IQcad — User Manual

Release 1.0

IQSoft

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Contents

IQcad is a 2D/3D CAD application for engineering and civil survey work. It provides standard drafting tools together with specialised civil objects for survey points, TIN surfaces, horizontal alignments, tunnel section line deviation analysis, and coordinate transformations.

1 Interface Overview

IQcad uses a ribbon-based layout similar to modern CAD applications. All panels can be shown or hidden, and the drawing area resizes to fill the available space.

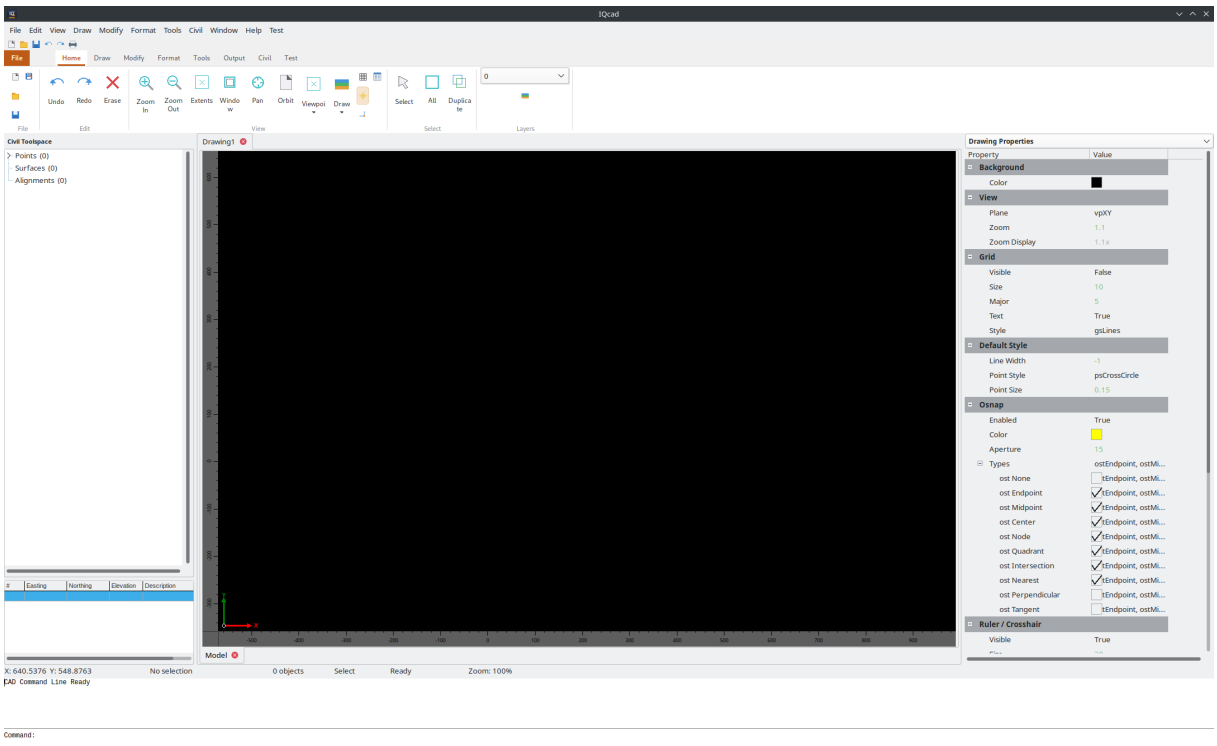

Fig. 1: IQcad main window layout.

```
┌──────────────────────────────────────────────────────────────┐
│  Quick Access Toolbar (QAT)                                  │
├──────────────────────────────────────────────────────────────┤
│  Menu bar  (File · Edit · View · Draw · Modify · Format · Civil …)  │
├──────────────────────────────────────────────────────────────┤
│  Ribbon  (Home · View · Draw · Modify · Annotate · Civil · Output)  │
├──────────────┬──────────────────────────┬────────────────────┤
│ Civil Toolspace │                       │  Object Inspector  │
│  (left panel)   │      Drawing Canvas   │  (right panel)     │
```

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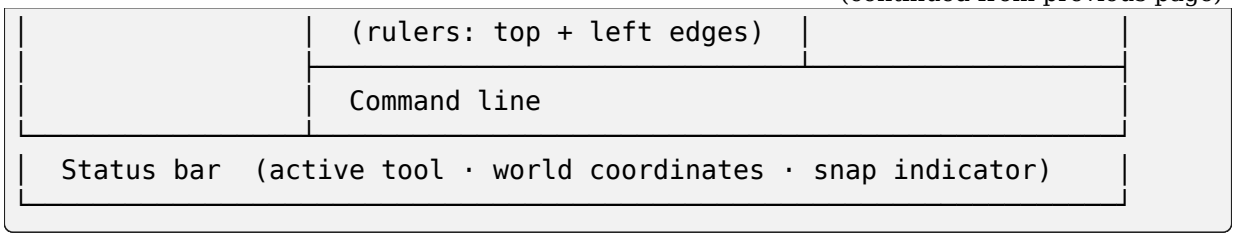


1.1 Main Areas

Area	Description
Quick Access Toolbar	A small toolbar above the menu bar with frequently-used buttons: New, Open, Save, **Save As**, Undo, Redo, and a **Properties** toggle that shows or hides the Object Inspector panel.
Menu bar	Traditional pull-down menus: File, Edit, View, Draw, Modify, Format, Civil, Window, Help.
Ribbon	Tabbed toolbar built on the IQRibbon component with theme support. Click a tab — *Home*, *View*, *Draw*, *Modify*, *Annotate*, *Civil*, *Output*, *Help* — to access tools grouped by function.
Civil Toolspace	Left panel (toggle with **Civil › Civil Toolspace**). Displays Survey Points, Tunnel Section Lines, Surfaces, and Alignments in a tree view with a property grid below. Double-click a leaf node to select and zoom to that object in the canvas.
Drawing Canvas	The main work area. Each open drawing occupies a tab above the canvas. Rulers along the top and left edges show world coordinates.
Object Inspector	Right panel (toggle with the **Properties** button on the QAT). Displays and edits the properties of the selected object(s), the active layer, or drawing-level settings. Uses a tree-based property grid with collapsible categories. All fields are live — changes apply immediately. See *Object Inspector* (page 33) for full details.
Command line	Dark strip at the bottom. Shows the current operation, prompts for coordinate or text input, and accepts typed CAD commands (see *Command Line* (page 83)).
Status bar	Shows the active tool name and the cursor position in world coordinates.

1.2 Layout Persistence

Panel sizes are saved to `settings.json` under a `"layout"` section and restored automatically when IQcad starts:

- Prospector panel width
- Object Inspector panel width and column split position
- Command line height

1.3 Ribbon Tabs

Tab	Contents
Home	File (New, Open, Save, Save As, Close, Close All); Edit (Undo, Redo); Clipboard (Cut, Copy, Paste, Paste Orig).
View	Navigate (Zoom In/Out/Extents/Window, Pan, Orbit, Viewpoint, Draw Order); Display (Grid, Osnap, Ortho toggles, Properties panel); Select (Select, Select All, Duplicate).
Draw	All drawing tools: Line, Polyline, Multiline, Arc, Circle, Ellipse, Spline, Rectangle, Polygon, Hatch, Text, Multileader, Arrow, Point, XLine, 3D Face, 3D Polyline, Bézier, Table, Image, and more.
Modify	Erase, Move, Copy, Rotate, Scale, Offset, Trim, Extend, Chamfer, Fillet, Explode.
Annotate	Dimension tools (Linear, Aligned, Angular, Radius, Diameter, Ordinate, Arc Length, Baseline, Continue, Jogged), Dimension Styles.
Civil	Survey Point, Tunnel Section Line, Create Surface, Decimate, Spot Elevation, Alignment, Parcel, Civil Toolspace toggle, Point Import, Point Manager, Point Groups, LandXML import/export, Coordinate Transformations (CSTRANSFORM, RUBBERSHEET), Civil Style Manager.
Output	Export DXF, Export DWG, Export Image, Export SVG, Export LandXML, Page Setup, Print, Export PDF.
Help	Documentation links, keyboard shortcuts reference, About dialog.

2 Drawings

IQcad supports multiple drawings open simultaneously, each in its own tab.

2.1 New Drawing

Use **File › New Drawing** or press **Ctrl+N**. A new tab opens with an empty canvas ready for drawing.

2.2 Open a Drawing

Use **File › Open...** or press **Ctrl+O**. IQcad supports two native formats:

- `.iqz` — compressed format (gzip-compressed IQML). This is the **default format** for new drawings.
- `.iqml` — uncompressed XML-based format.

IQcad auto-detects both formats on open (gzip magic bytes are checked first). After loading, the view zooms to fit all objects.

Note: IQcad can also open DXF and DWG files (**File › Open...** — select the appropriate file-type filter) and import LandXML files (**File › Import LandXML...**).

2.3 Saving

Command	Description
File › Save (Ctrl+S)	Saves to the current file name in IQZ format (compressed) by default. The tab title loses the * modified indicator.
File › Save As... (Ctrl+Shift+S)	Prompts for a new file name and saves. The file-type filter lets you choose between `.iqz` (compressed) and `.iqml` (uncompressed). Also available from the **Save As** button on the Quick Access Toolbar.

The tab title shows an asterisk (`Drawing1*`) when the drawing has unsaved changes.

2.4 Multiple Drawings

- Each drawing occupies a **tab** above the canvas.
- Click a tab to switch to that drawing. The Object Inspector, Layer Manager, and Civil Toolspace all update to reflect the newly active drawing.
- Close the active drawing with **Window › Close Drawing** (**Ctrl+W**) or by clicking the **×** button on the tab.
- If you close the **last open tab**, IQcad automatically opens a fresh empty drawing so there is always at least one drawing available.
- If a drawing has unsaved changes, a *Save / Discard / Cancel* prompt appears before the tab closes.

2.4.1 Drawing Tabs

```
[ Drawing1  × ]  [ Tunnel_A.iqml  × ]  [ Untitled*  × ]  [ + ]
```

The **+** button at the right end of the tab bar creates a new drawing (same as **Ctrl+N**).

3 Navigation

3.1 Zoom

Action	How
Zoom in / out	Scroll the **mouse wheel**, or press **+** / **−**.
Zoom extents	**Ctrl+Shift+E** — fits all objects in the window.
Zoom to window	**View › Zoom Window** — drag a rectangle; the view zooms to fill it.
Zoom to selection	Select objects, then **View › Zoom Selection**.

3.2 Pan

Action	How
Real-time pan	Hold the **middle mouse button** and drag.
Pan from menu	**View › Pan** — click two points (displacement vector).

3.3 Grid

Toggle the background grid with **Ctrl+Shift+G** or **View › Grid**.

The grid is **off by default** for new drawings. Grid spacing is controlled by the *GridSpacing* field in the Drawing Variables tab of the Layer Manager.

3.4 Rulers

Rulers run along the **top** and **left** edges of the canvas. They always show world coordinates and update dynamically as you zoom or pan.

Note: IQcad uses a **right-hand CAD coordinate system**: X increases to the right, Y increases upward. Screen Y is inverted internally but all displayed coordinates are in world space.

3.5 3D View Commands

IQcad provides several commands for viewing the drawing from different angles:

Command	Description
3DORBIT (`ORBIT`)	Interactive 3D orbit mode — rotate the view around the model.
PLAN	Return to the standard top-down plan view.
VPOINT (`VP`)	Set the viewpoint to a preset direction.
VIEWTWIST (`VT`)	Set a 2D view rotation angle.
ALIGNVIEW (`AV`)	Align the view to two picked points on the canvas.
PLANVIEW	Reset the view twist back to north-up (0° rotation).

3.5.1 3D Behaviour

When the view is rotated away from the standard plan view (using 3DORBIT, VPOINT, or the UCS Gizmo), several canvas behaviours adapt automatically:

- **Zoom at mouse point** — the scroll wheel zooms toward the 3D point under the cursor, keeping the area of interest centred.
- **3D pan** — middle-mouse-button dragging pans along the current view plane rather than the XY plane.
- **3D crosshair** — the crosshair cursor draws three coloured axes (**red** = X, **green** = Y, **blue** = Z) to help orient the view.
- **Rulers auto-hide** — rulers along the canvas edges are hidden automatically in 3D mode, since world-axis labels are not meaningful for oblique views. They reappear when the view returns to plan.

3.6 UCS Gizmo

The **UCS Gizmo** is an interactive 3D orientation widget displayed in a corner of the canvas. It replaces the traditional flat UCS icon and provides both a visual reference for the current viewing direction and direct mouse interaction for navigating 3D views.

3.6.1 Using the Gizmo

Action	Result
Click an axis label (X, Y, or Z)	Snaps the view so that the selected axis points toward you. For example, clicking **Z** returns to the standard top-down plan view; clicking **X** shows a YZ elevation view.
Click a quadrant face	Snaps to the corresponding isometric view (e.g. top-front-right).
Drag a rotation ring	Constrains rotation to a single axis (see *Rotation Rings* below).
Drag on the gizmo (outside a ring)	Free-orbit the view — the model rotates interactively as you drag, the same as 3DORBIT but initiated from the gizmo area.

3.6.2 Rotation Rings

Three coloured rings surround the gizmo sphere, one per axis:

- **Red ring** — X axis (drag to change elevation)
- **Green ring** — Y axis (drag to change azimuth)
- **Blue ring** — Z axis (drag to change azimuth)

Each ring is projected onto the screen as an ellipse. The front half of the ring draws fully opaque over the sphere; the back half draws behind it, giving a clear sense of 3D orientation. Hovering over a ring highlights it to confirm which axis will be constrained before you begin dragging.

When a ring is viewed nearly edge-on (i.e. the axis points almost directly at the camera), the ring becomes too thin to click reliably. In this case the gizmo falls back to **free orbit** so you are never stuck without a way to rotate.

Note: The gizmo and its rotation rings are only shown on **Model** tabs. On layout tabs the gizmo is hidden, since layouts represent fixed paper space.

3.6.3 Gizmo Settings

The gizmo appearance can be adjusted in **Settings > General > UCS Gizmo**:

Setting	Description
Corner	Which corner of the canvas the gizmo occupies (default: top-right).
Size	Diameter of the gizmo in pixels (default: 120).
Opacity	Transparency of the gizmo background (0 = fully transparent, 255 = fully opaque; default: 200).

3.7 Map Background

Use the `MAPBG` command to toggle a background map layer behind the drawing canvas. This is useful for georeferenced drawings where you want to see the drawing overlaid on an aerial or map tile layer.

4 Drawing Tools

Activate a tool from the **Draw menu**, the **Draw ribbon tab**, or by typing its command alias in the command line. Press **Escape** at any time to abandon the current operation and return to Select mode.

4.1 Object Snapping (Osnap)

While drawing, IQcad snaps the cursor to geometric points on nearby objects. A coloured marker and label appear near the cursor when a snap point is active.

Snap type	Description
Endpoint	Start or end of a line, arc, or polyline vertex.
Midpoint	Midpoint of any segment.
Centre	Centre of a circle, arc, or ellipse.
Intersection	Where two objects cross.
Nearest	Closest point on any object.
Perpendicular	Perpendicular foot from the cursor onto a line.

4.2 Lines and Curves

Tool	How to use
Line (L)	Click start point, click end point. Continue clicking to chain segments. Right-click or **Escape** to finish.
Polyline (PL)	Click successive vertices. Right-click or **Escape** to finish. Vertex *bulge* (arc segment) can be set afterwards in the Object Inspector.
Multiline (ML)	Click successive vertices like a polyline. Each stroke produces two or more parallel strands as defined by the current Multiline Style (see *Format Settings* (page 89)). Right-click or **Escape** to finish.
Spline (SP)	Click control points. The curve passes through each point using Catmull–Rom interpolation. Right-click or **Escape** to finish.
Arc (A)	Click three points: start, a point on the arc, end. All arc methods show a live phantom arc preview. Additional methods are available from the *Draw › Arc* submenu or the Arc dropdown button on the ribbon: **Start, Center, End** (ARC_SCE) — click start, center, endpoint. **Start, Center, Angle** (ARC_SCA) — click start, center; mouse sets endpoint. **Start, Center, Length** (ARC_SCL) — click start, center; mouse sets endpoint. **Start, End, Angle** (ARC_SEA) — click start, end; mouse sets arc shape. **Start, End, Direction** (ARC_SED) — click start, end; mouse sets arc shape. **Start, End, Radius** (ARC_SER) — click start, end; mouse sets arc shape. **Center, Start, End** (ARC_CSE) — click center, start, endpoint. **Center, Start, Angle** (ARC_CSA) — click center, start; mouse sets endpoint. **Center, Start, Length** (ARC_CSL) — click center, start; mouse sets endpoint. **Continue** (ARC_CONT) — continues from the last entity's endpoint.
Circle (C)	Click the centre, then click a second point or type the radius. Additional methods are available from the *Draw › Circle* submenu or the Circle dropdown button on the ribbon: **Center, Diameter** (CIRCLE_CD) — click center; mouse distance = diameter. **2 Points** (CIRCLE_2P) — click two diameter endpoints. **3 Points** (CIRCLE_3P) — click three points for a circumscribed circle.
Ellipse	Click the centre, drag to set the semi-major axis, then drag to set the semi-minor axis.
3D Polyline (3DP)	Click successive vertices in 3-D space (each vertex stores X, Y, Z). Right-click or **Escape** to finish. Enable **SplineFit** in the Object Inspector to render the polyline as a smooth Catmull–Rom spline through all vertices. Exports as `3DPOLYLINE` in DXF.
Bézier	Click control points to define a Bézier curve. Right-click or **Es**

4.3 Shapes and Fills

Tool	How to use
Rectangle (REC)	Click two opposite corners.
Polygon (POL)	Enter the number of sides, click the centre, then click a vertex to set the circumradius. Creates a regular polygon.
Hatch (H)	Click inside a closed area to flood-fill it. Pattern, angle, and scale are set in the Object Inspector after placement.
3D Face	Click four corner points. Renders as a filled flat face.
Polyface Mesh	A collection of 3D faces grouped into a single mesh entity. Polyface meshes are typically created by importing DXF files that contain `POLYLINE`-based polyface meshes, or by using the `SURFACE2MESH` command to convert a TIN surface. Each face in the mesh stores three or four vertex indices. Select the mesh and use the Object Inspector to view vertex and face counts. Use `EXPLODE` to break the mesh into individual 3D Face entities, or `MESH2SURFACE` to convert it to a TIN surface.

4.4 Annotation

Tool	How to use
Text (T)	Click an insertion point, type the text, press **Enter**. Font and size come from the current Text Style (see *Format Settings* (page 89)).
Multi-leader (MLD)	Type the label text in the prompt, then click the **arrowhead tip**, then click the **text anchor**. A horizontal dogleg connects the anchor to the label automatically.
Arrow	Click the arrowhead tip, then click the tail. Simple single-segment leader line.
Point (PO)	Click to place a marker. Appearance is controlled by the active Point Style (see *Format Settings* (page 89)).
Table (TBL)	Type `TABLE` (or `TBL`) in the command line, or use *Draw › Table* on the menu / ribbon. Click a single point to place the table; a default 3 × 3 table is created at the insertion point. The table entity supports named styles — **Standard**, **Schedule**, and **Legend** — which control title/header/data row formatting (see *Format Settings* (page 89)). After placement, select the table and use the Object Inspector to change style, row/column counts, and the title text. Double-click a cell to edit its content; cells support formulas and clipboard paste from Excel or LibreOffice Calc.

4.5 Insert

Tool	How to use
Image (IA)	Type `IMAGEATTACH` or `IA` in the command line. Enter the file path (or press **Enter** with an empty path to open a file dialog). Supported formats: **PNG**, **JPG/JPEG**, **BMP**, **TIFF**. After selecting the file, specify the **width** in world units (or press **Enter** to accept the pixel-based default) and the **rotation** angle (default 0). Click to place the image — the insertion point is the **bottom-left** corner. If an ESRI world file (`.jgw`, `.pgw`, `.bpw`, `.tfw`) exists alongside the image, the command reports the georeferencing parameters and asks: **"Use georeferenced placement? [Yes/No]"**. Press **Enter** or type **Yes** to place the image at the world-file origin automatically (no clicks needed). Type **No** to proceed with interactive placement using the world-file width and rotation as defaults.

4.5.1 Image Properties

After placing an image, select it and open the **Object Inspector** to adjust:

Property	Description
ImagePath	File path of the source image (referenced mode).
PixelSize	Pixel dimensions of the source image (read-only, "W × H").
Embedded	When True, image bytes are stored inside the drawing file. Toggle to embed or unembed the image.
WorldWidth	Width of the image in world units. Changing this automatically adjusts `WorldHeight` to preserve the pixel aspect ratio.
WorldHeight	Height in world units (read-only, computed from width + aspect ratio).
Rotation	Counter-clockwise rotation in degrees.
Opacity	0 (transparent) to 255 (fully opaque). Default 255.
ShowImage	When False, a dashed placeholder frame with the filename is displayed instead of the raster data.
ClipEnabled	Enable rectangular sub-region clipping.
ClipX, **ClipY**, **ClipW**, **ClipH**	Pixel coordinates and size of the clipping rectangle.

4.6 Dimensions

Dimension tools annotate distances, angles, and radii on the drawing. All dimension tools share the same workflow: click the definition points, then click to place the dimension line. Appearance is controlled by the current **Dimension Style** (see *Format Settings* (page 89)).

Tool	How to use
Aligned Dimension (DAL)	Click the first definition point, click the second definition point, then click to place the dimension line. The measurement shows the true distance between the two points regardless of angle.
Linear Dimension (DLI)	Click the first definition point, click the second, then click to place the dimension line. Measures the horizontal or vertical distance depending on cursor movement direction. For a rotated measurement, set `RotationAngle` in the Object Inspector.
Angular Dimension (DAN)	Click the vertex point, click the first arm endpoint, click the second arm endpoint. An arc dimension line shows the included angle in degrees.
Radius Dimension (DRA)	Click the centre of the arc or circle, then click a point on the curve. A leader line with "R" prefix annotates the radius.
Diameter Dimension (DDI)	Click the centre, then click a point on the curve. A leader line with the diameter symbol (Ø) annotates the full diameter.
Ordinate Dimension (DOR)	Click the feature point, then click the leader endpoint. Displays the absolute X or Y ordinate of the feature. Toggle X/Y with `OrdIsX` in the Object Inspector.
Arc Length Dimension	Click the arc centre, click the start point on the arc, click the end point. The measurement shows the arc length along the curve.
Baseline Dimension	Extends a series of dimensions from a shared baseline. Each measurement starts from the same first definition point.
Continue Dimension	Chains dimensions end-to-end. Each new dimension starts where the previous one ended.

4.6.1 Dimension Properties

After placing a dimension, select it and open the **Object Inspector** to adjust:

Property	Description
DimStyle	Dropdown to select a named dimension style from the style library. Controls all visual properties (colours, arrows, text size, etc.).
TextOverride	Custom text to display instead of the measured value. Use `<>` as a placeholder for the measurement (e.g. `<> mm`).
Measurement	The computed value (read-only). Updated automatically from the definition points.
Rotation	Rotation angle for linear rotated dimensions.

4.6.2 Dimension Styles

Dimension styles control the appearance of all dimension components. Open **Format › Units...** and switch to the **Dimensions** tab to edit the current style.

The Dimensions tab groups settings into five areas:

Lines — dimension line and extension line colours, weights, offsets, extension amounts, and suppression flags.

Arrows — arrowhead type (Closed Filled, Open, Dot, Arch Tick, None, and others) and size for each end of the dimension line.

Text — text colour, height, gap from the dimension line, vertical placement (centred or above), and font.

Fit — controls what happens when text and arrows do not fit between extension lines. Options: move text outside first, move arrows outside first, move both outside, or best fit.

Primary Units — number format (Decimal, Scientific, Engineering, Architectural, Fractional), decimal precision (0–8 places), angle format (Decimal Degrees, DMS, Gradians, Radians), leading/trailing zero suppression, prefix, suffix, scale factor, and rounding.

Use the style dropdown at the top of the Dimensions tab to switch between named styles. Click **Reset** to revert the current style to its defaults.

4.7 Civil Drawing Tools

These tools are also on the **Civil ribbon tab** and the **Civil menu**.

Tool	How to use
Survey Point	Click to place an AEC Survey Point. Fill in PointNumber, Northing, Easting, Elevation, and description in the Object Inspector.
Tunnel Section Line	Click successive survey points along the measured profile. Right-click to finish. Link to a theoretical polyline via *SectionLine* in the Object Inspector to enable deviation analysis.

5 Modifying Objects

Select one or more objects first, then apply a Modify command from the **Modify menu**, the **Modify ribbon tab**, or the keyboard.

5.1 Modify Commands

Command	Shortcut / Alias	Description
Erase	Del · E	Deletes all selected objects. If no objects are selected, prompts "Select objects:" — pick objects then right-click to confirm or press Escape to cancel.
Move	M	Enter a displacement as X,Y in the command line, or pick two reference points on the canvas.
Copy	CO	Creates copies of selected objects. Enter displacement the same way as Move.
Rotate	RO	Enter a rotation angle in degrees (positive = counter-clockwise).
Scale	SC	Enter a uniform scale factor. Values > 1 enlarge; values < 1 shrink.
Offset	O	Creates a parallel copy of an entity at a specified distance. Supports Line, Circle, Arc, XLine, Polyline, Ellipse, Spline, and Rectangle. The default distance is stored in OFFSETDIST. Options: **T** = through point, **E** = erase source, **U** = undo. A phantom preview shows the offset entity while picking the side.
Mirror	MI	Pick two points to define the mirror axis. Optionally delete the original.
Trim	TR	Two-phase: select cutting edges (or type ALL), then click objects to trim. Supports Line, Arc, Polyline, Ellipse, and Spline entities.
Extend	EX	Two-phase: select boundary edges, then click the end of an entity to extend it. Supports Line, Arc, Polyline, Ellipse, and Spline entities.
Chamfer	CHA	Pick two lines to chamfer. Use the D sub-option to set chamfer distances ($CHAMFERA / $CHAMFERB). The second distance defaults to the first. Zero distance trims to the intersection.
Fillet	F	Pick two lines to fillet with an arc. Use the R sub-option to set the radius ($FILLETRAD). Zero radius trims to the intersection.
Explode	(none)	Breaks compound objects into their component entities. Blocks are exploded into individual entities; multilines into separate lines; polyface meshes into individual 3D Face entities.
PEDIT	PE	Edit a polyline: Close/Open, Join, Width, Edit vertex, Spline, Decurve, Reverse. Converts Lines and Arcs to polylines. Supports 2D and 3D polylines.

5.2 Mesh and Surface Conversion

Command	Alias	Description
Mesh2Surfa	M2S	Converts a selected polyface mesh entity into a TIN surface. The mesh vertices become surface points and the mesh faces become TIN triangles. Prompts for a surface name (defaults to the mesh layer name). The original mesh entity is preserved.
Surface2Mesh	S2M	Converts a TIN surface into a polyface mesh entity on the canvas. Prompts for the surface name (auto-selects if only one surface exists). The resulting mesh can be exported to DXF as a standard polyface mesh, exploded into 3D Faces, or moved/copied like any other drawing entity.

5.3 Clipboard

IQcad supports clipboard operations for copying entities between drawings and between separate IQcad instances. Entities are serialised to the system clipboard as IQML (IQcad's XML format), so all entity types are preserved including civil objects, survey points, and their associated layers.

Command	Shortcut	Description
COPYCLIP	Ctrl+C	Copies the selected entities to the clipboard. Associated layers and survey points are included automatically.
CUT	Ctrl+X	Copies the selected entities to the clipboard, then deletes them from the drawing.
PASTECLIP	Ctrl+V	Pastes clipboard contents at the centre of the current viewport. Missing layers are created automatically. Civil point numbers are renumbered if they conflict with existing points in the target drawing.
PASTEORIG	Ctrl+Shift+V	Pastes clipboard contents at their original coordinates instead of the viewport centre.

Tip: Because the clipboard uses the system clipboard, you can copy entities in one IQcad instance, switch to a completely separate IQcad window, and paste them there.

5.4 OSNAP in Edit Commands

MOVE, COPY, ROTATE, SCALE, and OFFSET use OSNAP when picking reference points and destinations. During the object-selection phase of these commands, OSNAP is temporarily disabled so that snapping does not interfere with object picking.

5.5 Grips

When objects are selected, **blue grip handles** appear at key points (endpoints, midpoints, centres). Drag a grip to move or reshape the object interactively without invoking a Modify command.

5.6 Undo and Redo

- **Ctrl+Z** — undo the last action.
- **Ctrl+Y** — redo.

The undo history is per-drawing and is preserved as long as the drawing tab remains open.

6 Selection

6.1 Selection Methods

Action	Result
Click an object	Selects it; deselects any previous selection.
Click empty space	Deselects all objects.
Drag **left → right**	**Window selection** — selects objects *fully inside* the rectangle.
Drag **right → left**	**Crossing selection** — selects objects that *touch or cross* the rectangle (dashed outline).
Ctrl+A	Select all objects in the drawing.
Click + **Shift**	Add to or remove from the current selection.
Escape	Cancels the active operation with priority: active command (OFFSET, ERASE, MOVE, etc.) → active drawing tool (polyline, circle, etc.) → deselect all. When nothing is active, deselects all objects.

6.2 Selection Feedback

- Selected objects highlight and show **blue grip handles** at key geometric points.
- The status bar shows the count of selected objects.
- The Object Inspector switches to show the properties of the selected object (or a summary if multiple objects with different types are selected).

6.3 Selection Filter

The Object Inspector includes a **Selection Filter** combo box at the top of the panel. When set to a specific entity type (e.g. *Line*, *Polyline*, *Circle*, *Survey Point*, etc.), only entities of that type can be selected on the canvas — all other entity types are ignored during selection.

Set the filter to **All** (default) to allow selection of any entity type.

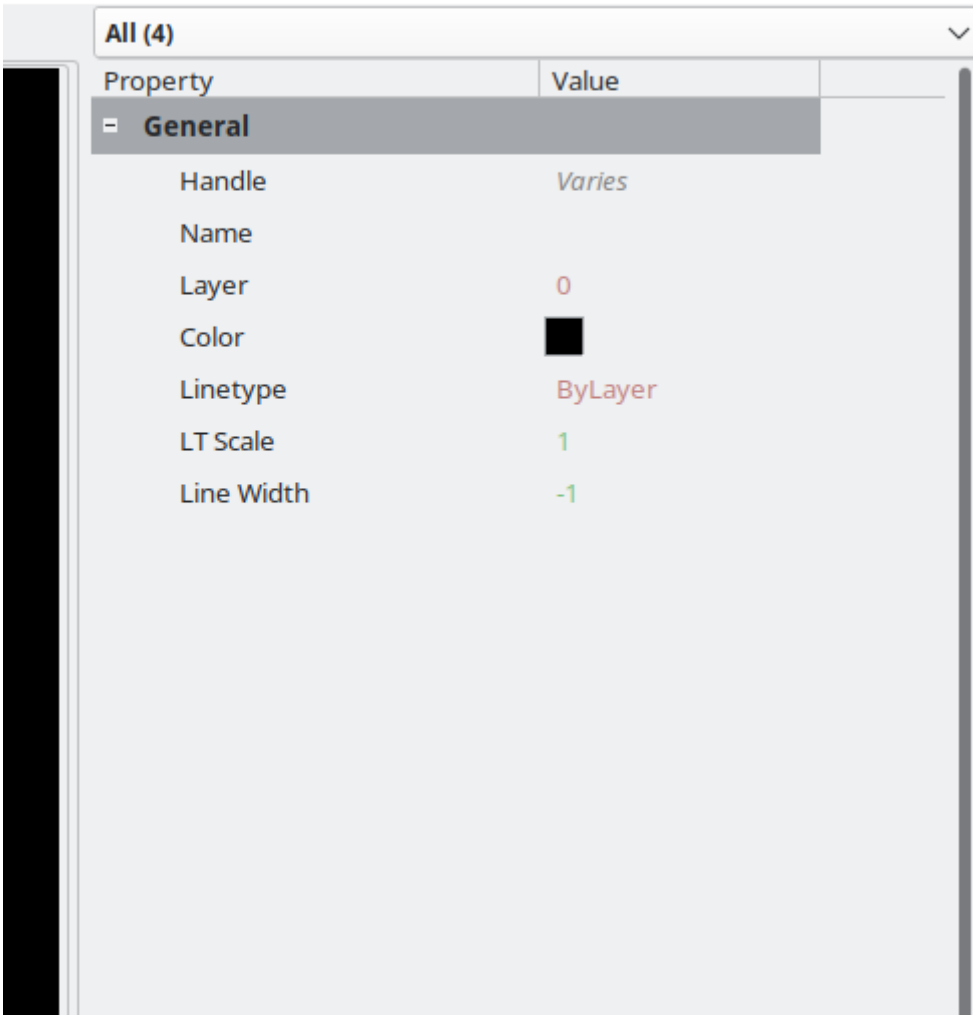


Fig. 1: The selection filter combo at the top of the Object Inspector.

Tip: To select objects on a specific layer only, first make that layer the only visible layer in the Layer Manager, then use **Ctrl+A**. Alternatively, use the selection filter to limit selection by entity type.

6.4 Cursor Modes

The cursor appearance changes to indicate the current interaction mode:

- **Full crosshair** — the default cursor, shown when idle, during drawing tools, and whenever a command prompts for a point (e.g. base point, destination, offset side). OSNAP is active in this mode.
- **Pickbox only** — shown when a command prompts for object selection (e.g. OFFSET "Select object to offset:", ERASE "Select objects:"). OSNAP is disabled in this mode so snapping does not interfere with object picking.

6.5 Right-Click Behaviour

Right-click context depends on the current state:

Context	Action
Drawing tool active (polyline with points)	Finishes the entity (closes/ends the polyline).
Drawing tool active (circle before first click)	Cancels the tool.
Command object-selection phase	Confirms the current selection (equivalent to Enter).
Civil points selected, no active tool	Opens the **point group context menu** (see below).
No active tool or command	Repeats the last command.

6.5.1 Point Group Context Menu

When one or more **civil survey points** are selected and you right-click with no active tool or command, a context menu appears instead of repeating the last command. The menu provides quick group assignment:

- **Header** — shows "Add *N* Point(s) to Group" (read-only).
- **Existing groups** — one entry per point group defined in the drawing. Click a group name to add all selected points to that group immediately.
- **New Group...** — prompts for a group name, creates the group, and adds the selected points to it.

This provides a fast alternative to typing group-management commands in the command line.

7 Layers, Linetypes and Text Styles

Open the **Layer Manager** from **Format › Layers…** or the corresponding ribbon button. The dialog has four tabs.

7.1 Layers Tab

Every object belongs to a layer. Layers control the default colour, linetype, and visibility of objects assigned to them.

Column	Description
Visible	Eye icon. Hidden layers are not drawn and their objects cannot be selected.
Name	Layer name. The active layer (used for new objects) is shown in bold.
Colour	Click the colour swatch to change the layer's default colour.
Linetype	Click to assign a linetype from the loaded set.
Linewidth	Default pen width for objects on this layer.

To create a new layer click **New Layer**; to delete an empty layer click **Delete Layer**. Double-click the name cell to rename.

7.2 Linetypes Tab

Lists all available linetypes with a **pattern preview** strip for each entry.

Button	Action
Load from File	Opens a file browser to load a standard AutoCAD `.LIN` linetype definition file. All linetype entries in the file are added to the library.
Assign to Current Layer	Assigns the selected linetype to the currently active layer.

Custom linetype names can also be set per-object in the Object Inspector (*LineType* field).

Built-in linetypes: **Solid**, **Dashed**, **Dotted**, **DashDot**, **DashDotDot**, **LongDash**, **ShortDash**, **Divide**, **Center**.

7.3 Drawing Variables Tab

Shows and edits global drawing settings that apply to the whole file:

Variable	Description
LtScale	Global linetype scale factor. Increase to stretch dash patterns; decrease to compress them. Command: `LTSCALE`.
LUnits	Linear unit type (Decimal, Engineering, Architectural, ...).
LUprec	Linear precision (decimal places).
AUnits	Angular unit type (Degrees, Radians, Grads, ...).
AUprec	Angular precision.
CurrentTextStyleName	The active text style used for new Text and Multileader objects.

7.4 Text Styles Tab

Lists all named text styles with eight columns: **Name**, **Font**, **Height**, **Width Factor**, **Oblique**, **Bold**, **Italic**, **Description**.

Five built-in styles are always present:

Name	Font	Height	WFactor	Oblique	Bold	Italic	Notes
Standard	Arial	0	1.0	0°	No	No	Default for all new text
Title	Arial	0	1.0	0°	Yes	No	Headings
Subtitle	Arial	0	1.0	0°	No	Yes	Captions
Annotative	Arial	0	1.0	0°	No	No	Scale-aware annotation
Mono	Courier New	0	1.0	0°	No	No	Fixed-width labels

Height = 0 means the height is set individually per text object.

To edit or add styles use **Format › Text Style...** (see *Format Settings* (page 89)).

7.5 Colour and Linetype Inheritance

An object's colour and linetype can be set to **ByLayer** or to an explicit value:

Value	Meaning
ByLayer	The object inherits the colour / linetype of its layer. This is the recommended default.
Explicit value	The object always draws in that colour / linetype regardless of the layer setting.

8 Object Inspector

The Object Inspector is the right-side panel that displays and edits properties of the selected object(s), the active layer, or drawing-level settings. Toggle its visibility with the **Properties** button on the Quick Access Toolbar.

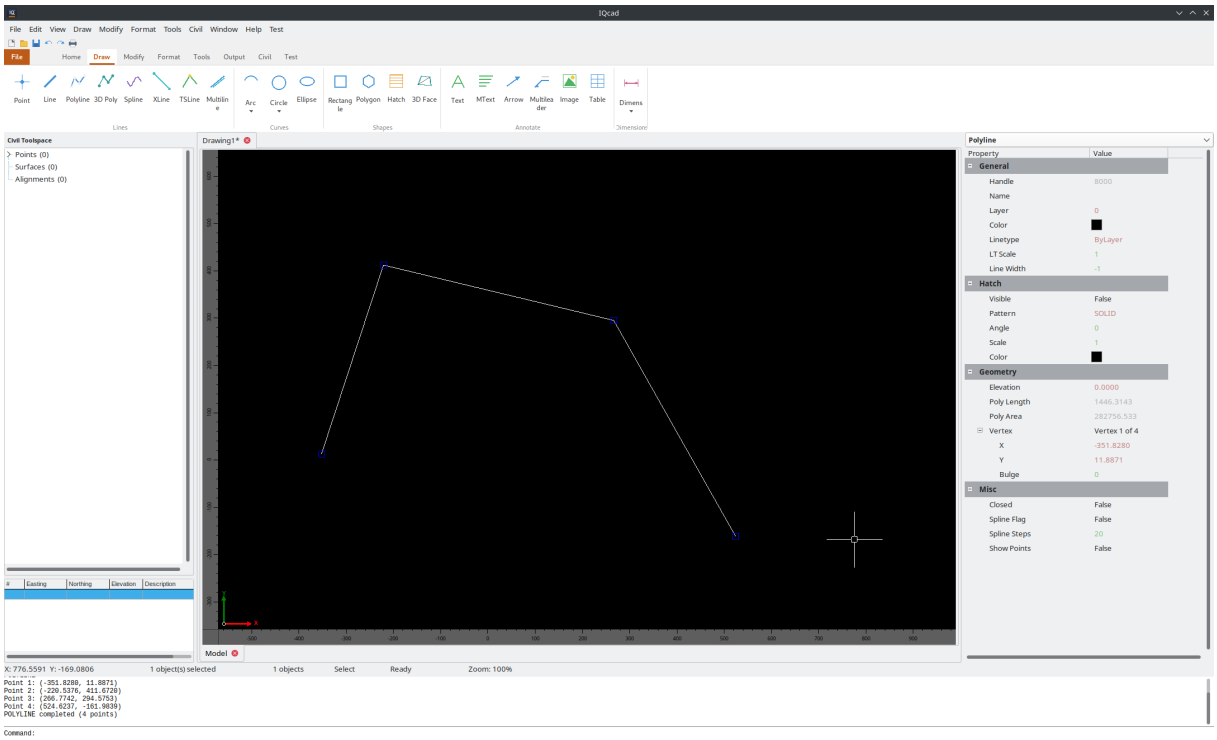


Fig. 1: The redesigned Object Inspector with collapsible categories.

8.1 Architecture

The inspector is built on **TVirtualStringTree** — a high-performance tree control that renders property rows as tree nodes organised into collapsible **category groups**. This replaces the earlier custom panel implementation.

Key design features:

- **Collapsible categories** — click a category header to expand or collapse its properties.
- **Owner-drawn combo editors** — Color properties show an inline colour swatch (no text). Layer combos show colour swatch + name. Linetype combos show a dash pattern preview. Lineweight combos show a thickness preview line.
- **Value type colour-coding** — numeric values are shown in green, strings in orange, read-only values in grey, and multi-select differing values in dimmed italic ("Varies").
- **Keyboard navigation** — **Tab** / **Shift+Tab** cycles through editable rows; **Enter** commits a value; **Escape** reverts.
- **Human-friendly labels** — PascalCase property names are automatically converted to spaced labels (e.g. `BackgroundColor` becomes "Background Color"). Proxies can override labels for context-aware naming (e.g. `ShowScaleBar` becomes "Show" under the Scale Bar group).

8.2 Selection Filter

At the top of the inspector panel is a **Selection Filter** combo box. Set it to a specific entity type (e.g. *Line*, *Polyline*, *Circle*, *Survey Point*) to restrict which entity types can be picked on the canvas. Set it to **All** (default) to allow selection of any entity type.

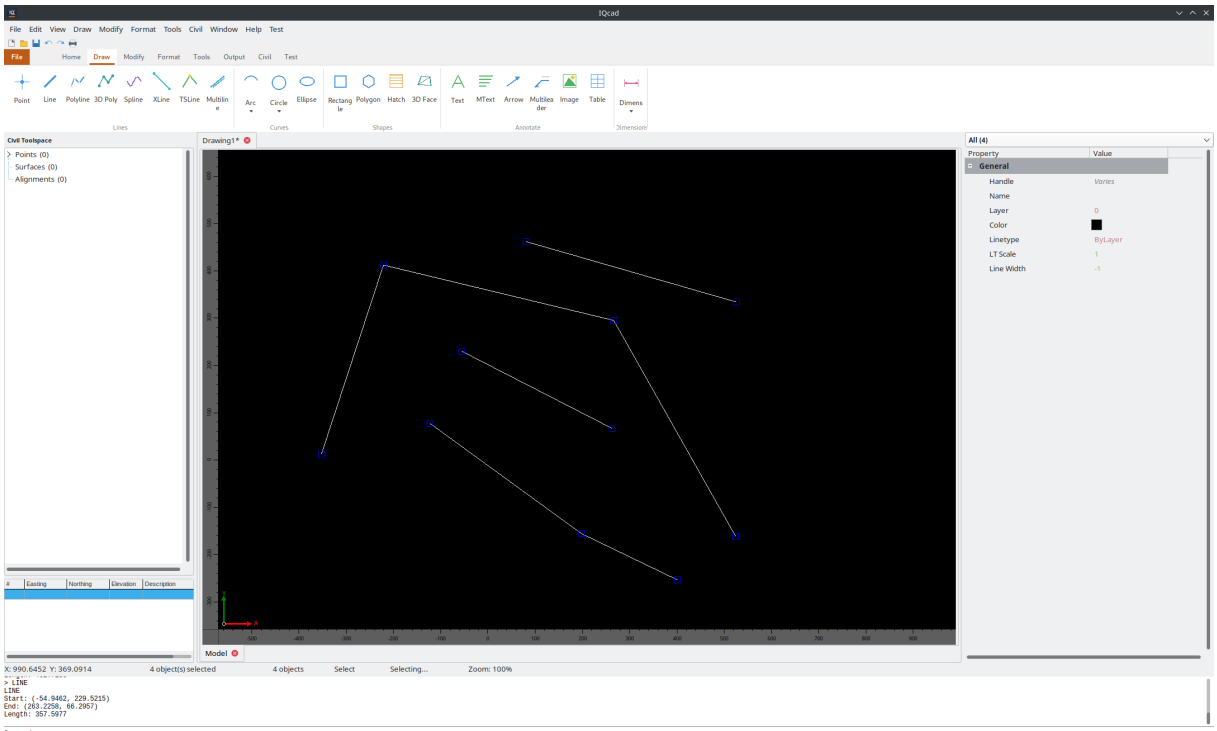


Fig. 2: Selection filter combo restricting picks to a specific entity type.

8.3 Multi-Selection

Select multiple objects (window, crossing, Ctrl+click, or Ctrl+A) to inspect them all at once. The inspector shows properties shared by all selected entities:

- Properties with the **same value** across all entities display that value normally.
- Properties with **different values** display as italic *Varies*.
- Editing a value applies the change to **all** selected entities simultaneously.

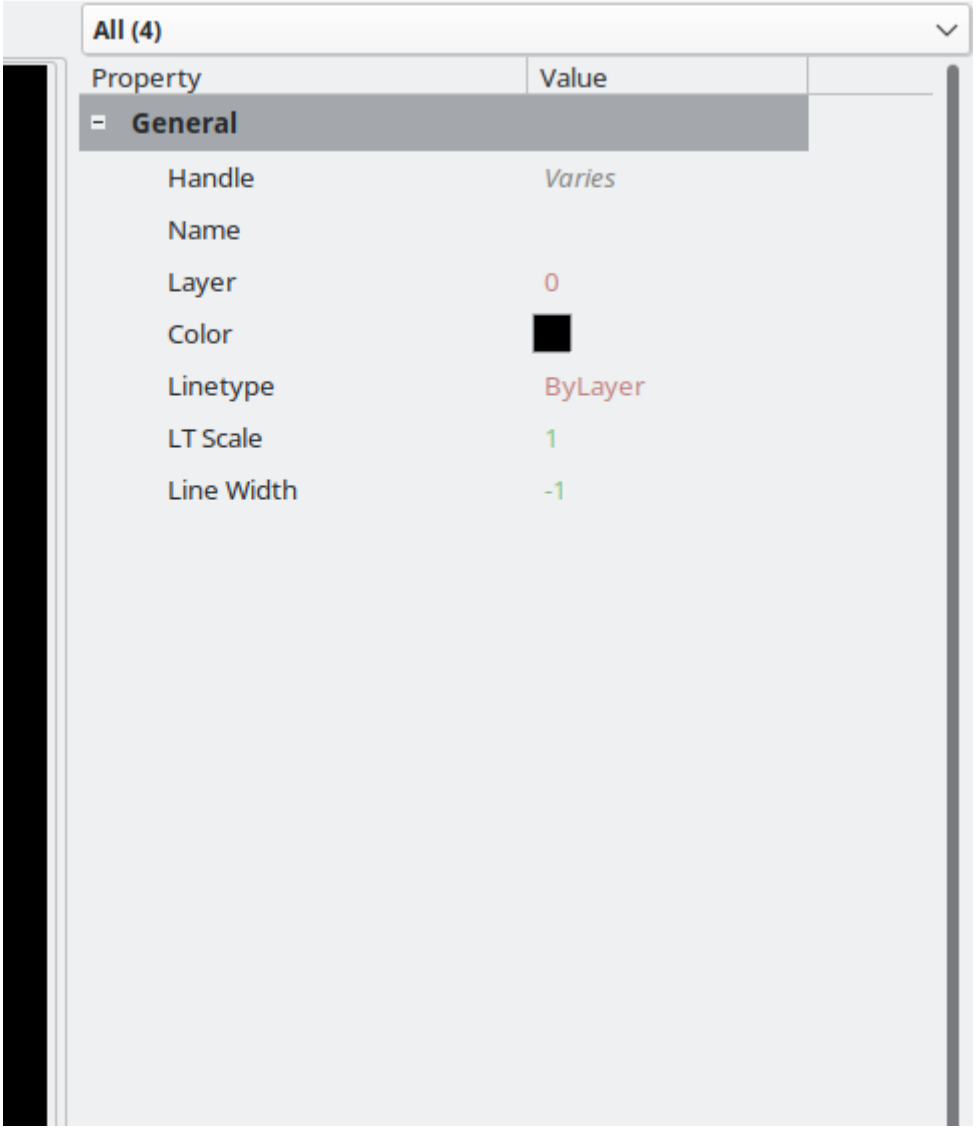


Fig. 3: Multi-selection showing “Varies” for differing property values.

8.4 Common Properties (All Objects)

Property	Description
Handle	Unique numeric identifier — read-only.
Name	Optional user-assigned label for the object.
Layer	The layer this object belongs to. Owner-drawn combo shows colour swatch + layer name.
Color	Object colour. `ByLayer` inherits from the layer. Owner-drawn combo shows colour swatch only.
Line Type	`ByLayer`, a built-in type, or a custom named type loaded from a `.LIN` file. Owner-drawn combo shows a dash pattern preview.
Line Width	Pen width. Owner-drawn combo shows a thickness preview line.

8.5 Canvas / Drawing Defaults

When **no object is selected**, the inspector shows drawing-level defaults used for new objects, organised into categories:

Property	Description
Current Color	Default colour for new objects (`ByLayer` recommended).
Current Linetype	Default linetype for new objects.
Current Line Width	Default pen width for new objects.
Grid Visible	Show or hide the background grid.
Background Color	Canvas background colour.

8.6 Line Properties

Property	Description
Start Point / End Point	World coordinates of the endpoints. Edit to reposition precisely.

8.7 Polyline and Multiline Properties

Property	Description
Closed	Whether the polyline is closed (last vertex connects to first).
Vertex	Vertex navigation row with **[<]** and **[>]** buttons and a label showing **Vertex N of M** between them. Click the arrows or change the index to navigate. Sub-properties: **X**, **Y**, **Bulge** (Z is also shown for 3D polylines).
End Caps (Multiline)	When checked, perpendicular lines are drawn across both ends of the multiline.

8.8 Hatch Properties

Hatch properties are shown on polylines, rectangles, and other entities that support hatching:

Property	Description
Hatch Pattern	Pattern name combo (ANSI31, ANSI32, NET, DOTS, SOLID, etc.).
Hatch Scale	Pattern scale factor.
Hatch Angle	Pattern rotation angle in degrees.
Hatch Color	Hatch line colour.
Hatch Background Color	Fill colour behind the hatch pattern.
Hatch Transparency	0 (opaque) to 255 (fully transparent).

8.9 3D Polyline Properties

Property	Description
Closed	Whether the 3D polyline is closed.
Spline Flag	Enable Catmull-Rom spline interpolation in full 3D (X, Y, Z).
Spline Steps	Number of interpolation steps per spline segment (default 20).
Point Count	Number of vertices — read-only.
Poly Length	Total polyline length — read-only.
Vertex	Navigation row with **[<] Vertex N of M [>]**. Sub-properties: **X**, **Y**, **Z**.

8.10 Text Properties

Property	Description
Text	The string content.
Height	Text height in world units.
Style Name	Named text style (font, width factor, oblique angle, bold/italic).
Bold / Italic	Per-object override of the style's weight/style.
H Align / V Align	Horizontal and vertical justification.
Rotation	Rotation angle in degrees.

8.11 Multileader Properties

Property	Description
Text	Label text content.
Arrow Style	*Filled*, *Open*, or *None*.
Arrow Size	Arrowhead size in world units.
Landing Gap	Length of the horizontal dogleg connecting the leader to the label.
Text Height	Label text height in world units.
Style Name	Named text style for the label.

8.12 Arc / Circle Properties

Property	Description
Centre	World coordinates of the arc/circle centre.
Radius	Radius in world units.
Start Angle / End Angle (Arc)	Arc extents in degrees. 0° = east; increases counter-clockwise.

8.13 Dimension Properties

Property	Description
Dim Style	Dropdown to select a named dimension style from the style library.
Text Override	Custom text to display instead of the measured value. Use <> as a placeholder for the measurement (e.g. <> mm).
Measurement	The computed value (read-only).
Rotation	Rotation angle for linear rotated dimensions.

8.14 AEC Survey Point Properties

Property	Description
Point Number	Numeric survey identifier.
Point Name	Descriptive name.
Northing / Easting	World coordinates — kept in sync with the object's drawn position.
Elevation	Z value (stored; not used for 2D drawing position).
Raw Description	Survey field code (e.g. `EP`, `BM`).
Full Description	Expanded description for reports.
Point Group	Group name for filtering in the Civil Toolspace and exports.
Lock Point	Prevents accidental moves when checked.
Point Style Name	Named style from the Point Style Library (see *Format Settings* (page 89)).

8.15 Surface Properties

Property	Description
Style Name	Named surface style (Standard, Triangles & Contours, Contours Only, or a user-defined style). See *Format Settings* (page 89).
Point Count	Number of TIN vertices — read-only.
Triangle Count	Number of Delaunay triangles — read-only.
Surface Area	Total 3D surface area — read-only.
Min Elevation / Max Elevation	Elevation range — read-only.
Show Contours	Toggle contour line display.

8.16 Alignment Properties

Property	Description
Style Name	Named alignment style controlling centerline, ticks, PI markers, and direction arrows.
Label Style Name	Named alignment label style controlling station labels, PI data, and curve data labels.
Start Station	Station value at the beginning of the alignment.
Total Length	Total alignment length — read-only.

8.17 Table Properties

Property	Description
Insert X / Insert Y *(Geometry)*	Coordinates of the table insertion point.
Rotation *(Geometry)*	Table rotation angle in degrees.
Rows *(Table)*	Number of rows (including title and header rows if present).
Cols *(Table)*	Number of columns.
Style Name *(Table)*	Named table style (Standard, Schedule, Legend, or a user-defined style). See *Format Settings* (page 89) for style details.
Title *(Table)*	Text displayed in the title row (visible only when the style has **HasTitle** enabled).

8.17.1 Image Properties

Property	Description
Image Path	File path of the source image (referenced mode).
Pixel Size	Pixel dimensions of the source image (read-only, “W x H”).
Embedded	When True, image bytes are stored inside the drawing file.
World Width / World Height	Dimensions of the image in world units.
Rotation	Counter-clockwise rotation in degrees.
Opacity	0 (transparent) to 255 (fully opaque).
Show Image	When False, a dashed placeholder frame is displayed instead.
Clip Enabled	Enable rectangular sub-region clipping.

8.18 Viewport Properties

When a paper-space viewport is selected, the inspector shows categories for:

- **View** — scale, center position, locked flag.
- **Grid** — viewport grid visibility and spacing.
- **Border** — tick marks, ladder marks, crosses with coordinate labels, border interval.
- **North Arrow** — visibility, size, position.
- **Scale Bar** — visibility, style, position.

8.19 Tunnel Section Line Properties

See *Civil Tools* (page 43) for the full list of Tunnel Section Line deviation-analysis properties.

8.20 Set Properties

Set-type properties (e.g. `OsnapTypes`) expand **in-place** as checkbox children instead of opening a popup dialog. Check or uncheck individual items to modify the set value.

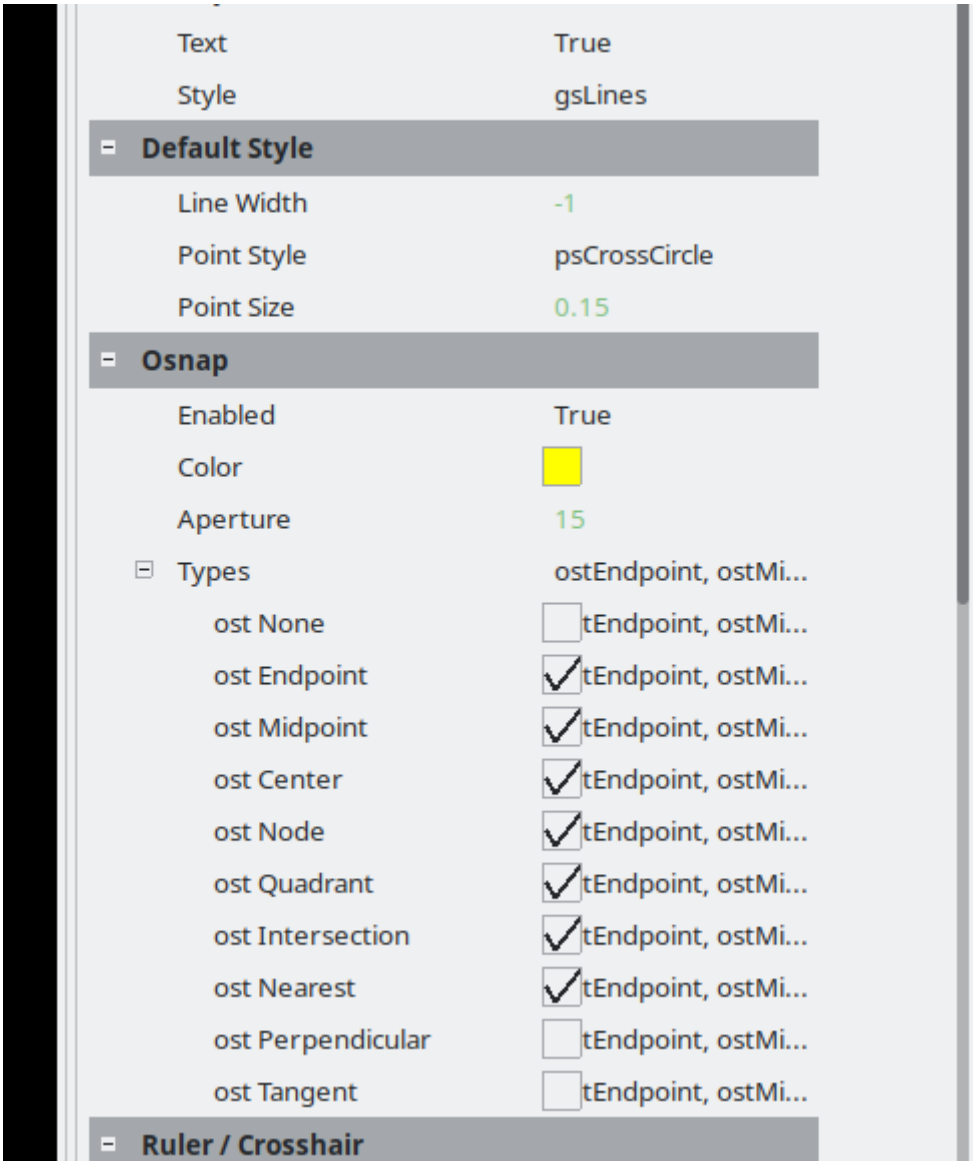


Fig. 4: A set property expanded as checkbox children.

9 Civil Tools

Civil tools extend the standard CAD objects with survey-specific capabilities. They are accessible from the **Civil menu**, the **Civil ribbon tab**, and the **Civil Toolspace** panel.

9.1 Civil Toolspace

Toggle the panel with **Civil › Civil Toolspace**. The panel shows a tree with four top-level branches:

```
▼ Survey Points  (N)
    ▼ _All Points  (N)
        └ #1   N=538345.123   E=4872341.456   Z=412.5   BM-001
        └ #2   …
    ▼ GroupA  (3)
        └ #1   …
▼ Tunnel Section Lines  (N)
    └ Measured-1  (43 pts)
▼ Surfaces  (1)
    ▼ Terrain
        ▼ Definition
            └ Point Groups
            └ Boundaries
        ▼ Contours
            └ Major @ 5.0
            └ Minor @ 1.0
▼ Alignments  (1)
    └ Alignment_1  (L=350.00  PIs=5)
```

- Click the **Refresh** button (top-right of the panel header) to rebuild the tree after bulk operations.
- **Double-click** a leaf node to select that object in the canvas and zoom to it.

Fig. 1: The Civil Toolspace panel with survey points, surfaces, and alignments.

9.2 Civil Settings

Open with **Civil › Civil Settings...** to configure per-drawing civil engineering parameters. All settings are saved inside the IQML file and restored when the drawing is reopened.

The dialog has four tabs.

9.2.1 Units & Zone

Setting	Description
Linear Unit	Choose **Meters**, **Feet**, or **US Survey Feet**.
Drawing Scale	Numeric scale denominator — e.g. enter `500` for a 1:500 drawing.
Coordinate System	Browse by category or search by name/code from ~182 built-in EPSG systems. The detail panel shows the EPSG code, datum, projection method, and linear unit.

9.2.2 Transformation

Setting	Description
Enable Transformation	Check to activate coordinate transformation for the drawing.
Reference Easting (X)	X coordinate of the reference (base) point.
Reference Northing (Y)	Y coordinate of the reference (base) point.
Rotation	Rotation angle in degrees.
Scale Factor	Multiplicative scale factor (default `1.0`).

9.2.3 Ambient Settings

Setting	Description
Precision	Number of decimal places (0–8) for distance, elevation, coordinate, angle, grade, and slope values.
Angle Format	Choose **Degrees**, **DMS** (degrees-minutes-seconds), **Grads**, or **Radians**.
Direction Format	Choose **Bearing**, **South Azimuth**, or **North Azimuth**.

9.2.4 Abbreviations

Standard abbreviations used in labels and reports:

Abbreviation	Default value
Station	`STA`
Right	`RT`
Left	`LT`
North / South / East / West	`N` / `S` / `E` / `W`
Elevation	`EL`
Grade Break	`GB`

Click **Reset to Defaults** to restore the factory abbreviation values.

Dialog buttons:

- **OK** — applies all changes.
- **Cancel** — discards all changes.
- **Reset All** — restores every setting across all tabs to its default value.

9.3 AEC Survey Points

An AEC Survey Point is a full civil survey marker storing a complete set of survey attributes alongside its drawing position.

Place with **Civil › Survey Point** or the ribbon button, then fill in the properties in the Object Inspector.

9.3.1 Properties

Property	Description
PointNumber	Numeric survey ID. Used as the primary key in the database and displayed as the point label.
PointName	Descriptive name.
Northing / Easting	World coordinates. Moving the marker on the canvas automatically updates Northing and Easting, and vice versa.
Elevation	Z value stored with the point.
RawDescription	Survey field code (e.g. `EP`, `BM`, `CL`).
FullDescription	Expanded description used in reports and exports.
PointGroup	Assigns the point to a named group.
LockPoint	Prevents the point from being moved accidentally.
PointStyleName	Selects a named point style from the library.

9.3.2 Point Style Library

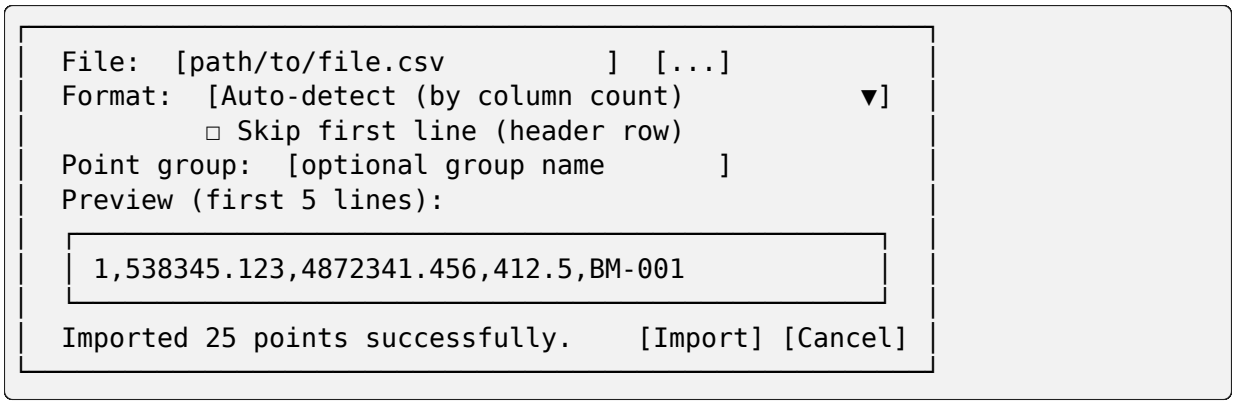
Named point styles control the marker shape and label appearance. Five built-in presets are always available:

Style	Default marker
Standard	Cross (+)
Benchmark	Triangle with dot
Control Point	Circle with cross
GPS Rover	Square with dot
Iron Rod	Circle with vertical bar

Edit or add styles via **Format › Point Style...** (**Ctrl+Shift+D**).

9.3.3 Importing Survey Points from CSV

Use **Civil › Points › Import Points...** to open the CSV import dialog.



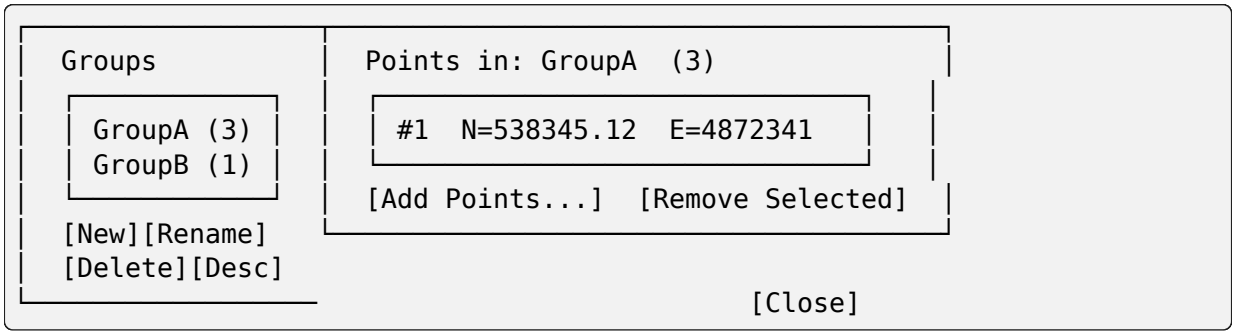
Supported formats:

Format	Column order
Auto-detect (by column count)	Detects automatically from the number of columns.
P, N, E, Z, Desc	PointNumber, Northing, Easting, Elevation, Description
N, E, Z, Desc	Northing, Easting, Elevation, Description
N, E, Z	Northing, Easting, Elevation
P, E, N, Z, Desc	PointNumber, Easting, Northing, Elevation, Description
E, N, Z, Desc	Easting, Northing, Elevation, Description
E, N, Z	Easting, Northing, Elevation

Accepted file types: `.csv`, `.txt`, `.pts`. Lines starting with `#` or `;` are treated as comments. Decimal separator is always `.`.

9.3.4 Point Groups

Use **Civil › Points › Point Groups...** to organise points into named groups.



- **New** — create a group.
- **Rename / Description** — edit group metadata.
- **Delete** — remove the group (points are not deleted).
- **Add Points...** — opens a checklist of all database points; check to add.
- **Remove Selected** — removes highlighted points from the group.

From the canvas: Select civil points on screen, then either:

- Run **ADDTOGROUP** (`ATG`) and pick or type a group name.
- **Right-click** the selection — the context menu shows existing groups and a *New Group...* option for instant assignment.

Other commands: **REMOVEFROMGROUP** (`RFG`) removes selected points from a group; **CREATEGROUP** (`CRG`) creates a group and lets you click points to add.

Converting AutoCAD Points

The **CONVERTPOINTS** command (alias `CPT`) converts standard AutoCAD point markers into AEC civil survey points. This is useful when importing DXF files that contain point entities with X/Y/Z coordinates but no civil metadata.

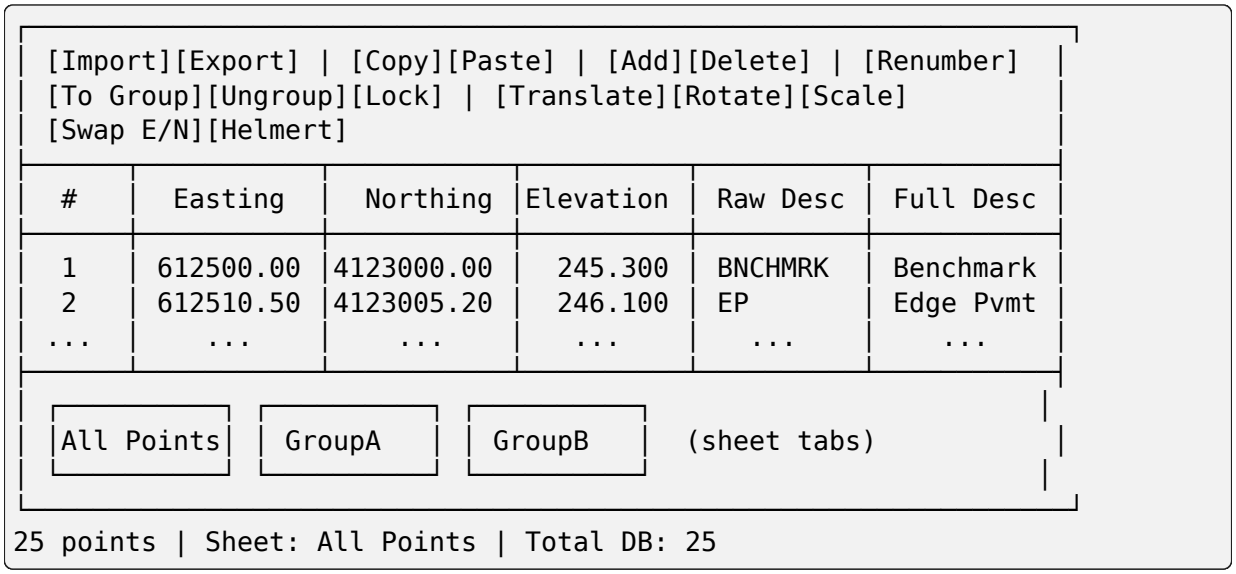
Workflow:

1. Select one or more AutoCAD point entities on the canvas.
2. Type `CONVERTPOINTS` (or `CPT`) in the command line.
3. Optionally enter a **group name** to assign all converted points to a point group. Press Enter to skip.
4. Choose whether to **delete the original point entities** after conversion (`Y` / `N`).

Each converted point receives the next available point number and inherits its X/Y/Z coordinates from the original point entity.

9.3.5 Point Manager

The **Point Manager** is a spreadsheet-style window for viewing, editing, importing, and transforming survey points. Open it with **Civil › Points › Point Manager** or the ribbon button.



Layout:

- **Toolbar** at the top with all operations.
- **Grid** in the centre — 7 columns (#, Easting, Northing, Elevation, Raw Desc, Full Desc, Lock). All cells are editable; changes are applied immediately to the database and the canvas updates.
- **Sheet tabs** at the bottom — "All Points" shows every point in the database. Each point group appears as its own tab, showing only the points in that group.
- **Status bar** — current point count, active sheet name, total database count.

Toolbar Operations

Button	Description
Import	Opens the CSV/TXT/PTS import dialog. Imported points are added to the database and appear on the canvas.
Export	Opens the export dialog. If a group tab is active, only those points are exported; otherwise all points. Supports CSV and Excel (XLSX/ODS) formats.
Copy	Copies the selected rows to the system clipboard as tab-separated text. Can be pasted into Excel, LibreOffice, or a text editor.
Paste	Parses tab-separated text from the clipboard and creates new points in the database. **Only works on the "All Points" tab.** Expected columns: Number, Easting, Northing, Elevation, Description (optional). Header rows and duplicate point numbers are skipped automatically. Ideal for pasting data from Excel or LibreOffice Calc.
Add	Creates a new point at (0, 0, 0) with the next available point number. Edit the coordinates in the grid afterwards.
Delete	Deletes the selected points from the database and the canvas (with confirmation).
Renumber	Opens the renumber dialog to reassign point numbers.
To Group	Assigns selected points to a group (new or existing). A dialog asks for the group name.
Ungroup	Removes selected points from the current group (only available on group tabs, not "All Points").
Lock	Toggles the Lock flag on selected points. Locked points cannot be moved accidentally on the canvas.
Translate	Opens the Translate dialog — shifts selected points by dE, dN, dZ.
Rotate	Opens the Rotate dialog — rotates selected points around a base point.
Scale	Opens the Scale dialog — scales selected points from a base point.
Swap E/N	Swaps the Easting and Northing values of selected points.
Helmert	Opens the Helmert transformation dialog — 2D conformal transformation (translate + rotate + scale) fitted to control point pairs.

Sheet Tabs & Group Management

The tab bar at the bottom of the Point Manager shows one tab per group plus the "All Points" tab which always appears first.

Right-click a tab to open the group context menu:

- **New Group...** — create a named group.
- **Rename Group...** — change the name (not available for "All Points").

- **Delete Group** — remove the group; points are not deleted from the database, only the group membership is removed.

Typical workflows:

1. **Create a group from selected points:** select rows on "All Points", click **To Group**, type a name.
2. **Remove points from a group:** switch to the group tab, select rows, click **Ungroup**.
3. **Paste points from Excel:** copy rows in Excel (columns: Number, Easting, Northing, Elevation, Description), switch to "All Points" tab in the Point Manager, click **Paste**.
4. **Export a group:** switch to the group tab, click **Export**.
5. **Apply a coordinate transform:** select rows, click one of the transform buttons (Translate, Rotate, Scale, Swap E/N, Helmert).

Inline Editing

Click any cell in the grid to edit it directly. Changes are committed when you press Enter or move to another cell. The following columns are editable:

- **Easting, Northing, Elevation** — numeric coordinates.
- **Raw Desc, Full Desc** — text descriptions.
- **Lock** — type `Yes` or `No` (case-insensitive; also accepts `True` / `False` / `1` / `0`).

After editing, the canvas entity is updated immediately via `UpdateSurveyPoints-FromDB`. The point number column (`#`) is not editable from the grid — use the **Renumber** button instead.

9.4 TIN Surfaces

A TIN (Triangulated Irregular Network) surface models terrain or any 3D surface from a set of survey points. The surface is built using Delaunay triangulation and can display elevation contour lines.

9.4.1 Triangulation Algorithm

The triangulation engine uses the **Bowyer-Watson incremental Delaunay** algorithm (`UTINTriangulation.pas`), accessed through the `ITINTriangulator` interface for future algorithm swappability.

How Bowyer-Watson works:

1. Create a super-triangle that encloses all input points.
2. Insert points one at a time in randomised order (Fisher-Yates shuffle).
3. For each inserted point, find all existing triangles whose circumcircle contains the new point (these are the "bad" triangles).

4. Remove the bad triangles, leaving a star-shaped polygonal hole.
5. Re-triangulate the hole by connecting the new point to all edges of the hole boundary.
6. After all points are inserted, remove any triangles that share vertices with the original super-triangle.

Performance optimisations for large point sets (100K+):

- **Randomised insertion** — prevents worst-case $O(n^2)$ behaviour on ordered point sets (e.g. grid scans, sorted CSV files).
- **Flat-grid spatial index** — triangles are assigned to grid cells based on their circumcircle AABB. Point insertion only checks triangles in nearby cells instead of scanning all triangles.
- **Auto-scaling grid** — resolution scales as `sqrt(N)` cells per axis, clamped to [16..1024], balancing cell occupancy and lookup cost.
- **Overall complexity** — $O(n\sqrt{n})$ average, compared to $O(n^2)$ without the spatial index.

9.4.2 Creating a Surface

Use any of the following methods:

- **Civil › Surfaces › Create Surface** or ribbon button **Create Srf**
- Type `CREATESURFACE` (alias `CS`) in the command line
- Right-click **Surfaces** in the Civil Toolspace and choose **Create Surface...**

A surface with an auto-generated name (`Surface_1`, `Surface_2`, ...) is created. If survey points already exist in the drawing they are triangulated automatically; otherwise an empty surface definition is created.

9.4.3 Adding Data to a Surface

An empty surface can be populated in several ways, matching the AutoCAD Civil 3D workflow:

From survey points:

- Type `ADDSURFACEPOINTS` (alias `ASP`) and enter the surface name. All survey points in the drawing are collected and the TIN is built.
- Or right-click the surface name in the Civil Toolspace and choose **Add Survey Points**.

From drawing objects (3DFaces, Lines, Polylines, etc.):

1. Select the source entities on the canvas.
2. Type `ADDSURFACEENTITIES` (alias `ASE`). If only one surface exists it is used automatically; otherwise you are prompted for the name.

Supported entity types:

Entity	How it contributes
3DFace	3 or 4 corner vertices loaded as TIN triangles directly (no re-triangulation). Quads are split into two triangles.
Line	Both endpoints contribute as TIN data points.
Polyline / Spline	All vertices contribute as TIN data points.
Point / Survey Point	Position contributes as a TIN data point.

When the selection contains **only 3DFaces**, triangles are loaded verbatim (preserving the original mesh topology). When non-face entities are present, all collected vertices are triangulated using Delaunay.

You can also right-click a surface name in the Civil Toolspace and choose **Add Drawing Objects...** to add the currently selected entities.

Rebuilding:

After adding or moving survey points, type `REBUILDSURFACE` (alias `RS`) and enter the surface name to re-triangulate from the current point positions.

9.4.4 Surface Display & Styles

Surface display is controlled through **Surface Styles** — named presets that bundle all visual settings into one reusable object.

Each surface references a style by name via the **StyleName** property in the Object Inspector. Three built-in presets are provided:

Style	Description
Standard	Shows triangles, contours, boundaries, and contour labels.
Triangles & Contours	Triangles and contours visible, boundary hidden.
Contours Only	Only contour lines and labels.
Elevation Banding	Contours and elevation bands visible.
Empty	All components hidden. Use to suppress a surface from display without deleting it.

Open the **Surface Style Editor** via:

- **Format > Surface Styles...**
- Right-click a surface in the Civil Toolspace > **Surface Style...**

The editor has 3 property tabs (Border & Triangles, Contours, Contour Labels) plus a style list for creating/editing/deleting styles.

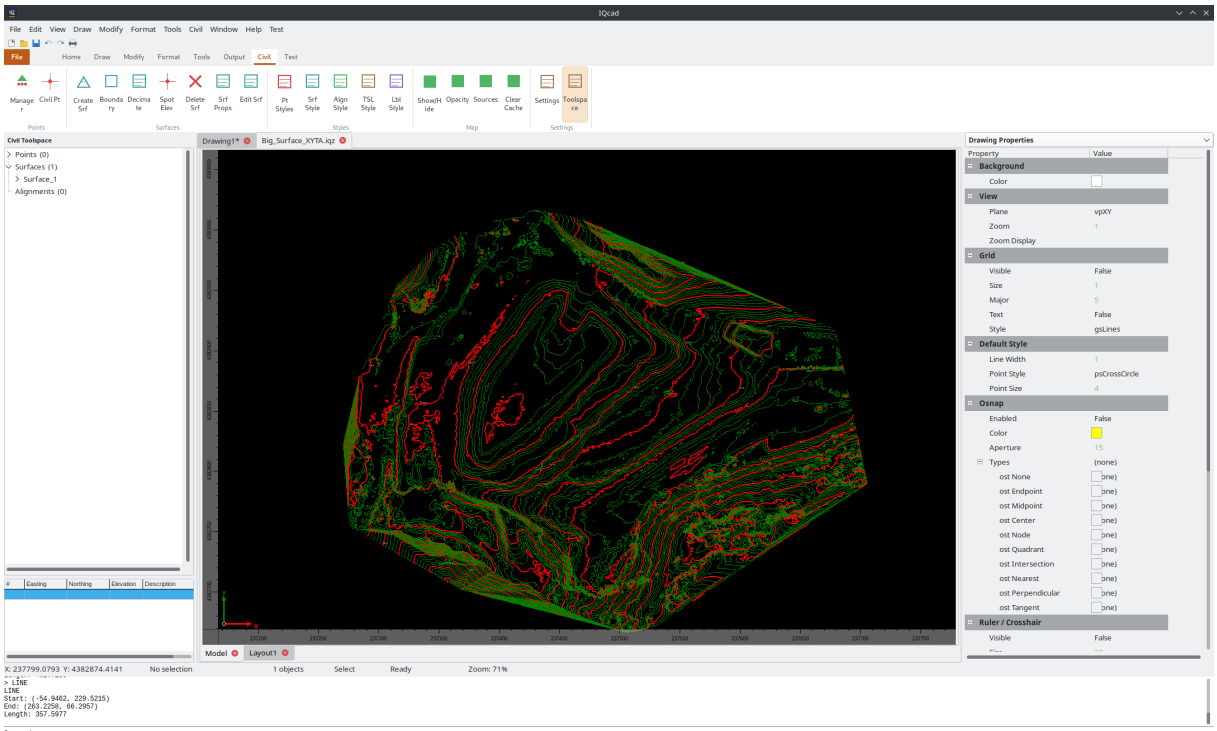


Fig. 2: A TIN surface with contour lines and elevation labels.

Style properties cover 5 groups (~35 settings): border (visibility, colour, weight), triangles (visibility, colour, weight), contours (visibility, major/ minor interval, colours, weights, smoothing, base elevation), contour labels (visibility, interval, text height, precision, prefix/suffix, colour, font, background mask, uphill-readable rotation), and points (visibility, colour, size).

Contour labels are placed automatically along contour polylines with:

- Interval-based placement with collision avoidance
- **Uphill-readable** rotation — label text top faces uphill
- Optional background mask for readability
- Manual label placement via user-placed points

Changing the style immediately regenerates contours if the interval or smoothing parameters differ from the cached values.

Contour Generation Algorithm

1. **Edge marching** — for each triangle, for each contour elevation within its Z range, find the two edge crossings by linear interpolation. Each crossing produces a 2-point segment.
2. **Segment joining** — chain the 2-point segments into continuous polylines by matching endpoints. Uses a **spatial hash table** with linked-list chaining for O(1) endpoint lookup (Fibonacci hashing, QUANT = 1e-6, table size = next power of 2 ≥ 2×N segments). This replaces the naive $O(s^2)$ greedy scan and makes joining nearly instant even for millions of segments.

3. **Chaikin smoothing** — apply corner-cutting subdivision (`ContourSmoothing` passes) to produce smooth curves.

Lazy generation for large surfaces. When `LoadTINData` receives more than 100 000 triangles, contour generation is deferred: `ShowContours` is set to False and contours are only computed when the user first enables `ShowContours` via the Object Inspector. This prevents the UI from blocking during large LandXML imports.

9.4.5 Boundaries

Boundaries clip the TIN to a specific area. Use **Civil › Surfaces › Add Boundary** or the command `ADDSURFACEBOUNDARY` (alias `ASB`) to add an outer boundary or hole boundary to a surface.

- **Outer boundary** — triangles whose centroids fall outside the polygon are removed.
- **Hole boundary** — triangles whose centroids fall inside the polygon are removed.

9.4.6 Surface Statistics

The Object Inspector shows the following read-only statistics:

- **PointCount** — number of TIN vertices.
- **TriangleCount** — number of Delaunay triangles.
- **SurfaceArea** — total 3D surface area. For surfaces exceeding 500 000 triangles the area is estimated by sampling every N-th triangle and extrapolating, so the calculation remains instant.
- **MinElevation / MaxElevation** — elevation range.

These statistics are also displayed in the Civil Toolspace grid when the surface node is selected.

9.4.7 Elevation Query

The surface provides a `GetElevationAt(X, Y)` method that returns the interpolated Z elevation at any (X, Y) position on the TIN. Interpolation uses **barycentric coordinates** inside the triangle that contains the query point — no re-triangulation is needed. This method is used internally by the greedy decimation algorithm and can be called from scripts.

9.4.8 Performance & Rendering

Large surfaces (millions of triangles) use several automatic optimisations to keep the editor responsive:

- **Triangle sub-sampling** — when the TIN exceeds 500 000 triangles, only every *N*-th triangle is drawn (`MAX_DRAW_TRIANGLES = 500 000`). This caps GDI draw calls and keeps panning/zooming smooth.
- **Viewport culling** — triangles whose three vertices all fall outside the same viewport edge (left, right, top, or bottom) are skipped entirely.
- **Sub-pixel culling** — triangles that project to a single screen pixel (all three screen coordinates identical) are not drawn.
- **Lazy contour generation** — when `LoadTINData` receives more than 100 000 triangles (e.g. during a LandXML import), `ShowContours` is set to False and contours are only computed when the user first enables them via the Object Inspector. This prevents the UI from blocking.
- **Surface area sampling** — for surfaces exceeding 500 000 triangles the 3D surface area statistic is computed by sampling rather than iterating every triangle.

No user configuration is required — all thresholds are applied automatically.

9.4.9 IQML Streaming Save

Surface entities (and all other entity types) are serialised to IQML using a **streaming writer** that writes directly to a text file instead of building an in-memory DOM tree. This eliminates millions of XML node allocations and keeps memory usage constant regardless of drawing size.

- Drawings with 1 000 000+ entities save in seconds instead of minutes.
- The IQML file format is identical — streaming is transparent.

9.4.10 Decimating (Simplifying) a Surface

Dense TIN meshes — for example from drone photogrammetry, LiDAR, or large LandXML imports — can contain millions of triangles. The **Decimate Surface** command reduces the TIN to a much smaller mesh while preserving the surface shape within a user-specified vertical tolerance.

Use any of the following methods:

- **Civil › Surfaces › Decimate Surface...**
- Ribbon button **Decimate** in the Surfaces pane of the Civil tab
- Type `DECIMATESURFACE` (alias `DS`) in the command line

You will be prompted for:

1. **Surface name** — auto-selected if only one surface exists.

2. **Max elevation tolerance** — the maximum allowed vertical error (in drawing units, e.g. `0.05` for 5 cm).

Decimation Algorithms

The system automatically selects the best algorithm based on the number of input points (threshold: 100 000 points).

Algorithm A — Grid-Based Decimation (> 100K points)

O(n) single-pass algorithm designed for very large surfaces (millions of points). Completes in seconds even for 4M+ points.

1. **Bounding box pass** — compute the XY extent and simultaneously track the 4 boundary extreme points (min-X, max-X, min-Y, max-Y). These replace an expensive O(n log n) convex hull computation.
2. **Grid setup** — divide the XY extent into an aspect-ratio-aware grid. Grid resolution: `N / 50` cells (roughly 2% of input), capped at **50 000** cells to keep the subsequent triangulation fast.
3. **Cell statistics pass** — single pass over all N points. For each grid cell, track the point with the minimum Z and the maximum Z.
4. **Point selection** — for each occupied cell:
   - Always keep the **max-Z** point (preserves terrain highs).
   - Also keep the **min-Z** point if the cell's Z range exceeds the tolerance (preserves valleys, ridges, and terrain features).
5. **Triangulation** — Bowyer-Watson on the reduced point set (typically 30K–80K points).

Algorithm B — Greedy-Insertion Refinement (≤ 100K points)

Higher-quality iterative algorithm where each inserted point is chosen to maximise error reduction.

1. **Seed** — start with a triangulation of the convex hull corners only.
2. **Error computation** — for every omitted point, compute its vertical error against the current (coarse) TIN surface using a grid-accelerated triangle lookup for Z interpolation.
3. **Batch insertion** — pop a batch of the highest-error points from a binary max-heap and insert them all at once, then re-triangulate. Adaptive batch sizes (20–500 points) scale with remaining count.
4. **Error update** — recompute errors for all remaining omitted points against the updated TIN. O(n) bottom-up heap rebuild.
5. **Stop** — repeat until max error ≤ tolerance, or `MaxPoints` reached.

Typical results:

Input	Algorithm	Tolerance	Time	Reduction
4 235 712 pts	Grid	0.10 m	< 5 sec	~99%
500 000 pts	Grid	0.05 m	< 2 sec	~97%
50 000 pts	Greedy	0.02 m	~10 sec	~70%

After decimation the contours and boundaries are automatically regenerated.

9.4.11 Deleting a Surface

Use **Civil › Surfaces › Delete Surface** or type `DELETESURFACE` in the command line and enter the surface name.

9.4.12 Importing Large Surfaces (LandXML Fast Path)

LandXML files ≥ 10 MB are imported using a **streaming fast path** that bypasses DOM parsing entirely:

- **Line-by-line reader** (`ULandXMLFastReader`) — reads the file sequentially without building an XML DOM tree in memory.
- **Direct array ID→index mapping** — O(1) point ID lookup instead of `TFPGMap` sorted-list binary search.
- **Inline number parsing** — float and integer values are parsed in-place without allocating `TStringList` per XML element.
- **Memory** — O(points + triangles) only; doubling array growth for amortised O(1) insertions.

The fast path is activated automatically and transparent to the user — the import dialog and workflow are identical. Small files continue to use the standard DOM-based path.

9.4.13 Exporting Surfaces

- **DXF**: triangles export as `3DFACE` entities; contour lines export as 3D polylines on dedicated layers (`<Name>-Contour-Major` and `<Name>-Contour-Minor`).
- **LandXML**: surfaces export as `<Surface>/<Definition surfType="TIN">` with `<Pnts>` and `<Faces>` elements.
- **IQML**: full round-trip including TIN data, boundaries, contour settings, and source group names.

9.4.14 Surface Editing Commands

IQcad provides interactive TIN editing commands for modifying a surface after it has been created. All surface edit operations are logged and can be undone.

Command	Alias	Description
SURFADDPOINT	SAP	Add a single point to the surface TIN interactively.
SURFDELETE-POINT	SDP	Delete a point from the surface TIN.
SURFMOVEPOINT	SMP	Move a surface TIN point to a new position.
SURFMODI-FYELEV	SME	Modify the elevation of a surface point.
SURFSWAPEDGE	SSE	Swap a TIN edge between two adjacent triangles.
SURFADDLINE	SAL	Force an edge between two points in the TIN (break-line).
SURFDELETE-LINE	SDL	Remove a TIN edge.
SURFRAISELOWER	SRL	Raise or lower the entire surface by a specified elevation offset.
SURFUNDO	(none)	Undo the last surface edit operation.
SURFCLEARED-ITS	SCE	Clear the surface edit log.
SURFLISTEDITS	SLE	List all surface edit operations performed since the last clear.

9.4.15 Spot Elevations

The **Spot Elevation** tool (SPOTELEV, alias SE) places an elevation label at a clicked point on a surface. The tool queries the TIN to interpolate the Z value at the click position and displays it as a text annotation on the canvas.

Access via:

- **Civil > Surfaces > Spot Elevation**
- Ribbon button **Spot Elev** on the Civil tab
- Command SPOTELEV (alias SE)

9.4.16 Contour Label Placement

The **Add Contour Labels** command (ADDCONTOURLABEL, alias ACL) places elevation labels along contour lines of a surface. Labels are positioned automatically with collision avoidance and uphill-readable rotation.

9.5 Horizontal Alignments

A horizontal alignment defines the centreline geometry of a road, railway, pipeline, or other linear infrastructure project. The alignment represents the designed path in plan view (the horizontal plane) and serves as the reference axis for stationing, profile views, and cross-sections.

9.5.1 Geometry Elements

Every alignment is built from a sequence of geometric elements placed end-to-end. The alignment engine computes the precise geometry from **PI (Point of Intersection)** data that you provide.

Element	Description
Tangent	A straight segment connecting two consecutive PIs, or connecting a curve end to a PI. Tangents have constant bearing along their length.
Circular Curve	A constant-radius arc that rounds the angle between two tangents. Defined by the curve **radius** and the **deflection angle** at the PI. The curve produces a smooth transition from one tangent direction to the next.
Spiral (Clothoid)	An Euler spiral where curvature increases linearly with arc length. Clothoid spirals provide a gradual transition between a tangent (zero curvature) and a circular curve (constant curvature), or between two curves of different radii. Specified by either the spiral **length (L)** or the spiral **parameter (A)**.
Spiral (Cubic Parabola)	A transition curve defined by the equation y = x^3 / (6RL). Used in some European road design standards. Like the clothoid, it can be specified by **length (L)** or **parameter (A)**.

A typical alignment follows the pattern: *Tangent - Spiral In - Circular Curve - Spiral Out - Tangent - ...* but simpler configurations (tangent-curve-tangent without spirals, or tangent-only) are also supported.

9.5.2 Creating an Alignment

There are two ways to create an alignment: interactively by picking PI points, or by converting an existing polyline.

Method 1 — ALIGNMENT command (interactive PI picking)

1. Type `ALIGNMENT` (alias `ALIGN`) in the command line, or choose **Civil > Alignments > Create Alignment** from the menu.
2. Click points on the canvas to place each PI (Point of Intersection). The first click places PI #1, the second places PI #2, and so on. A rubber-band preview line follows the cursor.
3. Right-click or press **Enter** to finish. The alignment is created and appears on the canvas with its default style.

The initial alignment has straight tangent segments only (no curves). To add curves and spirals, open the PI Table Editor (see below).

Method 2 — ALIGNFROMPOLYLINE command

1. Type `ALIGNFROMPOLYLINE` (alias `AFP`) in the command line.
2. Click on an existing polyline or line in the drawing.
3. The alignment is created using the polyline vertices as PI points. The original polyline remains unchanged.

This is useful when you have already drawn the approximate route as a polyline and want to convert it into a civil alignment for further design.

9.5.3 PI Table Editor

The PI Table Editor is the primary tool for fine-tuning alignment geometry. Open it from the **Civil ribbon > Edit PIs** button, or by double-clicking an alignment in the Civil Toolspace.

The editor has two panels:

Left panel — Alignment list:

- Shows all alignments in the drawing with their names.
- **New** — creates a new empty alignment.
- **Delete** — removes the selected alignment.
- **Rename** — changes the alignment name.
- **Import** — imports alignment data from ALM or PSIMO files.

Right panel — PI data grid:

Each row represents one PI. The following columns are available:

Column	Description
PI #	Sequential PI number (read-only).
Easting	X coordinate of the PI point. Editable.
Northing	Y coordinate of the PI point. Editable.
Radius	Radius of the circular curve at this PI (0 = no curve). Editable.
Spiral In	Length or parameter of the entry spiral. Editable.
Type (In)	Spiral type for the entry spiral. Choose from the dropdown: Clothoid L, Clothoid A, Cubic L, Cubic A.
Spiral Out	Length or parameter of the exit spiral. Editable.
Type (Out)	Spiral type for the exit spiral.
Deflection	Deflection angle at this PI (computed, read-only).
Tangent	Tangent distance from PI to curve start/end (computed, read-only).
Curve Length	Arc length of the curve at this PI (computed, read-only).
Station	Station value at this PI (computed, read-only).

After editing values, click **Apply** to rebuild the alignment geometry. The canvas updates immediately to show the new alignment shape.

Spiral types explained:

- **Clothoid L** — specify the spiral by its arc length (L).
- **Clothoid A** — specify the spiral by its parameter (A), where A^2 = R * L.
- **Cubic L** — cubic parabola spiral specified by arc length.
- **Cubic A** — cubic parabola spiral specified by parameter.

9.5.4 Alignment Properties

When an alignment is selected, the Object Inspector displays the following properties:

Property	Description
Name	The alignment name, displayed in the Civil Toolspace and used to link profile views and cross-sections to the alignment.
Style Name	The named alignment style that controls all visual aspects of the alignment on the canvas (see Alignment Styles below).
Start Station	Station value at the beginning of the alignment. Change this to shift the stationing (e.g., set to `1000` if the alignment starts at station 1+000).
Total Length	Total alignment length in drawing units (read-only).

9.5.5 Alignment Commands

Command	Alias	Description
`ALIGNMENT`	`ALIGN`	Create a new alignment by picking PI points interactively on the canvas. Click to place each PI, right-click or Enter to finish.
`ALIGN-FROMPOLYLINE`	`AFP`	Create an alignment from an existing polyline. Click on a polyline to convert its vertices into alignment PIs.
`ALIGNREVERSE`	(none)	Reverse the direction of an alignment. The start becomes the end and vice versa; stationing is recalculated accordingly.
`ALIGNPROPS`	(none)	Display alignment properties (name, length, PI count, element list) in the command line output.

9.5.6 Alignment Styles

Alignment styles control every visual aspect of how an alignment appears on the canvas. Each alignment references a style by name via the **Style Name** property. Edit styles via **Format > Alignment Styles...** or right-click an alignment in the Civil Toolspace and choose **Alignment Style...**.

The style editor has three tabs:

Tab 1 — Centerline & Ticks:

Setting	Description
Centerline visible	Show or hide the alignment centerline.
Centerline color / weight / linetype	Visual appearance of the centerline.
Major tick interval / length	Spacing and length of major station ticks (e.g., every 100 m).
Minor tick interval / length	Spacing and length of minor station ticks (e.g., every 20 m).
Tick color / weight	Visual appearance of station ticks.

Tab 2 — PI & Arrows:

Setting	Description
PI markers visible / color / size	Show PI points as markers on the alignment.
Show PI Details	When enabled, geometry tables are drawn at each PI showing the computed curve parameters (see PI Detail Tables below).
PI lines visible / color / weight / linetype	Show the tangent extension lines through each PI.
Direction arrows visible / interval / color / size	Show arrows along the centerline indicating the alignment direction.

Tab 3 — Labels:

Setting	Description
Text height / color	Base text properties for all labels.
Station labels (major / minor + offset)	Station values at major and minor tick marks.
PI labels (radius, tangent, deflection, spiral length + offset)	Curve parameter labels placed near each PI.
Curve labels (length, chord, degree + offset)	Arc geometry labels placed along curves.
Name label	The alignment name displayed at the start of the alignment.
Station equation labels	Labels at station equation points (if any).

Four built-in styles are provided: **Standard** (centerline and ticks only), **Centerline Only** (ticks, PI markers, and arrows hidden), **Design Phase** (includes PI detail tables, PI lines, and full labels), and **Empty** (all components hidden — use to suppress an alignment from display without deleting it).

9.5.7 Alignment Label Styles

Labels are part of the alignment style (Tab 3 in the style editor). The following label categories can be independently enabled or disabled:

- **Station labels** — placed at major and minor tick positions along the centerline. Major labels show the full station value (e.g., `0+100.000`); minor labels show an abbreviated value. The label offset controls how far the text sits from the centerline.
- **PI data labels** — placed near each PI marker. They can show radius, tangent distance, deflection angle, and spiral lengths. Useful during design to see curve parameters directly on the plan.
- **Curve data labels** — placed along circular curve arcs. They can show curve length, chord length, and degree of curvature.

All label text respects the text height and color settings from the style.

9.5.8 PI Detail Tables

When **Show PI Details** is enabled in the alignment style, geometry tables are drawn at each PI showing the computed parameters:

- **Start / End PIs** — PI number and coordinates (X, Y).
- **Symmetric curves** (equal entry and exit spirals) — single column showing: deflection angle, radius, arc length, spiral parameter (A), spiral length (L), shift (epsilon), and tangent distance (T).
- **Asymmetric curves** (different entry and exit spirals) — two columns showing A1/A2, L1/L2, epsilon1/epsilon2, and T1/T2.

Tables are placed on **alternating sides** of the alignment with leader lines connecting the table to the PI point. Tables **auto-hide** when you zoom out and PIs are too close together on screen, keeping the display uncluttered.

9.5.9 Import Formats

Alignments can be imported from several external formats:

Format	Description
LandXML	International standard for civil engineering data exchange. Imports horizontal geometry (lines, curves, spirals) and vertical profile. Use **File > Import LandXML**.
ALM	Alignment Solver format. Reads both geometry elements and PI data including spiral parameters. Use **File > Import ALM** or the Import button in the PI Table Editor.
PSIMO	Greek road design format (`.S01` for horizontal, `.S02` for vertical alignment). PI-based with spiral parameters. Use **File > Import PSIMO** or the Import button in the PI Table Editor.

9.5.10 Station Format

Station display format is configurable in Civil Settings (**Civil ribbon > Settings**):

- **Station Index Increment** — `1000` for metric notation (e.g., `0+300.000`) or `100` for imperial notation (e.g., `3+00.000`).
- **Station Precision** — 0 to 4 decimal places.

9.6 Profile Views

A profile view is a graph that shows elevation along the length of a reference line. The horizontal axis represents station (distance along the alignment or polyline), and the vertical axis represents elevation. Profile views are used to visualise existing ground levels, design vertical alignments, and compare surfaces.

Profile views can contain two types of profiles:

- **Sampled profiles** — elevation data sampled from a TIN surface along the alignment at regular intervals. These represent existing conditions (e.g., natural ground, rock surface).
- **Design profiles** — manually defined vertical alignments consisting of PVI (Point of Vertical Intersection) points connected by straight grades and optional vertical curves.

9.6.1 Creating a Profile View

Method 1 — CREATEPROFILEVIEW command (from alignment)

Use this when you have an alignment and want to see how it crosses one or more surfaces.

1. Type `CREATEPROFILEVIEW` (alias `CPV`) in the command line, or choose **Civil > Profile > Create Profile View**.
2. If multiple alignments exist, type the alignment name or click on it. If only one alignment exists, it is selected automatically.
3. Optionally select a surface to sample. Press **Enter** to skip if you only want to show a design profile.
4. Click a point on the canvas to place the profile view.

The command creates a profile view entity at the insertion point. If a surface was selected, the existing ground profile is sampled automatically and displayed as a line in the view. If the alignment has a vertical profile (e.g., imported from LandXML), a design profile is also added.

Method 2 — QUICKPROFILE command (from any line or polyline)

Use this for a quick elevation check along any line or polyline, without needing a formal alignment.

1. Type `QUICKPROFILE` (alias `QP`) in the command line.
2. If multiple surfaces exist, type the surface name or click on it. If only one surface exists, it is selected automatically.
3. Click on a line or polyline in the drawing.

The command samples the selected surface along the line/polyline and creates a profile view near the selected entity. This is the fastest way to see a terrain profile.

9.6.2 Creating a Design Profile

A design profile represents the proposed vertical alignment (the road grade line). To create one inside an existing profile view:

1. Type `DESIGNPROFILE` (alias `DP`) in the command line.
2. Click on a profile view in the drawing to select it.
3. Click points inside the profile view to place PVI (Point of Vertical Intersection) points. Each click defines a station and elevation.
4. Right-click or press **Enter** to finish placing PVIs.
5. For each interior PVI (not the first or last), you are prompted for a **vertical curve length**. Enter `0` for a sharp grade break, or a positive value for a smooth parabolic vertical curve.

The design profile is added to the profile view and drawn as a line.

9.6.3 Profile View Properties

When a profile view is selected, the Object Inspector displays the following properties:

Property	Description
Name	Display name of the profile view.
AlignmentName	Name of the source alignment (read-only for alignment-based views).
Title	Title text displayed above the profile view grid.
StartStation	Start station of the horizontal axis.
EndStation	End station of the horizontal axis.
DatumElevation	Bottom elevation of the vertical axis.
TopElevation	Top elevation of the vertical axis.
ViewWidth	Width of the profile view on the canvas (in drawing units).
ViewHeight	Height of the profile view on the canvas (in drawing units).
VerticalExaggeration	Ratio that stretches the vertical axis relative to the horizontal. A value of 5 means 1 m of elevation is drawn as 5 m on screen. Useful for seeing subtle grade changes on long alignments.
MajorGridX / MinorGridX	Major and minor grid line spacing on the horizontal (station) axis.
MajorGridY / MinorGridY	Major and minor grid line spacing on the vertical (elevation) axis.
GridColor / MinorGridColor	Colors for major and minor grid lines.
ShowAxisLabels	Show or hide station and elevation labels along the axes.

Profile views update automatically when the source alignment PIs are edited or when a source polyline is modified (for quick profiles).

9.6.4 Profile View Commands

Command	Alias	Description
`CREATEPROFILEVIEW`	`CPV`	Create a profile view from an alignment and optionally sample a surface along it.
`QUICKPROFILE`	`QP`	Create a quick profile view by sampling a surface along any line or polyline in the drawing.
`DESIGNPROFILE`	`DP`	Add a design profile (vertical alignment) to an existing profile view by clicking PVI points.

9.7 Cross-Sections

Cross-sections are perpendicular slices through terrain at stations along an alignment. Each section can show **multiple surface profiles** (e.g., existing ground, rock layer, design surface), with cut/fill computed between any two selected surfaces.

9.7.1 Creating a Section Sheet

Use **Civil > Cross-Sections > Create Section Sheet** or type `CREATESECTIONSHEET` (alias `CSS`) in the command line.

Workflow:

1. Select alignment
2. Enter surface names to sample (comma-separated)
3. Set station interval (default 20m)
4. Set left/right widths (default 20m each)
5. Set columns and rows per sheet
6. Optionally select two surfaces for cut/fill comparison
7. Click insertion point

The command generates sample lines along the alignment, samples all specified surfaces at each station, computes cut/fill areas, and creates one or more section sheet entities on the canvas.

9.7.2 Earthwork Volumes

Type `EARTHWORKVOLUMES` (alias `EWV`) to compute and display an earthwork volume table using the **average end area method**.

The table shows for each station: cut area, fill area, cut volume, fill volume, cumulative cut, cumulative fill, and net volume. Totals are printed at the bottom.

9.7.3 Cross-Section Commands

Command	Alias	Description
`CREATESECTIONSHEET`	`CSS`	Create a cross-section sheet interactively.
`EARTHWORKVOLUMES`	`EWV`	Compute and display earthwork volume table.

9.8 Association Highlighting

When you select a civil entity that references other objects, IQcad highlights the associated entities in light cyan to show their relationship:

- **Selecting a Profile View** highlights the parent alignment, all surfaces sampled by the view, and any path entities used as the profile source. The surface boundary is force-drawn during highlighting even if the surface style normally hides it.
- **Selecting a Section View or Section Sheet** highlights the parent alignment and all surfaces sampled by the sections.

This makes it easy to visually confirm which alignment and surfaces a profile or section view is based on, especially in drawings with multiple alignments and overlapping surfaces.

9.9 Prospector Style Columns

In the **Civil Toolspace** (prospector panel), clicking the **Surfaces** or **Alignments** top-level node displays a summary grid. The grid includes a **Style** column with a dropdown that lets you change the style of any surface or alignment directly from the prospector, without opening the Object Inspector.

9.10 Parcels

A parcel is a closed boundary polygon representing a land area such as a property lot, easement, or right-of-way. Each parcel stores its boundary geometry together with area, perimeter, and user-defined data fields. Parcels participate in the civil entity hierarchy alongside survey points, surfaces, and alignments, and are saved/loaded in IQML and LandXML formats.

9.10.1 Creating a Parcel

Use the `CREATEPARCEL` command (alias `PARCEL`) or choose **Civil > Parcels > Create Parcel** from the menu.

Workflow:

1. Type `CREATEPARCEL` in the command line (or use the menu/ribbon).
2. Enter a **parcel name** when prompted (e.g., `Lot-1`).
3. Click on a **closed polyline** in the drawing to use as the parcel boundary. The polyline must be closed (first and last vertex coincide, or the `Closed` flag is set).
4. The parcel is created and appears on the canvas with the active parcel style. The source polyline remains in the drawing.

The parcel entity computes its **area** and **perimeter** automatically from the boundary geometry. These values update if the boundary is edited.

9.10.2 Parcel Properties

When a parcel is selected, the Object Inspector displays the following properties:

Property	Description
ParcelName	Display name of the parcel (e.g., `Lot-1`, `Parcel A`).
ParcelNumber	Numeric identifier for the parcel.
StyleName	Named parcel style controlling boundary, fill, and label display.
Area	Computed area of the parcel boundary polygon (read-only).
Perimeter	Computed perimeter of the parcel boundary (read-only).
UserData	Free-form key-value data attached to the parcel. Common fields include Owner, Description, Zoning, LandUse, and TaxID.

9.10.3 Parcel Styles

Four built-in parcel styles are provided:

Style	Description
Standard	Boundary line only, no fill or segment labels.
Property	Boundary with semi-transparent fill and bearing/distance labels on each boundary segment.
Easement	Dashed boundary with a light fill pattern to indicate a restricted zone.
ROW	Right-of-way style with a heavy boundary and cross-hatch fill pattern.
Empty	All components hidden (`BoundaryVisible=False`). Use to suppress a parcel from display without deleting it.

Edit parcel styles via the **Civil Style Manager** (Civil > Styles) or **Format > Parcel Styles...**. Style settings include boundary colour, weight, and linetype; fill colour and transparency; label visibility, bearing format (bearing, azimuth, or angle), and segment label text properties.

9.11 Tunnel Section Line — Measured Profile

A Tunnel Section Line (`TAECC_TunnelSectionLine`) is a measured polyline representing the surveyed cross-section of a tunnel or excavation. It inherits from `TIQCustomObject` (the AEC base class) rather than `TCADPolyline`, placing it in the civil entity hierarchy alongside survey points and surfaces. When linked to a theoretical profile it automatically computes and displays radial deviations.

The entity lives in `UAECC_TunnelSectionLine.pas` under the `cad/Civil/` directory and is serialised as `<TunnelSectionLine>` in IQML.

9.11.1 Creating a Tunnel Section Line

1. Draw the **theoretical profile** as a normal closed polyline on a dedicated layer (e.g. `Theoretical`).
2. Activate **Civil › Tunnel Section Line** (or type `TSLINE`) and click the measured survey points. Right-click to finish.
3. In the Object Inspector, set **SectionLine** to the theoretical polyline.
4. Enable **ShowDR** to display deviation annotations.

9.11.2 Tunnel Section Line Properties

Property	Description
SectionLine	The theoretical polyline to compare against.
SplineFlag	Renders the measured profile as a smooth spline curve.
SplineSteps	Interpolation steps per segment (higher = smoother curve).
PointSize	Size of the survey point markers along the profile.
ShowDR	Show deviation (DR) annotation lines and values.
DRDecimals	Number of decimal places in DR labels.
DRFontSize	Label font size in world units.
DROffset	Radial offset of the label from the profile line.
DRUnit	Unit for DR values: `mm`, `cm`, or `m`.
DROrientation	`Auto` (follows deviation direction), `Inside`, or `Outside`.
DRAlignment	`Horizontal`, `Vertical`, or `Aligned` (label follows the deviation line direction).
ShowAreaHatch	Fills the area between the measured and theoretical profiles with a hatch pattern.
AreaBetween / AreaInner / AreaOuter	Computed areas (read-only) between the two profiles.

9.11.3 DR Display Modes

The **DRDisplayMode** property controls how deviation labels are rendered:

Mode	Description
dmAll (default)	Shows a deviation label at every measured point.
dmZoneExtremes	Shows only the highest (most extreme) deviation per overbreak and underbreak zone. This reduces label clutter while highlighting the worst-case deviations in each zone.

9.11.4 Deviation Colour Coding

DR annotation lines are colour-coded automatically:

- **Green** — measured profile is *outside* the theoretical (overbreak).
- **Red** — measured profile is *inside* the theoretical (underbreak / intrusion).

Note: Radial sorting is performed clockwise from the bottom (−Y direction), which corresponds to the invert of a tunnel cross-section.

9.11.5 Area Calculation Algorithm

The area computation between the measured and theoretical profiles uses the **Greiner-Hormann polygon intersection** algorithm (`UPolygonClip.pas`).

Step-by-step process:

1. **Polygon densification** — both the measured Tunnel Section Line and the theoretical section are sampled into dense point arrays using `DensifyPoly` with a maximum step of `SampleMaxStep` (default 0.02 m). This ensures that spline curves and bulge arcs are accurately represented as polygons. For the measured profile, `GetWorldPoly` first produces the polyline's own sample points (including Catmull-Rom spline interpolation if `SplineFlag` is enabled); then `DensifyPoly` subdivides any segment longer than `SampleMaxStep`. For the theoretical section, `SampleSectionLine` does the same two-pass process.
2. **Zone clipping** (optional) — if `AreaLevels` is non-zero, both polygons are clipped to the selected quadrant using **Sutherland-Hodgman** rectangle clipping (four successive half-plane clips: Left, Right, Bottom, Top). This allows reporting overbreak/underbreak per tunnel quadrant independently (e.g. crown only, or left wall only).
3. **Area computation** — three polygon areas are calculated:
   - **AM** = `PolygonArea2D(MeasuredPoly)` — measured polygon area (shoelace formula).
   - **AS** = `PolygonArea2D(TheoreticalPoly)` — theoretical polygon area.
   - **AI** = `PolygonIntersectionArea(MeasuredPoly, TheoreticalPoly)` — exact intersection area via Greiner-Hormann.
4. **Result derivation:**
   - **AreaOuter** (overbreak) = AM − AI — area of the measured profile that lies outside the theoretical section.
   - **AreaInner** (underbreak) = AS − AI — area of the theoretical section not covered by the measured profile.
   - **AreaBetween** = AreaOuter + AreaInner — total deviation area.
5. **Numerical guards** — AI is clamped to min(AM, AS) to prevent floating-point over-subtraction; negative results are clamped to zero.

Greiner-Hormann algorithm (six phases):

1. **Build** — normalise both polygons to CCW orientation; build circular vertex linked lists.
2. **Intersect** — find all edge-edge intersections and insert intersection vertices with parametric t values along each edge.
3. **Mark** — classify each intersection vertex as Entry or Exit relative to the subject polygon.
4. **Containment check** — if no intersections exist, use `PointInPolygon` (winding number) to detect full containment.
5. **Trace** — walk the intersection-marked lists to extract the output polygon(s); sum their areas.
6. **Free** — release all linked-list memory.

Numeric constants: `GH_EPS = 1e-9` (parallel guard), `GH_CORNER_EPS = 5e-3` (near-vertex rejection), `MIN_REGION_AREA = 1e-4 m²` (sliver filter).

Caching — all area values are cached and only recomputed when the section geometry changes (`FAreaCacheDirty` flag).

Hatch rendering — the `PolygonDifferenceRegions` function traces the same Greiner-Hormann linked lists to extract the actual overbreak (outer) and underbreak (inner) polygon regions, which are then filled with colour-coded hatch patterns (green = overbreak, red = underbreak).

9.12 Coordinate Transformations

IQcad provides two coordinate transformation commands for aligning drawings, survey data, and imported plans to a target coordinate system. Both commands use the IQCalc computation engine and share a common point-picking workflow.

9.12.1 CSTRANSFORM — Global Transformation

Command: `CSTRANSFORM` (alias `CST`)

Computes a single global transformation from common (control) point pairs and applies it to all selected entities. The transformation is solved by **least-squares adjustment**, producing residuals that allow you to identify and remove blunder points.

Supported transformation types:

Type	Min Pts	Description
Helmert 2D	2	4-parameter similarity (conformal): translation, uniform scale, rotation. Preserves angles and shape. The standard choice for local survey alignment.
Affine 2D	3	6-parameter: translation, non-uniform scale (independent X/Y), shear, rotation. Does not preserve angles. Use for scanned plans with differential paper shrinkage.
Polynomial Deg 1	3	6-parameter 1st-degree polynomial (equivalent to affine).
Polynomial Deg 2	6	12-parameter 2nd-degree polynomial for modelling non-linear distortions across large areas.
Polynomial Deg 3	10	20-parameter 3rd-degree polynomial for complex systematic distortions.

Workflow:

1. Select entities to transform (or type `All` for all entities in the drawing).
2. Pick common point pairs:
   - **Click** source point on canvas, then click target point
   - **Type coordinates**: `1000.5,2000.3` or `1000.5,2000.3,100.0`
   - **Type point number**: `#123` (looks up point 123 in the survey database)
   - **Load from file**: type `F` to open a `.cpt` or `.csv` file
3. Type `D` (Done) when all pairs are entered.
4. Choose the transformation type (`H` = Helmert, `A` = Affine, `P1`/`P2`/`P3` = Polynomial).
5. Review the residual table printed in the command line.
6. Save the transformation report (`.trpt`) and common points (`.cpt`) when prompted.
7. Confirm `Y` to apply the transformation.

Residuals and quality control:

When more than the minimum number of points are provided, the system is overdetermined and the least-squares solution produces **residuals** at each control point — the difference between the transformed source and the known target. Large residuals indicate:

- A blunder in the control point pair (wrong target entered)
- A point in a locally distorted area that the global model cannot fit

Review the residuals, disable suspect points (re-enter the workflow), and re-solve until the RMS is acceptable. The report file records all residuals, statistics, and the computed parameters for archival.

Mathematical detail — Helmert 2D:

```
Model:   X' = tx + a*X - b*Y
         Y' = ty + b*X + a*Y

where a = scale * cos(rotation),  b = scale * sin(rotation)

Parameters: tx, ty (translations), scale, rotation (4 unknowns)

Each control point provides 2 equations (X' and Y'), so n points give
2n equations.  With n >= 2 the system is solved by least squares:

    A * p = b + v     (design matrix A, parameter vector p, residuals v)
    p = (A'A)^(-1) * A'b       (normal equations)
    RMSE = sqrt( v'v / n )
```

Mathematical detail — Affine 2D:

```
Model:   X' = tx + a11*X + a12*Y
         Y' = ty + a21*X + a22*Y

Parameters: tx, ty, a11, a12, a21, a22 (6 unknowns)
Minimum points: 3  (6 equations for 6 unknowns)

Decomposition:
    Scale X  = sqrt(a11^2 + a21^2)
    Scale Y  = sqrt(a12^2 + a22^2)
    Rotation = atan2(a21, a11)
    Shear    = (a11*a12 + a21*a22) / (Scale_X * Scale_Y)
```

Mathematical detail — Polynomial 2D:

```
Model (degree d):
    X' = SUM( c_ij * x'^i * y'^j )   for i+j <= d
    Y' = SUM( d_ij * x'^i * y'^j )   for i+j <= d

where x' = x - cx, y' = y - cy  (centroid-reduced for numerical stability)

Terms per coordinate:  (d+1)*(d+2)/2
    Degree 1:  3 terms  (1, x, y)
    Degree 2:  6 terms  (1, x, y, x^2, xy, y^2)
    Degree 3: 10 terms  (1, x, y, x^2, xy, y^2, x^3, x^2*y, xy^2, y^3)
```

Warning: Polynomial transformations must not be used for extrapolation beyond the convex hull of the control points. The polynomial may oscillate wildly outside the fitted area (Runge's phenomenon).

9.12.2 RUBBERSHEET — Local Non-Uniform Transformation

Command: RUBBERSHEET (alias RBS)

Applies a spatially-varying correction where the displacement at each point depends on its proximity to nearby control points. Unlike CSTRANSFORM, there is **no single global model** — the transformation varies continuously across the drawing.

Two modes:

Linear (Delaunay Piecewise Affine)

The source control points are triangulated using the Bowyer-Watson Delaunay algorithm. For each triangle, a unique affine transformation is computed that maps its three source vertices exactly to their three target positions (6 equations, 6 unknowns — exact solution). For any query point, the algorithm locates the containing triangle and applies that triangle's affine.

```
For each triangle T_k with source vertices (S0, S1, S2)
mapping to target vertices (T0, T1, T2):

    X' = a11*X + a12*Y + tx
    Y' = a21*X + a22*Y + ty

Solved by Cramer's rule:
    D = x0*(y1-y2) + x1*(y2-y0) + x2*(y0-y1)
    a11 = (X'0*(y1-y2) + X'1*(y2-y0) + X'2*(y0-y1)) / D
    ... (similarly for a12, tx, a21, a22, ty)

Point location uses barycentric coordinates:
    Q is inside triangle ABC if u >= 0, v >= 0, (1-u-v) >= 0
```

Properties: C0 continuous (slope breaks at triangle edges), exact at control points, O(n log n) triangulation, brute-force O(m) point location.

Smooth (Thin Plate Spline)

The TPS minimizes the bending energy of a thin metal plate passing through prescribed displacements. Two independent TPS functions are solved — one for X displacement, one for Y displacement.

```
f(x,y) = a0 + a1*x + a2*y + SUM_i( w_i * U(r_i) )

where U(r) = r^2 * ln(r)  (radial basis function)
      r_i  = distance from (x,y) to control point i

Linear system (n+3 x n+3):

    | K   P | | w |   | v |      K[i,j] = U(|Pi - Pj|)
    | P'  0 | | a | = | 0 |      P[i]   = [1, xi, yi]

The constraint P'*w = 0 ensures affine far-field behavior:
far from all control points, f reduces to a0 + a1*x + a2*y.
```

Properties: C2 continuous everywhere, exact at control points, O(n^3) solve, O(n) per-point evaluation. Natural affine extrapolation in far field.

Workflow:

1. Select entities (or `All`).
2. Pick common point pairs (same methods as CSTRANSFORM).
3. Type `D` (Done).
4. Choose mode: `L` = Linear (default), `S` = Smooth.
5. Review displacement table and save report/points when prompted.
6. Confirm `Y` to apply.

Key differences from CSTRANSFORM:

- **No residuals** — rubber sheeting interpolates exactly through all control points, so there is no over-determined system and no residual analysis. Blunder points cannot be detected from the math — verify independently.
- **Spatially varying** — different parts of the drawing are corrected differently based on proximity to control points.
- **Outside convex hull** — points outside the control network are extrapolated (linear: nearest triangle, smooth: affine). A warning count is reported.

Elevation (Z) handling:

Both CSTRANSFORM and RUBBERSHEET preserve the original Z coordinate by default — only Easting (X) and Northing (Y) are transformed.

9.12.3 Common Points File Format (.cpt)

Common point pairs can be saved and loaded in JSON format:

```
{
  "version": 1,
  "description": "Site A to Grid transform",
  "coordinateOrder": "ENZ",
  "points": [
    {
      "name": "CP1",
      "source": { "e": 1000.000, "n": 2000.000, "z": 100.000 },
      "target": { "e": 1000.152, "n": 2000.318, "z": 100.023 },
      "enabled": true
    }
  ]
}
```

Alternatively, CSV format is supported:

```
Name,SrcE,SrcN,SrcZ,TgtE,TgtN,TgtZ,Enabled
CP1,1000.000,2000.000,100.000,1000.152,2000.318,100.023,True
```

9.12.4 Transformation Report (.trpt)

The `Save Report` dialog writes a detailed text report including:

- Transformation type and date
- Common point table with source/target coordinates
- Computed parameters (for global transforms)
- Per-point residuals with positional magnitude (for global transforms)
- RMS statistics, redundancy, and degrees of freedom
- Displacement table (for rubber sheet)
- Number of entities transformed and locked points skipped
- IQCalc engine version

9.12.5 Practical Guide: Which Transformation to Use

Choosing the right transformation depends on the nature and magnitude of the coordinate differences, the number and distribution of control points, and whether the distortion is uniform or spatially varying.

Decision Flowchart

```
Do you have common points in both systems?
 │
 ├─ No → You cannot compute a transformation.
 │        Obtain at least 2 common points first.
 │
 └─ Yes
     │
     Is the distortion uniform across the area?
     (i.e., a simple shift/rotate/scale explains the differences)
      │
      ├─ Yes → Use CSTRANSFORM
      │     │
      │     How many common points?
      │     ├─ 2     → Helmert 2D (exact fit, no residuals)
      │     ├─ 3-5   → Helmert 2D (least-squares, with residuals)
      │     ├─ 3+    → Affine 2D (if X/Y scales differ)
      │     └─ 6+    → Polynomial deg 2 (if residuals show spatial pattern)
      │
      └─ No → The distortion varies across the area
            │
            Use RUBBERSHEET
            ├─ Many control points (>20) → Linear mode
            └─ Few control points (<20)  → Smooth (TPS) mode
```

Common Survey Scenarios

Scenario 1: Aligning a total station survey to control points

You have a local total station survey (arbitrary setup) and 3-5 points with known coordinates in the national grid.

Recommended: **CSTRANSFORM → Helmert 2D**

This is the classic case: the local survey differs from the grid by a translation, rotation, and uniform scale. Helmert preserves angles (conformal) which is essential for survey data.

```
Workflow:
1. Import your total station points into IQcad
2. Run CSTRANSFORM
3. For each control point: click the local position, then enter the
   known grid coordinate (e.g. #101 or 538345.12,4872341.56)
4. Type D (Done), select H (Helmert)
5. Check residuals — all should be < 0.01 m for a good survey
6. If one point has a much larger residual, investigate (blunder?)
7. Apply
```

Typical RMS: 3-10 mm for a well-executed survey.

Scenario 2: Georeferencing a scanned cadastral plan

You digitised an old cadastral plan and need to bring it into the national grid. The paper has shrunk non-uniformly (different scale in X and Y).

Recommended: **CSTRANSFORM → Affine 2D** (minimum 3 points)

Affine allows independent X and Y scales and a shear component, which models paper shrinkage. Use at least 4 points for redundancy.

```
Workflow:
1. Identify 4+ points on the plan that you can also locate in the
   national grid (road intersections, property corners, benchmarks)
2. Run CSTRANSFORM, pick the digitised positions and enter grid coords
3. Select A (Affine)
4. Check residuals — if they show a spatial pattern (e.g., all positive
   in one corner), the plan may have local folds → use RUBBERSHEET
```

Typical RMS: 0.1-0.5 m depending on plan age and condition.

Scenario 3: Aligning an imported DXF from a different coordinate system

A colleague sent you a DXF in a local grid, and you need to merge it with your project in the national grid. You have 2-3 matching points.

Recommended: **CSTRANSFORM → Helmert 2D** (2 points for exact fit, 3 for QC)

With exactly 2 points, the Helmert gives an exact solution (no residuals). If you have 3 points, use all three — the third point's residual tells you whether the two coordinate systems are related by a simple similarity transform. If the residual is large, the systems may have different scales in X and Y (→ try Affine) or local distortions (→ try RUBBERSHEET).

Scenario 4: Correcting a drawing with known local distortions

Your drawing has localized errors: some areas are shifted by 0.2 m, others by 0.5 m in different directions. You have 10+ control points scattered across the project.

Recommended: **RUBBERSHEET → Linear mode**

The Delaunay triangulation adapts the correction locally — each triangle gets its own affine transform, so areas near a shifted control point are corrected by that point's displacement. With 10+ points the triangles are small enough that the C0 discontinuities at edges are negligible.

```
Workflow:
1. Select All entities
2. Pick all 10+ control point pairs
3. Choose L (Linear)
4. Review the displacement table — are the magnitudes consistent?
5. Check the "outside hull" count — if high, add control points at
   the project boundary
6. Apply
```

Scenario 5: Deformation monitoring — comparing two epochs

You have two sets of measurements of the same points at different times and want to visualise the displacement field smoothly.

Recommended: **RUBBERSHEET → Smooth (TPS) mode**

TPS produces a C2-continuous displacement field ideal for deformation visualisation. The smooth gradient avoids artificial slope breaks that would appear with linear rubber sheeting.

Scenario 6: Large-area datum transformation (hundreds of km)

You have survey data in a local datum and need to convert to a national or global reference frame. The area is large enough that a simple 4-parameter transform leaves systematic residual patterns (bowl-shaped or tilted).

Recommended: **CSTRANSFORM → Polynomial degree 2** (minimum 6 points)

The 2nd-degree polynomial captures regional curvature that Helmert/Affine cannot model. Place control points at the edges and centre of the area.

> **Warning:** Never extrapolate polynomial transforms beyond the control network. Outside the convex hull, the polynomial may diverge rapidly.

Scenario 7: Quick approximate shift (no rotation/scale)

You just need to shift your drawing by a known offset (e.g., "everything is 100 m too far East").

Recommended: **CSTRANSFORM → Helmert 2D** with 1 point pair.

Although Helmert needs 2 points, with 1 point it effectively computes a pure translation (scale = 1, rotation = 0). Alternatively, use the MOVE command with a known delta.

Quality Control Checklist

After any transformation, verify the result:

1. **Check the RMS** (CSTRANSFORM only). Compare with your expected survey accuracy. RMS >> expected accuracy suggests blunders or wrong model.
2. **Examine individual residuals**. A single large residual (> 3× RMS) suggests a blunder in that control point. Disable it and re-solve.
3. **Look for spatial patterns** in the residuals. If positive residuals cluster in one area and negative in another, the model may be too simple → try a higher-order transform.
4. **Check the outside-hull count** (RUBBERSHEET). A large number means many entities are being extrapolated — add boundary control points.
5. **Spot-check transformed points** against known coordinates not used in the transformation (independent check points).
6. **Save the report and common points** for audit trail and repeatability.
7. **Verify locked points** were correctly skipped (check the "locked skipped" count in the output).

Control Point Distribution Tips

Guideline	Reason
Surround the project area	Minimises extrapolation; rubber sheet needs enclosing hull
Distribute points evenly	Avoids poorly conditioned least-squares solutions
Avoid collinear arrangements	Collinear points cannot define 2D transforms (singular matrix)
Use more than the minimum	Extra points give redundancy for residual-based QC
Include points at different elevations	Important for 3D transforms (Bursa-Wolf)
Remove one point at a time	When testing outliers, remove one, re-solve, then evaluate
Keep point names consistent	Helps match pairs when loading from files

10 Command Line

The command line strip at the bottom of the window serves two purposes:

1. **Output** — IQcad writes operation prompts, results, and messages here.
2. **Input** — type a command alias and press **Enter** to activate a tool or run an operation.

While a tool is active, the command line shows the current prompt (e.g. *"Specify start point:"*). Type coordinates as `X,Y` and press **Enter** to supply a precise point.

10.1 Command Reference

10.1.1 Drawing Commands

Command	Alias	Action
`LINE`	`L`	Start the Line tool.
`PLINE`	`PL`	Start the Polyline tool.
`MLINE`	`ML`	Start the Multiline tool.
`ARC`	`A`	Start the Arc tool.
`CIRCLE`	`C`	Start the Circle tool.
`ELLIPSE`	`EL`	Start the Ellipse tool.
`SPLINE`	`SP`	Start the Spline tool.
`RECTANGLE`	`REC`	Start the Rectangle tool.
`HATCH`	`H`	Start the Hatch tool.
`TEXT`	`T`	Start the Text tool.
`MLEADER`	`MLD`	Prompt for label text, then start the Multileader tool.
`POINT`	`PO`	Start the Point tool.
`XLINE`	`XL`	Start the XLine (infinite construction line) tool.

10.1.2 Modify Commands

Command	Alias	Action
ERASE	E	Erase selected objects. If nothing selected, prompts "Select objects:" — pick then right-click to confirm.
MOVE	M	Move selected objects.
COPY	CO	Copy selected objects.
ROTATE	RO	Rotate selected objects.
SCALE	SC	Scale selected objects.
OFFSET	O	Offset an entity by distance or through point. Supports Line, Circle, Arc, XLine, Polyline, Ellipse, Spline, Rectangle. Options: T = through, E = erase source, U = undo. Phantom preview shown.
MIRROR	MI	Mirror selected objects.
TRIM	TR	Two-phase: select cutting edges (or ALL), then click objects to trim.
EXTEND	EX	Two-phase: select boundary edges, then click the end of a line to extend.
CHAMFER	CHA	Pick two lines to chamfer. D sub-option sets distances ($CHAMFERA / $CHAMFERB).
FILLET	F	Pick two lines to fillet. R sub-option sets radius ($FILLETRAD).
PEDIT	PE	Edit a polyline. Sub-options: Close/Open, Join, Width, Edit vertex (Next/Prev/Move/Insert/Delete/Straighten), Spline, Decurve, Reverse. Converts Lines and Arcs to polylines.

10.1.3 View Commands

Command	Alias	Action
ZOOM	Z	Sub-options: E = extents, W = window, + / - = in/out.
PAN	P	Activate real-time pan (middle-mouse drag).
REGEN	—	Force a full redraw of the canvas.

10.1.4 Settings Commands

Command	Alias	Action
UNITS	—	Opens a multi-step wizard to set linear units, precision, and angular units.
LTSCALE	—	Prompts for a new global linetype scale factor.
LAYER	LA	Opens the Layer Manager dialog.

10.1.5 Inquiry Commands

Command	Alias	Action
LIST	LI	List selected object properties.
ID	—	Click a point — report its world X, Y, Z.
DIST	DI	Measure distance between two points.
AREA	AA	Measure area (pick points or select object).
ANGLE	AN	Measure angle (vertex + two points).

10.1.6 Surface Commands

Command	Alias	Action
CREATESURFACE	CS	Create a TIN surface. If survey points exist they are triangulated automatically; otherwise an empty surface is created for later population.
ADDSURFACEPOINTS	ASP	Add all survey points in the drawing to a named surface and build/rebuild the TIN.
ADDSURFACEENTITIES	ASE	Add selected drawing objects (3DFace, Line, Polyline, Point) to a surface.
REBUILDSURFACE	RS	Rebuild an existing surface TIN from current survey points.
ADDSURFACEBOUNDARY	ASB	Add a boundary to a surface (select a closed polyline).
DELETESURFACE	—	Delete a surface by name.
DECIMATESURFACE	DS	Decimate (simplify) a TIN surface.
SURFACEPROPERTIES	—	Display surface statistics.
SPOTELEV	SE	Place a spot elevation label on a surface.
ADDCONTOURLABEL	ACL	Place contour labels along surface contour lines.

10.1.7 Alignment Commands

Command	Alias	Action
ALIGNMENT	ALIGN	Create a horizontal alignment by picking PI points.
ALIGNREVERSE	—	Reverse the direction of an alignment.
ALIGNPROPS	—	Display alignment properties in the command line.
ALIGNFROMPOLYLINE	AFP	Create an alignment from a polyline.

10.1.8 Profile Commands

Command	Alias	Action
QUICKPROFILE	QP	Quick profile along a line or polyline.
CREATEPROFILEVIEW	CPV	Create profile view from alignment + surface.
DESIGNPROFILE	DP	Create design profile (vertical alignment) in profile view.
PROFILEPROPS	—	Display profile view properties.

10.1.9 Cross-Section Commands

Command	Alias	Action
CREATESECTIONSHEET	CSS	Create a cross-section sheet from alignment + surfaces.
EARTHWORKVOLUMES	EWV	Compute earthwork volume table (average end area method).

10.1.10 Coordinate Transformation Commands

Command	Alias	Action
CSTRANSFORM	CST	Global coordinate transformation (Helmert, Affine, Polynomial).
RUBBERSHEET	RBS	Non-uniform rubber-sheet transformation (Linear or Smooth TPS).

10.1.11 Layout Commands

Command	Alias	Action
LAYOUT	LO	Sub-options: N = new, D = delete, L = list, S = set active.
MVIEW	MV	Create a viewport in paper space (must be on a Layout tab).
PAGESETUP	—	Open page setup dialog for the active layout.
EXPORTPDF	PDF	Export the active layout to PDF.
PLOT	PRINT	Open the Print dialog (Ctrl+P).
PLOTALL	—	Export all layouts to a multi-page PDF.

10.2 Entering Coordinates

When a tool prompts for a point you can type a coordinate directly:

- **Absolute:** `X,Y` — e.g. `100,50`
- **Relative:** `@dX,dY` — e.g. `@10,0` (10 units to the right of the last point)
- **Polar relative:** `@distance<angle` — e.g. `@25<45` (25 units at 45°)

Press **Enter** or **Space** to confirm. Press **Escape** to cancel the current prompt.

11 Format Settings

All format dialogs are under the **Format** menu.

11.1 Layers

Format › Layers… opens the standalone **Layers Manager** form. See *Layers, Linetypes and Text Styles* (page 29) for full details.

11.2 Linetypes

Format › Linetypes… opens the standalone **Linetypes Manager** form. Displays all loaded linetypes with name, description, pattern preview, source, and complex flag. Toolbar buttons: *Load from File…* (import `.LIN` files) and *Assign to Current Layer*.

11.3 Drawing Variables

Format › Drawing Variables… opens the **Drawing Variables** form showing all per-drawing settings in a two-column grid.

11.4 Point Style (Ctrl+Shift+D)

Opens the **Point Style Editor** — a 4 × 5 grid of 19 marker shapes. Click a cell to select the active global marker shape, and set the display size in the *Size* field below the grid.

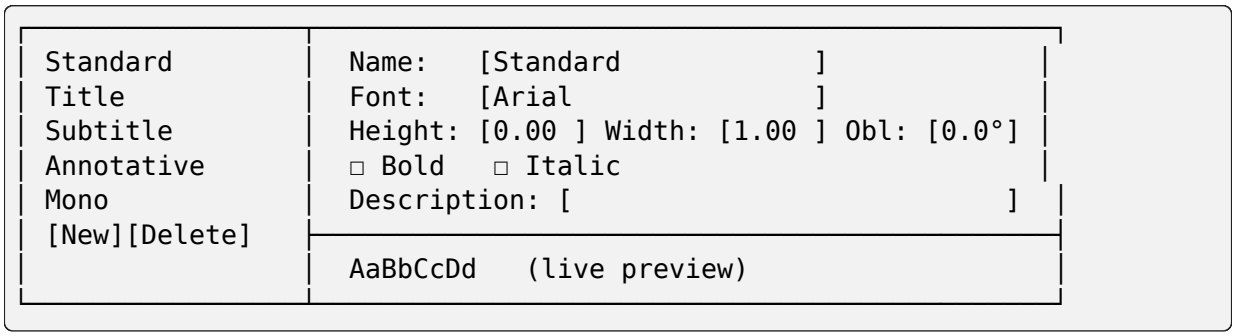
The named **Point Style Library** stores per-style settings that can be assigned to individual AEC Survey Points via the `PointStyleName` property.

Built-in style	Default marker
Standard	Cross (+)
Benchmark	Triangle with dot
Control Point	Circle with cross
GPS Rover	Square with dot
Iron Rod	Circle with vertical bar

Additional styles can be created in the editor and saved with the drawing.

11.5 Text Style (Ctrl+Shift+T)

Opens the **Text Style Editor** — a list on the left and an edit panel on the right with a live preview strip at the bottom.



Fields:

Field	Description
Name	Unique style name.
Font	Font family name (any font installed on the system).
Height	Fixed height in world units. `0` = variable (set per-object).
Width Factor	Horizontal scale. `1.0` = normal width.
Oblique Angle	Slant in degrees. Positive = forward lean.
Bold / Italic	Font weight and style.
Description	Free-text note for your reference.

The style selected in the **Drawing Variables** (*CurrentTextStyleName*) is used automatically for new Text and Multileader objects.

11.6 Surface Styles

Format > Surface Styles... opens the **Surface Style Editor**. A surface style bundles all visual settings for a TIN surface into one named preset: border, triangle, contour, contour label, and point display properties.

Five built-in presets are provided:

Preset	Description
Standard	Triangles + contours + boundaries + labels. All features visible.
Triangles & Contours	Triangles and contours visible, boundary hidden.
Contours Only	Only contour lines and labels displayed.
Elevation Banding	Contours and elevation colour bands visible.
Empty	All components hidden. Use to suppress a surface from display without deleting it.

The editor has a style list on the left and 3 tabs on the right:

- **Border & Triangles** — visibility, colour, and weight for boundary polygons and TIN triangle edges; point marker settings.
- **Contours** — major/minor intervals, colours, weights, smoothing passes, base elevation.
- **Contour Labels** — visibility, text height, precision, prefix/suffix, colour, font, uphill-readable rotation, background mask, label interval.

Styles are saved with the drawing. Assign a style to a surface via the **StyleName** property in the Object Inspector, or right-click a surface in the Civil Toolspace and choose **Surface Style...**.

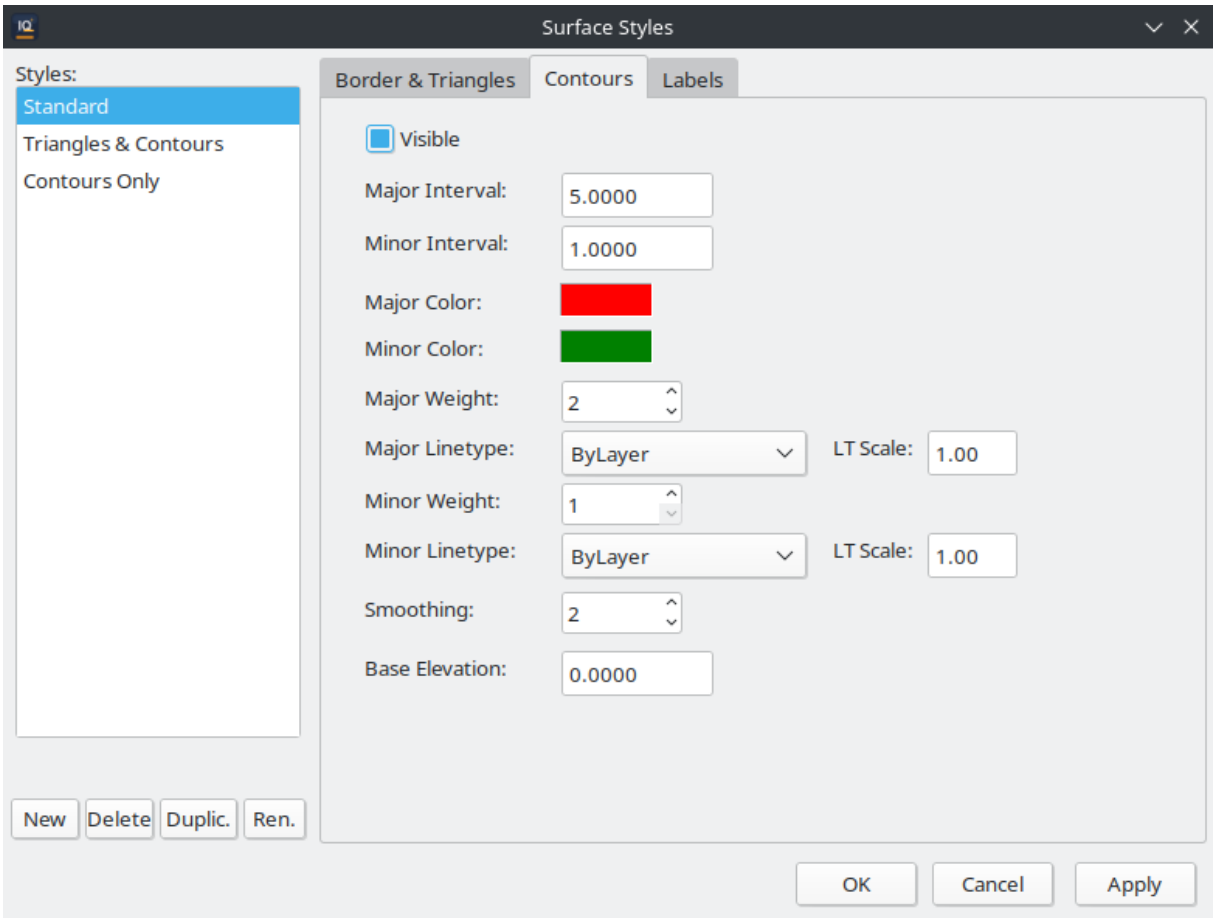


Fig. 1: The Surface Style Editor dialog.

11.7 Table Styles

Format › Table Styles… opens the **Table Style Manager**. Select a style and click **Edit** to open the **Table Style Editor**, or click **New** to create a style from scratch.

Three built-in presets are provided:

Preset	Description
Standard	General-purpose table with a bold title row, a header row, and plain data rows.
Schedule	Optimised for quantity schedules — compact data rows with alternating fill colours for readability.
Legend	Suitable for map legends — no title row, header row uses a coloured background.

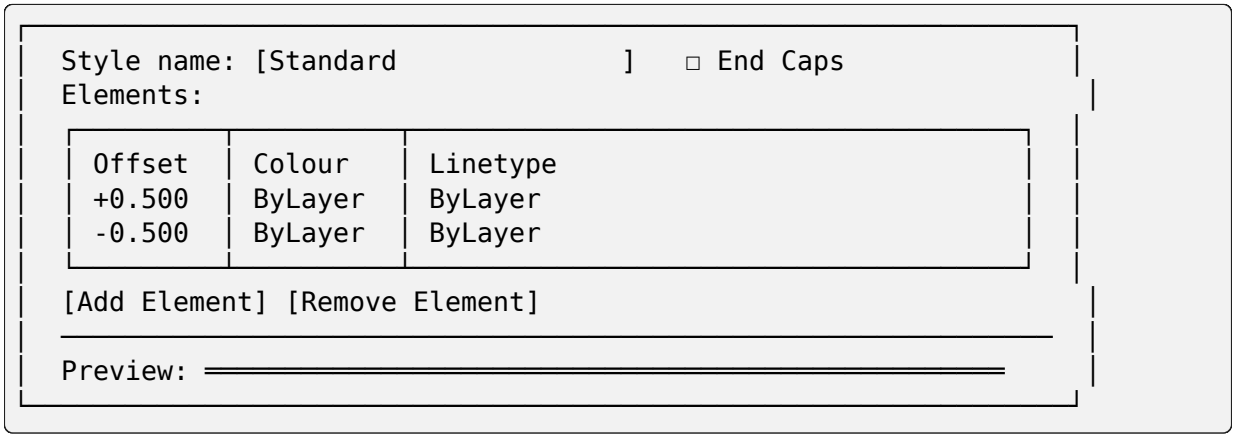
The editor organises settings into three row categories — **Title**, **Header**, and **Data** — each with its own tab. Per-category properties:

Property	Description
Text Height	Height of cell text in world units.
Alignment	Horizontal alignment: Left, Centre, or Right.
Bold / Italic	Font weight and style for the row category.
Fill Color	Background colour of the cells.
Borders	Border visibility and weight for horizontal / vertical / outline edges.
Margins	Horizontal and vertical padding inside each cell.

The **HasTitle** and **HasHeader** checkboxes at the top of the editor control which row categories appear in new tables that use the style. Unchecking **HasTitle**, for example, omits the title row entirely.

11.8 Multiline Styles (Ctrl+Shift+M)

Opens the **Multiline Style Editor**. A Multiline Style defines how many parallel strands a Multiline entity has, their spacing, colours, and linetypes.



Field	Description
Style name	Name saved with the drawing.
End Caps	When checked, perpendicular lines close the open ends of the multiline.
Offset	Distance from the centreline. Use positive and negative values to place strands symmetrically.
Colour	Per-strand colour override (`ByLayer` to inherit).
Linetype	Per-strand linetype override.
Preview strip	Live preview of the style at the bottom of the dialog.

11.9 Dimension Styles

Format › Dimension Styles… (or type `DIMSTYLE` in the command line) opens the **Dimension Style Manager**. Select a style and click **Edit** to open the **Dimension Style Editor**, or click **New** to create a style from scratch.

The editor groups settings into five areas:

- **Lines** — dimension line and extension line colours, weights, offsets, extension amounts, and suppression flags.
- **Arrows** — arrowhead type (Closed Filled, Open, Dot, Arch Tick, None, and others) and size for each end of the dimension line.
- **Text** — text colour, height, gap from the dimension line, vertical placement (centred or above), and font.
- **Fit** — controls what happens when text and arrows do not fit between extension lines.
- **Primary Units** — number format (Decimal, Scientific, Engineering, Architectural, Fractional), decimal precision, angle format, zero suppression, prefix, suffix, scale factor, and rounding.

Use the style dropdown at the top to switch between named styles. Click **Reset** to revert the current style to its defaults.

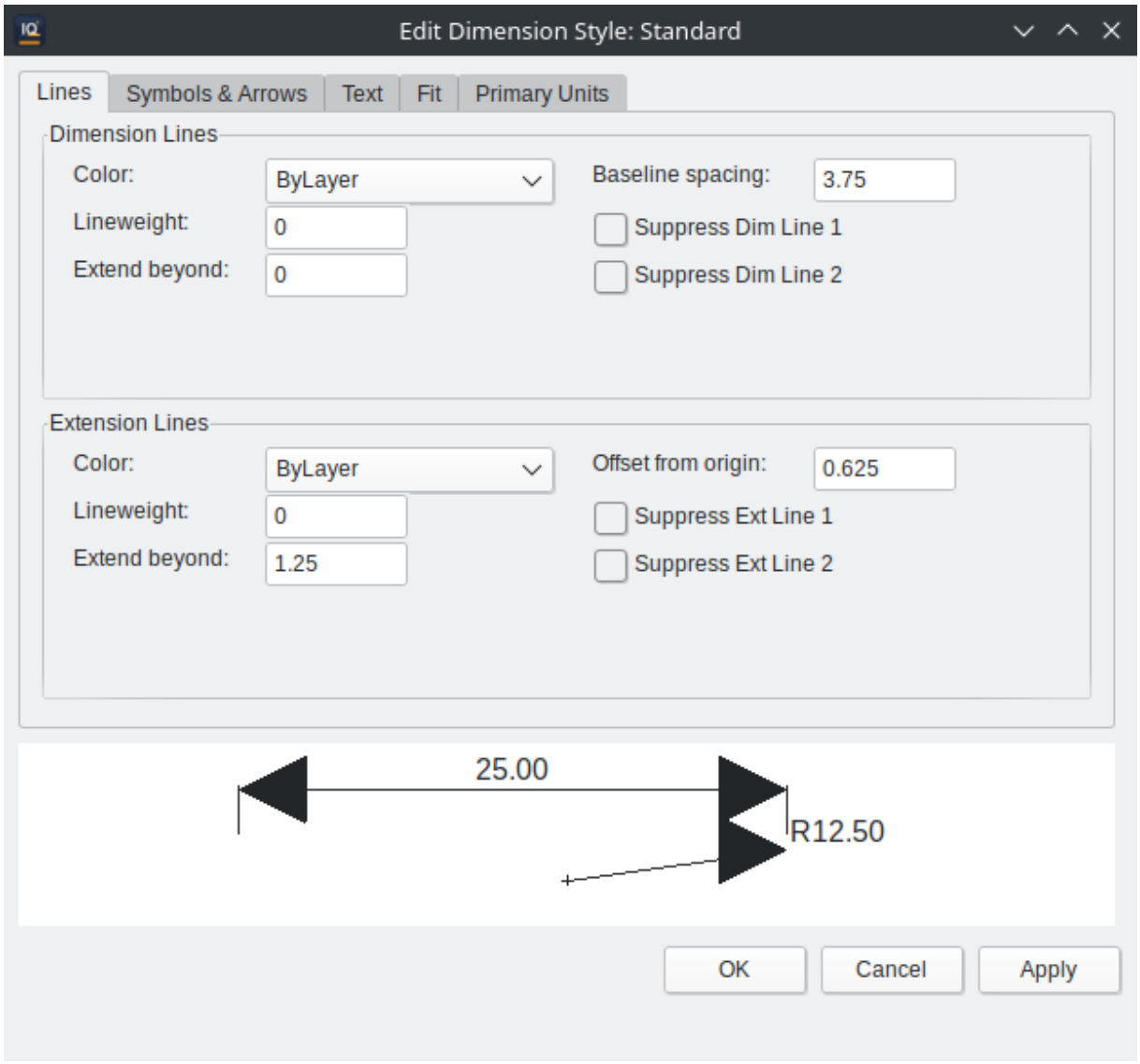


Fig. 2: The Dimension Style Editor dialog.

11.10 Plot Style Tables (CTB)

Format › Plot Styles... opens the **Plot Style Editor**. Plot style tables (CTB files) map AutoCAD colour indices to pen settings (colour, weight, screening) for printing and PDF export.

11.11 Tunnel Section Line Styles

Format › Tunnel Section Line Styles… opens the **Tunnel Section Line Style Editor**. A style bundles all visual settings for a tunnel section line entity into one named preset.

Three built-in presets are provided:

Preset	Description
Standard	Measured line with deviation annotations visible, no area hatch.
Hatched	Measured line with coloured area hatch (green = overbreak, red = underbreak) between measured and theoretical profiles.
Simple	Measured line only, no annotations or hatch.

The editor organises settings into groups:

- **Measured Line** — colour, weight, linetype, spline interpolation settings.
- **Deviation Lines** — visibility, weight, linetype, overbreak/underbreak colours.
- **Area Hatch** — visibility, pattern, scale, angle, alpha, separate overbreak/underbreak hatch colours.
- **Center Marker** — visibility, colour, size.
- **DR Display** — orientation (Auto/Inside/Outside), alignment (Horizontal/Vertical/Aligned), display mode (All, None, Extremes, Zone Extremes, Threshold, Interval, Smart), threshold and interval values.
- **DR Label Style** — reference to a named civil label style for the deviation labels.

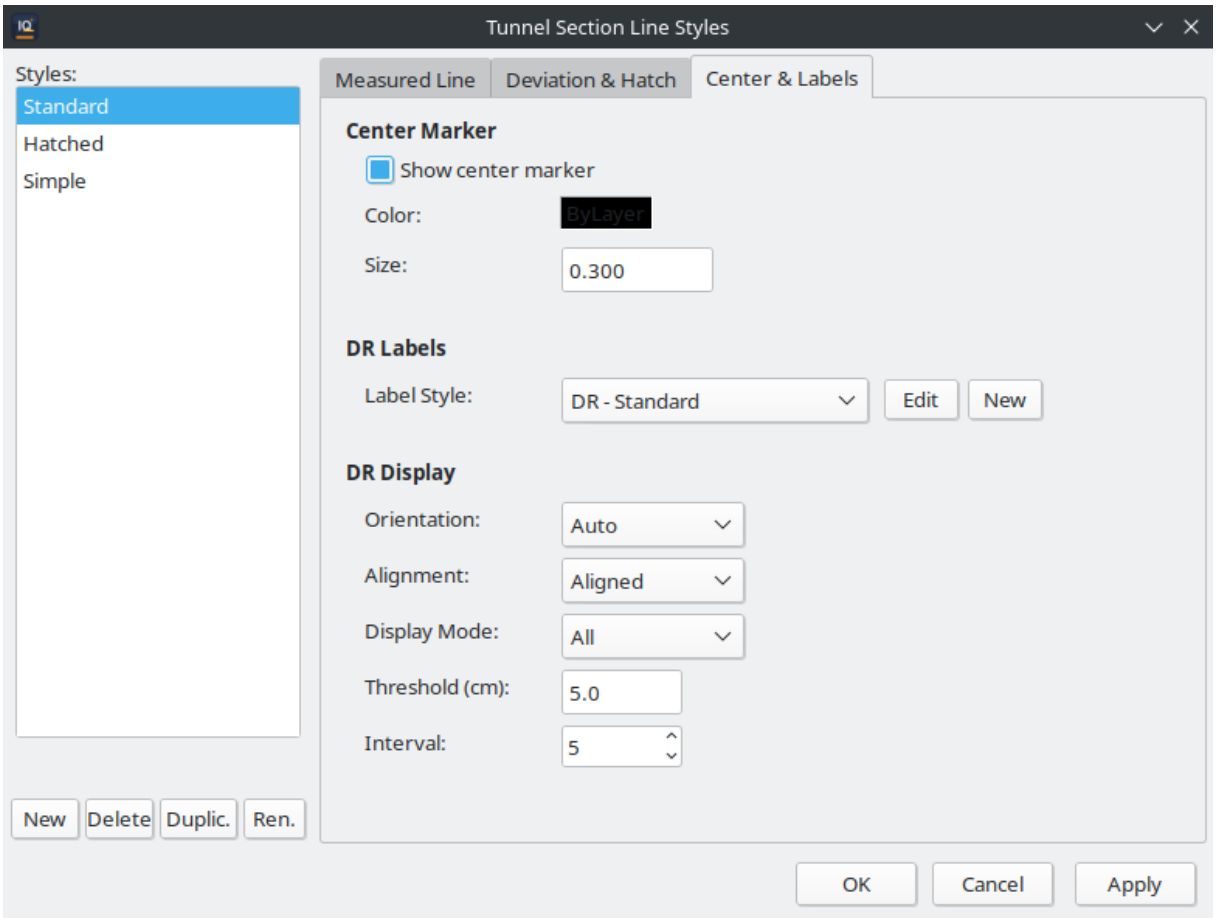


Fig. 3: The Tunnel Section Line Style Editor.

11.12 Parcel Styles

Format › Parcel Styles… opens the **Parcel Style Editor**. A parcel style controls the visual display of parcel boundary polygons, fills, and segment labels.

Five built-in presets are provided:

Preset	Description
Standard	Boundary line only, no fill or segment labels.
Property	Boundary with semi-transparent fill and bearing/distance labels on each boundary segment.
Easement	Dashed boundary with a light fill pattern for restricted zones.
ROW	Right-of-way style with a heavy boundary and cross-hatch fill.
Empty	All components hidden (`BoundaryVisible=False`). Use to suppress a parcel from display without deleting it.

The **BoundaryVisible** flag in the Boundary settings group controls whether the parcel outline is drawn. Setting it to False (as the Empty style does) hides the boundary entirely while preserving the parcel data.

The editor organises settings into groups:

- **Boundary** — visibility, colour, weight, linetype.
- **Fill** — visibility, fill colour, transparency.
- **Labels** — visibility, text height, colour, bearing format (Bearing, South Azimuth, North Azimuth, Angle), distance display, segment label text properties.

11.13 Alignment Styles

Format › Alignment Styles... opens the **Alignment Style Editor**. An alignment style controls the display of horizontal alignment entities: centerline, station ticks, PI markers, and direction arrows.

Four built-in presets are provided:

Preset	Description
Standard	Centreline + station ticks + PI markers + direction arrows.
Centerline Only	Centreline visible; ticks, PI markers, and arrows hidden.
Design Phase	Centreline as CENTER linetype, PI details and PI lines visible, full labels.
Empty	All components hidden. Use to suppress an alignment from display without deleting it.

Property Group	Settings
Centerline	Visibility, colour, weight, linetype, linetype scale.
Station Ticks	Visibility, major/minor tick intervals, tick lengths, colour, weight, linetype.
PI Markers	Visibility, colour, marker size.
Direction Arrows	Visibility, interval, colour, arrow size.

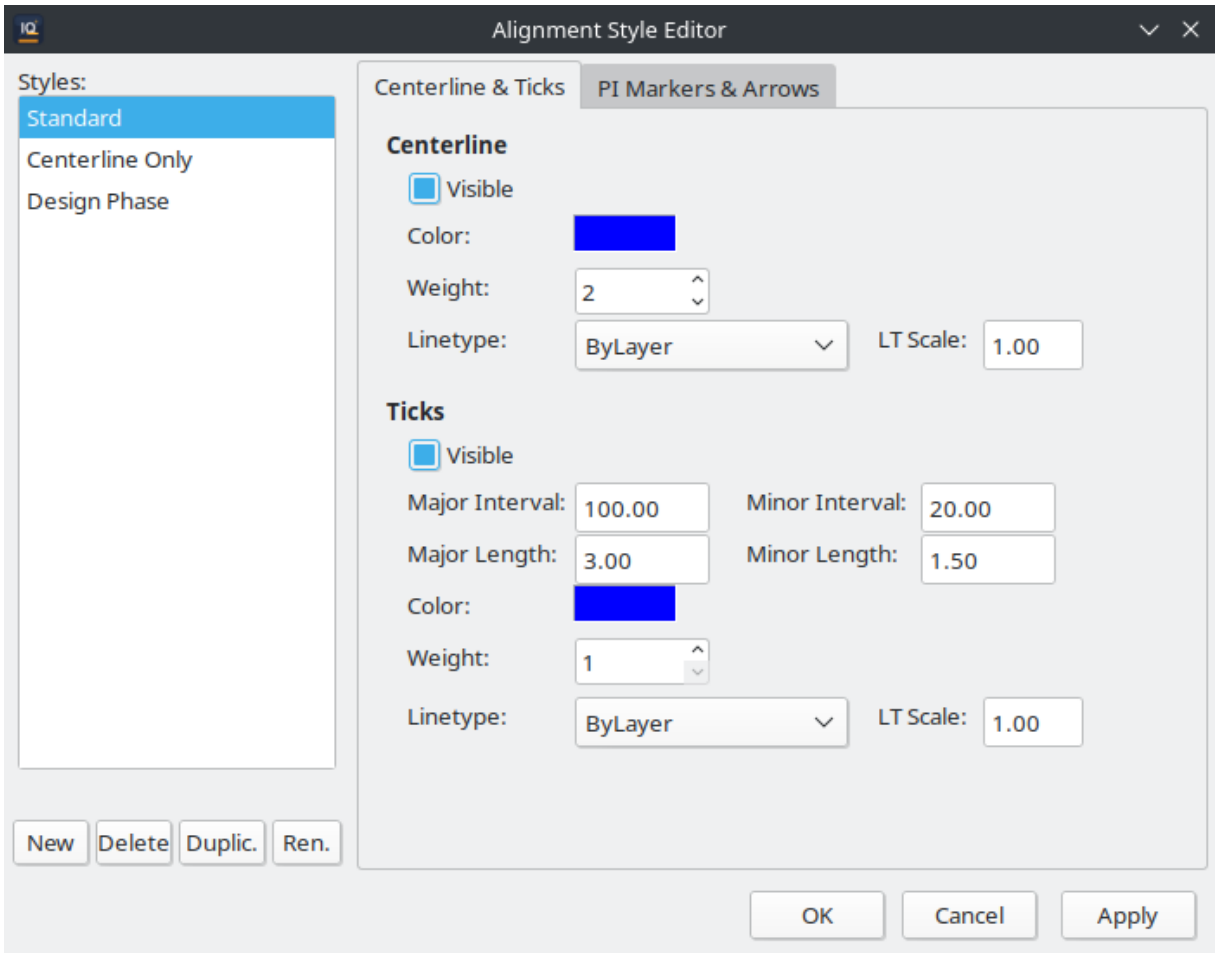


Fig. 4: The Alignment Style Editor.

11.14 Alignment Label Styles

Format › Alignment Label Styles… opens the **Alignment Label Style Editor**. Label styles control the text annotations shown along an alignment:

Property Group	Settings
Text	Text style name, text height, text colour.
Station Labels	Major/minor station label visibility, label offset from centerline.
PI Labels	Visibility, which data to show (radius, spiral length, tangent length, deflection angle), label offset.
Curve Data Labels	Visibility, which data to show (arc length, chord length, degree of curve), label offset.
Other	Alignment name label visibility, station equation labels.

11.15 Civil Label Styles

Format › Civil Label Styles… opens the **Civil Label Style Editor**. This is a unified label style system shared by all civil entities: survey points, surfaces (contour labels), alignments, tunnel deviations, and parcels.

A civil label style defines:

- **Components** — a list of label rows, each specifying a content type (e.g. point number, elevation, station, contour elevation, deviation), prefix, suffix, and number format.
- **Font** — text style, height, colour, bold/italic.
- **Placement** — anchor mode (point, linear, or area), offset, rotation, background mask settings.

Built-in presets cover common use cases for points, contours, alignments, tunnel deviations, and parcels. The label style editor groups styles by category: Point, Contour, Spot Elevation, Station, PI, Tunnel (DR), and Parcel.

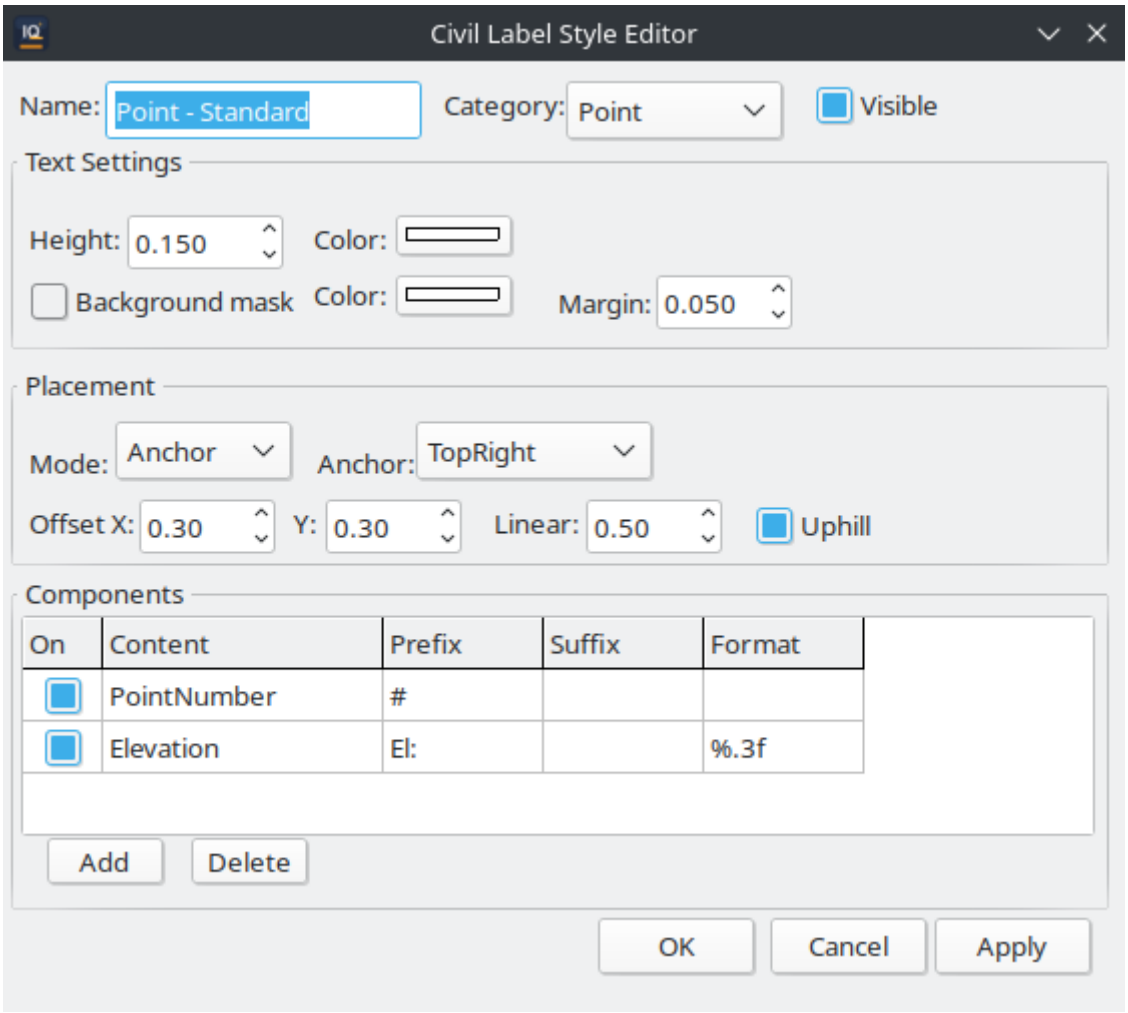


Fig. 5: The Civil Label Style Editor.

11.16 Unified Style Managers

IQcad provides two unified style manager windows that consolidate all style editors into a single dialog, eliminating the need to open individual style editors from separate ribbon buttons.

CAD Style Manager (*Format > CAD Style Manager...*) — a single window with a category tree on the left and the corresponding embedded editor on the right. Categories include:

- Text Styles
- Dimension Styles
- Table Styles
- Multiline Styles
- Point Styles (CAD point marker shape)
- Plot Style Tables (CTB)

Civil Style Manager (*Civil > Styles* or *Format > Civil Style Manager...*) — a single window for all civil-specific styles:

- Point Styles (survey point marker + label)
- Surface Styles
- Tunnel Section Line Styles
- Alignment Styles
- Parcel Styles
- Civil Label Styles

Both managers support creating, editing, duplicating, and deleting styles. Select a category in the tree, then use the style list and editor panel on the right. Styles are saved with the drawing.

The individual *Format* menu entries (e.g., *Format > Text Style..., Format > Surface Styles...*) remain available as shortcuts that open the corresponding section directly.

12 Exporting and Importing

12.1 Native File Formats

IQcad uses two native file formats:

Format	Description
.iqz	**Compressed** (gzip-compressed IQML). This is the default format for new drawings. Files are typically 5-10x smaller than uncompressed IQML.
.iqml	**Uncompressed** XML-based format. Human-readable and suitable for version control or debugging.

Both formats are auto-detected on open. Use **File > Save As...** to choose between them.

Large drawings with 1 000 000+ entities use a **streaming writer** that writes directly to the file instead of building an in-memory DOM tree, keeping memory usage constant.

12.2 Exporting

12.2.1 DXF Export

File › Export › Export DXF exports the current drawing to an AutoCAD- compatible DXF file.

- All layers, colours, linetypes, and linewidths are preserved.
- Supports both R12 and R2000 format (selectable in the export dialog).
- AEC Survey Points are exported as standard POINT entities.
- Tunnel Section Line deviation annotations are exported as LINE and TEXT entities.

- Polyface mesh entities are exported as DXF `POLYLINE` polyface meshes (vertex list + face records), compatible with all AutoCAD versions.
- ACIS-based entities (3DSOLID, REGION, SURFACE) are passed through on export — their SAT/SAB data is preserved unchanged so they can be opened in AutoCAD or other ACIS-capable software.

12.2.2 Image Export

File › Export › Export Image saves a raster snapshot of the current view.

- Supported formats: PNG, BMP.
- The exported image represents the current zoom and pan position.

12.2.3 SVG Export

File › Export › Export SVG creates a Scalable Vector Graphics file.

- Suitable for embedding in reports, web pages, or vector editing tools.
- All geometry is preserved at full precision.

12.2.4 DWG Export

File › Export › Export DWG exports the current drawing to AutoCAD's native DWG binary format.

- Requires an external converter: **LibreDWG** (`dxf2dwg`) or **ODAFileConverter** (free download from the Open Design Alliance).
- IQcad exports a temporary DXF, then converts it to DWG automatically.
- If no converter is found on the system, an error message with install instructions is displayed.

12.2.5 PDF Export

File > Export > Export PDF or the `EXPORTPDF` command exports the active layout to a PDF file. Use `PLOTALL` to export all layouts to a single multi-page PDF.

- Supported from model space and paper space (layout) tabs.
- Page size and orientation come from the **Page Setup** dialog.
- Plot style tables (CTB) are applied if configured.

12.2.6 LandXML Export

File › Export › Export LandXML... writes survey data to LandXML 1.2 format.

- **Survey Points** → `<CgPoints>` elements.
- **Polylines** → `<Alignments>` elements.

Coordinate mapping: World X → Easting, World Y → Northing.

12.3 Importing

12.3.1 Open DXF

Use **File › Open...** and select a `.dxf` file. IQcad supports DXF R12 and R2000. Layers, colours, linetypes, lines, polylines, arcs, circles, texts, and hatches are imported.

Additional 3D entity support on import:

- **Polyface meshes** — DXF `POLYLINE` entities with the polyface-mesh flag are imported as native polyface mesh entities. Use `EXPLODE` to break them into individual 3D Faces or `MESH2SURFACE` to convert to a TIN surface.
- **ACIS entities** — 3DSOLID, REGION, and SURFACE entities are imported as pass-through objects. Their ACIS SAT/SAB geometry data is preserved so that re-exporting to DXF produces a valid file, but IQcad does not render or edit the ACIS geometry itself. These entities appear in the drawing as bounding-box placeholders on their original layer.

12.3.2 Open / Import DWG

Use **File › Open...** and select a `.dwg` file, or use **File › Import DWG...**

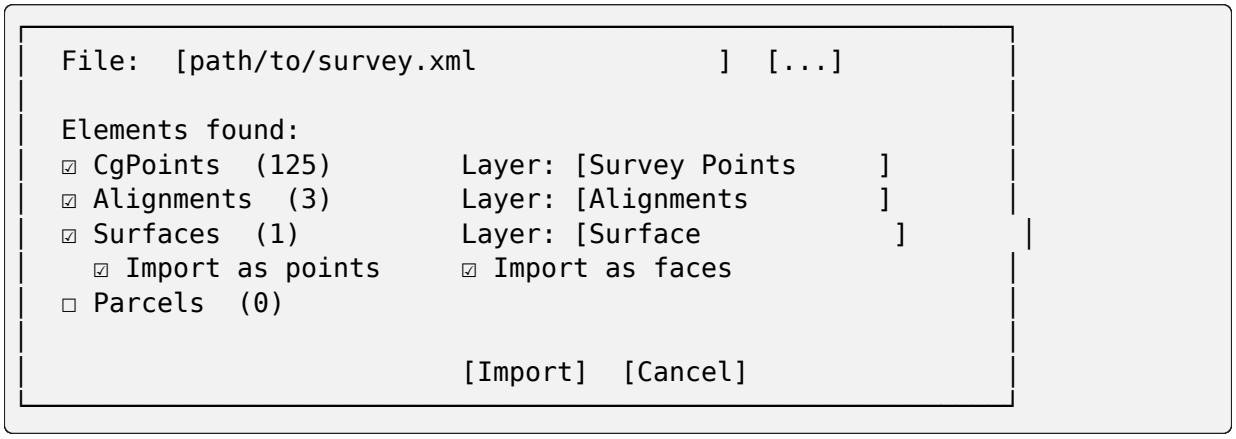
- Requires an external converter: **LibreDWG** (`dwg2dxf`) or **ODAFileConverter**.
- The DWG file is converted to a temporary DXF behind the scenes, then loaded using the standard DXF importer.
- All DWG versions supported by the installed converter are accepted.

Installing a converter:

- **Linux:** `sudo apt install libredwg-tools` or build from source (https://github.com/LibreDWG/libredwg).
- **Windows:** download pre-built binaries from the LibreDWG releases page, or install the free ODAFileConverter from https://www.opendesign.com/guestfiles/oda_file_converter.

12.3.3 LandXML Import

File › Import LandXML... opens the LandXML import dialog.



LandXML element	Imported as	Notes
CgPoints	AEC Survey Points	PointNumber, Name, Northing/Easting/Elevation, Description preserved.
Alignments	Polylines	Arc elements are tessellated to line segments.
Surfaces	Points and/or 3D Face tiles	Toggle *Import as points* and *Import as faces* independently.
Parcels	Closed polylines	Boundary curves tessellated.

Coordinate mapping: LandXML Northing → Y, LandXML Easting → X.

IQcad auto-detects LandXML versions 1.1 and 1.2 from the `xmlns` attribute.

13 Keyboard Shortcuts

13.1 File

Shortcut	Action
Ctrl+N	New drawing
Ctrl+O	Open drawing
Ctrl+S	Save drawing
Ctrl+Shift+S	Save As...
Ctrl+W	Close drawing (opens a new blank if it was the last tab)
Ctrl+P	Print / Export PDF
Alt+F4	Exit IQcad

13.2 Edit

Shortcut	Action
Ctrl+Z	Undo
Ctrl+Y	Redo
Ctrl+A	Select all
Ctrl+D	Duplicate selected
Ctrl+X	Cut
Ctrl+C	Copy
Ctrl+V	Paste
Ctrl+Shift+V	Paste to Original Coordinates (places pasted objects at their original world position instead of requiring an insertion point)
Del	Erase selected objects

13.3 View

Shortcut	Action
+	Zoom in
−	Zoom out
Ctrl+Shift+E	Zoom extents (fit all objects)
Ctrl+Shift+G	Toggle grid on/off

13.4 Format

Shortcut	Action
Ctrl+Shift+D	Point Style editor
Ctrl+Shift+T	Text Style editor
Ctrl+Shift+M	Multiline Style editor

13.5 Drawing Tools

These aliases are entered in the command line (type and press **Enter**):

Key	Alias	Tool
L	LINE	Line
PL	PLINE	Polyline
ML	MLINE	Multiline
A	ARC	Arc
C	CIRCLE	Circle
EL	ELLIPSE	Ellipse
SP	SPLINE	Spline
REC	RECTAN-GLE	Rectangle
H	HATCH	Hatch
T	TEXT	Text
MLD	MLEADER	Multileader
PO	POINT	Point marker
XL	XLINE	Infinite construction line

13.6 Modify Tools

Alias	Tool
E	Erase
M	Move
CO	Copy
RO	Rotate
SC	Scale
O	Offset
MI	Mirror
TR	Trim
EX	Extend
CHA	Chamfer
F	Fillet
PE	PEDIT (polyline edit)

13.7 General

Key	Action
Escape	Cancel current operation; return to Select mode
Enter / Space	Confirm current prompt or repeat last command
F1	Open this User Manual (HTML help)

14 Command Reference

Complete list of every command recognised by the IQcad command line. Type a command name or its alias and press **Enter**.

14.1 CAD Commands

14.1.1 Drawing

Command	Alias	Description
LINE	L	Draw a line (click start and end points, or type coordinates).
PLINE	PL	Draw a polyline (multi-segment, optional arc segments via A).
MLINE	ML	Draw a multiline (parallel strands using the current multiline style).
ARC	A	Draw a three-point arc (start, pass-through, end).
ARC_SCE		Arc: Start, Center, End (3 mouse clicks).
ARC_SCA		Arc: Start, Center, then mouse defines endpoint (angle).
ARC_SCL		Arc: Start, Center, then mouse defines endpoint (chord length).
ARC_SEA		Arc: Start, End, then mouse defines arc midpoint (angle).
ARC_SED		Arc: Start, End, then mouse defines arc midpoint (direction).
ARC_SER		Arc: Start, End, then mouse defines arc midpoint (radius).
ARC_CSE		Arc: Center, Start, End (3 mouse clicks).
ARC_CSA		Arc: Center, Start, then mouse defines endpoint (angle).
ARC_CSL		Arc: Center, Start, then mouse defines endpoint (chord length).
ARC_CONT		Arc: Continue from last entity's endpoint.

continues on next page

Table 1 – continued from previous page

Command	Alias	Description
CIRCLE	C	Draw a circle (centre + radius).
CIRCLE_CD		Circle: Centre, then mouse defines diameter.
CIRCLE_2P		Circle: Two points define the diameter endpoints.
CIRCLE_3P		Circle: Three points define the circumscribed circle.
ELLIPSE	EL	Draw an ellipse (centre, then X-radius, then Y-radius).
SPLINE	SP	Draw a spline through a series of control points.
RECTANGLE	REC	Draw a rectangle (two opposite corners).
POLYGON	POL	Draw a regular polygon (number of sides, centre, radius).
HATCH	H	Create a hatch fill area.
TEXT	T	Place single-line text.
MLEADER	MLD	Draw a multileader (arrowhead, landing, and text label).
ARROW	AR	Draw an arrow entity.
POINT	PO	Place a point marker.
XLINE	XL	Draw a construction line (infinite in both directions).
3DFACE	3F	Draw a 3-D face (3 or 4 corner points).
3DPOLY	3DP	Draw a 3-D polyline (vertices with X, Y, Z). Supports spline-fit (Catmull-Rom interpolation in full 3-D). Right-click to finish.
IMAGEATTACH	IA	Attach a raster image (PNG, JPG, BMP, TIFF). Enter file path or press Enter to browse. If an ESRI world file (`.jgw`, `.pgw`, `.bpw`, `.tfw`) exists, prompts `Use georeferenced placement? [Yes/No]`. **Yes** (default): places at the world-file origin automatically. **No**: interactive placement with pre-filled width and rotation.
BEZIER	BEZ	Draw a Bézier curve.
TABLE	TBL	Place a table. Click an insertion point to create a default 3 × 3 table. After placement, edit cells, row/column counts, and style in the Object Inspector. Cells support formulas and clipboard paste from Excel / LibreOffice.

14.1.2 Modify

Command	Alias	Description
ERASE	E	Delete selected objects. If no objects are pre-selected, prompts "Select objects:" — pick objects then right-click to confirm or press Escape to cancel (matches AutoCAD behaviour).
MOVE	M	Move selected objects (base point → destination point).
COPY	CO	Copy selected objects.
ROTATE	RO	Rotate selected objects about a base point.
SCALE	SC	Scale selected objects from a base point.
OFFSET	O	Offset an entity by a distance or through a point. Supports Line, Circle, Arc, XLine, Polyline, Ellipse, Spline, and Rectangle. The default distance is stored in the OFFSETDIST system variable. Sub-options: **T** = offset through a picked point, **E** = erase the source entity after offsetting, **U** = undo last offset. A phantom preview shows the offset result while picking the side.
MIRROR	MI	Mirror selected objects across a two-point axis.
TRIM	TR	Trim objects to cutting edges. Phase 1: select cutting edges (or type ALL). Phase 2: click the portion to remove.
EXTEND	EX	Extend a line to a boundary edge. Phase 1: select boundary edges. Phase 2: click the end to extend.
CHAMFER	CHA	Chamfer (bevel) two lines. Sub-option D sets chamfer distances ($CHAMFERA / $CHAMFERB). Zero distance trims to intersection.
FILLET	F	Fillet (round) two lines with an arc. Sub-option R sets the radius ($FILLETRAD). Zero radius trims to intersection.
PEDIT	PE	Edit a polyline. Select a polyline (or Line/Arc to convert). Sub-options: **C**lose / **O**pen, **J**oin, **W**idth, **E**dit vertex (N/P/M/I/D/S sub-mode), **S**pline, **D**ecurve, **R**everse, e**X**it. Supports both 2D and 3D polylines.
UNDO	U	Undo the last action.
REDO	—	Redo the last undone action.

14.1.3 View

Command	Alias	Description
ZOOM	Z	Zoom the viewport. Sub-options: E = extents, W = window, + / - = in / out, P = previous.
PAN	P	Activate real-time pan (or use middle-mouse drag).
REGEN	—	Force a full redraw of the canvas.
UCSICON	—	UCS icon display: ON, OFF, ORigin, NOorigin, Size.
3DORBIT	ORBIT	Interactive 3D orbit mode — rotate the view around the model.
PLAN	—	Return to the standard top-down plan view.
VPOINT	VP	Set the viewpoint to a preset direction.
VIEWTWIST	VT	Set a 2D view rotation angle.
ALIGNVIEW	AV	Align the view to two picked points on the canvas.
PLANVIEW	—	Reset the view twist back to north-up (0° rotation).
DRAWORDER	DR	Display order menu. Sub-options: F = front, B = back, A = above, U = below (under).
FRONT	—	Bring selected objects to front (drawn last).
BACK	—	Send selected objects to back (drawn first).
ABOVE	—	Move selected objects above a reference object (click to pick).
BELOW	—	Move selected objects below a reference object (click to pick).

14.1.4 Inquiry

Command	Alias	Description
LIST	LI	Print all properties of the selected object.
ID	—	Click a point and report its world X, Y, Z.
DIST	DI	Measure the distance between two clicked points.
AREA	AA	Measure an area (pick points or select an object).
ANGLE	AN	Measure an angle (pick vertex + two ray points).

14.1.5 Blocks

Command	Alias	Description
BLOCK	B	Create a block definition from selected entities.
INSERT	INS	Insert a block reference.
BLOCKS	BL	List all defined blocks in the drawing.
BEDIT	BE	Edit a block definition in-place.
BCLOSE	BC	Close the block editor and return to the drawing.
BLOCKMANAGER	BM	Open the Block Manager dialog.
EXPLODE	—	Explode blocks, multilines, and polyface meshes into individual entities.
MESH2SURFACE	M2S	Convert a polyface mesh entity into a TIN surface.
SURFACE2MESH	S2M	Convert a TIN surface into a polyface mesh entity.

14.1.6 Dimensions

Command	Alias	Description
DIMLINEAR	DIML	Create a linear (horizontal/vertical) dimension.
DIMALIGNED	DIMAL	Create an aligned dimension (measures true distance).
DIMANGULAR	DIMANG	Create an angular dimension.
DIMRADIUS	DIMRAD	Create a radius dimension.
DIMDIAMETER	DIMDIA	Create a diameter dimension.
DIMORDINATE	DIMORD	Create an ordinate dimension.
DIMARC	—	Create an arc length dimension.
DIMBASELINE	DIMBASE	Create a baseline dimension series.
DIMCONTINUE	DIMCONT	Create a continue dimension chain.
DIMJOGGED	DIMJOG	Create a jogged radius dimension.
DIMSTYLE	—	Open the Dimension Style Manager dialog.

14.1.7 Settings & Drawing Variables

Command	Alias	Description
UNITS	—	Multi-step wizard to set linear/angular units and precision.
LUNITS	—	Set $LUNITS — linear format (1 = Scientific, 2 = Decimal, 3 = Engineering, 4 = Architectural, 5 = Fractional).

continues on next page

Table 2 – continued from previous page

Command	Alias	Description
LUPREC	—	Set $LUPREC — linear precision (0–8 decimal places).
AUNITS	—	Set $AUNITS — angular format (0 = Decimal degrees, 1 = DMS, 2 = Grads, 3 = Radians, 4 = Surveyor).
AUPREC	—	Set $AUPREC — angular precision (0–8 decimal places).
ANGDIR	—	Set $ANGDIR — angle direction (0 = CCW, 1 = CW).
ANGBASE	—	Set $ANGBASE — base angle in degrees (0 = East, 90 = North).
INSUNITS	—	Set $INSUNITS — insertion units (0 = Unitless, 1 = Inches, 2 = Feet, 4 = mm, 5 = cm, 6 = m, 7 = km).
MEASUREMENT	—	Set $MEASUREMENT — 0 = Imperial, 1 = Metric.
UNITMODE	—	Set $UNITMODE — 0 = stacked display, 1 = single string.
LIMCHECK	—	Set $LIMCHECK — 0 = off, 1 = enforce drawing limits.
LIMITS	—	Set $LIMMIN / $LIMMAX — drawing limits (lower-left, upper-right).
LTSCALE	—	Set $LTSCALE — global linetype scale factor.
TEXTSIZE	—	Set $TEXTSIZE — default text height.
DIMSCALE	—	Set $DIMSCALE — dimension scale factor.
OSMODE	—	Set $OSMODE — object snap bitmask (1 = END, 2 = MID, 4 = CEN, 8 = NOD, 16 = QUA, 32 = INT, 128 = PER, 256 = TAN, 512 = NEA).
GRID	—	Set grid spacing or toggle ON / OFF (also **F7**).
GRIDUNIT	—	Set $GRIDUNIT — grid spacing (saved with drawing).
GRIDMAJOR	—	Set $GRIDMAJOR — minor lines between bold major lines (default 5).
GRIDTEXT	—	Toggle $GRIDTEXT — X/Y coordinate labels on major grid lines.
GRIPSIZE	—	Set $GRIPSIZE — grip square half-size in pixels (default 5).
ORTHO	—	Toggle orthogonal constraint (also **F8**).
SNAP	—	Toggle grid snap (also **F9**).
ORTHOMODE	—	Set $ORTHOMODE — 0 = off, 1 = on (saved with drawing).
SNAPMODE	—	Set $SNAPMODE — 0 = off, 1 = on (saved with drawing).
PICKADD	—	0 = replace selection, 1 = additive selection.
PICKAUTO	—	0 = no implied window, 1 = implied windowing.
LAYER	LA	Open the Layer Manager dialog.
TABLESTYLE	—	Open the Table Style Manager (create, edit, and delete table styles).
SETVAR	SV	Set any system variable by name and value.
SCALELISTEDIT	SLST	Edit the scale list (add, remove, rename annotation scales).

14.1.8 Layout & Paper Space

Command	Alias	Description
LAYOUT	LO	Layout management. Sub-options: N = new, D = delete, L = list (* marks active), S = set active.
MVIEW	MV	Create a viewport in paper space (Fit or 2-point). Must be on a Layout tab.
MVSETUP	MVS	Viewport setup: rotate, scale, and title a viewport.
VPCLIP	—	Clip a viewport boundary to a custom shape.
VPFADE	VPF	Toggle viewport fade (dimmed display of inactive viewports).
VPSCALEBAR	VPSB	Toggle scale bar display in a viewport.
PAGESETUP	—	Open the Page Setup dialog for the active layout.
PLOTPDF	PDF	Unified PDF export command. Exports the active layout to PDF. Replaces the older EXPORTPDF alias.
PLOT	PRINT	Open the Print dialog (Ctrl+P).
PLOTALL	—	Export all layouts to a multi-page PDF.

14.1.9 Utility

Command	Alias	Description
PURGE	—	Remove all unused items (layers, blocks, styles, linetypes).
PURGELAYERS	—	Remove unused layers only.
PURGEBLOCKS	—	Remove unreferenced block definitions.
PURGESTYLES	—	Remove unused text, dimension, and table styles.
PURGELINETYPES	—	Remove unused linetypes.
AUDIT	—	Check drawing file integrity and report issues.
RECOVER	—	Fix drawing integrity issues found by AUDIT.
RECOVERCREATELAYERS	—	Recover and recreate any missing layers referenced by entities.

14.1.10 Miscellaneous

Command	Alias	Description
HELP	?	Show command help in the command line.
MAPBG	—	Toggle background map tile layer behind the drawing canvas.

14.2 Civil Commands

14.2.1 Survey Points

Command	Alias	Description
SURVEYPOINT	SRVPT	Place an AEC survey point (Northing, Easting, Elevation).
TSLINE	TSL	Draw a tunnel section line (measured cross-section profile for deviation analysis).
TSOPTIMIZE	TSOPT	Optimize the fit between a measured tunnel profile and its theoretical section. Supports five optimization levels: 2P (translate), 3P (translate + uniform scale), 4P (translate + non-uniform scale), 5P (translate + scale + rotation), and per-vertex radial adjustment. Constraints: max overbreak/underbreak DR, max overbreak/underbreak area. Uses the Nelder-Mead simplex algorithm for 2P-5P modes.

14.2.2 Surfaces

Command	Alias	Description
CREATESURFACE	CS	Create a TIN surface. If survey points exist in the drawing they are triangulated automatically; otherwise an empty surface definition is created so point groups and boundaries can be attached later.
ADDSURFACE-POINTS	ASP	Add all survey points to a named surface and build (or rebuild) the TIN.
ADDSURFACEEN-TITIES	ASE	Add selected drawing objects to a surface. Supported entity types: 3DFace (loaded as TIN triangles directly), Line, Polyline, Spline, Point, and Survey Point (vertices triangulated). If only one surface exists it is used automatically; otherwise prompts for the surface name.
REBUILDSUR-FACE	RS	Rebuild an existing surface TIN from the current survey points.
ADDSURFACE-BOUNDARY	ASB	Add a boundary polyline to a surface (outer or hole).
DECIMATESUR-FACE	DS	Decimate (simplify) a TIN surface. Prompts for the surface name (auto-selects if only one exists) and a max elevation tolerance. Two algorithms are selected automatically: **grid-based O(n)** for surfaces > 100K points (single-pass min/max Z per cell, capped at 50K output points, < 5 sec for 4M points); **greedy insertion** for ≤ 100K points (convex hull seed, binary max-heap, batched refinement).
DELETESURFACE	—	Delete a surface by name.
SURFACEPROP-ERTIES	—	Display surface statistics (points, triangles, area, elevation range).

14.2.3 Surface Editing

Command	Alias	Description
SURFADDPOINT	SAP	Add a single point to a surface TIN interactively.
SURFDELETE-POINT	SDP	Delete a point from a surface TIN.
SURFMOVEPOINT	SMP	Move a surface TIN point to a new position.
SURFMODI-FYELEV	SME	Modify the elevation of a surface point.
SURFSWAPEDGE	SSE	Swap a TIN edge between two adjacent triangles. Runs continuously (click edges one after another) until cancelled with Escape or right-click.
SURFADDLINE	SAL	Force an edge (breakline) between two surface points.
SURFDELETE-LINE	SDL	Remove a TIN edge.
SURFRAISELOWER	SRL	Raise or lower the entire surface by a specified elevation offset.
SURFUNDO	—	Undo the last surface edit operation.
SURFCLEARED-ITS	SCE	Clear the surface edit log.
SURFLISTEDITS	SLE	List all surface edit operations performed since the last clear.

14.2.4 Spot Elevations & Labels

Command	Alias	Description
SPOTELEV	SE	Place a spot elevation label at a clicked point on a surface.
ADDCONTOURLA-BEL	ACL	Place contour labels along surface contour lines with collision avoidance and uphill-readable rotation.

14.2.5 Alignments

Command	Alias	Description
ALIGNMENT	ALIGN	Create a horizontal alignment from PI (Point of Intersection) picks.
ALIGNREVERSE	—	Reverse the direction of an alignment.
ALIGNPROPS	—	Display alignment properties (element table, total length, etc.).
ALIGN-FROMPOLYLINE	AFP	Create an alignment from a selected polyline with optional curve radius at interior PIs.

14.2.6 Profiles

Command	Alias	Description
QUICKPROFILE	QP	Create a quick profile along a polyline or line by sampling a surface. Select source entity, then surface, then click insertion point.
CREATEPROFILEVIEW	CPV	Create a profile view from an alignment. Select alignment, then surface, then click insertion point. Samples ground profile and includes design vertical alignment if present.
DESIGNPROFILE	DP	Create a design profile (vertical alignment) inside a profile view. Click PVIs in the view, then enter curve lengths at each interior PVI.
PROFILEPROPS	—	Display profile view properties (station range, elevation range, profile count).

14.2.7 Cross-Sections

Command	Alias	Description
CREATESECTIONSHEET	CSS	Create a cross-section sheet: select alignment, surfaces, interval, widths, grid layout, cut/fill surfaces, and click insertion point.
EARTHWORKVOLUMES	EWV	Compute and display earthwork volume table using the average end area method (cut/fill areas, volumes, cumulative totals).

14.2.8 Parcels

Command	Alias	Description
CREATEPARCEL	PARCEL	Create a parcel from a closed polyline. Prompts for a parcel name, then click a closed polyline to define the boundary. Area and perimeter are computed automatically.

14.2.9 Point Groups

Command	Alias	Description
ADDTOGROUP	ATG	Add selected civil points to a point group. Select points first, then run the command. Lists existing groups by number; type a number to pick one or type a new name to create a group.
REMOVEFROM-GROUP	RFG	Remove selected civil points from a point group. Select points first, then run the command and pick the group.
CREATEGROUP	CRG	Create a new point group. Prompts for a name, then lets you click individual points to add. Press Enter to finish.
CONVERTPOINTS	CPT	Convert selected AutoCAD point markers into AEC civil survey points. Optionally assigns a group and deletes the original point entities.

14.2.10 Coordinate Transformations

Command	Alias	Description
CSTRANSFORM	CST	Global coordinate transformation using common/control points. Supports Helmert 2D (4-parameter similarity), Affine 2D (6-parameter), and Polynomial degree 1/2/3. Interactive point picking on canvas, keyboard coordinate entry (`E,N` or `E,N,Z`), survey point lookup (`#PointNumber`), and file loading (`.cpt` JSON / `.csv`). Produces least-squares residuals, RMS statistics, and transformation reports (`.trpt`). Common points can be saved for reuse.
RUBBERSHEET	RBS	Non-uniform rubber-sheet transformation using control points. Two modes: **Linear** (Delaunay piecewise affine — C0 continuous) and **Smooth** (Thin Plate Spline — C2 continuous). Both achieve exact interpolation at control points (zero residual). Points outside the convex hull are extrapolated using the nearest triangle (linear) or affine far-field (smooth). Reports outside-hull count. Saves common points and transformation reports.

15 Tutorials

Step-by-step guides for common civil engineering workflows in IQcad. Each tutorial starts from scratch and walks through the complete process.

15.1 Tutorial 1: Working with Survey Points

This tutorial covers importing survey data, organising points into groups, applying styles, and performing coordinate transformations.

15.1.1 Step 1 — Open a New Drawing

1	Choose **File > New** or press **Ctrl+N** to create a blank drawing.
2	The drawing opens with a default empty canvas. The coordinate system defaults to metres (metric).

15.1.2 Step 2 — Import Points from CSV

Survey points are typically collected in the field and exported as CSV files. IQcad can import these directly.

1. Choose **Civil > Points > Import Points...** from the menu, or open the **Point Manager** (Civil > Points > Manager) and click the **Import** button on its toolbar.
2. In the Import dialog, click **[...]** to browse to your CSV file.
3. Select the **Format** from the dropdown. The most common format is **P, N, E, Z, Desc** (Point Number, Northing, Easting, Elevation, Description). If unsure, choose **Auto-detect (by column count)**.
4. Check **Skip first line** if your file has a header row.
5. Optionally enter a **Point group** name (e.g., `Topo`) to assign all imported points to a group automatically.
6. Review the preview at the bottom of the dialog to verify the data looks correct.
7. Click **Import**. The status bar shows how many points were imported.

CSV file format example:

```
1,538345.123,4872341.456,412.500,BM-001
2,538350.200,4872345.100,413.200,EP
3,538360.500,4872350.800,414.100,CL
4,538370.000,4872355.300,413.800,EP
```

Each line contains: PointNumber, Northing, Easting, Elevation, Description. Lines starting with `#` or `;` are treated as comments. Accepted file types: `.csv`, `.txt`, `.pts`.

15.1.3 Step 3 — View Points in the Point Manager

1. Open the **Point Manager** from **Civil > Points > Manager** or the ribbon button.
2. The grid displays all imported points with columns: #, Easting, Northing, Elevation, Raw Desc, Full Desc, and Lock.
3. Click any cell to edit its value directly. Changes apply immediately to the database and the canvas.
4. Use **Zoom Extents** (`Z` then `E` in the command line, or double-click the mouse wheel) to see all points on the canvas.

15.1.4 Step 4 — Create Point Groups

Groups let you organise points by category (e.g., boundary, topo, control).

1. In the Point Manager, **right-click a sheet tab** at the bottom and choose **New Group...**.
2. Enter a group name (e.g., `Boundary`) and click OK. A new tab appears.
3. Switch to the **All Points** tab. Select the rows you want to add to the group (click the first row, hold **Shift** and click the last row for a range, or hold **Ctrl** and click individual rows).
4. Click the **To Group** button on the toolbar. Select the target group from the dialog and click OK.
5. Switch to the group tab to verify the points appear there.

15.1.5 Step 5 — Change Point Styles

Point styles control the marker shape and label appearance for survey points on the canvas.

1. Open the style editor via **Civil > Styles** (Civil Style Manager) and select the **Point Styles** category, or use **Format > Point Style...** (**Ctrl+Shift+D**).
2. Select a point in the drawing, then in the Object Inspector change the **PointStyleName** property to one of the built-in styles: Standard, Benchmark, Control Point, GPS Rover, or Iron Rod.
3. The marker on the canvas updates immediately to reflect the new style.

15.1.6 Step 6 — Export Points to Excel

1. In the Point Manager, switch to the tab you want to export (a specific group tab, or **All Points**).
2. Click the **Export** button on the toolbar.
3. Choose the format: **CSV**, **XLSX** (Excel), or **ODS** (LibreOffice).
4. Choose a save location and click **Save**.

15.1.7 Step 7 — Lock Points

Locking prevents accidental modification of control points or benchmarks.

1. In the Point Manager, select the rows you want to lock.
2. Click the **Lock** button on the toolbar. The Lock column changes to `Yes` for the selected points.
3. Locked points cannot be moved on the canvas. To unlock, select them again and click **Lock** to toggle.

15.1.8 Step 8 — Transform Points

IQcad provides several coordinate transformation tools accessible from the Point Manager toolbar.

1. Select the points you want to transform in the Point Manager grid.
2. Click one of the transform buttons on the toolbar:
   - **Translate** — shift by dE, dN, dZ offsets.
   - **Rotate** — rotate around a base point by a specified angle.
   - **Scale** — scale from a base point by a factor.
   - **Swap E/N** — swap Easting and Northing values.
   - **Helmert** — 2D conformal transformation (translate + rotate + scale) using control point pairs.
3. Enter the required parameters in the dialog and click **OK**. The points are transformed and the canvas updates.

For more advanced transformations (Affine, Polynomial, Rubber-sheet), use the `CSTRANSFORM` or `RUBBERSHEET` commands from the command line.

15.2 Tutorial 2: Working with TIN Surfaces

This tutorial covers creating a terrain surface from survey points, customising its display, adding boundaries, and performing analysis.

15.2.1 Step 1 — Import Survey Points

If you do not already have survey points in the drawing, import them following the steps in Tutorial 1 (Steps 1-2). You need at least 3 non-collinear points to create a TIN surface.

15.2.2 Step 2 — Create a Surface

1	Choose **Civil > Surfaces > Create Surface** from the menu, click the **Create Srf** ribbon button on the Civil tab, or type `CREATESURFACE` (alias `CS`) in the command line.
2	A surface is created with an auto-generated name (`Surface_1`). If survey points exist in the drawing, they are triangulated automatically using the Bowyer-Watson Delaunay algorithm.
3	The surface appears on the canvas showing triangulation edges and contour lines (depending on the active style).
4	Use **Zoom Extents** to see the full surface.

15.2.3 Step 3 — View Contour Lines and Triangulation

1	Select the surface on the canvas by clicking on it.
2	In the Object Inspector, look at the surface properties. The **ShowContours** and **ShowTriangles** flags control what is visible.
3	Toggle **ShowContours** to `True` to display contour lines.
4	Adjust the **MajorContourInterval** and **MinorContourInterval** values to control contour spacing (e.g., 5.0 m major, 1.0 m minor).

15.2.4 Step 4 — Change the Surface Style

1. With the surface selected, change the **StyleName** property in the Object Inspector.

2. Three built-in presets are available:
   - **Standard** — triangles, contours, boundaries, and labels.
   - **Triangles & Contours** — triangles and contours visible.
   - **Contours Only** — only contour lines and labels.

3. To create or edit styles, open the **Surface Style Editor** via **Format > Surface Styles...** or right-click the surface in the Civil Toolspace and choose **Surface Style...**.

15.2.5 Step 5 — Add a Boundary to Clip the Surface

1. Draw a closed polyline around the area you want to keep (use the `PLINE` command, alias `PL`). Close it by typing `C` at the last vertex prompt.

2. Type `ADDSURFACEBOUNDARY` (alias `ASB`) in the command line.

3. Enter the surface name (or press Enter if only one surface exists).

4. Click the boundary polyline.

5. Choose **Outer** to clip everything outside the boundary, or **Hole** to clip everything inside.

6. The TIN is rebuilt with triangles outside (or inside) the boundary removed.

15.2.6 Step 6 — Add Spot Elevations

1. Type `SPOTELEV` (alias `SE`) in the command line, or choose **Civil > Surfaces > Spot Elevation**.
2. Click points on the surface. At each click, the tool queries the TIN to interpolate the elevation and places a label annotation.
3. Right-click or press **Escape** to exit the command.

15.2.7 Step 7 — Decimate a Large Surface

If your surface has a very large number of points (e.g., from LiDAR or photogrammetry), decimation reduces the triangle count while preserving the surface shape.

1. Type `DECIMATESURFACE` (alias `DS`) in the command line.
2. Enter the surface name (auto-selected if only one exists).
3. Enter the **max elevation tolerance** in drawing units (e.g., `0.05` for 5 cm accuracy).
4. The system automatically selects the best algorithm: grid-based for surfaces > 100K points, greedy insertion for smaller surfaces.
5. Contours and boundaries are regenerated automatically after decimation.

15.2.8 Step 8 — Edit Surface Points

1	Use the surface editing commands to modify the TIN interactively: • `SURFADDPOINT` (`SAP`) — add a point to the TIN. • `SURFDELETEPOINT` (`SDP`) — remove a point. • `SURFMOVEPOINT` (`SMP`) — move a point. • `SURFMODIFYELEV` (`SME`) — change a point's elevation. • `SURFSWAPEDGE` (`SSE`) — swap a TIN edge between triangles.
2	Use `SURFUNDO` to undo the last edit, or `SURFLISTEDITS` (`SLE`) to review the edit history.

15.2.9 Step 9 — Export to LandXML

1	Choose **File > Export LandXML...** or use the **Output** ribbon tab.
2	In the export dialog, check the surfaces you want to include.
3	Choose a file location and click **Export**.
4	The surface is written as a `<Surface>` element with `<Pnts>` and `<Faces>` sub-elements in LandXML format.

15.3 Tutorial 3: Working with Alignments

This tutorial covers creating a horizontal alignment, adding curves and spirals, and generating profile views and cross-sections.

15.3.1 Step 1 — Create an Alignment from PIs

1. Type `ALIGNMENT` (alias `ALIGN`) in the command line, or choose **Civil > Alignments > Create Alignment**.
2. Click points on the canvas to place each PI (Point of Intersection). A rubber-band preview line follows the cursor as you click.
3. Right-click or press **Enter** to finish. The alignment is created with straight tangent segments only (no curves yet).

Alternatively, convert an existing polyline: type `ALIGNFROMPOLYLINE` (alias `AFP`) and click on a polyline. Its vertices become the alignment PIs.

15.3.2 Step 2 — Add Curves at PIs

1. Open the **PI Table Editor** from the **Civil ribbon > Edit PIs** button, or double-click an alignment in the Civil Toolspace.
2. In the PI data grid, find the interior PI where you want a curve.
3. Enter a **Radius** value (e.g., `200` for a 200 m curve). The radius of `0` means no curve (tangent intersection).
4. Click **Apply** to rebuild the alignment geometry. The canvas updates to show the curved alignment.

15.3.3 Step 3 — Add Spiral Transitions

1	In the PI Table Editor grid, locate the PI with a curve.
2	Enter a value in the **Spiral In** column (e.g., `50` for a 50 m entry spiral length).
3	Select the **Type (In)** from the dropdown: Clothoid L, Clothoid A, Cubic L, or Cubic A.
4	Similarly, enter a **Spiral Out** value and select its type.
5	Click **Apply** to rebuild. The alignment now shows smooth spiral transitions between the tangent and the circular curve.

15.3.4 Step 4 — View Station Labels and PI Details

1	Select the alignment on the canvas.
2	In the Object Inspector, change the **Style Name** to **Design Phase** to see full labels and PI detail tables.
3	Station labels appear at major and minor tick positions along the centreline. PI detail tables display computed curve parameters (radius, arc length, spiral parameter, tangent distance).
4	Tables are placed on alternating sides of the alignment with leader lines and auto-hide when zoomed out.

15.3.5 Step 5 — Create a Profile View

1	Type `CREATEPROFILEVIEW` (alias `CPV`) in the command line, or choose **Civil > Profile > Create Profile View**.
2	If multiple alignments exist, enter the alignment name. If only one exists, it is selected automatically.
3	Enter the surface name to sample (or press **Enter** to skip).
4	Click a point on the canvas to place the profile view.
5	The profile view appears as a graph with station on the horizontal axis and elevation on the vertical axis. If a surface was selected, the existing ground profile is drawn as a line in the view.

15.3.6 Step 6 — Add a Design Profile

1	Type `DESIGNPROFILE` (alias `DP`) in the command line.
2	Click on a profile view in the drawing to select it.
3	Click points inside the profile view to place PVI (Point of Vertical Intersection) points. Each click defines a station and elevation.
4	Right-click or press **Enter** to finish placing PVIs.
5	For each interior PVI, you are prompted for a **vertical curve length**. Enter `0` for a sharp grade break, or a positive value (e.g., `100`) for a smooth parabolic vertical curve.
6	The design profile is drawn in the profile view as a line overlaying the ground profile.

15.3.7 Step 7 — Create Cross-Sections

1	Type `CREATESECTIONSHEET` (alias `CSS`) in the command line, or choose **Civil > Cross-Sections > Create Section Sheet**.
2	Select the alignment to use.
3	Enter surface names to sample (comma-separated for multiple surfaces, e.g., `Surface_1,Design_Surface`).
4	Set the **station interval** (default 20 m) — how often cross- sections are cut along the alignment.
5	Set the **left and right widths** (default 20 m each) — how far each section extends from the centreline.
6	Set the number of **columns and rows** per sheet for the grid layout.
7	Optionally select two surfaces for **cut/fill comparison** (e.g., existing ground vs. design surface).
8	Click an insertion point on the canvas. The section sheet is generated with all cross-sections arranged in a grid layout.

15.3.8 Step 8 — View Earthwork Volumes

1	Type `EARTHWORKVOLUMES` (alias `EWV`) in the command line.
2	Select the section sheet to analyse.
3	The command computes volumes using the **average end area method** and displays a table showing, for each station: cut area, fill area, cut volume, fill volume, cumulative cut, cumulative fill, and net volume.
4	Totals are printed at the bottom of the table.

15.3.9 Step 9 — Import an Alignment from LandXML

1. Choose **File > Import LandXML...** or use the LandXML import button on the Civil ribbon tab.
2. Browse to the `.xml` file and click **Open**.
3. The import dialog shows the contents of the file. Check the alignments you want to import.
4. Click **Import**. The alignment(s) appear on the canvas with their horizontal geometry (tangents, curves, spirals) and vertical profile (if present in the LandXML data).

15.4 Tutorial 4: Working with Parcels

This tutorial covers creating parcel boundaries, attaching metadata, and customising parcel display.

15.4.1 Step 1 — Draw a Closed Polyline

1. Type `PLINE` (alias `PL`) in the command line to start a polyline.
2. Click points on the canvas to define the parcel boundary corners.
3. After placing the last corner, type `C` and press **Enter** to close the polyline (connect the last point back to the first).

15.4.2 Step 2 — Create a Parcel

1. Type `CREATEPARCEL` (alias `PARCEL`) in the command line, or choose **Civil > Parcels > Create Parcel**.
2. When prompted, enter a **parcel name** (e.g., `Lot-1`).
3. Click on the closed polyline you drew in Step 1.
4. The parcel entity is created and appears on the canvas with the default **Standard** style. The source polyline remains in the drawing.

15.4.3 Step 3 — Set Parcel Name and Number

1. Select the parcel on the canvas by clicking on it.
2. In the Object Inspector, set the **ParcelName** property (e.g., `Lot-1` or `Parcel A`).
3. Set the **ParcelNumber** property to a numeric identifier (e.g., `1`).

15.4.4 Step 4 — View Area and Perimeter

1	With the parcel selected, look at the Object Inspector.
2	The **Area** property shows the computed area of the boundary polygon in square drawing units (e.g., square metres).
3	The **Perimeter** property shows the total boundary length.
4	These values are read-only and update automatically if the boundary geometry is edited.

15.4.5 Step 5 — Add User Data

1	With the parcel selected, expand the **UserData** category in the Object Inspector.
2	Add key-value pairs for the parcel metadata. Common fields include: • **Owner** — name of the property owner. • **Description** — free-text description of the parcel. • **Zoning** — zoning classification (e.g., Residential, Commercial). • **LandUse** — current land use description. • **TaxID** — tax parcel identifier.
3	User data is saved with the drawing and included in LandXML exports.

15.4.6 Step 6 — Change the Parcel Style

1. With the parcel selected, change the **StyleName** property in the Object Inspector.

2. Four built-in styles are available:
   - **Standard** — boundary line only, no fill.
   - **Property** — boundary with semi-transparent fill and bearing/distance labels on each segment.
   - **Easement** — dashed boundary with light fill for restricted zones.
   - **ROW** — heavy boundary with cross-hatch fill for rights-of-way.

3. To create or edit parcel styles, open the **Civil Style Manager** via **Civil > Styles** and select the **Parcel Styles** category, or use **Format > Parcel Styles...**.

15.4.7 Step 7 — Import Parcels from LandXML

1. Choose **File > Import LandXML...** from the menu.

2. Browse to the `.xml` file containing parcel data and click **Open**.

3. In the import dialog, check the parcels you want to import.

4. Click **Import**. The parcels appear on the canvas with their boundary geometry, names, and any associated metadata from the LandXML file.

16

Program Defaults Reference

This chapter lists every factory default in IQcad. Use it as a quick reference when you need to know the out-of-the-box value for any setting, style, or variable. All values are applied when you create a new drawing or choose **Reset to Defaults** in a settings dialog.

16.1 Application Settings

Table 1: Window & UI

Setting	Default	Notes
Theme	MetroDark	SpkToolbar ribbon theme
Menu bar visible	False	Ribbon-only by default
Debug log	False	Writes to `iqcad_debug.log`
Prospector width	220 px	Left panel
Inspector width	360 px	Right panel
Command panel height	120 px	Bottom panel

Table 2: Canvas Display

Setting	Default	Notes
Background colour	Black	
Crosshair size	50 px	Arm length
Grip size	5 px	
Pick aperture	5 px	Half-side of pick box
Snap colour	Yellow	
OSNAP aperture	15 px	
OSNAP mode	575	END + MID + CEN + NOD + QUA + INT + NEA

Table 3: Ruler

Setting	Default	Notes
Visible	True	
Size	28 px	
Colour	clBtnFace	System button-face colour
Text colour	Black	
Opacity	200	0 = transparent, 255 = opaque

Table 4: Grid

Setting	Default	Notes
Visible	True	
Grid size	10.0	World units
Major interval	5	Lines per major grid
Grid text	False	Coordinate labels on major lines
Grid style	Lines	Lines / Dashed / Dots

Table 5: UCS Gizmo

Setting	Default	Notes
Visible	True	
At origin	False	Corner placement by default
Size	80 px	
Corner	Bottom-left	
Background opacity	80	0–255

Table 6: North Arrow

Setting	Default	Notes
Visible	False	
Style	Simple	Simple / Compass Rose / Ornate / Circle
Corner	Top-right	
Size	48 px	
Colour	Black	

16.2 Drawing Variables

These are per-drawing system variables, equivalent to AutoCAD system variables. They are stored with each drawing.

Table 7: Units & Angles

Variable	Default	Notes
LUNITS	2 (Decimal)	Linear unit format
LUPREC	4	Linear unit precision
AUNITS	0 (Decimal Degrees)	
AUPREC	0	Angular precision
ANGBASE	0.0	Angle base (east)
ANGDIR	0	0 = CCW, 1 = CW
INSUNITS	4 (Millimetres)	5 = cm, 6 = m, 7 = inches
MEASUREMENT	1 (Metric)	0 = Imperial

Table 8: Linetype & Point Display

Variable	Default	Notes
LTSCALE	1.0	Global linetype scale
CELTSCALE	1.0	Current entity linetype scale
MSLTSCALE	1	Model-space linetype scale
PDSIZE	0.15	Point marker size (world units)
PDMODE	Cross + Circle	Point display style
TEXTSIZE	2.5	Default text height
DIMSCALE	1.0	Overall dimension scale

Table 9: Drawing Limits

Variable	Default	Notes
LIMMIN	0, 0	Lower-left limit
LIMMAX	420, 297	Upper-right limit (A3 paper)
LIMCHECK	0	No limit enforcement

Table 10: Hatch Defaults

Variable	Default	Notes
HPNAME	SOLID	Default hatch pattern
HPSCALE	1.0	
HPANG	0.0	Pattern angle
HPASSOC	True	Associative hatch
HPMAXLINES	1 000 000	Line limit

16.3 Layer Defaults

Every new layer starts with these defaults:

Property	Default	Notes
Colour	White	
Linetype	Solid	
Line width	1	
Visible	True	
Frozen	False	
Locked	False	
Printable	True	
Transparency	0	0–90 %
Plot style	Normal	

16.4 Text Styles

Table 11: Built-in Text Styles

Name	Font	Bold	Italic	Description
Standard	Arial	No	No	Default text style — variable height
Title	Arial	Yes	No	Bold title text
Subtitle	Arial	No	Yes	Italic subtitle text
Annotative	Arial	No	No	Annotative text style
Mono	Courier New	No	No	Monospaced (dimensions, tables)

16.5 Dimension Styles

Table 12: Standard Dimension Style

Property	Default	Notes
Arrow type	Closed filled	Both sides + leader
Arrow size	2.5	
Text height	2.5	
Text placement	Above, centred	
Text gap	0.625	
Baseline spacing	3.75	
Extension line extend	1.25	
Extension line offset	0.625	
Decimal precision	2	
Overall scale	1.0	
Unit format	Decimal	
Angular format	Decimal degrees	

16.6 Surface Styles

Table 13: Standard Surface Style

Component	Colour	Weight	Notes
Border	Yellow	2	Visible by default
Triangles	Grey	1	Hidden by default
Major contours	Brown (180, 60, 0)	2	Interval: 5.0
Minor contours	Dark green (0, 140, 0)	1	Interval: 1.0
Points	Gold (255, 200, 0)	—	Hidden by default, size 3
Contour labels	—	—	Style: Contour - Standard, interval 50
Spot elevations	—	—	Style: Spot Elevation - Standard
Elevation bands	—	—	Hidden by default

Built-in presets:

- **Standard** — contours + border visible, triangles hidden
- **Triangles & Contours** — both triangles and contours visible
- **Contours Only** — border hidden
- **Elevation Banding** — contours + elevation bands visible
- **Empty** — all components hidden

16.7 Alignment Styles

Table 14: Standard Alignment Style

Component	Colour	Weight	Notes
Centreline	Red	2	Linetype: ByLayer
Station ticks	Red	1	Major 100 m, minor 20 m
PI markers	Red	—	Size: 2.0
PI lines	Green	1	Hidden, dashed linetype
Direction arrows	Red	—	Interval 200 m, size 2.0
Label text	White	—	Height: 2.0 mm

Built-in presets:

- **Standard** — centreline + ticks + PI markers + arrows
- **Centreline Only** — ticks, PI markers, arrows hidden
- **Design Phase** — centreline as CENTER linetype, PI details + PI lines visible
- **Empty** — all components hidden

16.8 Parcel Styles

Table 15: Built-in Parcel Styles

Style	Boundary	Fill	Notes
Standard	ByLayer, width 1	Hidden	Centroid label: name + area
Property	Dark brown, width 2	Light tan, 20% transparent	Full label, segment distances + bearings
Easement	Red, dashed	ANSI31 hatch, red	Name label
ROW	Green	Lime, 15% transparent	Name label
Empty	Hidden (BoundaryVisible=False)	Hidden	All components hidden

16.9 Tunnel Section Line Styles

Table 16: Built-in Tunnel Section Line Styles

Style	Description
Standard	Measured line with deviation annotations visible, no area hatch.
Hatched	Measured line with coloured area hatch (green = overbreak, red = underbreak) between measured and theoretical profiles.
Simple	Measured line only, no annotations or hatch.

16.10 Civil Object Layer Defaults

When civil object layers are enabled (default: on, prefix `C`), each civil entity automatically creates dedicated layers for its components. The following table shows all layer name patterns and their default colours.

Table 17: Surface Layers

Component	Layer Pattern	Default Colour
Geometry (TIN)	`C-TOPO-{Name}`	Grey
Major contours	`C-TOPO-{Name}-MAJR`	Brown (180, 60, 0)
Minor contours	`C-TOPO-{Name}-MINR`	Dark green (0, 140, 0)
Boundary	`C-TOPO-{Name}-BNDY`	Yellow
Points	`C-TOPO-{Name}-PNTS`	Gold (255, 200, 0)
Labels	`C-TOPO-{Name}-LABL`	White
Spot elevations	`C-TOPO-{Name}-SPOT`	Cyan

Table 18: Alignment Layers

Component	Layer Pattern	Default Colour
Centreline	`C-ROAD-{Name}`	Red
PI markers	`C-ROAD-{Name}-PI`	Yellow
Labels	`C-ROAD-{Name}-LABL`	White

Table 19: Profile View Layers

Component	Layer Pattern	Default Colour
Grid	`C-PROF-{Name}`	Dark grey (60, 60, 60)
Axis	`C-PROF-{Name}-AXIS`	White
Title	`C-PROF-{Name}-TITL`	White
Existing profile	`C-PROF-{Name}-PROF`	Green (0, 160, 0)
Design profile	`C-PROF-{Name}-DSGN`	Red

Table 20: Parcel Layers

Component	Layer Pattern	Default Colour
Boundary	`C-PROP-{Name}`	Magenta
Fill	`C-PROP-{Name}-FILL`	Light pink (255, 200, 255)
Labels	`C-PROP-{Name}-LABL`	White
Segment labels	`C-PROP-{Name}-SEGL`	Cyan

Table 21: Survey Point Layers

Component	Layer Pattern	Default Colour
Markers	`C-PNTS`	Gold (255, 200, 0)
Labels	`C-PNTS-LABL`	White

Table 22: Section View Layers

Component	Layer Pattern	Default Colour
Grid	`C-SECT-{Name}`	Dark grey (60, 60, 60)
Axis	`C-SECT-{Name}-AXIS`	White
Section lines	`C-SECT-{Name}-SECT`	Green (0, 160, 0)

16.11 Civil Label Styles

All label styles use paper-mm text height, scaled by the civil drawing scale.

Table 23: Built-in Label Styles

Name	Height (mm)	Placement	Components
Point - Standard	2.0	Anchor TR	Number, Elevation
Point - Full	1.5	Anchor TR	Number, E, N, Elevation, Description
Point - Number Only	2.0	Anchor TR	Number
Point - Elevation Only	2.0	Anchor TR	Elevation (%.2f)
Point - No Label	—	—	Hidden
Contour - Standard	2.0	Linear aligned	Elevation (%.1f), uphill readable
Contour - Horizontal	2.0	Linear horizontal	Elevation (%.1f)
Spot Elevation - Standard	1.5	Anchor TR	Elevation (%.2f)
DR - Standard	1.5	Linear perpendicular	Deviation (%.1f cm)
DR - Millimeters	1.5	Linear perpendicular	Deviation (%.0f mm)
Station - Standard	2.0	Linear perpendicular	Station chainage
PI - Standard	1.5	Anchor TR	Station, Radius, Deflection

The **Tunnel** category provides label styles for deviation (DR) labels on tunnel section lines. The two built-in presets are:

- **DR - Standard** — deviation value in centimetres (`%.1f cm`), placed perpendicular to the measured profile line.
- **DR - Millimeters** — deviation value in millimetres (`%.0f mm`), placed perpendicular to the measured profile line.

16.12 Civil Settings

Table 24: Drawing Scale & Units

Setting	Default	Notes
Drawing scale	1:1000	
Linear unit	Metre	Metre / Foot / US Survey Foot
Distance precision	3	
Elevation precision	3	
Coordinate precision	3	
Angle precision	4	
Angle format	Degrees	
Direction format	North azimuth	
Station increment	1000	
Station precision	3	

Table 25: Abbreviations

Abbreviation	Default
Station	STA
Right	RT
Left	LT
North	N
South	S
East	E
West	W
Elevation	EL
Grade Break	GB

Table 26: Object Layers

Setting	Default	Notes
Enabled	True	
Prefix	C	NCS discipline designator
Use object name	True	Append entity name to layer

17 Features and Changelog

A summary of all features available in IQcad, followed by a changelog of recent releases.

17.1 Changelog

17.1.1 2026-03-30

- **LOD rendering system** — screen-space aware rendering for drawings with 100K–1.4M+ entities. Sub-pixel entities (< 1.5px) drawn as colored dots; ellipse tessellation adapts from 8–72 segments based on screen radius; spline points decimated when < 1px apart; hatch fill suppressed below 10px; civil point labels hidden below 5px.
- **Surface LOD** — three-layer optimization for surfaces with 1M+ triangles: (A) sub-pixel triangle culling before coordinate transforms; (B) √N×√N spatial render grid for viewport-aware iteration; (C) bitmap cache for instant pan drag (zero triangle processing during interaction).
- **Selection performance** — SelectAll uses O(1) flag check instead of O(n) IndexOf. 140K entities: 14.7s → 0.5s.
- **Ribbon reorganization** — new View tab (Navigate, Display, Select panes

moved from Home); Clipboard pane moved from Modify to Home; Erase removed from Home (in Modify).

- **Full benchmark** — 14 entity types × 10K each. Reports per-type creation speed, operation timings (Repaint, Zoom Extents, Select All), and grand total.

17.1.2 2026-03-29

- **Blender-style gizmo rotation rings** — 3 colored rings for constrained axis rotation.
- **Point group commands** — ADDTOGROUP, REMOVEFROMGROUP, CREATEGROUP for managing groups from the canvas.
- **Right-click context menu** — select points, right-click to add to group instantly.
- **Association highlighting** — selecting profile/section views highlights associated surfaces and polylines.
- **Label style editor fix** — Tunnel and Parcels categories added; DR label text scaling corrected.
- **PDF export unified** — single PLOTPDF command with overwrite prompt.
- **UI reorganization** — Explode to Modify; Mesh/Surface conversions to Civil > Surfaces.
- **Tunnel test improvements** — CivilScale 100, ISO axes linetype, acadiso.lin in resources.

17.1.3 2026-03-28

- **UCS Gizmo** — interactive 3D navigation gizmo replacing the flat 2D UCS icon. Click an axis to snap the view; drag background to orbit. Depth-sorted rendering with cone arrowheads and semi-transparent background circle. Configurable corner, size, and opacity in Settings.
- **3D rendering** — rulers auto-hide in 3D mode; 3D crosshair with colored axes (red X, green Y, blue Z); zoom-at-mouse-point and pan in 3D mode; fixed entity clipping (spatial index uses ScreenToWorld3D).
- **Polyface Mesh** (`TCADPolyfaceMesh`) — shared vertex pool + face index array. DXF import (POLYLINE flag 64), DXF export, IQML serialization, wireframe rendering, grip editing (<500 vertices).
- **ACIS Pass-Through** (`TCADAcisEntity`) — opaque round-trip for 3DSOLID, REGION, BODY, SURFACE and subtypes. Stores raw SAT data, renders as labeled placeholder. Preserves Civil 3D data.
- **MESH2SURFACE** (`M2S`) — convert polyface mesh to TIN surface.
- **SURFACE2MESH** (`S2M`) — convert TIN surface to polyface mesh.
- **EXPLODE** — implemented for polyface mesh (produces 3DFace entities).

- **Civil label style fixes** — all built-in label styles updated to paper-mm TextHeight values; constructor default changed from 1.0 to 2.5 mm.
- **UI** — Draw menu: Polyface Mesh. Modify menu: Mesh to Surface, Surface to Mesh, Explode. Ribbon: Convert pane. Test menu: AddSampleEntities includes polyface mesh and ACIS samples.
- **SpkToolbar ribbon** — migrated from IQRibbon to SpkToolbar with 5 built-in themes (Office 2007 Blue/Silver/Black, Windows 10, Metro Light). Theme selection is persisted in settings.json.
- **Per-tab command line history** — each drawing tab now maintains its own command history, so switching tabs restores the command context for that drawing.
- **Parcel entity** (`TAECC_PARCEL`) — closed boundary polygons with computed area/perimeter, user data fields, 4 built-in styles (Standard, Property, Easement, ROW). `CREATEPARCEL` command. Full IQML and LandXML I/O support.
- **Unified CAD Style Manager** — single window for Text, Dimension, Table, Multiline, Point, and Plot styles with embedded editors.
- **Unified Civil Style Manager** — single window for Point, Surface, Tunnel Section Line, Alignment, Parcel, and Label styles with embedded editors.
- **Point Style Editor redesign** — checkbox-based marker shape selection replacing the old grid picker.
- **Help tab** — new ribbon tab with links to documentation, keyboard shortcuts reference, and About dialog.

17.1.4 2026-03-27

- **Cross-section system** — multi-surface cross-sections perpendicular to alignments with cut/fill computation and earthwork volumes.
- **CREATESECTIONSHEET** (`CSS`) — interactive command to create section sheets from alignment + surfaces with grid layout.
- **EARTHWORKVOLUMES** (`EWV`) — earthwork volume table using average end area method.
- **Multi-surface model** — each section can show multiple surface profiles with cut/fill computed between any two selected surfaces.
- **Dependency reconnection** — profile views and section views now reconnect to source entities after save/load.
- **Prospector** — added “Section Sheets” root node.

17.1.5 2026-03-25

- **CSTRANSFORM** (`CST`) — global coordinate transformation using common/control points. Supports Helmert 2D, Affine 2D, and Polynomial degree 1/2/3 with least-squares adjustment and residual analysis.
- **RUBBERSHEET** (`RBS`) — local non-uniform rubber-sheet transformation. Linear (Delaunay piecewise affine) and Smooth (Thin Plate Spline) modes.
- **Object Inspector redesigned** — now uses TVirtualStringTree with collapsible categories, owner-drawn combo editors (colour swatches, linetype patterns, lineweight previews), multi-selection support ("Varies" display), value type colour-coding, keyboard navigation, human-friendly property labels.
- **Selection filter** — combo at the top of the inspector limits picks to a specific entity type.
- **Quick Access Toolbar** — New, Open, Save, Save As, Undo, Redo, Properties toggle.
- **Layout persistence** — panel sizes saved to settings.json.
- **IQZ compressed format** — gzip-compressed IQML as default save format.

17.1.6 2026-03-23

- **Point Manager paste** — paste tab-separated text (from Excel) into the Point Manager to create survey points.

17.1.7 2026-03-22

- **Hatch system variables** — 20 AutoCAD-compatible HP* variables.
- **Hatch transparency** — per-entity HatchBackgroundColor and HatchTransparency.
- **Drawing Variables dialog** — System Variables grid tab with editable values and Scope column.
- **Tunnel section line styles** — separate overbreak/underbreak hatch patterns; scanline-based hatch rendering.

17.1.8 2026-03-21

- **Codebase audit** — 122 findings resolved across core engine, entity system, and civil/AEC subsystem.
- **DXF locale fix** — `DXFFloat()` helper ensures valid DXF on non-English systems.
- **Scale/Rotate overrides** — Circle, Ellipse, Text, MText, Multileader, Arrow now update entity-specific fields on transform.
- **Block insert caching** — eliminates 10K+ allocations per frame for block-heavy drawings.

- **Entity class registry** — runtime registration for all 24 entity types.
- **Selection manager** — extracted from TCADCanvas into separate unit.

17.1.9 2026-03-19

- **3D wireframe view** — `3DORBIT`/`ORBIT` command with arcball rotation, `PLAN` and `VPOINT` commands.
- **VIEWTWIST / ALIGNVIEW / PLANVIEW** commands.
- **Elevation banding** — colour ramps (green-to-red, blue-to-red, grayscale) on TIN surfaces.
- **Civil linetypes** — configurable linetypes for surface, alignment, and tunnel section line style components.
- **Alignment Style Editor** — new dialog for editing alignment display styles.

17.1.10 2026-03-18

- **TSOPTIMIZE / TSOPT command** — optimize tunnel section line fit using Nelder-Mead simplex minimizer. Five optimization levels.
- **Trim/Extend** — now supports arc, polyline, ellipse, and spline entities.
- **Chamfer** — second distance defaults to first distance.
- **Hatch fill engine** — pattern-based and solid hatch generation.
- **Spatial index** — grid-based spatial index for viewport-culled rendering.
- **Background tasks** — parallel infrastructure with modal progress dialog.

17.1.11 2026-03-16

- **OFFSET command** — full implementation with phantom preview and `OFFSETDIST` system variable.
- **ERASE enhancement** — prompts “Select objects:” when nothing selected.
- **Cursor modes** — full crosshair / pickbox-only based on context.
- **Escape key** — priority-based cancel (command > tool > selection).
- **OSNAP for edit commands** — MOVE, COPY, ROTATE, SCALE, OFFSET use OSNAP when picking points.
- **dmZoneExtremes** — new DR display mode for Tunnel Section Lines.

17.2 Drawing & Editing

- All CAD entity types: Line, Polyline, Circle, Arc, Ellipse, Spline, Rectangle, Polygon, Text, MText, Hatch, Image, Table, Dimensions, Multileader, Multiline, XLine, Point, 3D Face, 3D Polyline, Bezier, Arrow
- Grip editing, move, copy, rotate, scale, mirror, offset, explode
- Trim, extend, chamfer, fillet
- PEDIT (polyline vertex editing — close, join, width, vertex edit, spline, decurve, reverse)
- Block creation, insertion, in-place editing (BEDIT/BCLOSE), Block Manager
- Drawing order (front, back, above, below)
- Undo/redo per drawing
- Multiple drawing tabs (MDI)
- PURGE (layers, blocks, styles, linetypes), AUDIT, RECOVER

17.3 Civil / AEC

- **Survey Points** — import/create with style-driven markers and labels; Point Manager with paste, lock, transform, renumber, group management
- **TIN Surfaces** — Bowyer-Watson triangulation, contours (Chaikin smoothing), spot elevations, boundary clipping, decimation, surface editing commands (add/delete/move points, swap edges, add/remove lines, raise/lower), elevation banding, contour label placement
- **Tunnel Section Lines** — measured cross-section deviation analysis with DR labels, smart display modes (All, ZoneExtremes, Threshold, Interval), area hatch, style-driven rendering, TSOPTIMIZE fit optimization
- **Horizontal Alignments** — tangents, circular curves, spiral (clothoid) transitions; PI-based creation, station labelling, style-driven rendering
- **Cross-Sections** — multi-surface section sampling perpendicular to alignments, section views with cut/fill shading, section sheets with grid layout, earthwork volumes (average end area method)
- **Coordinate Transformations** — CSTRANSFORM (Helmert, Affine, Polynomial) and RUBBERSHEET (Linear, Smooth TPS) with common point management, residual analysis, and transformation reports
- **Civil Toolspace / Prospector** — tree view with surfaces, points, sections, alignments, and property grid
- **Civil Settings** — units, coordinate system (182 EPSG), transformation, ambient settings, abbreviations
- **LandXML** — import/export for surfaces, survey points, and alignments

17.4 Styles

- Text Style Editor
- Dimension Style Manager + Editor (5 property areas)
- Table Style Editor (Title/Header/Data tabs)
- Multiline Style Editor
- Point Style Editor (19 marker shapes + named library)
- Surface Style Editor (3 tabs: Border & Triangles, Contours, Contour Labels)
- Tunnel Section Line Style Editor (measured line, deviation/hatch, center/labels/DR display)
- Alignment Style Editor (centerline, ticks, PI markers, arrows)
- Alignment Label Style Editor (stations, PI data, curve data)
- Civil Label Style Editor (unified system for all civil label types)
- Plot Style Tables (CTB)

17.5 Layout & Printing

- Multiple layouts per drawing with paper-space viewports
- Viewport border: ticks, ladder, crosses with coordinate labels
- Viewport grid, north arrow, scale bar
- Page setup: paper size, orientation, margins
- Print dialog with layout selector
- PDF export (single layout, all layouts, or from layout tab right-click)
- Plot style tables (CTB)
- Viewport setup (MVSETUP), clipping (VPCLIP), fade (VPFADE)

17.6 File I/O

- Native IQZ (compressed) and IQML (uncompressed) formats with streaming writer for large files
- DXF export (R12 / R2000) and import
- DWG export/import (via LibreDWG or ODAFileConverter)
- SVG export
- Image export (PNG, BMP)
- PDF export
- LandXML import/export dialog

- Recent Files menu (up to 10 entries, persisted)

17.7 User Interface

- Ribbon toolbar with Home, Draw, Modify, Annotate, Civil, Output tabs
- Quick Access Toolbar (QAT) with Save As and Properties toggle
- AutoCAD-style command line with aliases
- Object Inspector (TVirtualStringTree-based, categorized, multi-select, owner-drawn combos, keyboard navigation)
- Selection filter by entity type
- Layer Manager
- Civil Toolspace / Prospector panel with property grid
- Status bar with progress indicator
- Dark theme editor dialogs
- Layout persistence (panel sizes saved to settings.json)
- Keyboard shortcuts
- 3D orbit view, viewpoint presets, view twist