AutoCAD in ArcGIS Pro

A Detailed Workflow

Adding a DWG, Projecting it to a UTM Zone, and Producing a Continuous Elevation Raster from CAD Survey Points using IDW

Dr Aran Castro

GIS Manager, Geospatial Campus

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1. Overview and Learning Objectives

AutoCAD drawings in DWG or DXF format are the standard exchange medium between surveyors, civil engineers, architects, and infrastructure consultants. These drawings often contain rich geometric information, but they arrive in a working environment that does not understand a geographic frame of reference. Three operations therefore become necessary before the drawing can be analysed in ArcGIS Pro: it has to be added as a layer, it has to be aligned with a real-world Coordinate Reference System (CRS) such as Universal Transverse Mercator (UTM), and any survey points carrying elevation values must be converted to a continuous raster surface. This tutorial documents the full workflow for each of these steps, with worked parameter values and accuracy controls.

By the end of the tutorial, the reader is expected to:

- Add a DWG or DXF file to ArcGIS Pro and identify its sub-layers.
- Recognise whether the CAD geometry is in true UTM coordinates or in a local site grid.
- Assign a CRS using Define Projection or perform a full georeferencing using ground control points.
- Export CAD geometry into editable feature classes within the project geodatabase.
- Apply Inverse Distance Weighted (IDW) interpolation to elevation points and produce a continuous raster surface.
- Validate the output using a hold-out sample and report the Root Mean Square Error (RMSE).

Audience: Postgraduate students of Geomatics, Civil Engineering, Earth Sciences, and practising GIS professionals working with engineering drawings.

2. Theoretical Background

2.1 CAD and GIS Data Models

AutoCAD stores geometry as primitives organised into named layers. The primitives include points, lines, polylines, arcs, splines, hatches, blocks, and text. There is no concept of a feature attribute table in the GIS sense; descriptive information is held either as block attributes, layer names, or as separate text entities placed alongside the geometry. A GIS data model, in contrast, links each feature to a row in an attribute table and stores both within a feature class that carries an explicit CRS. ArcGIS Pro bridges these two models by exposing a DWG as a feature dataset containing five read-only feature classes that group the AutoCAD primitives by geometry type.

AutoCAD primitive	Exposed in ArcGIS Pro as	Typical use
Point, Block insertion	Point sub-layer	Spot levels, trees, manholes
Line, Polyline, Arc	Polyline sub-layer	Contours, roads, kerbs
Closed polyline, Hatch boundary	Polygon sub-layer	Plot boundaries, building footprints
Text, MText	Annotation sub-layer	Spot height labels, plot numbers
3D Face, Solid	MultiPatch sub-layer	3D building or roof models

2.2 Coordinate Reference Systems Primer

A CRS specifies how locations on the curved Earth are translated into coordinates. It comprises a datum (a reference ellipsoid plus an origin), a coordinate system (geographic in degrees or projected in linear units), and, where applicable, a projection that converts geographic coordinates into a flat plane. ArcGIS Pro identifies CRSs using EPSG codes maintained by the IOGP. For Indian terrestrial work, two families are commonly encountered: WGS 84 geographic (EPSG:4326) for satellite imagery, and WGS 84 / UTM zones 42N to 46N (EPSG:32642 to 32646) for projected analysis in metres.

A CAD drawing typically lacks any CRS metadata. ArcGIS Pro reports its CRS as Unknown until the user supplies one through Define Projection. Assigning an incorrect CRS is the single most common cause of misalignment between CAD data and basemaps.

2.3 UTM Zones for India

India spans five UTM zones (42N to 46N). Each zone is 6 degrees of longitude wide. Selection of the correct zone depends on the central longitude of the study area.

UTM Zone	Longitude band	EPSG code (WGS 84)	Example region
42N	66 E - 72 E	32642	Western Gujarat, Rann of Kachchh
43N	72 E - 78 E	32643	Rajasthan, Maharashtra (west), Karnataka (west)
44N	78 E - 84 E	32644	Madhya Pradesh, Telangana, Andhra Pradesh
45N	84 E - 90 E	32645	Odisha, West Bengal, Bihar, eastern Uttar Pradesh
46N	90 E - 96 E	32646	Assam, Arunachal Pradesh, Manipur, Nagaland

Choosing the zone: When the study area straddles two UTM zones, choose the zone that covers most of the area, or use a custom Lambert Conformal Conic projection if linear distortion at the edge exceeds project tolerances.

2.4 IDW Interpolation Theory

Inverse Distance Weighted (IDW) interpolation is a deterministic, exact-interpolator method. The estimated value Z at an unsampled location x_0 is the distance-weighted average of N surrounding sample points (Shepard, 1968). The weight assigned to sample i is the inverse of its distance d_i to x_0 raised to a power p:

```
Z(x_0) = SUM_i [ w_i * Z_i ]   where  w_i = (1 / d_i^p) / SUM_j (1 / d_j^p)
```

The power p controls how rapidly weight decays with distance. Low values (p approaching 0) produce smoother surfaces with regional averaging; high values (p of 4 or above) produce surfaces dominated by the nearest neighbour. A power of 2 is the conventional default for elevation interpolation. The number of contributing points and the search radius further control how local or regional the interpolation becomes.

IDW is suitable when the variable being interpolated has a smooth spatial trend and the sample density is reasonably uniform. For highly anisotropic surfaces or for variables with strong directional structure, geostatistical methods such as Ordinary Kriging are preferred (Watson and Philip, 1985; Li and Heap, 2014).

3. Software, Licences and Prerequisites

The workflow has been verified on ArcGIS Pro 3.2 running on Windows 11. Earlier versions back to ArcGIS Pro 2.5 support the same toolset with minor menu differences. The Spatial Analyst extension is required for the IDW step. The following table summarises the licensing and the installer dependencies.

Component	Required version	Licence type	Purpose
ArcGIS Pro	3.x	Standard or Advanced	Core geoprocessing

Spatial Analyst	Matching Pro version	Named-user or concurrent	IDW, hillshade, raster math
AutoCAD or DWG TrueView	2018+	Free for TrueView	Optional, for inspecting DWG layers
Survey of India sheet / OSM tile	Current	Open or licensed	Reference layer for georeferencing

Spatial Analyst: Project ‣ Licensing ‣ Configure your licensing options. Toggle Spatial Analyst to ON. Restart ArcGIS Pro if the toggle was previously OFF.

4. Inputs, Data Preparation, and CRS Selection

Before opening ArcGIS Pro, the analyst should obtain four items from the data provider and document them in a metadata sheet. Documenting the inputs at this stage avoids repeated rework once the project file (.aprx) has been built.

Item	What to confirm	Where it is recorded
DWG/DXF file	AutoCAD version (2013 or 2018 preferred), file size, last edit date	Survey delivery note or email
Coordinate origin	True UTM, true Indian grid, or local site grid	Survey report; ask the surveyor explicitly
Elevation field	Stored as 3D Z geometry, point attribute, or text label	Open the DWG in TrueView and inspect
Reference CRS	Target UTM zone, EPSG code, datum	Project specification or NRSC sheet index
Reference layer	Imagery, Survey of India sheet, or vetted OSM tile	Project basemap, with date of acquisition
Survey accuracy	Total station, DGPS, or RTK; horizontal and vertical RMSE	Survey report

Once the inputs are confirmed, create a clean folder structure inside the project directory and copy raw data into a read-only sub-folder. The folder layout shown below has been used successfully for repeated engineering projects in our laboratory.

```
ProjectRoot/
  01_raw/         original DWGs, surveyor reports (read-only)
  02_working/     georeferenced DWGs, intermediate exports
  03_geodatabase/ project.gdb (feature classes)
  04_outputs/     IDW raster, hillshade, accuracy CSV
  05_layouts/     map layouts and exported PDF
  06_docs/        this tutorial, methodology log
```

5. Adding the AutoCAD File to ArcGIS Pro

5.1 Opening the Project

1. Launch ArcGIS Pro from the Start Menu.
2. Either open an existing project (.aprx) or create a new Map project. For a new project, set the project location to the ProjectRoot folder so all default outputs are written inside it.
3. On the Map tab, set the Map's Coordinate System to the target UTM zone (Map Properties ‣ Coordinate Systems ‣ search for 32643 or the relevant EPSG).

5.2 Connecting the Source Folder

4. Open the Catalog Pane (View tab ‣ Catalog Pane).
5. Right-click Folders ‣ Add Folder Connection.
6. Browse to the 01_raw folder containing the DWG file and click OK. The folder appears in the Catalog tree.

Caution: Avoid working directly on a network drive while georeferencing. Network latency can corrupt the world file (.wld3) when ArcGIS Pro writes it during long sessions. Copy the DWG to a local drive first.

5.3 Adding the DWG to the Map

7. Expand the DWG entry inside the Catalog pane. Five sub-layers appear (Annotation, MultiPatch, Point, Polygon, Polyline).
8. Drag the parent DWG node onto the map. ArcGIS Pro adds all five sub-layers as a group layer.
9. If the CAD file opens far away from the basemap, do not panic; this indicates that the CRS has not yet been assigned or that the drawing is in a local grid. The alignment problem is addressed in Section 6.
10. Right-click the group layer ‣ Zoom To Layer to inspect the drawing in its native coordinate space.

5.4 The Five CAD Sub-Layers

Each sub-layer is read-only and reflects only the geometric type stored in the parent DWG. Editing requires export to a feature class. The Symbology of CAD layers is driven by the original AutoCAD layer name: features are coloured and labelled according to the source layer property. Right-click a sub-layer ‣ Symbology ‣ Unique values to view the AutoCAD layer breakdown.

Note: If a CAD layer is set to 'Frozen' or 'Off' in AutoCAD, it still appears as a feature in ArcGIS Pro because the ArcGIS reader does not honour the layer-state flags. Use Definition Query on the Layer field to filter unwanted entities.

5.5 Inspecting the Attribute Table

Right-click any sub-layer ‣ Attribute Table. The table contains system fields generated by the CAD reader (Layer, EntType, Color, LineWt, Elevation, Thickness, Handle, RefName, Text), followed by any block attribute fields. The Elevation field carries the Z geometry where it exists; otherwise its value is zero. The RefName and Text fields are useful when survey points carry the elevation as a text label rather than a geometric Z value.

If the elevation is stored as a text label such as "275.42", a numeric copy must be created before IDW can use it. The procedure is as follows.

11. Add a new field of type Double named Z_VAL using Add Field on the Fields tab.
12. Open Calculate Field. Select Z_VAL as the input field.
13. Use the expression below in Python 3.

```
Z_VAL = float(!Text!.replace(",", "."))
```

14. Run the tool. Validate the result by sorting the Z_VAL field and inspecting outliers.

6. Projecting the CAD into a UTM Frame

6.1 Identifying the Correct UTM Zone

The UTM zone is determined by the central longitude of the survey area. The simplest method is to identify the centroid of the survey boundary on Google Earth or on a Survey of India map and read off the longitude. Each 6-degree band corresponds to one zone (Section 2.3). Where the survey crosses two zones, choose the zone of the centroid and accept linear distortion below 0.04 percent within roughly 3 degrees of longitude on either side of the central meridian.

6.2 Scenario A: True UTM Coordinates

If the surveyor used a GNSS-controlled total station and produced the drawing in true UTM coordinates, the file aligns with the world the moment a CRS is assigned. The Define Projection tool only writes the CRS metadata; it does not move the geometry.

15. Open Toolboxes ‣ Data Management Tools ‣ Projections and Transformations ‣ Define Projection.
16. Input Dataset: the CAD parent layer or any sub-layer.
17. Coordinate System: type 32643 (or the correct EPSG) in the search box. Select WGS 1984 UTM Zone 43N.
18. Click Run.
19. Right-click the layer ‣ Zoom To Layer. The drawing should now overlay the basemap. If it does not, the assumption that the CAD is in true UTM was incorrect, and Scenario B applies.

Sanity check: Pick one CAD point with a known easting and northing (a survey control monument). Read its Map coordinates from the lower-right of the ArcGIS Pro window. They must match the expected UTM coordinates within survey tolerance.

6.3 Scenario B: Local or Assumed Grid (Georeferencing)

When the drawing is in a local grid (for example, a survey origin of 1000, 1000 with no real-world tie, or coordinates in feet relative to a building corner), the geometry must be moved, scaled, and rotated onto a real-world CRS. ArcGIS Pro performs this through the Georeference tab, which writes a world file (.wld3) next to the DWG. Once written, every subsequent open of the DWG honours the world file.

20. Set the Map's CRS to the target UTM zone (see 5.1).
21. Add a reference layer that is already in the correct CRS: World Imagery basemap, an orthorectified drone image, or a Survey of India sheet that has been georeferenced.
22. Select the CAD layer in the Contents pane.
23. On the Imagery tab (or Edit tab for vector CAD), click Georeference. The Georeference ribbon appears.
24. Click Fit to Display. This crude initial transformation moves the CAD into the visible extent of the basemap as a starting position.
25. Click Add Control Points. The cursor turns into a crosshair.

6.4 Transformation Types and Control Points

Each control point is a pair: a click on a recognisable feature in the CAD followed by a click on the matching feature in the basemap. Place control points on permanent features whose location is unambiguous: building corners, road intersections, survey monuments, or boundary stones. Place at least four pairs for a Similarity transformation, six for an Affine, and ten for a 2nd-order polynomial.

Transformation	Minimum points	Effect	When to use
Similarity (Helmert)	4	Translation, uniform scale, rotation	Surveyed CAD with consistent linear units
Affine (1st-order)	6	Translation, scale, rotation, skew	Drawings with non-uniform X/Y scaling
Projective	8	Like Affine plus perspective	Photographs taken at oblique angles
2nd-order polynomial	10	Non-linear warp	Distorted historical maps; rarely needed for CAD

Strategy: Distribute the control points evenly across the survey extent. Concentrating all points in one corner introduces a strong bias and inflates the residual at the opposite corner.

6.5 Residual Analysis and Saving the World File

After placing control points, open the Control Point Table from the Georeference ribbon. Inspect the X Residual, Y Residual, and Total Residual columns. The Forward RMS Error reported at the bottom of the table summarises the overall fit. For engineering work the Total RMS should be below 1 m; for cadastral work it should be below 0.3 m. If the RMS is high, identify the worst control point in the table, delete it, and place a replacement at a more clearly identifiable feature.

Once the residuals are acceptable, click Save on the Georeference ribbon. ArcGIS Pro writes a sidecar file (.wld3) and an auxiliary XML file next to the DWG. To make the result permanent, also export the georeferenced CAD point sub-layer to a feature class (Section 7) so downstream geoprocessing reads from a stable source.

7. Exporting CAD Geometry to a Feature Class

CAD layers in ArcGIS Pro are read-only; the attribute table cannot be edited and new fields cannot be added directly. Exporting the layer into a feature class inside the project geodatabase produces a writeable copy and stabilises the CRS metadata, which is required for every subsequent geoprocessing step.

26. Right-click the CAD point sub-layer in Contents ‣ Data ‣ Export Features.
27. Output Location: project.gdb inside 03_geodatabase.
28. Output Feature Class: spotlevels_utm43n_v1 (follow the project naming convention).
29. Confirm Output Coordinate System under Environments: WGS 1984 UTM Zone 43N (EPSG:32643).
30. Click Run. Verify that the Z_VAL field is preserved as Double.
31. Repeat for any other CAD sub-layers needed downstream (for example, the boundary polygon used as the IDW mask).

Naming convention: project_datatype_date_version.extension. Example: site42_spotlevels_utm43n_v1, site42_dem-idw_utm43n_v1.tif.

8. IDW from CAD Elevation Points

8.1 Pre-processing Spot Levels

Before running the IDW tool, the spot-level feature class needs to be cleaned. Three pre-processing steps reduce the most common sources of interpolation artefacts: bullseyes, plateau patches, and edge slumps.

32. Remove duplicate XY points. Use Toolboxes ‣ Data Management Tools ‣ General ‣ Delete Identical with the Shape field as the comparison key.
33. Remove zero or null elevations. Open the attribute table, sort Z_VAL ascending, select rows with Z_VAL = 0 or Z_VAL is NULL, and delete them. Survey points that store elevation as text 'NA' should be addressed during the field calculation step (Section 5.5).
34. Buffer-clip the input. If the IDW will be limited to a boundary polygon, also include any control points within 50 m outside the boundary so that interpolation near the edge has neighbours on both sides. The boundary polygon itself becomes the IDW mask.

8.2 Running the IDW Tool

35. Open Toolboxes ‣ Spatial Analyst Tools ‣ Interpolation ‣ IDW.
36. Input point features: spotlevels_utm43n_v1.
37. Z value field: Z_VAL.
38. Output raster: dem_idw_utm43n_v1.tif (write to 04_outputs).
39. Output cell size: a value derived from the average point spacing s. As a starting rule, set cell size = s / 2. A 50 ha site with 1500 spot heights has a mean spacing of about 18 m, so a 9 m cell is appropriate.
40. Power: 2 (default).
41. Search radius: choose Variable, with 12 nearest neighbours.
42. Click Environments. Set Output Coordinate System to EPSG:32643. Set Mask to the survey boundary. Set Extent to Same as Mask. Set Snap Raster to any existing reference raster if the project requires pixel alignment.
43. Click Run. The output appears in Contents.

8.3 Parameter Recommendations

Parameter	Recommended value	When to deviate
Power (p)	2	Use 1 for smoother regional surfaces; use 3 only when point density is high and uniform
Search type	Variable	Switch to Fixed when point density is uniform across the area
Number of points	10-15	Increase to 20 in low-density areas; decrease to 8 in high-density areas
Cell size	Mean spacing / 2	Coarsen for regional studies; finer than s/2 implies false precision
Mask	Survey boundary polygon	Mandatory when the polygon is available
Output extent	Same as mask	Default extent is the bounding box and produces unwanted artefacts at corners

8.4 Symbology and Hillshade

44. Right-click the IDW raster ‣ Symbology.
45. Set Primary symbology to Stretch and choose a hypsometric ramp (Elevation #1 or Spectrum-Elevation).
46. Set the stretch type to Standard Deviation with n = 2 for a balanced contrast across the elevation range.
47. Optional hillshade for visual relief: Toolboxes ‣ Spatial Analyst Tools ‣ Surface ‣ Hillshade. Use Z_factor = 1, Azimuth = 315, Altitude = 45.
48. Place the hypsometric raster above the hillshade with 60-70 percent transparency.

9. Accuracy Assessment

Every interpolated surface should be evaluated using a hold-out sample. The standard procedure is as follows.

49. Before running IDW, randomly select 10-20 percent of the spot-level points using Subset Features. Save them as spotlevels_validation_v1; save the remaining 80-90 percent as spotlevels_train_v1.
50. Run IDW on the training set (Section 8). Output: dem_idw_train_v1.tif.
51. Use Spatial Analyst Tools ‣ Extraction ‣ Extract Values to Points to read the predicted elevation at each validation point. Output field: RASTERVALU (default).
52. Add a field DIFF (Double). Calculate Field as DIFF = !RASTERVALU! - !Z_VAL!.
53. Compute Mean Error and Root Mean Square Error.

```
Mean Error  = (1/n) * SUM_i (Z_pred_i - Z_obs_i)
RMSE        = sqrt( (1/n) * SUM_i (Z_pred_i - Z_obs_i)^2 )
```

Mean Error reports systematic bias (positive bias = over-prediction, negative bias = under-prediction). RMSE summarises the random error magnitude. Acceptance thresholds depend on the project specification, but the values in the table below are typical.

Survey class	Acceptable RMSE	Typical applications
Cadastral / engineering	< 0.30 m	Plot demarcation, road levelling, drainage design
Topographic	0.30 - 1.00 m	Site grading, contour generation at 0.5 m interval
Regional terrain	1.00 - 3.00 m	Watershed delineation, regional planning
Reconnaissance	> 3.00 m	Preliminary studies; reject for engineering use

10. Worked Example: 50 ha Survey Block

The following example is drawn from a hypothetical engineering survey for a 50 ha site near Bengaluru (longitude 77.59 E). The drawing was produced by a contractor in a local site grid with origin (1000, 1000) and units in metres. The survey contains 1500 spot levels with elevations ranging from 845 m to 902 m, and a closed boundary polyline.

Step	Action	Output
1	Identify UTM zone (longitude 77.59 E ‣ Zone 43N)	EPSG:32643
2	Set Map CRS to EPSG:32643 and add World Imagery basemap	Map ready for georeferencing
3	Add the DWG as a group layer; CAD plots near origin	Drawing visible at (1000, 1000) on map
4	Georeference: place 6 control points on building corners visible in basemap	Total RMS = 0.42 m using Similarity

5	Save world file (site42_survey.wld3)	Permanent alignment
6	Export CAD point sub-layer to feature class	site42_spotlevels_utm43n_v1 in project.gdb
7	Calculate Z_VAL from Text field; remove duplicates and zeros	1492 valid points
8	Subset 15 percent for validation	1268 train, 224 validation
9	Run IDW: power 2, variable search, 12 NN, cell 5 m, mask = boundary	site42_dem-idw_utm43n_v1.tif
10	Hillshade with Az 315, Alt 45; overlay hypsometric ramp	Cartographic terrain map
11	Extract Values to Points on validation set; compute DIFF	Mean Error = -0.04 m, RMSE = 0.31 m
12	Conclude: surface meets engineering tolerance	Surface accepted for site grading design

11. Common Pitfalls and Fixes

Symptom	Likely cause	Fix
DWG does not appear when dragged	Folder not connected, or DWG saved in an unsupported AutoCAD version	Re-add the folder; resave DWG to AutoCAD 2018 format using DWG TrueView
CAD plots in the middle of the ocean (lon=0, lat=0)	Local coordinates were assumed as WGS 84	Run Define Projection only when coordinates are truly UTM; otherwise georeference using control points (Section 6.3)
IDW raster appears as bullseyes around individual points	Power too high, or duplicate XY points present	Reduce power to 2; remove duplicate points using Delete Identical
Output raster has no data over the survey area	Mask or extent was set to a layer that does not overlap the points	Set Environments ‣ Mask to the boundary polygon, Extent to Same as Mask
Elevation values look uniform or zero	Z_VAL field is text or stores a wrong attribute	Convert to Double using float(!Text!.replace(...)); inspect attribute table
RMS Error is high after georeferencing	Control points concentrated in one corner, or one point misplaced	Distribute points evenly; identify and delete the worst residual; replace it
Surface looks blocky at boundaries	Cell size larger than half the mean point spacing	Decrease cell size to s/2; rerun IDW
Edges of raster have unrealistic high or low values	Edge points have only one-sided neighbours	Include points within a 50 m buffer outside the mask; rerun IDW
Hillshade looks flat	Z_factor incorrect when CRS units differ from elevation units	Use Z_factor = 1 when both are metres; Z_factor = 0.3048 if CRS in feet, elevation in metres
Drawing looks rotated 90 degrees	Surveyor used a north-pointing-up site grid instead of a UTM grid	Use Affine transformation with at least 6 control points to correct rotation

12. Glossary

Term	Definition
CAD	Computer-Aided Design. A drawing system based on geometric primitives in a local plane.
CRS	Coordinate Reference System. Datum + coordinate system + projection.
Datum	A reference ellipsoid plus an origin used to express positions on the Earth.
DEM	Digital Elevation Model. Raster surface representing bare-earth elevation.
DTM	Digital Terrain Model. DEM plus structure lines such as ridges, breaks, and hydrolines.
DWG	Native binary file format of AutoCAD.
DXF	Drawing Exchange Format. ASCII or binary text format for CAD interchange.
EPSG	European Petroleum Survey Group. Now maintained by IOGP. Source of standard CRS codes.
IDW	Inverse Distance Weighted interpolation. Distance-weighted average estimator.
MultiPatch	ArcGIS geometry type representing 3D surfaces by adjacent triangles or rings.
RMS Error	Root Mean Square Error. Standard summary of interpolation or transformation residuals.
Spatial Analyst	ArcGIS Pro extension that provides raster geoprocessing tools, including IDW.
UTM	Universal Transverse Mercator. Set of cylindrical projections in 6-degree zones.
World file	Sidecar file (.wld3 in ArcGIS Pro) that stores georeference parameters for a raster or CAD file.

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