

Trimble Access™ Tunnels

User Guide

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Introduction

Trimble® Tunnels software is specifically designed for surveying in tunnels. It provides tools to define, survey, stakeout, and report on tunnel operations and guides you through tasks such as marking areas of underbreak and overbreak, and positioning machinery.

Use Tunnels to:


- Define your tunnel
 - Define tunnel components including horizontal and vertical alignments, templates, and rotation, or import a definition from a LandXML file.
 - Define end-face blast holes and set out positions typically used for bolt holes or for stabilizing pipe umbrellas.
 - Review the tunnel before going underground.
- Survey your tunnel
 - Auto scan cross sections including options to manually measure and delete points.
 - Measure positions relative to the tunnel definition.
 - Set out predefined positions for blast holes, bolt holes, and pipes.
 - Position machinery, typically a drilling rig, relative to the tunnel.
- Output and reports
 - Review auto scanned and manually measured points.
 - Review set out points.

Using Tunnels

To use Tunnels, you must switch to the Tunnels app. To switch between applications, tap  and tap the name of the app you are currently using, and then select the application to switch to.

TIP – The Tunnels app includes the full **Cogo** menu from General Survey so that you can carry out coordinate geometry (cogo) functions without having to switch to General Survey. You can also access some of these cogo functions from the tap and hold menu in the map. For information on all available cogo functions, refer to the *Trimble Access General Survey User Guide*.

When starting a survey you are prompted to select the survey style you have configured for your equipment. To learn more about survey styles and related connection settings refer to the appropriate topics in the *Trimble Access Help*.

To define and survey the tunnel using the term 'chainage' rather than 'station' for the distance along the tunnel, tap  and select **Settings / Language** and then select the **Use chainage distance terminology** check box.

TXL files




A tunnel file is a TXL file. TXL files typically contain a horizontal and vertical alignment along with templates that define the shape of the tunnel.


TXL files that you create by keying in the definition using Trimble Access Tunnels are automatically shown in the map once they are created.



If you are using a TXL file created in Trimble Business Center or that you have converted from a LandXML file, you may need to open the **Layer manager** and select the file to display it.

The tunnel file must be in the current project folder.

Viewing TXL files in the map

To display a TXL file in the map, tap  in the map toolbar to open the **Layer manager** and select the **Map files** tab. Tap the TXL file once to make it visible (), and tap it again to make items in the file selectable ().

To change the labels shown in the map, for example to view alignment station values, tap  and select **Settings** and then modify the options in the **Display** group box.

To rotate the alignment, tap  and then tap the map and drag to rotate the view. The  icon in the center of the map indicates the point of orbit.

Working with TXL files

From the map, you can select items in TXL files and then use them in other software functions, for example to perform cogo functions, such as a surface inspection. For information on all available cogo functions, refer to the *Trimble Access General Survey User Guide*.

Converting LandXML files to TXL files

You can convert a LandXML file that defines a tunnel to a Trimble TXL file for use in the Tunnels software.

Before you start


Go to the [Software and utilities page](#) of the Trimble Field Systems Help Portal to download the **File and Report Generator** utility and install it to your office computer.

Go to the [Stylesheets page](#) of the Trimble Field Systems Help Portal to download the **LandXML To TunnelXML** stylesheet and save it to a folder on your office computer.

To convert a LandXML file to a txl file

1. On the office computer, select **Start / Programs / File and Report Generator** to start the **File and Report Generator** utility.
2. From the **Source JobXML or Job file** field, select **Browse**. Set the **File of type** field to **All files**. Browse to the appropriate folder and then select the LandXML file to convert.
3. From the **Output format** field, select the **LandXML To TunnelXML** stylesheet. Click **OK**.
4. From the **User Value Input** screen, select the tunnel surface to be converted. Click **OK**.
5. Confirm the **Save in** folder and **File name** for the txl file and then select **Save**.
6. When done, select **Close**.
7. Transfer the TXL file to the controller.

Coordinate systems in Tunnels

The Tunnels software treats all tunnel distances, including station and offset values, as grid distances. The value in the **Distances** field in the **Cogo settings** screen has no effect on the tunnel definition or the way tunnel distances are displayed. To view the **Cogo settings** screen, tap  and select **Settings / Units Cogo / Cogo Settings**).





If a ground coordinate system is defined in the job, the grid coordinates are, in effect, also ground coordinates.

Plan and cross section view

During auto-scan, set out, machine positioning or when measuring a position in the tunnel, the plan view or cross section view of the tunnel appear alongside the map.



If available, the instrument video view is available instead of the map so that you can see where the instrument is pointing. In split screen view:

- To fine-tune the position of the instrument, use the **Zoom level** tool in the **Video** screen to zoom in and then press the up, down, left or right arrow keys on the controller keypad to move the instrument. The arrow keys do not move the instrument during scanning.

- When the map is shown, use the left or right arrow keys to increment points and the up or down arrow keys to increment stations.
- To switch to the map view, tap  in the video toolbar. To switch to the video view, tap  in the map toolbar.
- To view more softkeys, tap  or swipe right to left (or left to right) along the row of softkeys.
- To make the map/video view or the plan/cross section view larger, tap  and swipe across the screen.

Delta display

Information on the current position and, if applicable, its relationship to the selected set out position appears below the plan view or cross section view. For more information on available deltas, see [Current position information, page 82](#).

To change the position of the delta display area, tap  and swipe left. The plan or cross section view resizes to the closest preset position, so that the delta display area is positioned alongside the plan or cross section view, rather than below. Tap  and swipe right to make the plan or cross section view smaller with the delta display area below.

Plan view

The plan view of the tunnel appears when you first select the tunnel.

Tunnel element	Indicated by
Horizontal alignment	Black line
Offset alignment (where applicable)	Green line
Current station	Red circle
Selected stations	Solid blue circle
Instrument position	Solid black circle
Direction instrument is pointing	Dashed red line

NOTE – Stations shown grayed out have no vertical alignment or no template assigned and cannot be selected for scanning.

To select a station to measure:

- Tap the up or down arrow on the controller keypad (not available if the video view is shown alongside the plan view).
- Tap an individual station.

- Tap and hold on the screen and then tap **Select a station**. Select the station from the list in the **Select a station** screen.

The selected station appears as a red circle.


To deselect the point, tap elsewhere on the screen. Alternatively, tap and hold on the screen and then select **Clear selection**.

To add a station that is not defined by the station interval, tap and hold on the screen and then select **Add station**.

Tap and hold on a position on the alignment or offset alignment to view more information about the position.

To calculate grid and tunnel coordinates to confirm the definition before surveying the tunnel, tap **Calc**.

To pan around the screen, tap the **Pan** softkey and then press an arrow key.

To switch to the cross section view, tap .

Cross section view


To view a pop-up window showing information including (where applicable), horizontal and vertical offsets, northing, easting, elevation, surface name, and code information for an item, tap any of the following:

Item	Shown as
Alignment	Red cross
Offset alignment	Smaller green cross
Pivot position	Circular green icon
Design points	Blue circles
Vertex point	Short green line
Blast hole set out point	A hollow black circle
Pipe set out point	A hollow black circle with a dot inside it
Any other set out point	A hollow black circle with a line defined by the origin of the position

Tap and hold on the alignment, offset alignment, design point, set out point, or vertex point to view its horizontal and vertical offsets, northing, easting, elevation, surface name, and code.












To view a station to scan from the cross section view, tap and hold on the screen and then select **Scan current station**.



To review other stations during scanning, tap the up/down arrows to view the next/previous station. The station being scanned is indicated in the top left of the screen. The station being viewed is indicated at the top center of the screen.

To switch to the plan view, tap .

Icons that appear in the plan and cross section view during a survey

The icons that appear when surveying a tunnel are shown below.

Icon	In plan view	In cross section view
	Station available for selection	–
	Station unavailable for selection	–
	Selected station (Auto scan)	–
	Scanned station within tolerance	Scanned position within tolerance
	Scanned station with positions outside of tolerance	Scanned position outside of tolerance
	Current station	–
	High-power laser pointer active	High-power laser pointer active
	–	Stored set out position
	–	Alignment axis
	–	Offset alignment axis / Rotated alignment axis
	–	Current position

Icon	In plan view	In cross section view
	–	The tunnel profile is displayed in the direction of increasing station.
	–	The tunnel profile is displayed in the direction of decreasing station.

Tunnel definition

When defining a tunnel, you create a TXL file and then key in tunnel components from construction drawings and plans to complete the tunnel definition.

The tunnel definition must include the horizontal alignment, vertical alignment, templates, and template positions. Other elements are optional.

- The **horizontal alignment** defines a line that runs along the center of the tunnel.
- The **vertical alignment** defines the changes in the elevation of the tunnel.
- The **template** defines a cross section of the tunnel at a point across the tunnel to define how wide it is at different points.

Add a template for each change in width. The template may consist of any number of surfaces.

- Add **template positions** to assign the appropriate template at different points along the tunnel.
- Add **rotation** to tilt or rotate a tunnel template and the associated set out positions around an origin point.

Rotation is mainly used around a horizontal curve to represent superelevation. However, it can be used anywhere in the tunnel alignment provided that there is a valid horizontal alignment, vertical alignment, and template assigned.

- Add **set out positions** to pre-define blast holes, bolt holes, or pipe insertion points to be set out in the tunnel.
- **Station equations** define station values for an alignment.
- **Alignment offsets** offset the horizontal and/or vertical alignment, typically for carriage clearance around curves in a rail tunnel. See [Alignment offsets, page 48](#).


Keyed in tunnels are saved to the current project folder as TXL files.

To define the tunnel

To define a new tunnel, you can key in the definition or in the map select points, lines, arcs, or polylines in the job or in DXF, STR, SHP, or LandXML files and then create the tunnel from the selected items.

Once a tunnel is defined, you can edit it as required.

To key in the tunnel definition


1. Tap  and select **Define**.
2. Tap **New**.
3. Enter a name for the tunnel.
4. To define a new tunnel from an existing tunnel definition, enable the **Copy existing tunnel** switch and then select the file to copy from. The file must be in the current project folder.
5. Select the method you will use to key in each component.
 - a. To define the **horizontal alignment** you can use the:
 - [Length or coordinate entry method, page 13](#)
 - [End station entry method, page 15](#)
 - [Points of intersection \(PI\) entry method, page 16](#)
 - b. Select the transition type. See [Transition types, page 16](#).
 - c. To define the **vertical alignment** you can use the:
 - [Vertical points of intersection \(VPI\) entry method, page 25](#)
 - [Start and end point entry method, page 25](#)
6. Tap **Accept**.


The list of components that can be defined for the tunnel appears.

TIP – To change the entry method or the transition type for the road, tap **Options**. However, once you have entered two or more elements defining the horizontal or vertical alignment definition, the entry method and transition type cannot be changed.

7. Select each component and define it as required.
8. To save your changes at any time, tap **Store**

To define the tunnel from the map

1. If the items you want to select are not visible in the map, tap  in the map toolbar to open the **Layer manager** and select the **Map files** tab. Select the file and then make the appropriate layer(s) visible and selectable.
2. In the map, tap the items that will define the horizontal alignment.
 The order in which items are selected and the direction of the lines, arcs, or polylines defines the direction of the horizontal alignment.
 If the items have elevations, then the elevations are used to define the vertical alignment.
3. Tap and hold in the map and select **Store tunnel**.
4. Enter the tunnel name, start station, and station interval.
5. Tap **OK**.

To add other components such as templates and set out positions to the new tunnel, tap  and select **Define**. See [To key in the tunnel definition, page 11](#).

To key in the horizontal alignment

Use the steps below to key in the horizontal alignment for the selected tunnel. To define the horizontal alignment by selecting items from the map, see [To define the tunnel from the map, page 11](#).

1. Tap **Horizontal alignment**.
2. Tap **New**.
The **Element** field is set to **Start point**.
3. To define the start point:
 - a. Enter the **Start station**.
 - b. In the **Method** field, select:
 - **Key in coordinates** and then enter values in the **Start north** and **Start east** fields.
 - **Select point** and then enter the **Point name**.
The **Start north** and **Start east** fields will update with the values for the entered point.
To edit the **Start north** and **Start east** values when they have been derived from a point, change the method to **Key in coordinates**.
 - c. Enter the **Station interval**.
 - d. Tap **Store**.
The start point appears in the graphical view.
4. To add elements to the alignment:
 - a. Tap **New**.
 - b. Select the **Element** type and fill out the remaining fields.
For more information, refer to the topic for the selected entry method.
 - c. Tap **Store**.
The element appears in the [graphical view](#).
 - d. Continue adding elements as required.
Each element is added after the previous element. To insert it at a particular place, highlight the element in the graphical view that you want it to follow and tap **New**.
5. When you are done, tap **Accept**.
6. Enter the other tunnel components, or tap **Store** to store the tunnel definition.

Length or coordinate entry method

As you add each element to the alignment, fill out the fields required for the selected element type.

Line elements

To add a line to the alignment, select **Line** in the **Element** field and then select the method to construct the line:

If you select...	Then...
Azimuth and length	Enter the Azimuth and Length to define the line. The End north and End east fields automatically update.
End coordinates	Enter the End north and End east values to define the line. The Azimuth and Length fields automatically update.
Select end point	Enter the Point name . The Azimuth , Length , End north and End east fields automatically update.

NOTE – If this line is not the first line to be defined, the **Azimuth** field displays an azimuth calculated from the previous element.

To edit the azimuth, tap ► next to the **Azimuth** field and select **Edit azimuth**. If the element is non tangential the icon at the start of the element is shown in red.

Arc elements

To add an arc to the alignment, select **Arc** in the **Element** field and then select the method to construct the arc:

If you select...	Then...
Radius and length	Select the arc direction. Enter the Radius and Length to define the arc. The End north and End east fields automatically update.
Delta angle and radius	Select the arc direction. Enter the Angle and Radius to define the arc. The End north and End east fields automatically update.
Deflection angle and length	Select the arc direction. Enter the Angle and Length to define the arc. The End north and End east fields automatically update.
End coordinates	Enter the End north and End east values to define the arc. The Arc direction , Radius , and Length fields automatically update.

If you select...	Then...
Select end point	Enter the Point name . The Azimuth , Length , End north and End east fields automatically update.
End coordinates and center point	Enter the End north , End east , Center point north and Center point east values to define the arc. If required, select Large arc . The Azimuth , Arc direction , Radius , and Length fields automatically update.
Select end and center points	Enter the End point name and Center point name values to define the arc. If required, select Large arc . The Azimuth , Arc direction , Radius , and Length , End north and End east fields update with the values entered.

NOTE – For an arc defined by **Radius and length**, **Delta angle and radius** or **Deflection angle and length**, the **Azimuth** field shows the azimuth as calculated from the previous element. If the element is non tangential the icon at the start of the element is shown in red. To reload the original azimuth, tap ► next to the **Azimuth** field and select **Restore tangency**.

Entry transition/exit transition elements

To add a transition to the alignment:

1. Select **Entry transition** or **Exit transition** in the **Element** field.
2. Select the arc direction.
3. Enter the **Start radius**, **End radius** and **Length** to define the transition.

The **End North** and **End East** fields update automatically.

NOTE – For more information on supported transition types, see [Transitions](#).

The **Azimuth** field displays the azimuth as calculated from the previous element. To edit the azimuth, tap ► next to the **Azimuth** field and select **Edit azimuth**. If the element is non tangential the icon at the start of the element is shown in red.

If the transition type is NSW cubic parabola the computed **Transistion Xc** value is displayed. If the transition is between two arcs the **Transistion Xc** displayed is the value computed for the common tangent point with the smaller of the two arcs.

End station entry method

As you add each element to the alignment, fill out the fields required for the selected element type.

Line elements

To add a line to the alignment:

1. Select **Line** in the **Element** field.
2. Enter the **Azimuth** and **End station** to define the line.
The **End North** and **End East** fields update automatically.

NOTE – If this line is not the first line to be defined, the **Azimuth** field displays an azimuth calculated from the previous element.

To edit the azimuth, tap ► next to the **Azimuth** field and select **Edit azimuth**. A solid red circle is shown at the start of an element if adjoining elements are non tangential.

Arc elements

To add an arc to the alignment, select **Arc** in the **Element** field and then select the method to construct the arc:

If you select...	Then...
Radius and end station	Select the arc direction. Enter the Radius and End station to define the arc.
Deflection angle and end station	Select the arc direction. Enter the Angle and End station to define the arc.

The **End North** and **End East** fields automatically update.

NOTE – The **Azimuth** field displays the azimuth as calculated from the previous element.

To edit the azimuth, tap ► next to the **Azimuth** field and select **Edit azimuth**. The icon preceding the element name is shown red if adjoining elements are non tangential or if adjoining elements defining a curve have different radii.

Entry transition/exit transition elements

To add a transition to the alignment:

1. Select **Entry transition** or **Exit transition** in the **Element** field.
2. Select the arc direction.

3. Enter the **Start radius**, **End radius** and **Length** to define the transition.

The **End North** and **End East** fields update automatically.

NOTE – For more information on supported transition types, see [Transitions](#).

The **Azimuth** field displays the azimuth as calculated from the previous element. To edit the azimuth, tap ► next to the **Azimuth** field and select **Edit azimuth**. If the element is non tangential the icon at the start of the element is shown in red.

If the transition type is NSW cubic parabola the computed **Transistion Xc** value is displayed. If the transition is between two arcs the **Transistion Xc** displayed is the value computed for the common tangent point with the smaller of the two arcs.

Points of intersection (PI) entry method

As you add each element to the alignment, fill out the fields required for the selected element type.

1. Define the points of intersection.
2. Select the **Curve type**. If you select:
 - **Circular**, enter the **Radius** and **Arc length**.
 - **Transition | Arc | Transition**, enter the **Radius**, **Arc length**, **Transition length in** and **Transition length out**.
 - **Transition | Transition**, enter the **Radius**, **Transition length in** and **Transition length out**.
 - **None**, no further values are required.
3. Tap **Store**.

Transition types

The software supports the following transition types.

Method	Length	End station	PI
Clothoid spiral	*	*	*
Egg-shaped clothoid spiral	*	*	–
Cubic spiral	*	*	*
Bloss spiral	*	*	*
Korean cubic parabola	*	*	*
NSW cubic parabola	*	*	–

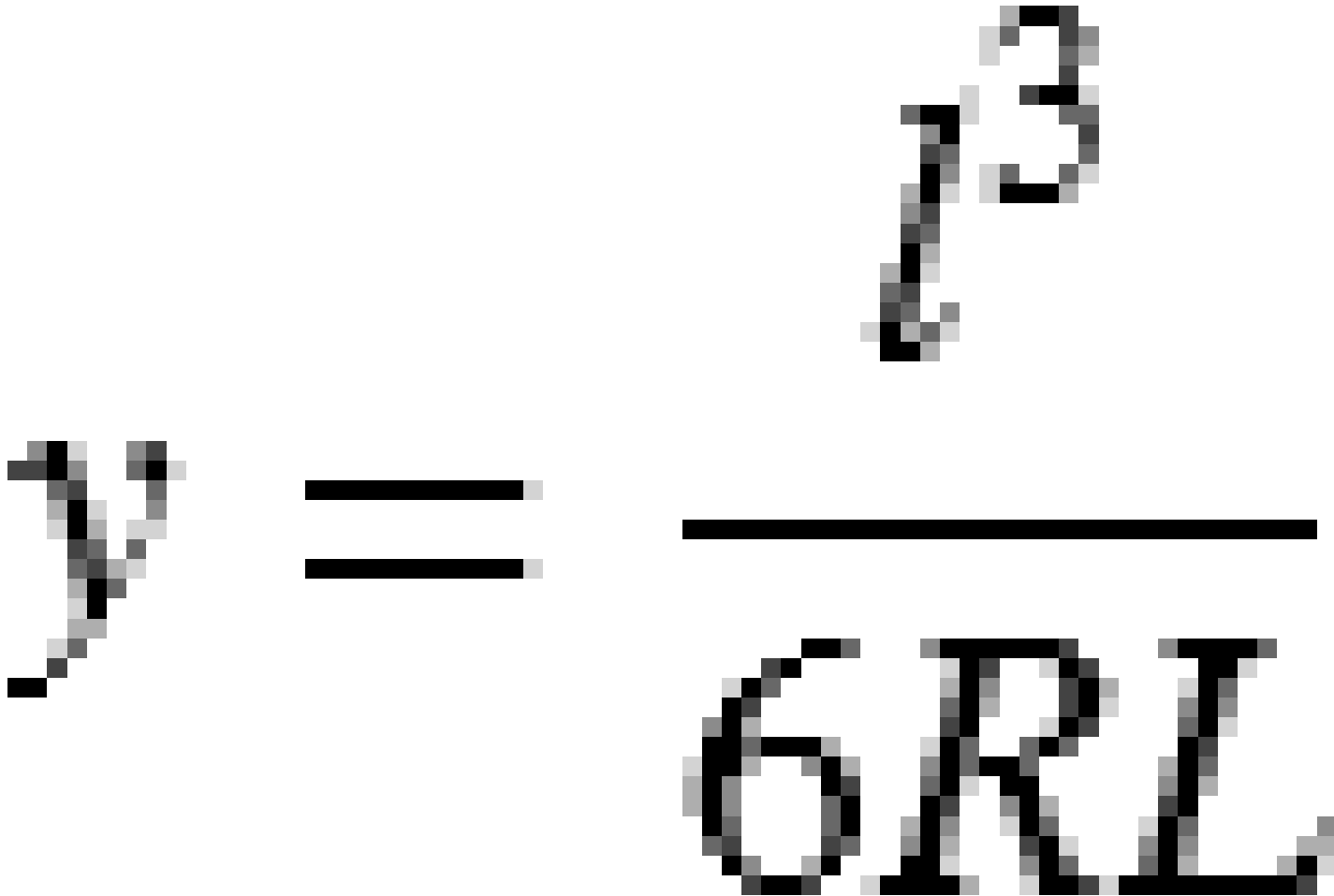
Clothoid spiral

The clothoid spiral is defined by the length of the spiral and the radius of the adjoining arc. The formulae for the **x** and **y** parameters in terms of these two values are as follows:

Parameter **x**:

$$x = \frac{L^2}{24R}$$

Parameter **y**:



Egg-shaped clothoid spiral

By editing the **Start / End radius** for an **Entry / Exit transition** from **Infinite** to a required radius it is possible to define an egg shaped clothoid. To return to an infinite radius, select **Infinite** from the pop-up menu.

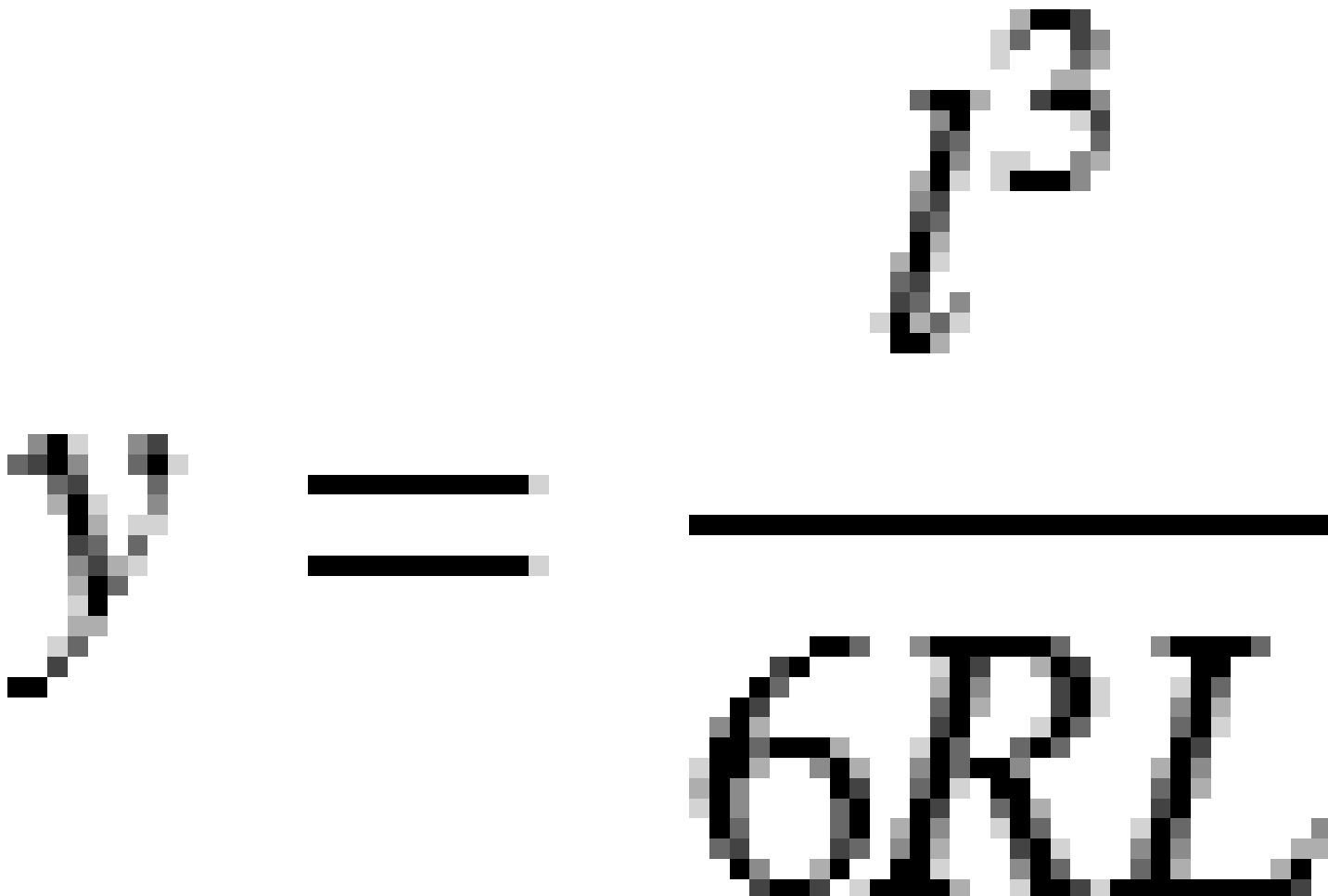
Cubic spiral

The cubic spiral is defined by the length of the spiral and the radius of the adjoining arc. The formulae for the **x** and **y** parameters in terms of these two values are as follows:

Parameter **x**:

$$x = \frac{L^3}{24R} + \frac{L^2}{2R} + \frac{L}{2R} + \frac{1}{24R}$$

Parameter **y**:

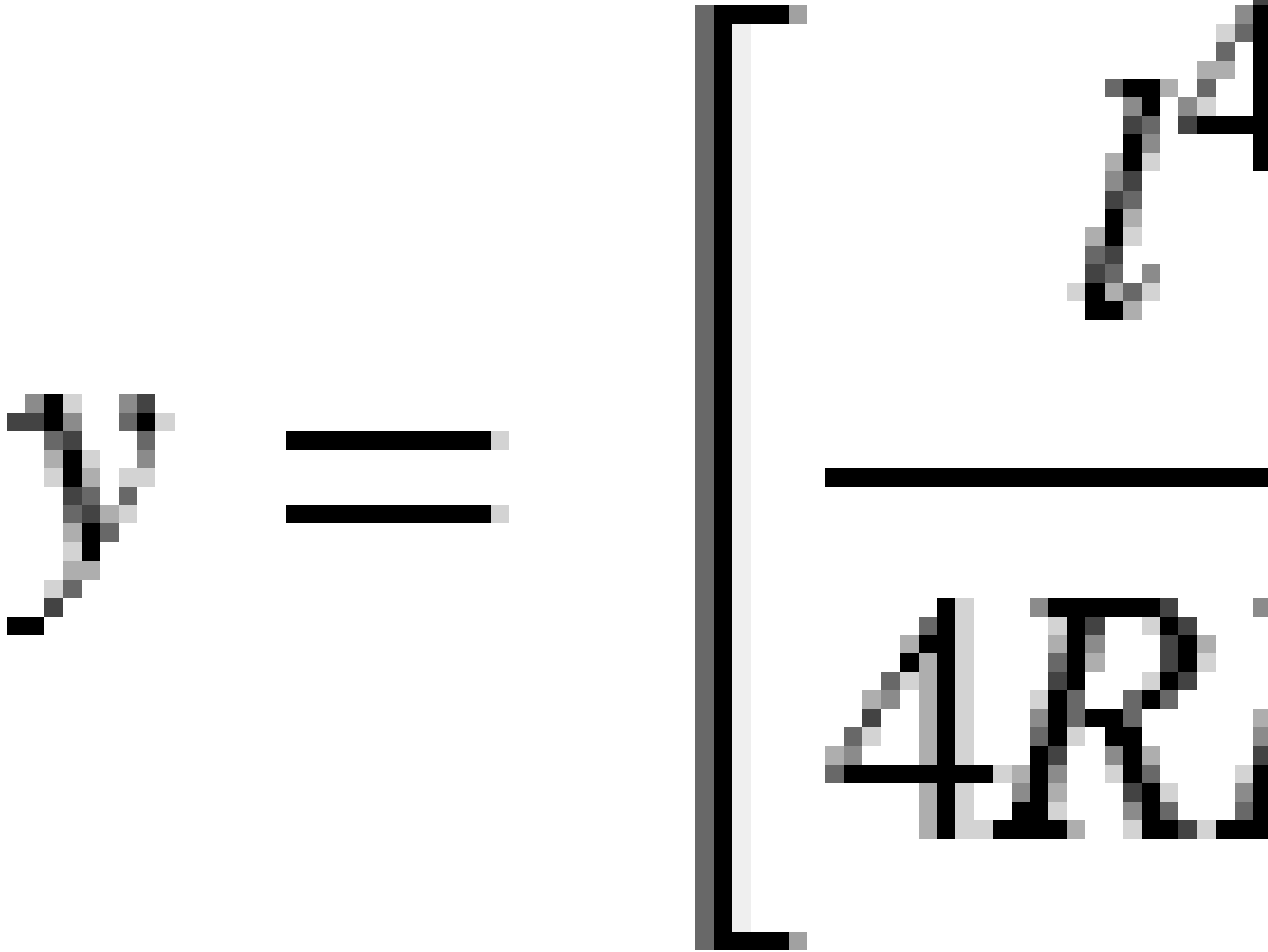


Bloss spiral

Parameter **x**:

$$x = l \left[1 - \frac{l^6}{14R^2L^4} + \frac{l^7}{16R^2L^5} - \frac{l^8}{72R^2L^6} + \frac{l^{12}}{312R^4L^8} - \frac{l^{13}}{168R^4L^9} + \frac{l^{14}}{240R^4L^{10}} - \frac{l^{15}}{768R^4L^{11}} + \frac{l^{16}}{6528R^4L^{12}} \right]$$

Parameter **y**:



NOTE – The Bloss spiral can only be fully developed, that is, for an entry transition the start radius is infinite and similarly for an exit transition the end radius is infinite.

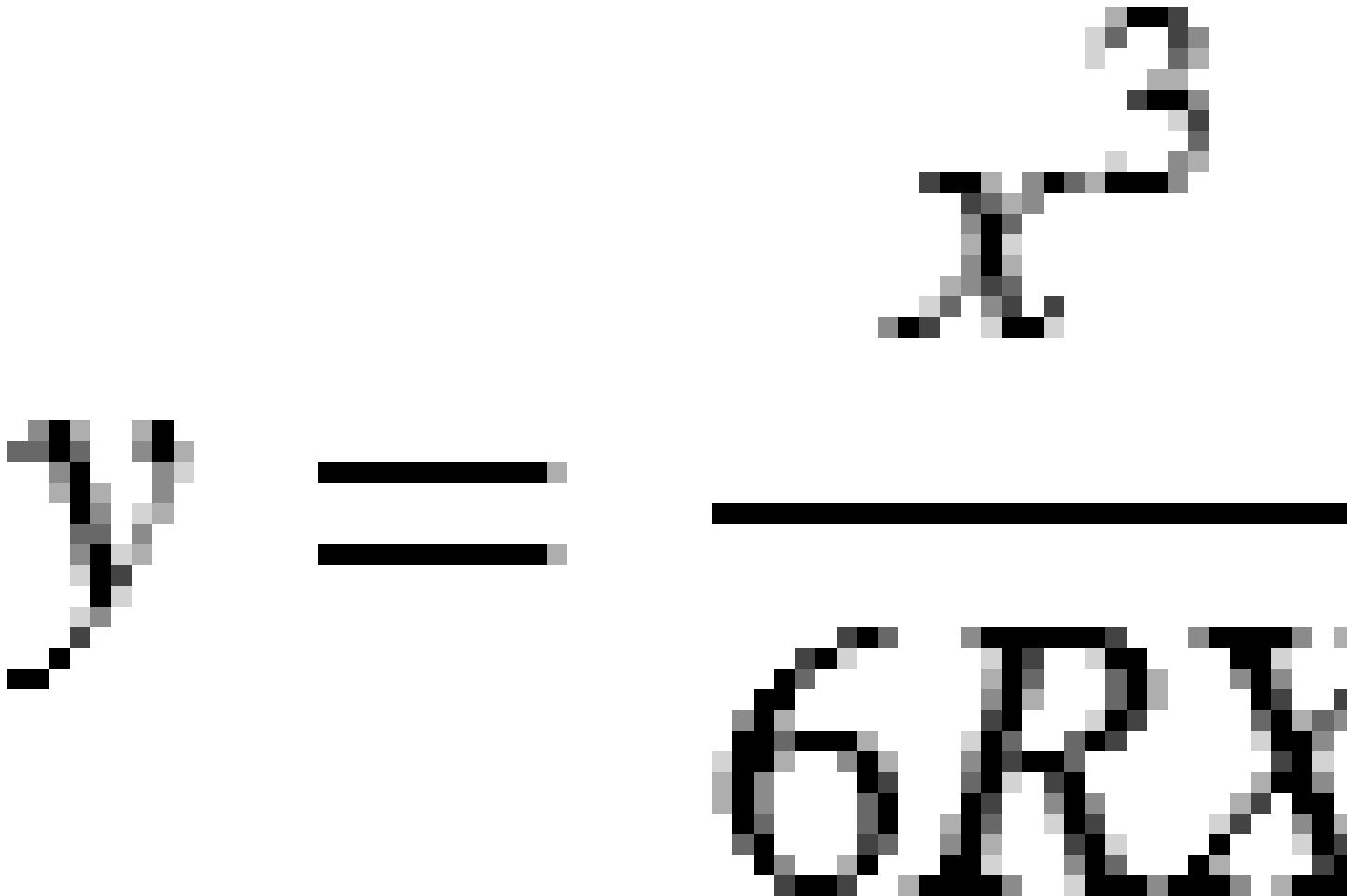
Korean cubic parabola

This cubic parabola is defined by the length of the parabola and the radius of the adjoining arc. The formulae for the **x** and **y** parameters in terms of these two values are as follows:

Parameter **x**:

$$x = \frac{L^2}{24R} \left[1 - \frac{L^2}{64R^2} \right]$$

Parameter **y**:



NOTE – The Korean cubic parabola can only be fully developed, that is, for an entry transition the start radius is infinite and similarly for an exit transition the end radius is infinite.

NSW cubic parabola

The NSW cubic parabola is a special parabola used for rail projects in New South Wales, Australia. It is defined by the length of the parabola and an **m** value. Refer to [NSW Government Technical Note ESC 210 Track Geometry and Stability](#).

To key in the vertical alignment

TIP – If you created the tunnel definition by selecting items in the map, the elevations of those items are used to define the vertical alignment as a series of **Point** elements. The vertical alignment can be edited if required.

To key in the vertical alignment for the selected tunnel:

1. Tap **Vertical alignment**.

2. Tap **Add**.

The **Element** field is set to **Start point**.

3. To define the start point:

- a. Enter the **Station (VPI)** and the **Elevation (VPI)**.
- b. To change the **Grade** units, tap **Options**.
- c. Tap **Store**.

4. To add elements to the alignment:

- a. Select the **Element** type and fill out the remaining fields.
For more information, refer to the topic for the selected entry method.
- b. Tap **Store**.
- c. Continue adding elements as required.
Each element is added after the previous element.
- d. When you are done, tap **Close**.

TIP – To edit an element or to insert an element further up the list, you must first tap **Close** to close the **Add element** screen. You can then select the element to edit in the list and then tap **Edit**. To insert an element, tap the element that will come after the new element and then tap **Insert**.

5. Tap **Accept**.

6. Enter the other tunnel components, or tap **Store** to store the tunnel definition.

Vertical points of intersection (VPI) entry method

To add an element to the alignment:

1. Select the **Element**. If you select:

- **Point**, enter the **Station** and **Elevation** to define the VPI.
- **Circular arc**, enter the **Station** and **Elevation** to define the VPI and enter the **Radius** of the circular arc.
- **Symmetric parabola**, enter the **Station** and **Elevation** to define the VPI and enter the **Length** of the parabola.
- **Asymmetric parabola**, enter the **Station** and **Elevation** to define the VPI and enter the **In length** and **Out length** of the parabola.

The **Slope in** field shows the calculated slope value.

The **Length**, **K factor** and **Slope out** fields update when the next element is added. The exact fields shown depend on the selected element.

2. Tap **Store**.

NOTE –

- A vertical alignment defined by VPIs must end with a point.
- When you edit an element, only the selected element is updated. All adjoining elements remain unchanged.

Start and end point entry method

1. Select the **Element**. If you select:

- **Point**, enter the **Station** and **Elevation** to define the start point.
- **Circular arc**, enter the **Start station**, **Start elevation**, **End station**, **End elevation** and **Radius** to define the circular arc.
- **Symmetric parabola**, enter the **Start station**, **Start elevation**, **End station**, **End elevation** and **K factor** to define the parabola.

The other fields show calculated values. Depending on the selected element, these may include **Length**, **Slope in**, **Slope out**, **K factor** and **Sag / Summit** values.

2. Tap **Store**.

NOTE – When you edit an element, only the selected element is updated. All adjoining elements remain unchanged.

To add templates

A template defines a cross section of the tunnel at a point across the tunnel to define how wide it is at different points. Add a template for each change in width. The template may consist of any number of surfaces.

NOTE – Templates must be defined in a clockwise direction. Surfaces can be open or closed.

To define a template for the selected tunnel definition:

1. Tap **Templates**.
 2. To add a new template:
 - a. Tap **Add**.
 - b. Enter the template name.
 - c. In the **Copy from** field, select whether to copy an existing definition from a tunnel or another template, into the template.
- TIP** – To create a template library, define a tunnel that only contains templates.
- d. Tap **Add**.
 3. To define a new surface:
 - a. Tap **Add**.
 - b. Enter the surface name.
 - c. In the **Copy from** field, select whether to define the surface by offsetting an existing surface.
 - d. Tap **Add**.
 4. To define the start point for the surface:
 - a. Tap **New**.
 - b. In the **Horizontal offset** and **Vertical offset** fields, enter the values that define the **Start point**.
 - c. Tap **Store**.

The element appears in the graphical view.

TIP – If you have started a survey, you can tap **Measure** to measure positions within a tunnel to define elements in a surface. If no surface elements have been defined, tap **Measure** to define the **Start point**. If the surface consists of one or more elements, tap **Measure** to define the end point of a line element.

5. To add further elements to the surface:
 - a. Tap **Add**.
 - b. Select the **Element** and enter the required information. The information required depends on the selected element:

[Line elements](#)

Arc elements

- c. Tap **Store**.

TIP – If you have started a survey, you can tap **Measure** to measure positions to define further elements in the surface.

6. Continue adding elements as required.
Each element is added after the selected element.
Use the **Start**, **Prev**, **Next** and **End** softkeys to view other elements in the template.
7. To save the template and return to the **Surfaces** screen, tap **Accept**.
8. Add or select a different surface to edit, or tap **Accept** to return to the list of templates.
9. Add or select a different template to edit, or tap **Accept** to return to the list of components for the selected tunnel definition.
10. Enter the other tunnel components, or tap **Store** to store the tunnel definition.

Line elements

To add a line to the template definition, select **Line** in the **Element** field and then select the method to construct the line.

If you select...	Then...
Cross slope and offset	Enter the Cross slope and Offset values to define the line. To change the way a cross slope value is expressed, tap Options and then change the Grade field as required.
Delta elevation and offset	Enter the Delta elevation and Offset values to define the line.
End point	Enter the Horizontal offset and Vertical offset values to define the end point of the line.

Arc elements

To add an arc to the template definition, select **Arc** in the **Element** field and then select the method to construct the arc.

If you select...	Then...
End point and Radius	<p>Enter the Horizontal offset and Vertical offset values to define the end point of the arc. Enter the Radius. Select Large arc, if required.</p> <p>By default the arc is created in a clockwise direction between the start and end point. To change the direction of the arc to anti-clockwise, select the Inverted check box.</p>
Alignment and Delta angle	<p>Enter the Delta angle for the arc. The center point for the arc is defined by the horizontal and vertical alignments.</p>
Center point and delta angle	<p>Enter the Horizontal offset and Vertical offset values to define the center point of the arc. Enter the Delta angle for the arc.</p> <p>By default the arc is created in a clockwise direction between the start and end point. To change the direction of the arc to anti-clockwise, select the Inverted check box.</p>

To add template positions

After adding templates, you must specify the station at which the Tunnels software starts to apply each template. For more information on how the software does this, see [Template application, page 33](#).

1. Select **Template positioning**.
2. To specify a new position at which template(s) should be applied:
 - a. Tap **Add**.
 - b. Enter the **Start station**.
 - c. In the **Template** field, select the template to use. To create a gap in the tunnel definition, select **None**.
 - d. Select the surface from the selected template you want to use.
 - e. Tap **Store**.
3. Continue adding positions where templates should be applied, as required.
4. Tap **Options** to specify if the templates are applied **Vertical** or **Perpendicular** to the vertical alignment.
5. When you are done, tap **Close**.
6. Tap **Accept**.
7. Enter the other tunnel components, or tap **Store** to store the tunnel definition.

To add rotation

To define rotation for the selected tunnel definition:

1. Tap **Rotation**.
2. Tap **Add**.
3. Enter the **Start station**.
4. Enter the **Rotation** value.

If the tunnel is to rotate to the left, enter a negative value.


If the tunnel is to rotate to the right, enter a positive value.

If you are defining the start of the rotation, enter a rotation value of 0%.

5. If required, enter the **Horizontal offset** and **Vertical offset** of the **Pivot position**.

If the rotation pivots around the alignment, leave the offsets as 0.000.

NOTE –

- If the horizontal and/or vertical alignment has been offset, the **Horizontal offset** and the **Vertical offset** of the **Pivot position** are relative to the offset alignment.
- If the pivot position has been offset from the alignment, an icon  indicating the offset position is displayed in the cross section view when:
 - reviewing a tunnel definition
 - surveying a tunnel
 - reviewing a surveyed tunnel

6. Tap **Store**.
7. Continue adding rotation values for other stations.
8. When you are done, tap **Close**.
9. Tap **Accept**.
10. Enter the other tunnel components, or tap **Store** to store the tunnel definition.

NOTE – The following describes the order that templates of different shapes, with rotation applied, are computed before interpolation of intermediate stations takes place:

1. Construct the first template and apply rotation
2. Construct the second template and apply rotation
3. Interpolate between the two resolved templates

To add set out positions

Set out positions typically define bolt hole or drill hole locations within a tunnel. They are defined by the station range, offset values, and method. See [Set out position requirements, page 39](#).

The station range can be defined as a single station or multiple stations with defined start and end stations:

- Single station: Ideal for single bolt points, or pipes with a defined length that are designed for specific geological conditions.
- Multiple stations: Ideal for blast holes that are repeated over multiple stations within a segment of the tunnel.

NOTE – Trimble recommends that you define the tunnel template before you key in or import set out positions. If you define set out positions before defining the tunnel template they will be assigned to the first surface defined in the template when the tunnel is stored.

To key in set out position values

1. Tap **Set out positions**.
2. Tap **Add**.
3. Define the **Station range** using the **Start station** and **End station** fields.

If the set out position can be:

- Set out at any station, leave the **Start station** and **End station** fields empty.
- Set out from a specific station to the end of the tunnel, enter the **Start station** and then leave the **End station** field empty.
- Set out at only one specific station, enter the same station value in the **Start station** and **End station** fields.
- Set out at multiple stations within a range, enter the **Start station** and the **End station**.

TIP – A description of the defined station range is shown in the **Station range** group box, indicating where the defined set out position can be set out.

4. Select the **Method** to define the set out position and then fill out the fields for the selected method as required:

TIP – For each method, the **Horizontal offset** and **Vertical offset** values are relative to the alignment. If the alignment has been offset, the offsets are relative to the offset alignment. If the offset is to the left or down, enter a negative value or tap ► next to the offset field and select **Left** or **Down**.

- For a **Blast hole** set out position, in the **Horizontal offset** and **Vertical offset** fields enter the offset values that define the position to be set out.
- For a **Radial** set out position:

- a. Select the **Surface** that the set out position is relative to.
 - b. In the **Horizontal offset** and **Vertical offset** fields, enter the offset values that define the position to be set out.
 - c. To define a new center offset from the alignment, enter the **Horizontal center** and **Vertical center** values.
- For a **Horizontal** set out position:
 - a. Select the **Surface** that the set out position is relative to.
 - b. In the **Vertical offset** field, enter the offset value that defines the position to be set out.
 - c. In the **Direction** field, select the direction that the horizontal offset is to be applied.
- For a **Vertical** set out position:
 - a. Select the **Surface** that the set out position is relative to.
 - b. In the **Horizontal offset** field, enter the offset value that defines the position to be set out.
 - c. In the **Direction** field, select the direction that the vertical offset is to be applied.
- For a **Multiple radial** set out position:
 - a. Select the **Surface** that the set out position is relative to.
 - b. Enter the **Interval** between the radial positions.
- For a **Pipe** umbrella set out position:
 - a. In the **Horizontal offset** and **Vertical offset** fields, enter the offset values from the alignment for the start point.
 - b. In the **End horizontal offset** and **End vertical offset** fields, enter the offset values from the alignment for the end point.
 - c. In the **Length** field, enter the length from the start station to the end station.

NOTE – The **Length** value is the 2D distance along the alignment, not the true 3D length.

5. If required, specify the **Code**.

The annotation entered in the **Code** field is assigned to the end of the position and is displayed when setting out the position.

6. Tap **Store**.
7. Continue adding set out positions as required.
8. When you are done, tap **Close**.
9. Tap **Accept**.

10. Enter the other tunnel components, or tap **Store** to store the tunnel definition.

To import set out positions

To import set out positions from a comma-separated file into the selected tunnel definition, in the **Set out positions** screen tap **Import**. Select the file to import and then tap **Accept**.

For information on the required format for the CSV file, see [Set out position requirements, page 39](#).

NOTE – You cannot import **Multiple radial** set out points.

To add station equations

Use **Station equations** to define the station values for an alignment.

To define an equation for the selected tunnel definition:

1. Tap **Station equations**.
2. Tap **Add**.
3. In the **Back station** field, enter a station value.
4. In the **Ahead station** field, enter a station value. The **True station** value is calculated.
5. Continue adding records as required.
6. Tap **Store**.

The values entered in the **Back station** and **Ahead station** fields are shown.

The zone is indicated by a number after the colon in each field. The zone up to the first station equation is zone 1.

The calculated **Progression** indicates whether the station value increases or decreases after the station equation. The default setting is **Increasing**. To change the **Progression** for the last station equation to **Decreasing**, define and store the last equation and then tap **Edit**.

7. When you are done, tap **Close**.
8. Tap **Accept**.
9. Enter the other tunnel components, or tap **Store** to store the tunnel definition.

To add alignment offsets

To add an [alignment offset](#) to the selected tunnel definition:

1. Tap **Alignment offsets**.
2. Tap **Add**.
3. Enter the **Start station**.
4. Enter the **Horizontal offset** and / or **Vertical offset**.
5. Tap **Store**.

6. Continue adding offsets at different stations as required.
7. When you are done, tap **Close**.
8. Tap **Accept**.
9. Enter the other tunnel components, or tap **Store** to store the tunnel definition.

NOTE – If the alignment has been offset and a rotation has been applied to the templates, the rotation is applied first and then the alignment is offset.

Template application

When you add templates to the tunnel definition, you must add template positions to specify the station at which the Tunnels software starts to apply each template. For station values between applied templates, the template element values are interpolated.

NOTE – The templates applied must have the same number of elements.

Interpolation methods

The following interpolation methods are supported.

Norwegian interpolation method

This method maintains the radii of the first and last arcs (referred to as wall arcs), as well as the radii of the second and fourth 'transition' arcs when present, and computes a new radius for the central (or roof) arc. It uses interpolation of the arc angles rather than the radii values.

This method is automatically used if the templates applied at the previous and next stations fulfill the following requirements:

- Each template consists of 3 or 5 arcs in sequence joined tangentially
- There is no 'tilt' to the defined section (template)

If the above requirements are not met the **Linear interpolation** method is used.

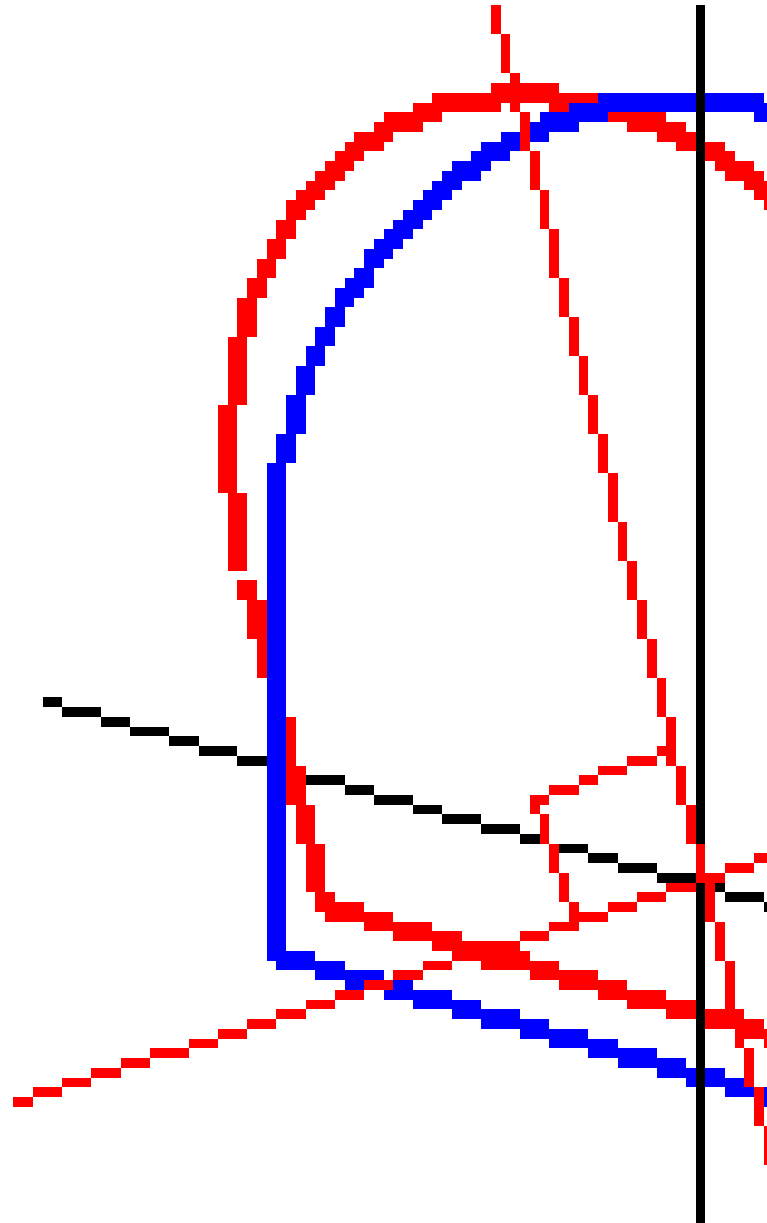
Linear interpolation

For this method, the template element values are interpolated linearly (applied on a pro rata basis), from a template applied at the previous station to the station where the next template is applied.

This method is used if the requirements for the **Norwegian method** are not met.

Applying templates to the vertical alignment

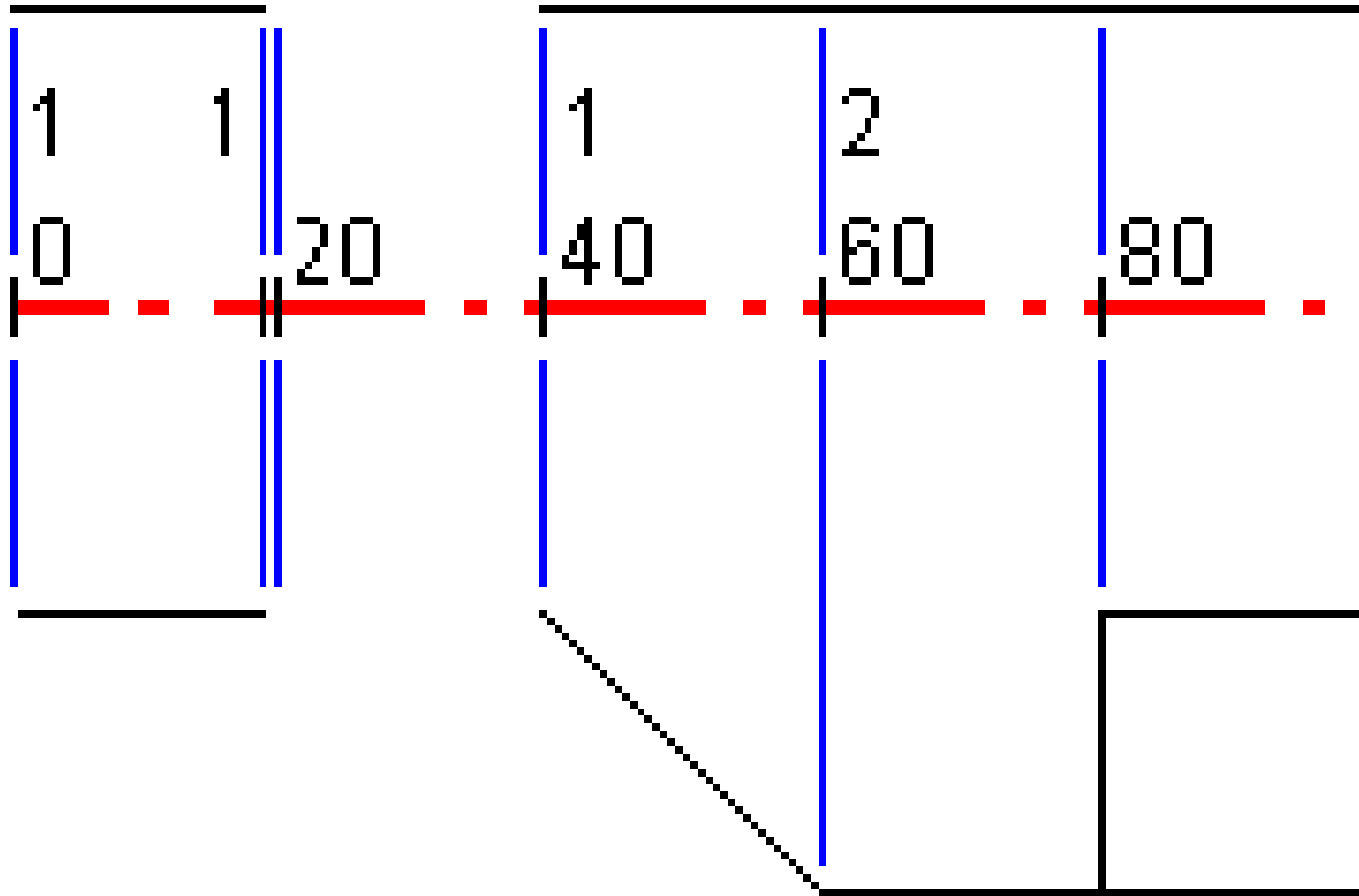
Templates can be applied vertical or perpendicular to the vertical alignment. See the following diagram where the red linework indicates the template applied perpendicular and the blue linework a template applied vertically.



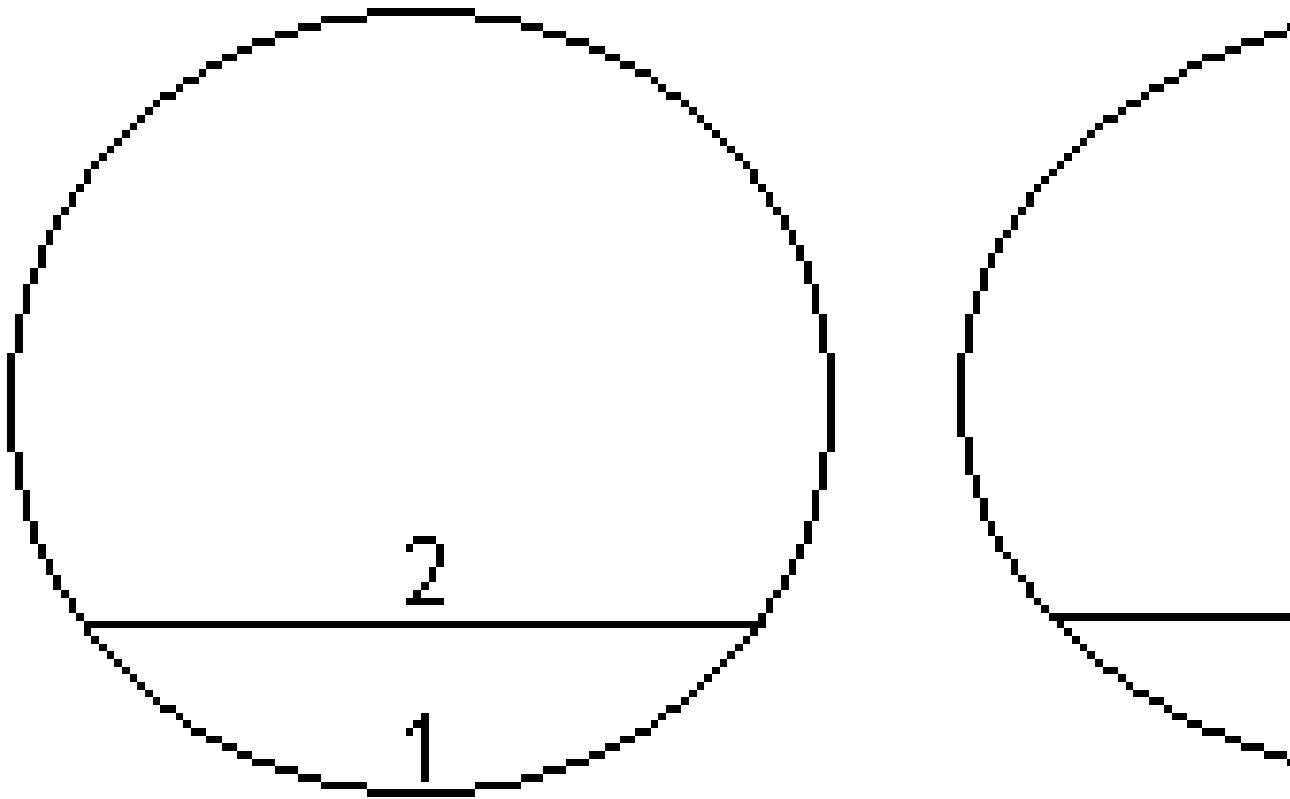
The station and offset display of points relative to a tunnel using **Point manager** or **Review job** are only calculated vertical to the alignment. If the templates were applied perpendicular in Tunnel positioning then the station and offsets will be different.

Example alignment using templates

The following discussion explains how the template assignments, including the <None> template, and the **Surfaces to use** option can be used to control a tunnel definition. See the plan in the following figure where the tunnel is a consistent width from station 0 to 20, has a gap between stations 20 and 40, widens from station 60 to 80 and then is a constant width to station 140.



See also the two templates in the following figure where template 1 (on the left side in the figure) has two surfaces and template 2 has three surfaces:



To define this design you need to assign the templates with the appropriate surfaces selected as shown in the following table:

Start station	Templates	Surface 1	Surface 2	Surface 3
0.000	Template 1	On	On	–
20.000	Template 1	On	On	–
20.005	<None>	–	–	–
40.000	Template 1	On	On	–
60.000	Template 2	On	On	Off
80.000	Template 2	On	On	On
120.000	Template 2	On	On	Off
140.00	Template 2	On	On	Off

Set out position requirements

Set out positions typically define bolt hole or drill hole locations within the tunnel, and are also used to define blast holes in the tunnel face or holes for installing pipes. All set out positions are defined by the station range, offset values, and method. The station range can be defined as a single station or multiple stations with defined start and end stations.

You can key in set out positions as part of the tunnel definition using the **Set out** screen in Trimble Access. Alternatively, you can design the set out positions in Trimble Business Center and then save them as a TXL file for use in Trimble Access, or you can import set out positions from a CSV file. To key in or import set out positions, see [To add set out positions, page 30](#).

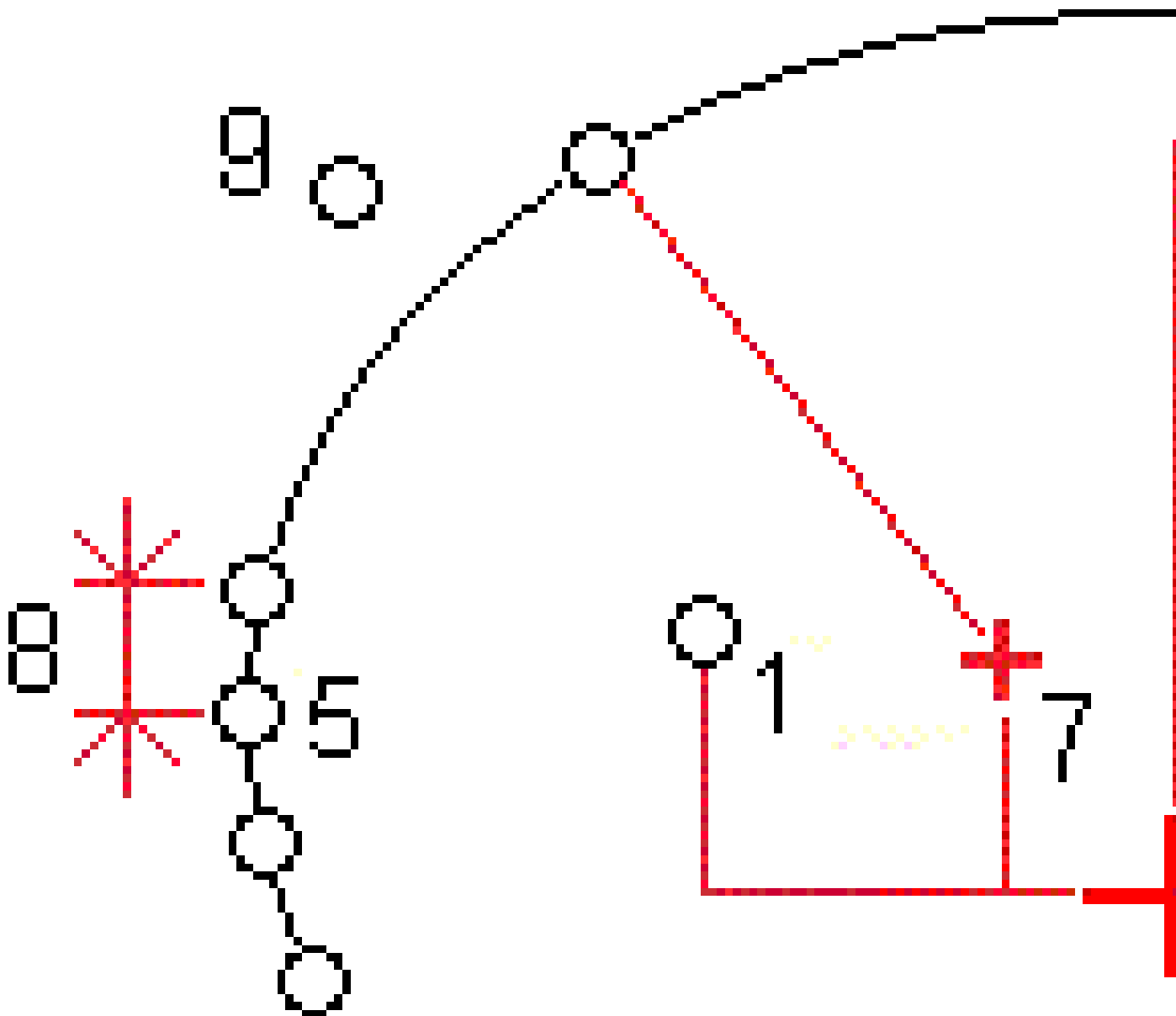
Setting out positions using Trimble Access Tunnels refers to the process of staking out the designed positions, and physically marking the location of set out points on the tunnel surface so that drilling equipment can be guided to the correct location of each point for drilling the hole and installing the bolt or pipe. See [To set out predefined positions, page 59](#).

Set out position methods

Supported types of set out positions are:

- End-face blast holes
- Bolt holes using the following methods:
 - Radial
 - Horizontal
 - Vertical
 - Multiple radial
- Pipes

Refer to the following diagram:



- | | | | |
|---|-----------------|---|-----------|
| 1 | Blast hole | 2 | Radial |
| 3 | Horizontal | 4 | Vertical |
| 5 | Multiple radial | 6 | Alignment |

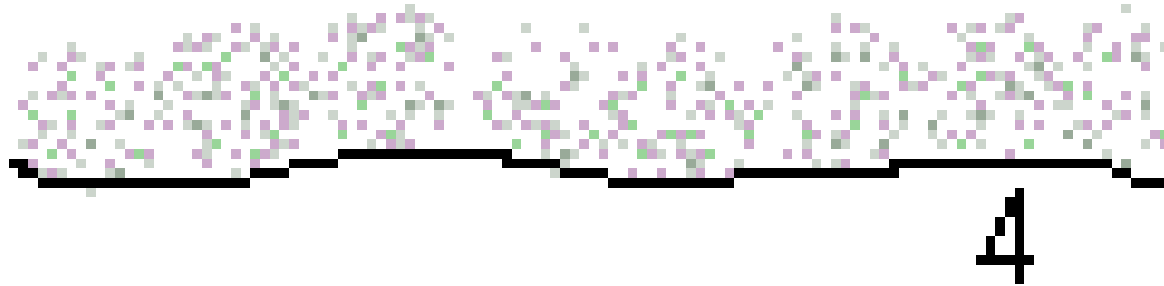
7 Offset center

8 Interval

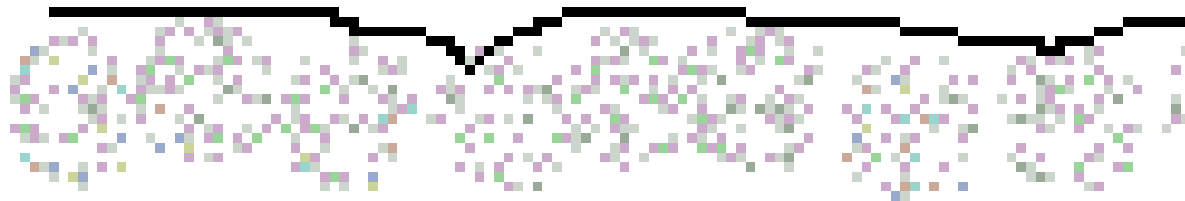
9 Pipes

Blast hole set out

Refer to the diagram below to set out positions for blast holes.



5



1 Blast hole position

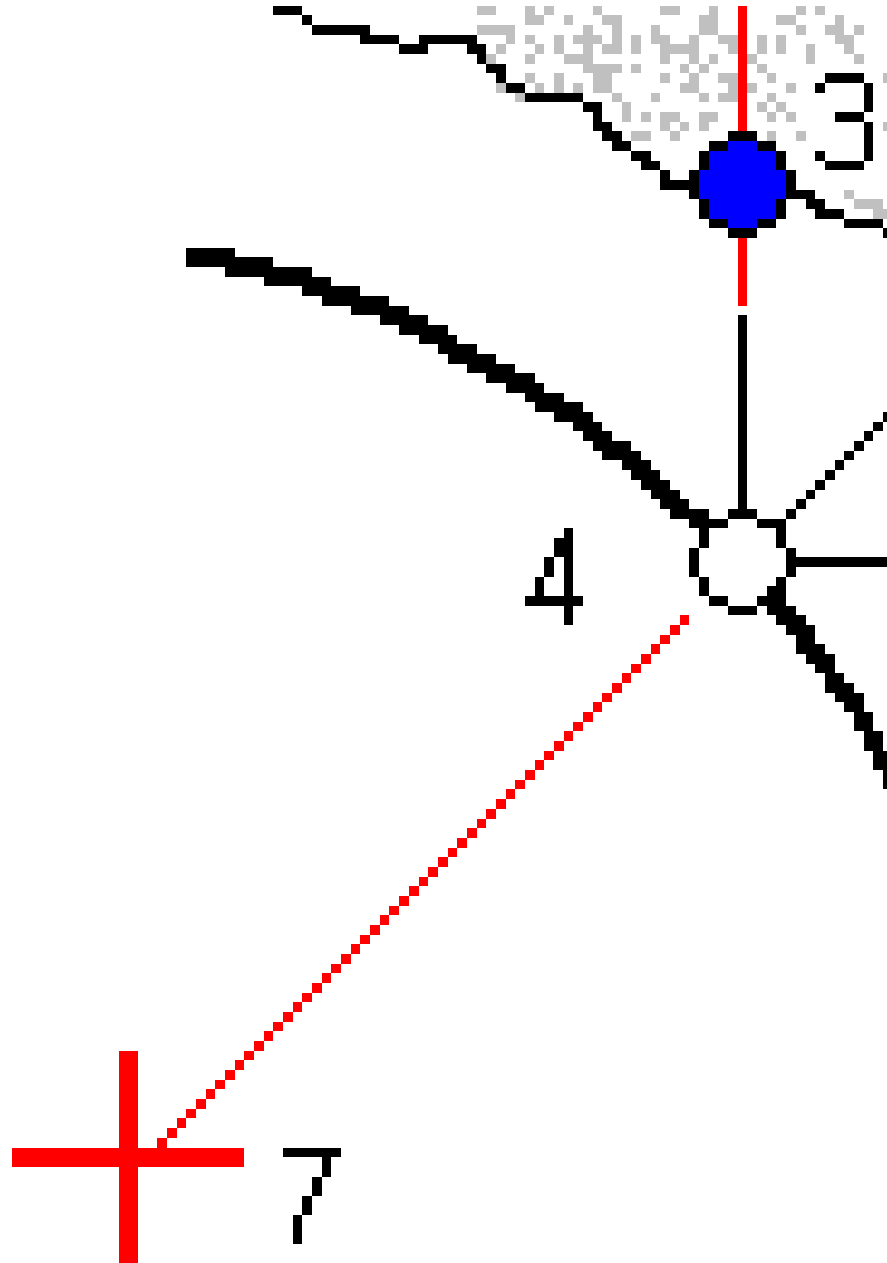
2 Design position

- 3** Design surface
- 5** Tunnel alignment

- 4** Tunnel surface

Bolt hole set out

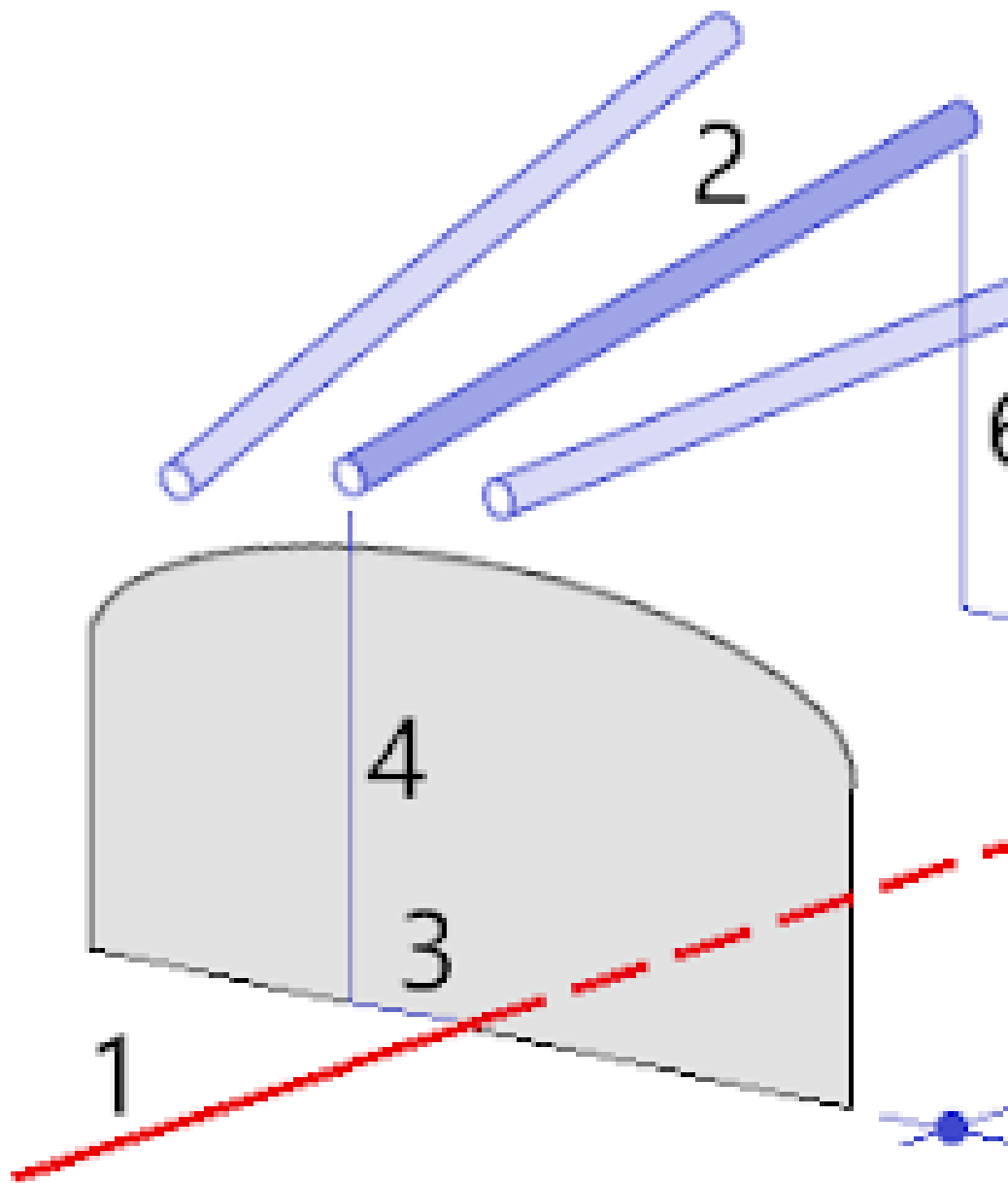
Refer to the diagram below to set out positions for bolt holes defined by the radial (including multiple radial), horizontal, and vertical methods.



1	Set out position defined radial	2	Set out position defined horizontal
3	Set out position defined vertical	4	Design position
5	Design surface	6	Tunnel surface
7	Center for radial position		

Pipe set out

Set out pipe positions to install an arch of pipes that extend lengthwise along the planned tunnel alignment to reinforce the roof of the working area. Typically, a series of regularly spaced and overlapping arches of pipes (a ***pipe umbrella*** or ***canopy tube***) are installed throughout the sequential excavation of the tunnel.



1	Alignment	2	Pipe umbrella
3	Horizontal offset (pipe start)	4	Vertical offset (pipe start)
5	Horizontal offset (pipe end)	6	Vertical offset (pipe end)

7 2D distance along the alignment.

Imported set out position requirements

NOTE – You cannot import **Multiple radial** set out points.

The required format for the CSV file is:

StartStation, EndStation, Type, HorzOffset, VertOffset, Code, Direction, Surface, ExtraHorzOffset, ExtraVertOffset, Length.

See the following examples for the format for each set out method:

Set out positions	Method	Values	Example
End face blast holes	Blasthole	StartStation, EndStation, Type, HorzOffset, VertOffset, Code	40,60,Blasthole,0.5,-0.5,Blast hole
Radial bolt holes	Radial	StartStation, EndStation, Type, HorzOffset, VertOffset, Code, Direction, Surface, HorzCenter, VertCenter	0,40,Radial,-3.2,2.2,Bolt hole,,S2,1.05,0.275
Horizontal bolt holes	Horizontal	StartStation, EndStation, Type, HorzOffset, VertOffset, Code, Direction, Surface	0,20,Horizontal,,3.1,Bolt hole,Right,S2
Vertical bolt holes	Vertical	StartStation, EndStation, Type, HorzOffset, VertOffset, Code, Direction, Surface	0,,Vertical,3.2,,Bolt hole,Up,S2
Pipes	Pipe	StartStation, EndStation, Type, HorzOffset, VertOffset, Code, EndHorzOffset, EndVertOffset, PipeLength	0,,Pipe,-1.0,2.5,Pipe,-1.1,2.6,5.0

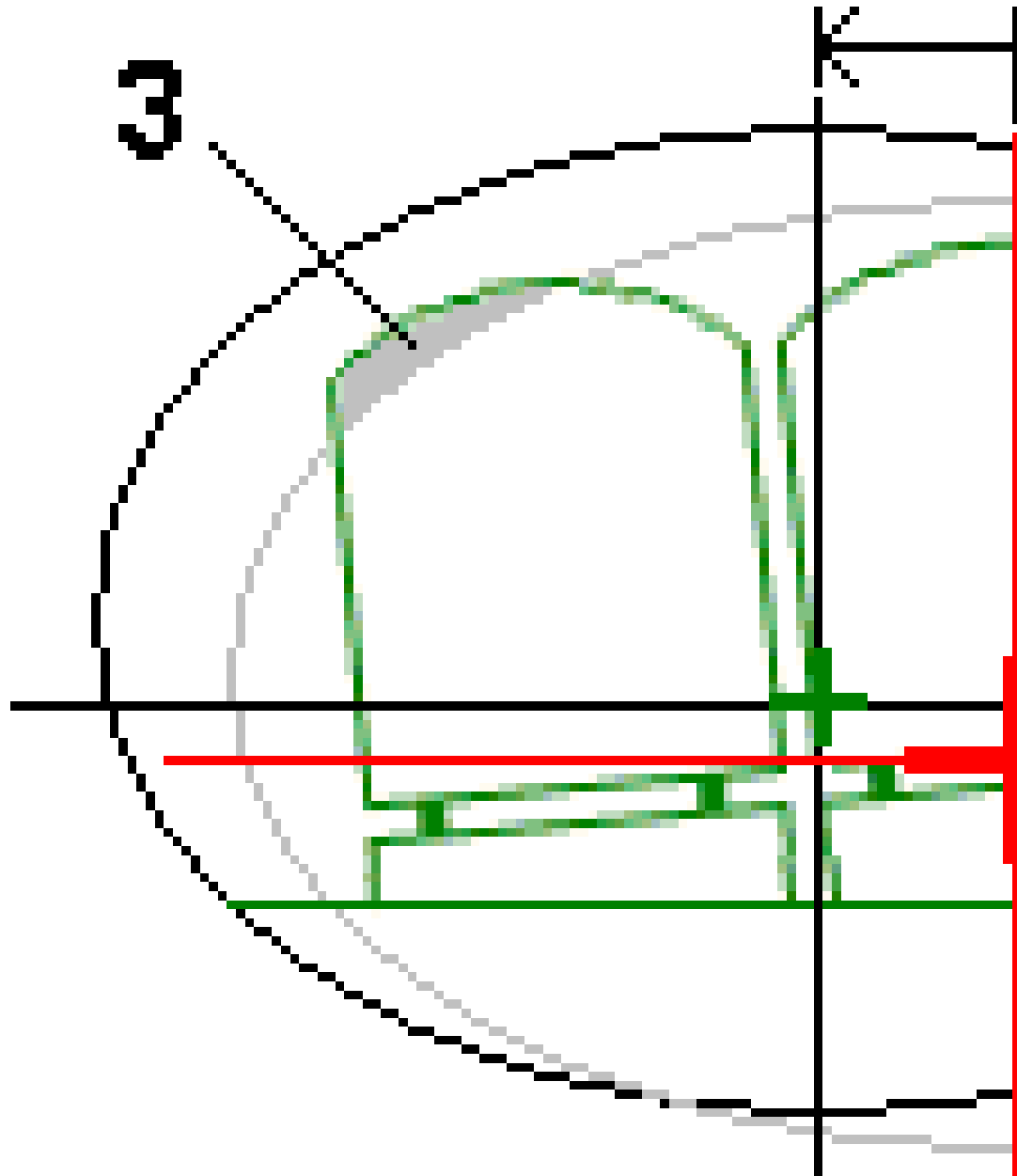
NOTE –

- The Surface name, Code, Horizontal offset, and Vertical offset values are optional.
- If no Surface name is specified, or the Surface name is not applicable for the specified station range, the first template surface suitable for the station range is used.
- The Method value must be one of the following: Blasthole, Horizontal, Vertical, Radial, Pipe.
- The Direction value must be one of the following: Up, Down, Left, Right, or empty (for a radial offset, blast hole, or pipe).

Alignment offsets

Alignment offsets are typically used at horizontal curves in a rail tunnel to ensure that carriage clearance is maintained when the track is rotated. However, they can be used anywhere along the tunnel alignment provided there is a valid horizontal alignment, vertical alignment, and template assigned.

The following diagram illustrates using alignment offsets to avoid carriage conflict with the design tunnel.



1	Horizontal offset	4	Offset tunnel
2	Vertical offset	5	Design tunnel
3	Carriage conflict		

To add alignment offsets to the tunnel definition, see [To add alignment offsets, page 32](#).

To review the tunnel definition

You can review the definition of a tunnel at any time. View the tunnel in 3D to visually confirm the tunnel definition.

1. In the map, tap the tunnel.
2. Tap the **Review** softkey to see a plan view of the tunnel.

The horizontal alignment is shown as a black line and the offset alignment (where applicable) is shown as a green line.

By default the first station is selected.

The selected station appears as a red circle. The station value of the selected station, its rotation value where applicable, and the alignment offset values where applicable, appear at the top of the screen.

3. To confirm the definition before surveying the tunnel, tap **Calc** to calculate the grid and tunnel coordinates.
4. To add a unique station, tap and hold on the screen and then select **Add station**.
5. To select another station to review:
 - Tap and hold on the screen and then tap **Select a station**. Select the station from the list in the **Select a station** screen.
 - Tap an individual station.
 - Press an up or down arrow key.

TIP – Tap the pan softkey to make it active and then use the left, right, up, or down arrow keys to pan around the screen.

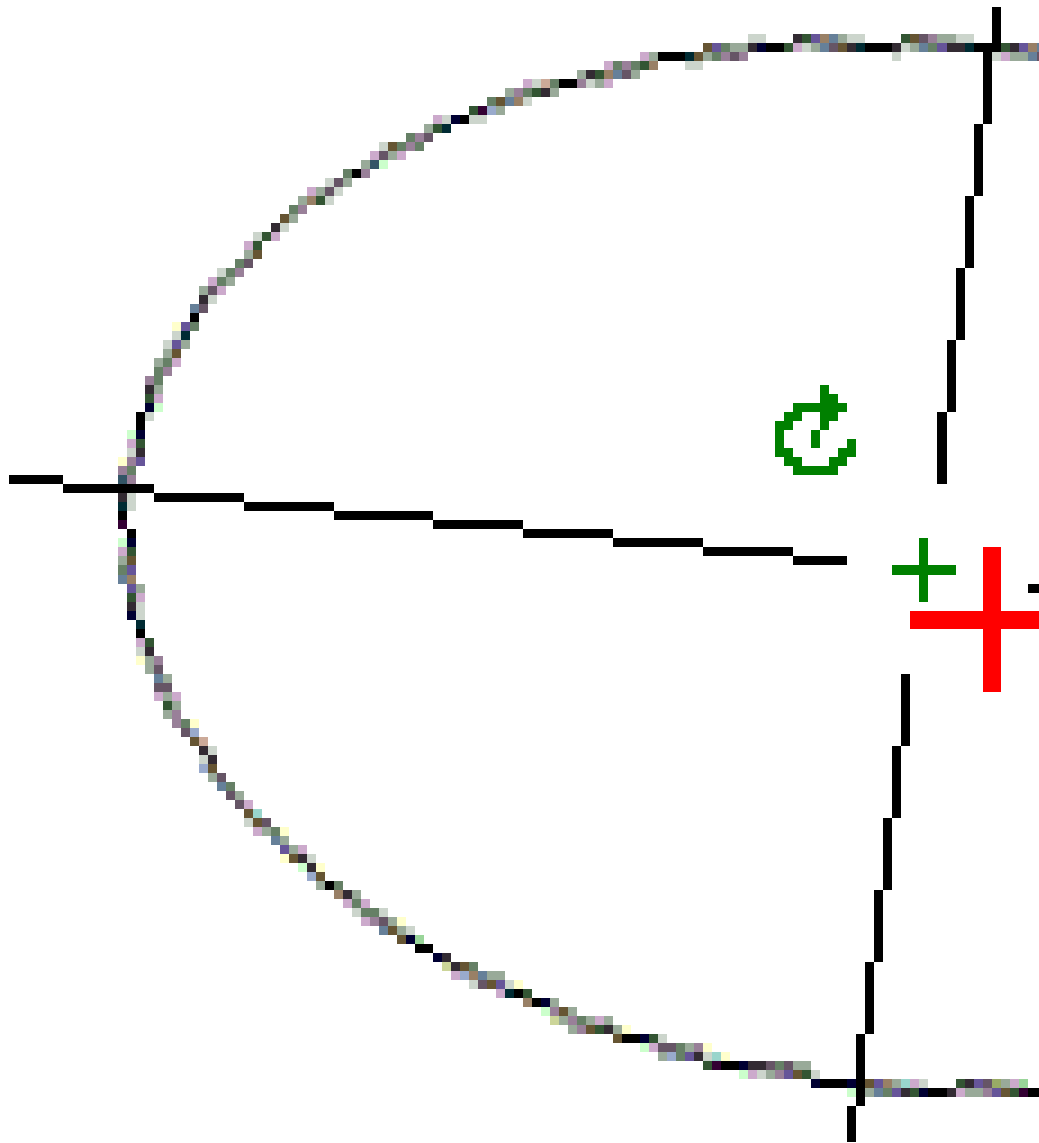
6. To view the cross section for the selected station, tap  or press the **Tab** key.

Refer to the following diagram where:

- A red cross indicates the design alignment.
- If the alignment is offset, a small green cross indicates the offset alignment.
- If the tunnel has been rotated and the pivot position for the rotation is offset from the

alignment, a green circular icon indicates the pivot position.

- A short green line at the top of the profile indicates the vertex point.



Tap and hold on a position to see its horizontal and vertical offsets, northing, easting, and elevation.

If the design alignment has been offset, the reported offset values are to the offset alignment. If rotation has been applied and the pivot position has been offset, the reported offsets are to the offset position.

To return to the plan view, tap .

7. To view an automated 3D drive through of the tunnel:

- a. In the plan view of the Review tunnel screen, tap **3D drive**.
- b. Tap ► to start the drive through.
- c. To pause the drive through and inspect a particular part of the tunnel, tap ■■ . To orbit the tunnel while the drive through is paused, tap the screen and swipe in the direction to orbit.
- d. To move forward and back along the tunnel, press the up and down arrow keys.
- e. To exit 3D drive, tap **Close**.

Tunnel survey

Start a survey to survey the as-built tunnel, stake out set out positions for blast holes, bolt holes, and pipe umbrellas during tunnel construction, and to position machinery in the tunnel.

When starting a survey you are prompted to select the survey style you have configured for your equipment. To learn more about survey styles and related connection settings refer to the *Trimble Access Help*.

CAUTION – Do not change the coordinate system or calibration after you have staked out points, or computed offset or intersection points. If you do, the previously staked out or computed points will be inconsistent with the new coordinate system and any points computed or staked out after the change.

After a scan is completed, you can do the following:

- To review a summary for each station, return to the plan view, tap and hold on the screen and then select **Results**.
- To see details for the current station, return to the cross section view, tap and hold on the screen and then select **Details**. See also [Review tunnel](#).
- To edit the tolerance values from either the plan or cross section view, tap and hold on the screen and then select **Tolerances**. The **Station**, **Overbreak**, and **Underbreak** deltas are updated to reflect the new tolerance values.

Laser pointer

If you are using a total station equipped with a laser pointer:

- The laser indicates the location of the current position or the selected set out position on the tunnel surface.
- The instrument is automatically set to DR tracking mode with the laser pointer on. The cross section for the current position is displayed on screen.

To disable DR mode, set a target height, or make other changes to the instrument setting, tap the arrow at the right of the screen to access the status bar.

To blink the laser and the tracklight or the target illumination light (TIL) when storing a point measured with DR, select **Instrument / EDM settings** and then set the number of times the laser will blink in the **Blink laser** field. The **Blink laser** field is not available when the **Laser power** field is set to **Extended range flashing** (SX12 only).

NOTE –

- The Tunnels software defaults to tracking mode when scanning and measuring in a tunnel. If you select standard mode, you achieve better quality but slower measuring times.
- Using an instrument that is not equipped with a laser pointer requires a different workflow when setting out positions. For more information, see [To set out predefined positions, page 59](#).

3R Laser Pointer

If you are using a total station equipped with a high-power laser pointer, before storing a point, tap **3R Laser** to enable the high-power laser pointer and show the mark on the tunnel surface. The high power laser pointer icon



at the bottom right of the screen indicates the laser is active. Tap **Measure** to measure the position and then tap **Store** to record the current position in the job's database.

NOTE –

- Even though the high-power laser pointer is not coaxial with the telescope, the instrument can automatically turn to measure to the laser pointer location. When you tap **3R Laser**, a preliminary measurement is taken to determine the vertical angle to turn the instrument so that the distance is measured to where the high-power laser pointer is pointing. When you tap **Measure**, the instrument automatically turns to that location and takes the measurement. The instrument then turns so that the high-power laser again points to the measured position. The preliminary measurement is not stored.
- The calculation of the vertical angle to turn to assumes the horizontal distance to the preliminary measurement is similar to the distance to the high-power laser pointer location. To measure to the high-power laser point when it is near the upper or lower edge of an object, consider using face 1 to take measurements at the lower edge of an object, and face 2 to take measurements at the upper edge of an object so that the preliminary measurement does not overshoot the object you are measuring to.



WARNING – The high power laser is a class 3R laser that emits laser radiation – do not stare into the beam or view directly with optical instruments.

To automatically scan positions


Use auto scan to measure points at a defined scan interval for selected stations. The measured positions are compared to the design template surface for that station.

If parts of the tunnel profile do not require measuring or cannot be measured (for example, areas behind ventilation ducts), add a **scan zone** to measure only points within the scan zone(s). Scan zones are applied to the entire length of the defined station range.


To auto scan positions in the tunnel

1. Start a survey.
2. Tap  and select **Survey / Auto scan**.
3. Select the tunnel file. Tap **Accept**.
4. Define the scan station range:
 - a. To define the **Start station** and **End station**, you can:
 - Key in the station value.
 - Tap  and select **List** and then select one of the design station values from the TXL file.
 - If you can see the station range that you want to scan from your position in the tunnel, tap in the **Start station** field and then turn the instrument to the required

start point of the scan and tap **Measure** to calculate the station value. Repeat the process for the **End station**.

If you are using a Trimble instrument that has VISION technology, you can tap  in the map toolbar to view the video feed and then tap the location in the video (for example the prism or tunnel wall), and then tap **Measure** to calculate the station value.

TIP – To scan in the direction of decreasing station, enter a **Start station** value that is greater than the **End station** value.

- b. Enter the **Station interval** used to determine subsequent station values. Tap  and make sure that the correct interval method is selected:
 - The **0 based** method is the default method and gives station values that are multiples of the station interval. For example, if the start station is 2.50 and the station interval is 1.00, the **0 based** method produces stations at 2.50, 3.00, 4.00, 5.00, and so on.
 - The **Relative** method gives station values relative to the start station. For example, if the start station is 2.50 and the station interval is 1.00, the **Relative** method produces stations at 2.50, 3.50, 4.50, 5.50, and so on.
- c. Select the template surface to scan.
- d. Tap **Next**.

The selected station range is shown in the plan view. If you need to change the station range, tap Back and edit the **Start station** and **End station** values.

5. Tap **Next**.

The cross section of the first selected station is shown. The selected template surface is highlighted.

6. If only part of the tunnel needs to be measured, add a scan zone:

- a. Tap and hold on the screen and then select **Add scan zone**.
- b. Point the instrument to where you want the scan zone to start. The instrument ray appears as a solid red line on screen. Tap **Accept**.

NOTE – Scan zones must be defined in a clockwise direction.

- c. Point the instrument to where you want the scan zone to end. The instrument ray appears as a solid red line on screen and the scan zone start appears as a red dashed line. Tap **Accept**.

The auto scan profile view appears. Points outside the scan zone are grayed out and will not be measured.

To add another scan zone, repeat the steps above.

7. Tap **Start**.
8. Configure the **Scan settings**. Tap **Accept**.

9. Configure the **Scan tolerances**. Tap **Accept**.

The Tunnels software begins scanning the first station.

For each scanned point, the point name overbreak / underbreak and delta station values are displayed. Each scanned position appears as a green circle (if within tolerance) or a red circle (if not within tolerance).

Once all points for the current station are scanned, the Tunnels software automatically advances to the next station until all selected stations are scanned.

Once all points for all selected stations are scanned, results show which stations have errors. Expand each record to view more information.

10. Tap **Close**.
11. To exit the plan view, tap **Esc**.

To end the scan before it is complete, tap **Stop**, or tap **Pause** to pause the scan and then tap **Continue** to resume scanning. While paused, you can select any scanned position to view the deltas. If you are using a Trimble VX spatial station **and** the **VX scanning** check box is enabled in the **Settings** screen, tap **Stop** and then tap **Start** to resume the scan.

NOTE –

- Auto scan defaults to tracking mode for each scan but will work in standard mode.
- When a scan starts, the DR target height and prism constant are automatically set to 0.00.
- When scanning with **On station adjustment** selected and using a:
 - Trimble S Series total station or Trimble SX10 scanning total station, each point is scanned until it is found within tolerance.
 - Trimble VX spatial station, fifty points will be scanned at a time. The scan is repeated for those points that were not within tolerance.
- If the number of iterations is exceeded or the EDM times out, the point is skipped.

To manually measure a position

Use **Manual measure** to measure a position that could not be measured by a scan, or to delete a scanned or manually measured position.

1. Follow the procedure for performing an [Auto scan](#) up to step 5, where the selected scan range is shown in plan view.
To select manual mode, tap and hold on the screen and then select **Manual measure**.
The selected mode, **Manual**, is shown at the top left of the screen.
2. If required, configure the [Settings](#) and [Tolerances](#).

3. Select the station to measure. You can:
 - Select a station that has been defined by the **Scan interval**. To do this, tap and hold on screen and tap **Select a station**.
 - Tap the location that you want to measure. The instrument automatically turns to that position. Alternatively, manually aim the instrument at the position you want to measure.

The **Station**, **Underbreak**, **Overbreak** and **Delta station** values are shown.

4. Tap **Next**. The cross section view of the selected position is shown.
5. Configure the **Manual settings**. Tap **Accept**.
6. Configure the **Scan tolerances**. Tap **Accept**.
7. Tap **Store**.

Stations with no errors appear as solid green circles, while those with errors appear as solid red circles.

TIP – If you experience issues getting a measurement:

- If the instrument struggles to get a measurement due to, for example, reflective or dark surfaces, increase the value in the EDM timeout field in the [Settings](#) screen.
- If you can't measure to the tunnel surface with DR, then you can [measure to a prism](#) that is offset perpendicular to the design surface, where the target height is applied perpendicular to the tunnel profile. To do this, select the **Apply target height perpendicular to profile** option from [Settings](#). In the case where the prism is held against the tunnel surface you would enter the prism radius as the target height.
- If, when measuring without a prism, your current position (displayed as a cross) fails to update, then ensure the **Apply target height perpendicular to profile** option from **Settings** is not selected.

To delete a measured position

1. From the cross section view, tap a point to select it. The selected point is indicated with a black circle.
2. Tap **Delete**.

NOTE – When you select a point for deletion, the instrument target will be the design position for that point. If you select **Store** immediately after deleting the point, the instrument remeasures the design position for the deleted point.


To restore deleted points, tap and hold on the screen and then select **Restore deleted points**.

To measure a position in the tunnel

Use the **Position in tunnel** function to:

- Measure a position at any station within the tunnel.
- Compare the position with the design parameters of the tunnel.


To measure the position:

1. Start a survey.
2. Tap  and select **Survey / Position in Tunnel**.
3. Select the tunnel file. Tap **Accept**.
Information on the current position appears at the bottom of the screen. See [Current position information, page 82](#).
4. If the tunnel has more than one surface, select the surface to measure relative to. To select the surface you can:
 - Tap and hold on the plan view and tap **Select surface**. Select the surface from the list.
 - Tap the template surface.
5. Point the instrument at the position you want to measure. Tap **Store**.
6. Enter the **Position settings**. Tap **Accept**.
7. Enter the **Position tolerances**. Tap **Accept**.
The position is stored.
8. To exit the plan view, tap **Esc**.


To set out predefined positions



Set out positions typically define bolt holes or drill hole locations within a tunnel. They are defined by station and offset values and a method. See [Set out position requirements, page 39](#).

NOTE – When setting out positions, the software attempts to navigate you to the defined position. Often this is not possible and the software instead calculates a position on the tunnel surface that is projected from the selected station. The location of this position depends on the method used to [define the set out position](#).

1. Start a survey.
2. Tap  and select **Survey / Set out**.
3. Select the tunnel file. Tap **Accept**.
4. In the **Set out type** field, select the type of positions to set out.

TIP – Only positions of the type selected in the **Set out type** field will be shown in the cross section view and can be set out. This allows you to use a single TXL file for all set out positions, and then set out only one type of position at a time. To view all positions in the cross section view, choose **All** from the **Set out type** field.

5. Define the station you want to set out:
 - a. To define the **Station**, you can:
 - Key in the station value.
 - Tap  and select **List** and then select one of the design station values from the TXL file.
 - Tap inside the **Station** field and then turn the instrument to the tunnel face or a prism and tap **Measure** to calculate the current station value.

If you are using a Trimble SX10 or SX12 scanning total station, tap  in the map toolbar to view the video feed and then tap the location in the video (for example the prism or tunnel wall). The instrument automatically turns to the selected location.
 - b. Enter the **Station interval** used to determine subsequent station values. Tap  and make sure that the correct interval method is selected:
 - The **0 based** method is the default method and gives station values that are multiples of the station interval. For example, if the start station is 2.50 and the station interval is 1.00, the **0 based** method produces stations at 2.50, 3.00, 4.00, 5.00, and so on.
 - The **Relative** method gives station values relative to the start station. For example, if the start station is 2.50 and the station interval is 1.00, the **Relative** method produces stations at 2.50, 3.50, 4.50, 5.50, and so on.
6. Tap **Next**. The cross section view of the selected station is shown.
7. In the cross section view, select the position to set out. To automate the set out of multiple set out positions, tap and hold in the cross section view and then select **Select all**.
8. Set out the selected position:
 - a. Tap **Auto** to set out the selected position.
 - b. When prompted, configure the **Set out settings**. Tap **Accept**.
 - c. When prompted, configure the **Set out tolerances**. Tap **Accept**.

The instrument automatically turns to the selected position by an iterative process indicated by the progress bar at the top left of the screen. If you have chosen **Select all** to set out multiple set out positions, the instrument turns to the first defined set out position.
 - d. When the position is found you are instructed to mark the point indicated by the laser on the tunnel surface.

When using a Trimble SX12 scanning total station in **TRK** mode with the **laser pointer enabled**, the **Stakeout** screen shows the **Mark point** softkey instead of the **Measure** softkey. Tap **Mark point** to put the instrument into **STD** mode. The laser pointer stops flashing and moves to position itself at the EDM location. When you tap **Accept** to store the point, the instrument automatically returns to **TRK** mode and the laser pointer resumes flashing. To remeasure and update the stakeout deltas, tap **Measure** after you tap **Mark point** and before you tap **Accept**.

If you are using an instrument equipped with a high-power laser pointer, tap **3R Laser** to enable the high-power laser pointer and then tap **Measure** to measure the position.

If you are using an instrument that is not equipped with a laser pointer, the point is not indicated on the tunnel surface. To mark the tunnel surface, tap **≡** and select **Video** from the **Return to** list (the **Video** screen must already be open). Use the inner crosshair in the **Video** screen as a guide to mark the position on the tunnel surface. (Do not use the outer crosshair as it is less precise.) To return to the **Set out** screen, tap **≡** and select **Set out** from the **Return to** list. Alternatively, tap ☆ to add the **Video** and **Set out** screens to your **Favorites** list.

- e. If you are setting out multiple set out positions, when a position is found within tolerance, the **Mark point** event sounds and:
 - If the instrument has a tracklight, the laser pointer **and** the tracklight flash for the period defined in the **Mark delay** field.
 - If the instrument is a Trimble SX12 scanning total station, the laser pointer **changes to solid** and the Target Illumination light (TIL) flashes for the period defined in the **Mark delay** field.

At the end of the **Mark delay** period the instrument turns to the next set out position and so on until all set out positions have been set out.

If the position cannot be found within the position tolerance, the software shows **Failed** above the delta display. If you are setting out multiple set out positions, the software skips the position and moves to the next set out position. Specify **Start delay** and **Mark delay** values in the **Settings** screen.

TIP – To manually locate the set out position, use the **Turn** softkey to point the instrument at the selected set out position and then fine-tune the position manually.

Information on the current position and its relationship to the selected set out position appears at the bottom of the screen. See [Current position information, page 82](#).

9. Tap **Store**. The stored position is indicated by a solid black circle.
10. To exit the plan view, tap **Esc**.

Scanning

3D scanning is an automated direct reflex (DR) measuring process that digitally captures the shape of physical objects you have defined using a laser of light. 3D laser scanners create point clouds of data from the surface of an object.

You can scan inside a tunnel using a Trimble SX10 or SX12 scanning total station from within the Trimble Access Tunnels app.

NOTE – To scan a tunnel using a Trimble VX Series or S Series instrument that has Trimble VISION technology, you will need to switch to the General Survey app.

Scan preparation

When scanning, set up the instrument so that you have a good view of the object you are scanning. For example, when scanning a horizontal surface, set up the instrument as high as possible overlooking the plane. For a vertical surface, the instrument should be set up as close as perpendicular to the plane as possible.

When measuring or selecting scan points, choose points that are reasonably spaced and provide a good spread. For example, when scanning a vertical plane, choosing points that are in diagonally opposing corners of the plane provides the best geometry.

You must complete a station setup before you can perform a scan.

You can set up the instrument on a point for which there are no known coordinates and create a **scan station**. When using a scan station, you can capture scans and panoramas only.

To perform scans along with normal survey measurements, you must set up the instrument on a known location and perform a **standard station setup**.

Scan progress information

During a scan, the following progress information appears in the scanning window:

- Panorama progress information (if applicable).
- The percentage of scan completed.
- The number of points scanned.
- The estimated time remaining.

Tilt tolerance checking

If the compensator is enabled, the software performs a tilt tolerance check when a scan is paused, completed, or canceled and compares the current tilt value with the tilt value recorded when the scan started or resumed. If the instrument level has changed more than the defined tilt tolerance during the scan, a tilt error message shows the amount of change at the distance specified in the **At distance** field in the **Scanning** screen. To continue/save the scan, tap **Yes**. To cancel the scan, tap **No**.

A tilt check is not performed if the scan is interrupted because the instrument has shut down due to low power.

The tilt change is displayed in the scan record in **Review job**. If multiple tilt tolerances messages are displayed for a single scan, the largest tilt change is displayed in the scan record in **Review job**. If the instrument level is tilted such that it is outside the compensator range when the tilt check is performed, the scan record shows "Compensator out of range".

Pausing and resuming scans

While a scan is in progress, other conventional instrument/survey functions are disabled. If you need to access a conventional survey or instrument function during a scan, you must pause the scan, perform the operation and then continue the scan.

To pause the scan while it is in progress, tap **Pause**. To resume the paused scan, tap **Continue**.

If the connection to the instrument is interrupted during scanning and the "Total station not responding" message appears:

- To continue scanning, reconnect to the instrument and then tap **Continue**.
- To end the survey, tap **Cancel**.

If you tap **Cancel** and then reconnect to the instrument, you can still access the interrupted scan. To do this, select **Use last** in the **Station setup** screen and then **Scanning** from the **Measure** menu. You are prompted to continue the previous scan or to download the partially captured scan.

Scan storage

When the scan is complete, the name of the scan file and the scan properties are stored in the job file.

When you delete a scan, the scan data is still saved but the record is marked as deleted. Go to the scan record in the **Review job** screen to restore a scan.

Scanned points are not stored in the job file and are not shown in Point manager.

- Scanned points from Trimble VX Series or S Series instruments are written to a TSF file that is saved to the <project>\<job name> **Files** folder.
- Scanned points from a Trimble SX10 or SX12 scanning total station are written to an RWCX file that is saved to the <project>\<job name> **Files\SdeDatabase.rwi** folder.

TIP – When a scan point measured using a Trimble SX10 or SX12 scanning total station is used in the job, for example in a Cogo calculation, a point is created in the job at the same position as the scan point.

- Panorama images are stored as JPG files and saved to the **<project>\<job name> Files** folder.

NOTE – If a scan contains over 100,000 points, the points will not appear in the map or in point manager.



You can import the JOB or JXL file into the Trimble Business Center or Trimble RealWorks Survey software. Associated TSF, RWCX and JPG files are imported at the same time.


When creating DC files, either on the controller or when downloading the file with office software, the data from the TSF file(s) associated with the job is inserted into the DC file as regular conventional observations.


To export scan data, in the **Jobs** screen tap **Export**. Select **Comma delimited** in the **File format** field and then tap **Accept**. In the **Select points** screen, select **Scan file points**. A message confirms the export is complete.

To scan using an SX10 or SX12

NOTE – Connections to the SX10 or SX12 are not supported when using the TCU5 controller or the TDC600 model 1 handheld.

1. In the Tunnels app, tap  and select **Survey / Scanning**.
Alternatively, from General Survey, tap  and select **Measure / Scanning**.
2. Enter the **Scan name**.
3. To select the area inside the video window that needs to be captured, select the **Framing** method and then define the frame area.

Framing method	To define the frame area...
Rectangle - corners	<p>Tap in the video window to define the first corner and then tap the diagonally opposite corner of the scan rectangle.</p> <p>If required, tap Complementary frame</p>  <p>to select the horizontal complement to the currently defined frame. For example, if you define a frame that is 90°, tap Complementary frame to select the area that is 270°.</p>
Rectangle - sides	<p>Tap in the video window to define the left side and then the right side of the scan frame. By default the vertical edges of the rectangle are up to the zenith and down to 148° (164 gon), but you can limit this if required.</p> <p>To limit the vertical edges of the frame, tap a third time in the video window. To switch between the upper and lower selection, tap Nadir or Zenith. If required, tap again in the video window to limit the upper or lower edge of the rectangle you have defined.</p>

Framing method	To define the frame area...
	<p>If required, tap Complementary frame</p>  <p>to select the horizontal complement to the currently defined frame. For example, if you define a frame that is 90°, tap Complementary frame to select the area that is 270°.</p>
Polygon	Tap in the video window to define each vertex of the polygon scan area.
Horizontal band	<p>Tap in the video window to define the vertical edges of the full 360° horizontal band.</p> <p>Do one of the following:</p> <ul style="list-style-type: none"> • To define the upper limit of a band down to 148°, tap in the video window above 90° VA. • To define the lower limit of a band up to the zenith, tap in the video window below 90° VA. <p>To switch between the upper and lower selection, tap Nadir or Zenith.</p>

Framing method	To define the frame area...
	If required, tap again in the video window to limit the upper or lower vertical edge of the horizontal band you have defined.
Full dome	No frame definition is required. The full dome always scans a full 360° horizontally and vertically up to the zenith and down to 148° (164 gon).
Half dome	No frame definition is required. The half dome always scans 180° horizontally (centered at the HA of the instrument), and vertically up to the zenith and down to 148° (164 gon).

TIP – When the frame is filled it is an acceptable frame; if the frame is hollow then the closing line is crossing another line which must be rectified before you are able to start the scan.

When defining the frame area, tap **Undo**



to remove the last created frame point, or tap **Reset region**




to clear the framing region and start again.


The software uses the defined frame area to calculate the **Number of points** and **Estimated time** required to complete the scan.

NOTE – The time to complete a scan is an estimate only. Actual scan times will vary depending on the surface or object being scanned.

4. Select the required **Scan density**.

To check the point spacing for the selected scan density, enter the distance to the target in the **At distance** field. To measure the distance to the target, tap  and select **Measure**. The value shown in the **Point spacing** field shows the point spacing at the specified distance.

NOTE – Only the Telecamera is coaxial with the telescope. For accurate framing at close range, enter the approximate distance from the instrument to the object being scanned in the **At distance** field and then define the scan frame. Entering the correct distance ensures the scan frame is drawn in the correct position by correcting for the offset between the Overview or Primary camera and the telescope.


5. To limit the scan range, select the **Scan limits** check box, and then enter the **Minimum distance** and **Maximum distance** values for acceptable scan points. **Points outside the specified range will not be stored.** To measure the distance to a target or object, tap  and select **Measure**.
6. To capture a panorama image with the scan, select the **Panorama** check box and specify the panorama settings.
7. To change the tilt tolerance, tap **Options** and then enter a new value in the **Tilt tolerance** field. The software automatically checks the tilt of the instrument during scanning.

NOTE – If the compensator is disabled, the value entered in the **Tilt tolerance** field is ignored.

8. Tap **Next**.

If you are using the SX10/SX12 Telecamera, or have enabled the **Fixed exposure** setting, the software prompts you to point the instrument toward the location that defines the camera exposure and/or focal distance that you want used for the image.

NOTE – This location is only used for the camera settings. When scanning using a **half dome** frame, the HA of the instrument when you previously tapped **Next** is used for the center of the scan frame.

TIP – If you are using the SX10/SX12 Telecamera, make sure the zoom level indicator in the top left of the Video feed shows **Telecamera**. If the Telecamera cannot focus automatically on the object of interest, tap  in the **Video** toolbar to view the Instrument camera options. Select the **Manual focus** check box and then tap the arrows to adjust the camera focus.

9. Tap **Start**.

The software shows the progress of the scan. When the scan is complete, the instrument returns to its original position.

To cancel a scan that is in progress, tap **Esc** and then select whether to save or delete the scan. The scanning record and associated RWCX file will still be written if you manually cancel a scan.

TIP – To repeatedly scan the same area, you can quickly and easily repeat scans by loading a previous scan in the same job or a linked job. See [To repeat SX10 or SX12 scans, page 70](#).

To repeat SX10 or SX12 scans


If you are using a Trimble SX10 or SX12 scanning total station to scan the same area multiple times, you can quickly and easily repeat scans by loading a previous scan in the same job or a linked job. For example, you

can scan a floor once to find the high or low areas that need leveling, and after performing remedial work you can repeat the scan to confirm the floor is within the required tolerances.

NOTE – To load a scan:

- The instrument must be set up on the same point as the scan you want to repeat.
- Make sure the **At distance** value is accurate so that the software can correctly recalculate the vertical angles and account for differences in instrument height between the scans.

To load a previous scan

1. Tap  and select **Measure / Scanning**.
2. Tap **Load**.

The software shows a list of all of the scans in the current job and linked jobs that have been taken at the same point as the current station.



3. Select the scan to load.

The **Scanning** screen shows the scan parameters of the selected scan, including the scan frame. The **Scan name** is automatically based on the name of the loaded scan.

4. If required, edit the scan parameters.
5. Tap **Start**.

To save scan parameters without scanning

You can define scan parameters and save them to load later, without having to complete the scan.

1. Tap  and select **Measure / Scanning** and define the scan parameters, including the frame. Alternatively, load a previous scan and modify it.
2. Tap  or swipe right to left (or left to right) along the row of softkeys and tap **Save**.

A scan record containing zero points is written to the job. Note that there is no associated .rwcx file for an empty scan.

TIP – If you create an empty scan and then later do not want it to appear in the list of scans to load, you can delete it in the **Review job** screen.

Surface inspection

The **Surface inspection** cogo function compares the scan point cloud of an as-built surface with a reference surface and calculates the distance to the reference surface for each scan point to create an inspection point cloud. The selected reference surface can be a plane, cylinder, scan, or existing surface file.





You can create a **region** to include in the inspection only the scan points you are interested in. A region contains scan points from one or more .rcwx scan point clouds or from other regions. The region can be used to compare against any reference surface or, when performing a scan to scan surface inspection, create a region so that you can compare multiple scans with multiple scans.

Points in the inspection point cloud are color-coded to provide immediate visual feedback between the point cloud and the reference surface. When inspecting a horizontal floor, for example, you will be able to see immediately any parts of the floor that are lower than they should be, and any parts of the floor that are higher than they should be.

You can save the inspection point cloud to the job. You can also save screen captures and annotate them if required, to highlight particular point details and problem areas.

NOTE – Only scans created using a Trimble SX10 or SX12 scanning total station can be used in the surface inspection. Multiple scans can be used if more than one scan is required to cover the as-built surface.

To inspect a surface


1. In the Tunnels app, tap  and select **Survey / Surface inspection**.
Alternatively, from General Survey, tap  and select **Cogo / Surface inspection**.
You can perform the inspection in the map view or the video view.
 2. Set up the map or video screen so that it shows only the scan points you want to inspect:
 - a. Tap  in the **Map** toolbar or the **Video** toolbar to open the **Layer manager** and select the **Scans** tab.
 - b. Select the scan or scans to include in the inspection.
The check mark inside a square  next to the file name appears, indicating scan points are visible and selectable in the map and video view.
 - c. To create a region, select the scan points in the map or video screen, and then from the tap and hold menu select **Create region**. Enter the region **Name** and tap **Accept**. The region you created is listed in the **Scans** tab of the **Layer manager**. Tap the region to make the region visible in the map and video view.
 - d. If there are scans or regions visible that you do not want to show in the map or video screen, tap each of them in turn. The check mark next to the scan or region name disappears when they are hidden from view.
- TIP** – If you are doing a scan to scan inspection, at this point the map or video screen should show the scan points you are most interested in and all other scans or regions should be hidden. You will select the scan or region to compare against from the list of hidden scans in the **Surface inspection** form.
- e. To return to the **Surface inspection** form, tap **Accept** in the **Layer manager**.
 3. Enter a **Name** for the surface inspection.

4. Select the **Method** and then enter the parameters to define the **Reference surface** against which to compare the as-built scan or region:

- If you select **Scan to horizontal plane**, select a point and enter the elevation to define the **horizontal plane**.
- If you select **Scan to vertical plane**, select two points to define the **vertical plane**.
- If you select **Scan to inclined plane**, select three points to define the **inclined plane**.
- If you select **Scan to cylinder**, select two points that define the axis of the **inclined or horizontal cylinder** and then enter the radius of the cylinder.
- If you select **Scan to vertical cylinder**, select three points to define the **vertical cylinder**.
- If you select **Scan to surface**, the currently selectable surfaces in the job are listed. Supported surface file types are DTM and TTM, and files that include selectable surfaces (DXF, RXL, TXL, 12da) as well as whole objects or individual faces in a BIM model.

Surfaces must be visible and selectable to be used as the reference surface. If the file contains selectable surfaces you must select the surface or surfaces to use in the inspection from the map.

TIP – To use individual faces as surfaces in the BIM model, open the **Map settings** screen and set the **Surface selection mode** field to **Individual faces**.

To change the listed surfaces, tap  and change which surfaces are selectable in the **Map files** tab of the **Layer manager**.

- If you select **Scan to scan**, select the scan or region to compare against earlier scan data.

TIP – To compare against more than one scan, create a region that includes scan points from all the scans you are interested in. Only scans or regions **not currently visible** in the map or video screen are listed in the **Reference scan** field. For more information, see **To manage scans** in the *Trimble Access General Survey User Guide*.

5. In the **Color scale** field, select the color scale to use for the inspection results.


To modify the color scale parameters, tap the color scale softkey in the **Surface inspection** screen. See [To define the color scale parameters](#) below.

6. Tap **Calc**.

The software compares the visible scans or regions or the selected scan points to the defined **Reference surface** and creates an inspection point cloud. Points in the inspection point cloud are colored using the selected **Color scale**.

The **Actual** range group shows the minimum and maximum distances between the scan and the reference surface.

To inspect the surface further:

- Tap any inspection point to view the coordinates of the point. The **Dev** value shows the deviation (distance) from that point to the reference surface. The **Dev** value is stored in the **Code** field for the inspection point.
 - To turn the connected instrument to the selected point, tap **Turn to**. If the connected instrument has a laser pointer, turn on the laser pointer to highlight where any remedial work may be required.
 - To create a screen capture of the current software view, including the map and **Surface inspection** form, tap . If required, annotate the screen capture using the **Draw** tools and tap **Store**. To save the screen capture to the job, tap **Store**.
7. Tap **Store**. The inspection parameters are saved to the job.
- All inspection points that you had selected in the map or **Video** screen are saved to the job.
- You can view the saved inspection in the map at any time. See [To view a saved surface inspection](#) below.
- The surface inspection is immediately hidden from the map and the **Surface inspection** form is ready for a new inspection.

TIP – You can create a **Surface inspection** report PDF file from the **Job / Export** screen. The **Surface inspection** report includes a summary of the surface inspection parameters, any screen captures of the surface inspection, and any inspection points stored with the surface inspection.

To define the color scale parameters

Depending on the surface being inspected and the tolerances required, you can create multiple color scale definitions with different colors and different distance separations. Select the most appropriate color scale definition to highlight variations in distance from the scan to the reference surface.

To define the color scale parameters:


1. Tap the color scale softkey below the **Surface inspection** form.
2. In the **Color scales** screen, select the color scale you want to change and then tap **Edit**.
Alternatively, tap **Copy** to create a new color scale based on the one you have selected. To create a new empty color scale, tap **New**. Enter the color scale name and tap **Accept**. The software shows the edit screen for the selected color scale.
3. To change the distances used for the color scale, enter or edit the values in the left column. To remove distances, delete the value in the appropriate fields, or select the field and tap **Delete**.
Distances do not have to be entered in strict order. To insert a distance, simply add it anywhere and the list is automatically resorted.
4. For each distance value, in the right column select the color to use for scan points within that distance from the reference surface.

TIP – To better highlight scan points of interest, you can select **Transparent** for scan points that you do not want to be shown. For example, set the color for scan points **outside** of the ranges you are interested in to **Transparent**, so that only points you are interested in are colorized and shown on the map.

5. To set the color scale to use gradients which transition smoothly between colors, select the **Smooth transition** check box at the top of the screen. To turn off gradients and display the color scale as blocks, clear the **Smooth transition** check box.
6. Tap **Accept**.
7. To return to the **Surface inspection** screen, tap **Esc** in the **Color scales** screen.

To view a saved surface inspection

When you tap **Store** in the **Surface inspection** screen, the inspection is saved to the job. To view the inspection later:

1. Tap  in the **Map** toolbar or the **Video** toolbar to open the **Layer manager**.
2. Select the **Inspections** tab.
3. Tap an inspection to select it or deselect it. A check mark indicates the inspection is selected. You can select only one inspection to view at a time.


The inspection is shown in the map.


For more information, see **To manage inspections** in the *Trimble Access General Survey User Guide*.

To stake out the tunnel alignment

When staking an alignment defined in a TXL file, you can work from the map or from the menu.

To stake out the alignment:

1. In the map, tap the alignment and then tap **Stakeout**. Alternatively, tap  and select **Stakeout**. Tap **Alignments**, select the alignment to stake and tap **Next**.

If the alignment you want to stake out is not shown in the map, tap  in the map toolbar to open the **Layer manager** and select the **Map files** tab. Select the file and then make the appropriate layer (s) visible and selectable. The file must be in the current project folder.

2. If you have not yet started a survey, the software prompts you through the steps to start the survey.

The alignment is ready to stake, using your preferred stakeout method. For more information, refer to the topic for the selected method. See:

[To stake out to the tunnel alignment, page 76](#)

[To stake out a station on the tunnel alignment, page 76](#)

To stake out to the tunnel alignment

1. Tap the alignment in the map or select **To the alignment** in the **Method** field.
2. If **construction offsets** are required, enter the required values in the **Horizontal offset** and/or **Vertical offset** field. See [Tunnel construction offsets, page 78](#).

3. Tap **Next**.

On the map, a dashed green line is drawn at a right angle from your current position to the alignment. The elevation of your current position and the design elevation of the computed position are shown.

The cross section shows your current position and the target, and is orientated in the direction of increasing station. Construction offsets appear as yellow lines. If construction offsets are specified, the smaller single circle indicates the selected position and the double circle indicates the selected position adjusted for the construction offsets.

4. Point the instrument at the position you want to measure. To turn the instrument to the nearest point on the alignment, tap **Turn**.

If required, tap **Options** to stakeout options. See [Tunnel survey settings and tolerances, page 85](#).


5. When the point is within tolerance, tap **Accept** to store the point.


NOTE – When using a Trimble SX12 scanning total station in **TRK** mode with the *laser pointer enabled*, the **Stakeout** screen shows the **Mark point** softkey instead of the **Accept** softkey. Tap **Mark point** to put the instrument into **STD** mode. The laser pointer stops flashing and moves to position itself at the EDM location. When you tap **Accept** to store the point, the instrument automatically returns to **TRK** mode and the laser pointer resumes flashing. To remeasure and update the stakeout deltas, tap **Measure** after you tap **Mark point** and before you tap **Accept**. For more information, see [Tunnel survey settings and tolerances, page 85](#).

6. Tap **Esc** to return to the **Stake alignment** selection screen.

To stake out a station on the tunnel alignment

1. Tap the alignment in the map, and then select **To station** in the **Method** field.
2. If **construction offsets** are required, enter the required values in the **Horizontal offset** and/or **Vertical offset** field. See [Tunnel construction offsets, page 78](#).
3. To select the station to stake:
 - In the **Station** field, enter the station value.
 - Tap ► next to the **Station** field, select **List** and then select one of the design station values from the TXL file.
 - If you can see the station that you want to measure from your position in the tunnel, tap in the **Station** field and then turn the instrument to the required station and tap **Measure** to calculate the station value.

If you are using a Trimble instrument that has VISION technology, you can tap  in the map toolbar to view the video feed and then tap the location in the video (for example the prism or tunnel wall), and then tap **Measure** to calculate the station value.

4. Enter the **Station interval** used to determine subsequent station values. Tap  and make sure that the correct interval method is selected:
 - The **0 based** method is the default method and gives station values that are multiples of the station interval. For example, if the start station is 2.50 and the station interval is 1.00, the **0 based** method produces stations at 2.50, 3.00, 4.00, 5.00, and so on.
 - The **Relative** method gives station values relative to the start station. For example, if the start station is 2.50 and the station interval is 1.00, the **Relative** method produces stations at 2.50, 3.50, 4.50, 5.50, and so on.

5. Tap **Next**.

On the map, a dashed green line is drawn at a right angle from your current position to the alignment. The elevation of your current position and the design elevation of the computed position are shown.

The cross section shows the target station with your current position projected onto it. Construction offsets appear as yellow lines. If construction offsets are specified, the smaller single circle indicates the selected position and the double circle indicates the selected position adjusted for the construction offsets.

6. Point the instrument at the position you want to measure. To turn the instrument to the nearest point on the alignment, tap **Turn**.

If required, tap **Options** to stakeout options. See [Tunnel survey settings and tolerances, page 85](#).

7. When the point is within tolerance, tap **Accept** to store the point.

NOTE – When using a Trimble SX12 scanning total station in **TRK** mode with the **laser pointer enabled**, the **Stakeout** screen shows the **Mark point** softkey instead of the **Accept** softkey. Tap **Mark point** to put the instrument into **STD** mode. The laser pointer stops flashing and moves to position itself at the EDM location. When you tap **Accept** to store the point, the instrument automatically returns to **TRK** mode and the laser pointer resumes flashing. To remeasure and update the stakeout deltas, tap **Measure** after you tap **Mark point** and before you tap **Accept**. For more information, see [Tunnel survey settings and tolerances, page 85](#).

8. Continue staking points along the alignment. To select the previous station, tap the **Sta-** softkey. To select the next station, tap **>** and then tap the **Sta+** softkey.

Tap **Esc** to return to the **Stake alignment** selection screen.

Tunnel construction offsets

A point to be staked can be offset by a horizontal or a vertical offset.

The direction of vertical offsets is determined by the orientation of TXL templates (see [Applying templates to the vertical alignment, page 34](#)). If templates are perpendicular, vertical offsets will be perpendicular to alignment.

During stakeout a construction offset is indicated by a green line, with the double circle indicating the selected position adjusted for the specified construction offset(s).

Horizontal construction offsets

When staking stations on the alignment, you can define a horizontal construction where:

- A negative value offsets points to the left of the alignment.
- A positive value offsets points to the right of the alignment.

Vertical construction offsets


You can define a vertical construction offset where:

- A negative value offsets points vertically down.
- A positive value offsets points vertically up.


Measure to a surface

Use the **Measure to surface** measurement method to calculate and store the closest distance from the measured point to the selected surface model. The surface model can be a BIM model or a digital terrain model (DTM).

NOTE – If more than one surface is selected, the nearest surface is used.

1. If the surface is in:
 - a DTM, in the Tunnels app, tap  and select **Survey / Measure to surface**. If there is more than one surface available, select the surface in the **Select surface** field.
 - a BIM model, select the surface in the map and then from the tap and hold menu select **Measure to selected surface**.

NOTE – To select the surface the BIM model must be displayed as a solid object and the layer containing the surface must be selectable.

TIP – You can choose whether selecting surfaces in the map selects **Individual faces** or selects the **Whole object**. To change the **Surface selection** mode, tap  on the BIM toolbar and select your preferred **Surface selection** mode.

2. Enter the **Distance to surface limit**.
3. If required, enter a value in the **Antenna height/Target height** field.
4. Tap **Start**.

If the surface is not already visible in the map, it becomes visible.

The software calculates and reports the closest distance from the current position to the selected surface model and displays it in the **Distance to the surface** field. The **Distance to the surface** is only shown if it is within the **Distance to surface limit**.

The position on the surface is highlighted in the map and a line is drawn from the measured position to the position on the surface. Negative distances are reported for positions between you and the model and positive distances are reported for positions on the other side of the model.

TIP – If the software warns **Terrain models disagree**, there are overlapping surfaces with different elevations in the map. Hide any surfaces you are not using in the **Map files** tab of the **Layer manager**.



5. Enter the **Point name** and, if required, the **Code**.
6. Tap **Measure**.
7. Tap **Store**.

The **Distance to surface** value and the coordinates of the closest point on the surface are stored with the measured point and can be viewed in **Review job** and **Point manager**.

To determine the station elevation

In a conventional survey, use the station elevation function to determine the elevation of the instrument point by making observations to points with known elevations.

NOTE – The station elevation calculation is a grid calculation. Use only points that can be viewed as grid coordinates. To calculate the station elevation you need at least one angles and distance observation to a known point, or two angles only observations to different points.

1. Start a survey and perform a station set up.
2. In the Tunnels app, tap  and select **Survey / Station elevation**.
Alternatively, from General Survey, tap  and select **Measure / Station elevation**.
The instrument point details entered during the station setup are shown.
3. If you did not enter the instrument height during station setup, enter the instrument height now. Tap **Accept**.

4. Enter the point name, code, and target details for the point with the known elevation.
5. Tap **Measure**. Once the measurement is stored, the **Point residuals** screen appears.
6. In the **Point residuals** screen, tap:
 - **+ Point** to observe additional known points
 - **Details** to view or edit point details
 - **Use** to enable or disable a point
7. To view the station elevation result, tap **Results** in the **Point residuals** screen.
8. Tap **Store**.

Any existing elevation for the instrument point is overwritten.

To position the machine

Use machine positioning to position a machine, typically a drilling rig, relative to the tunnel.

How machine positioning works

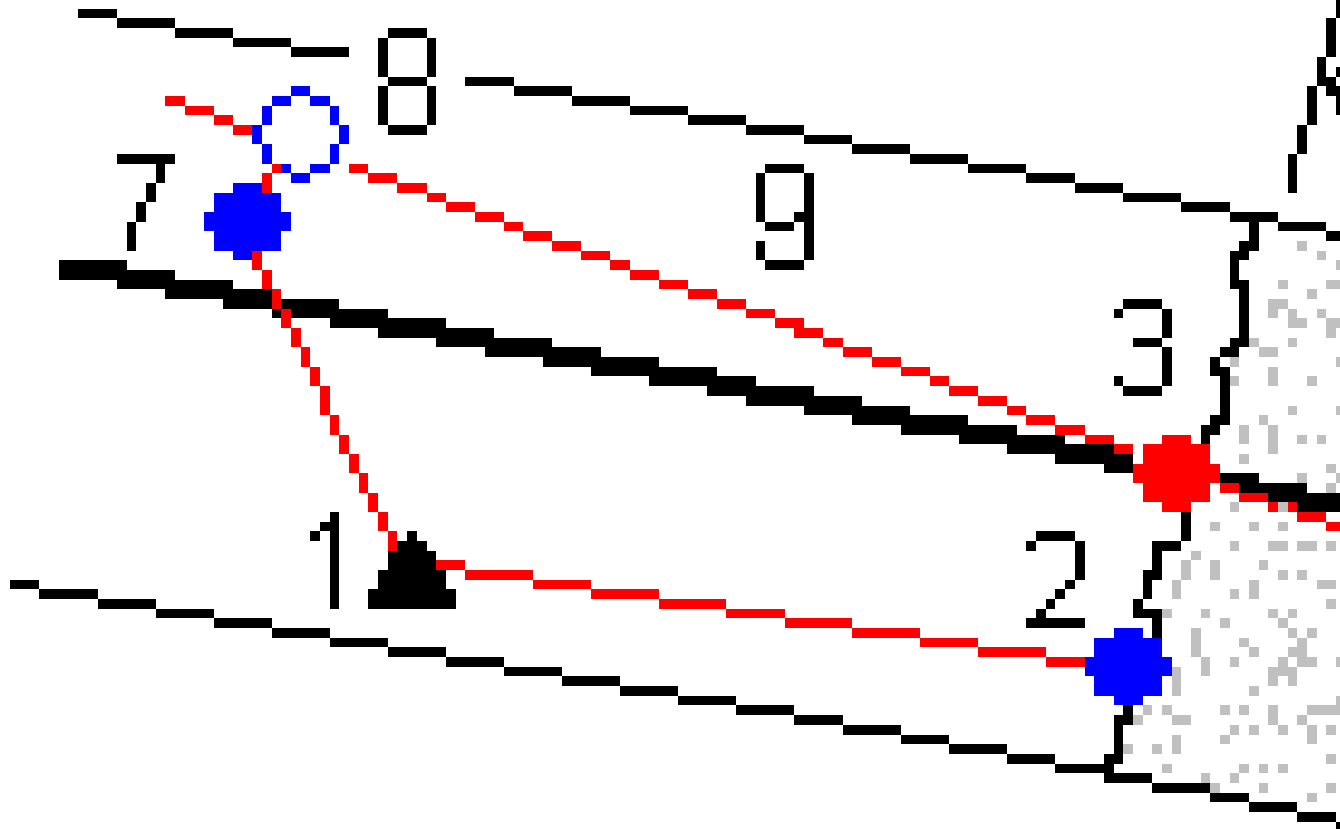
To position the machine relative to the tunnel, the software calculates positions on the horizontal alignment at the nominal station and at the station defined by the drill depth. A reference line is calculated using these two positions.

NOTE – The reference line cannot be calculated if the:

- nominal station is before the start of the tunnel
- drill depth is zero
- drill depth results in a station beyond the end of the tunnel

Once the reference line is calculated, the transverse and vertical offsets from a measured point to a position calculated perpendicular onto the reference line are displayed, along with the longitudinal offset from the calculated position on the reference line to the calculated position at the tunnel face.


You can use these deltas to position the machine.



- | | | | |
|----------|---|----------|--------------------------------|
| 1 | Instrument position | 2 | Nominal station at tunnel face |
| 3 | Calculated position on the alignment projected from 2 | 4 | Drill depth |
| 5 | Calculated position on alignment at drill | | |

depth	6	Reference line	7
Measured point	8	Calculated position on reference line projected from 7	
7 to 8	Transverse and Vertical offsets	9	Longitudinal offset

To position the machine

1. Start a survey.
2. Tap  and select **Machine position / Machine positioning**.
3. Select the tunnel file. Tap **Accept**.
4. Enter the **Nominal station** of the tunnel face. Key in a value or tap **Measure** and measure the station.
5. Enter the **Drill depth**.
6. Tap **Next**.
The calculated station and elevation values and coordinates for the two positions defining the reference line are displayed along with the azimuth and grade of the reference line.
7. Use these values to confirm the reference line. Tap **Next**.
The offsets from the measured point to the position calculated perpendicular onto the reference line are displayed, along with the longitudinal offset from the calculated position on the reference line to the calculated position at the tunnel face.
8. Use these deltas to position the machine.
9. If required, enter **Construction offsets**. You can enter a:
 - **Transverse offset** – to offset the reference line left or right of its computed position
 - **Vertical offset** – to offset the reference line up or down from its computed position
10. Tap **Finish**.

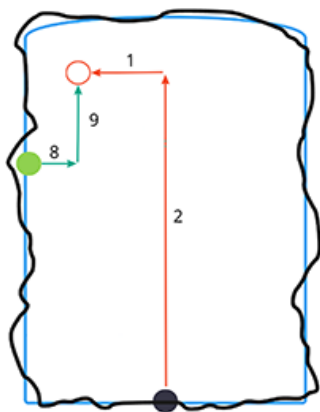
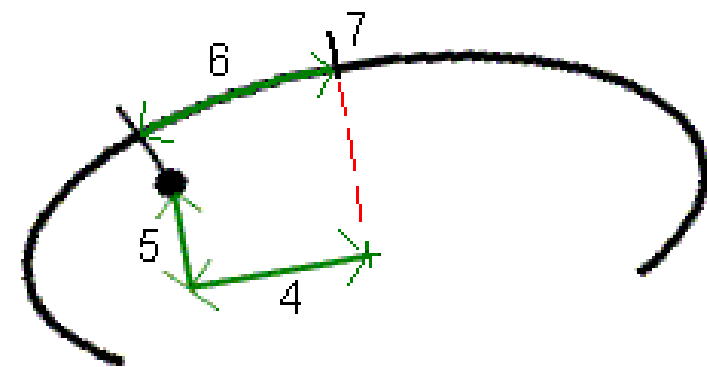
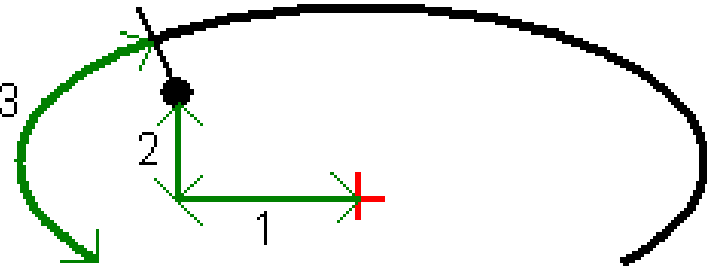
Current position information

Information on the current position and, if applicable, its relationship to the selected set out position appears below the plan view or cross section view.

To show or hide deltas, tap and hold in the delta display area of the screen. In the **Deltas** list, tap a delta to change whether the delta is displayed. A check mark indicates the delta will be shown. To reorder the deltas, tap and hold a delta and drag it up or down the list. Tap **Accept**.

If, when measuring without a prism, your current position (displayed as a cross) fails to update, then ensure the **Apply target height perpendicular to profile** option from **Settings** is not selected.

To scroll through the values, tap the arrow to the left of the text. Refer to the diagrams and the table below for a description of the information that may appear.



Number	Value	Description
–	Station	The station of the current position in terms of the tunnel design.
–	Underbreak/Overbreak	The underbreak or overbreak of the current position in terms of the selected template surface. Appears in red if it is out of tolerance.
–	Rotation	The rotation value of the cross section at the current position.
–	Delta station	The difference between the station of the current position and the station of the target.
–	Delta offset	The radial difference between the measured position and the set out position. Appears in red if it is greater than the <i>Position tolerance</i> .
–	Rotation	The rotation value of the cross section at the current position.
1	H.Offset	The horizontal offset of the current position from the alignment (shown as a red cross). If the alignment has been offset, the horizontal offset is from the offset alignment (shown as a smaller green cross).
2	V.Offset	The vertical offset of the current position from the alignment (shown as a red cross). If the alignment has been offset, the vertical offset is from the offset alignment (shown as a smaller green cross). May be either perpendicular or true vertical, depending on the template position options in the Tunnel design.
3	Profile dist.	The profile distance of the current position measured along the selected template surface from its start point.
4	Hz. off. (rot)	The horizontal offset of the current position from the rotated alignment (shown as a green cross) and rotated with the tunnel.
5	Vt. off. (rot)	The vertical offset of the current position from the rotated alignment (shown as a green cross) and rotated with the tunnel. Maybe either perpendicular or true vertical, depending on the template position

Number	Value	Description
		options in the tunnel design.
6	Dist. to vertex	The profile distance from the vertex (7) to the current position. The vertex (shown as a black line) is defined by the intersection of a perpendicular line from the rotated alignment (shown as a green cross) to the tunnel roof.
8	Δ H.Offset	The difference between the horizontal offset of the projected line of the pipe or blast hole and the current position measured by the instrument.
9	Δ V.Offset	The difference between the vertical offset of the projected line of the pipe or blast hole and the current position measured by the instrument.
–	Distance along alignment	The slope distance of the alignment. Due to the slope of the alignment, this value may be greater than the Station delta, which uses 2D stationing or chainage.
–	Northing	Northing of the current position.
–	Easting	Easting of the current position.
–	Elevation	Elevation of the current position.

Tunnel survey settings and tolerances

The available fields depend on the survey method.

TIP – To improve performance when surveying, configure the **EDM timeout** field if it is available. If the instrument struggles to get a measurement due to, for example, reflective or dark surfaces, increase the EDM timeout. This setting is not available when connected to a Trimble SX10 scanning total station because the EDM times out automatically.

Scan and manual settings

- Enter the **Start point** name, **Point code**, and **Scan interval**. Points to be scanned are defined by the scan interval, and include the start and end points that define each element in the template surface.
- Use the **On station adjustment** option to control where the position will be measured when the tunnel surface does not match the design, for example if the tunnel surface is irregular in places. If

selected, **Auto OS** appears at the top left of the screen. You must specify a station tolerance if using this option. See [On station adjustment, page 89](#).

- When measuring manually with a prism, select the **Apply target height perpendicular to profile** option. This option enables a position to be measured perpendicular to the tunnel profile when using a prism by entering the prism radius as the target height. See [Position measurements using a prism, page 91](#).
- If you are using a Trimble VX spatial station, select the **VX scanning** option for improved scanning performance.
- Select **Instrument perspective profile display** to display the tunnel profile in the direction the instrument is facing. This option is especially useful when you are facing in the direction of decreasing station, as the tunnel profile is then displayed in the same sense that the instrument is pointing, rather than always assuming you are facing in the direction of increasing station.

Position in tunnel settings

- Set the **Point name** and **Point code**.
- When measuring manually with a prism, select the **Apply target height perpendicular to profile** option. This option enables a position to be measured perpendicular to the tunnel profile when using a prism by entering the prism radius as the target height. See [Position measurements using a prism, page 91](#).
- Select **Instrument perspective profile display** to display the tunnel profile in the direction the instrument is facing. This option is especially useful when you are facing in the direction of decreasing station, as the tunnel profile is then displayed in the same sense that the instrument is pointing, rather than always assuming you are facing in the direction of increasing station.

Stakeout settings

- Set the **Point name** and **Point code**.
- Select the **Measurement mode** for the connected instrument:
 - Select **STD** to use EDM Standard mode, where the instrument averages the angles while a standard distance measurement is taken.
 - Select **FSTD** to use EDM Fast Standard mode, where the instrument averages the angles while a fast standard measurement is taken.
 - Select **TRK** to use EDM Tracking mode, where the instrument constantly measures distances and updates them in the status line.
- To set the total station EDM to **TRK** mode regardless of the **Measurement mode** setting when you enter stakeout, select the **Use TRK for stakeout** check box.
- If you are using the Trimble SX12 scanning total station in **TRK** mode and the laser pointer is enabled, the **Mark point with laser pointer** check box is available.

- When the **Mark point with laser pointer** check box is selected, the stakeout screen shows the **Mark point** softkey instead of the **Accept** softkey. Tap **Mark point** to put the instrument into **STD** mode. The laser pointer stops flashing and moves to position itself at the EDM location. When you tap **Accept** to store the point, the instrument automatically returns to **TRK** mode and the laser pointer resumes flashing. To remeasure and update the stakeout deltas, tap **Measure** after you tap **Mark point** and before you tap **Accept**.
- When the **Mark point with laser pointer** check box is not selected, the **Stakeout** screen shows the **Accept** softkey as usual and the point is measured at the location of the laser pointer.

Set out settings

- In the **Start point** field, enter the required point name for the first set out point. The names of subsequent set out points will automatically increment from the entered point name.
- If you are setting out all blast holes, enter the **Start delay** and **Mark delay** values to control the automated set out process.

The **Start delay** gives you time to walk to the location of the first point to be marked.

The **Mark delay** is the length of time, in seconds, that the laser pointer flashes once the position is found, which gives you time to mark the point on the tunnel wall.

When a position is found within tolerance, the **Mark point** event sounds and:

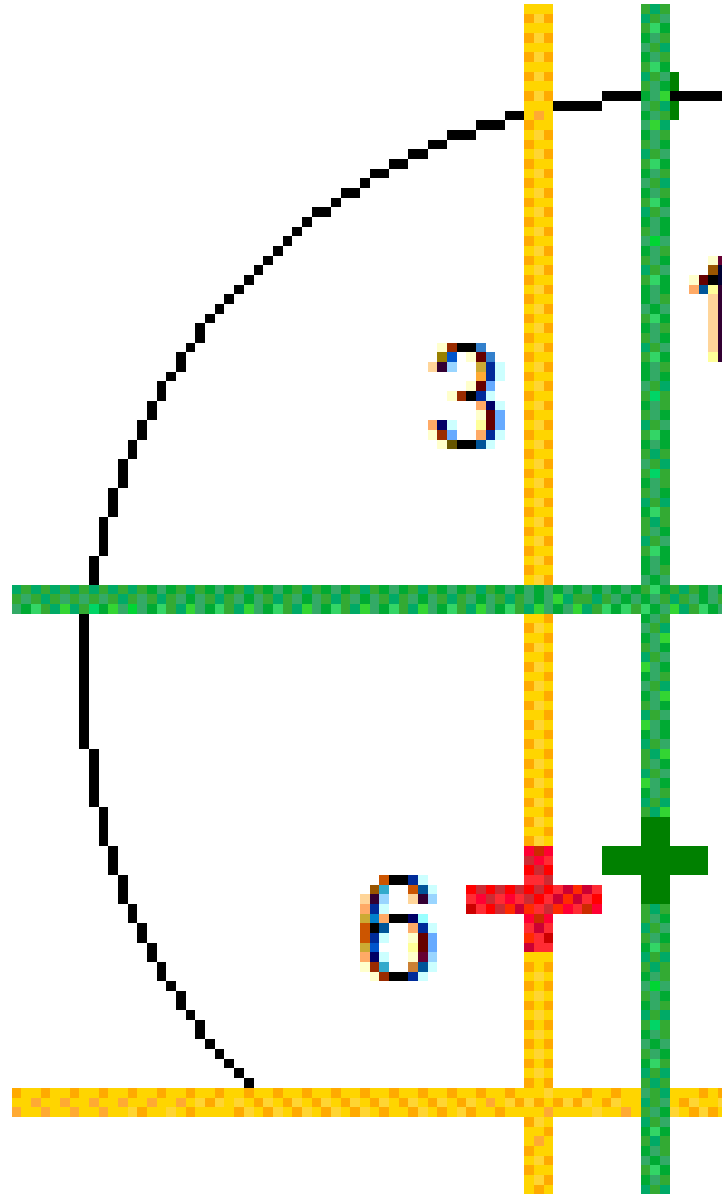
- If the instrument has a tracklight, the laser pointer *and* the tracklight flash for the period defined in the **Mark delay** field.
- If the instrument is a Trimble SX12 scanning total station, the laser pointer *changes to solid* and the Target Illumination light (TIL) flashes for the period defined in the **Mark delay** field.
- Select **Instrument perspective profile display** to display the tunnel profile in the direction the instrument is facing. This option is especially useful when you are facing in the direction of decreasing station, as the tunnel profile is then displayed in the same sense that the instrument is pointing, rather than always assuming you are facing in the direction of increasing station.

Cross section guidelines

For all survey methods you can display guide lines in the cross section view. Select:

- **Display profile vertical centerline** to display a vertical green line through the alignment or, if the alignment has been offset, the offset alignment.
- **Display spring line** to display a horizontal green line through the alignment or, if the alignment has been offset, the offset alignment.
- **Display alignment vertical centerline** to display a vertical orange line through the alignment.
- **Display floor line** to display a horizontal orange line through the alignment or, if the alignment has been offset, the offset alignment.

NOTE – The spring and floor lines can be offset vertically (up and down), relative to the alignment or, if the alignment has been offset, the offset alignment.



1 Profile vertical centerline

2 Spring line (offset vertically from the offset alignment)

3 Alignment vertical centerline

4 Floor line (offset vertically from the offset

alignment)	5	Offset alignment	6
Alignment			

Tolerances

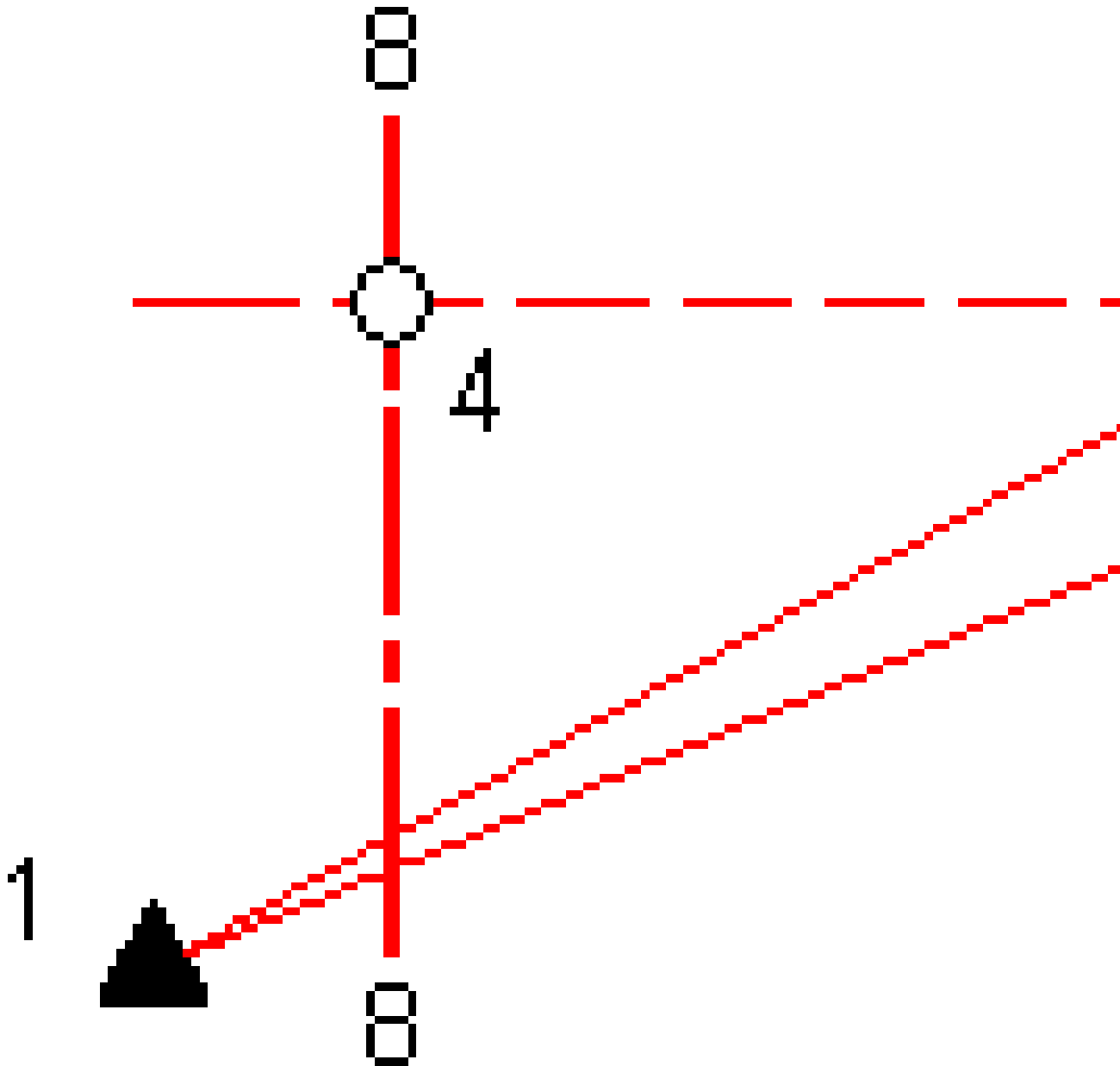
The available fields depend on the survey method.

- For **Auto scan**, set the **Station**, **Overbreak** and **Underbreak tolerances**, and the number of **Iterations**.
- For **Position in tunnel**, set the **Overbreak** and **Underbreak tolerances**.
- For **Set out**, set the **Position tolerance** and the number of **Iterations**. See [Set out position tolerance, page 93](#).

On station adjustment

From the **Settings** screen use the **On station adjustment** option to control the position that will be measured when the tunnel surface does not match the design, that is, the surface is in either underbreak or overbreak.

Refer to the following diagram and table that illustrates an underbreak situation.



1	Instrument position	5	Measured position when On station adjustment is selected
2	Tunnel surface	6	Measured position when On station adjustment is not selected

3	Tunnel design	7	Design position
4	Station	8	Horizontal alignment

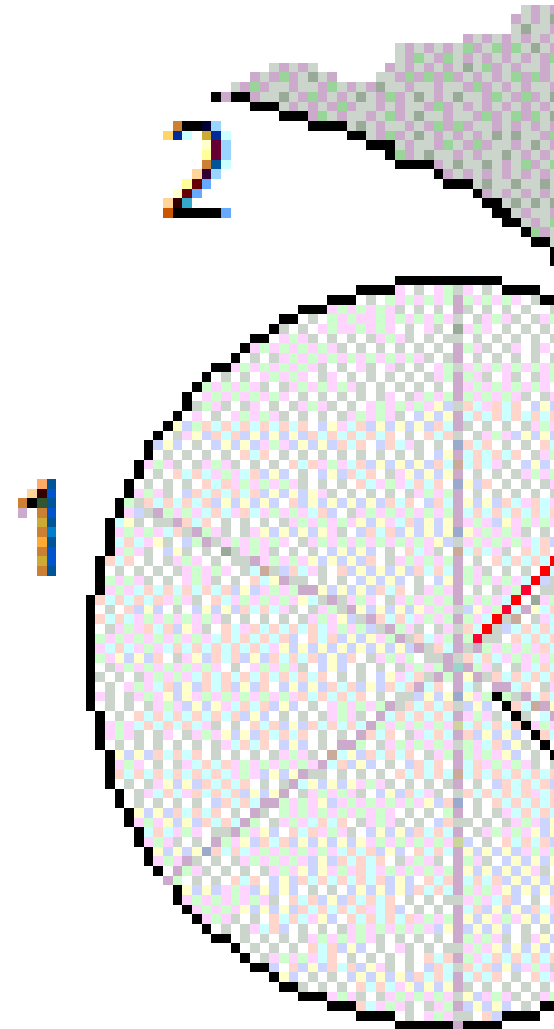
The overbreak is similar to the underbreak situation.

Position measurements using a prism

To measure a position perpendicular to the tunnel profile using a prism:

1. From the tap and hold menu, select **Settings**.
2. Select the **Apply target height perpendicular to profile** option.
3. Tap **Accept**.
4. From the status bar, enter the prism radius as the target height.

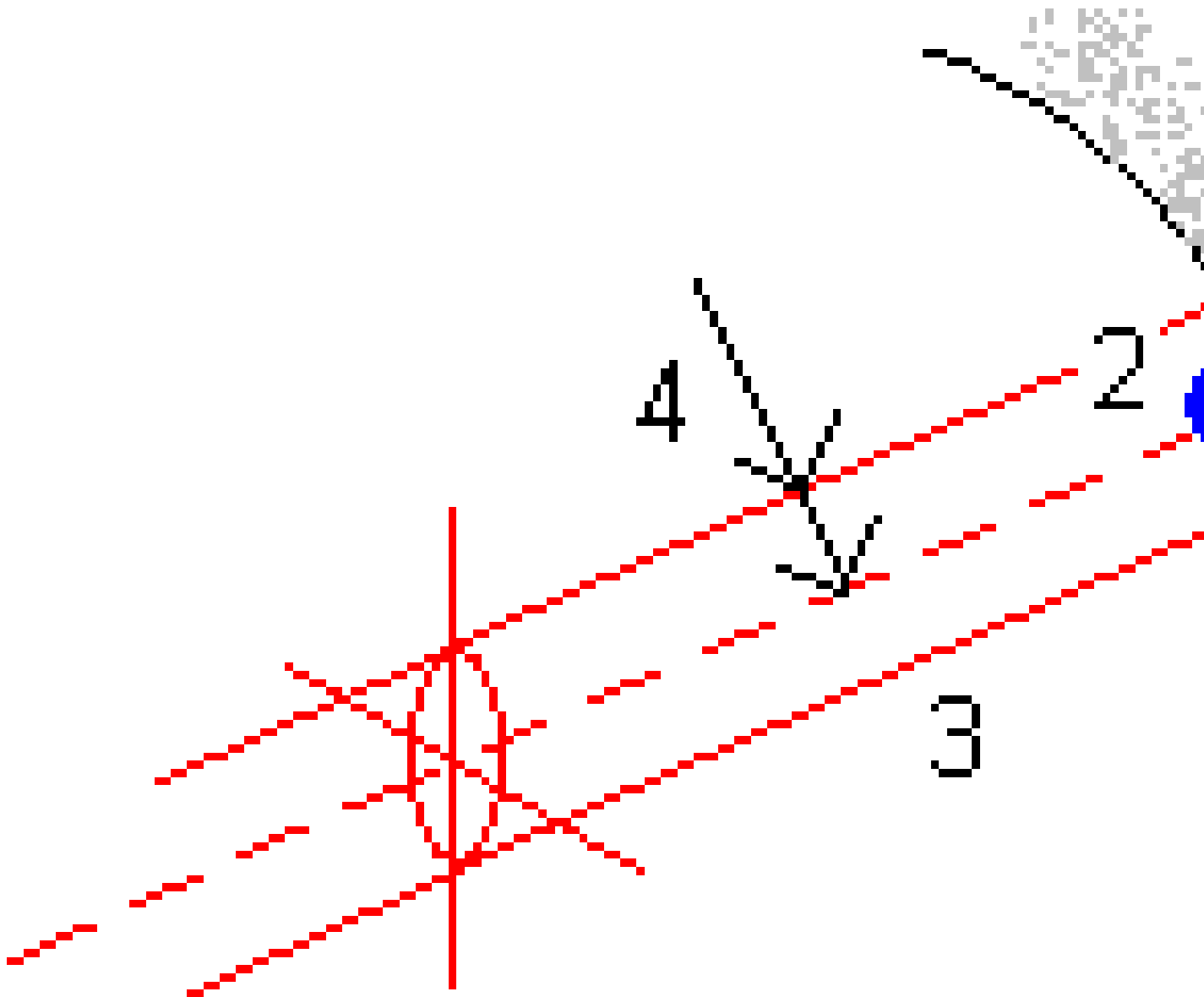
You can use the prism on a pole held perpendicular to the tunnel design surface, where the target height is used to project the prism measurement perpendicular onto the tunnel surface.



- | | | | |
|---|---------------|---|------------------------------|
| 1 | Prism | 2 | Tunnel surface |
| 3 | Design tunnel | 4 | Target height (prism radius) |
| 5 | Overbreak | | |

Set out position tolerance

The **Position tolerance** is defined as the radius of a cylinder that passes through the axis of the set out position. If the measured point is within this cylinder the point is within tolerance.



1 Tunnel surface

2 Set out position

3 Axis of cylinder

4 Radius of cylinder

Tunnel review

Create reports of the as-built tunnel in the field to:


- Check that the tunnel construction matches the design.
Assess the excavation, shotcrete, and lining process.
- Report on deltas between the staked location and design point for quality control.
- Report on tunnel volumes for underbreak and overbreak analysis.
- Share progress information with stakeholders and clients.


Reports show survey results for scanned points, manually measured points, and set out points.

NOTE – All scanned, measured and set out points are face 1 measurements and are stored in the database. You can review them in the **Review Job** screen.

TIP – When reviewing a tunnel the number of points within or outside tolerance and their delta values is controlled by the tolerance values defined when the tunnel was scanned. To edit these tolerance values after a survey, select **Tolerance** from the tap and hold menu at the plan or cross section review screens. This option is useful if incorrect values were specified for the survey.

To review surveyed tunnel points

1. Tap  and select **Review**.
2. Select the tunnel file. Tap **Accept**.
The plan view of the tunnel appears.
Stations with no scan points outside tolerance appear as solid green circles, while those with errors appear as solid red circles.
3. By default the first station is selected. Select other stations as required. The selected station appears as a red circle.
4. To view a summary for each station:
 - a. Tap **Results**.
 - b. Expand the station that you want to review. To view the number of:
 - Scanned points, the number of points within tolerance, and the number of points outside tolerance, expand the **Scanned points** record.

- Set out points and the number of points within tolerance expand the **Set out points** record
 - Points in underbreak/overbreak and delta station, expand the **Points outside tolerance** record.
- c. Tap **Close**.
5. To view the cross section for the current station:
- a. Tap  or press the **Tab** key to switch to cross section view.
 - b. Tap and hold on the screen and then select **Scanned points** or **Set out points**.

The selected mode, **Scan** or **Set out**, is shown at the top left of the screen.

Each scanned position appears as a green circle if it is within tolerance or as a red circle if it is not within tolerance.

Measured set out positions are indicated by a solid black circle.

The point name, underbreak/overbreak and delta station values appear for the current position.

6. Tap other points to view their delta values.
7. To delete the selected point, tap and hold on the screen and then select **Delete point**. To restore deleted points, tap and hold on the screen and then select **Restore deleted points**.
8. To edit the selected point:
 - a. Tap and hold on the screen and then select **Edit point**.
 - b. Enter an **Under/overbreak correction** value.

The displayed **Underbreak/Overbreak** value updates to reflect the correction. The correction is applied perpendicular to the tunnel design and is used to modify the original observation and calculate new HA, VA, and SD values. A note is attached to the cross section record in the job and records the name of the point edited, the original under/overbreak value, the correction applied, the new under/overbreak value and the original HA, VA and SD values.

Use this option to correct scan points that have been measured to an obstacle other than the tunnel surface, for example ventilation ducting.

9. To view details for a selected point:
 - a. Tap **Details**.
 - b. Expand the point that you want to review.

The Offsets (true), Offsets (rotated), Grid coordinates, Underbreak/Overbreak, and Delta station values are shown for each point. To view the:

- Horizontal and vertical offsets from the intersection of the horizontal and vertical alignments to the scanned/measured position, expand the **Offsets (true)** record.
- Rotated horizontal and vertical offsets from the intersection of the rotated horizontal and vertical alignments to the scanned/measured position, expand the **Offsets (rotated)** record.

- North, east, and elevation values for the measured positions, expand the **Grid** record.
 - c. Tap **Close**.
10. To close the **Review** screen, tap **Esc**.

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