Preservation Handbook

Computer Aided Design (CAD)

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Version	1.2
Date	19/07/2005
Change History	2nd draft 15-10-2004 1st draft 03-07-2003

Definition

Computer Aided Design applies to all aspects of design using computer software tools. It usually covers geometry creation, manipulation and the production of plotted drawings. CAD differs from bitmap graphics by defining a drawing as a collection of objects and coordinates rather than encoding an image as specific pixel values in a raster. The object definitions are stored internally in a database. CAD requires software to plot the drawing from the coordinates and object definitions either to a computer screen or to a printer/plotter or to create the objects in solid materials by driving manufacturing machinery. A major consequence of this is that images may be viewed and printed at any scale.

Most CAD packages support 3D modelling usually as both wireframe, which is the skeletal geometry, and as solid models in which faces are applied to the wireframe geometry thus depicting the model as a solid object. The 3D model can be viewed from any angle at any scale, and possibly in perspective views.

Description

CAD was originally designed for the engineering draftsman but its potential for use in other fields, particularly mapping, has resulted in many changes and extensions to its initial capabilities. It is becoming normal for CAD packages to support 3D solid modelling, and some also offer rendering and animation capabilities. CAD packages often allow objects in a drawing (or model) to be linked to data held in an external database. The ability to link to or include raster images in drawings or models as backdrops or as rendering textures is also becoming general. In parallel some GIS capability may also be supported.

Additional Information

- CAD: A Guide to Good Practice
  < http://ads.ahds.ac.uk/project/goodguides/cad/ > Last checked 25/02/2005
- CSA CAD Guide for Archaeologists and Architectural Historians
  < http://csanet.org/inftech/cadgd/cadgd.html > Last checked 25/02/2005

Technical Environment

CAD packages have been available for most standard operating systems (DOS, Windows, Macintosh, Solaris, Irix) but support for platforms other than Windows is decreasing.

Common Formats

Format	File Extension	Notes
ACIS Solid Model	.sat, .sab	3D modelling software from Dassault Systemes. Data may be stored in either ASCII (sat files) or binary (sab files) format. A proprietary binary format which is not widely supported and so not suitable for preservation.
AutoDesk AutoCAD drawing	.dwg	A common file format deposited with AHDS Archaeology. A de facto standard, but there may be problems with older versions. A proprietary binary format which changes frequently and so not suitable for preservation.
AutoDesk AutoCAD drawing exchange file	.dxf	A 3D vector ASCII format that is well supported by other CAD, drawing and even word processing package. It is likely that depositors can supply data in DXF format, and many in DWG format, however the versions may be archaic. Note that the files may contain a preview image as binary data. Suitable for preservation.
Bentley MicroStation drawing format; Intergraph standard file format	.dgn, .isff	The principal high-end competitor to AutoCAD. Aimed more at civil engineers and currently capable of operating on AutoCAD DWG files. A proprietary binary format and so not suitable for preservation.
FastCAD	.fcd	Proprietary file format in use by FastCAD for drafting and 3D modelling. Not suitable for preservation. A proprietary binary format which is not widely supported and so not suitable for preservation.
HOOPS Stream Format	.hsf	An open specification described as a 'lightweight' method of streaming CAD visualisation data over a network. An emphasis is placed upon error correction, rather than features. HOOPS is highly compressed and therefore not suitable for preservation, but may be useful as a delivery format.
IGES (Initial Graphics Exchange Specification)	.iges	A neutral (ie. not specific to either platforms or applications), ASCII data format for data transfer between CAD systems. IGES has a number of supporters but STEP appears to be supplanting it as the preferred format as a result of the additional information that may be stored. IGES plug-ins for AutoCAD are available. Suitable for preservation.
Imsi DesignCAD	.dc, .dc2	A proprietary binary format and so not suitable for preservation.
Imsi TurboCAD	.dat, .tcw	A proprietary binary format and so not suitable

		for preservation.
STEP (Standard for the Exchange of Product Data)	.step, .stp	An ASCII-based standard (ISO-10303) that describes geometry as a series of instructions rather than objects and points. STEP files may be exported by several CAD systems. It is aimed principally at solid modelling in the engineering/manufacturing community and is unlikely to be encountered from depositors. It may prove to be a valuable archive format because of the extra information that can be stored. There is a patch for recent versions of AutoCAD (2002+) enabling translation to and from STEP files. Suitable for preservation.

Additional Information

- SAT Save File Format
  < http://astronomy.swin.edu.au/~pbourke/geomformats/sat/sat.pdf >
  Last checked 07/03/2005
- AutoCAD R13/R14/R2000 DWG File Specification
  < http://www.opendesign.com/downloads/spec/formatSpec13-15.rtf >
  Last checked 07/03/2005
- Determining the version of a DWG or DXF file
  <http://usa.autodesk.com/adsk/servlet/ps/item?siteID=123112&id=2886793&linkID=2475323 > Last checked 07/03/2005
- Bentley's OpenDGN Initiative
  < http://www.bentley.com/en-us/corporate/opendgn/ > Last checked 07/03/2005
- IGES Project
  < http://www.nist.gov/iges/ > Last checked 25/02/2005
- OpenHSF Initiative
  < http://www.openhsf.org/ > Last checked 07/03/2005
- STEP Overview
  <http://www.steptools.com/library/standard/ > Last checked 25/02/2005

Ingest Checklist

Level 1 (Essential)

- ☐ Title or caption must be included in the metadata.
- ☐ Creator must be included in the metadata.
- ☐ Creation/completion date must be included in the metadata.
- ☐ Purpose must be included in the metadata.
- ☐ Relationships to other document must be included in the metadata.
- ☐ Embedded copyright material must be documented and cleared.
- ☐ Invisible material (in frozen / off / invisible layers) must be documented and relevant.
- ☐ Any use of attributes or extended data must be documented.

Level 2 (Preferred)

- ☐ Software and version used to create image/model should be included in the metadata.
- ☐ Captions/purpose of plot layouts should be described in documentation.
- ☐ Intended plot size/scale of plot layouts should be described in documentation.
- ☐ Invisible material (in frozen / off / invisible layers) should be documented and their contents relevant.
- ☐ Documentation should explain the significance of specific conventions:
    - o Use of layers
    - o Use of line types
    - o Use of line weights
    - o Use of colours
    - o Use of fonts
    - o Meanings of symbols
    - o Other conventions used
- ☐ Any primary survey data the CAD data is based on should be described in documentation, this may have important implications for the accuracy and precision of the drawing or model

Level 3 (Best Practice)

- ☐ Accompanying primary survey data could be included
- ☐ Images generated from 3D models, plus purpose and caption

Inform Depositor

- ☐ Copyright problems (e.g. inclusion of OS vector data)
- ☐ Missing ancillary files
- ☐ Relevance of invisible material, do they really want it archived?

Preservation

Significant Characteristics

The most significant characteristic is the geometry, the disposition of lines, points, text, and other simple or complex drawing objects in the two- or three-dimensional space of the model. CAD developed as a drafting aid in which the final product would be hardcopy plots and hence CAD drawings often incorporate conventions in the use of line style, line weight and symbols. These add meaning to the model and thus must be documented. CAD offers layers and colour to the draftsman that may also be used to enhance the meaning of elements in the drawing or to control line type and weight used when plotting and, if their use is significant, the implied convention or function must be documented.

When the model is linked to a database then the database must be present and fully documented (see Relational Databases Preservation Handbook) and any extra supporting software must either be included or, if proprietary software, fully described and documented.

Technique

Purge the drawing to remove unused layers, blocks, line-type and text definitions. This may significantly reduce the file size.

Check layer definitions for invisible layers; consider the relevance/value and, particularly, copyright of material in invisible layers.

Ensure all externally linked elements (drawings, images, fonts, shapes, etc.) are present and can be loaded by the drawing, i.e. they are not defined by absolute paths that cannot be replicated.

Bind externally linked elements where possible. External images, databases, etc. must also be suitably preserved (see relevant preservation manuals). Additional documentation must be created to describe the links to and locations of all of the archived externally referenced data files.

Save the file to the preferred version number of the original application if one is defined and so doing does not degrade the data. This will, in general, only be feasible if the preferred version is a more recent version.

Generate high definition raster copies of relevant defined plots.

Export to the lowest DXF version that supports all significant features of the CAD package used. Ensure that the precision is set at a suitable level to ensure there is no degradation of the data. By default the data is likely to be exported at a high precision, 16 decimal places for AutoCAD, which will generally be excessive and result in extreme bloat in the resultant DXF file. Some software may use zero decimal places as the default, which will usually result in substantial degradation of the data. If you have some idea of the scale of the drawing, i.e. what 1 drawing unit represents, or the precision with which the original data was collected then use this knowledge to judge a suitable export precision. For example, if the basic unit is 1 metre and the subject is a ground plan then three decimal places is probably sufficient.

Creating SVG versions is advisable as this format is less likely to be sensitive to version changes than DXF, but as yet SVG cannot be read by most CAD packages. SVG can also incorporate, and thus encapsulate, external image files. But note that invisible material is likely to become visible in the SVG version.

If there is a linked database consider transferring drawing, database and linked bitmap images to GIS if this seems a better preservation strategy and refer to the GIS Preservation Handbook.

Validation of Exported Data

Import the exported version into a suitable application, or view the SVG file, and check that the geometry looks the same, in particular check there has been no degradation resulting using an

unsuitable precision (see above), that text fonts have not been changed beyond recognition, and other significant features are intact. Ensure that any externally referenced material is found and displayed correctly.

Problems and Issues

CAD software has been used over several years and, in many cases, changed quite substantially. Unfortunately many packages have not retained backwards compatibility with the file formats of older versions. AutoCAD generally opens files from one or two previous dwg and dxf versions and provides tools to deal with some older versions. TurboCAD is not so good at backwards compatibility and old drawing file formats, particularly those created with DOS versions of TurboCAD, cannot be opened with current versions of the software. It is then necessary to use an old version, quite probably on an old machine and operating system to export the drawing to a standard or neutral format, if indeed this is possible.

Although DXF is a widely supported exchange format it has changed considerably since its inception. The changes can give rise to compatibility problems. In particular, some applications may not support some elements in a particular DXF version and may simply skip that part of the data resulting in a loss of data that may not be apparent to the user.

The ability to include linked or externally referenced data in CAD drawings offers users many benefits such as re-use of library components, objects scaled to fit from template shapes (e.g. a unit length of an architectural moulding which can then be inserted into a 3D model in any position and at any length). By default the full path to external material, including the drive, is stored in the drawing database and it may not be possible to duplicate this path on another machine. These absolute paths can be converted to relative paths but this may still pose problems because of the structure of the file store being used in the archive. It is, therefore, essential to document the location of the archived version and what format changes it has been subjected to. Externally referenced material should be 'bound' into the drawing file, preferably by the depositor, which then converts the data into in internal block.

Database data linked to a drawing will have path problems similar to those outlined above. There are a number of methods by which the link can be made. In older versions of CAD packages this was often complex and used code written in a language peculiar to the application to establish and maintain the data link. This code was generally stored in external files. Linking data has been simplified substantially and replicating links for old file versions may not be a problem unless the data format is no longer supported. However, the mechanisms used to make these links is likely to change in the future so be prepared for the possibility of problems and even for being unable to link the drawing and database.

Additional Information

- CAD Archival Preservation - and Some Practical Consequences
  < http://csanet.org/newsletter/winter02/nlw0205.html > Last checked 25/02/2005
- The National Archives Digital Preservation Guidance Note 4: Graphics file formats
  < http://www.nationalarchives.gov.uk/preservation/advice/pdf/graphic_file_formats.pdf > Last checked 25/02/2005