

# TUNNELS

## USER GUIDE

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## Introduction

Trimble® Tunnels software is specifically designed for surveying in tunnels.

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.
  - 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.
  - 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

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 switch between applications, tap the application icon in the status bar and then select the application to switch to.

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

## Tunnel files

A tunnel file is a TXL file. When defining, surveying and reporting your tunnel the tunnel file must be in the current project folder.

## LandXML 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 <https://geospatial.trimble.com/product-and-solutions/access> and click **Downloads**.

- Download the ASCII File Generator utility program and install it to your office computer.
- Download the **LandXML To TunnelXML** XSL file and save it to the **\Custom ASCII Files** folder on your office computer.

### To convert a LandXML file to a txl file

1. On the office computer, select **Start / Programs / Trimble Data Transfer / ASCII File Generator** to start the ASCII File Generator utility program.
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** style sheet. 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

This topic describes the information that appears in the plan view and cross section view of the tunnel.

To switch between the plan view and the cross section view, tap  or , or press the **Tab** key.

Information on the current position and, if applicable, its relationship to the selected set out position appears at the bottom of the screen.

### 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 an up or down arrow on the controller keyboard.
- Tap an individual station.
- Tap and hold on the screen and then select a station from the list in the **Select stations** field.

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, from the second row of softkeys tap **Calc**.

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

## Cross section view

To view a popup 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

Item	Shown as
Blast hole set out point	A hollow black circle
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.

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

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

Plan view icon	Description	Cross section view icon	Description
	Station available for selection		Scanned position within tolerance
	Station unavailable for selection		Scanned position outside of tolerance
	Selected station (Auto scan)		Stored set out position
	Scanned station within tolerance		Set out position
	Scanned station with positions outside of tolerance		Selected set out position
	Current station		Alignment axis
	High-power laser pointer active		High-power laser pointer active
			Offset alignment axis / Rotated alignment axis
			Current position
			The tunnel profile is displayed in the direction of increasing station.

Plan view icon	Description	Cross section view icon	Description
			The tunnel profile is displayed in the direction of decreasing station.

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## Tunnel definition

When defining a tunnel, you create a TXL file and add elements to complete the tunnel definition.

- 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 or bolt holes 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 27](#).

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, or arcs in the job or in DXF, STR, SHP, or LandXML files and then create the tunnel from the selected entities.

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 10](#)
    - [End station entry method, page 12](#)
    - [Points of intersection \(PI\) entry method, page 13](#)
  - b. Select the transition type. See [Transition types, page 13](#).
  - c. To define the **vertical alignment** you can use the:
    - [Vertical points of intersection \(VPI\) entry method, page 16](#)
    - [Start and end point entry method, page 17](#)

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 entities you want to select are not visible in the map, tap , select the file and then make the appropriate layer(s) visible and selectable.
2. In the map, tap the entities that will define the horizontal alignment.

The order in which entities are selected and the direction of the lines and arcs defines the direction of the horizontal alignment.

If the entities 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 8](#).

## 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 entities from the map, see [To define the tunnel from the map, page 9](#).

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...
<b>Azimuth and length</b>	Enter the <b>Azimuth</b> and <b>Length</b> to define the line. The <b>End north</b> and <b>End east</b> fields automatically update.
<b>End</b>	Enter the <b>End north</b> and <b>End east</b> values to define the line. The <b>Azimuth</b> and <b>Length</b>

If you select...	Then...
coordinates	fields automatically update.
Select end point	Enter the <b>Point name</b> . The <b>Azimuth</b> , <b>Length</b> , <b>End north</b> and <b>End east</b> 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 <b>Radius</b> and <b>Length</b> to define the arc. The <b>End north</b> and <b>End east</b> fields automatically update.
Delta angle and radius	Select the arc direction. Enter the <b>Angle</b> and <b>Radius</b> to define the arc. The <b>End north</b> and <b>End east</b> fields automatically update.
Deflection angle and length	Select the arc direction. Enter the <b>Angle</b> and <b>Length</b> to define the arc. The <b>End north</b> and <b>End east</b> fields automatically update.
End coordinates	Enter the <b>End north</b> and <b>End east</b> values to define the arc. The <b>Arc direction</b> , <b>Radius</b> , and <b>Length</b> fields automatically update.
Select end point	Enter the <b>Point name</b> . The <b>Azimuth</b> , <b>Length</b> , <b>End north</b> and <b>End east</b> fields automatically update.
End coordinates and center point	Enter the <b>End north</b> , <b>End east</b> , <b>Center point north</b> and <b>Center point east</b> values to define the arc. If required, select <b>Large arc</b> . The <b>Azimuth</b> , <b>Arc direction</b> , <b>Radius</b> , and <b>Length</b> fields automatically update.
Select end and center points	Enter the <b>End point name</b> and <b>Center point name</b> values to define the arc. If required, select <b>Large arc</b> . The <b>Azimuth</b> , <b>Arc direction</b> , <b>Radius</b> , and <b>Length</b> , <b>End north</b> and <b>End east</b> 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 **Transition Xc** value is displayed. If the transition is between two arcs the **Transition 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...
<b>Radius and end station</b>	Select the arc direction. Enter the <b>Radius</b> and <b>End station</b> to define the arc.
<b>Deflection angle and end station</b>	Select the arc direction. Enter the <b>Angle</b> and <b>End station</b> 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 **Transition Xc** value is displayed. If the transition is between two arcs the **Transition 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	*	*	–

Method	Length	End station	PI
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**:

$$x = l \left[ 1 - \frac{l^4}{40R^2L^2} + \frac{l^8}{3456R^4L^4} - \dots \right]$$

Parameter **y**:

$$y = \frac{l^3}{6RL} \left[ 1 - \frac{l^4}{56R^2L^2} + \frac{l^8}{7040R^4L^4} - \dots \right]$$

### 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**:

$$x = l \left[ 1 - \frac{l^4}{40R^2L^2} + \frac{l^8}{3456R^4L^4} - \dots \right]$$

Parameter **y**:

$$y = \frac{l^3}{6RL}$$

## 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**:

$$y = \left[ \frac{l^4}{4RL^2} - \frac{l^5}{10RL^3} - \frac{l^{10}}{60R^3L^6} + \frac{l^{11}}{44R^3L^7} - \frac{l^{12}}{96R^3L^8} - \frac{l^{13}}{624R^3L^9} \right]$$

**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**:

$$x = l \left[ 1 - \frac{l^4}{40R^2L^2} \right]$$

Parameter **y**:

$$y = \frac{x^3}{6RX}$$

**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 entities in the map, the elevations of those entities 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...
<b>Cross slope and offset</b>	Enter the <b>Cross slope</b> and <b>Offset</b> values to define the line. To change the way a cross slope value is expressed, tap <b>Options</b> and then change the <b>Grade</b> field as required.
<b>Delta</b>	Enter the <b>Delta elevation</b> and <b>Offset</b> values to define the line.

If you select...	Then...
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**elevation and offset**

<b>End point</b>	Enter the <b>Horizontal offset</b> and <b>Vertical offset</b> values to define the end point of the line.
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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...
------------------	---------

<b>End point and Radius</b>	Enter the <b>Horizontal offset</b> and <b>Vertical offset</b> values to define the end point of the arc. Enter the <b>Radius</b> . Select <b>Large arc</b> , if required.
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<b>Alignment and Delta angle</b>	Enter the <b>Delta angle</b> for the arc. The center point for the arc is defined by the horizontal and vertical alignments.
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<b>Center point and delta angle</b>	Enter the <b>Horizontal offset</b> and <b>Vertical offset</b> values to define the center point of the arc. Enter the <b>Delta angle</b> for the arc.
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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 23](#).

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 holes within a tunnel. They are defined by station and offset values and a method. See [Set out position requirements, page 25](#).

**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. In the **Start station** field, specify the start station for the position to be set out.
4. In the **End station** field, specify the end station for the position to be set out.  
If the set out position is to apply to all stations, leave the **End station** field empty.
5. Select the **Method** to define the set out position and then:
  - a. Specify the offsets and offset direction.
  - b. Select the surface that the set out position is relative to. The **Surface** field is not available for the Blast hole method.
  - c. If required, specify a **Code**.  
The annotation entered in the **Code** field is assigned to the end of the position and is displayed when setting out the position.
  - d. If you selected the radial method, to define a new center offset from the alignment, enter **Horizontal offset** and **Vertical offset** values in the **Radial center offsets** group box.
  - e. If you selected the multiple radial method, enter the **Interval**.
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, tap **Set out positions** and select **Import**.

For information on the required format for the CSV file, see [Set out position requirements, page 25](#).

**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.

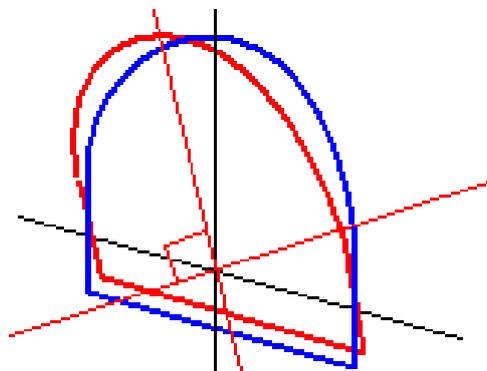
#### Linear interpolation

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

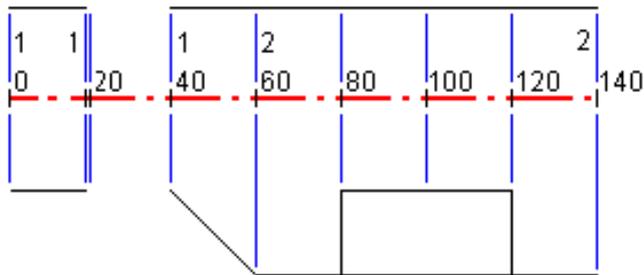
Templates can be applied vertical or perpendicular to the vertical alignment. See the following diagram where the red line work indicates the template applied perpendicular and the blue line work a template applied vertically.



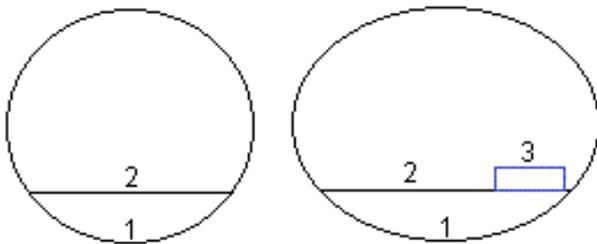
The station and offset display of points relative to a tunnel using **Point manager** or **Review job** are only calculated vertical to the alignment. If the templates were applied perpendicular in Tunnel positioning then the station and offsets will be different.

### 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>	-	-	-

Start station	Templates	Surface 1	Surface 2	Surface 3
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 holes within a tunnel. They are defined by station and offset values and a method.

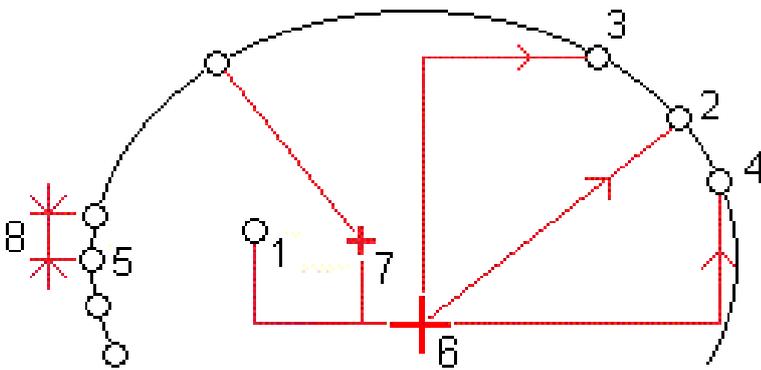
To add pre-defined set out positions to the tunnel definition, see [To add set out positions, page 21](#).

### Set out position methods

Supported types of set out positions are:

- End-face blast holes
- Radial bolt holes
- Horizontal bolt holes
- Vertical bolt holes
- Multiple radial holes

Refer to the following diagram:



1	Blast hole	5	Multiple radial
2	Radial	6	Alignment
3	Horizontal	7	Offset center
4	Vertical	8	Interval

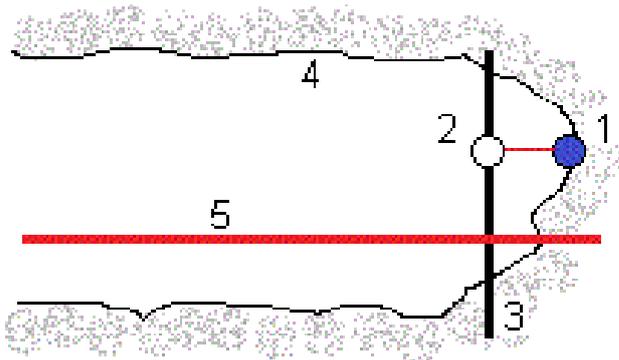
For each method, you must specify the **Start station** and **End station** and, if required, the horizontal or vertical offset and the direction of the offset. Horizontal and vertical offsets are relative to the alignment. If the alignment has been offset, the offsets are relative to the offset alignment.

For multiple radial set out positions, enter the Interval between positions.

You can key in set out positions or import them from a CSV file.

### Blast hole set out

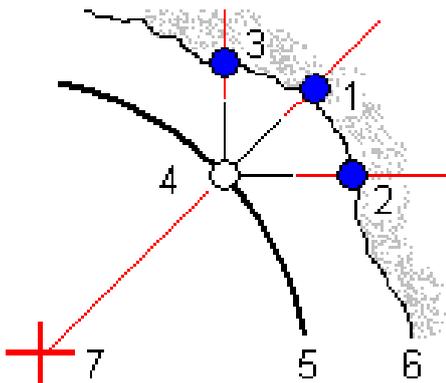
Refer to the diagram below to set out positions for blast holes.



- |   |                     |   |                  |
|---|---------------------|---|------------------|
| 1 | Blast hole position | 4 | Tunnel surface   |
| 2 | Design position     | 5 | Tunnel alignment |
| 3 | Design surface      |   |                  |

### Bolt hole set out

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



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

## Imported set out position requirements

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

The required format for the CSV file is:

Start station, End station, Method, Hz offset, Vt offset, Code, Direction, Surface name, Center hz offset, Center vt offset

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

Set out positions	Method	Example
End face blast holes	Blasthole	40,60,Blasthole,0.5,-0.5,Blast hole
Radial bolt holes	Radial	0,40,Radial,-3.2,2.2,Bolt hole,,S2,1.05,0.275
Horizontal bolt holes	Horizontal	0,20,Horizontal,,3.1,Bolt hole,Right,S2
Vertical bolt holes	Vertical	0,,Vertical,3.2,,Bolt hole,Up,S2

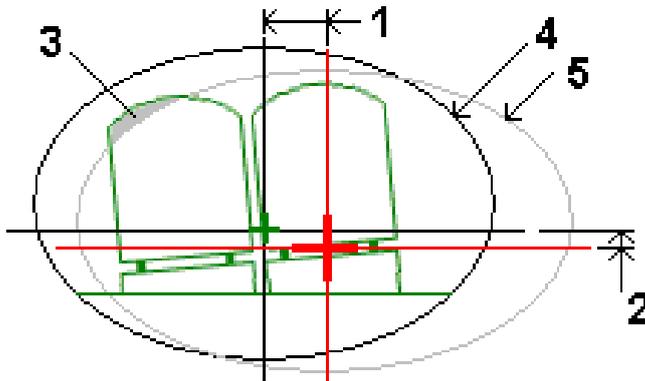
### **NOTE** –

- The Surface name, Code, Center hz offset, and Center vt 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.
- The Direction value must be one of the following: Up, Down, Left, Right, or empty (for a radial offset or blast hole).

## 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 superelevated. 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 |   |               |

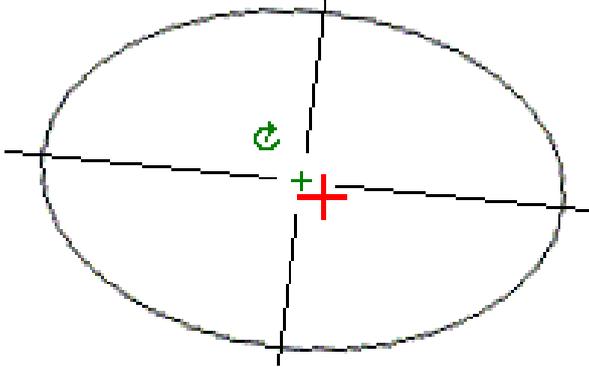
To add alignment offsets to the tunnel definition, see [To add alignment offsets, page 22](#).

## To review the tunnel definition

1. 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.
2. To confirm the definition before surveying the tunnel, tap **Calc** to calculate the grid and tunnel coordinates.
3. To add a unique station, tap and hold on the screen and then select **Add station**.
4. To select another station to review:
  - Tap and hold on the screen and then select a station from the list in the **Select stations** field.
  - Tap an individual station.
  - Press an up or down arrow key.

**TIP** – Tap and hold on the pan softkey to make it active and then use the left, right, up, or down arrow keys to pan around the screen.
5. 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.

## Tunnel survey

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*.

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 **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.

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**TIP** – To quickly measure a check point when surveying, press **Ctrl + K** on the keypad, or tap and hold in the map. If there are no points selected, **Check backsight** is available; if one point is selected **Check shot** is available.

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 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.

**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 35](#).

## 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.

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 **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.

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## 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 scan zones 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. To define the scan station range:
  - a. Define the **Start station** and **End station**.  
You can:
    - Key in values
    - Tap  and select **List** and then select the values.
    - Select the **Start station** field, point the instrument to the required start point of the scan and then tap **Measure**. Repeat the process for the **End station**.

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

- b. Define the **Station interval**.

Enter the required station interval for the scan. 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.

5. If required, edit the station range.
6. Tap **Next**.

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

7. 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.

8. Tap **Start**.
9. Configure the **Scan settings**. Tap **Accept**.
10. 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.

11. Tap **Close**.
12. 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 39](#).

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 within a tunnel. They are defined by station and offset values and a method. See [Set out position requirements, page 25](#).

**NOTE** – *When setting out positions, the software attempts to navigate you to the defined position. Often this is not possible and the software instead locates a position on the tunnel surface that is on 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. To define the scan station range:
  - a. Define the **Start station** and **End station**.

You can:

- Key in values
- Tap ► and select **List** and then select the values.
- Select the **Start station** field, point the instrument to the required start point of the scan and then tap **Measure**. Repeat the process for the **End station**.

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

b. Define the **Station interval**.

Enter the required station interval for the scan. 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**. The selected station range is shown in the plan view.

6. Select a station to measure. Tap **Next**.

The cross section view of the selected position is shown.

7. Select the position to set out.

To automate the set out of multiple blast holes, from the tap and hold menu select **All blast holes**.

8. Set out the selected position:

- Tap **Auto** to set out the selected position.
- Configure the **Set out tolerances**. Tap **Accept**.
- Configure the **Set out settings**. 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 are setting out **All blast holes**, the instrument turns to the first defined blast hole.

d. When the position is found you are instructed to mark the point indicated by the laser on the tunnel surface.

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.

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.

- e. If you are setting out **All blast holes**, the instrument turns to the next blast hole and so on until all blast holes 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 **All blast holes**, the software skips the position and moves to the next blast hole. 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 39](#).

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

## To position the machine

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

### How machine positioning works

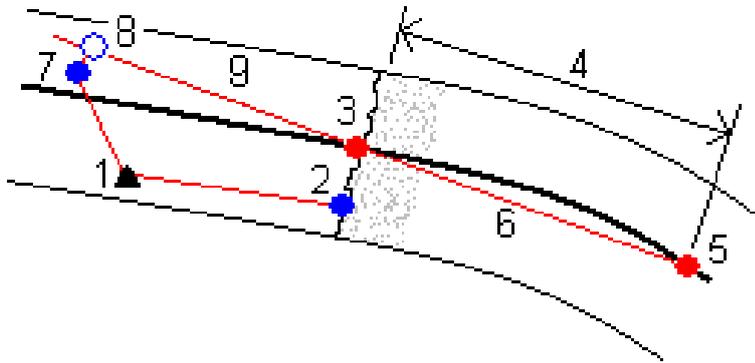
To position the machine relative to the tunnel, the software calculates positions on the horizontal alignment at the nominal station and at the station defined by the drill depth. A reference line is calculated using these two positions.

**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	6	Reference line
2	Nominal station at tunnel face	7	Measured point
3	Calculated position on the alignment projected from 2	8	Calculated position on reference line projected from 7
4	Drill depth	7 to 8	Transverse and Vertical offsets
5	Calculated position on the alignment at drill depth	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

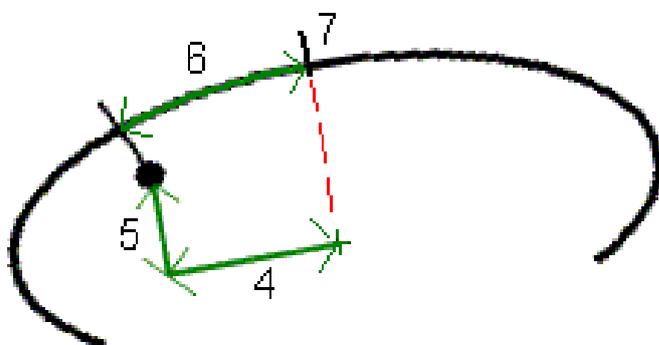
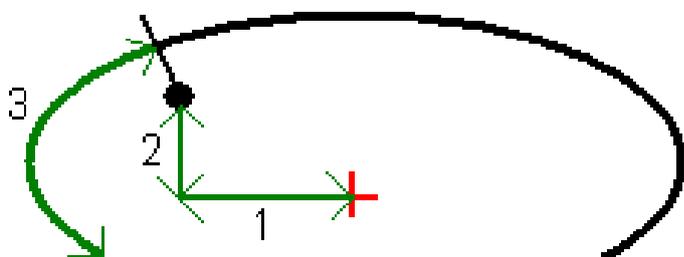
10. Tap **Finish**.

## Current position information

Information on the current position and, if applicable, its relationship to the selected set out position appears at the bottom of the screen.

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.
-	Under/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.

Number	Value	Description
-	Delta station	The station of the current position in terms of the tunnel design.
-	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	Hz. 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	Vt. 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 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.
-	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. 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 43](#).
- 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 43](#).
- 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 43](#).
- 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.

## Set out settings

- Enter the **Start point**.
- 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 point flashes once the position is found.
- Select **Instrument perspective profile display** to display the tunnel profile in the direction the

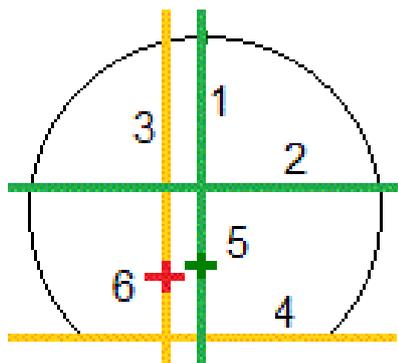
instrument is facing. This option is especially useful when you are facing in the direction of decreasing station, as the tunnel profile is then displayed in the same sense that the instrument is pointing, rather than always assuming you are facing in the direction of increasing station.

## Cross section guidelines

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

- **Display profile vertical center line** 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 center line** 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 center line                              | 4 | Floor line (offset vertically from the offset alignment) |
| 2 | Spring line (offset vertically from the offset alignment) | 5 | Offset alignment   |
| 3 | Alignment vertical center line                            | 6 | Alignment  |

## Tolerances

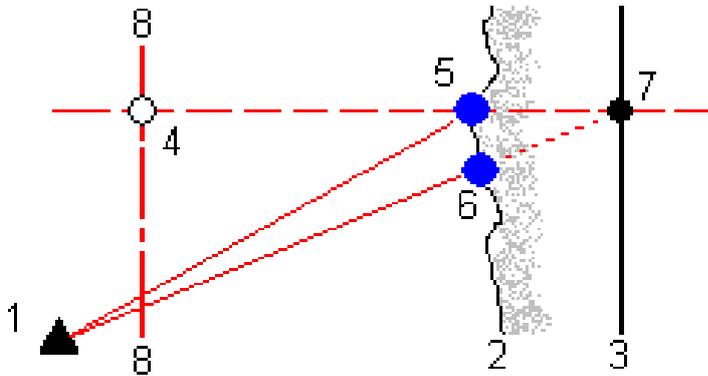
The available fields depend on the survey method.

- 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 44](#).

## 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 <b>On station adjustment</b> is selected
2	Tunnel surface	6	Measured position when <b>On station adjustment</b> is not selected
3	Tunnel design	7	Design position
4	Station	8	Horizontal alignment

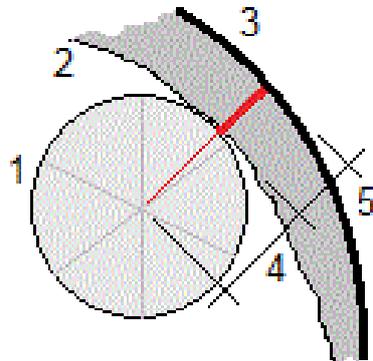
The overbreak is similar to the underbreak situation.

## 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.

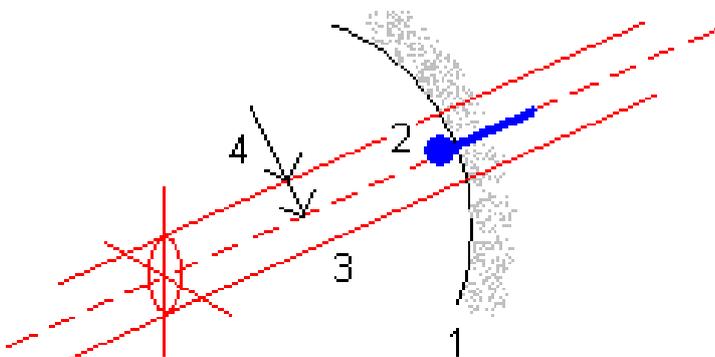
You can use the prism on a pole held perpendicular to the tunnel design surface, where the target height is used to project the prism measurement perpendicular onto the tunnel surface.



- 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

Use **Review** to see the 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**.

## To generate a report

1. Open the job that contains the data to export.
2. Tap  and select **Report**.
3. In the **File format** field, specify the type of file to create.
4. Tap  to select an existing folder or create a new one.
5. Enter a filename.

By default, the **File name** field shows the name of the current job. The filename extension is defined in the XSLT style sheet. Change the file name and extension as required.

6. If more fields are displayed, complete them.

You can use the XSLT style sheets to generate files and reports based on parameters that you define. For example, when generating a Stakeout report, the **Stakeout horizontal tolerance** and the **Stakeout vertical tolerance** fields define acceptable stakeout tolerances. When generating the report you can stipulate the tolerances, then any stakeout delta greater than the defined tolerances appears in color in the generated report.

7. To automatically view the file after you create it, select the **View created file** check box.
8. To create the file, tap **Accept**.

Alternatively, export the job as a JobXML file and then use the ASCII File Generator utility to create the report from the exported JobXML file, using the required XSLT style sheet as the output format. To download the utility, go to <https://geospatial.trimble.com/product-and-solutions/access> and click **Downloads**.

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