



KEYSTONE
PRECISION SOLUTIONS

Survey Monitoring – What's Moving?

Kenneth Fronheiser, PLS – KPS
Taylor Shepley, PLS – KPS

About Keystone

For 35 years, Keystone Precision Solutions has provided you with the solutions you need to get the job done. We offer training, seminars, rentals, repairs, and education.

Serving over 55 million people over 180,000 square miles in 13 states.

KPS has you covered.



FOUNDED IN 1989



HEADQUARTERED
IN ALLENTOWN, PA



40+ EMPLOYEES

We have grown into the premier construction and survey equipment consulting company in the Northeastern United States.



A Little Introduction...

Ken Fronheiser, PLS

Director of Strategic Integration & Technology

- With Keystone Precision Solutions for 11 Years
- Report to Keystone's Allentown PA office
- Previous experience includes 17 years of survey work both in the field and in the office
- Licensed Surveyor in the Commonwealth of Pennsylvania
- Some of my free time I spend watching and coaching baseball. In addition, I really enjoy doing anything outside. Boating, fishing, skiing, etc.



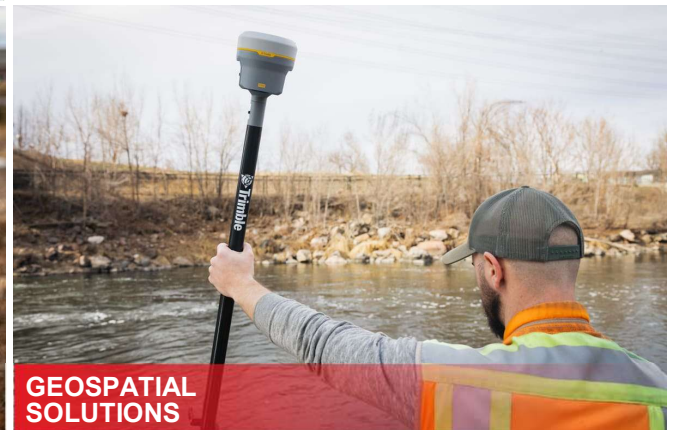
A Little Introduction...

Taylor Shepley, PLS *Technical Sales Consultant*

- With Keystone Precision Solutions since February 2025.
- Provides Sales, Support, & Service for UAS, SLAM, Monitoring, & Rail.
- Reports to Keystone's Allentown, PA office.
- A.S. in Surveying Engineering from Penn State.
- Professional Land Surveyor in PA & MD.
- FAA Part 107 Remote Pilot.
- PA State Coordinator for Young Surveyors Network
- Enjoys woodworking and genealogy.



KPS Solutions



What is Monitoring?

By Definition

The repeated or continuous observation, measurement, and recording of positional changes, displacements, or movements of specified points or structures using various technologies including total stations, GNSS, or Geotechnical sensors.



Who's done monitoring before?

What did you monitor...How did you do it?



Monitoring Goals

Why do we monitor?



Confirm whether or not a structure or area is moving

Often times movement is unexpected or the behavior of a structure is unknown.



Answer specific questions about structural health

Engineers may expect a certain behavior, and a good monitoring system can give valuable data to confirm or update models.

Methodologies

How can we monitor?

Tools to answer different questions...



Total Stations

- Movement and displacements
- 3D data
- Multiple targets



GNSS

- Movement and displacements
- 3D data
- Single point



Geotechnical

- Many data types
- Surface and subsurface measurements

Semi-automated vs. Fully-automated Monitoring



- Multiple visits to site are preferred
- Sensor is not fixed (e.g. tripod)
- Slow and low risk movement
- Small data sets/local storage



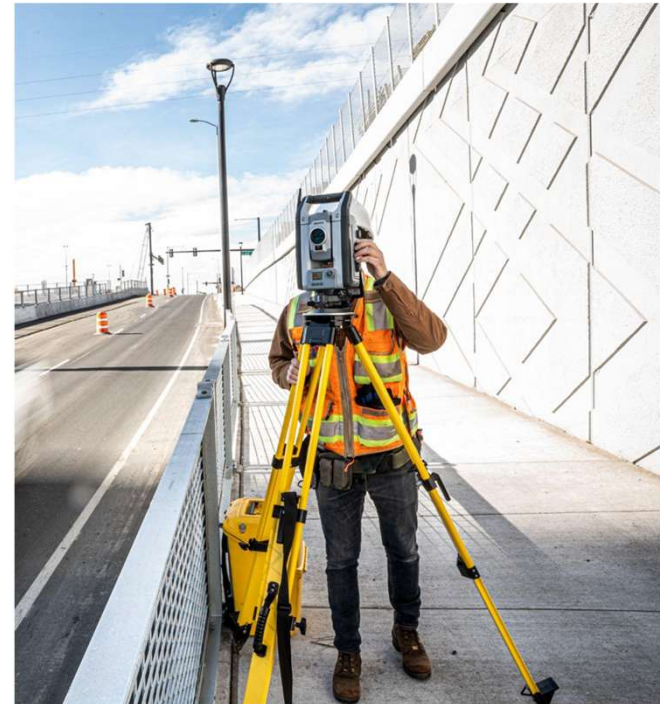
- Automated/remote collection and alarming
- Sensors permanently on site (e.g. pillar)
- Time sensitive movement detection
- Large datasets/local or virtual database

Increasing Project Requirements



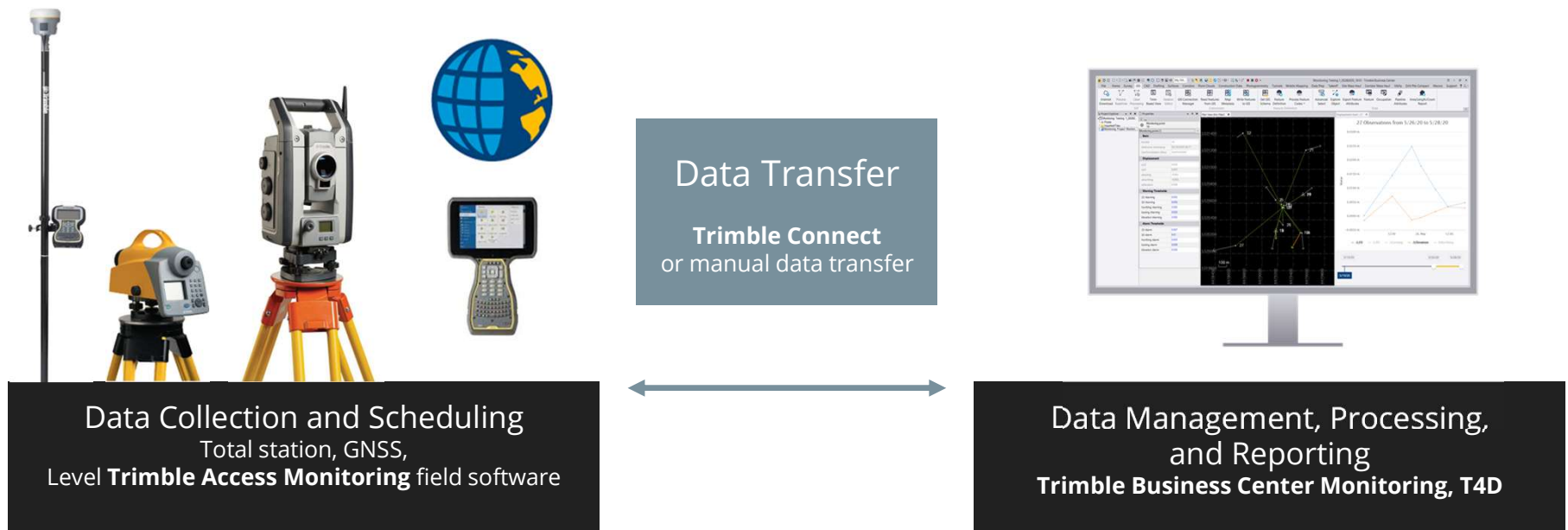
Why Semi-Autonomous Monitoring?

- **Reduces** measurement time in the field using conventional measurement methods
- **Simplified** in-field reporting
- **Smooth** transition of field data to office software (T4D/TBC)
- **Time-based** auto total station measurements
- **Define movement** thresholds and generate warnings
- **Direct data analysis** and reporting in the field
- **Ease in transitioning** to automated monitoring.



Semi-Automated Monitoring

System Overview



Semi Autonomous Monitoring

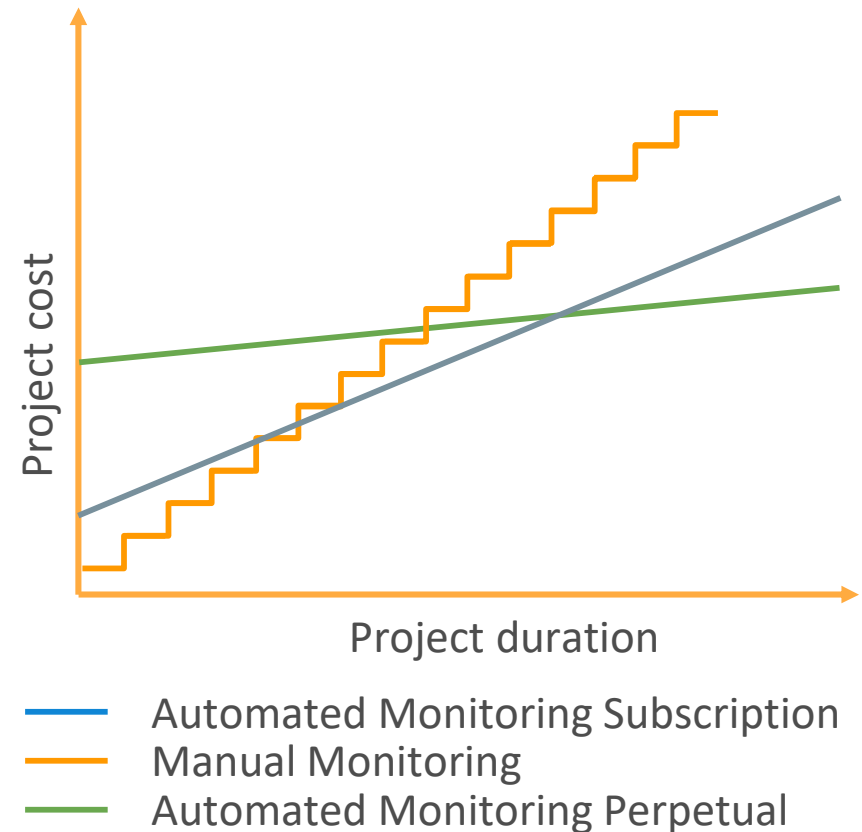
Field Workflow

- Establish baseline
- Setup instrument
- Establish control – Backsight(s), resection
- Create monitoring campaign
 - # of readings
 - Frequency
- Field analysis and reporting
- Data export



Why Automated Monitoring?

- **Safety** of people of infrastructure
- **Integration** into construction and BIM processes
- **Asset utilization** with personnel and equipment available for other projects,
- **Productivity**, increasing efficiency with minimal engagement required.
- **Profitability**, lowers operational costs and cuts labor expenses
- **Scalable**, increase/decrease as needed with no downtime.
- **Efficiency**, managing the project from the office with little interaction
- **Reliability** with higher frequency measurements and earlier warning capabilities



Total Station

Pro's and Con's...

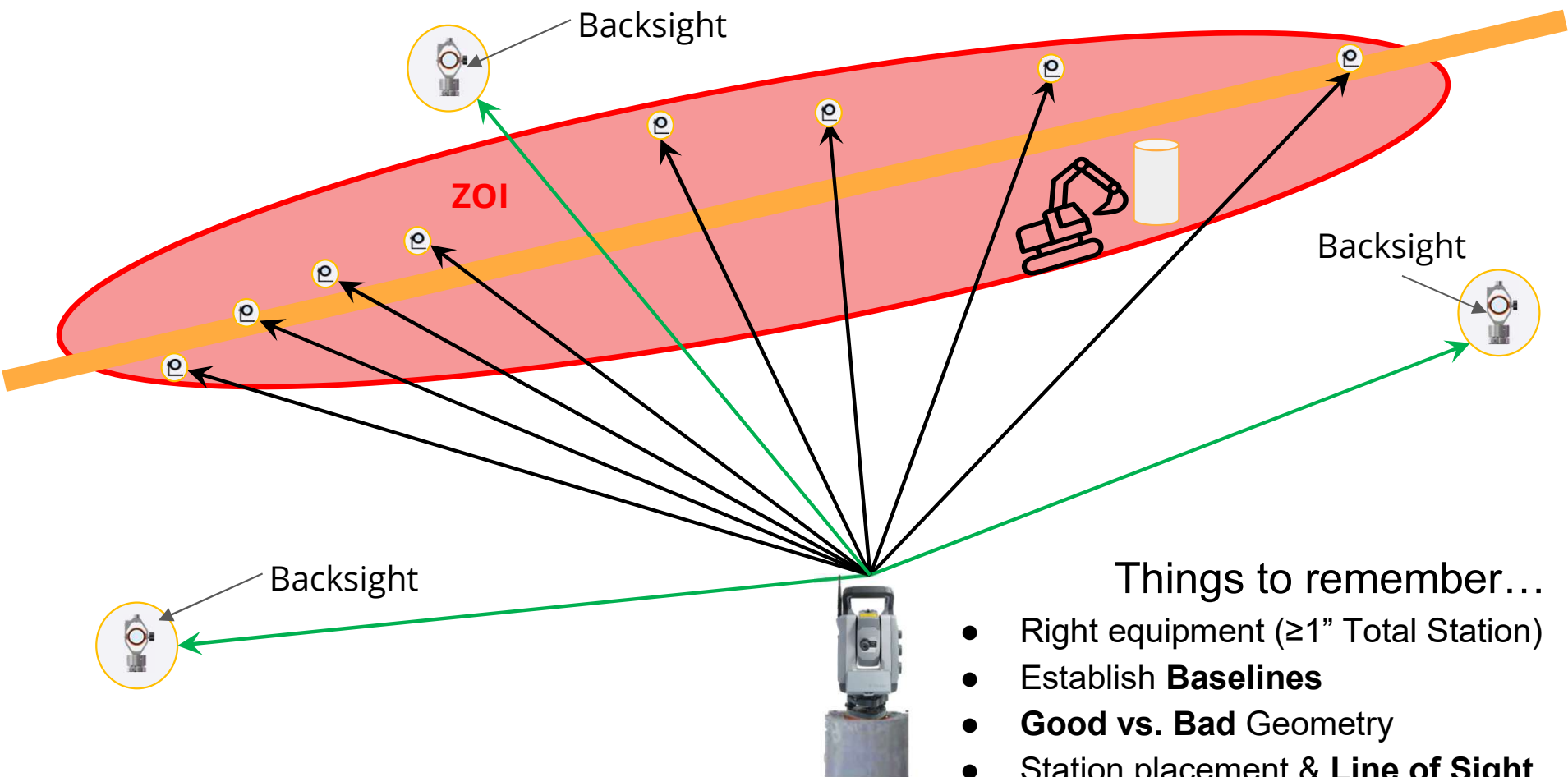
Pro's

- 3D positions
- High precision
- Many targets from a single location
- Familiar for surveyors

Con's

- Limited by line-of-sight
- Site noise
- Relies on stable backsights





Things to remember...

- Right equipment ($\geq 1''$ Total Station)
- Establish **Baselines**
- **Good vs. Bad** Geometry
- Station placement & **Line of Sight**

GNSS

Pro's and Con's...

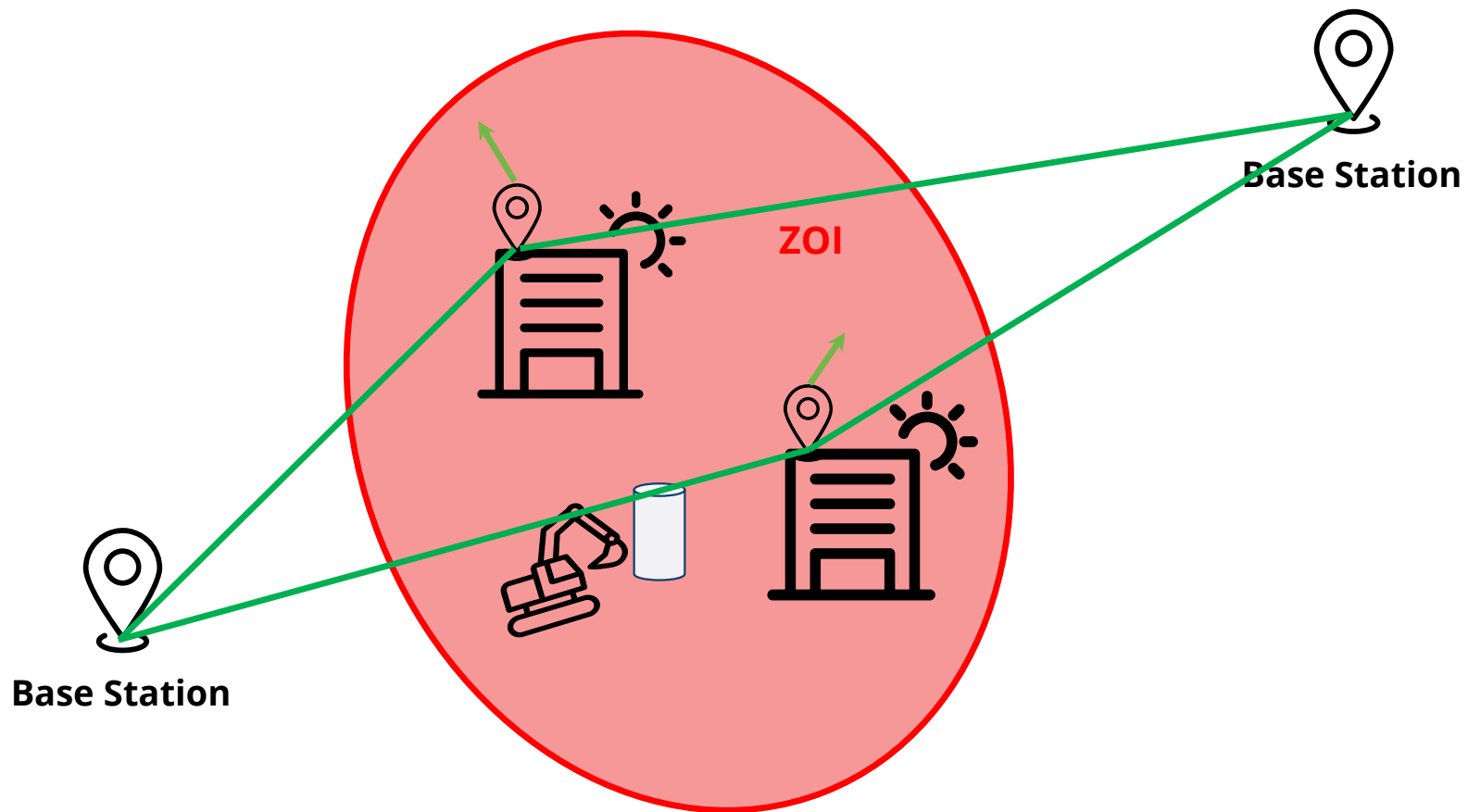
Pro's

- 3D positions
- High precision
- Real-time and post-processed options
- Familiar for surveyors

Con's

- Single-point only
- Requires clear sky-view





Geotechnical Sensors

Pro's and Con's...

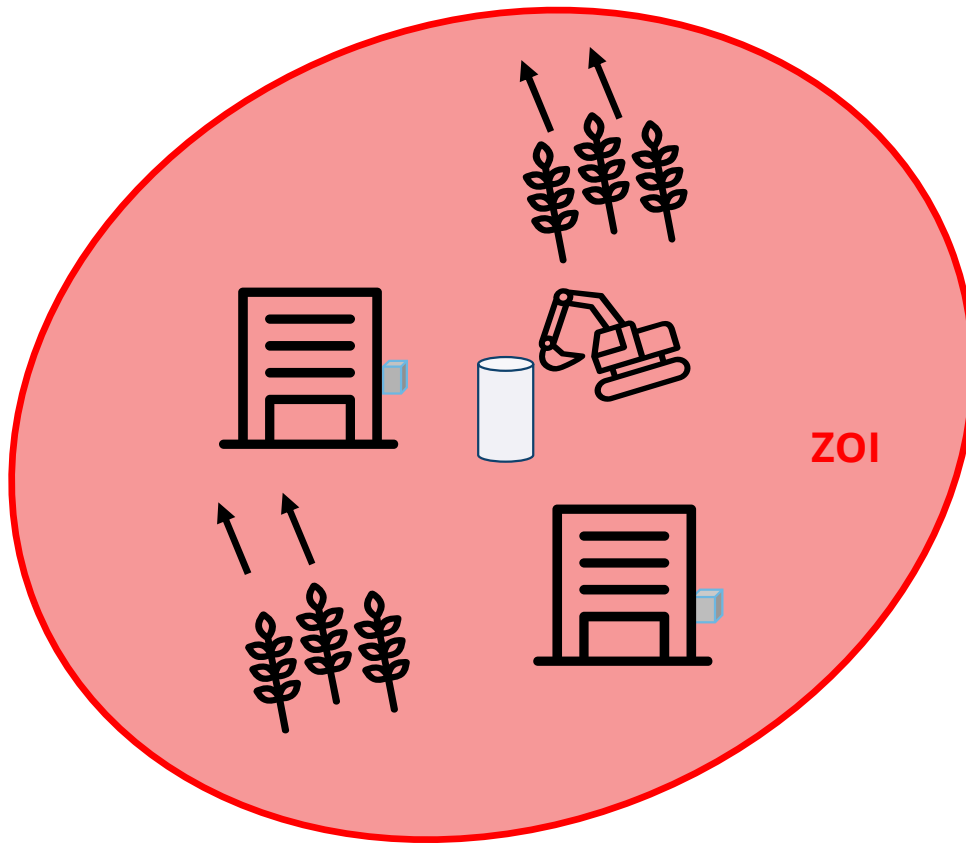
Pro's

- Many types of sensors available
- Easily automate data
- Not limited by line-of-sight

Con's

- No 3D data
- Costly installation (boreholes)
- Data management and conversion





Automated Monitoring

System Overview

**TRIMBLE S SERIES, SETTOP M1,
R750, GEOTECHNICAL, ACCESSORIES**

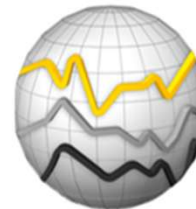


**Sensors based on the
project requirements**



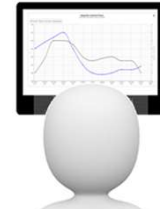
**Power and
communication**

TRIMBLE 4D CONTROL



**Trimble 4D
Control**

**Configuration, Storage
and Data Management**

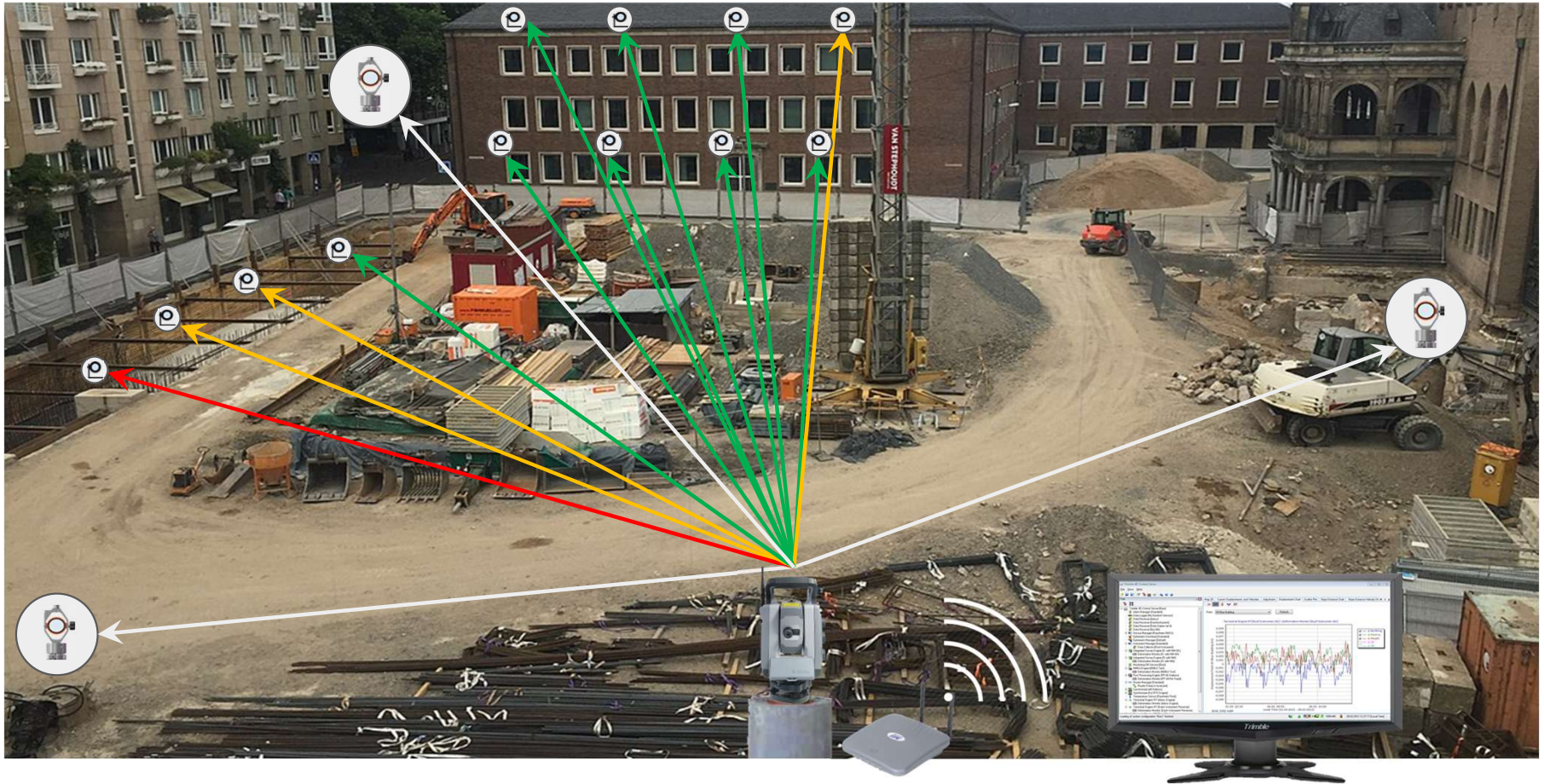


**Trimble 4D
Web**

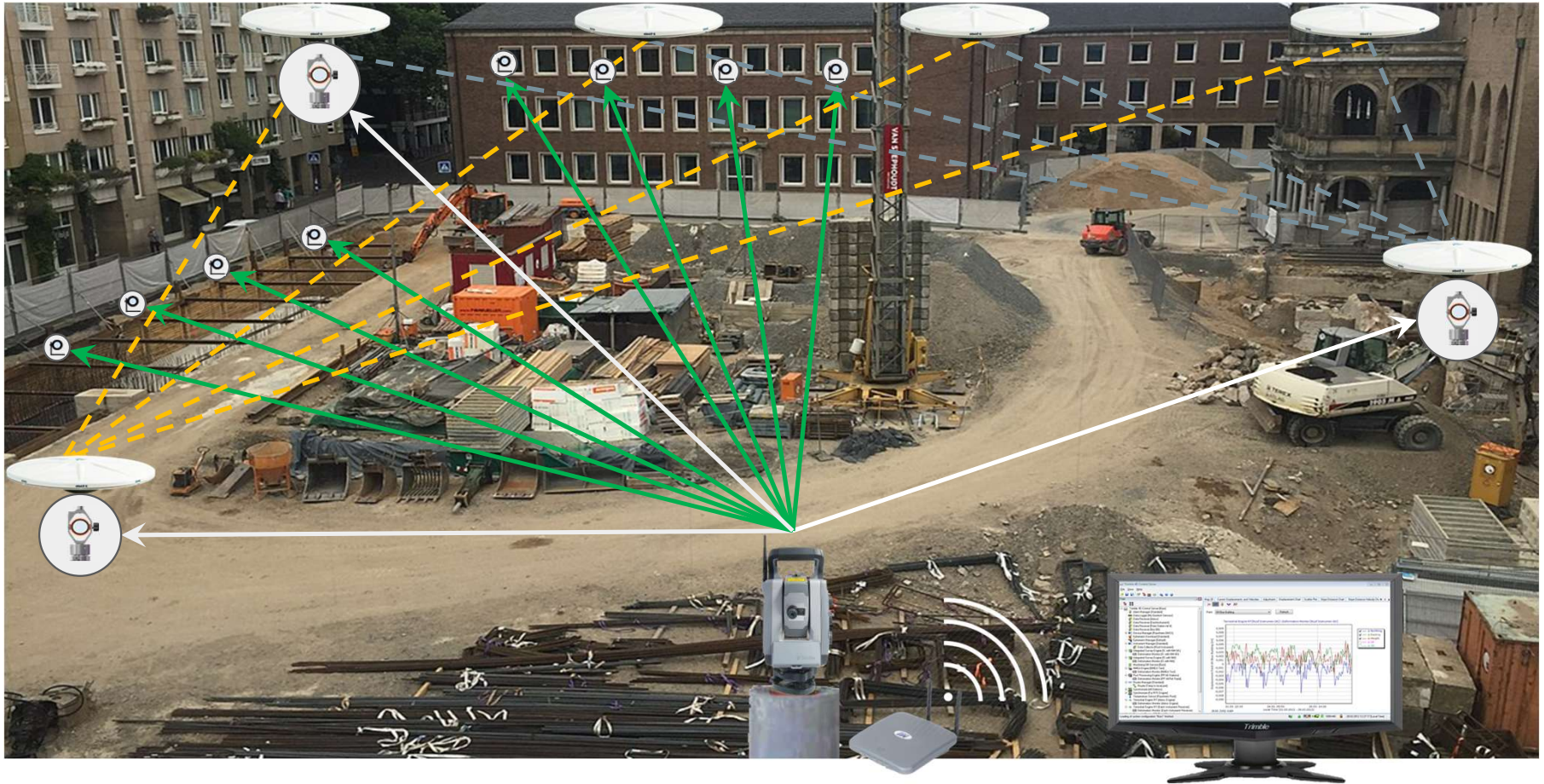
**Visualization, Reporting
and Alarming**



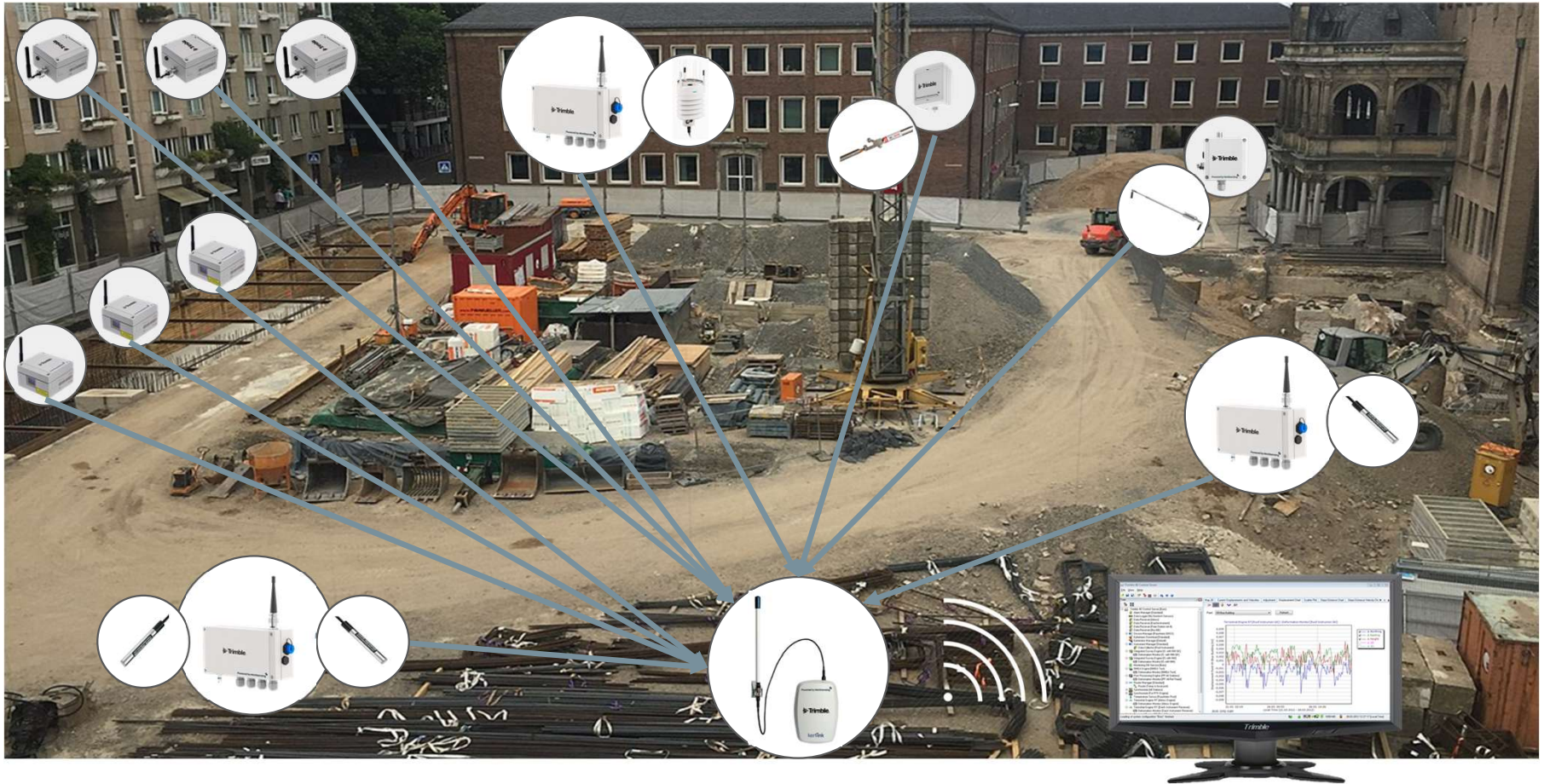
Total Station



GNSS/Integrated



Geotechnical





Applications

Where can we do monitoring?

Transportation/ Infrastructure

- Road
- Rail
- Tunnel
- Bridge
- Towers
- Viaducts
- Subsurface
Utilities

Buildings and Structures

- Foundations
- Retaining Walls
- New construction
- Excavation and
shoring
- Renovation
- Historical Sites

Landslides and Natural Hazards

- Landfills
- Landslides
- Flood control
structures
- Engineered
Slopes

Dams and Mines

- Open pit mines
and quarries
- Concrete dams
- Earthen dams
- Reservoirs



Monitoring Scenarios

Buildings and Structures

- New building construction: excavation and structural monitoring
- New building construction next to existing structures (landmark building monitoring)
- During renovation or structural repairs
- Major structural concerns identified (sinking foundation, major cracking identified, etc.



Monitoring Scenarios

Transportation and Infrastructure

- Construction on or near existing structures
- Boring or tunneling under roadway/ railway
- In-tunnel monitoring during and after construction
- Post-inspection bridge monitoring



Monitoring Scenarios

Landfills and Natural Hazards

- Landfill slope movement and settlement
- Existing landslide movement
- Post natural disaster slope monitoring (flood, fire, earthquake)
- Flood mitigation structure monitoring (dams, levees, etc)



Monitoring Scenarios

Dams and Mines

- Mine pit stability
- Tailings dam monitoring
- Underground mine monitoring
- Environmental monitoring



Applications

Which sensors are best?

Total Station

- Railway and linear infrastructure
- Excavation
- Landslides/Landfills
- Mining and Dams

GNSS

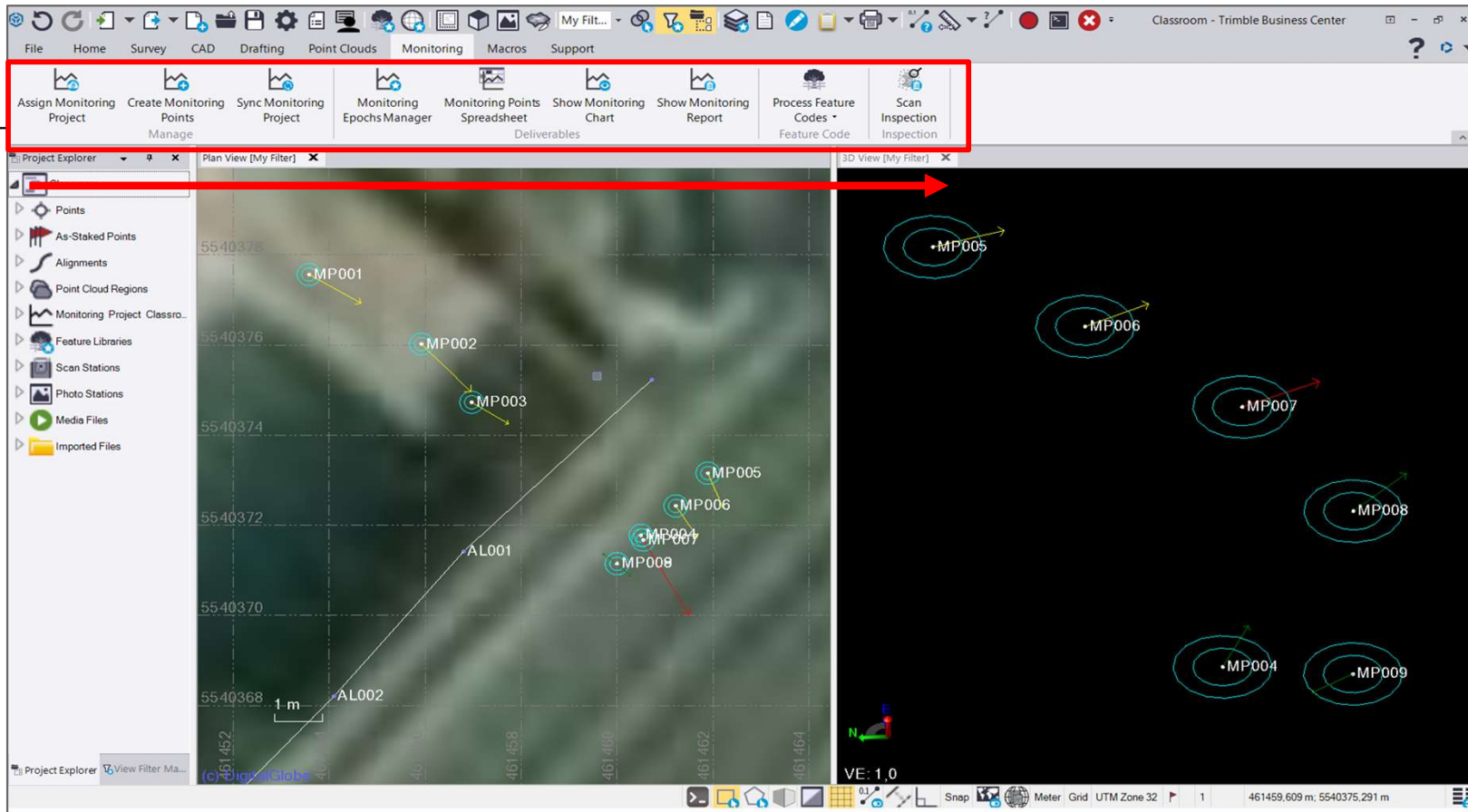
- Dams and bridges
- Regional movement
- Buildings and high risk structures

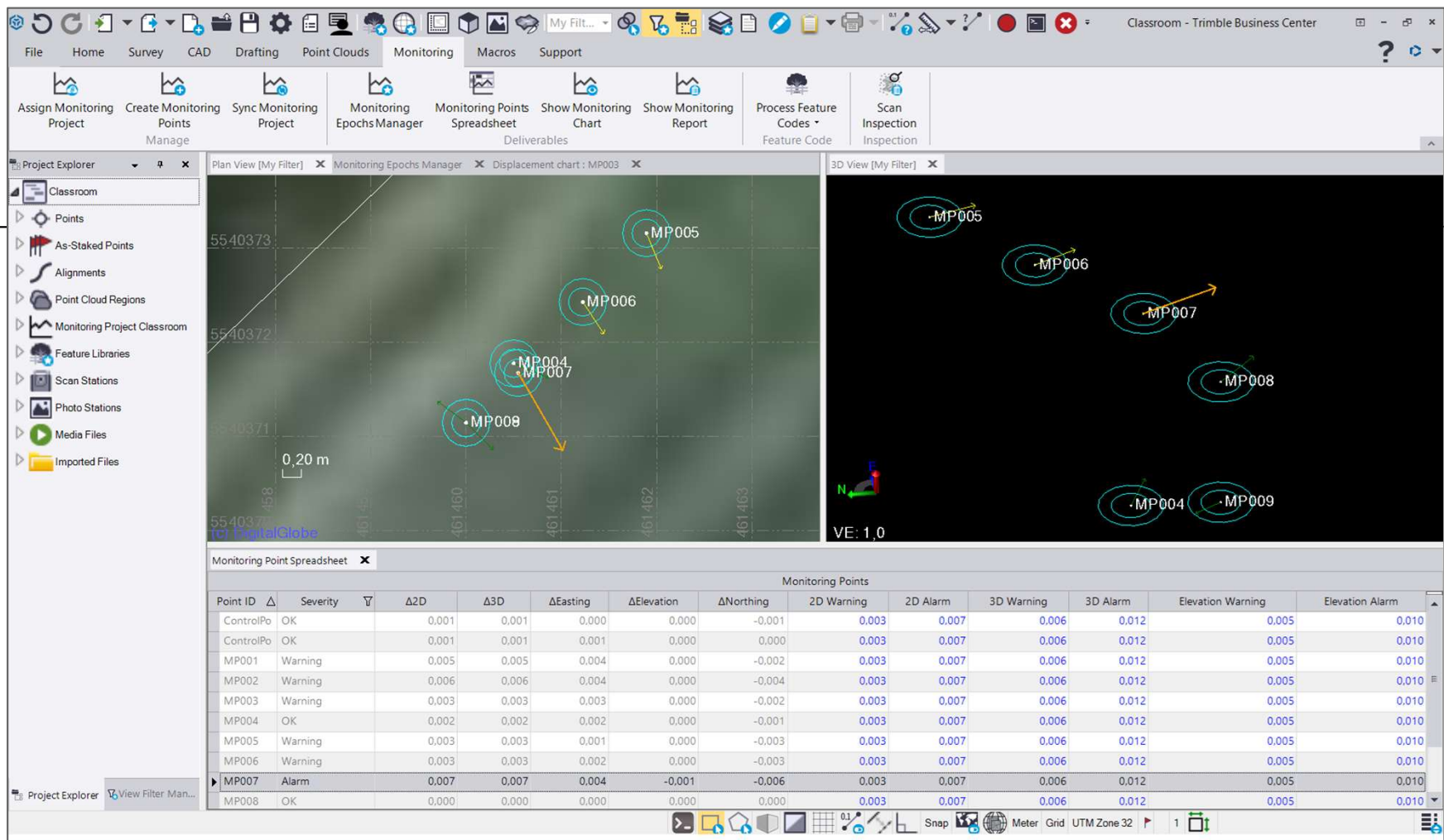
Geotechnical

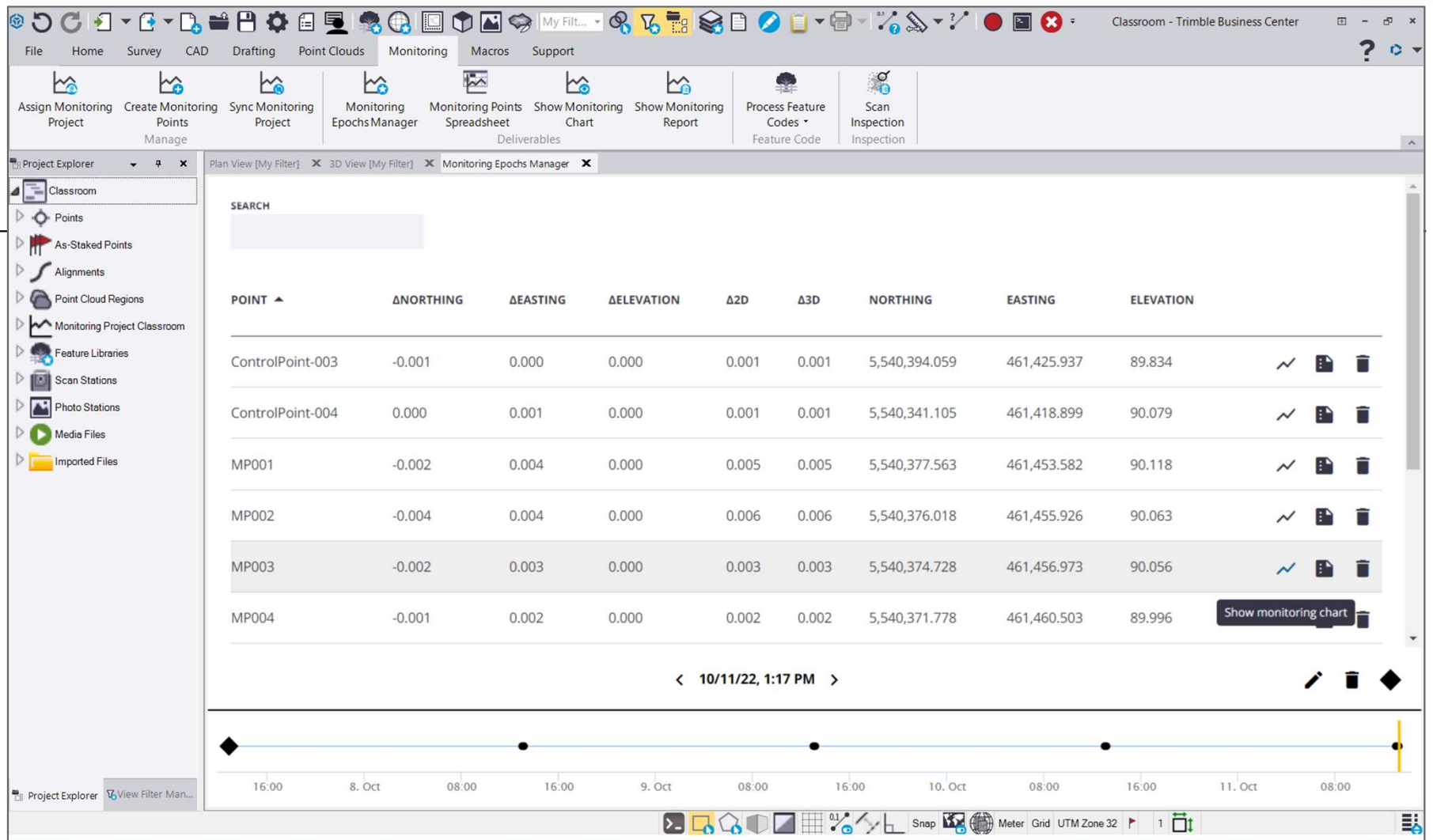
- Tunneling
- Mining
- Dams and bridges
- Subsurface measurements

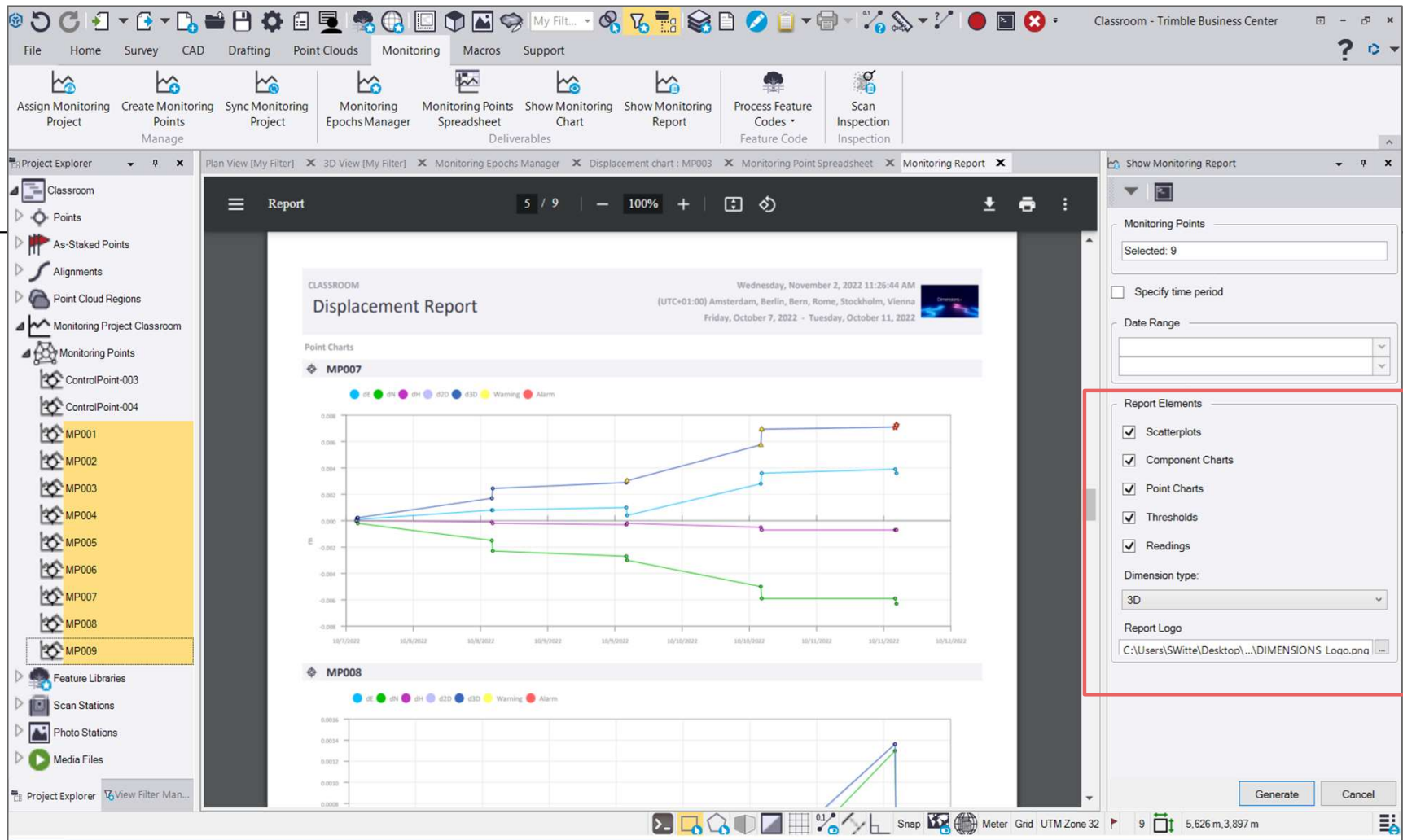


Semi Autonomous Monitoring - TBC









T4D Manual Entry

Trimble 4D Control™

HomeSensorsTerrain ViewCharting and AnalysisMonitoringAdministration

Select Sensor

Configure Sensor Information

Settings

Data Type Reductions

Project: 20250325-HQ Demo (UTC -5)10/16/2025 08:01:490System Administrator (Admin)Sign Out

Data Entry

Create Manual SensorsUpload Data XLSX File

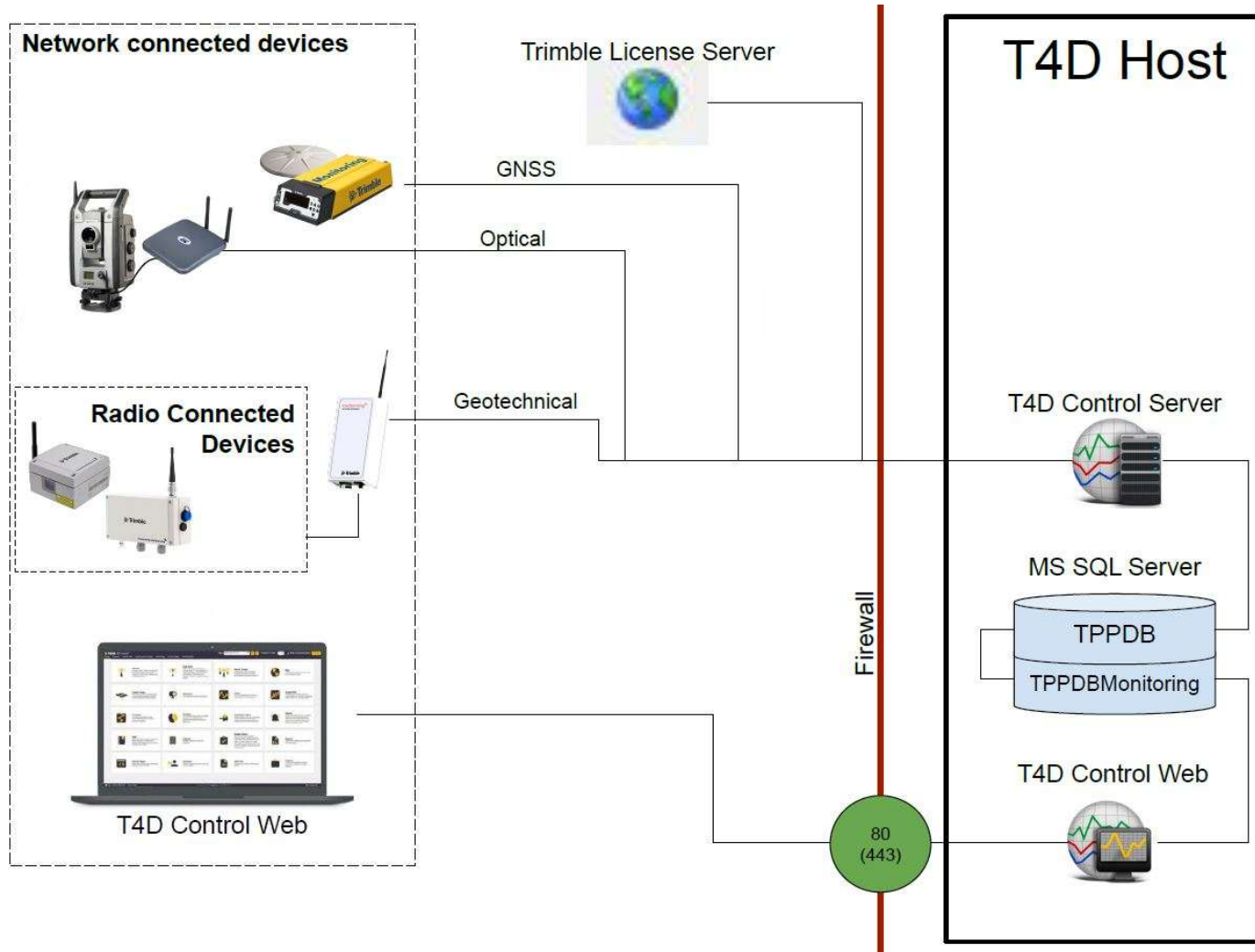
Data Entry enables you to manually import sensor observations. This can be done by entering observation data online in a dataset or exporting a Data Entry XLSX template file and entering observation data offline. XLSX Data Entry files created offline can be uploaded to dataset for online review and the datasets can be imported as sensor observations.

Saved Datasets (0) +

Either select a Sensor or a Sensor Type below and download the Template Data XLSX File for offline data entry or create a new dataset for online data entry.

Sensor

There are no sensors for data entry in your project.



Trimble 4D Control Server

FileViewHelp

Tree

Trimble 4D Control Server [2025-03-25_HQ-Monitoring-Demo]

Coordinate Export [HQ_Demo_Export]

Instrument Manager [HQ_Demo]

Data Collector [20250325_S7_Deck Beam]

Monitoring DB Service [Default]

Temperature Sensor [Default]

Terrestrial Engine RT [20250325_S7_Deck Beam]

Integrity Monitor [20250325_S7_Deck Beam]

Round MeasurementRound HistoryReference MeasurementTotal Station Info

Overview of reference measurement.

Point Name	Hz Circle Reading ["]	V Angle ["]	EDM Distance [m]	Prism Constant [m]	Target Height [m]	Face	Measurement Time [Local]
BS1-Corner	51.3312	85.7509	24.527	-0.030	0.000	1	5/2/2025 7:47:27 AM
BS1-Corner	231.3325	274.2484	24.528	-0.030	0.000	2	5/2/2025 7:47:27 AM
BS2-Scale	67.8974	87.7967	21.075	-0.030	0.000	1	5/2/2025 7:46:40 AM
BS2-Scale	247.8998	272.2021	21.075	-0.030	0.000	2	5/2/2025 7:46:40 AM
BS3-Bathroom	118.1104	86.1616	23.812	-0.030	0.000	1	5/2/2025 8:54:06 AM
BS3-Bathroom	298.1128	273.8377	23.812	-0.030	0.000	2	5/2/2025 8:54:06 AM
BS4-Office	155.6693	81.6278	13.329	-0.030	0.000	1	4/9/2025 12:20:24 PM
BS4-Office	335.6725	278.3655	13.329	-0.030	0.000	2	4/9/2025 12:20:24 PM
MP1	54.4167	79.7534	12.116	-0.030	0.000	1	4/9/2025 12:20:24 PM
MP1	234.4198	280.2430	12.115	-0.030	0.000	2	4/9/2025 12:20:24 PM
MP2	58.5117	85.6794	14.106	-0.030	0.000	1	4/9/2025 12:20:24 PM
MP2	238.5137	274.3136	14.106	-0.030	0.000	2	4/9/2025 12:20:24 PM
MP3	91.4977	83.8464	12.476	-0.030	0.000	1	4/9/2025 12:20:24 PM
MP3	271.5002	276.1496	12.476	-0.030	0.000	2	4/9/2025 12:20:24 PM
MP4	117.2258	90.1068	19.684	-0.030	0.000	1	4/9/2025 12:20:24 PM
MP4	297.2273	269.8913	19.683	-0.030	0.000	2	4/9/2025 12:20:24 PM
MP5	121.9304	87.6212	15.083	-0.030	0.000	1	4/9/2025 12:20:24 PM
MP5	301.9350	272.3760	15.083	-0.030	0.000	2	4/9/2025 12:20:24 PM
MP6	140.0813	88.4163	14.049	-0.030	0.000	1	4/9/2025 12:20:24 PM
MP6	320.0838	271.5750	14.049	-0.030	0.000	2	4/9/2025 12:20:24 PM

Status Messages: Last 20 Items

Type	Event Time [Local]	Source	Group	Message Text
i	10/16/2025 12:07:31...	Temperature Se...	Framework	Disconnecting from m13523276.istconnect.com.istconnect.com
i	10/16/2025 12:07:32...	Terrestrial Engi...	Processing	Coordinates of total station DECKBEAM_1 not computed. All points measured from this instrument cannot be calculated.
i	10/16/2025 12:08:16...	Temperature Se...	Framework	Disconnecting from m13523276.istconnect.com.istconnect.com
i	10/16/2025 12:09:01...	Temperature Se...	Framework	Disconnecting from m13523276.istconnect.com.istconnect.com
i	10/16/2025 12:09:46...	Temperature Se...	Framework	Disconnecting from m13523276.istconnect.com.istconnect.com
i	10/16/2025 12:10:31...	Temperature Se...	Framework	Disconnecting from m13523276.istconnect.com.istconnect.com
i	10/16/2025 12:11:17...	Temperature Se...	Framework	Disconnecting from m13523276.istconnect.com.istconnect.com
i	10/16/2025 12:12:02...	Temperature Se...	Framework	Disconnecting from m13523276.istconnect.com.istconnect.com
i	10/16/2025 12:12:47...	Temperature Se...	Framework	Disconnecting from m13523276.istconnect.com.istconnect.com

Properties - Data Collector [20250325_S7_Deck...

Incoming Connection

Connection typeSetup M1 IST Connect (Pr

Connection Settings

Custom namem13523276

Use secure connectionYes

User nameKPS6

Password*****

Setup M1

Credentialsadmin: *****

Project name20250325_S7_Deck_Bea

Storage pathC:\Users\russ\Desktop\T4D

Total Station

Mission name20250325_Deck Beam Mis

Selected total station20250325_Deck Beam Mis

Serial number37252125

PIN****

Rounds Scheduler

Enable schedulerYes

Scheduler configurationevery 30 min, every day

Calibration Scheduler

Compensator calibrationNo

Weather Condition

Temperature [°C]20

Refraction coefficient0.142

Round Settings

Round modeF1/F2...

Repeat measurementYes

Set of rounds1

Alarm Evaluation

Evaluation modePer round

No data interval [dd hh:00:01:00:00

Target Integrity Thresholds

Default





Sensors

Configure sensor data to be displayed in the web interface, view sensor properties, latest sensor readings and current sensor state.



Data Entry

Import observation data to your manual sensors. Create datasets for online data entry or use XLSX data templates for offline data entry. Convert JXL files to datasets for data import.



Sensor Groups

Create sensor groups to refer to groups of sensors, or to define representative calculation sensors.



Map

View sensor location, data and state on an interactive map.



Webcams

View webcams linked to the project.



Custom Views

View sensor location, data and state on user supplied images, with data updates at specified time intervals.



Charts

View the selected data series of a single sensor in a simple chart.



Scatter Plot

Visualize and animate positional displacement over time for a particular sensor within two different planes.



Analysis

View selected data series of multiple sensors in a complex chart to graphically analyze the structural behaviour.



Composite Views

Create, maintain and view composite views by combining plan views, scatter plots and multiple analyses.



Visual Inspection

Visually inspect the target images of a single sensor.



Vibration Events

View and analyse Vibration Events recorded by vibration sensors.

Select Sensor

Location

All

Sensor Type

All

Text Search

Clear Search

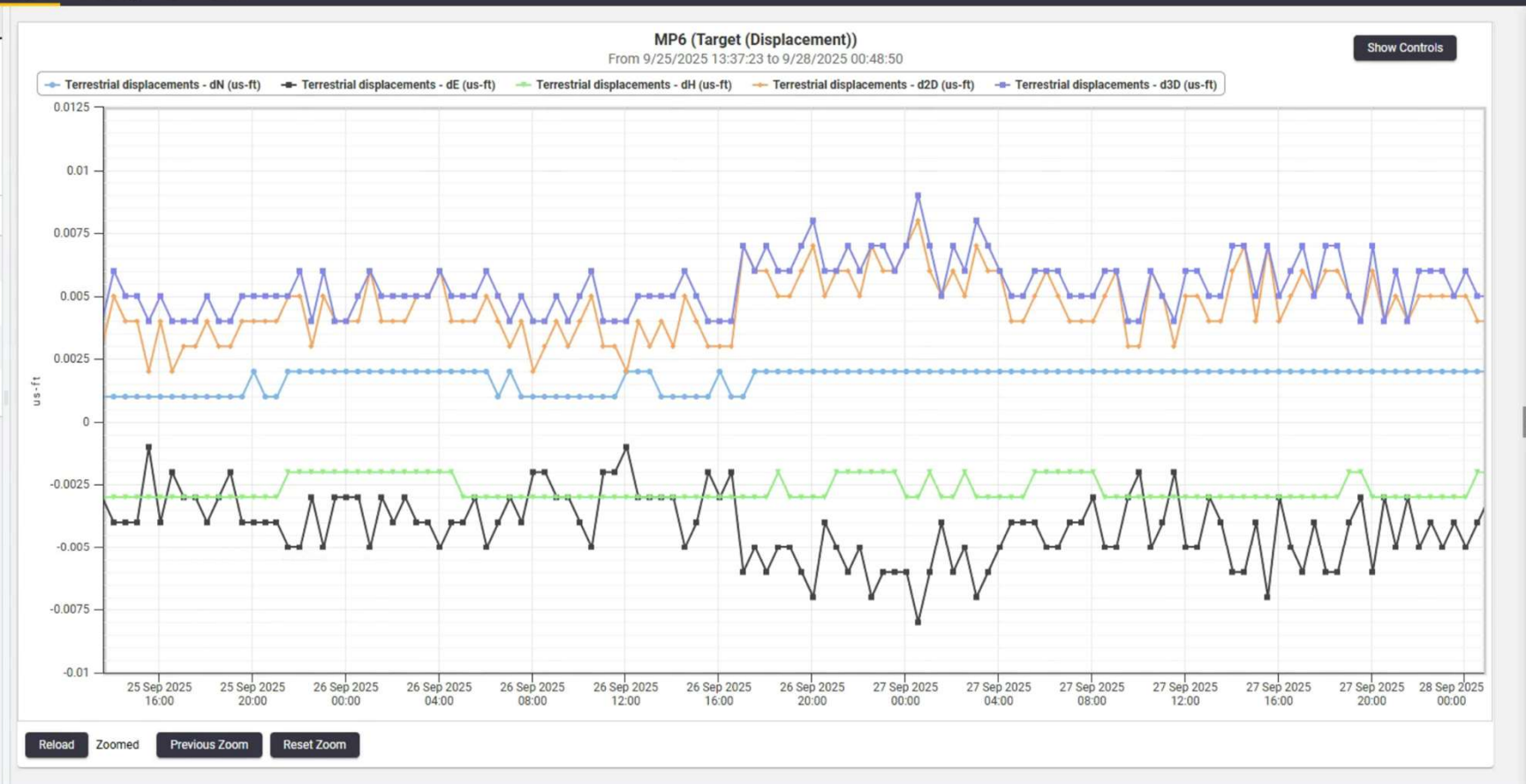
2 of 2

44674 - Chainlink Fence

48907 - Beam Pocket

66127 - Stairwell

DECKBEAM_1



Select Alarm Definition

OwnerAll

Data TypeAll

Sensor TypeAll

Alarm StateAll

Alarm Name

Sensor Name

Clear Search

Add Alarm Definition

HQ Demo Alarms - Geotech (No Conditions)

HQ Demo Alarms - TS (Alarm)

View Alarm (Alarm Enabled) - Alarm

NameHQ Demo Alarms - TSEvaluation Frequency10 MinutesCondition Merge OrderAnd before Or

Revision0Evaluation Window EnabledNoNotification granularityAlarm status changed

OwnerSystem AdministratorLast Evaluated10/15/2025 23:07:00Require AcknowledgeNo

DescriptionCustomize messagesNo

Last Changed9/19/2025 15:04:00

Disable For Edit

Create Copy

Notification Recipients

Batch Files

View Charts

History

Refresh

Conditions

	Merge Operand	Data Type	Sensor Link Mode	Evaluation	Condition Type	Reference Date	σ Filter	Attention Threshold	Warning Threshold	Alarm Threshold	No Data Threshold	
1	Where	Terrestrial displacements	Specific Sensor(s)	Latest Value	Absolute Measurement		Disabled	$ dN \geq 0.005$ us-ft	$ dN \geq 0.010$ us-ft	$ dN \geq 0.020$ us-ft	2 Hours	
2	And	Terrestrial displacements	Specific Sensor(s)	Latest Value	Absolute Measurement		Disabled	$ dE \geq 0.005$ us-ft	$ dE \geq 0.010$ us-ft	$ dE \geq 0.020$ us-ft	2 Hours	
3	And	Terrestrial displacements	Specific Sensor(s)	Latest Value	Absolute Measurement		Disabled	$ dH \geq 0.005$ us-ft	$ dH \geq 0.010$ us-ft	$ dH \geq 0.020$ us-ft	2 Hours	
Or												
4		Terrestrial displacements	Specific Sensor(s)	Latest Value	Calculation		Disabled	$\sqrt{(dN^2 + dE^2 + dH^2)} \geq 0.010$ us-ft	$\sqrt{(dN^2 + dE^2 + dH^2)} \geq 0.020$ us-ft	$\sqrt{(dN^2 + dE^2 + dH^2)} \geq 0.050$ us-ft	2 Hours	

Export To PDF

KeyPre.com

Trimble 4D Control™

HomeSensorsTerrain ViewCharting and AnalysisMonitoringAdministration

My Account

Select User

Role Configuration

Admin

Analyst

Guest

Recipient

Add Role

Security Settings

Background Settings

Notification Settings

Configure Role

Name*Guest

Permissions	View	Create	Edit	Delete	All	None
An asterisk (**) indicates that ownership is applied within the indicated functional area.						
This implies that any user will be able to edit or delete items created by themselves without having edit or delete permissions.						
3D Viewer	☒	☐	☐	☐	All	None
Account Settings Page	☒	☐	☐	☐	All	None
Account Settings Page - Email Server Configuration			☐		All	None
Account Settings Page - Security Settings			☐		All	None
Account Settings Page - SMS Gateway Configuration			☐		All	None
Alarms Page *	☒	☐	☐	☐	All	None
Analysis Page *	☒	☒	☐	☐	All	None
Chart Page	☒		☐		All	None
Composite View Page *	☒	☒	☐	☐	All	None
Custom View Page	☒	☐	☐	☐	All	None
Data Maintenance	☒	☐	☐	☐	All	None
License Server Settings			☐		All	None
Live Update	☒				All	None

KeyPre.com

Thank you!



For additional information contact your solutions team:

- kfronheiser@keypre.com
 - tshepley@keypre.com
 - Sales@keypre.com
-

Creating success through collaboration

