InTouch Geospatial Services

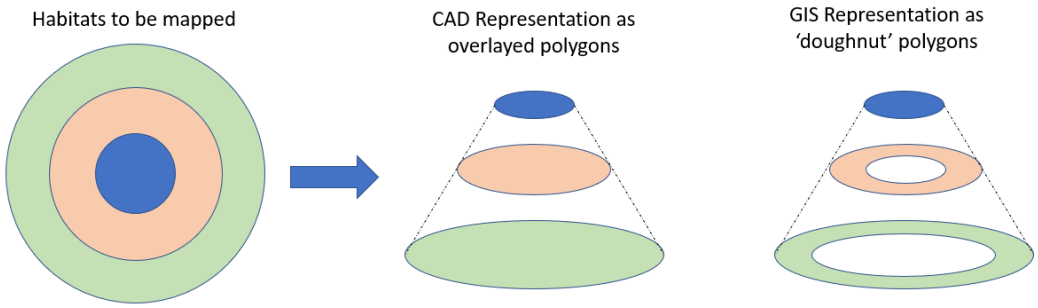
How to use CAD files in GIS: A Technical specification

GIS and CAD are two different but overlapping technologies used for mapping and designing sites and development plans. Data integration and data sharing is common between many different GIS and CAD software packages either allowing direct use of data in a variety of formats or the export/import to a third-party format such as ESRI Shape (*.shp) or AutoCad DWG (*.dwg) files. Once exported, data can then be imported into specific software packages such as ESRI's **ArcPro**, **QGIS**, **MapInfo** or **LandApp** GIS packages or **Autocad**, **VectorWorks**, **Revit** or **Sketchup** CAD packages (many more software packages are available for both GIS and CAD).

GIS and CAD data structures

A key aspect for use of CAD data within GIS is ensuring the '**structure'** of data created in CAD is compatible with how data is used in GIS. For many CAD landscape design uses, the focus is on how the final landscape design plan "*looks*", but for use in GIS, the focus is on how the different features, layers and underlying attribute data associated with a development plan is created and structured.

For example, the example below shows different representations of 'nested' habitat areas, with the CAD version showing an overlayed 'pancake' representation and the GIS, a nested 'doughnut' representation. Where habitat types are 'overlayed' this will result in 'double' or 'triple' counting of areas, the total habitat area being greater than the site being mapped.



Use of geospatial 'layers' also needs different 'features types' within a CAD file to be explicity defined. For example, the underlying OS mapping data should be identified in a DWG file with appropriate notation in the "Layer" field, as should the site boundary. Landscape features defining different types of habitat should also be appropriatley notified with correct "Layer" attributes. Compressing or 'flattening' the layers during CAD export creates problems when trying to extract explicit features for use in GIS.

Likewise, use of correct geometry types to define and represent features is also important. A "Site Boundary" or "Survey Area" should be defined as polygon type geometry, although the fence surrounding the site may be represented as a "polyline" or linear feature as this will no doubt have gaps in for access to the site. Buildings should also be represented as polygon features rather than as interconnecting 'polylines'. As polygons, the complete building features can be easily identified, extracted and coded as such, whereas represented as "polylines", definition of building features within GIS would need these to be digitised or 'traced' as polygon features adding to the time needed in processing the supplied CAD file.

Accurate digitising of features is also required, with adjacent and adjoining features being 'snapped' to coincident boundary vertices. Small 'gaps' or 'overlaps' in adjoining features need to be corrected when used in GIS analysis to avoid errors when undertaking total area calculations.

Brief Technical Specification for CAD files for use in GIS

The following highlights the key 'ideal' requirements for supply of CAD files for use in GIS, a more detailed explanation of each of these points is given below with there being various ways to adjust and process the supplied data if not supplied in the 'ideal' format, but all of these adds time and cost to CAD data import.

CAD files should be supplied which fulfill the following criteria;

- Supplied in GIS compatible format (eg. ESRI Shape files, KML/KMZ, DWG).
- Correctly georeferenced using recognised map projections and/or coordinate systems (eg. British National Grid, Ordnance Survey Grid Coordinates).
- Coordinates should be in meter units (GIS tends to use meters as a standard unit. Supply in millimeters requires conversion to be displayed in correct geographic location).
- DWG drawings should be done in "Model Space" rather than "Layout" space (avoid multiple versions of the same design in "Model Space" – they can't all be in the correct location).
- Feature types should be correctly identified with "Layer" attributes and not 'compressed' or 'flattened' when exporting.
- Representation of polygonal features (habitat areas, buildings, ponds etc.) should be as "polygon" features and not as joined and intersecting "polylines".
- 'Nested features' (where one feature is surrounded by another) should be represented as 'doughnuts' and not 'pancakes. ie Inset polygons should be 'cut out' from the surrounding area, not placed on top.
- Clear definition of "Site Boundary", "Land Ownership Boundary", "Planning Boundary", "Survey Area" as polygon features.
- Point features are defined as 'points' and not as a "label" within the CAD file (The location of the label is often offset from where the actual feature is located).
- DWG XRefs/Reference Drawings/attached files also need supplying alongside the main DWG that references them.

A more detailed description of the implications of these issues and how to overcome them is given below. Most issues in the supply of CAD data can be addressed in one way or another using functions available in most GIS software packages, but this can add time and cost to data import which could be avoided by appropriate CAD design.

- **Supplied in GIS compatible format (eg. ESRI Shape files, KML/KMZ, DWG)** – There are many different types of CAD software each using their own proprietary file format, but all will provide a variety of output formats for data exchange to other software packages. For use in GIS, supply in the following formats is frequently required; ESRI Shape files, KML/KMZ, DWG. However, there are many different formats that can be used, so the most effective approach is for GIS and the CAD users to talk to each other to discuss what is a suitable exchange format in any given situation.
- **Correctly georeferenced** – For use in GIS, the real-world location is needed and hence the CAD file should use recognised map projections and coordinate systems. In the UK, this will be the British National Grid and OS grid co-ordinates, but in other parts of the world this will be different. For example, For the Republic of Ireland and Northern Ireland, the Irish National Grid should be used.

If a CAD file is not correctly georeferenced, there are various GIS techniques that can be used to reposition the CAD file in its correct geographic location by, for example, applying a map-projection correction if known, or by matching the representation of known features such as corners of buildings, fence intersections etc. with their representation on correctly located OS mapping data.

- **Coordinates should be in meter units** – GIS tends to use meters as a standard unit while CAD files are often set to use Millimeters as their standard unit to give the accuracy needed when producing building construction designs. This level of detail is typically not needed for GIS use where accuracy to +/- 1m is often adequate although accuracy to +/- 10cm (0.1m) is common, particularly for detailed small site mapping of habitat units and landscape features.

  Conversion from “mm” to “m” units is possible in many GIS software packages either as a “multiplication factor” on import, or from specifying a Map Projection using “mm” and applying this to the imported CAD data.

- **DWG drawings should be done in “Model Space” rather than “Layout” space** – the focus on CAD with how the final drawing ‘*looks’* rather than the way it is ‘*constructed’* often ends up with the development plan being drawn up in “Layout” space, rather than this being reserved for the display of the ‘model’ with associated surrounding marginalia needed in the final drawing output. CAD data held in “layout” space will have unpredictable results and may not be able to be imported.

  Similarly, if different versions of the same site design are all drawn in “Model Space” then there can be confusion over exactly which one of these should be used when imported (they can’t all be in the correct geographic location).

- **Feature types should be correctly identified with “Layer” attributes** – Correct identification of feature types using correct specification of the “layers” attributes allows key features to be instantly identified and extracted (eg. Site Boundary). Often CAD files have the supplied OS background map as one layer and ALL additional features marked as a separate ‘compressed’ or ‘flattened’ layer. This makes extraction of individual features such as the “site boundary”, “proposed development” or “spot heights” very difficult and time consuming.

- **Representation of polygonal features as polygons** – Any feature that is a polygon type feature (ie. an enclosed area such as a site boundary, building outline, pond etc) should be drawn as a defined “polygon” feature (there are separate “layers” within the DWG for polygon, points and polyline features). Often features that should be defined as an “enclosed space” or polygon, are actually drawn up in CAD as “polyline” features (composed of several individual line segments). If there are any gaps or mismatches between the end of one line segment and its neighbour, then these “polyline” features will not convert easily to polygons and entail additional work to ‘plug the gaps’. This is particularly noticeable with “Site Boundary” features where gaps are likely at site entrances and path ways.

- **‘Nested features’ should be represented as ‘doughnuts’ and not ‘pancakes’** - where one feature is surrounded by another eg. A pond surrounded by a grassy field, this should be represented as discrete individual polygons where the pond is ‘cut out’ from the grassy field and not just ‘overlayed’ on top. This will result in double-counting of feature areas when added up. The total area of all features within a site should be the same as the site area itself.

This issue can be rectified within the GIS environment by selecting the centre polygon and using feature ‘clip’ or ‘cut’ functions within the GIS software, but this can be time consuming if a large development plan has been drawn up using ‘overlaid’ rather than nested ‘cut’ features.

- **Clear definition of “Site Boundary”, “Land Ownership Boundary”, “Planning Boundary”, “Survey Area” –** These definitions are sometimes interchangeable or not clear what they refer to. They may not be marked explicitly within the CAD file but may be ‘assumed’ from features marked as ‘fences’ (which may not define a complete ‘polygon’ and may only be identified for certain parts of the site boundary). For creation of specific survey drawings and final marked up drawings, boundary definitions need to be clear and precise.

  It is common practice for a “land ownership boundary” to be marked in “Blue” and the “Planning Boundary” to be marked in “Red”, but any colour definitions with the CAD file itself will not necessarily transfer when the CAD file is imported into the GIS. This is again why correct identification of features using the “layers” attributes is important so that correct identification of features can take place irrespective of the colour they are displayed with.

- **Point features are defined as ‘points’ –** It seems to be a common practice (but not a good practice!), to have point features such as spot heights, utility infrastructure and survey locations within a CAD file shown as “labels” next to the point they relate to. This is extremely difficult and time consuming to import into GIS in a useable way as the “labels” will not be in the correct location of the feature they relate to. Good practice is to ensure any point features are defined as such and that labels relating to the point are stored as attributes. Eg. spot heights defined as points with the height information stored as attribute data in the “ELEV” attribute field of the DWG layer, this can then be imported directly into the GIS and this “layer” used to construct surface models if required.
- **DWG XRefs/Reference Drawings/attached files also need supplying** - An **“**Xref” is a DWG drawing file that is referenced by another DWG file. It can contain ‘common’ drawing data used by multiple DWG files such as OS base mapping, Site / Land Ownership boundaries, key infrastructure etc. and avoids having to replicate drawing data over multiple DWG files. If however the DWG is supplied without the associated Xref file, then there will be data missing when the recipient of the DWG file opens or imports the file in GIS. The same issue applied to any DWG file that uses linked/imported Shape (*.shp) files or uses *.tiff files as background mapping or aerial imagery data**.**

This is one of a series of “How to ..” guides and technical documents available on the InTouch Geospatial website. If you want to discuss any of these issues or have suggestions for other guides that might be helpful in your work, then please do get in touch.

Contact InTouch Geospatial Services
Email: intouchgeospatial@gmail.com
Tel: +44 (0)7806 816116
Web: intouchgeospatial.com

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