Monitoring Total Station FAQ

Trimble Monitoring

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Trimble

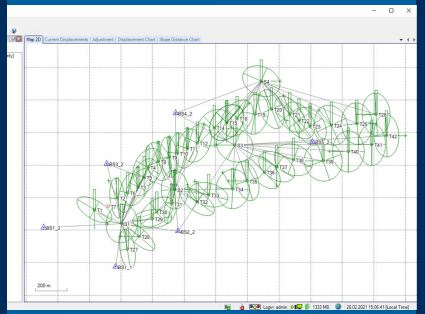
Agenda

1. Total Station Features
2. Best Practices for Setup
3. T4D Total Station Processing
4. Environmental Factors
5. Case Studies

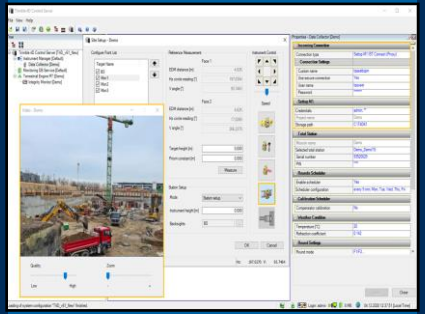
Key Points

Durability, flexibility, and automation

Durability of Trimble instruments using MagDrive



Automatic corrections and adjustments with T4D



See what the instrument sees using Trimble Vision and T4D

1

Total Station Features

An overview

Picking the Right Total Station for the Job

SX12 1”, Autolock, Vision, Scanning

Best Overall 3D scanning and imaging

S9 HP 0.5”, Autolock, Vision

Best non-scanning, imaging

S9 HP 0.5”, Robotic, Vision

Flexibility for Monitoring to Surveying

S9 HP 0.5”, Robotic, Long Range Finelock

Long Range Monitoring

S7 DR+ 1”, Robotic, Vision

Manual and Automated Monitoring

Total Station Overview

Considerations for monitoring

- MagDrive ™
- Tilt Sensor
- Autolock, FineLock ™
- Trimble Vision ™ camera system
- DR HP vs DR Plus EDM
- Lightning 3DM (SX only)

MagDrive Servo

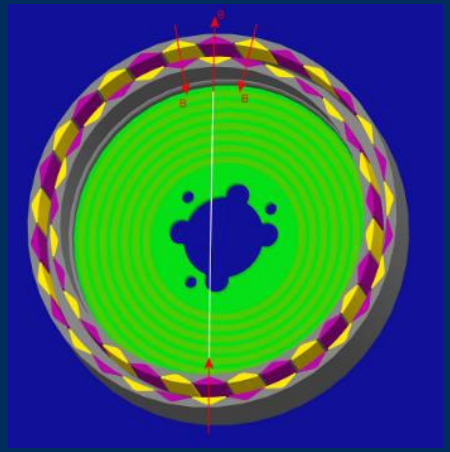
Durability

- Brushless, frictionless motor
- Integrated motor with angle sensors
- Direct drive
- No gear , no clutch
- Accurate positioning
- Low power consumption

Combine the motor with the angle sensor to one compact unit

The angle disc fits inside the winding

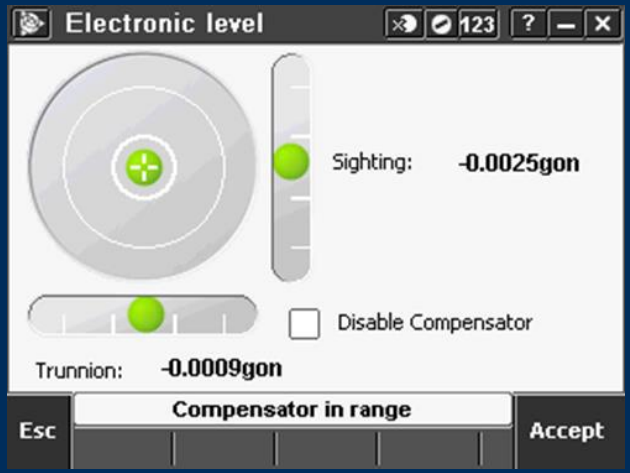
The magnetic system encloses the disc



Tilt Sensor

Anticipating tilt changes

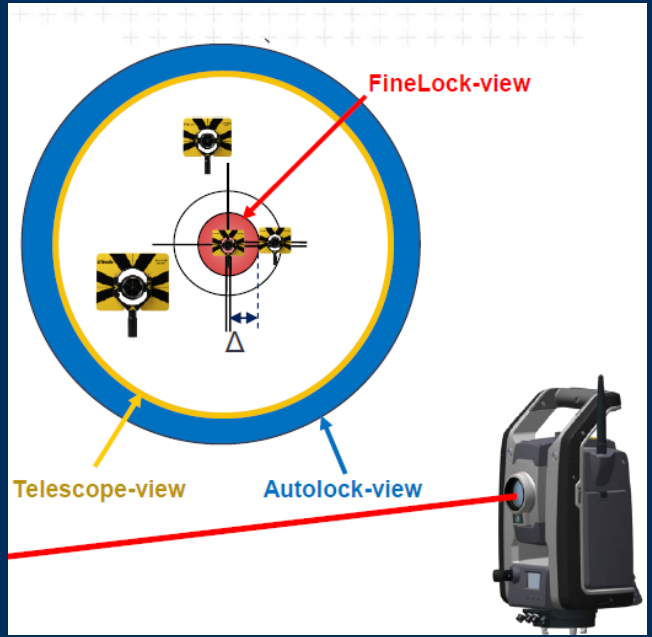
- Compact durable design
- Accurate and reliable
- Low power consumption
- Refresh rate of 6 Hz
- Mounted in the center of the instrument
- Tilt change makes the aim drift off target
- SurePoint ™ corrects the position back on to the target



Autolock, FineLock, Long Range FineLock

Tracker detector and auto prism locking

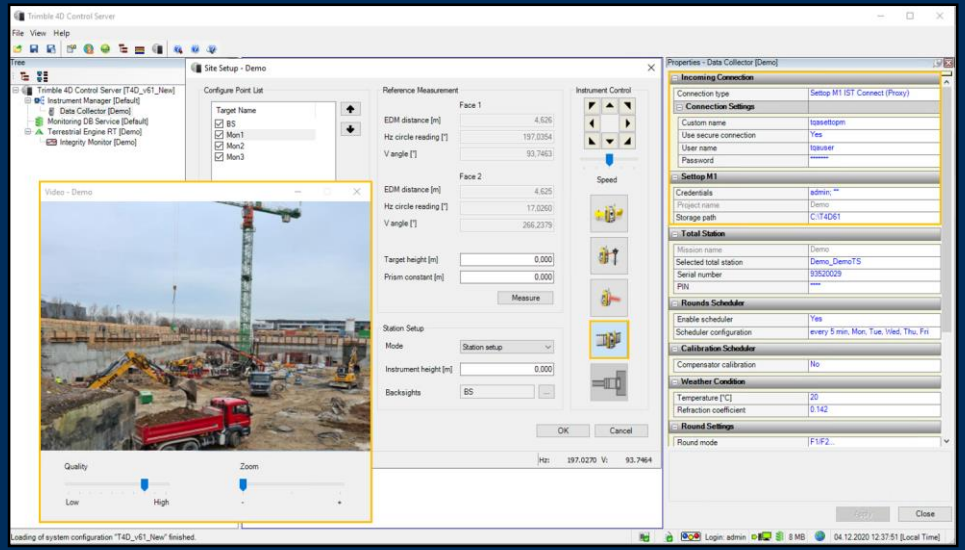
- Autolock is used to lock onto prism
- FineLock is for differentiating between prisms and reflections when locking
- Minimum Δ30cm separation between prisms @200m
- Long Range FineLock
  - Range to standard prism ~2500m



Trimble Vision Calibrated Cameras

See what the instrument sees

- Selected for high accuracy and temperature stability
- Calibrated
- Add new targets, edit existing using cameras in T4D



DR HP and DR PLUS for Reflectorless Measurements

- DR HP
  - Available with S9 HP model
- DR Plus
  - Available with S5, 7, 9

Lightning 3DM

Scanning + total stations

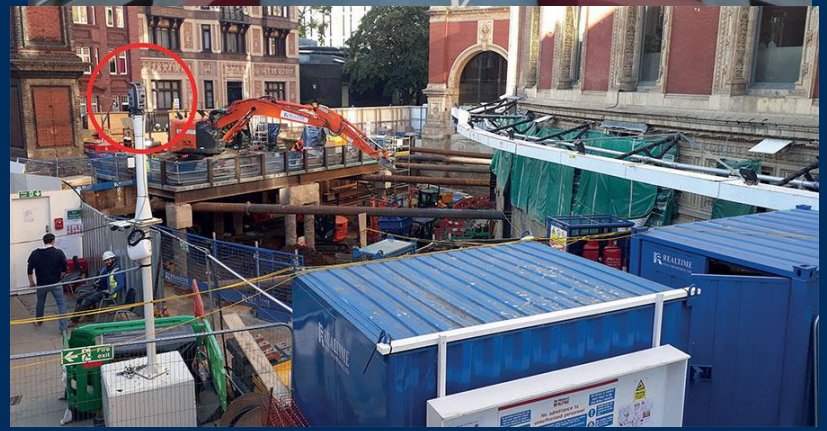
- Tilting mirror enabling SX12 total station to perform laser scanning up to 26.6 points per second
- Define specific scan ‘areas’ or perform full dome collection
- Scanning data collected, processed, and analyzed in T4D automatically
- Monitor areas where prisms cannot be installed and cover large surfaces to understands trends

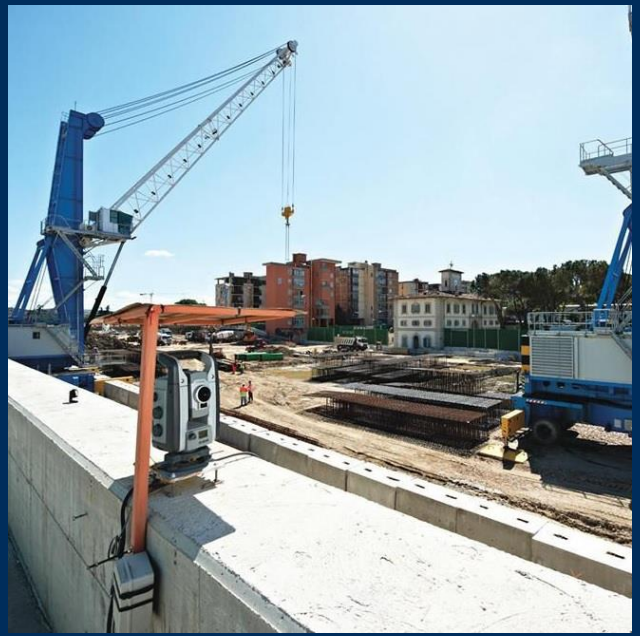
2

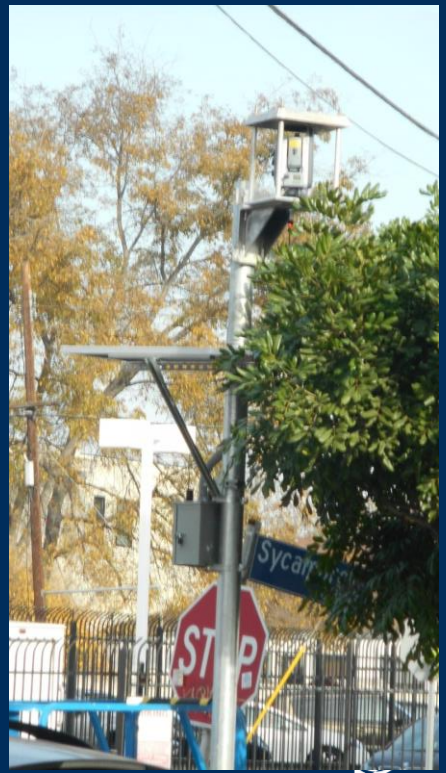
Station Setup Best Practices

Options and Criteria

Total Station Setup Examples

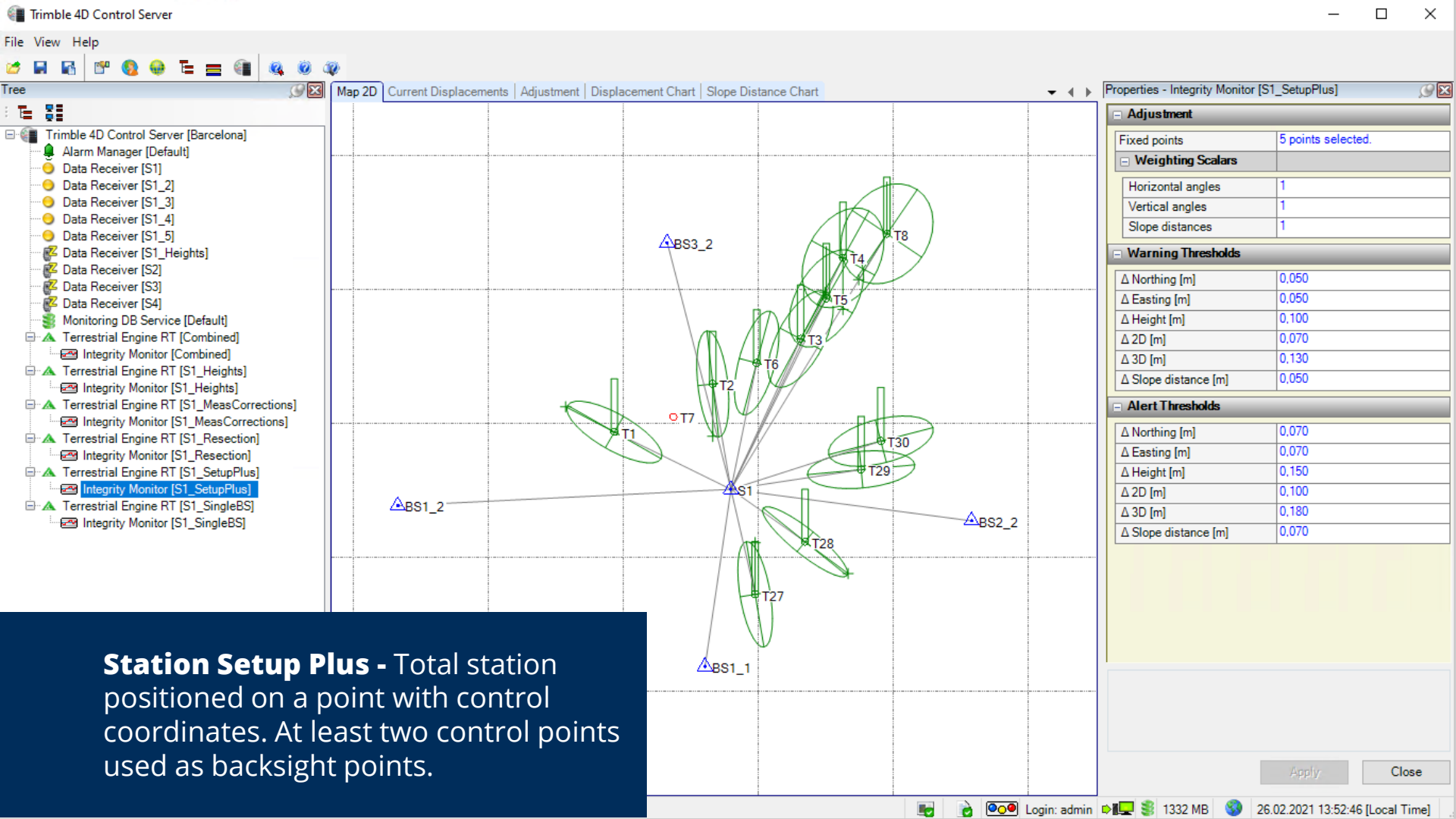




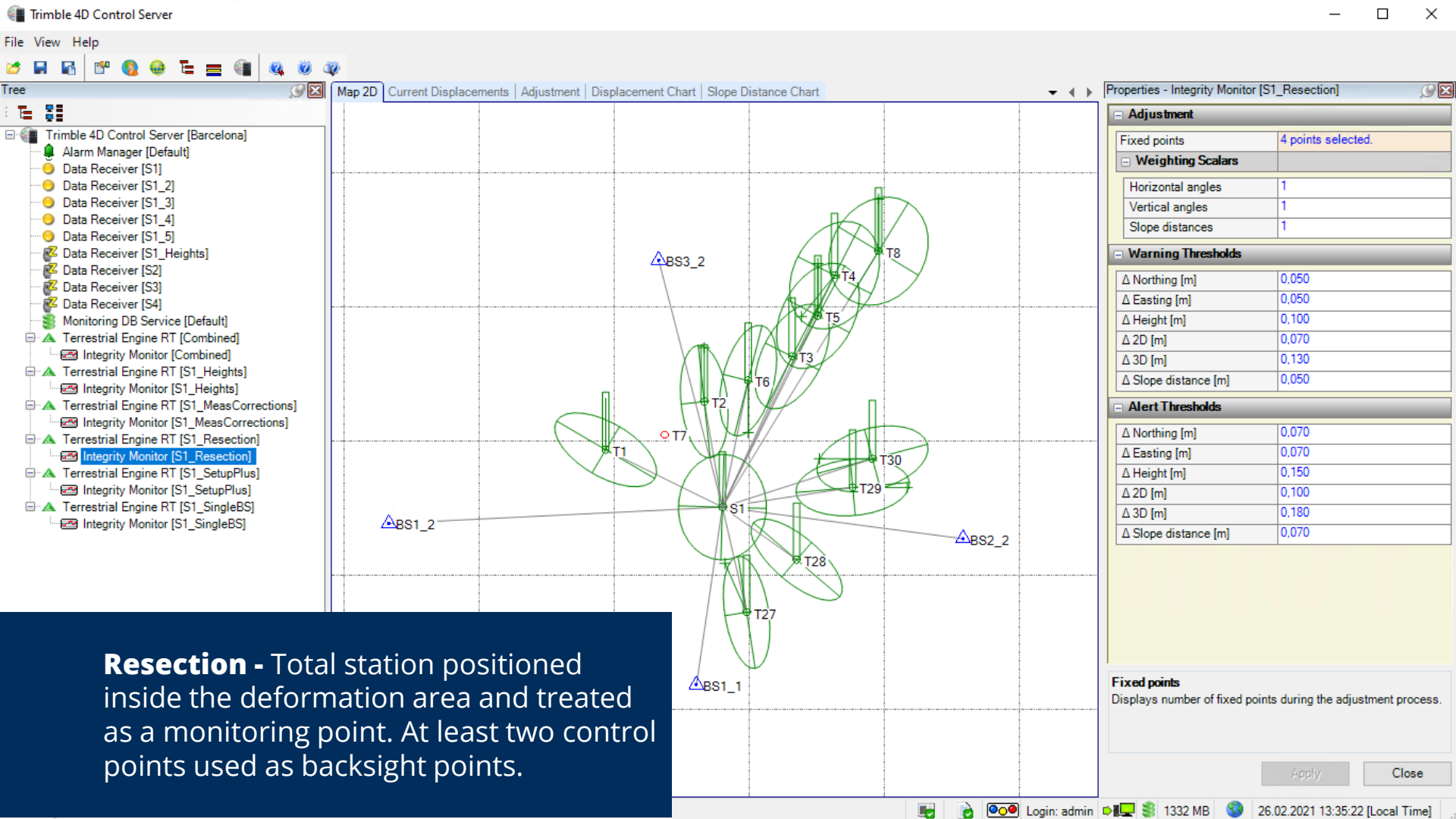


Total Station Setup Consideration

- Stability of the instrument
- Vibration from nearby activity or weather
- Accessibility to instrument
- Power supply and communications
- Theft and interference with instrument
- Reliable line of sight to targets
- Geometry with control and monitoring points
- Round scheduling and interval



Station Setup Plus - Total station positioned on a point with control coordinates. At least two control points used as backsight points.

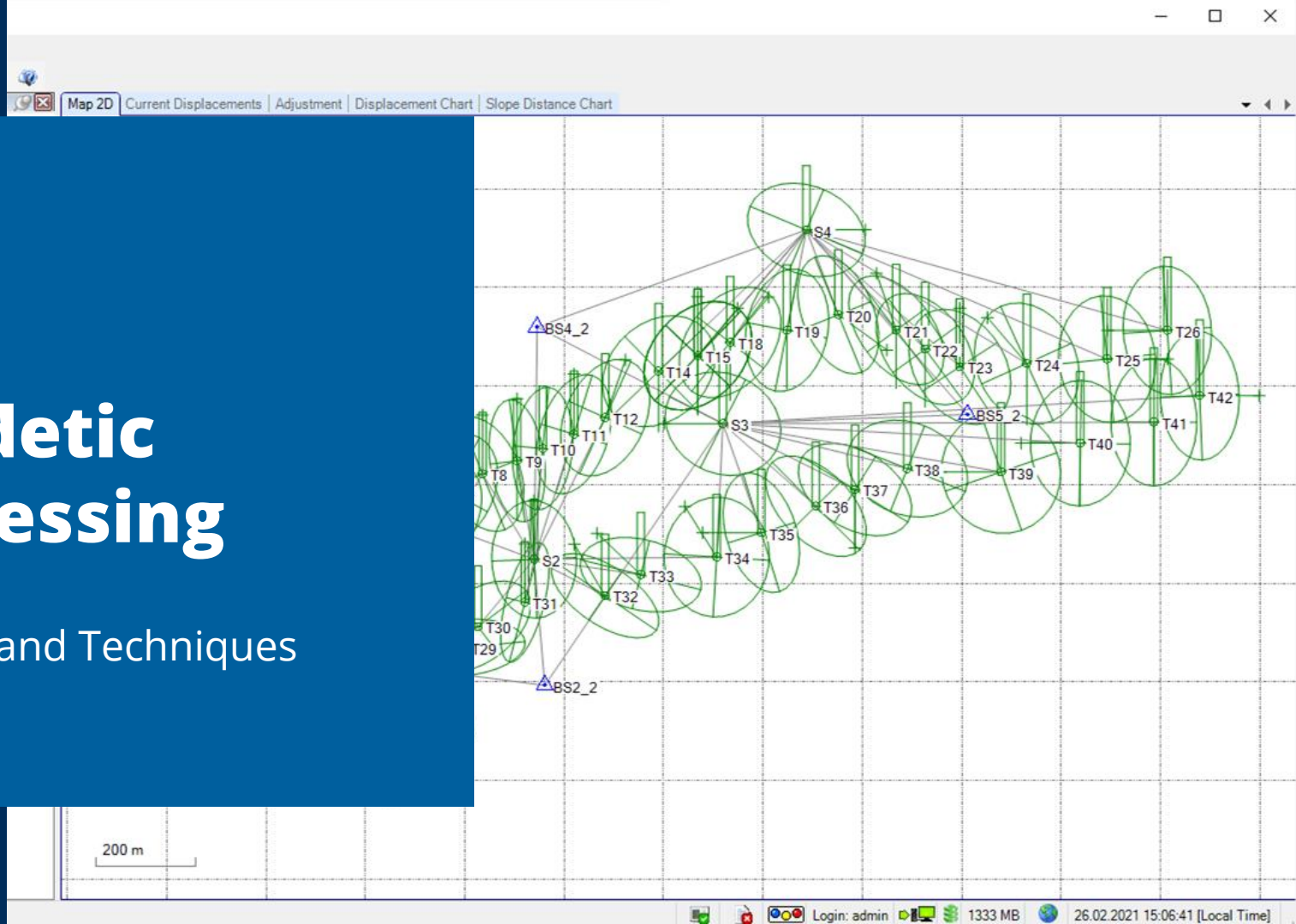


Resection - Total station positioned inside the deformation area and treated as a monitoring point. At least two control points used as backsight points.

3

Geodetic Processing

Settings and Techniques



Coordinate System Support

By including the Trimble Coordinate System Manager T4D provides full flexibility to establish your monitoring project in the coordinate system of choice.

Coordinate System and Zone

The Trimble Coordinate System Manager provides access to a geodetic database that contains defined grid coordinate systems worldwide. This should be your choice, if your control point coordinates are available in a certain coordinate system.

Calibrated Site

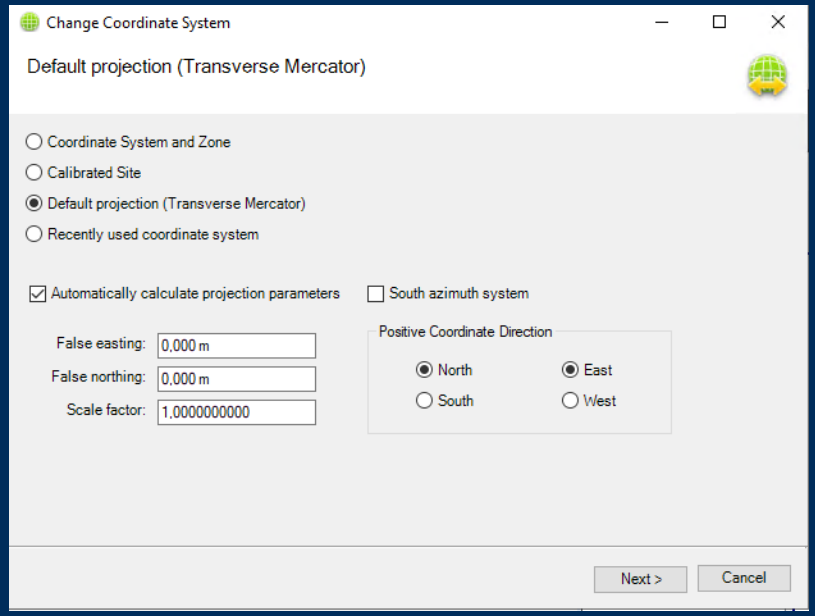
A coordinate system is designed to apply over a large area and does not provide for variations that occur in local coordinates. If you apply the extra correction transformations, you can correct for the local variations and do new work that fits with the existing control.

Default projection (Transverse Mercator)

For monitoring purposes, often pure local coordinate systems are used instead of a global projection system. These systems are purely local in the sense that no geocentric reference is given. You can freely define origin, scale and false easting/northing of a local coordinate system.

Scale Factor

- Used if a tension exists between the measurements and the reference coordinates provided for the site
- Scale factor is applied to the measured distances for the determination of displacements and residuals
- Default value of a default/local coordinate system is 1→ this implies that there is no tension in your coordinates; no scale applied



Quality of control point geometry

Vital factor for a reliable monitoring system

- The quality of the station setup decreases if the line of sight to a control point is blocked
- Bad geometry leads to jumps in prism displacement although no physical movement happened
- The **Horizontal DOP (Dilution Of Precision)** is a statistical value and a good measure of the horizontal quality of the geometry of a station setup
- Reject rounds and trigger alarms if round results in insufficient HDOP values

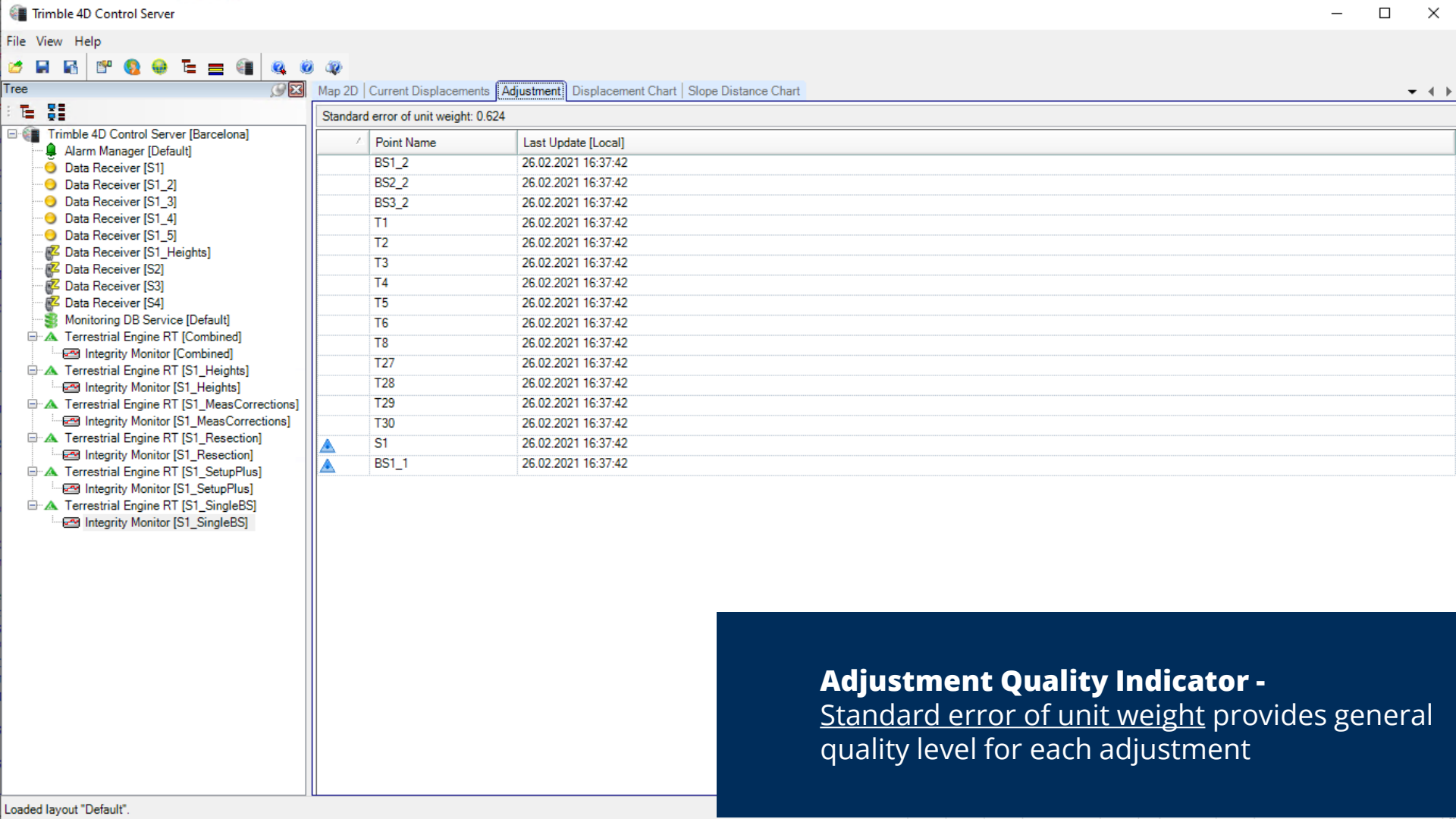
HDOP ratings

Selection	HDOP thresholds
None	Triggering an event is disabled.
Excellent	HDOP is < or = 2.
Good	HDOP is > 2, but < or = 5.
Moderate	HDOP is > 5, but < or = 10.
Fair	HDOP is > 10, but < or = 20.
Poor	HDOP is > 20.
Custom	The lower threshold (that is, the threshold to be exceeded for an event to be triggered) depends on additional user defined settings.

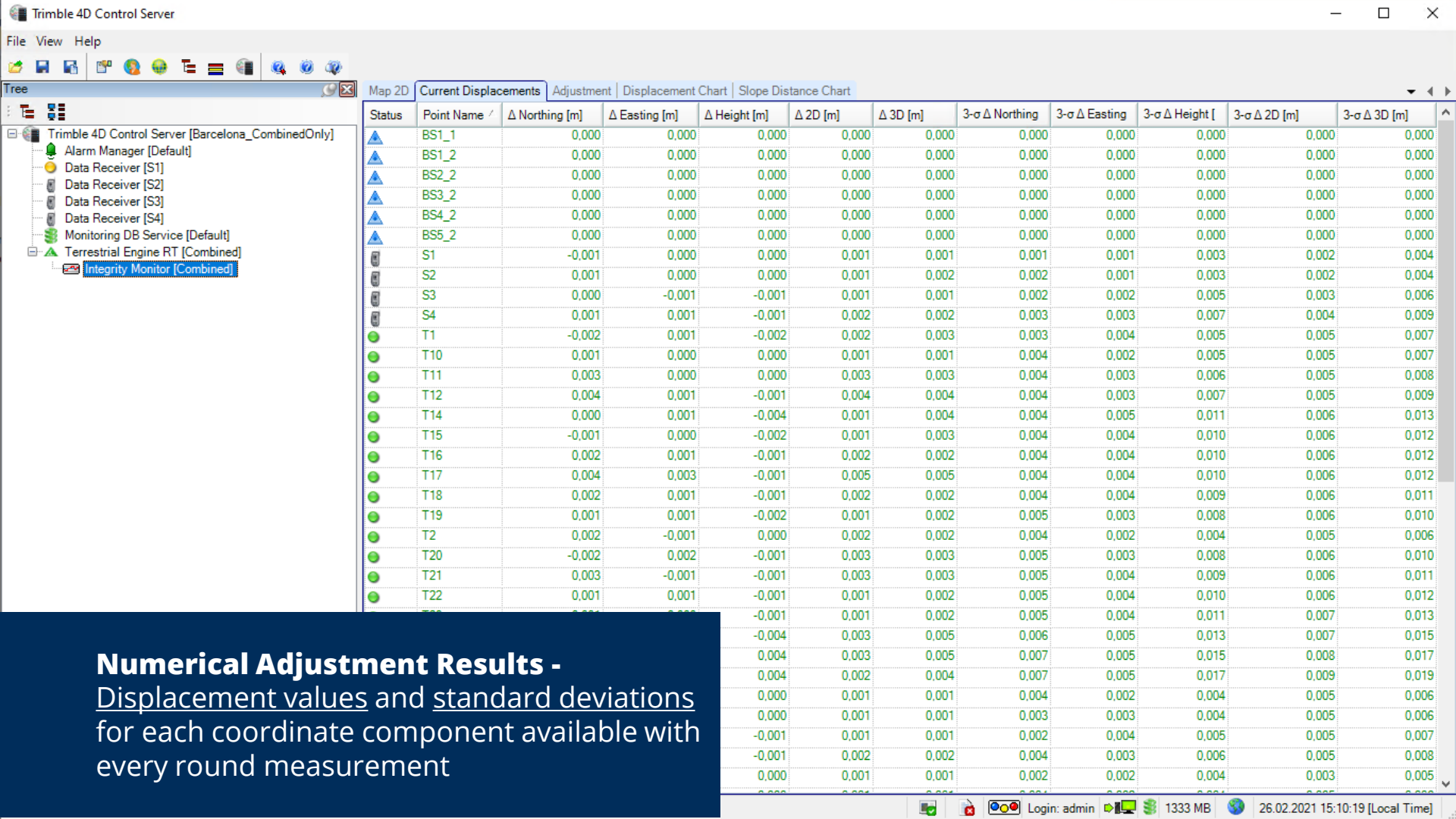
Least Square Adjustment

The adjustment functionality is most important in a deformation analysis environment. T4D performs least square adjustments of your total station observations and/or of your network of processed GNSS baselines.

- **Blunders and systematic errors in the observations are detected.**
- **It is ensured remaining small and random errors are minimized and properly distributed.**
- **Adjusted coordinates for all points and/or stations in the network are determined.**
- **Information for analysis, including estimates of precision values, are generated.**
- **The reliability of your current and future measurements is ensured.**



Adjustment Quality Indicator -
Standard error of unit weight provides general quality level for each adjustment



Numerical Adjustment Results -
Displacement values and standard deviations for each coordinate component available with every round measurement

4

Environmental Factors

Atmospheric and measurement corrections

Weather Conditions

Fixed/static values → Software setting!

Weather condition values are respected when calculating positions

Temperature

- Temperature can be specified; Default 20°C
- Only used if no external temperature sensor is available (next slides)

Refraction coefficient

- Weather-dependent
- For slope reduction
- Values between 1 and -1; Default: 0.142
- A value of zero (0) represents no refraction coefficient

Air pressure

- Values are continuously fed in from the built-in barometer of the total station

Meteorological Sensor

Dynamic values
→ Extracted from data stream

An alternative source of temperature (and pressure) values

- External sensor that is optionally configurable
- If not configured → Fixed values are used for processing (weather condition settings)
- If configured → external sensor provides temperature or temperature and pressure
- Information is used to correct the total station measurements
- Maximum age of data can be specified; if outdated fixed values are used instead

Information applied when using a Settop M1
(a meteorological sensor must not be configured and weather condition settings are not taken into account):

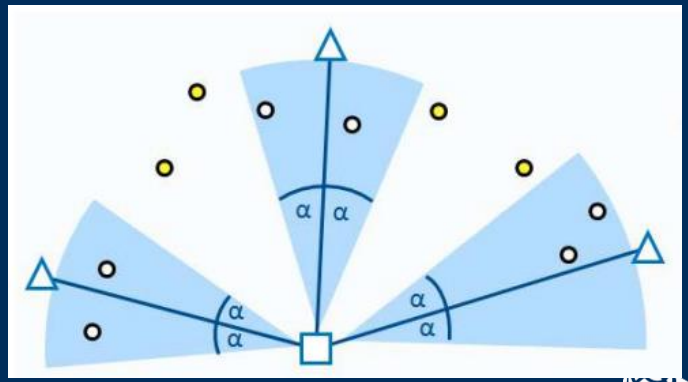
- Temperature → coming from temperature sensor of Settop M1
- Pressure → delivered by barometer of total station

Measurement Corrections

If configured applied <u>on top</u> of distance ppm and refraction corrections based on atmospheric information!

Minimize negative atmospheric influences to total station measurements

- Corrections applied from concurrent comparison measurements to reference targets
- Point with the minimum difference in horizontal direction to the monitored point automatically chosen as reference target
- T4D compares the calculated with the measured value. The difference of these values is transferred to a correction applied to the measured values of the monitored points
- Corrections are calculated for either the distance (**distance ppm correction**) and/or the vertical angle (**vertical refraction correction**) of a monitored point
- Configurable:
  - Maximum angle difference to a reference point
  - Decrease vertical angle corrections
  - Maximum coverage distance



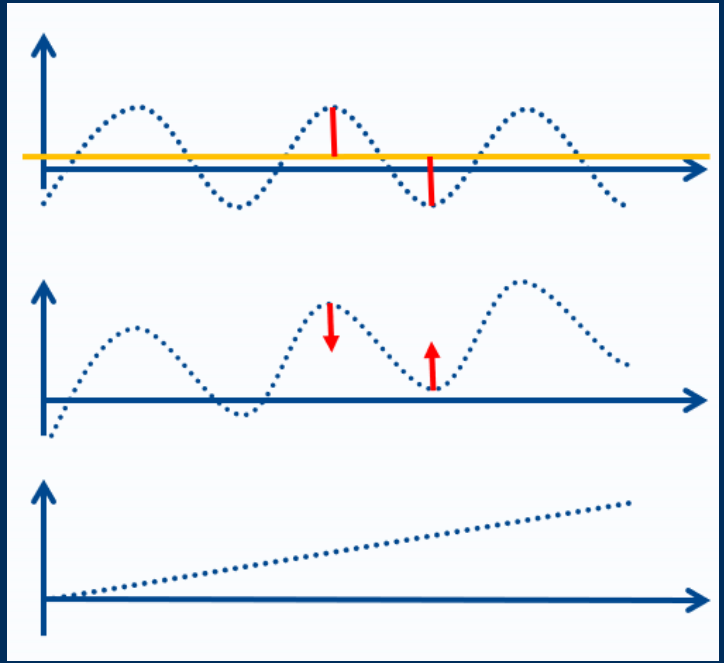
Measurement Corrections

An example how it works → correct for daily variations

1. Control point: calculated distance or vertical angle difference

2. Monitoring Point applied correction

1. Corrected monitoring point



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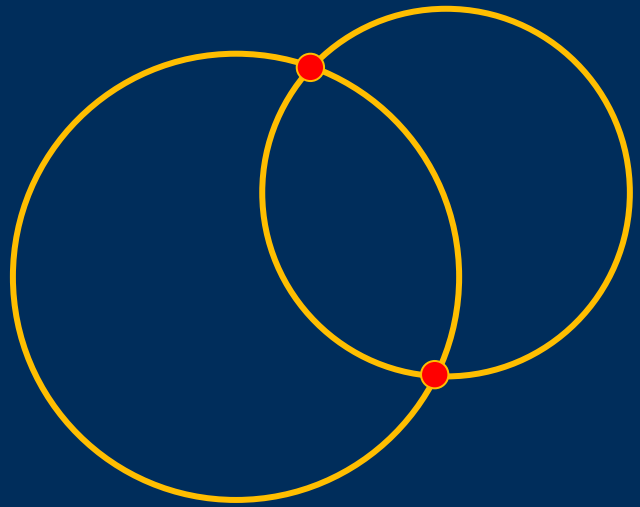
Case Studies

Out of experience

Situation- Resection with Minimal Backsights

Measurement and adjustment redundancy

- Minimum number of backsights for resection is two
  - Mathematical minimum, but not a recommended minimum
- Missed backsight causes either:
  - Observed changes to displacements
  - Failed measurements

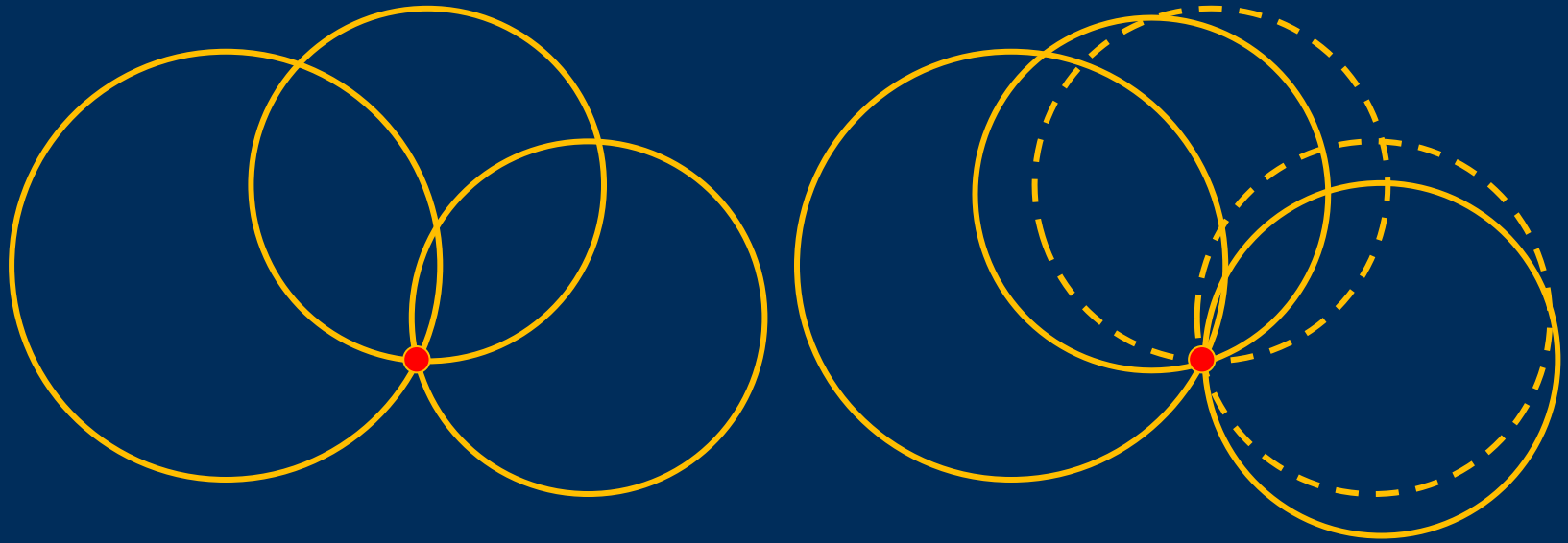


Situation- Moving Backsight

Slight change to measurement or backsight location

Situation- Moving Backsight

Compare to setup with three backsights

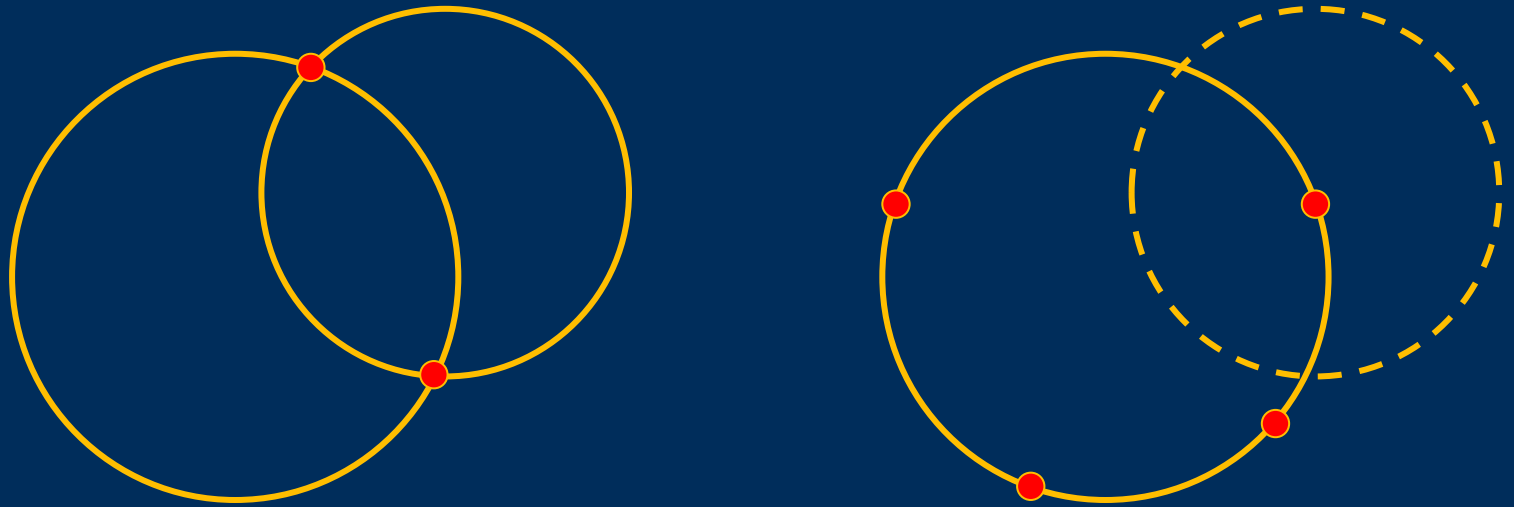


Situation- Missed Backsight

Three to Two Backsights

Situation- Missed Backsight

Two to One Backsight



Bad Station Setup - Only 1 Control Point

Changes of the control point causes displacements in all monitoring points: