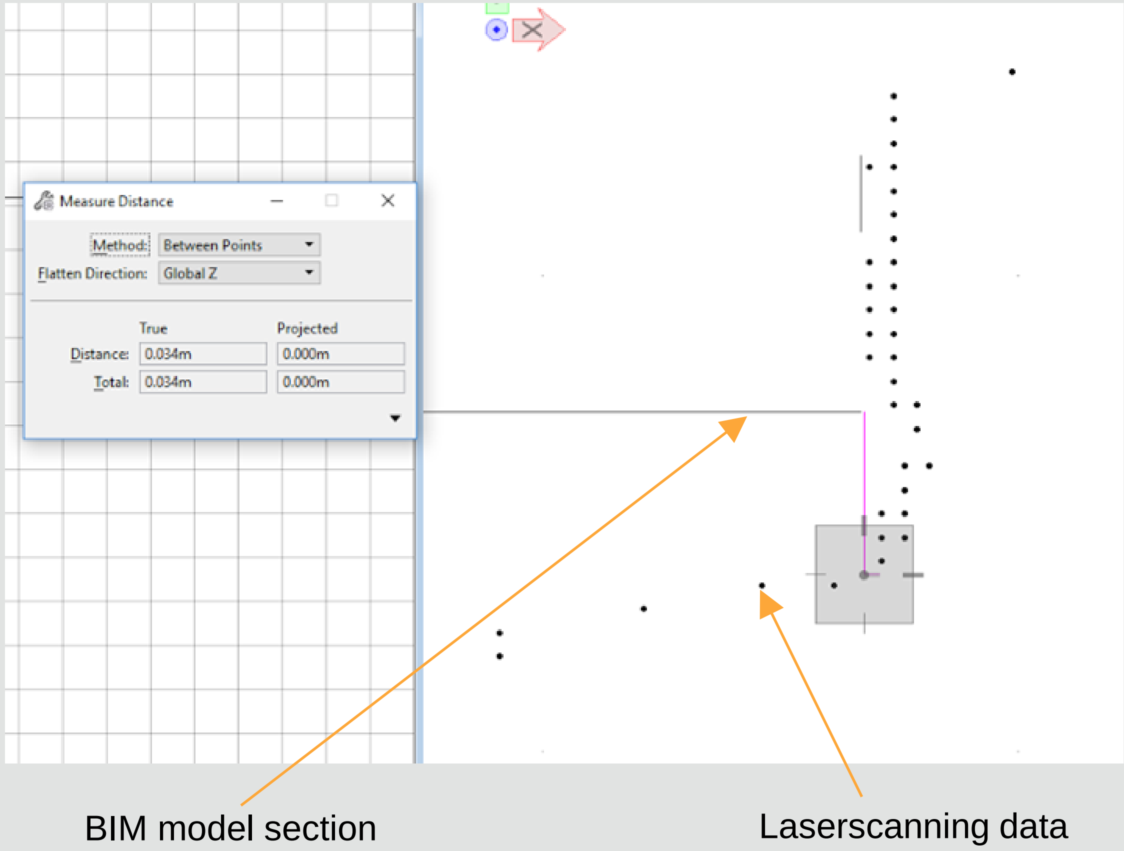
MORE—CONNECT



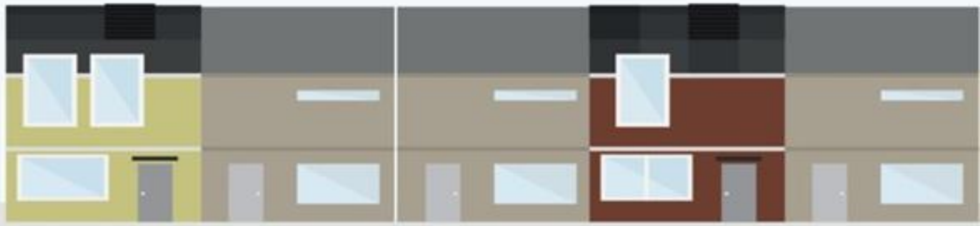
Comparison between BIM model and point cloud



GOOD



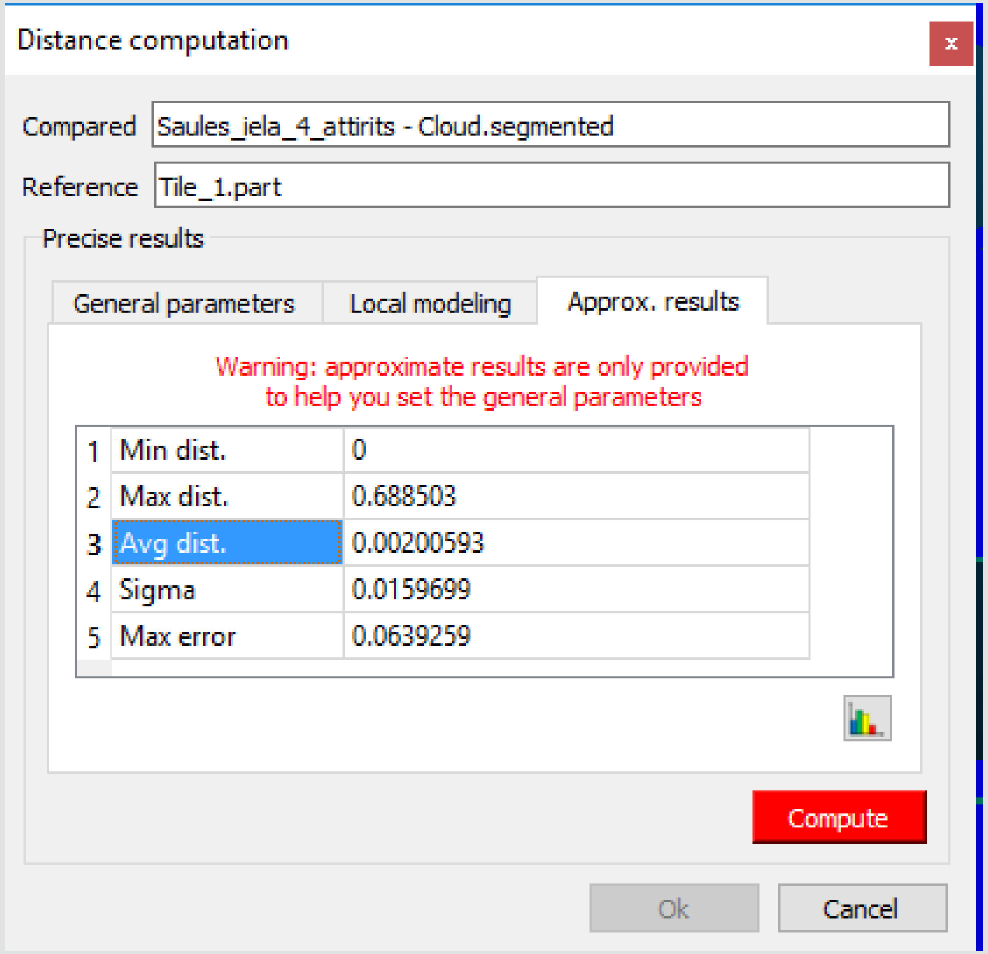
BAD



MORE—CONNECT

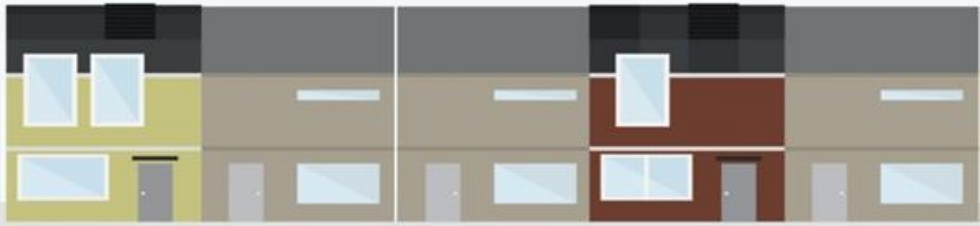
Comparing laserscanning data with photogrammetric data in Cloud Compare

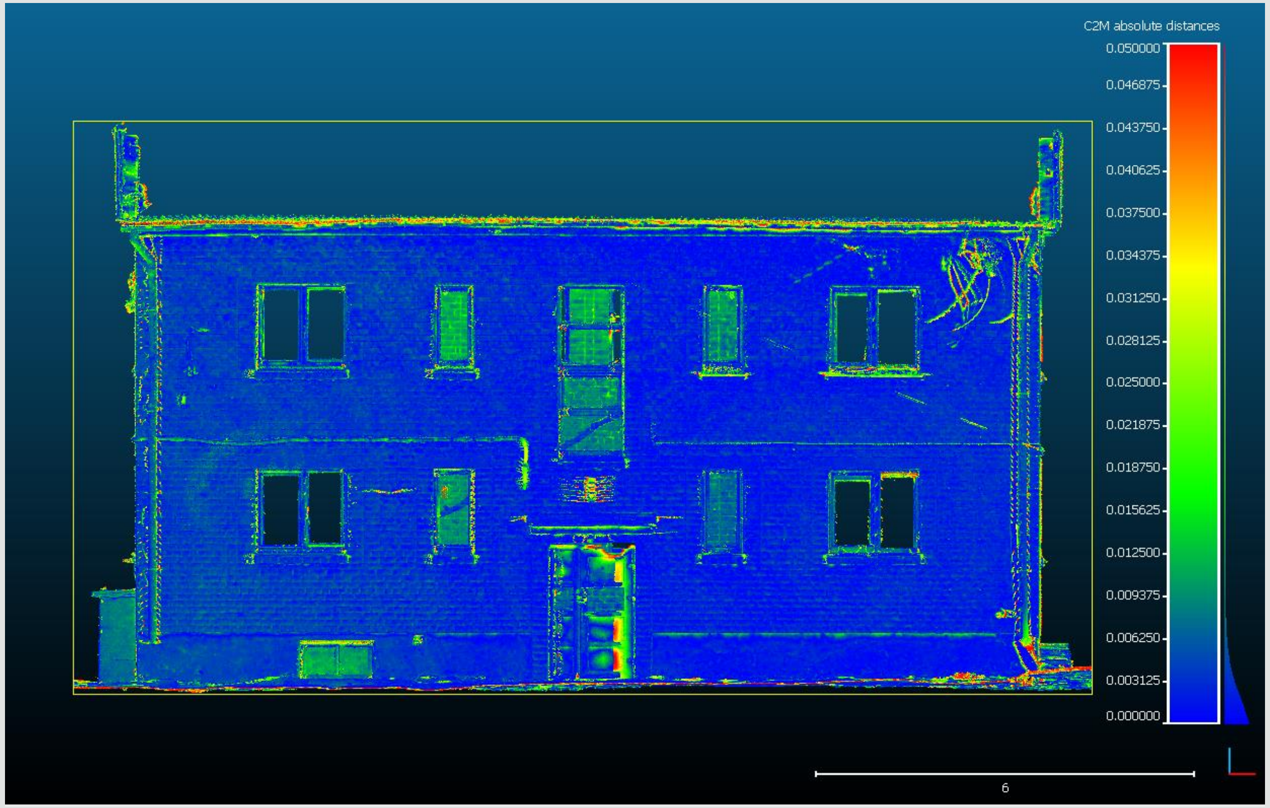
- CloudCompare
- Reality model was exported from Context Capture as *.obj format file.
- Compute cloud/mesh distance function.
- Good results:
  - Most of points are very close
  - Mostly distance between point cloud data and reality model is in +/- 1cm range.

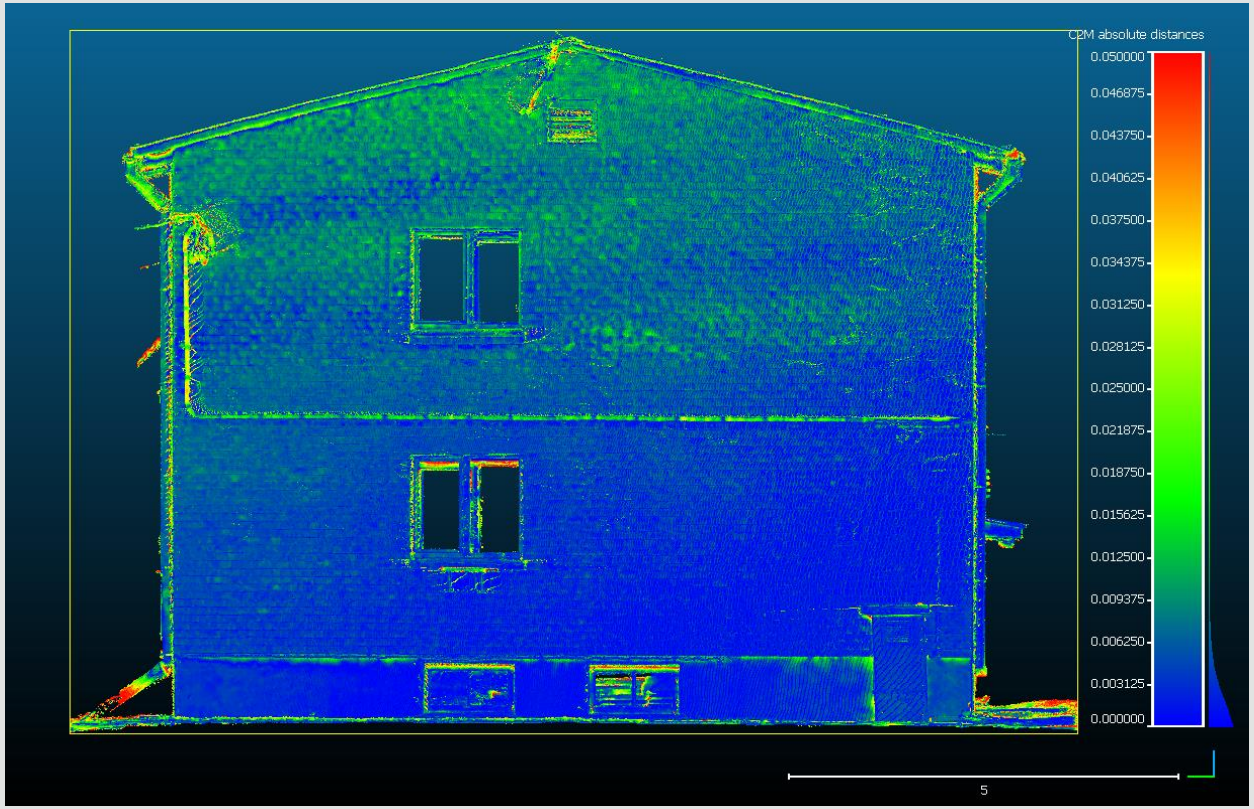


Absolute distances between points - mostly under 1cm.

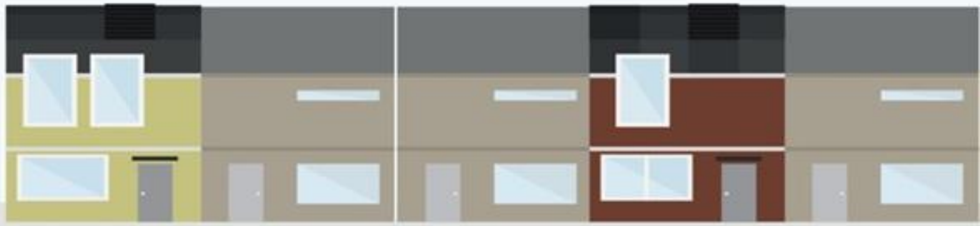
MORE—CONNECT

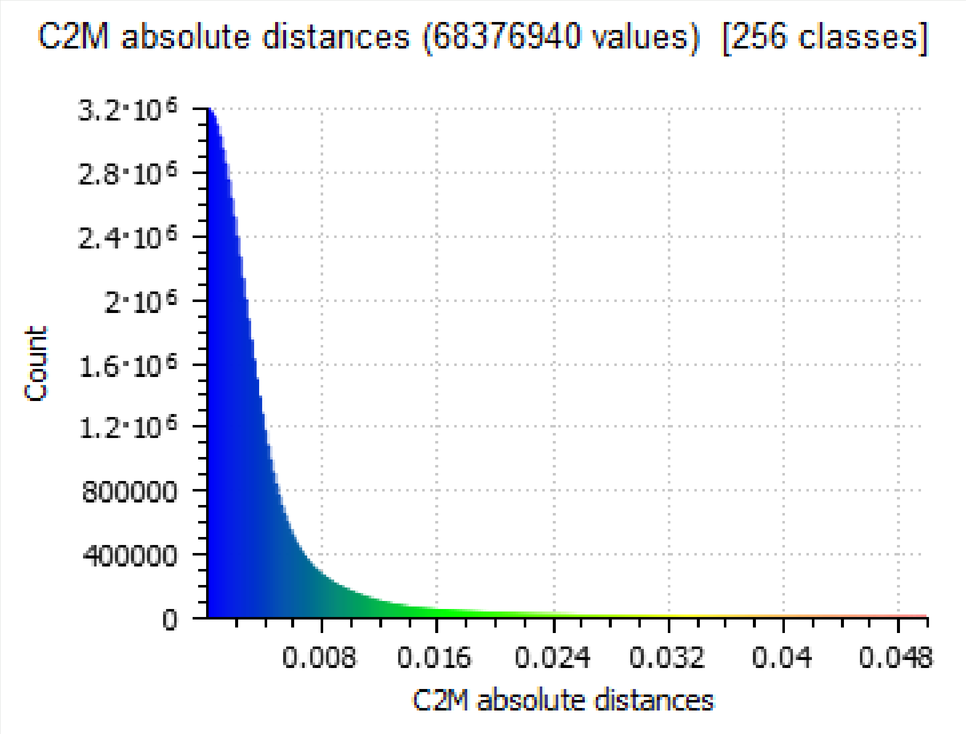


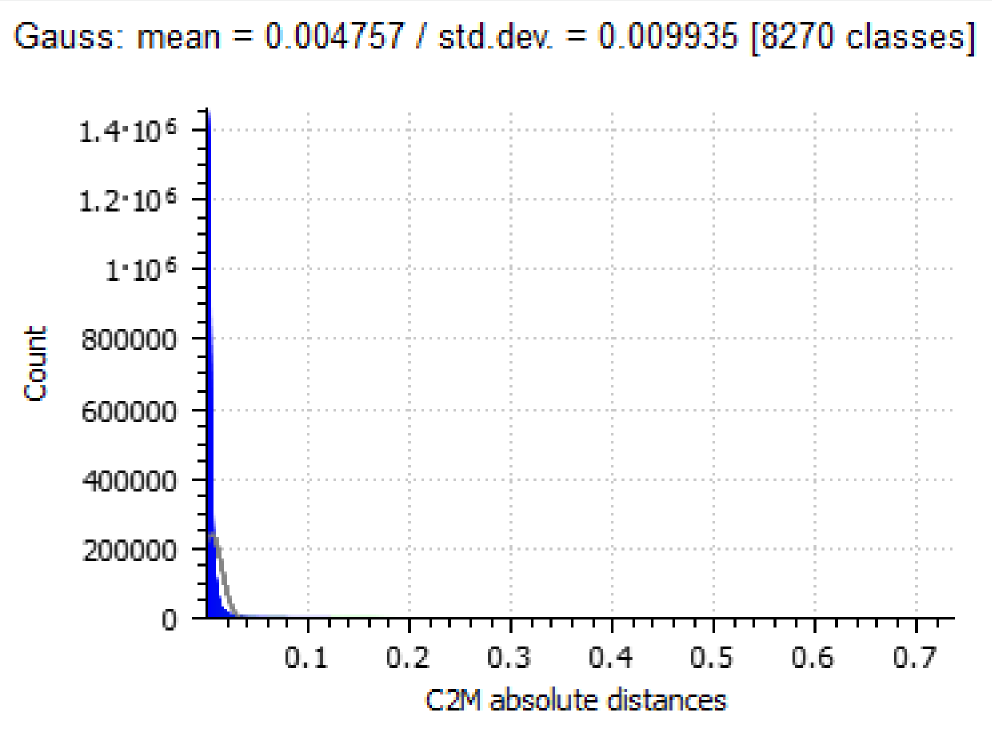




C2M = Cloud to Mesh

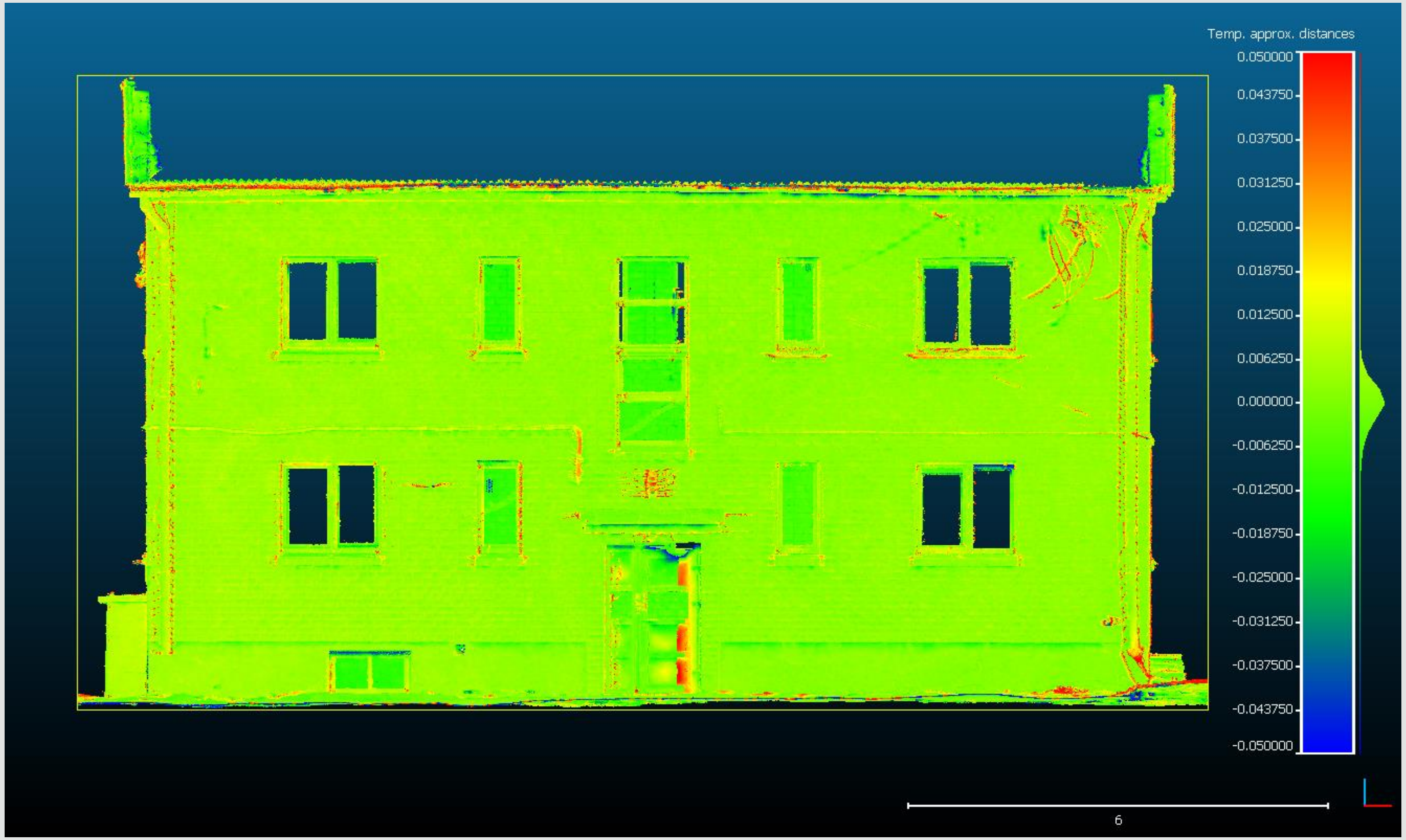


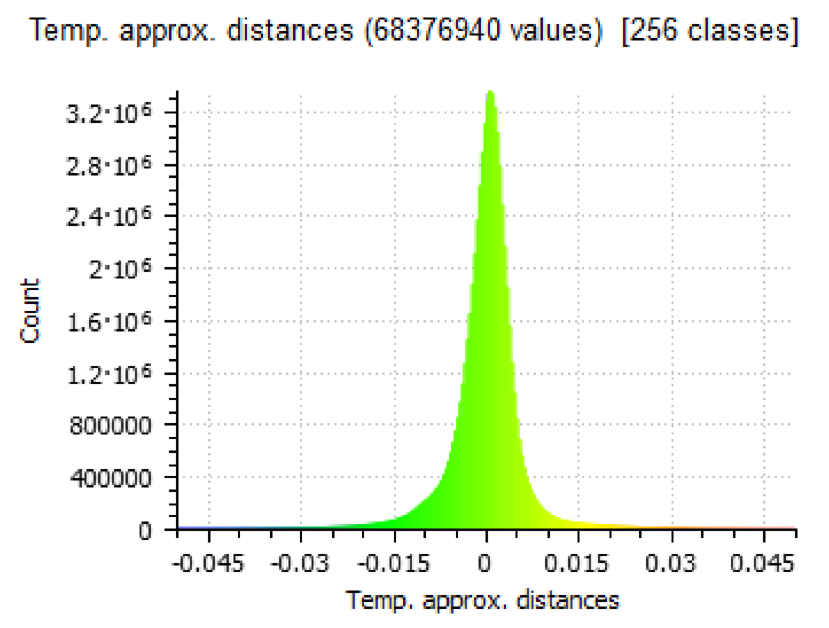


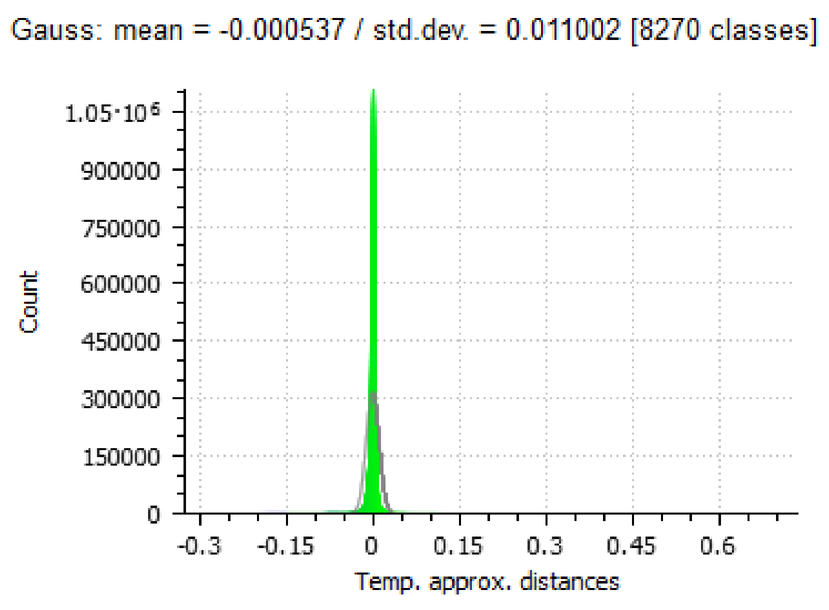


Point amplitude

MORE—CONNECT

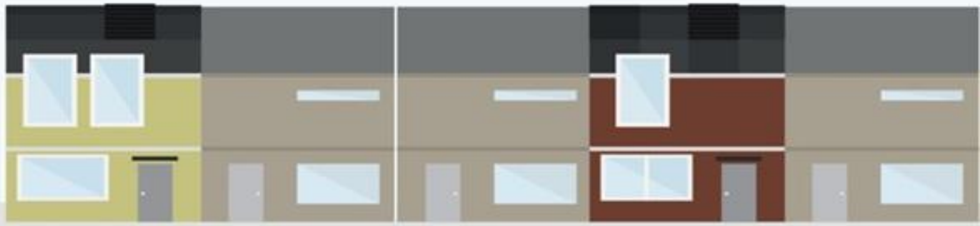




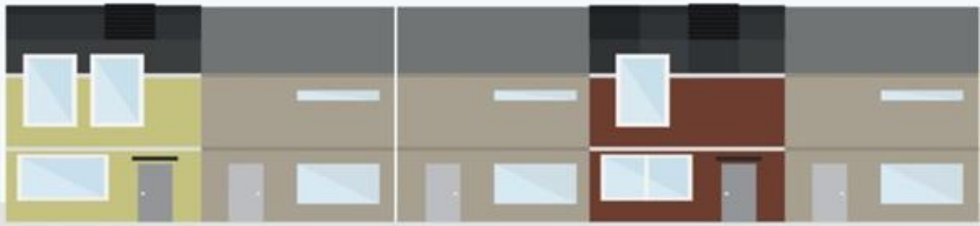


Converting model

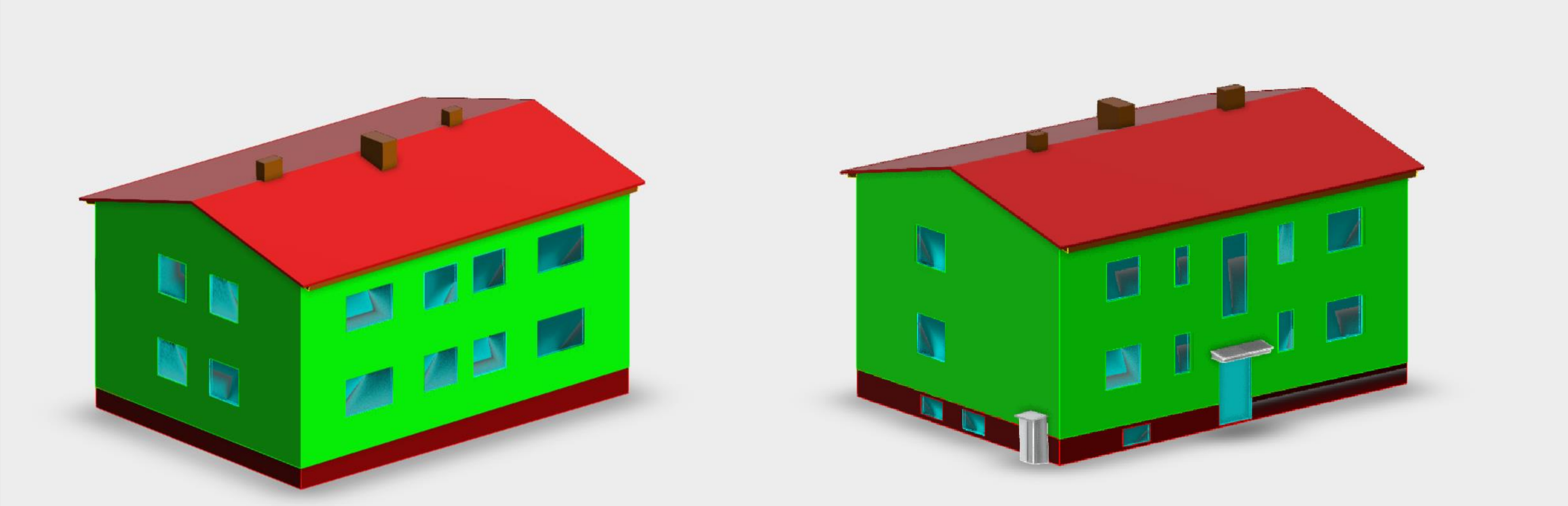
MORE—CONNECT

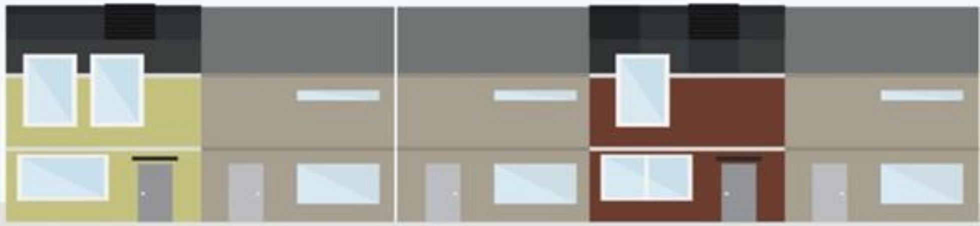


1) Converting in Bentley Descartes software
2) Output formats:
   - *.dgn;
   - *.dwg;
   - *.dxf;
   - *.dgnlib;
   - *.rdl.
   - *.ifc
3) Converting model form *.dgn format to *.dwg format
   - Checking model in AutoDesk 360 Viewer Online



Model in AutoDesk A360 Viewer online





Spent time to use drone and create 3D model

1) Flight planning
   - 1 hour
2) Flight and capturing images (arrival time to an object is not included):
   - 1 hour and 30 minutes
3) Point cloud cleanup and form
   - 2 hours
4) Processing photos in ContextCapture Master and searching for control points in Cloud Compare:
   - Searching for control points and indication (including control points area editing)
     - 3 hours
   - Creating production (reality model) -
     - 2 hours 12 minutes
5) Modeling:
   - ~2-3 days
6) Comparing data:
   - ~1-2 days
7) Converting and checking converted model:
   - 30 minutes

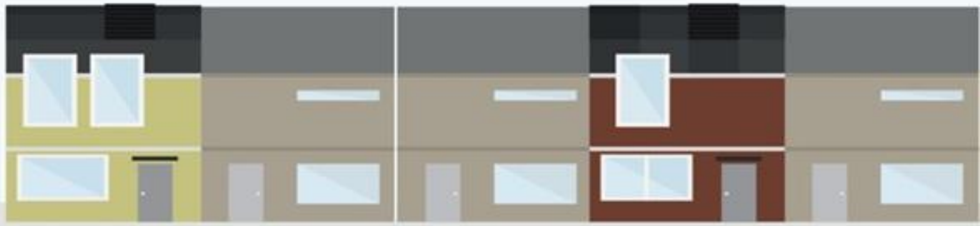
Spent time to use laserscanner

MORE — CONNECT

1) Field work
   - 4 hour
2) Point cloud cleanup and form
   - 5 hours
3) Modeling:
   - ~1 days
4) Comparing data:
   - ~1 day
5) Converting and checking converted model:
   - 30 minutes

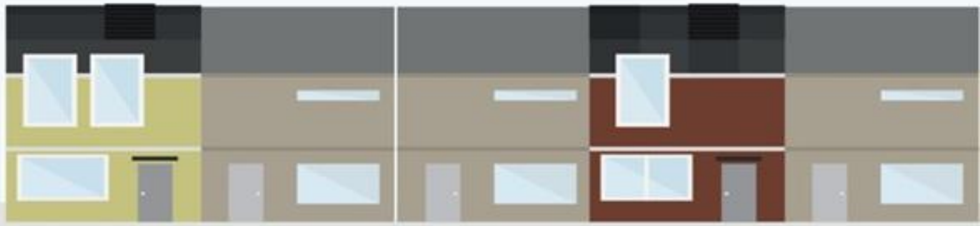
Costs to use photogrammetrical capturing

MORE—CONNECT



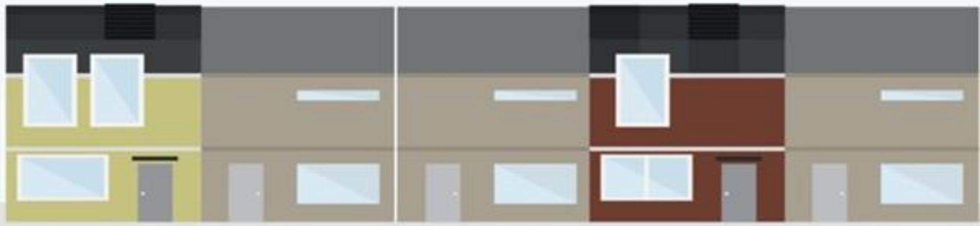
- Manpower - man hours costs (e.g. EUR 30)
- Drone Phantom 4 DJI FC330 with extra batteries - EUR 2000
- Software:
  - ContextCapture - EUR 6000
  - Acute 3D Viewer - free
  - Bentley Descartes - bundled with ContextCapture as ContextCapture Editor
  - AutoDesk 360 Viewer Online - free
  - Software for comparing (not obligatory):
    - Cloud Compare - free
- Hardware:
  - Intel Core i7 360 GHz, 64 GB RAM, GEFORCE GTX 1080TI ~ EUR 2300

Costs to use laserscanning



MORE—CONNECT

- Manpower - man hours costs (e.g. EUR 30)
- FARO laserscanner and software FARO SCENE-EURO 30000-45000
- Software:
  - Bentley Descartes - euro 7000
  - Bentley Aicosim EURO 10000
  - AutoDesk 360 Viewer Online - free
  - Software for comparing (not obligatory):
    - Cloud Compare - free
- Hardware:
  - Intel Core i7 360 GHz, 64 GB RAM, GEFORCE GTX 1080TI ~ EUR 2300



Thank you for your attention