Point Clouds to Digital Twin Concept Validation for CPP CE Geospatial Option

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Contents

Introduction

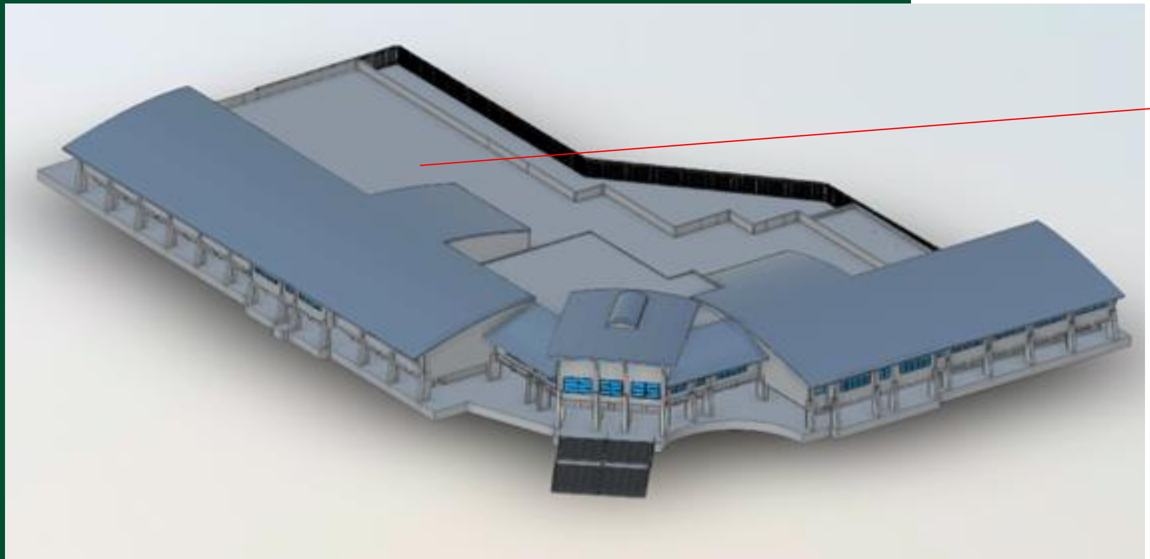
- CPP Civil Engineering, Geospatial Engineering option recognize the need to integrate Digital Twin in the curriculum.
- We are developing new modules that integrate digital twin technology with GNSS, Photogrammetry, LiDAR and other technology, fostering Civil engineering students through hands-on experience.
- Civil engineering students create virtual replicas and explore possibilities via simulation.
- Digital twin technology allows seamless integration of diverse data sources for comprehensive visualization, enabling more informed decision-making and asset management.

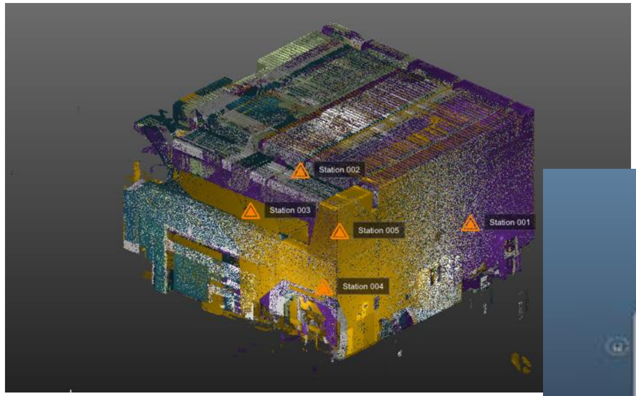
Goal

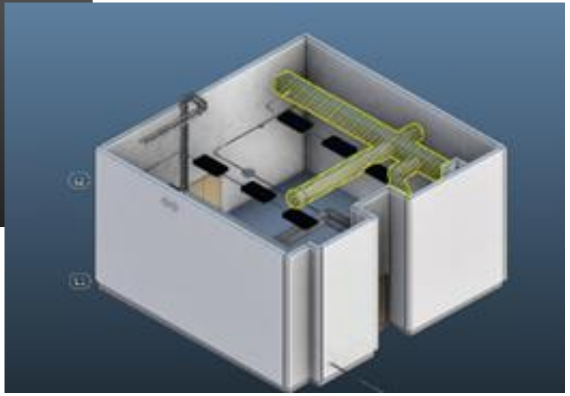
- Create modules for future Digital Twin course in CPP CE Geospatial Option, prepare students with current tools and technology for their professions.

Background

- Building Information Modeling for CPP Engineering Lab building from 2022-23 Senior Project (see QR Code)
  - UAV Photogrammetry
  - UAV and Terrestrial LiDAR
  - Fast Static GNSS for control network
  - Total Station for quality control and check
- LiDAR data collected for CPP Structural Engineering Lab
  - One of many labs inside the building
  - Concept validation from data collection and processing to Digital Twin
  - Create course modules to integrate all geospatial technology and address future demands.





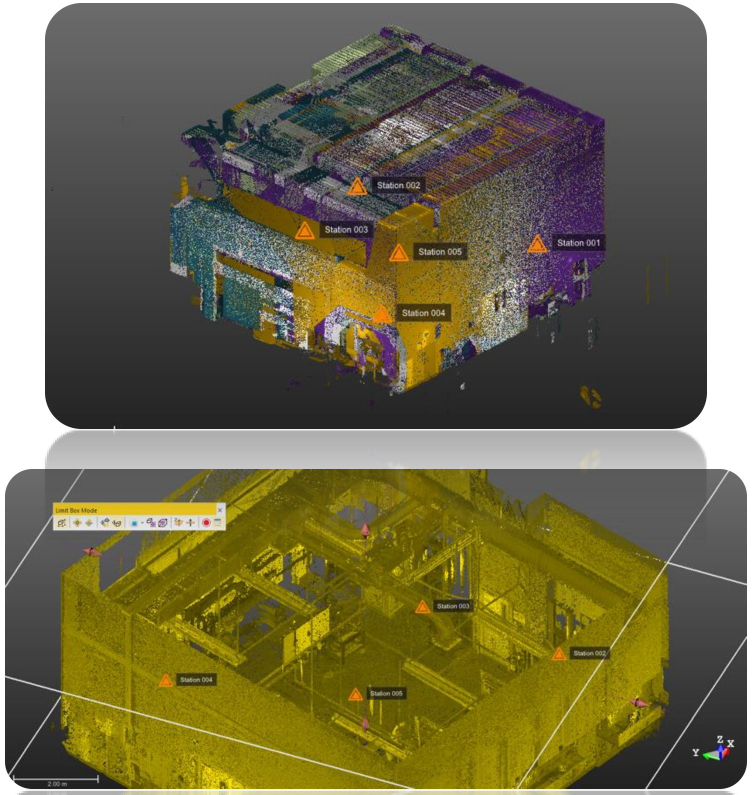


Software

- Trimble RealWorks
  - Point-Cloud processing
- Autodesk Revit
  - BIM modeling and asset creation
- Autodesk Tandem
  - Cloud-based digital twin management
- Unity
  - VR Simulation and development
- Unification via Autodesk Platform Services

Stage 1:
Point-Cloud with Trimble RealWorks 2024

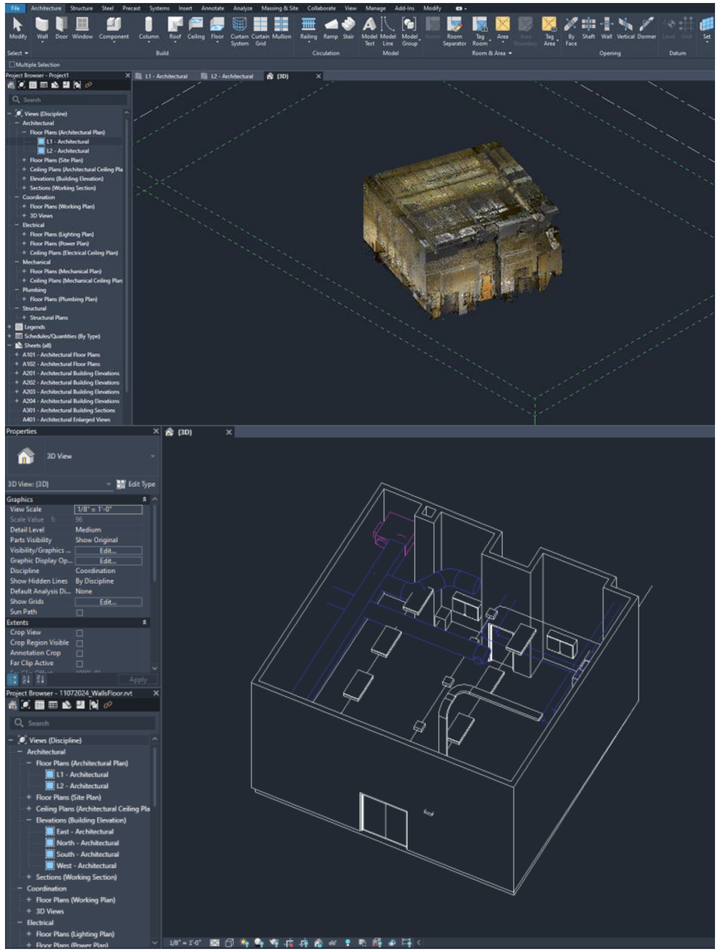
- Software for processing and cleaning raw point-cloud data of a real-life asset
- Eliminate unwanted noise and align scans
- 1:1 building accuracy
- Export a clean scan in a usable file format for further processing
- .las/.e57 → .rcp



Point-cloud file of CPP Engineering Lab

Stage 2:
Modeling in Autodesk Revit

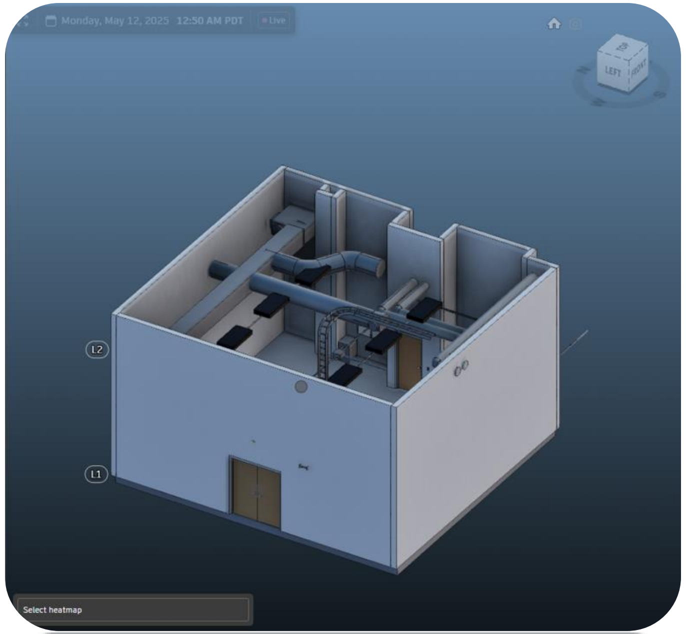
- Import cleaned point-cloud model
- Trace and extrude walls + entrances and assign materials
- Populate model with infrastructure and devices
  - Prioritized HVAC and electrical systems
- Result: A clean .fbx model that can be utilized in Unity and other services



Revit file ready for export as .fbx

Stage 3:
Autodesk Tandem - Digital Twin

- Cloud-based digital twin platform for BIM
- Model built with Revit can be imported to Autodesk Tandem
- Enables metadata integration, assignable data streams and systems for each IoT device
- Acts as a hub/visual for IoT data



3D view of digital twin, tandem.autodesk.com

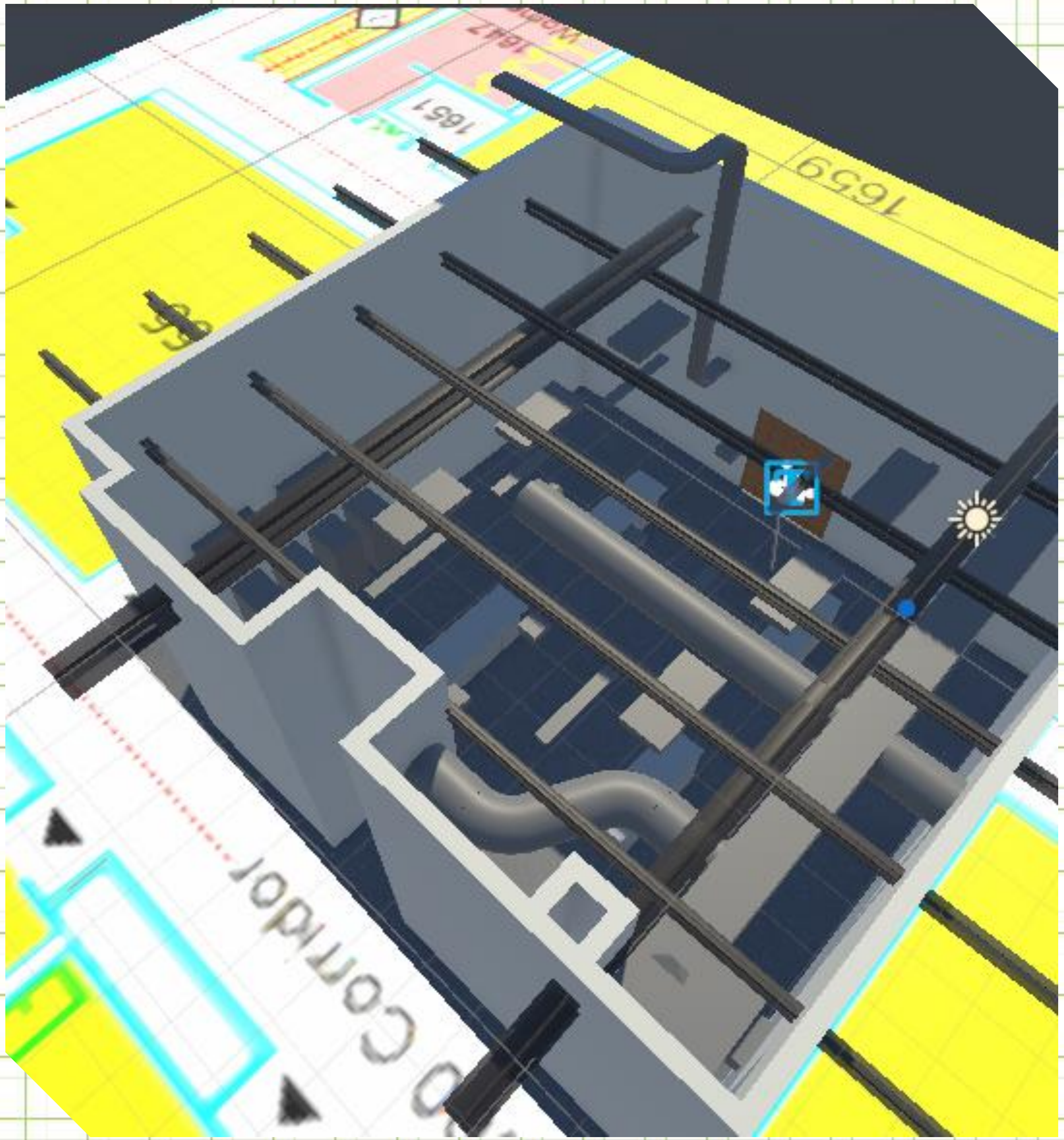
Middleware

AUTODESK
Platform Services

- Autodesk provides open-sourced APIs for custom applications for specific tasks
- Authenticate via an Oauth2.0 API request
- Tandem Data API enables IoT data querying via HTTP request

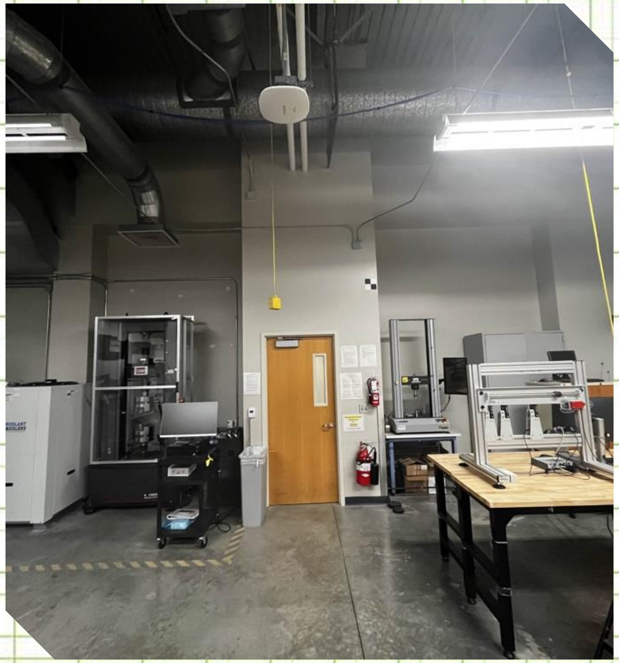
Stage 4:
AR/VR with Unity

- Revit model imported to Unity for VR development and user experience
- IoT devices are populated with sample data for concept validation
- User mechanics and data parsing programmed in C#
- Unity's OpenXR plugin enables compatibility with Meta Quest 2



Stage 4:
AR/VR with Unity

- Sample data is fed to objects in the scene marked as IoT devices
- User may highlight IoT assets and view relevant data
- Enables easy exploration and visualization of digital devices



Engineering Lab: actual vs model

Demo

- https://youtube.com/shorts/ezCihlXECuA?feature=share

Challenges & Future Development

- Autodesk Tandem is a new and evolving tool
- Data transfer works in a local test environment, but data flow from IoT devices to Unity on open networks remains unexplored
- Future developments could seek to streamline scalability and data security

Thank You!

Satellite Surveying in Engineer Lab CE 4341L

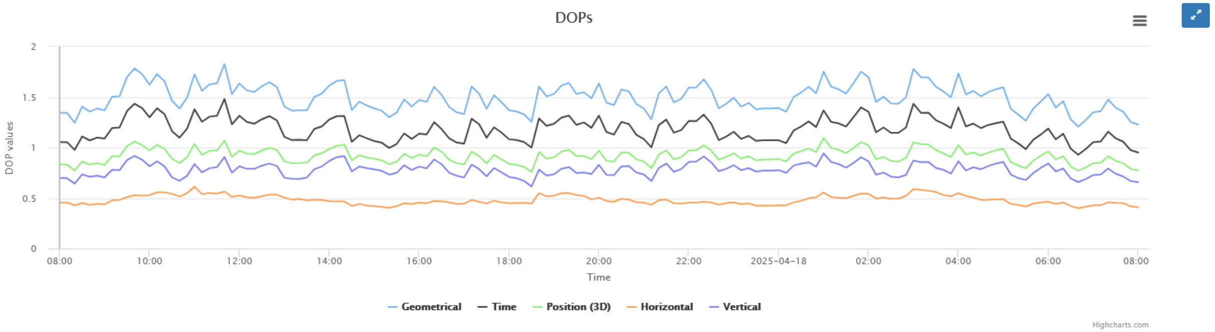
- Learning Outcomes
    - Set up Global Navigation Satellite System (GNSS) static, fast-static Real Time Kinematic (RTK)and Real Time Network (RTN) surveys equipment.
    - Conduct GNSS pre-survey planning and reconnaissance.
    - Analyze post-processed data.
    - Complete team/individual written report.

Satellite Surveying in Engineer Lab CE 4341L

- Field Exercises
  - GNSS survey planning
  - Field data collection
    - Fast Static
    - RTK
    - RTN
  - Postprocessing
  - Report writing
- Reading assignments
- Online Course
  - National Geodetic Survey
    - GNSS Positioning: Survey Planning and Data Acquisition

Field Exercises

- Lab safety
  - CSU Safety Training
- Pre-survey planning and reconnaissance



Dilution of Precession Plot for Static Field Day 4/17/2025

Field Exercises

- Bi-weekly field exercises
  - Fast–static and processing (Group report)
    - Including points with dense tree canopies and buildings. Students report on accuracy comparing points with open sky.
    - Compare results between TBC and OPUS-RS.
  - RTK (Group report)
    - Compare results with fast-static.
  - RTN (Group report)
    - Compare results with RTK and fast-static
  - Final Project (Individual report)
    - New location with 10-20 points, repeat fast-static, RTK and RTN.

Field Exercises

- Typical questions from students:
  - How to use TBC network adjustment and pass chi-square test.
  - Understanding ellipsoidal vs orthometric heights, resulting in +/- 30 m elevation locally
  - Understanding the difference between TBC vs OPUS-RS.
  - Understanding data quality degrades with buildings and tree canopies surrounding.
  - Differences between Static vs RTK vs RTN.
  - Writing technical reports.

```
RINEX FILE: 105g046r.22o                TIME: 20:57:48 UTC

SOFTWARE: rsgps  1.38 RS274.prl 1.99.3        START: 2022/02/15 17:08:19
EPHEMERIS: igr21972.eph [rapid]               STOP: 2022/02/15 17:40:40
NAV FILE: brdc0460.22n                    OBS USED:  1449 /  3663  :  40%
ANT NAME: TRMR10              NONE          QUALITY IND.  3.99/  3.94
ARP HEIGHT: 2.05                        NORMALIZED RMS:      0.397

REF FRAME: NAD_83(2011)(EPOCH:2010.0000)          ITRF2014 (EPOCH:2022.12527)

    X:   -2468750.950(m)  0.018(m)       -2468752.047(m)  0.018(m)
    Y:   -4678286.377(m)  0.027(m)       -4678284.772(m)  0.027(m)
    Z:    3552037.015(m)  0.025(m)        3552037.089(m)  0.025(m)

   LAT:   34  3 34.70191      0.016(m)      34  3 34.72042      0.016(m)
 E LON:  242 10 45.13796      0.010(m)     242 10 45.07093      0.010(m)
 W LON:  117 49 14.86204      0.010(m)     117 49 14.92907      0.010(m)
 EL HGT:          192.801(m)  0.036(m)             192.091(m)  0.036(m)
ORTHO HGT:        226.741(m)  0.041(m) [NAVD88 (Computed using GEOID18)]

                      UTM COORDINATES    STATE PLANE COORDINATES
                       UTM (Zone 11)       SPC (0405 CA 5)
Northing (Y) [meters]     3769072.585          562093.319
Easting (X)  [meters]      424253.400         2016544.134
Convergence  [degrees]    -0.45971389         0.10215000
Point Scale                0.99967073         0.99999440
Combined Factor            0.99964047         0.99996413

US NATIONAL GRID DESIGNATOR: 11SMT2425369072(NAD 83)

                         BASE STATIONS USED
PID       DESIGNATION                        LATITUDE    LONGITUDE DISTANCE(m)
DN5820 GISA ESRI GISA CORS ARP              N340409.474 W1171305.731   55635.8
DM7578 SBCC SBCC_SCGN_CS1999 CORS ARP       N333310.788 W1173941.302   58101.4
AF9714 TORP TORRANCE AIRPORT CORS ARP       N334752.061 W1181950.124   55367.1
DM7584 TOST TOST_SCGN_CS1999 CORS ARP       N341452.629 W1185011.944   95983.0
DH4099 P470 BALDYMESA_CS2004 CORS ARP       N342744.643 W1172337.951   59526.1
DG9740 P584 POTREROCRKCS2004 CORS ARP       N335333.357 W1165705.859   82436.7
DL7677 BAR1 BAR1_SCGN_CS2002 CORS ARP       N332849.615 W1190147.002  129103.7
DF9223 ZLA1 LA WAAS 1 CORS ARP              N343612.652 W1180501.969   65014.5
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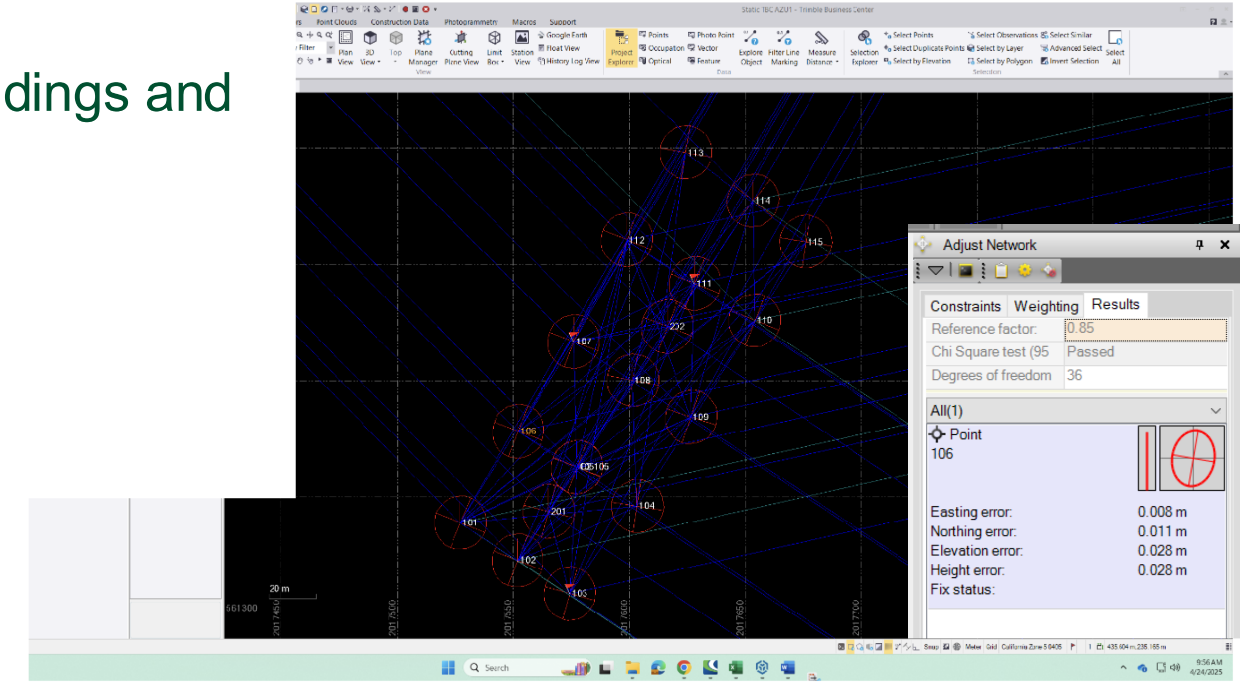

Field Exercises

- Best case scenario:
  - Understand pros and cons for each GNSS method.
  - Able to use OPUS-S or OPUS-RS and comparable desktop post-processing software for GNSS network adjustment.

Point 101			
Method	Northing	Easting	Elevation
Static	561338.808	2017527.031	218.64
RTK	561338.827	2017527.035	218.641
RTN	561338.829	2017527.015	218.434
Static/RTK Difference	0.019	0.004	0.001
Static/RTN Difference	0.021	0.016	0.206
RTK/RTN Difference	0.002	0.02	0.207

Figure 1. Point 101 coordinates and differences between methods

GNSS POINT OBSERVATION RECORD

Type of Measurement: ☐ Static ☒ Rapid- Static ☐ RTK

Observer Group Number: 103- AT-3

Station Point Number: 103

GNSS Receiver Type: Trimble R10

Station Mark Identification: DRONE TARGET AT-3 WITH MAG NAIL

Antenna Height: 2.00 ft

File Name : CE4341L_FP_250417

Observation time: Start 09:45 Stop 010:15

Description of Observed Point:

FD MAG FLUSH IN ASPHALT PAINTED DRONE TARGET "AT-3" AT SOUTH OF PARKING LOT ± 100' NORTHWEST FROM VALLEY BLVD AND KELLOGG DR INTERSECTION