Preserving CAD

An Overview

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26 July 2013

IMechE, One Birdcage Walk, London

Funded by JISC

Outline

What is CAD and why should we care?

Why is CAD challenging?

CAD standards

CAD non-standards

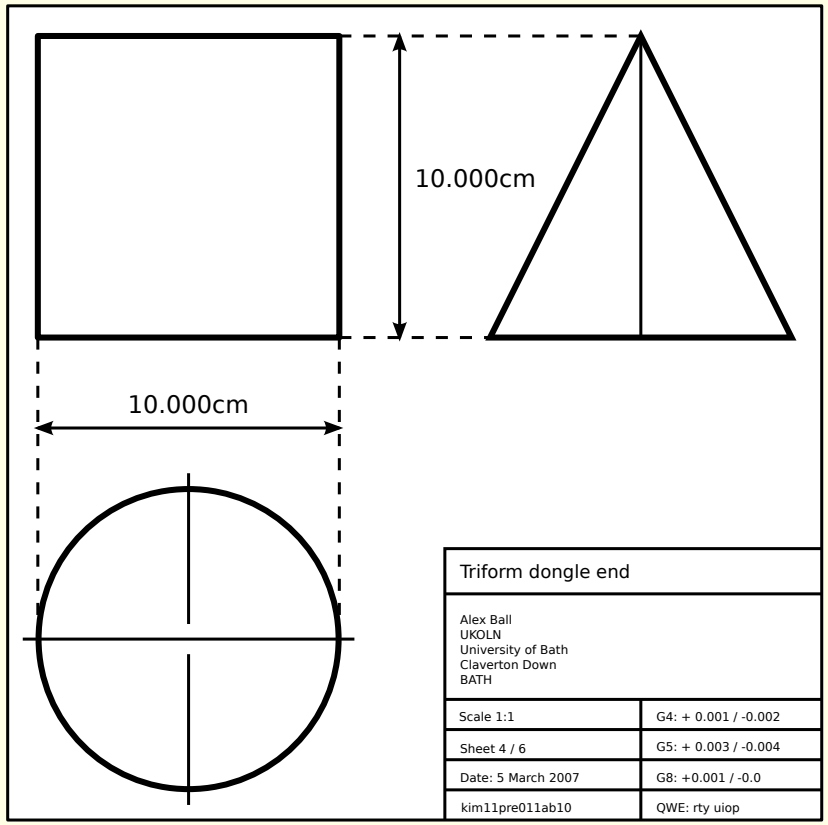
Preservation strategies

Final thoughts

What is CAD and why should we care?

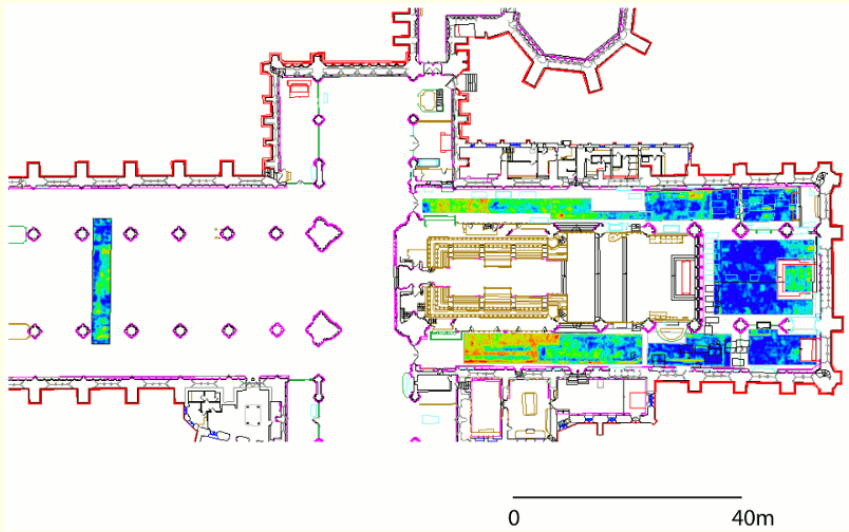
CAD is used for . . .

- 2D design drawings



CAD is used for . . .

- 2D design drawings
- Floor/site plans



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CAD is used for . . .

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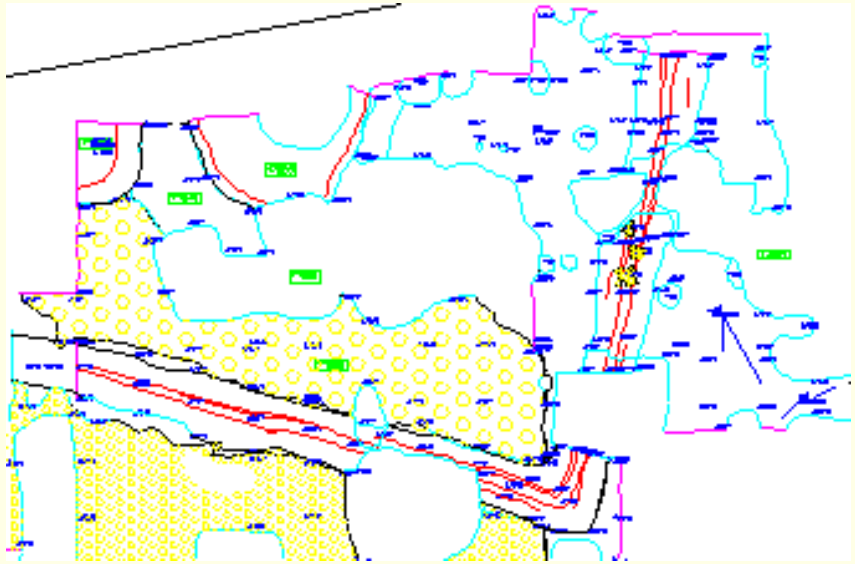
- Archaeological site records



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CAD is used for . . .

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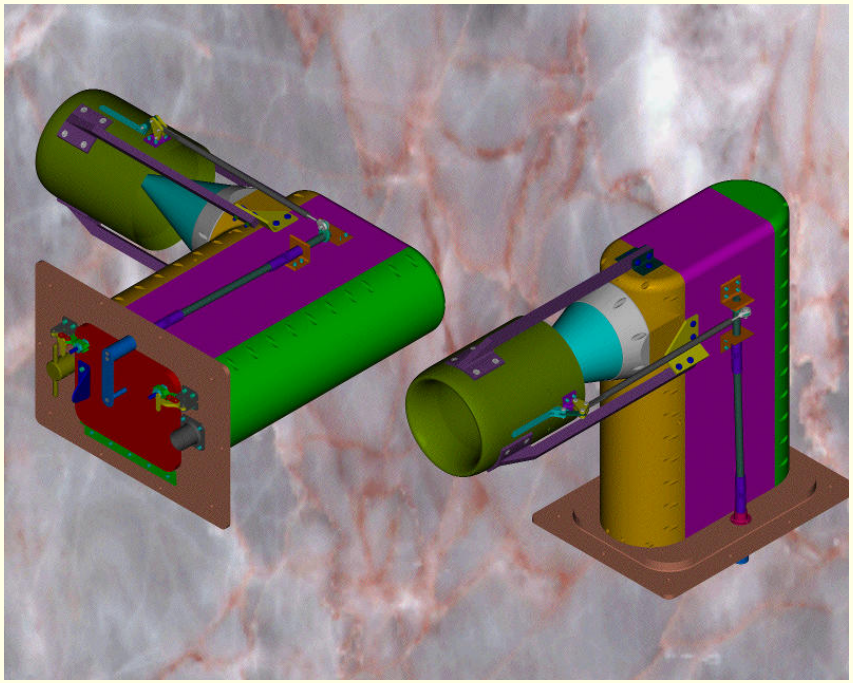
- 3D product models



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CAD is used for . . .

- 2D design drawings
- Floor/site plans
- Archaeological site records
- 3D product models
- 3D architectural models

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CAD is used for . . .

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- Floor/site plans
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- 3D product models
- 3D architectural models
- 3D impressions/ reconstructions of buildings

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CAD is used for . . .

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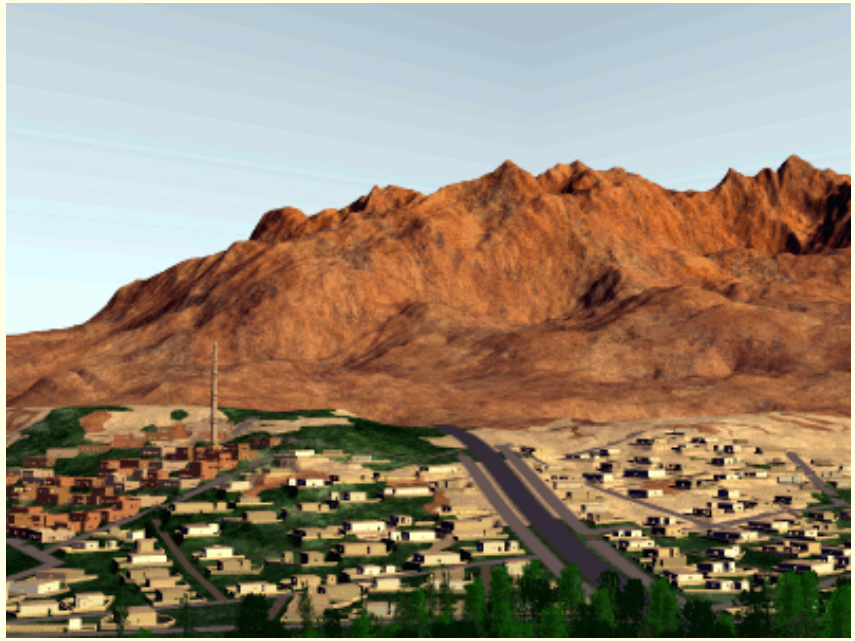
- 3D impressions/ reconstructions of buildings
- Virtual worlds



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CAD is used for . . .

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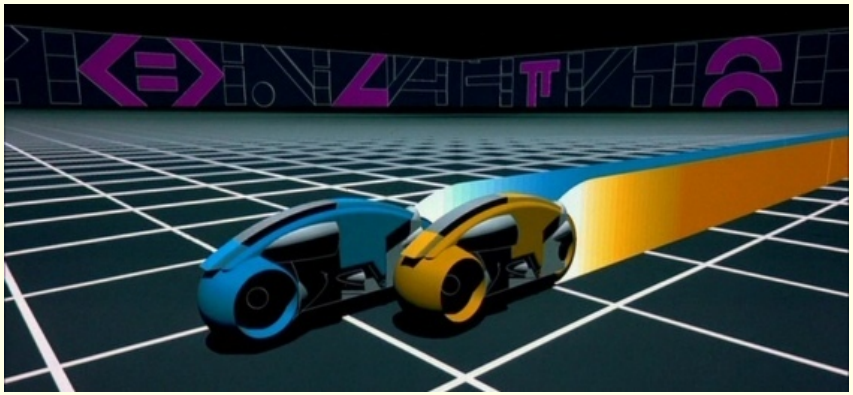
- 3D product models
- 3D architectural models
- 3D impressions/ reconstructions of buildings
- Virtual worlds
- 3D animations



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CAD is used for . . .

- 2D design drawings
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- 3D architectural models
- 3D impressions/ reconstructions of buildings
- Virtual worlds
- 3D animations

- Reference
- Rationale
- Reuse

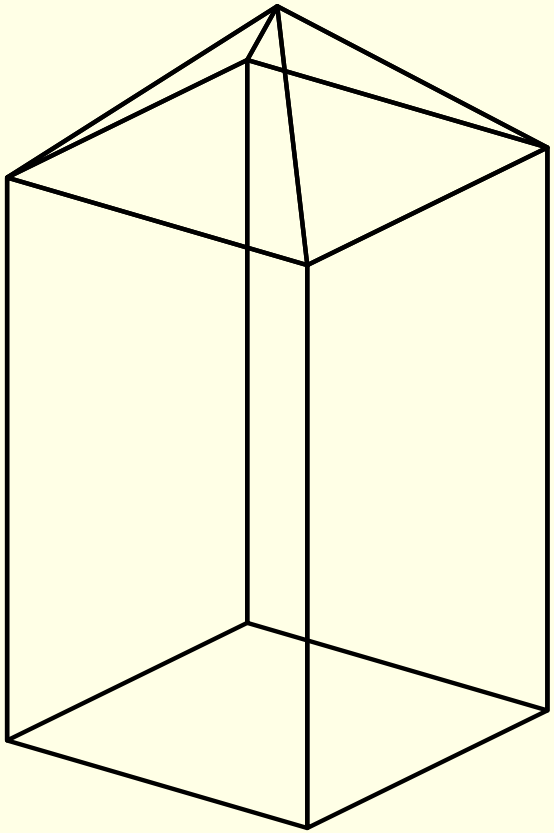
– Lubell et al. (2008)
http://dx.doi.org/10.2218/ijdc.v3i2.58

Importance of preserving CAD

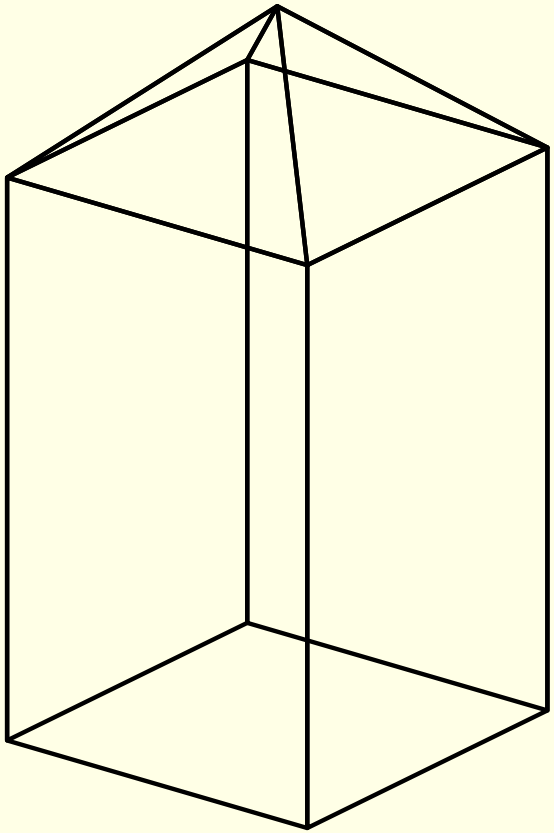
- CAD models contain irreplaceable information
- 3D CAD models cannot be satisfactorily represented in any other way (e.g. printouts, physical models)
- CAD models remain interesting longer than CAD systems remain usable

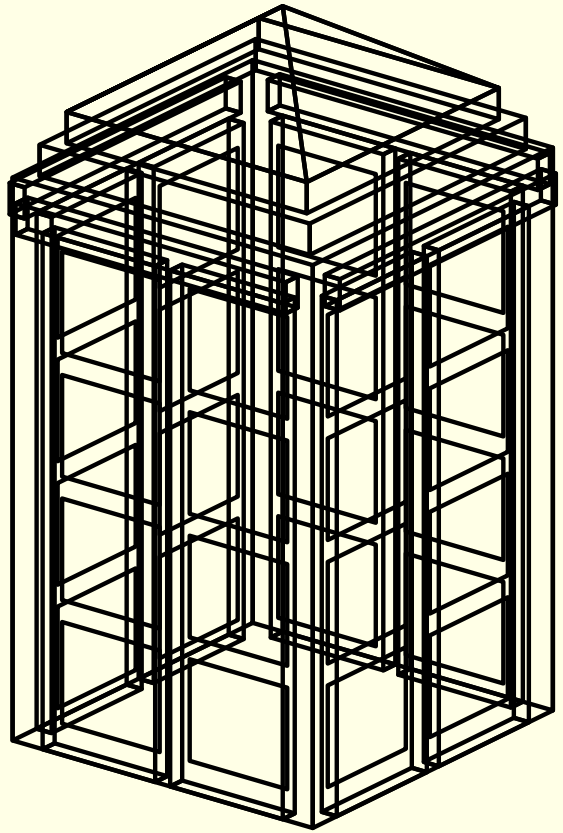
Why is CAD challenging?

Wire-frame modelling

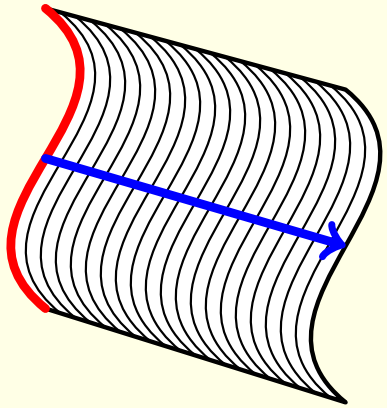


Wire-frame modelling

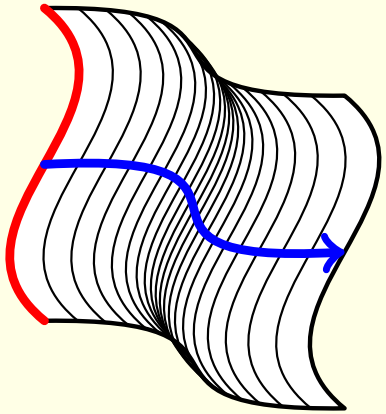




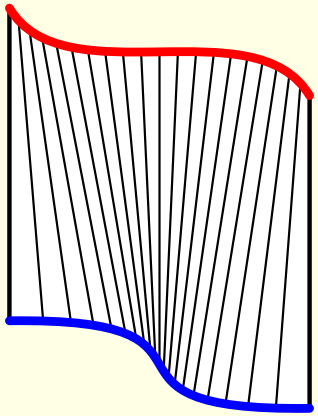
Surface modelling



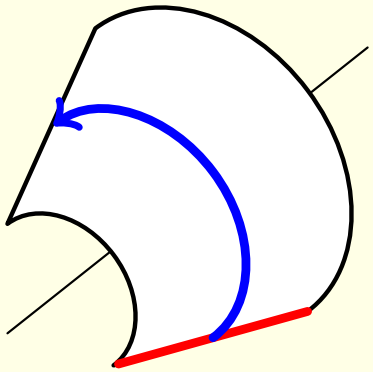
Extruding



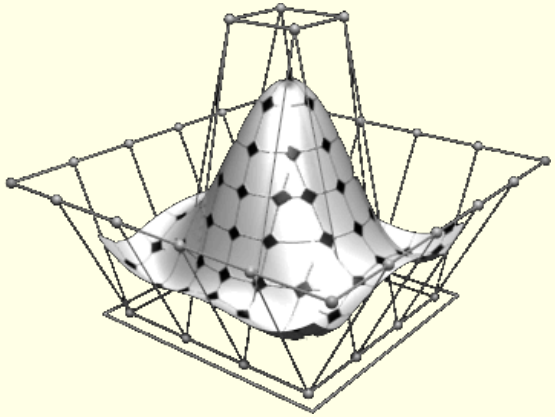
Sweeping



Lofting

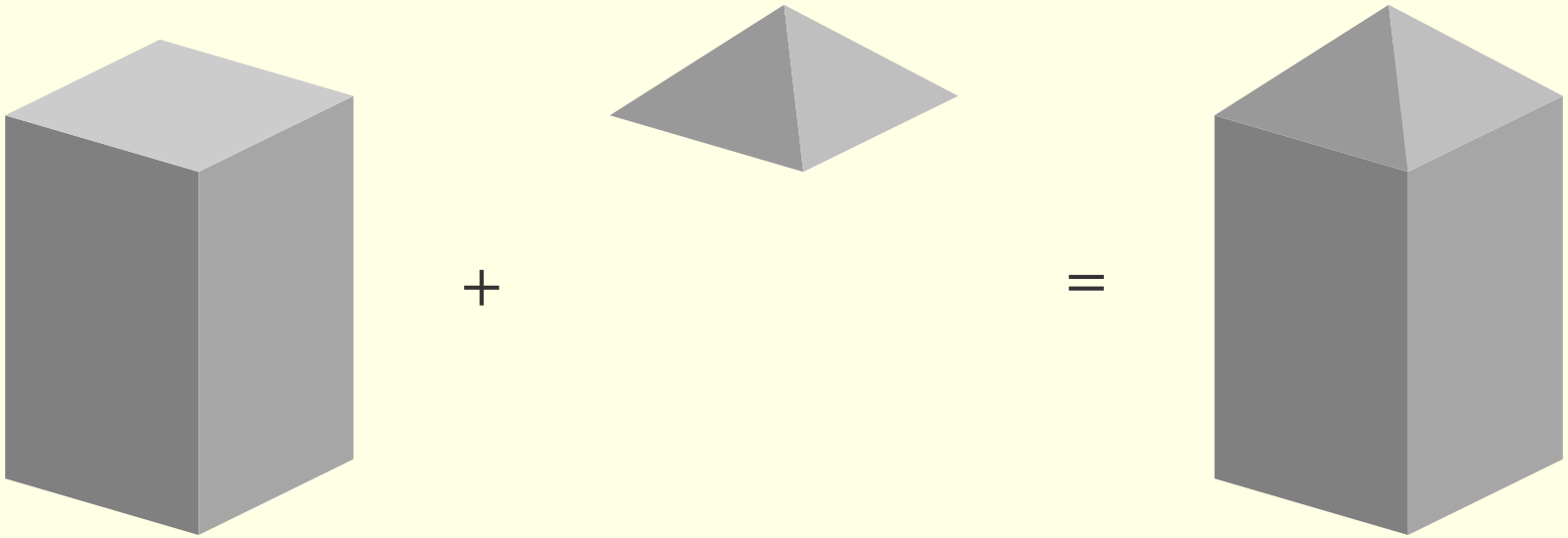


Revolving

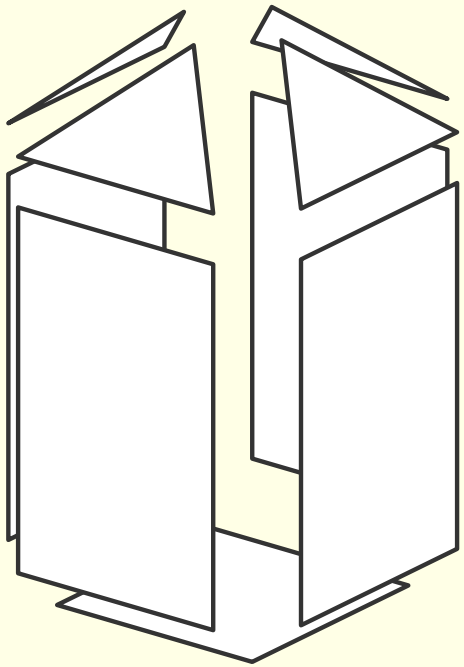


NURBS

Constructive Solid Geometry



Boundary representation



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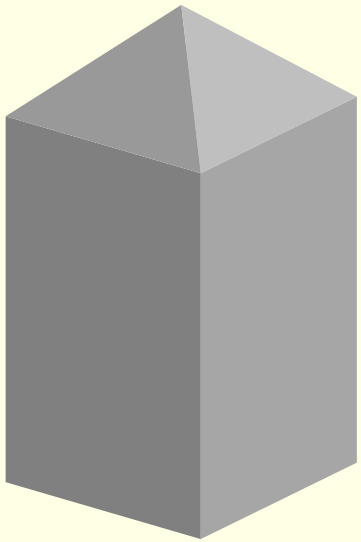
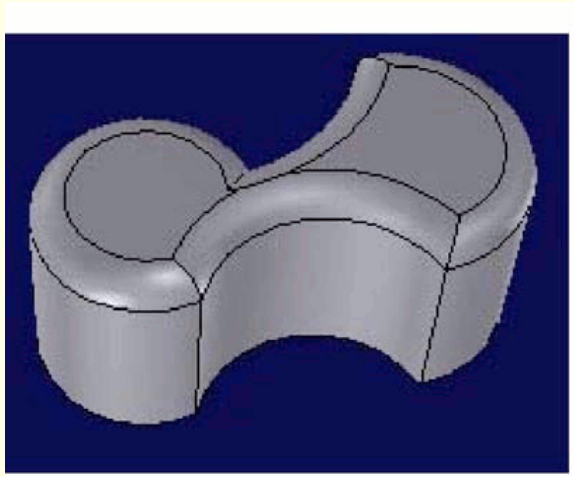
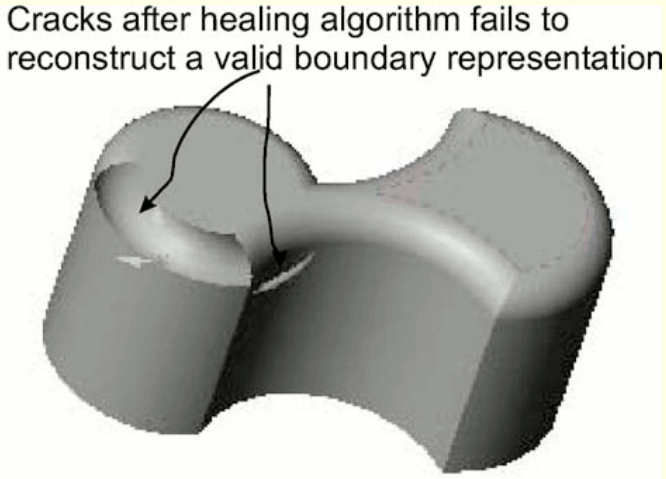


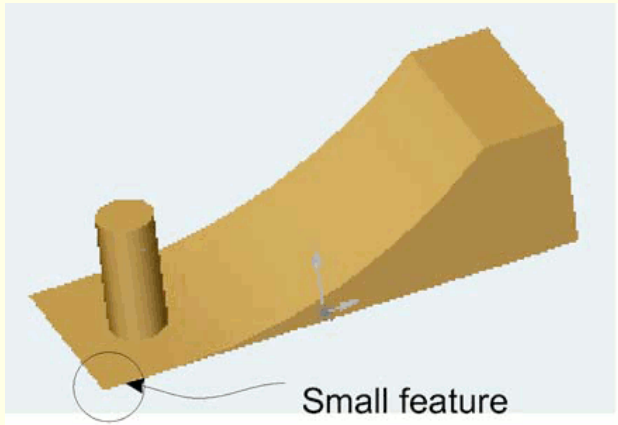
Mistranslation and misinterpretation



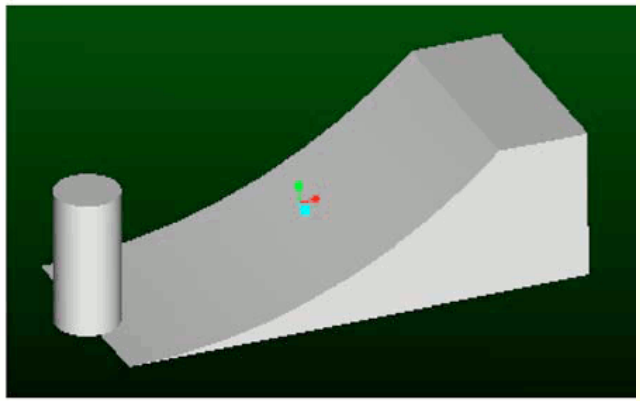
(a)



(b)



(a)



(b)

Construction history modelling

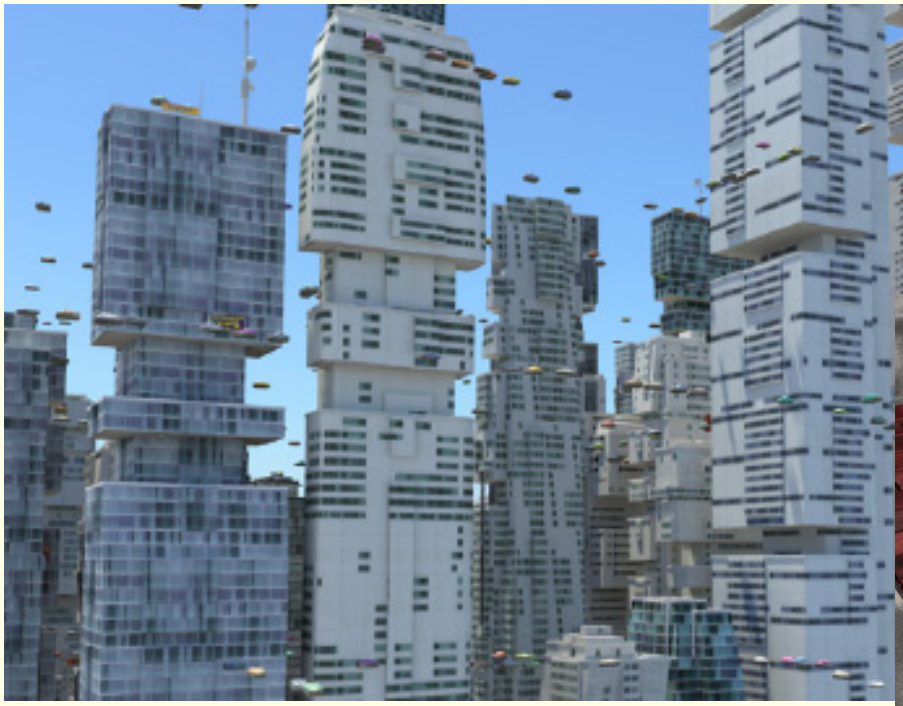
1. Insert cylinder $l = 20$ $r = 1.0$

⟵ Change cylinder $l = 40$ $r = 0.5$

2. Insert sprocket $r = 3.0$
3. Fit sprocket to cylinder
4. Group cylinder and sprocket
5. Scale group by $1.75\times$

...

Procedural modelling



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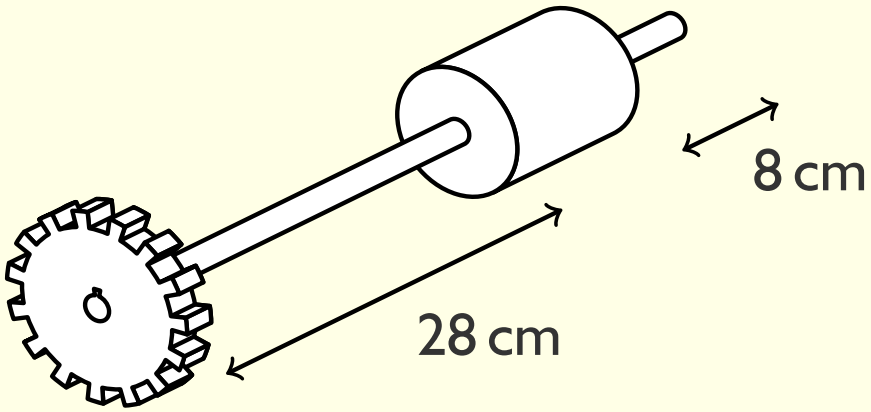
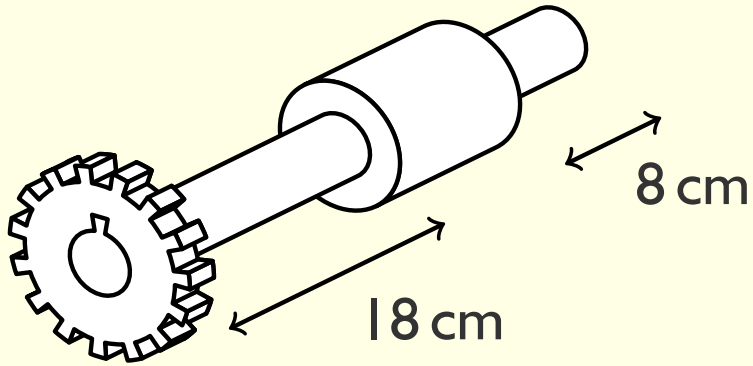
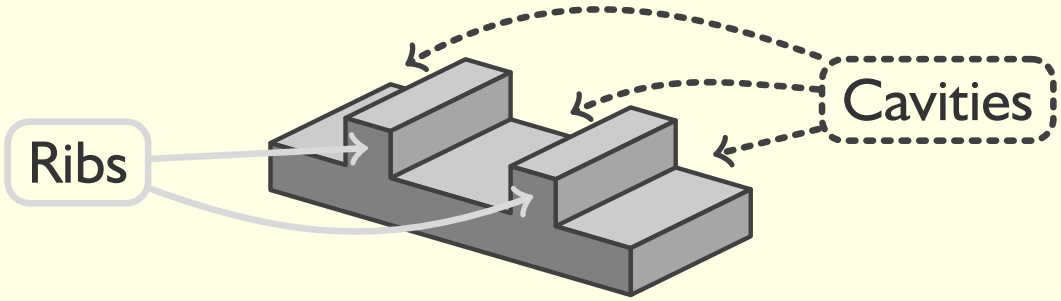
Parametric modelling

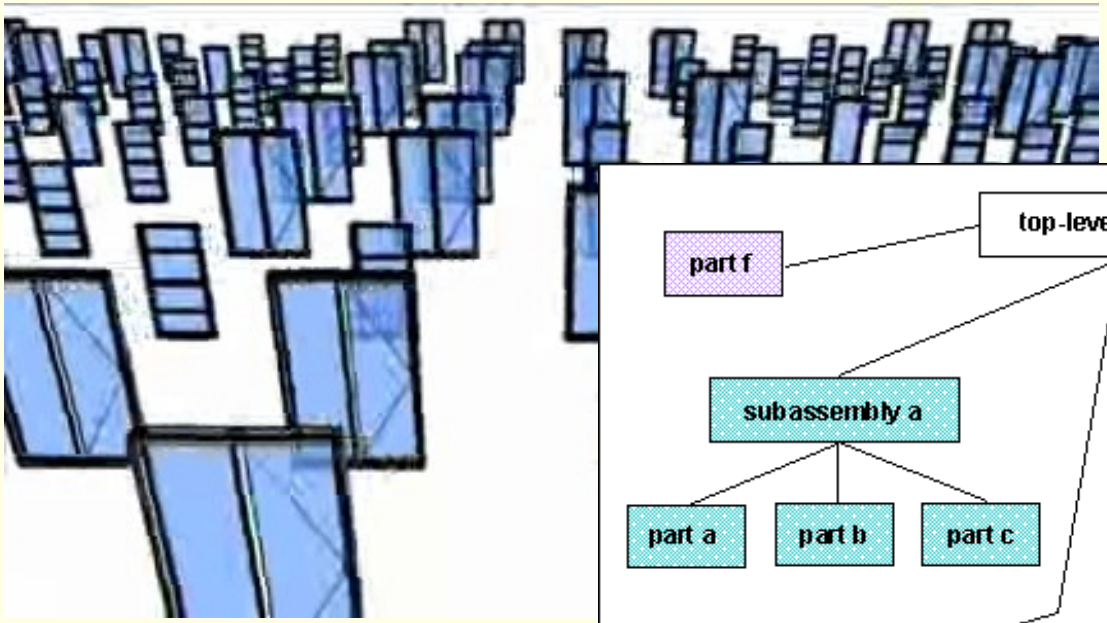




Feature-based modelling



Reusing standard parts



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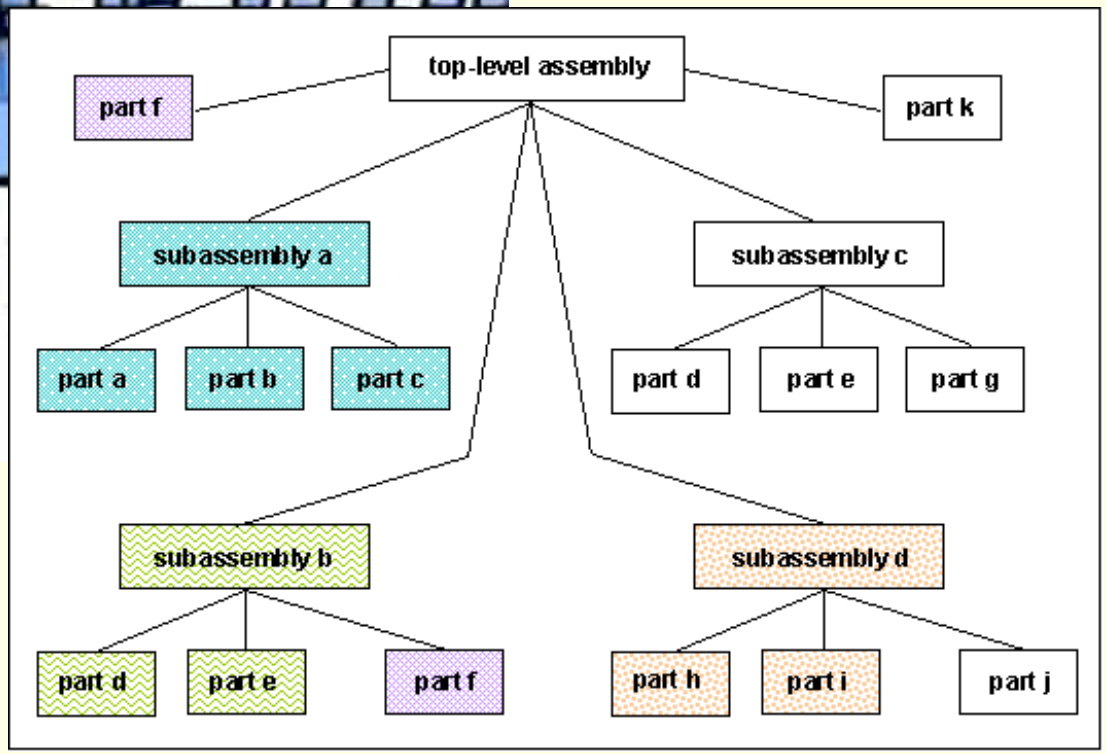

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CAD standards

General CAD standards

IGES	Initial Graphics Exchange Specification – ANSI Y14.26M-1981 . . . ANS US/PRO/IPO-100-1996
SET	Standard D'Echange et de Transfert – NF Z68-300 (AFNOR)
VDA-FS	Verband der Automobilindustrie-Flächen-Schnittstelle
STEP	Standard for the Exchange of Product Model Data – ISO 10303
IFC	Industry Foundation Classes (IFC) for data sharing in the construction and facility management industries – ISO 16739:2013
LOTAR	Long Term Archiving and Retrieval – EN 9300, NAS9300

CAD visualisation standards

JT	Engineering Animation & Hewlett Packard – UGS – Siemens PLM – ISO 14306:2012
U3D	Universal 3D – ECMA-363
PRC	Product Representation Compact – Trade and Technologies France – Adobe – ISO/PRF 14739-1, relevant to ISO/DIS 24517-2 (PDF/E-2)
VRML	Virtual Reality Markup Language – ISO/IEC 14772-1:1997
X3D	Web3D Consortium – ISO/IEC 19775, ISO/IEC 19776, ISO/IEC 19777

CAD non-standards

AutoCAD

DWG Native AutoCAD format, closed but supported by RealDWG (AutoDesk), Teigha (Open Design Alliance), LibreDWG (GNU).

DXF DWG Exchange Format, published, intended to enable full data exchange.

DWF/DWFx DWG Web Format, published, intended for visualisation.

Preservation strategies

Preserve the original CAD model

- Implies preserving software through emulation.

Pros preserves maximum information; easier to guarantee provenance.

Cons need to preserve expertise in the system; need an amenable software licence; hard to maintain integration with current systems.

Good for reference purposes, but not reuse.

Rolling format migrations

- Migration to newer format versions or new CAD systems.

Pros models usable by current designers and software.

Cons cost of validating each migration; incremental data loss/corruption.

Good for models in active development/use, but not for long-term archiving.

Normalisation

- Migration to (*a*) STEP/IFC (*b*) a visualisation format.

Pros only two migrations needed, so limited data loss/corruption; back-up in case a migration goes wrong

Cons cost of validating each migration.

Good for long-term archiving and reuse.

Good ideas

Validation	Record validation properties (volume, centre of gravity, point cloud) in original CAD system, then test for them after import into another.
Indirect links	With linked files, replace any absolute links with relative links or resolvable identifiers.
Split files	Archive part files as separate packages, and assemblies as super-packages.
Annotation	If information is known to be lost on migration, try preserving it using annotations.
Metadata	Supplement the CAD files with specifications, layer naming conventions, file naming conventions, data collection documentation . . .
House style	Encourage the use of a (documented) house style, to aid clarity, avoid migration problems and preserve semantics.

Final thoughts

Recommendations

- Establish why a CAD model will be kept, then target the required properties for preservation.
- Create tests that can prove whether these properties have survived.
- Keep native CAD models for as long as they can be read.
- Normalise to STEP/IFC and a visualisation standard (or two).
- Don't forget supporting documentation, especially local conventions and 'house style'.
- Campaign for better support for standard formats in CAD systems!
- Oh, and read the full report:
  `http://dx.doi.org/10.7207/twr13-02`

Thank you for your attention

DCC Website: `http://www.dcc.ac.uk/`
Alex Ball: `http://alexball.me.uk/`